EATON
Cutler-Hammer

White Paper

Next-generation power quality meters

Recent advancements in technology have redefined the possibilities for power quality monitoring.

Capabilities that formerly required expensive, specialized equipment and consultants can now be packaged into compact, affordable devices.

Detect fast transients, accurately capture waveforms, automatically display events on an ITIC curve, get graphic views of power quality, and more.

Executive Summary

Invisible and fleeting power disturbances can be silent killers—the electronic equivalent of high blood pressure—causing insidious damage to sensitive components and malfunctions in crucial processes.

Traditional power meters detect many of these power anomalies, such as sags, swells, and harmonic distortion— by sampling activity on an electrical circuit dozens of times per cycle. However, a transient power problem can appear, do its damage, and disappear in a few millionths of a second. If you want to capture and assess that voltage, you would have to sample several times in a millionth of a second— much faster than those traditional systems can perform.

In designing Power Xpert Meters, Eaton set out to demystify power quality — to take highly specialized data and convert it into useful information that doesn't require a power guru or consultant to understand.

In the past, identifying very fast transients required the use of specialized, portable monitoring equipment that costs up to $20,000—and frequently requires an outside consultant as well.

Recent advancements in technology have made it possible to match the sampling rate of these high-end systems in compact, affordable devices. These "next-generation" power quality meters can sample at rates of 256, 512 or 1024 samples per cycle for normal current, and up to 100,000 samples per cycle for transients. This data is stored in an internal database (with built-in Web servers), analyzed, and displayed in color-coded visuals that can be accessed over standard IT networks.

Eaton has developed a family of next-generation power quality instruments that offers models for various applications— from comprehensive metering/logging with ITIC representation of event data… to intelligent isolation of sub-cycle oscillatory transients… to 6 MHz capture of very fast transients.

In designing these Power Xpert™ Meters, Eaton set out to demystify power quality— to take highly specialized data and convert it into useful information that doesn't require a power guru or consultant to understand. The result is an uncommonly easy-to-use interface and new graphical representations of complex power quality data. With these capabilities, your power team can predict and prevent power quality problems before they lead to equipment malfunction, overheated circuits and system failure.

Read on for more about next-generation power meters and how this emerging technology can enhance the power management program in your facility.

TABLE OF CONTENTS

Next-generation power quality meters

Redefining the art, science and usefulness of power quality monitoring

The trouble with power quality

Utility companies are not required to provide computer-grade power— and they don't. By law, power can vary quite a bit over or under absolute specification. Deviation that is acceptable by industry standard may well be unacceptable to IT devices—which are getting more finicky with each advance in miniaturization and processing power.

Electrical power is also routinely plagued with surges, sags, electrical noise, harmonics, load fluctuations, and other interferences. A commercial customer on typical utility power will be subjected to these power anomalies daily and 4 to 15 complete outages per year.

Detectable power outages account for only a small percentage of power failure incidents. Even under normal utility operations—with no storm or lightning in sight— electrical systems could be bombarded daily by conditions that damage critical components. Invisible power anomalies can be silent killers, causing insidious damage to critical IT systems and interruptions in essential enterprise processes.

The problems and risks are intensifying. Electronic equipment is more sensitive than ever to minor and transient variations in voltage. Furthermore, every minute of downtime carries greater penalty than ever before. In short, the cost of downtime has increased dramatically – and so has the likelihood of failures caused by power quality problems.

"How can you, as an energy manager, be sure that your power quality doesn't suffer and that you are getting what you paid for? The answer is to monitor," wrote Michael Diash and John Fetters in Energy and Power Management ("The Key to Knowing the Quality of Your Purchased Power," August 7, 2000). "As we move into this new retail power environment, consumers, suppliers, and utilities should install monitoring equipment to verify power quality on a continuous basis."

Isn't it enough to have regular power management software?

Basic power management systems —such as the software systems that come with enterprise-class UPSs— sample power quality many times per cycle, log power disturbances, and generate basic trend and graph reports of those past events.

What about power problems that arise *inside* your facility, downstream from the UPS?

> Most of the damaging transients that occur in facilities are the result of equipment startup and shutdown. For instance, when you try to suddenly stop a large current from flowing (as when shutting down a piece of equipment), the load resists the change. This inductive 'kick' generates a momentary surge in voltage. Surges can also occur when backup generators kick in. A 500V spike wouldn't be unusual.
>
> Conversely, when an electrical motor gears up to operating speed, it can draw more than 10 times its normal load from the power grid. If the normal load current was 100 amps, for instance, you might see more than 1000 amps gulped from available power when a power-hungry piece of equipment starts up. This can result in a voltage sag that affects other equipment on the same circuit or an adjacent circuit. Even though sags usually last only a few cycles, the sudden dip in voltage can cause corruption or loss of data, flickering lights, equipment shut-off or malfunction with automatic shut-off.
>
> Does your power management software capture these inside killers?

What about power problems that are more fleeting than the typical sampling interval?

A transient voltage problem can appear, inflict its damage, and disappear before power management software or a traditional power meter can detect it. Some switching transients reach their peak in about one millionth of a second and then decay, so if you want to capture and assess that voltage, you would have to sample several times in a millionth of a second— much faster than traditional power management software.

Switching transients—extremely brief periods of over-voltage— do their damage in less than a millionth of a second, far less time than the sampling interval of traditional power management software. Damage may be incurred in both hardware and software, resulting in burned circuitry, component stress or failure, and memory and data losses.

In the past, identifying these very fast transients required the use of expensive, specialized, portable monitoring equipment. Organizations had to rent or buy this equipment (costing an average of $15,000 to $20,000) or bring in a power quality consultant. Temporary installation of the portable meter was cumbersome and sometimes required shutting down a system—and you still may not have found the problem.

What about insidious trends that signal impending trouble?

Graphs of basic trends don't do much to help you predict when processes, applications and data are at risk—and what to do about it. After all, by the time a threshold for a power quality parameter has been exceeded, it's too late to stop it from happening. The damage is done.

What is needed is a way to identify the problems that are brewing, before they have a chance to inflict harm. You need to know not only if an event exceeded certain trigger points, but whether the combination of voltage *and* duration threaten to exceed your equipment's tolerance level.

For all these scenarios, a power quality meter fits the bill:

- Instead of sampling a few times a cycle, a power quality meter samples power quality several times every *millionth* of a second—on all voltage input channels and neutral-to-ground.
- Instead of reporting simple trends of past events, a power quality meter can apply statistical measures to create actionable insights—and plot power events against a "power profile" that describes the comfort zone for your critical equipment.
- Rather than just logging the fact that a power disturbance took place, a power quality meter can accurately capture and display the waveform of the event, enabling more sophisticated analysis and troubleshooting.

With the accuracy of high-rate sampling—coupled with analytic insights—a power quality meter represents an entirely different category in power monitoring. That's why you'll find permanent power quality meters in universities, financial institutions, manufacturing centers, enterprise data centers, hospitals—anywhere clean, continuous power is essential for high-value equipment and operations.

A closer look at harmonic distortion

Harmonic distortion is the distortion of the normal current waveform. This condition is generally caused by non-linear loads, such as from sinusoidal equipment that places on-and-off demands on the power supply. That means harmonic distortions can be caused by everyday equipment found in any commercial setting, such as switch mode power supplies, variable speed motors and drives, pumps, heaters, robotics, copiers and fax machines—anything with variable power consumption. Harmonic distortions can cause communication errors, overheating, and hardware damage or premature failure.

Power managers have been monitoring for harmonic distortion since the early 1990s. The rise of PCs in enterprise environments (with their switch-mode power supplies) introduced harmful *triplen* harmonics into the power system. Power meters identify these harmonics and depict the waveform to support effective

What does a basic power quality meter do?

At its most fundamental level, a power meter does what the electric meter on your house does: it provides basic data about power consumption in a facility. Facility managers use this information to manage costs for heating and cooling, for instance. Product managers use this information to help calculate the manufacturing cost per unit of a widget. Operations managers use this information to budget for the electric bill, and so on. A host of vendors supply power meters that fulfill this basic need.

However, power meters can do far more than monitor electricity consumption. They can also:

- **Monitor voltage regulation** on a cycle-by-cycle basis to verify power quality. Some power monitors plot voltage on daily, weekly or monthly graphs. Managers can then determine whether voltage is maintained within agreed upon upper and lower limits, as stipulated in contracts with the utility company and/or as required by the facility's equipment.
- **Capture and record power events,** such as sags and swells that exceeded pre-set thresholds.
- **Plot these events against a power-tolerance curve** that describes the acceptable range for voltage variation/duration (usually requiring special software or custom-programming).
- **Support after-the-fact analysis** of events that have been captured as exceptions from pre-set thresholds and alarm triggers.

Moving beyond these foundation capabilities, there are "next-generation" power quality meters, which would more accurately be called *power quality instruments*. In addition to all the functions described above, next-generation devices provide detailed power quality information that is used by highly trained domain experts. Next-generation power quality meters satisfy the power gurus and consultants who understand and thrive on modified ITIC curves, sub-cycle transients, waveform analysis and other such mysticisms. Yet, a well-designed second-generation meter can make these obscure measures accessible and meaningful to a broader audience than ever before.

What constitutes a "next-generation" power meter?

In the past, basic power monitors were used to determine existing conditions on an electrical distribution system or to evaluate past power problems. If you wanted to track down fast voltage transients, you had to bring in expensive, portable power quality monitors.

Next-generation power quality meters redefine the art of power monitoring. These permanently installed devices provide multiple functions at once, serving as:

- A highly accurate digital meter - to measure and log current, voltage, power factor, etc.
- A circuit monitoring device - watching for harmonics, voltage transients and other potentially harmful power events

- An alarm system - sending notifications and emails to selected people and power management software when conditions exceed established tolerance ranges
- A power quality analyzer - capturing waveforms and other information to support in-depth statistical analysis.

Next-generation power quality meters use digital signal processing and high-speed sampling to capture and record all aspects of power. This data is stored in an internal database and made available for analysis and reporting. With these capabilities, you could predict and prevent power quality problems *before* they lead to equipment malfunction, overheated circuits and system failure.

Let's take a look at some key features you can expect to find in a next-generation power quality meter.

Very fast transient sampling
Traditional power meters can accurately measure a relatively broad spectrum of power events, but only next-generation meters can accurately record and depict very fast transients.

The key is sampling rate. Meters that sample at a rate of 256 or 512 samples per cycle are fine for monitoring general disturbances. They can sometimes even detect oscillatory transients, which tend to occur at low to medium frequencies, 1 MHz or less. However, impulsive transients are much harder to catch, because they peak and decay in mere microseconds. To capture the peak, the meter might have to sample at a rate of 2 MHz (33,333 samples per cycle) or faster.

Some next-generation power quality meters designated for "fast transient detection" will sample voltage at 5 MHz per channel or 83,333 samples per cycle—adequate to characterize most impulsive transients. The Eaton Power Xpert 8000 meter samples high-speed transients at 6 MHz— 100,000 samples per cycle.

High-speed sampling of harmonics and other events
In days past, it was considered enough for a power meter to sample routine power activity at 32 samples per cycle. Some power meters still perform at that rate. New technology has continued to raise the bar, leading to development of meters that sample at 64 samples per cycle, then 128, 256, 512 and up. Eaton Power Xpert™ Meters sample at 1024 samples per cycle using a Delta Sigma converter that accurately measures all power system frequencies. These 1024 data points are then statistically re-sampled into 256 samples per cycle.

A note of caution here… Don't look solely at raw sampling rate when comparing power meters. The real-world value of sample data depends on whether it is tainted by a common mathematical jinx known as "alias measurement error." (Please refer to page 9.)

Statistically derived trending
In the past, it was enough for a power meter to graph a reading of power parameters at designated time intervals, perhaps every five minutes. Power managers could see a general overview of their power quality. How high does voltage go? How low? How often did it happen?

Next-generation power meters not only record the value of the parameter every five minutes, but also the average, minimum and maximum of that parameter over that time interval. The result is a much more accurate view of the parameter you're trying to analyze—a composite picture of activity from the whole interval, rather than a snapshot in time.

Eaton Power Xpert Meters also provide a statistically derived, composite health check known as a Power Quality Index. (Please refer to page 10.)

Electronic notification of alarms

In this mobile, decentralized, Internet-connected age, engineers expect to be able to monitor their power meters from afar. They also expect to receive alerts and alarms wherever they are.

Next-generation power meters support industry-standard communications, such as TCP/IP Ethernet connections over a company's LAN/WAN, SNMP to network management systems, and HTTP over the Internet through a built-in Web server. A next-generation instrument should be able to send an email to concerned parties when power conditions exceed preset thresholds or tolerance curves— ideally, with a waveform of the anomaly attached to the email.

Representation of power events on an ITIC curve

Older power meters required engineers to program triggers, thresholds or set points to define what was normal and what was a "disturbance." Trouble is, when you only draw attention to the exceptions, you can miss conditions that are deteriorating yet staying under the radar for now. By the time the condition exceeds a trigger value, and you get an alarm, it is too late to prevent it from happening.

Some new meters can plot power quality events against a power-tolerance curve. Several standards bodies have developed curves that describe how much (or how little) voltage your IT equipment can sustain without damage and over what length of time (nanoseconds to seconds) this occurred. The ITIC (Information Technology Industry Council) curve is emerging as the de facto standard for IT equipment.

By viewing power events in a broader context—relative to an acceptable range— you can identify trouble that may be brewing, not just after trouble has already occurred.

Of the few meters that provide this function, most require special software to do it. In contrast, Eaton's Power Xpert Meters require no special software; these meters populate and display ITIC curves right out of the box. You can view ITIC plots on the local display as well as the Web interface. (See sidebar, "Grading on the ITIC curve.")

Generous memory for data storage

The obvious corollary to the very high sampling rate of next-generation meters is that you accumulate heaps of data. Some power monitors have limited memory and can capture only a few events before they stop monitoring due to lack of data storage space. The power meter must have sufficient onboard memory to store high-resolution captured waveforms along with all the data logging associated with standard monitoring functions. Eaton Power Xpert Meters use industry-standard compact flash memory cards to provide 512 MB of onboard memory.

General-purpose user interface

In the race to outdo each other with technical features, some power meter designers have created the equivalent of yesterday's VCR— a promising tool that no one really feels comfortable programming and using. With older power meters, user interfaces have often been cryptic and confusing - appearing as an afterthought to an array of obscure and little-used functions.

Eaton saw an opportunity to redefine the paradigm. Who says power quality has to be complex? When designing the Power Xpert family of meters, we asked, "What are the essential features that customers will really use? What supporting features will enrich the working value of the product? Now, how can we make all these features easy to use for the broadest possible audience?"

Our intent was to bring sophisticated capabilities to people who had a vested interest in power quality but were not necessarily electrical engineers or consultant specialists. As a result, the first design document the R&D team produced was a user interface design based on extensive human factors research. No doubt more vendors will be taking this approach in coming years.

Grading on the ITIC curve

In North America, the American National Standards Institute (ANSI), Computer Business Equipment Manufacturers Association (CBEMA), and Information Technology Industry Council (ITIC, a sub-group of CBEMA) have all created power-quality curves that define equipment tolerance for power deviations.

The curves are similar in concept. The vertical axis shows deviation from nominal voltage (as a percentage of absolute voltage), where nominal voltage is the centerline. The horizontal axis shows the maximum length of time allowable at that voltage level, from microseconds to seconds.

The area above the plot shows the danger zone from high-voltage conditions. The area below the plot represents danger from under-voltage conditions. If the voltage supply stays within the acceptable zone in the center, equipment will operate correctly.

Power-tolerance curves provide an accurate representation of power quality as it relates to risk. After all, the risk from high- or low-voltage conditions depends on how long the equipment is exposed to the condition. For example, a piece of equipment might withstand high voltage for only one millisecond or less, yet be able to tolerate deviations of ± 10 percent from nominal voltage for 0.5 to 10 seconds.

The standard curves should be considered guidelines. Your equipment and processes may be more sensitive— or more critical— so your power quality meter should enable you to modify curves to suit your situation.

The Eaton Power Xpert family of power quality instruments

Eaton has created a line of next-generation power quality instruments that monitor, record and analyze critical electrical patterns—so you can optimize energy utilization, process performance and cost. Three models are available, so you can choose the best unit for each application:

- The **Power Xpert 4000 Meter** provides core functions for monitoring power consumption and power quality. This model uses Delta Sigma technology to sample circuits at 1024 samples per cycle for extremely accurate measurement of harmonics and other events. You can add options to suit your requirements, such as modules for Web communications, additional inputs/outputs, or remote display of information from up to 16 power meters.
- The **Power Xpert 6000 Meter** adds another level of sampling speed. This model uses Delta Sigma technology to sample circuits at 1024 samples per cycle for extremely accurate measurement of harmonics, flicker, transients and other events. The local graphical display unit and Web interface plot these events on an ITIC curve - with no special software needed. The meter uses a combination of voltage and duration to isolate sub-cycle oscillatory transients. An optional 512MB compact flash card provides ample mass memory storage of waveforms and other event data.
- The **Power Xpert 8000 Meter**—our premier model—does all that and adds the ability to capture very fast transients. This unit samples at 6 MHz — 100,000 samples per cycle. This very fast rate provides a sample on each channel every 166 nanoseconds (six samples every millionth of a second, across three input channels and neutral-to-ground).

Let's take a closer look at some capabilities that make Eaton's new power quality meters stand apart from previous generation models and alternatives from other vendors.

Easy-to-use interface

In designing the Power Xpert Meters, Eaton set out to demystify power quality— to take highly specialized data and convert it into useful information that doesn't require a power guru or consultant to understand. The result was an easy-to-use interface and new graphical representations of complex power quality data.

Next-generation power quality monitoring is now as easy as point-and-click (over the Web) or twist-and-select (on a local, graphical display unit).

Users have two choices for viewing power quality information from the meter:

- **Large graphical display unit.** The crisp, clear, 320x240 pixel, backlit display is mounted near the meter or networked to support up to 16 meters. This local display provides intuitive graphics, such as an at-a-glance Power Quality (PQ) index, ITIC curve and meter summary.

  Navigating and drilling down through the views is easy. Simply turn the navigation control wheel until the arrow lands on the menu selection you want to display, and press the button. It's that easy. Feedback from users has been uniformly positive.

- **The Web.** A Web server application is built right into the meter. With a password-protected Web interface (with multiple user authorization levels), you have many options for assessing power conditions. Click to drill down into detail, zoom out to see the broader context, modify reporting parameters and more.

The user interface makes it natural and intuitive to assess power conditions in your facility—at a high level or in detail. For instance, the ITIC curve display has numbers plotted on it, each representing the number of events plotted to that point on the curve. You can immediately see if there are a substantial number of problems. If you want to look more closely, that's easy. Just click any number to display a list of disturbances that match that zone of severity, then drill down to see the individual waveform that created the disturbance. Many power meter products cannot even do this with their expensive host software (which the Meter does not require).

Or as another example… suppose you get an email notification that voltage sagged too low or surged too high. Visit the Power Xpert Web page or local display, whichever is closer, and pull up a trend chart. Click on the channel that was out of limits, look at the triggers, and click to drill down to see the waveform (if you're into that kind of thing). Zoom out to view minimum, maximum and average voltage for the previous 18 hours—or last week, or the last four years— and compare those figures with the present min./max./avg. value and the 200ms average.

Other next-generation power meters generally require custom software and/or special configuration to extract this level of information, if it is possible at all. With Power Xpert Meters, you only have to tell the application where to send the email. The rest is standard, out-of-the-box functionality.

Anti-aliasing for superior data quality

At first glance, it might seem that, the more data points recorded when digitizing the electronic waveform, the better. Not necessarily. Power quality data is subject to a mathematical peculiarity known as "alias measurement error" that can really skew the data. In a nutshell, higher frequencies (higher than the sample range) can mistakenly be recorded as lower frequencies. Almost all power meters are subject to this phenomenon. That's one reason there has been such a horse race in the industry to continuously increase sampling speed.

The hope was that by gathering more data than ever, this inherent aliasing error would be diluted. However, if you add more water to muddy water, you still have muddy water. It's just not as muddy. Ditto for muddy data. Eaton eliminates this false signal content by using a statistical data cleansing method known as "anti-alias filtering."

The Power Xpert Meter acquires data at a rate of 1024 samples per cycle (100,000 samples per cycle for transients). These data points are then filtered through a digital quantizing error filter. The meter then records a statistically representative 256 samples per cycle from this cleansed data. Because this data has been run through anti-aliasing filters, the resulting 256 samples are actually more accurate than a higher number of samples that have not been through an anti-aliasing process.

Self-learning capability—What is "normal?"

A key value of permanent power quality meters is that you can see in a glance if everything is normal. But how do you determine what "normal" is? Older power monitors require a complicated set-up of thresholds and triggers. It can be difficult to program these limits correctly. Set them too narrowly, and you'll be plagued with nuisance alarms and circuit trips. Set them too broadly, and you'll miss potentially harmful power events. The problem is particularly acute when you first install the power meter, because you don't yet know what is normal for that circuit.

Power Xpert Meters simplify this process with a self-learning capability. In learning mode, the meter monitors activity on the circuit, characterizes what is normal for that circuit, and statistically derives proper limits for routine health-checks and alarms. No operator intervention is required.

You can, however, override the self-learned alarm thresholds and apply your own settings. This may be desirable for circuits where there really is no across-the-board "normal" condition. For instance, in a three-shift operation, you might have a very intense first shift with high power demands, a modest second shift with lower power requirements, and no activity on the third shift. In this case, a picture of "normal" that has been averaged across all three shifts wouldn't be representative of any shift. In such cases, it's quite valuable to be able to set your own thresholds.

Power Quality index—at-a-glance view of overall power quality

Old-style power quality meters generated obscure metrics that only a power quality expert could comprehend. In designing the Power Xpert interface, Eaton sought to make this information meaningful to technicians and administrators who were not necessarily power quality specialists or consultants. One outcome of this design strategy is the Power Quality (PQ) index.

The PQ index takes a number of power quality parameters into consideration, runs this data through statistical analysis, and returns a color-coded, graphical display of overall power quality. Green-yellow-red indicators provide an at-a-glance view of how well power quality is measuring up to what is normal for that circuit— and how it compares to conditions and "normal" for 10 minutes ago or 24 hours ago.

Industry-standard communications

In the past, communications with power meters required complicated connectivity accessories and proprietary protocols. Not any more. Eaton Power Xpert Meters are very connectivity-ready.

- **Local communications**. The meter includes a built-in Ethernet port for local access. Just walk up to the unit and plug in a local laptop to perform a full range of analysis and reporting.
- **Remote communications**. An optional interface card supports remote communications with the onboard Web server application over your LAN/WAN and over the Internet. You can choose from a range of industry standard physical interfaces (RS-485, RS-232, RJ-45 Ethernet, fiber-optic port) and communication protocols (Modbus/TCP, Modbus RTU, HTML, SNMP, SMTP).

Other value-added features

Built on open standards and the latest technologies, Power Xpert Meters offer other capabilities that increase reliability while reducing overall cost of ownership.

Modular architecture. Power Xpert Meters are highly modular in design. Mix-and-match displays and base units provide configuration flexibility. Modularity within the meter itself (replaceable power supply card, communications card, input/output card) enables dynamic servicing and upgrading as necessary.

Flash upgrades in the field. You can upgrade your Power Xpert Meter without sending it back to the factory or loading custom software. Eaton sends a firmware file; you load new features from this file using password-protected access to the embedded Web server.

Easy configuration. Most power meters of this caliber require custom software for configuration—to set up triggers, alert notifications, etc. Power Xpert Meters have comprehensive configuration capabilities built right into the embedded Web server. There's no need for custom software.

Remote input monitoring. Power Xpert Meters accept digital inputs from other meters (not just power), record this information at user-specified intervals, and display it with the same options as available for power monitoring. With this feature, you can use the Power Xpert Meter to characterize the flow of other utilities, such as gas, water, pressed air, sewer or steam.

Networked display. From a single graphical display unit, you can view power quality information from up to 16 daisy-chained Power Xpert Meters.

User security. You can define which users can access the password-protected Power Xpert Web interface and what level of authority they have to use specific functions. You don't have to worry that unauthorized users will interfere with power quality systems.

Closing thoughts

Many organizations that rely on electronic systems are not aware of impending power problems until they happen—and that's too late. Proactive monitoring with permanent, next-generation power quality meters can deliver a host of benefits:

- **Accurately detect fast-acting problems**. By sampling circuit activity at very high rates (up to 100,000 samples per cycle), you can identify fast transients that previous generation monitors would miss.
- **Provide early warning of looming problems**. By plotting power events against an ITIC curve of acceptable conditions (rather than just simple thresholds and triggers), you can identify deteriorating conditions before they have a chance to damage sensitive equipment.
- **Reduce the cost of monitoring power quality**. Recent advances in technology enable next-generation capabilities to be packaged in compact units at affordable prices. Power Xpert Meters cost far less than yesterday's specialized power quality instruments and outside consultants.
- **Support continuous, non-disruptive monitoring**. There's no need to shut down systems and restart them to begin monitoring, as you often have to do with portable monitors. Permanently installed power meters are on the job 24 hours a day.

If your organization relies on clean power, consider installing next-generation power quality instruments at key locations in your facility—at the service entrance, on mains and on other key circuits that serve sensitive loads.

Detect, analyze and resolve problems early—before they lead to damaged equipment, corrupted data or production losses. With next-generation power quality meters in place, you can create an environment where critical equipment can perform up to specifications for maximum service life.

About Eaton Electrical Systems and Services

In the electrical industry, Eaton is a global leader in electrical control, power distribution, uninterruptible power supply and industrial automation products and services. Through advanced product development, world-class manufacturing methods, and global engineering services and support, Eaton's electrical business provides customer-driven solutions under brand names such as Powerware®, Cutler-Hammer®, Durant®, Heinemann®, Holec® and MEM®, which globally serve the changing needs of the industrial, utility, light commercial, residential, IT and OEM markets. For more information, visit www.eatonelectrical.com.