PQ Connection™
Your Power Quality News Source
Vol. 2 No. 1 Spring 2002

Partnering with Performance Power℠ provides power quality, reliability and energy management solutions

Performance Power provides the products and services needed to address power quality concerns, improve energy management and help you make appropriate choices for improving the efficiency of existing buildings and new facility designs.

As companies investigate ways of reducing the cost of their operations, improving the efficiency of power in their facilities is a key consideration. Cutler-Hammer Performance Power provides the products and services needed to

- address power quality and reliability concerns,
- create better energy monitoring and management systems,
- and develop value-added power solutions.

continued on page 2

Understanding Your Electric Utility Bill

By Dan Carnovale, Power Quality Team Leader, Cutler-Hammer

Energy costs for industrial business owners may be as much as 10-30% of total operating costs. Understanding your electric bill will help determine if there are ways to reduce your monthly energy expenses.

Your electric bill. You get one every month, but do you really understand what you're paying for? You're not alone. Many people, from homeowners to business owners, are confused when it comes to deciphering all their utility charges. And the energy costs for industrial business owners may be as much as 10-30% of total operating costs. Therefore, with a better understanding of your electric bill, you can determine if there are ways to reduce your monthly energy expenses – often by a significant amount.

Cost of Energy Based on Usage, Demand and Supply

First, in order to understand what the charges mean, it's helpful to understand how electric utilities determine the cost of providing electricity.

In simplest terms, the cost of electricity is based on usage, demand and available supply. Every home and business uses electricity. From turning on the lights or a hair dryer to running an industrial manufacturing facility,

continued on page 2

Eliminating the Cost of Lost Production in the Plastic Industry Using Modern Power Electronic Solutions

By Tom Dionise, Power System Engineering, Cutler-Hammer

Newly developed power electronics devices such as Static Voltage Compensators, rotary UPS and rotary UPS with generation can eliminate the costs of lost production, and pay for themselves in the process.

The intense competition in the extruded plastic market has led production managers to search for new ways to reduce production costs. Cost of materials, energy and labor are obvious costs that can be

continued on page 5

Index

Partnering with Performance Power℠ provides power quality, reliability and energy management solutions 1
Understanding Your Electric Utility Bill 1
Eliminating the Cost of Lost Production in the Plastic Industry Using Modern Power Electronic Solutions 1
Ask the Expert / Q & A 7
Power Solutions Working Conference 8
Upcoming Power Systems Training Programs 8

EATON | Cutler-Hammer

FEATURE

continued from page 1

Partnering with Performance Power℠ provides power quality, reliability and energy management solutions

Performance Power Solutions and Capabilities

Performance Power offers you:

- Strategies and implementation support to improve facility reliability and uptime
- Partnership approach to implement energy savings
- Outsource support for power systems
- Technology investment advice to maximize Return on Investment (ROI)

Our capabilities include:

- *Power Quality & Reliability* improvements to avoid business interruptions or equipment damage due to electrical sags/surges/harmonics, outages and other power system problems
- *Energy Monitoring & Management* systems to reduce the electric bill and other operational cost savings
- *Value-Added Power Solutions* to trouble-shoot electrical problems, turnkey improvement projects, maintenance programs and management of power systems

Power Quality and Reliability services and solutions keep facilities up and running

"We have experience and expertise in solving the most complex power quality problems in all industries," said Russ Barss, Performance Power marketing manager. "Our methodology and approach ensures a high return on investment and keeps your facility up and running."

The Cutler-Hammer Performance Power team recognizes a facility's need to ensure digital grade power, free from disturbances, outages, or power system problems. Our Performance Power products and services include:

- Turnkey Improvement Projects
- Consulting Studies
- Power System Infrastructure (distribution equipment, breakers, design tools)
- 24x7 Response for Engineering Services
- PQ Meters and Software
- Protective Relays
- Surge Protective Devices
- Sag Correction and Voltage Regulators
- Harmonic Mitigating Filters
- K-Rated Transformers
- Harmonic Cancellation Transformers
- Power Factor Correction Capacitors
- Power Distribution Units (PDU)
- Distributed Generation Solutions
- Packaged UPS systems

Energy Monitoring and Management systems improve operating efficiency and reduce costs

"Performance Power offers solutions and support to enable you to monitor, manage and control your power system to realize significant cost savings," said Barss. Energy Management products and services include:

- Power Management Software
- Turnkey Design and Installation of Power Management Systems
- Complete Offering of Industrial and Commercial Meters and Sub-Meters
- Circuit Breaker Trip Units
- Lighting and Load Control Components and Assemblies
- Distributed Generation Solutions
- Energy Monitoring and Billing Software
- Peak Shaving and Load Shedding Systems
- Automatic Transfer Switches
- Power Factor Capacitor Systems
- Energy Efficient Transformers (Energy Star rated)
- Power System Design Support

Value-Added Power solutions include a wide range of engineering services

Superior hardware is but one facet of efficient electrical control and distribution systems. Effective power strategies require intelligent system design, integration, coordination and control, all of which can be achieved by using the proper engineering service partner.

Cutler-Hammer Engineering Services & Systems (CHESS), is the ideal, single-point source for all facility electrical service and system needs. "Our team is available 24 hours a day, 7 days a week, providing an unrivaled array of value-added services," Barss said. These services include:

- Power Systems Engineering & Training
- Equipment Services
- Turnkey Project Management
- Switchgear & Controls Modernization
- Predictive and Preventive Maintenance
- Disaster Recovery Services
- Electrical Safety Studies
- Outsource Services

For more information, contact the Performance Power Hotline: 1-800-809-2772 (Option 1, Sub Option 2) or by e-mail at PQHotline@eaton.com.

continued from page 1

Understanding Your Electric Utility Bill

electricity is used to power numerous machines, circuits and processes, which are generically referred to as "loads." Users incur an *energy charge* for the amount and type of load they place on the utility's electric system, and the length of time they use the electricity.

When you use electricity is as important an issue as how much you use. If every utility customer decided, at the same time, to use the maximum amount of energy they could use, the utility has to be able to supply that energy, and also has to make sure its infrastructure has the capacity to transport the energy to where it is needed. Therefore, when demand for energy usage is high, or "*peaks*," such as during normal business hours or in warmer months,

utilities will put a premium, or *demand charge*, on the cost of providing electricity. This encourages users to try to reduce their load and/or their usage during peak times so that the utility does not have to incur the cost of generating and maintaining maximum supply and capacity on their system.

Utilities have to pay for the generator capacity, and by using anything other than real kilowatt (kW) power, customers are using system capacity that could be provided locally by capacitors. Therefore, some utilities will penalize users for using system capacity by adjusting their bill with a *power factor penalty*.

These charges factor into a customer's *rate*, which is how the utility determines the amount that a particular customer pays for their energy service. Electric companies have developed a series of rates that reflect different types of customer usage patterns, and the degree to which a customer wants or needs a guaranteed, constant supply of energy. For example, if you use energy when others are not using as much ("*off-peak*"), you will help balance your utility's required generation capacity, for which you'll receive a reduced rate. Each utility company has different rate schedules, and with the advent of energy deregulation, you may now shop for an electricity provider that can offer you rates and services that best suit your needs. However, make sure that you evaluate your energy provider based on total potential savings, not just savings in certain demand or usage charges. The variable cost of additional charges from other service providers -- generation, transmission, distribution and transition – may prevent you from realizing any significant benefits to switching utilities.

Customer: XYZ
Billing Period From: 9/1/01 12:00:01 AM

Payment To: XYZ Power
To: 9/30/01 12 Midnight

Demand (Power)				
Rate Period	Peak at	kW	$/kW	Charge
Off Peak	10:35 PM	1,487	3.25	$4,832.75
On Peak	1:05 PM	2,496	16.75	$41,808.00
Energy		kW hr	$/kW hr	Charge
Off Peak		224,600	0.0369	$8,287.74
On Peak		458,800	0.052	$23,857.60
Other Charges				
Connection Charge				$500.00
Power Factor Adjustment				$1854.00
Taxes and Special Charges				$3,178.04
Total Due				$84,318.13

Saving Money on Your Electric Bill

There are several ways to reduce your energy costs:

- Reduce usage and lower your energy charges
- Change usage patterns and lower your demand charges
- Negotiate lower rates
- Reduce power factor penalties

Lowering your Energy Charges

One of the easiest ways to save money on your bill is to monitor and reduce your energy usage. Energy charges are priced by the kilowatt hour (kWH). Typical energy charges may range from 3 cents per kWH to 15 cents per kWH.

Savings based on energy usage are possible if less energy is actually used, either because there are fewer loads on the electrical system or because the loads are more energy-efficient. Often, it is not possible to simply turn off loads that are required for production. However, becoming more conscious of minimizing energy usage – for example turning off lights in a facility when there are no working shifts, or switching off motors that would normally idle during lunch breaks – can create bottom-line savings over time.

Lowering your Demand Charges

The demand charge is priced by the kW and may account for one-half to two-thirds of the electrical bill for a large-use customer. Typical demand charges range from $3-30/kW, but during shortages or at times when energy is at a premium, the demand charge may be upwards of $300/kW.

Measuring demand is done as an average value of the kW used during 15-minute intervals. It is not measured as an instantaneous value, such as when a motor is initially powered up. Powering up a motor creates a momentary (5-10 second) increase in load, but is insignificant relative to the overall 15-minute kW measure. A customer is typically billed based on the highest 15-minute average demand for the previous month, and once a high demand has been recorded, the energy provider may use this same monthly demand charge for the following 12 months. In order to save money and reduce these high demand charges, large-use customers are required to reduce their peak time usage by either finding an alternate energy source such as local generation or by better managing the extent and timing of their load usage.

Buying energy at a higher voltage level may prove to be very cost effective. Purchasing a utility transformer to enable you to buy power at 69 kV instead of 4160 V could significantly reduce your kWH or kW demand rates.

Monitoring your power usage will also help you determine if your demand is excessive. If you don't have a monitoring system, a quick rule of

FEATURE

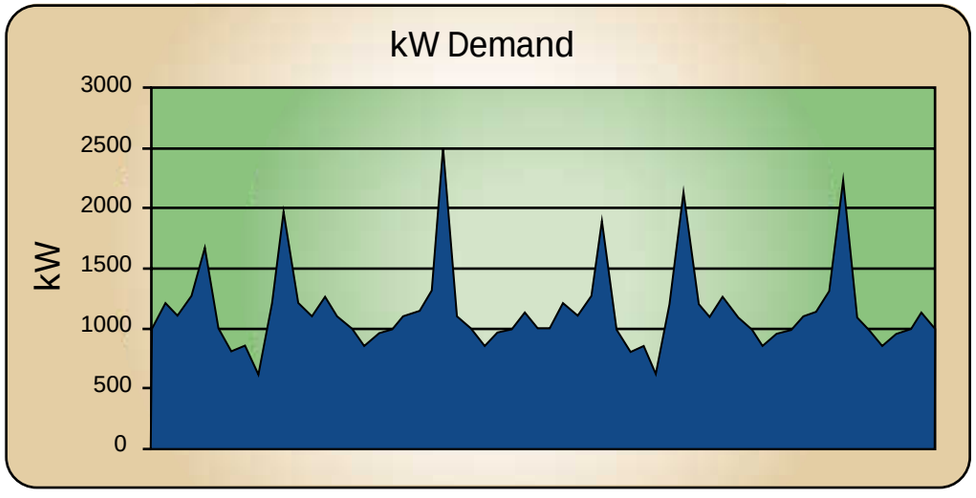
thumb to determine if you can save some money on demand charges is shown below.

$$\text{Ratio} = \frac{\frac{kWH}{\text{Hours (billing cycle)}}}{kW\ (\text{demand})} \times 100\%$$

Take the total kWH usage on your bill and divide by the number of adjusted hours in the billing period. This will give the average value of kW usage over the billing period. (You can adjust the hours accordingly to account for variations in loading and the fact that you're not operating 24 hours a day, 7 days a week.) Divide this number by the maximum kW demand value, and if the answer is less than 80%, then you can most likely save a reasonable amount of money on your demand bill by running or "shifting" loads to off-peak times or other peak "shaving" methods. Below is an example from the sample utility bill, using total energy usage as the peak kWH plus the off-peak kWH:

$$\text{Ratio} = \frac{\frac{(224600 + 458800)\ kWH}{720\ \text{hours}}}{2496kW} \times 100\% = 38\%$$

There is definitely room for improvement in this example. Notice on the demand graph, the peaks are significantly higher than the average value of kW usage.



Weekly Demand Summary

Talk to your utility account representative about ways to reduce your rates

An evaluation of your existing utility billing contract will help determine the appropriate measures to take to improve and reduce costs throughout your facility's power system. There may be opportunities to change your rate structure or level of service and your savings could be significant. Utilities are very willing to work with users and create incentives to use less energy, not only because of conservation efforts but because they would like to reduce capacity in generation on the utility grid in order to minimize shortage situations, an increasing problem for the utility industry.

Other independent companies may also be willing to fund your investment in energy savings methods. In return they negotiate to receive a percentage of your savings.

VAR Charges and Power Factor Penalties

The total "apparent" power (Volt-Amperes) supplied to loads is a combination of "real power" (Watts) and "reactive power" or VARs (Volt-Amperes-Reactive). Some energy suppliers charge a penalty for using VARs, especially if they have limited system capacity. VARs are reactive power required to maintain magnetic fields in equipment (motors, transformers, etc.) and do not provide real energy to do "work," but still use system capacity. VARs are included in the calculation of power factor, which is the ratio of the real (kW) power that is supplied to the load versus the total apparent power (kVA). A power factor penalty, therefore, is directly related to your VAR demand and usage and could be charged any time you're using system capacity to provide reactive power to the loads. The power factor penalty is often calculated during the maximum demand interval (15 minutes) for the month. Power factor penalties are typically a small fraction of the kW and kWH charges, but they can still be significant. Fortunately, installing capacitors at the utility metering point, or downstream closer to the loads, can compensate for the reactive component of the power used within a facility.

An energy supplier may specify a minimum power factor that you need to achieve in order to avoid a power factor penalty. An example of a power factor penalty schedule is shown below.

Power Factor	Penalty
0.699 or lower	Not permitted - 25%
0.700 to 0.749	3%
0.750 to 0.799	2%
0.800 to 0.849	1%
0.850 to 1.000	No penalty

A power factor of less than 1.000 indicates that part of the power taking up capacity from the generators to the loads could be provided locally by adding capacitors.

While these percentages may seem small, for large energy users they add up quickly. For example, a 3% penalty on a $500,000 monthly bill is $15,000 per month. Installing power factor correction capacitors can minimize VARs and prevent the power factor from dropping below the utility's minimum limit, and payback may be much less than two years, based upon the installed cost of the capacitors.

Though the power factor penalty is usually how a VAR charge is reflected on your bill, it is not uncommon for VAR charges to be incorporated into other charges, or as part of the rate, and therefore becomes a "hidden" cost. Variations sometimes include kVAR (reactive demand), kVARH (reactive hour), and kVA demand (which is a combination of kW and kVAR demand) charges. Look for these items on your bill.

If you would like further information on ways to reduce your energy bill, please contact the Performance Power Hotline at 1-800-809-2772, (Option 1, Sub Option 2) or by e-mail at PQConnection@eaton.com.

continued from page 1

Eliminating the Cost of Lost Production in the Plastic Industry Using Modern Power Electronic Solutions

reduced and managed, resulting in a competitive advantage. A less obvious, but no less significant cost is that of lost production due to disturbances on the electric power system. Until recently, it was often believed such disturbances had to be tolerated because the costs for solutions were out-of-reach.

Such was the case with a plastic manufacturer of extruded and injection molded plastic product for the replacement window industry. The facility is located on a 12,470 V rural distribution circuit. The problem as described by the plastic manufacturer has been frequent electrical outages of the 35 machines, both extrusion and injection molding. Most significant is the outage of the extrusion machines, which resulted in an estimated loss of production of $28,000 per outage. In 2001 alone, 13 such events occurred, with an average down-time of 24 hours, translating to annual loss of production of $364,000. Scheduled forced outages by the utility increase the total annual loss of production to $392,000.

Disturbance Monitoring

The first step in eliminating outages is to identify and quantify the nature of the electrical system disturbances. In our plastic manufacturer's situation, power monitoring equipment was used to monitor voltage and other significant electrical quantities for a period of two months. The monitoring equipment was capable of capturing very short duration and high-speed disturbances suspected as the root cause of the extruder outages. Engineers then analyzed the captured events and correlated them to outages of the extruders logged by plant operators. They determined the events were the result of a combination of sags, interruptions and scheduled forced outages (see Figure A).

Coming up with appropriate solutions

With this clear definition of the problem, engineers then considered solutions. In the past, solution options were limited to UPS and motor-generator sets. Both have the highest installed cost, and highest maintenance costs to operate.

More recently, low cost alternative solutions to UPSs have become available that utilize modern power electronics technology. These power electronic devices have lower installed costs, and inherently lower maintenance costs than the UPS or M-G set. These newer technologies include static voltage compensator (SVC) and rotary UPS (R-UPS) (see Figure B).

Estimate of Total Annual Cost of Lost Production

Type of Event	Number of Events	% of Total Events	Hours	Cost of Lost Production	% of Total Cost
Sag	11	68.8	264	308000	78.6
Interruption	2	12.5	48	56000	14.3
Forced Outage	3	18.8	24	28000	7.1
Totals	16	100.0	336	392000	100.0

Figure A Notes:
- *Sag or interruption results in 24 hours lost production.*
- *Forced outage results in 8 hours lost production.*
- *Cost of one event is $28,000 or $1167 per hour.*

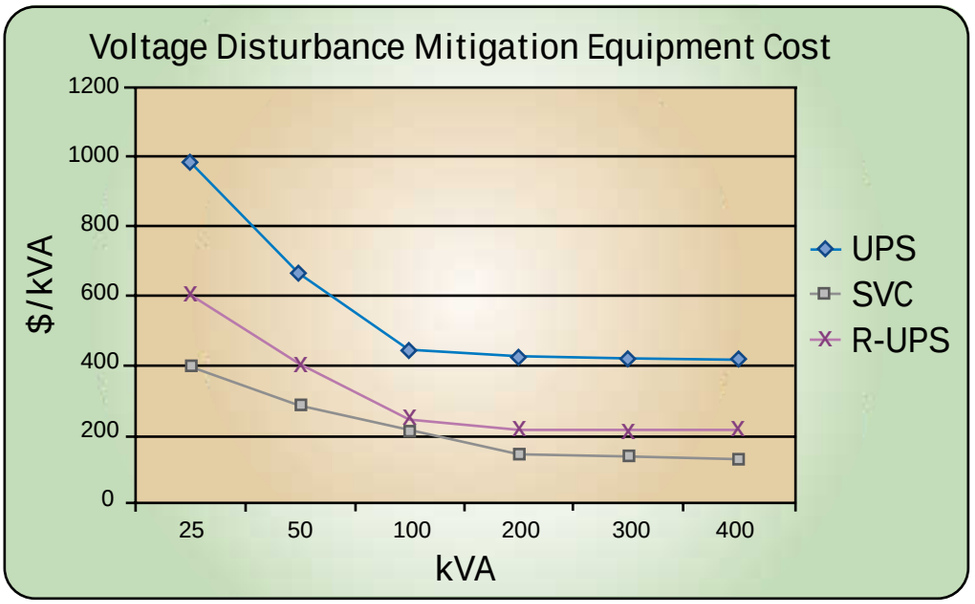


Figure B -- The cost per kVA of traditional and newer technology voltage variation solutions.

FEATURE & ASK THE EXPERT

The recommended solution was to apply a power electronic device at the switchboard. The switchboard supplies the critical loads of the extrusion machines. It is more economical and practical to locate one device at the switchboard rather than many smaller devices at each extrusion machine. A comparison of the types of device to install, and a decision made based on cost, payback and solution advantages/disadvantages, was the next step.

SVC

A static voltage compensator (SVC) is capable of correcting deep sags of 30% retained voltage on one or more phases. A SVC injects a corrective voltage to restore the sag to nominal voltage values. A SVC can restore sags indefinitely without a storage device such as a capacitor. Such a SVC has limited capacity to restore three-phase interruption. It can only restore a three-phase interruption for 3 cycles. Fortunately, most disturbances are single-phase in nature. A recent 2-year study by EPRI and DPQ indicates 92% of events are sags and 4% are short-term interruptions. At this plastics plant, 68.8% of the events were sags and a SVC would eliminate these.

Rotary UPS

In addition to correcting for sags, the rotary UPS (R-UPS) maintains voltage during an interruption of up to 15 seconds. During the interruption, the stored energy in the rotating mass of the R-UPS is converted to electrical power. The electrical power is transmitted to the load until voltage from the utility is restored. Because the R-UPS is online all the time, there is no loss of voltage to the load when the utility interruption occurs. In the same way, when a sag occurs, the R-UPS supports voltage to nominal until the sag is gone. At this plastics plant, a R-UPS would eliminate sags and interruptions representing 81.3% of events.

Rotary UPS with Generation

Scheduled forced outages by the utility can be a considerable loss in production. In conjunction with a R-UPS, on-site generation can be integrated. The R-UPS with on-site generation provides uninterruptible power to the extruders. For interruptions greater than 15 seconds, the generator provides continuous power. A R-UPS with generation is the choice for correction for 100% of the events at this plastics plant.

Summary

Any of the solutions will work. The question is, how much coverage do you want? In our plastics facility example, the SVC provides the most rapid pay back of 7 months, and coverage for sags that account for 78.5% of the total annual cost of lost production. The R-UPS payback is 1.4 years, and extends the coverage to interruptions of less than 15 seconds that account for 92.8% of the total annual cost of lost production. Finally, to achieve total 100% coverage for all voltage disturbances, or in other words, completely uninterruptible power to the extruders, the payback is 1.9 years. Interestingly, on-site generation can be a short payback as well because the power produced by the generator can be sold to the utility when not needed. In the competitive plastics industry that expects payback in 3 to 5 years, these solutions are very attractive. It is very clear that newly developed power electronic devices can eliminate the costs of lost production, and pay for themselves in the process.

If you would like to eliminate the cost of lost production due to power system disturbances, please contact the Performance Power Hotline at 1-800-809-2772, (Option 1, Sub Option 2) or by e-mail at PQConnection@eaton.com.

Comparison of Technologies Side by Side

Solution	Payback	Advantages	Disadvantages
SVC	7 months	corrects for sags, broadest coverage, least cost solution	does not correct for interruptions or outages
R-UPS	1.4 years	correct for sags, corrects for interruptions, moderate cost solution	does not correct for interruptions greater than 15 sec or outages
R-UPS with generator	1.9 years	uninterruptible power, (corrects for sags, interruptions and outages), option for peak shaving, lower cost than standard UPS	generator maintenance

Note:
Any of the solutions will work. The question is, how much coverage do you want?

EATON | Cutler-Hammer

Questions and Answers

Q: The other day, we were watching television and the TV set started to get dark. The lights dimmed, then became brighter than normal. This happened several times over the period of a couple of days. Sometime during those few days, the surge suppressor on my PC failed and my Playstation failed (both were severely burned). I checked the voltage on my outlets in those rooms and got measurements between 80V and 160V. What happened?
Submitted by: Dave W. Mars, PA

A: These are all symptoms of an open Neutral somewhere in the electrical system. The dimming/brightening of the lights points to unbalanced loading with an open neutral. Continuous overvoltage (resulting from a situation like this) is the number one leading cause of surge suppressor failure. The most common cause on the utility side is a failure of the splice where the ACSR or aluminum service drop meets the copper loop at the customer's weather head. If the ACSR or aluminum wire is not properly prepared and spliced with the proper bi-metal device, corrosion will destroy the connection in just a few years. Check the outlet neutral connection, the neutrals in your main service panel and call the utility to have them check their transformer/service neutral conductors.
Editor's note – Dave called the utility company and they found an open Neutral connection on the pole-mounted transformer. They fixed the problem and symptoms have not recurred.

Q: I recently purchased a new 15 kVA transformer for some auxiliary loads (lights, fans, and a few computers). The transformer is extremely hot to the touch. Could it be that the harmonics are making this transformer so hot? The transformer (480-208/120) is probably loaded to about 70% of full load amps.

A: UL permits the maximum total enclosure surface temperature to be as high as 90ºC (194ºF). The maximum temperature rise of the enclosure is 50ºC above a 40ºC ambient for ventilated transformers or 65ºC rise above a 25ºC ambient for encapsulated transformers. Though this is very warm, it will not blister skin and is well within the operating temperature of the transformer's insulation system. Since the enclosure may be warm to touch, a method such as thermal tape or infrared testing should be considered for enclosure temperature rather than touching it.

If there are only a few computer type loads on the transformer, harmonics should be insignificant. However, if the loads are primarily non-linear (computers, high harmonic electronic ballasts, drives, etc.) these would add significant heat to the transformer, and non-linear transformer types should be considered.

Q: We are re-sizing one of our UPS systems and were wondering what you see for loading factors. Our present system indicates 22% loaded. Is this low? At what level do hospitals typically load their units?

A: UPS loading is directly proportional to the battery duration during an event (i.e. 50% loading gives nearly twice as much ride-through time).

One consideration for light loading is that on larger UPS units, front end filtering is often turned "off" to avoid overcompensation (leading PF) with a large filter and light load. Generally, as a rule of thumb, the level is 30% loading. Therefore, harmonic currents may be higher (percentage, not necessarily magnitude) at these levels.

This is one of those situations where it seems as though there is no middle ground. Either the UPS owner is very conservative, say 50% or lower, or they are pushing the full rating as they have added new loads over the years. This is not a simple question for us to answer – your needs are best known by you – especially with regard to future growth plans. If you are certain there will be no expansion in the foreseeable future then 22% is too low, economically speaking. But if there is an expectation of growth, then that may be a perfectly acceptable loading level for now.

Q: A 40+-year-old building housing a photographic and computer graphics lab had a problem with computer screen interference. The facility thought power conductors running in close proximity to computer monitors was the cause. They received a quotation for $10,000.00 to move a room full of Wiremold a distance of three feet. Initially, the computers were moved (on a cart) just a few feet and the problem went away.

A: Alan Bown, Power Systems Engineer, CHESS used a multimeter and digital oscilloscope and checked the voltage magnitude, waveforms and wiring. In the electrical panel feeding the computer equipment, Alan found several grounds landed on the neutral bar. The grounds were traced to the laser printer, copy machines and other non-linear equipment. He asked if the loads could be shut off so that the panel could be rewired. A ground bus bar was installed in the electrical panel (originally, there was no ground conductor - just the rigid electrical conduit as a return path). The neutral and ground conductors were terminated on the proper buses. All loads were re-energized and the problem was eliminated. Total cost was simply the time it took to rewire the neutral and ground wiring mistakes – a substantial savings over the quote.

We encourage you to submit your questions and/or case studies. If your submission is published, you will receive a Home Surge Protection Package.
E-mail: pqconnection@eaton.com

FEATURE

EATON | Cutler-Hammer

Power Solutions Working Conference May 6-8, 2002 in Greenville, SC

The Power Solutions Working Conference is a dynamic forum designed for you to explore the latest strategies and improvement opportunities for managing facility operations and the electrical power system. Make it a point to join us May 6-8, 2002 in Greenville, South Carolina for what promises to be the industry's premier power-focused event.

Geared to those with fiscal, management or technical responsibility for facility operations and electrical systems, this conference will enable you to have your questions or issues addressed. You will leave with specific ideas and solutions that you can implement for immediate cost reductions and improved operational effectiveness. Speakers include representatives from Sony Electronics, Ford Motor Company, Johnson Controls, Energy Star, Eaton's Cutler-Hammer business, and many more. In addition, experts in all facets of power distribution will be available at this conference.

For additional information on this power-packed conference, or to register, visit:
www.PowerSolutionsWorkingConference.com

Upcoming Power Systems Training Programs

- Power Quality Monitoring
  May 29-30, Pittsburgh, PA
  October 23-24, Pittsburgh, PA
- Power Quality and Grounding
  July 9-12, Ottawa, ON
  September 17-20, Pittsburgh, PA
- Protective Relay Application
  July 9-12, Pittsburgh, PA
  November 19-22, Pittsburgh, PA
- Protection and Coordination
  April 30-May 3, Sudbury, ON
  June 4-7, Pittsburgh, PA
  October 8-11, Toronto, ON
- Distribution Systems Analysis
  March 19-21, Louisville, KY
  May 7-10, Pittsburgh, PA
- Electrical Equipment Maintenance
  May 7-10, Windsor, ON
  June 18-21, Pittsburgh, PA
  December 10-13, Pittsburgh, PA
- Electrical Safety
  April 4, Toronto, ON
  April 25, Pittsburgh, PA
  May 6, Windsor, ON
  July 2, Pittsburgh, PA
  December 3, Pittsburgh, PA

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 pqconnection@eaton.com, attention "Questions for the Power Quality Expert".

To Subscribe:

fax: (403) 717 0579
or e-mail: pqconnection@eaton.com,
"Attn: PQ subscription"
Please indicate hard copy or electronic version (available in PDF format)

PQ Connection™

Published by: Eaton Corporation's Cutler-Hammer business

Editors:

Russ Barss
Marketing Manager, Performance Power

Naomi Stuckert
Marketing Communications Manager, Performance Power

Contributors:

Dan Carnovale
Power Quality Team Leader, Engineering Services & Support

Tom Dionise
Power System Engineer, Engineering Services & Support

For more information on Cutler-Hammer products and services please contact us via:
tel: (800) 525 2000 • fax: (616) 982 0879
For engineering services: (800) 498 2678
web: www.cutler-hammer.eaton.com

Printed in the United States
Publication No. NL08312001E

Wallace
3801 Gantz Road
Suite A
Grove City, OH 43123
United States

PQ Connection™

FIRST-CLASS PRSRT
U.S. POSTAGE PAID
GROVE CITY, OH 43123
PERMIT NO. 1000