

Welcome to PQ Connection

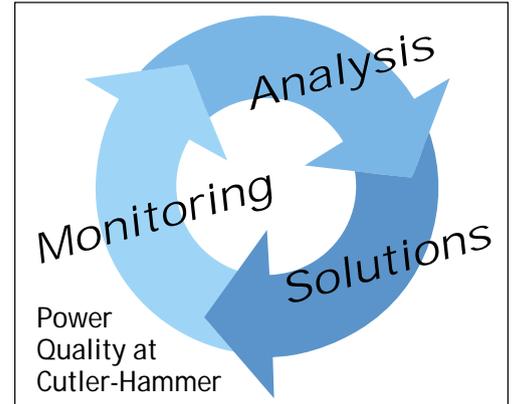
Cutler-Hammer Forms Power Quality Task Force

In an effort to consolidate our efforts in Power Quality Solutions and Services, Cutler-Hammer has recently formed a Power Quality Task Force. Dan Carnovale, Technical Leader responsible for Power Quality Consulting Services, Russ Barss, Product Line Manager for Surge Products, and David Gianamore, Product Line Manager for Power Management Products, have taken the initiative for forming this new Task Force.

Many of the Cutler-Hammer product lines already have a Power Quality program in

place. The Task Force will combine the best of each program to provide our customers with real solutions to their Power Quality system problems.

Power Quality has been likened to "chasing ghosts" because of the confusing approach that many "Power Quality Experts" have taken. In upcoming issues of PQ Connection we will help to take some of the mystery out of the term Power Quality. We invite your comments and questions related to Power Quality and how our team can help to solve your problems.



Cutler-Hammer's approach to Power Quality Problem Solving is the most complete in the industry. We provide detailed monitoring, sophisticated analysis and the most efficient and practical solutions and equipment to meet your Power Quality needs.

Exceeding Expectations: The Power Management Users Group

A Forum for Industrial, Commercial, Institutional and Utility Customers

Sixty-five professionals responsible for managing power convened in Pittsburgh last November to participate in the 1st Annual Power Management Users Group meeting. They came with the expectation of networking with peers from other organizations, trading accounts of challenges and successes, and walking away with tips on optimizing power quality, reliability, uptime, energy consumption and cost savings. They weren't disappointed.

The event was completely customer-driven, and therefore, completely customer-focused. A steering committee made up of power management experts from Ford, the University of Notre Dame, Alabama Power, Bayer and PPG

defined the agenda and set the tone of the meeting. Each presented facts on how they leverage their Cutler-Hammer power management investment to help them meet their power quality and energy management objectives.

Additionally, those in attendance had the opportunity to ask questions of the Cutler-Hammer leaders and product experts, provide product development feedback and get a sneak-peek at upcoming products. Said one attendee, "This was such a great opportunity for sharing best power management practices with other end-users and for learning about the trends in the industry as they affect me. I wouldn't hesitate to recommend this conference."

This fall, Cutler-Hammer will facilitate another Power Management Users Group meeting, only this time, it will be bigger and better. If you're an end-user of Cutler-Hammer products and you want to be a part of this year's event, or you simply want to learn more, visit www.cutlerhammer.eaton.com, or call your Cutler-Hammer sales engineer.



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Designing a Safe and Reliable Electrical System

By Jill Revolt, Dan O'Reilly
& Bill Vilcheck

Facility managers often believe that a relatively incident-free record guarantees future reliability of the electrical power system. This can lead to a false sense of security that can have dangerous repercussions, especially for electrical systems where no detailed records are kept about minor or major power disruptions within the facility. A record of such incidents, including location, duration and extent of an outage, can provide an invaluable indication of a design problem waiting to develop into a more serious mishap.

When designing a new electrical system, it is expected practice for a qualified and experienced electrical engineer to evaluate and coordinate the new system to provide a safe, reliable and effective design. The issues that are often overlooked are in coordinating an existing system with the design of a new expansion.

The facility manager must provide the electrical design engineer with current and accurate information on the existing system and insist that all power studies for the expansion incorporate the capabilities of the existing system. In many small addition or upgrade projects, there may not be an electrical design engineer involved in the project. Facility managers must be sure they are taking the necessary precautions to protect the entire system and should not trust the power systems engineering and reliability to an electrical contractor.

Power Systems Coordination

The following true-life example from a metropolitan hospital illustrates the critical nature of power system coordination.

A hospital added a new wing to its

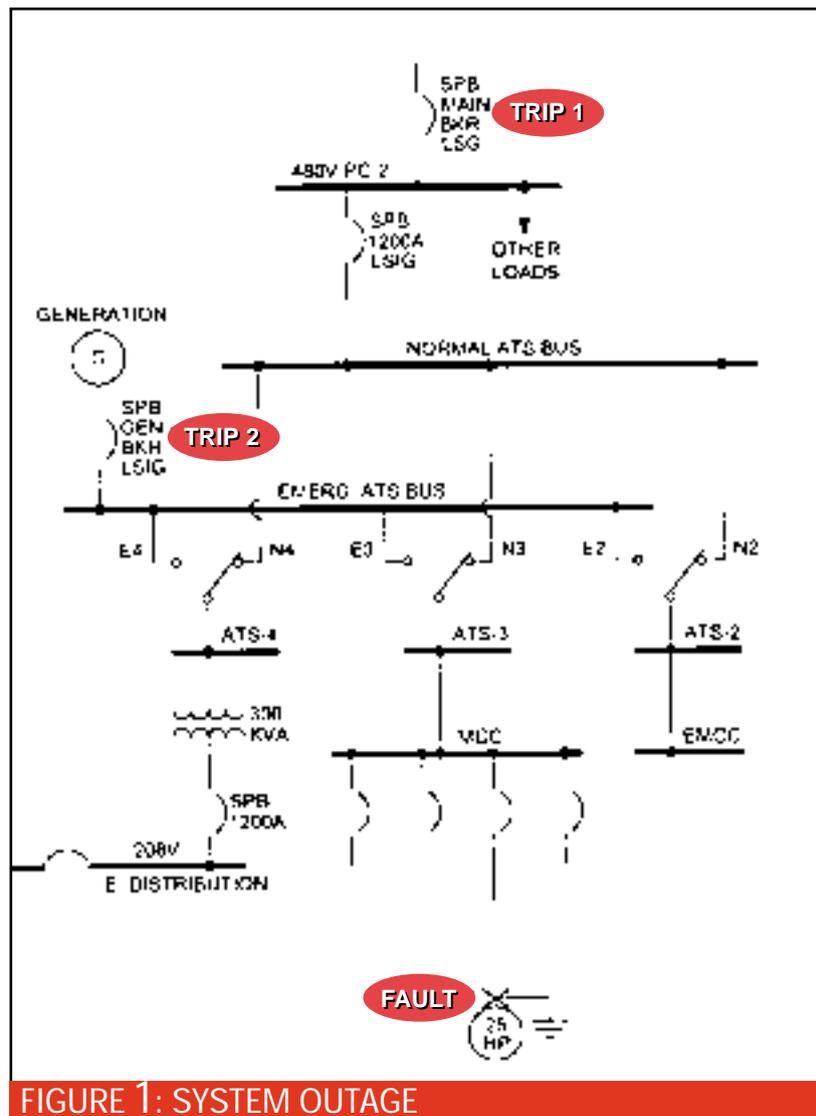


FIGURE 1: SYSTEM OUTAGE

existing 30-year-old facility. A power system study performed on the new electrical distribution system, only assured coordination between protective devices within the new system. The new electrical system consisted of a 4160V switchgear, 4160V primary/480V secondary substations, 480V and 208V panelboards and 480V and 208V motor control centers (MCC).

The contract for the power system study did not include the existing electrical system in the study.

At 1:25 a.m. on October 3, 1998, a ground fault occurred. It occurred in a 25-horsepower (hp) fan motor supplied from a motor control center located on the second floor of the existing building. The protective device in the motor control center did not trip, nor did it trip the upstream feeder

circuit breaker that supplied this MCC via an automatic transfer switch (ATS). The main breaker for the existing power center operated and removed power from the faulted system. This resulted in a loss of power to half of the existing facility. (See Figure 1 – Trip 1.) All power was lost to the critical care loads including life support and patient isolation ventilation systems.

Subsequent to the main circuit breaker trip, all automatic transfer switches sensed the loss of power. A signal was sent to start the emergency generators. Once the generators started, the automatic transfer switches operated and re-established a supply of power to the emergency system.

The emergency power was not supplied for long because the ground fault was still present at the 25hp fan. The circuit breaker on the emergency system which feeds all the transfer switches tripped, resulting in the complete loss of power to the hospital. (See Figure 1 – Trip 2.)

Fortunately, the medical staff, trained for this type of emergency, reacted without delay. Several patients on respirators were in severe danger of suffocating. The medical staff manually operated bag valve masks that breathed for the patients. After 20 minutes, the fault was isolated and power was restored with no harm to any of the patients.

The example above demonstrates the importance of a properly designed electrical distribution system. The electrical system that distributes power throughout a hospital — no matter if it is a single building or large campus — is the lifeblood of that operation. An unreliable system places the facility, the employees and the patients at risk.

Power Systems

By their very nature, power systems are

dynamic. They evolve and change over time. Every passing year sees the gradual decrease of reserve capacity and response time, as well as the slow erosion of insulation and contacts. More importantly, every new load, upgrade, expansion and reconfiguration creates unexpected stresses and interactions that the original power system was not designed to address.

To further complicate the situation, the proliferation of computers and other micro-chip technologies, and the advent of utility deregulation, makes the challenges of maintaining a safe, efficient and reliable power system more complex and daunting than ever before.

System Reliability

With so many issues to consider, how can a facilities manager assure the reliability of a system? The best place to start is by having a current, one-line diagram of the electrical system. This should be a comprehensive document that incorporates the entire system, including information on the original system and changes and expansions that have occurred. If the one-line diagram is not currently available, it is not difficult to develop. To do so, an experienced engineer can easily gather the necessary information by walking through the facility. The engineer should be someone experienced in design, protection and coordination of power systems.

From the information provided in a current, comprehensive one-line diagram, a power system engineer can evaluate the electrical system for potential problems and identify areas of concern. These areas of concern can be addressed more specifically through a power system study.

Power Systems Studies

There are several different types of power systems studies that can be performed on an electrical system. The proper study choice depends upon the areas of concern identified on the one-line diagram or the problems the system has already experienced.

The following is a description of several power system studies that can help facility managers develop and maintain a good electrical distribution system.

Short Circuit Study

A short circuit study calculates the available short circuit currents at each

protective device. Even the best-designed electrical distribution systems will occasionally experience short circuits. Over-current protective devices such as fuses and circuit breakers should safely isolate the fault current at desired locations with minimal equipment damage and minimal disruption to the facility. Other components of the distribution system, such as

“When designing new electrical systems, it is expected practice for a qualified electrical engineer to evaluate and coordinate the new system.”

transformers, cables and disconnect switches, must be able to withstand the mechanical and thermal stresses produced by the fault current flowing through them. Results of a short circuit study will provide the necessary electrical equipment rating for each protective device.

Protective Device Coordination Study

A protective device coordination study determines the necessary characteristics, ratings, and settings of all the over-current protective devices within the electrical distribution system. This study ensures that the minimum unfaulted load is interrupted when the protective devices isolate a fault or overload anywhere in the distribution system. It also ensures that the devices and settings are selected to provide satisfactory

protection against overloads on equipment and interrupt short circuits as rapidly as possible.

Load Flow Study

The load flow study is an analysis of system capability to supply energy to the connected load under steady state conditions. Study results allow the power system engineer to identify overloaded transformers and cables, select proper transformer tap settings, determine the need for power factor correction capacitors, and identify suitable areas for additional loads.

Power Quality Evaluation

A complete power quality evaluation is another tool that can be used to maintain a safe and reliable electrical distribution system.

A complete power quality evaluation will generally involve one or more of the following power system studies:

- Harmonic Analysis
- Transient Analysis
- Voltage Sag/Flicker Analysis
- Site Survey

Conclusion

When internal expansion or external utility changes affect a facility's power system, comprehensive power system studies will ensure greater protection and reliability of the entire power system. Following the study, it is imperative to annually maintain, test and update all equipment within the one-line diagram. When working with a power system that lacks this type of up-to-date information, it is highly recommended to schedule a comprehensive power system study of the entire system. Put plans in place for annual maintenance and testing of protective devices shown on the one-line diagram.

Facility managers benefit from knowing that the electrical system is capable of operating safely and reliably under any type of electrical fault and power system studies can help achieve this peace of mind.

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FEATURE

New Life for Old (and New) Motors: the Reflected Wave Trap

Motor Failures are Directly Related to the Increased Use of Variable Frequency Drives. The Reflected Wave Trap Can Reverse the Trend.

Anthony Mendoza, P.Eng
David J. Speideisbach, RET

Thousands of motors with a variety of horse power ratings are now tolling in plants and buildings throughout North America; more are being installed every week.

Many of these motors were initially installed with variable frequency drives (VFDs), and others have been retrofitted with VFDs to gain efficiencies. Most are opportunities for another installation; a solution to stop the disturbing trend of frequent failures caused by reflected wave overvoltages. That solution is the Cutler-Hammer Reflected Wave Trap (RWT).

There are many positive and negative benefits to the use of variable frequency drives. On the positive side, they improve the efficiency of motors and increase the control operators can exert over many plant operations. On the negative side, variable frequency drives/motor systems create reflected wave spikes that can erode motor winding insulation and cause premature failure of the motor and expensive downtime (see appendix one for details).

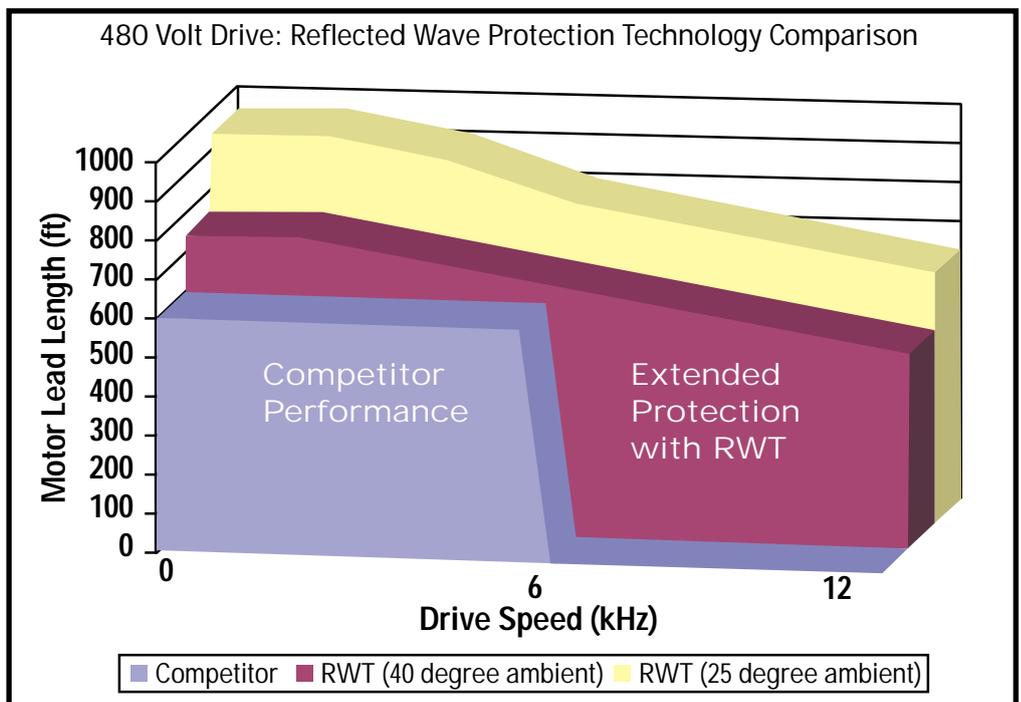
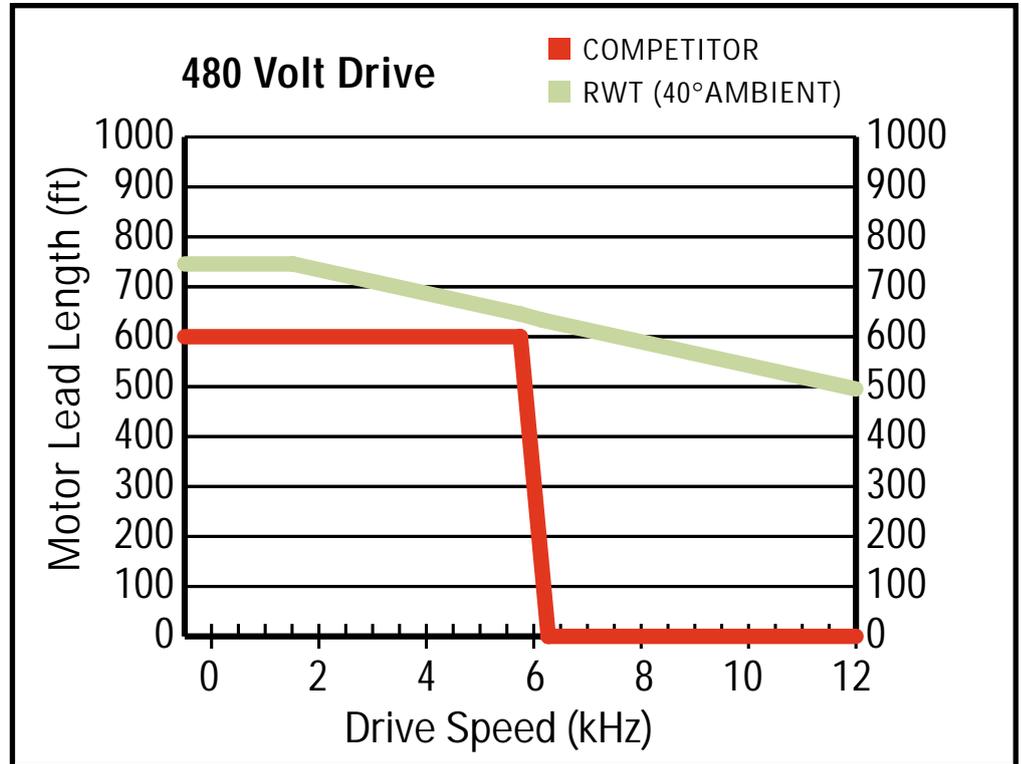
This situation can be particularly acute when cables between the drive and motor are longer than 50 feet (15 meters). In such installations, the impedance of the cable and motor are mismatched, causing higher voltage peaks at the motor terminals and even greater damage to the insulation.

Helping Motors Cope With Hostile Environments

The hostile environment created by VFDs and reflected wave spikes can be mitigated by installing the RWT at the motor terminals, or up to a maximum of 25 feet (8 meters) away from the motor terminals.

The RWT offers:

- Optimum protection without sacrificing motor efficiency. The RWT removes only the energy created by the reflected wave spike, and not the energy in the rest of the waveform, typical of other less effective solutions.



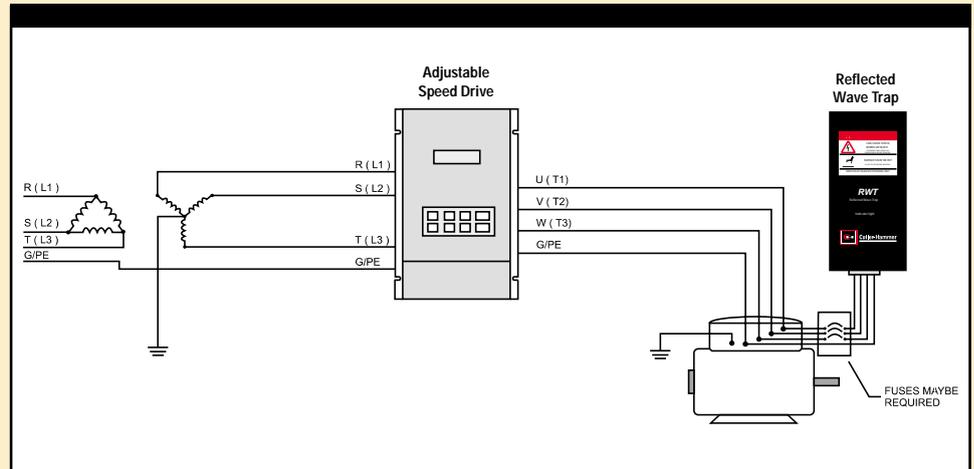
The RWT protects motors from reflected waves at frequencies up to 12 kHz, a far greater range than other devices.



Reflected Wave Trap

- Simplified and minimum inventory. Two models to meet the needs of virtually any installation, one for ordinary plant environments (NEMA 1), one for hazardous or corrosive environments such as chemical or paper plants (NEMA 4X, Class I, Division 2 rated). Both models are compatible with various drive systems, system horse power, voltage ratings and manufacturers.
 - Installation flexibility. The RWT protects motors located up to 750 feet (230 meters) from the drive and can be installed up to 25 feet (8 meters) from the motors' terminals — without sacrificing protection.
 - Operator confidence is higher with a status indicator light, another feature available only from Cutler-Hammer. The status indicator light tells operators that motors are protected, and alerts them should protection be interrupted. Operators know when other devices have stopped protecting the motor only when the motor has failed.
 - Safer, with lower operating temperatures. The surface temperature of the RWT is a maximum of only 90°C (185°F). The surface temperatures of other devices can be more than twice as high because higher operating losses are converted to heat.
 - Widest operating range. The RWT operates up to 12kHz, while other devices are limited to upper levels of between two and six kHz, depending on the lengths of motor leads and motor voltage.
- The RWT is simple to stock and specify, easy for contractors and plant engineers to install, and economical for plant and building owners. As such, it is the choice of industrial and commercial customers who demand the the highest possible motor reliability and plant uptime.

Installation Guidelines



*Install RWT less than 25ft. (7.5m) away from the motor.

Appendix One *Reflected Waves: Their Origins and Characteristics*

Overview

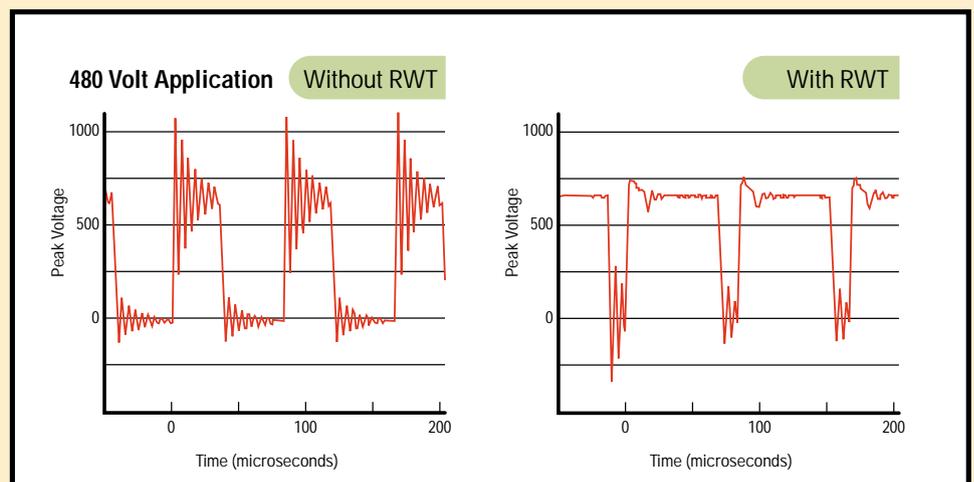
Variable Frequency Drives of all types, especially Insulated Gate Bipolar Transistor (IGBT) and Bipolar Junction Transistor (BJT) types produce very steep leading edge waveforms that provide power to motors to which they are connected. Long leads — typically longer than 50 feet (15 meters) — cause this steep voltage to reflect at the motor doubling the voltage to form a spike well beyond the design withstand voltage of the motor. Insulation is damaged and the motor fails prematurely.

More about Reflected Waves

Voltage wave reflections are functions of the voltage rise time (dV/dT) and the lengths of cable feeding the motor which behave as transmission lines. The impedance of the cables is mismatched at the VFD to motor terminals.

As a result some portion of the high frequency leading edge of the waveform is reflected back in the direction from which it arrived. As the reflected leading edges encounter other waveform leading edges their values add causing transient overvoltages.

The reflected wave trap (RWT) reduces the over voltages to harmless levels by converting the AC voltage to DC and setting the protection level to well under 1000 Volts, a safe level for motors. Clamping components draw enough current to remove any voltage spikes exceeding this level and the spike is dissipated as heat.





Questions and Answers

Q. At what % Total Harmonic Distortion (THD) of the current should I be concerned?

A. In fact, the % current distortion is a very misleading concept. Remember the % distortion is a function of the fundamental current (THD = total root mean square of all of the harmonics divided by the fundamental). IEEE 519 gives guidelines based upon % THD but these values are based upon base 60 Hz (or 50 Hz) loading. Consider the following examples:

EXAMPLE #1

$$I_{THD} = 50\%$$

$$I_{Fundamental} = 100 \text{ A}$$

Therefore, the rms value of all of the harmonics is 50 A

The total rms current including fundamental and harmonics is:
112 A ($=\sqrt{100^2+50^2}$)

EXAMPLE #2

$$I_{THD} = 224\%$$

$$I_{Fundamental} = 20 \text{ A}$$

Therefore, the rms value of all of the harmonics is 50 A

The total rms current including fundamental and harmonics is: 54 A

In both situations, the harmonic current is the same, however in the second case, the fundamental current is considerably less. The second case seems worse looking at the % THD but, in fact, it is less total rms current.

Careful attention to actual harmonic current will avoid problems when a new PQ meter is installed. This is especially true when the meter monitors neutral current where the %THD may be 2000%.

In summary, the total rms current is more critical to analysis of the power system harmonics. Determine the system design (ampacity) levels and base your analysis on these levels for comparison to total rms current. Tables are available (IEEE 1100) for derating transformers and cables when supplying harmonic producing loads.

Q. What are the "signature" harmonics generated by typical equipment?

A. See the following Table (harmonics are shown in decreasing order of magnitude):

EQUIPMENT	HARMONICS
Switched Mode Power Supply	3, 5, 7, 9, 11, etc.
6 Pulse AC drive	5, 7, 11, 13, 17, 19, etc.
6 Pulse DC drive	5, 7, 11, 13, 17, 19, etc.
12 Pulse AC Drive	11, 13, 23, 25, 35, 37, etc.
Florescent Lighting	3, 5, 7, 9, 11, etc.
Transformer (During Inrush or Saturated)	2, 3, 4, 5, 6
Arc Furnace	3, 5, 2, 4, 6, 7, 8, 9

Q. What is the difference between Total Power Factor and Displacement Power Factor?

A. The Total Power Factor includes harmonics (voltage and current). The Total Power Factor is a ratio of the total power input, in watts, to the total apparent power, in volt amperes. The Displacement Power Factor is simply a ratio of the fundamental (50 or 60 Hz) input power to the fundamental volt-ampere input. In many cases, simply reducing the harmonic current generated by the loads will significantly increase the Total Power Factor.

Q. Should I specify my Surge Protective Device (SPD) based upon Joules and Response Time?

A. No. Joules and response time are irrelevant specifications.

JOULE RATING - Joule ratings are not an approved specification for surge protection devices. IEEE, IEC, and NEMA do not recommend using Joule ratings when specifying or comparing surge suppressors because they can provide misleading and conflicting information. For example, on a

120/208 Volt system, a 150 Volt MOV or 175 Volt MOV could be used. Even though the 175 Volt MOV has a higher Joule rating, the 150 Volt has a much lower let through voltage. Joule ratings are a function of let through voltage, surge current and surge duration (time). Each manufacturer may use a different standard surge wave when publishing Joules. Given the confusion regarding Joule ratings, the power quality industry does not recommend the use of Joule ratings in performance specifications.

RESPONSE TIME - All suppressors have sufficient response time to react to surges. In fact, the MOV will react 1000 times faster than the surge. NEMA and IEEE do not recommend using "response time" as a performance criteria when comparing SPDs.

Q. If my computer monitor is "jiggling" what is the most likely cause?

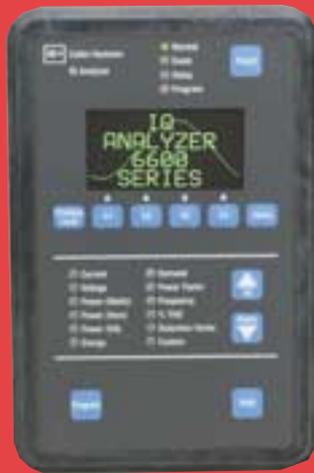
A. Aside from the obvious mechanical vibrations that may be associated with physical placement of the monitor, the most common problem with monitor oscillations are related to magnetic field interference. You can use a simple hand held magnetic field meter to measure the magnetic field strength near your monitor. Oscillations will be apparent if the magnetic field strength near the monitor is greater than 25 mG (milli-Gauss), as a general rule of thumb. Simply relocating the monitor away from the source of the magnetic field is the easiest method to reduce the effect (if the source of the magnetic field is generally concentrated in a small area, near a power panel, for example). If a large source of magnetic field exists, magnetic shielding may be required. Check what's on the other side of the wall where the monitor is located.

We encourage you to submit your questions and/or



case studies. If your submission is published, you will receive a Home Surge Protection Package. Write to: PQ Connection™, Cutler-Hammer, 1000 Cherrington Parkway, Moon Township, PA 15108 U.S.A.

NEW PRODUCT INFORMATION



Cutler-Hammer Reinvents Premier Power Quality Meter

Making the best meter in its class even better!

Cutler-Hammer's new IQ Analyzer 6600 is specifically designed for industrial power users and institutions that rely on power quality and reliability to ensure product and service quality. The IQ Analyzer is an excellent tool for anyone interested in preventing process disruptions and equipment damage, isolating and diagnosing power quality problems, controlling energy usage and costs, and managing the entire electrical distribution system.

The IQ Analyzer can be programmed to trend, up to a rate of every eight cycles, the most critical electrical parameters as identified by the user and store them in non-volatile memory. The new generation, IQ Analyzer can trend up to 24 parameters at once and store this data, at the meter, in non-volatile memory. In total, the IQ Analyzer meters over 150 electrical parameters, including line-ground, line-neutral and neutral-ground voltages, waveforms and harmonics. Phase, neutral and ground current are monitored up to 800% of nominal, resulting in precise inrush and fault data that can be used to prevent downtime.

For effective sag/swell disturbance monitoring, the IQ Analyzer is equipped with the ability to plot an event on the ITIC (formerly CBEMA) curve, in conjunction with Cutler-Hammer's PowerNet software.

In addition, the new IQ Analyzer is engineered with a dv/dt subcycle trigger of events which monitors and captures all voltage and current readings 128 times per cycle, providing more data for better diagnostics.

The IQ Analyzer 6600 offers a choice of three power supplies that enable it to be powered from 110 to 600VAC and from 24 to 250VDC.

The IQ Analyzer's high-performance metering functions comply with ANSI C12.20 Class 10 standards for revenue meters, UL, CUL, CSA, CE and Industry Canada.



Introducing the New Sag Ride Through (SRT)

Cutler-Hammer's Sag Ride Through (SRT) conditioner is the industry's first power conditioner to incorporate new technology to reduce voltage sags and maintain uptime and productivity.

The SRT protects distribution locations, or an entire facility, from problems associated with voltage sags. The SRT features a 65% sag ride through, phase shift correction, and Cutler-Hammer's clipper surge protector for increased protection of downstream loads.

Suited for many domestic applications, the SRT is designed in ratings from 20 to 700 kVA. Cutler-Hammer's SRT requires no engineering study to select the appropriate model and requires no maintenance. The SRT also operates with a three-millisecond response and 99% efficiency, offering customers higher performance than conventional voltage regulators.

Studies have indicated that voltage sags are one of the most common disturbances affecting a building's electrical system. Each year, sags cost companies thousands of dollars in lost productivity. Until recently, there was no technology that enabled facilities to combat these sags. Cutler-Hammer, with its SRT is now able to help customers prevent sags and maintain a high level of productivity.



2000 Power Quality Training Sessions

03 October 06 October Seattle

POWER QUALITY AND GROUNDING

08 November 09 November Pittsburgh

POWER QUALITY MONITORING

19 January 20 January Pittsburgh

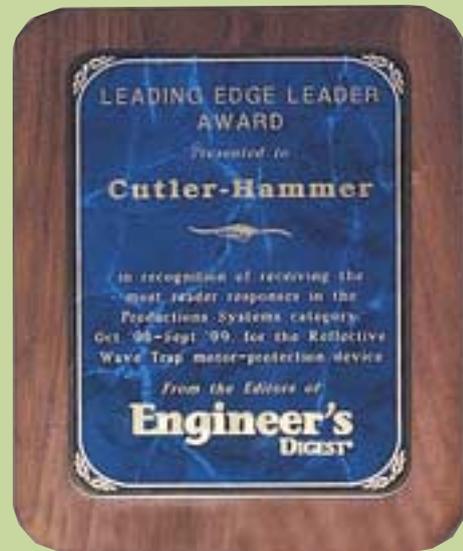
POWER QUALITY MONITORING

Upcoming Issues

- *What is the effect of adding a line reactor to the front end of my variable frequency drive?*
- *What level of voltage sag will cause my equipment to drop out or misoperate?*

RWT Wins Engineer's Digest Award

The Reflective Wave Trap (RWT) was recently selected as one of the top four products of 1999 by Engineer's Digest. Awards are based on number of reader inquiries. The RWT was the only winner in the motor/motor protection category. Full award details can be found in the March issue of Engineer's Digest.



Future Issues

We will continue to include "Ask the Expert" in upcoming issues and we encourage you to submit power quality questions or comments. Please fax your questions to (403) 717-0579 or e-mail chsurg@ch.etn.com, attention "Questions for the Power Quality Expert".

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