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A POWER QUALITY NEWSLETTER

Point of View

What we learn about system compatibility (SC) today is vital to a future that promises increasingly innovative uses for wireless technologies and microprocessor-controlled equipment. Industrial plants will employ more robotic automation, offices will rely more heavily on information technologies, and our homes will have more devices that are controlled via wireless or the power line.

At utilities, power electronics will be used to shape the voltage and current feeding customer loads. This proliferation of power electronics, coupled with the growth of wireless communications, will amplify SC issues in terms of high-frequency, radiated and conducted, electromagnetic interference.

Until recently, SC research has focused on power quality phenomena, such as voltage sags and transients, and their impacts on equipment performance. But as the microprocessor becomes ubiquitous to technology—making logic voltage lower, switching speeds higher, and interference more common—power quality events may contribute to equipment failure as well as performance degradation. Failure analysis techniques are now being introduced to expand the scope of SC investigations.

Utilities are also actively monitoring their grids to characterize the

Point of View: Continued on back

New IEEE Standards Foster Next-Generation System Compatibility

By François Martzloff

In an exclusive story, international standards expert and past *Signature* Editorial Board member, François Martzloff, presents a unique preview of three new surge-related standards that are bound to set the course for the future of system compatibility. This standards trilogy is scheduled for publication by the Institute of Electrical and Electronics Engineers early in 2003.

For electronic copies of the new standards, visit www.ieee.org. For general information about activities of the IEEE Surge Protective Devices Committee, see grouper.ieee.org/groups/spd. To access an anthology on surge protection, go to www.eeel.nist.gov/811/spd-anthology.

In November 2002, the Institute of Electrical and Electronics Engineers (IEEE) approved a set of three standards that provide critical parameters on the surge environment in low-voltage ac power circuits, and suggest improved test methods for end-use equipment connected to these circuits. When this standards trilogy is published in early 2003, manufacturers and users of surge protective devices (SPDs) will have a definitive set of documents to help them make more cost-effective and technically sound design decisions regarding the compatibility of their equipment with the surge environment.

The seminal IEEE Standard 587—*Guide on Surge Voltages in Low-Voltage AC Power Circuits*—has gone through several revisions, including a name change to C62.41, since it was first published in 1980. A companion, IEEE Standard C62.45—*Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits*—was also developed to provide guidance on test procedures.

IEEE 587/C62.41 and C62.45 served us well from 1980 to 1999. However, with the availability of new knowledge on surge protection, and after nearly 20 years of experience in applying the two standards, a major update was needed. The newly developed standards provide a more direct route to fulfilling the surge protection needs of users, and are designed to promote greater harmony with the related standards of international organizations.

The new trilogy consists of

- IEEE Standard C62.41.1™ 2002—*Guide on the Surge Environment in Low-Voltage AC Power Circuits,* which contains a comprehensive database describing the surge environment;
- IEEE Standard C62.41.2™ 2002—*Recommended Practice on Characterization of Surges in Low-Voltage AC Power Circuits,* which proposes a limited set of representative surge waveforms for test purposes; and

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New IEEE standards will help end users to evaluate the many surge protection options, and to make technically sound and cost-effective choices.

Failure Analysis: An Emerging Power Quality Tool

By Gregory Olson

In responding to damage claims over the years at PSE&G, we have found that customers often single out power quality as the cause of failures in their manufacturing equipment. The reality is that any number of factors can bring on the eventual demise of a prized piece of equipment. It might be contamination or deterioration by dust, water, heat, cold, or humidity that causes the equipment to fail. It could also be old age, extensive use, improper maintenance, inherently weak components, design issues, impacts of the long-term electrical environment, or inattention to proper nameplate specifications.

Even though much of today's technology is of the expendable or throwaway variety—with replacement being more cost-effective than performing labor-intensive circuit board repairs—customers understandably still want to know what causes a failure. This puts service technicians in a difficult position, since they are forced by competition and productivity requirements to spend less time troubleshooting and repairing customer equipment.

It is not unusual for well-intentioned technicians, looking to appease customer concerns, to suggest that the equipment failed due to an "electrical surge." But without any actual disturbance data, they would be hard-pressed to ascertain even a remote possibility of the cause for failure.

Finding the Cause

Use of forensic science techniques, or failure analysis, to reconstruct what may have actually happened is gaining popularity as a useful investigative tool for utilities. For years, power quality engineers have used power disturbance analyzers to qualify, disprove, or otherwise correctly describe an alleged electrical surge. They have learned that some basic components will fail under certain power variations.

Metal oxide varistors (MOVs), for instance, tend to fail in short-circuit mode. And MOVs with a maximum continuous operating voltage of 130 volts are more prone to overvoltage stresses than those rated for 150 volts. This basic knowledge has allowed power quality engineers to provide answers to what many customers consider to be the "mysteries of electricity."

But what about more complex types of equipment, such as adjustable speed drives (ASDs) and programmable logic controllers (PLCs)? The sheer volume of vendors, models, and applications makes characterizing this equipment a daunting and costly task for the utility.

EPRI PEAC has taken on this task as part of its System Compatibility Project. The Forensic and Failure Analysis of Electrical Equipment Initiative will provide utilities with greater knowledge about how failures occur, and allow them to better recognize a true failure as caused by an electrical anomaly rather than just a device's last gasp (see *R&D Corner* on back page). It will deliver detailed power disturbance data and an understanding of typical failure modes. It will also determine what equipment manufacturers can do to help prevent failures.

This type of insulation failure can be caused by contaminants, abrasion, vibration, or surges.

PSE&G, along with other utilities, is participating in the effort, providing research funding, case studies, and the utility perspective on customer needs and equipment failures. Future decisions on the types of equipment to be tested and failure modes to be analyzed will be guided by sponsors of the initiative.

Armed with knowledge gathered by this project, utilities and manufacturers will be able to work together in designing more robust and resilient equipment that can withstand the rigors of the real-world electrical environment. Ideally, domestic and international standards-making organizations will embrace the design enhancements suggested by this research. And ultimately, customers will experience less equipment failure associated with power disturbances.

Destructive Testing

The failure analysis project involves taking typical electrical products used in industrial settings and subjecting them to a battery of potentially destructive power disturbances. The goal is to fail each device under controlled laboratory conditions so that all electrical parameters can be accurately monitored. Investigators then analyze the damaged equipment to determine which components failed and how the failure manifested. They make vendor and device comparisons based on equipment design and protection philosophies that affect equipment immunity. They then apply these comparisons to establish generic failure modes, which provide equipment manufacturers with a clearer understanding of potential damage and preventive measures.

As part of a Phase I effort, project researchers identified a number of common devices for testing, reviewed the damage claim trends of utility and insurance carriers, evaluated failure samples, and developed rigorous testing protocols. They acquired test sample products from Duke Power—small, interconnected

Failure Analysis: *Continued on back*

EMI: The Next System Compatibility Challenge

Power lines. Electronic circuits. Electric motors. Just about anything that uses or creates electromagnetic energy can potentially conduct electromagnetic interference (EMI) through its wires. Then, there are the wireless technologies, such as cell phones and laptops, that radiate interference through the air.

The editors of *Signature* recently spoke with three active contributors to electromagnetic compatibility (EMC) research and development, gathering their insights on an issue of growing importance.

Stig Nilsson, P.E., is Principal Engineer and Director for the Electrical Practice at Exponent®, Inc. (www.exponent.com) in Menlo Park, California. Specializing in electrical and control system issues, he performs investigations of accidents; electrical equipment, appliance, and computer failures; and advanced electrical and electronic power converters.

Steven Whisenant, P.E., is Manager of the System Power Quality Group at Duke Power (www.dukepower.com) in Charlotte, North Carolina. He oversees all power quality activities, including EMC investigations, for the utility's largest industrial and commercial customers.

Arshad Mansoor, Ph.D., is Director of Engineering at EPRI PEAC Corporation (www.epri-peac.com) in Knoxville, Tennessee. He directs research and development efforts at the facility, including EMC investigations into power line filtering.

Signature: What is the state of EMC today?

Mansoor: In power quality circles, we have roughly the same level of awareness about EMC today as we had about power quality in the mid-1980s. Since then, there has been a lot of research aimed at demystifying power quality. Now we need to focus on EMC, and to remove interference as a barrier to using microprocessor-based controllers, adjustable speed drives (ASDs), and other life-enhancing equipment. Through better understanding of EMI and proper protective measures, we can make these electronic devices more compatible with the electrical environment.

Nilsson: Due to the push for efficiency, the way we use electricity has changed. Products like laptop computers, cell phones, high-efficiency light bulbs, and fluorescent light fixtures—anything with switching power supplies or digital electronics—emit conducted or radiated EMI, which needs to be controlled.

Whisenant: We are still learning about EMC and its issues. Once we gain a clearer understanding, we will be able to design solutions into electronic equipment so it does not emit, and is not impacted by, radiated or conducted interference.

Signature: What industries are most impacted by EMI?

Nilsson: Exponent is working with utilities to assess transmission line siting impacts, such as electric and magnetic fields and radio interference caused by corona. Prior to joining Exponent, I worked for EPRI, where I led studies on EMC of electronic equipment in substations. Electronics are being used increasingly in digital protective relays and monitoring systems for breakers and transformers.

Transportation—particularly electrified railroads and electric vehicles—is another industry facing EMC challenges. Even dc systems used for light rail vehicles can perturb the earth's magnetic fields enough to impact sensitive instruments nearby, such as magnetic resonance imaging equipment in research laboratories and hospitals.

EMI may also affect defibrillators, pacemakers, even hospital beds used in medical facilities. In industrial plants, it could cause malfunction of control equipment and robots. EMI has the potential to cause significant harm if not controlled.

Mansoor: We began investigating EMC at EPRI PEAC in 1995, mainly evaluating the performance of power line EMI filters for the U.S. government. Then in the late 1990s, utilities and commercial customers who suspected EMC problems started calling. Now utilities are looking into EMC issues in their own operations, which are using more microprocessor-based devices and digital relays to supply power.

Today, our investigations involve fieldwork and controlled immunity testing in an "EMI-proof" chamber in our laboratory. We test the tolerance of equipment to electromagnetic emissions, and also measure how much it emits. Then we look for solutions. It's the same as investigating a power quality problem, just in a different frequency range.

Signature: What products are being developed that address EMC?

Whisenant: In 1999, Marek Samotyj—then Manager of the EPRI Power Quality Product Line—envisioned EMI as the next system compatibility challenge (see *Point of View,* Spring 1999 *Signature,* NL-113032). Duke Power responded by working with EPRI PEAC to build the Portable Radiated Emissions Measurement System (PREMS). Currently in the laboratory testing and characterization phase, it is an automated system that power quality engineers and customers can use to help predict equipment malfunctions due to EMI, or to investigate ongoing interference problems.

The PREMS measures radiated frequencies and emission magnitudes

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The Portable Radiated Emissions Measurement System will automatically capture, record, and analyze radiated frequencies.

Power Monitoring Is Key to Failure Analysis

By Larry Ray

Power monitoring and control systems are proven tools for helping industrial and large commercial customers manage the power they use. These intelligent systems can help reduce energy costs, improve electrical distribution system reliability, decrease downtime and lost production, and optimize customer equipment. They provide metering, networking, real-time communications, and software technologies that not only help customers bring plants on-line sooner, but provide information to make their power system more resilient.

At Square D we are now seeing a trend toward using these capabilities to support forensic and failure analysis efforts—the latest step toward more effective power management in end-use facilities. Customers are using monitoring and control systems to "predict" problems in the electrical system and are taking steps to protect their equipment.

They are also applying the systems to determine the root cause of problems when failures do occur, instead of just looking at the symptoms. Voltage transients, for instance, can be particularly troublesome due to their elusive nature. Like rust, transients can have gradual damaging effects on a number of sensitive, microprocessor-based electronic devices commonly used on the factory floor.

Today's new circuit monitors can detect waveshape anomalies in the power supply that are imperceptible with typical sag/swell alarm detection—giving users warning of a potential failure. In the event of equipment failure, the circuit monitor can identify impulsive and oscillatory transients, record waveforms, and characterize events to within one microsecond. This allows users to determine whether voltages exceeded the withstand of sensitive industrial equipment, or if the equipment failed prematurely.

Power monitoring and control systems can support a wide range of failure analysis applications.

This is just one example of the role monitoring systems can play in failure analysis efforts at customer facilities. Square D has installed monitoring equipment at hundreds of locations across the country. The following case study highlights a variety of applications at one industrial site.

One Plant, Many Benefits

A large West Coast petroleum refinery used the Square D POWERLOGIC® power monitoring and control system to save costs by preventing disturbances and increasing the resilience of its power system.

Greater Service Reliability

The cogenerating refinery—which relies on the electric utility for approximately 15% of its load, and uses its own generators to supply the remaining load—had a nuisance-tripping problem costing more than $20,000 per occurrence. After installing the POWERLOGIC system, plant engineers were able to view the exact sequence of events and pinpoint the root cause of the problem.

With the utility circuit breaker set to reclose within four cycles for transmission line faults, the engineers had specified an 11,000-hp adjustable speed drive (ASD) and other process equipment at the refinery to ride through voltage sags as low as 15% and up to six cycles in duration. This specification should have prevented tripping of the equipment for most temporary faults on the supply system.

However, synchronized, high-speed time stamps generated by the monitoring system indicated that the 40 relay on the generator would trip first during disturbances. Real-time waveform captures showed this occurring while the generator was heavily excited and supplying VARs to a remote fault. The waveforms also revealed an inability of the ASD to ride through the specified six cycles during a voltage sag. This forensic information allowed the ASD manufacturer to recognize and repair a glitch in its firmware, solving the nuisance-tripping problem.

Reduced Downtime

In another area of the refinery, power monitoring helped diagnose why a 4500-hp hydrogen compressor would not start from the field during the night shift. The compressor operator checked the refinery substation and verified that four different electromechanical targets had dropped, usually indicating a power disturbance. A review of time stamp data and waveform captures convinced plant engineers that the compressor's breaker had never closed—and that a power disturbance had not occurred.

They focused on the motor-start permissives—relays that must operate for the motor to start—and found a failed lube oil permissive contact. It turned out that during bench-testing by maintenance personnel earlier in the week, the electromechanical relay flags had tripped. The flags had not been reset, since there were no waveforms to indicate a fault or motor inrush current. The monitoring system allowed the engineering

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in a given area and develops a baseline. If EMI occurs after a new electronic device is introduced, new data measurements can be taken and comparisons made with the baseline to identify interacting frequencies. The PREMS will be demonstrated in hospitals and other health care settings in early 2003, but will be a valuable tool in all types of commercial and industrial environments. It is similar in concept to the voltage sag generator, which Duke developed in 1995.

Nilsson: Exponent has been involved in the development and testing of electronic equipment for the Land Warrior Program of the U.S. Army. The objective is to provide individual soldiers with sophisticated communication systems. EMC is a part of the development process.

Signature: What is the next generation of EMC?

Mansoor: We will be seeing more microprocessor-based controls with lower logic voltages and electronic systems with higher switching frequencies. The same is true of ASDs, which are a major source of EMI because they use very high-speed switching. But because they also offer significant cost and efficiency advantages, we can expect most electric motors to be paired with ASDs in the future.

Wireless devices are an exploding area of EMC. With the increasing numbers of communication and control systems in use—including those used by utilities to transmit data from power quality monitors—the air space is getting crowded.

Nilsson: As faster digital processors are incorporated into products, we need to expand our knowledge about EMI effects at higher frequencies. Also, the increasing use of wireless communication systems will bring about a plethora of gadgets that emit EMI. Although radiated power is limited from such devices, when they are used in proximity to sensitive electronic equipment, even a small hole or crack in an enclosure is like an open barn door for interfering radiation at these higher frequencies.

Signature: What can we expect in equipment and business practices?

Whisenant: We expect to see wireless control technologies used in industrial plants. This will be another application for the PREMS—to measure background frequencies in the plant and then coordinate the wireless control frequencies so as not to interfere with existing equipment.

Nilsson*:* Utility transmission lines have become more difficult to maintain due to transmission and distribution wheeling contracts that limit the ability of utilities to schedule outages to service lines and equipment. There is a push toward just-in-time maintenance, and maintenance of lines while they are "hot," or energized. Utilities need more monitoring and on-line diagnostic tools to analyze line equipment and detect incipient failures, so they don't have to take lines out of service, or can schedule interruptions that are least disruptive to customers.

Signature: What challenge(s) would you make for the sake of improving EMC?

At a store in Maryland, any use of cell phones would cause the digital cash register to ring up the same phantom transaction—$1200 worth of cigarettes.

Nilsson: Utilities need to be proactive and characterize the electromagnetic environment of their transmission and distribution systems in higher-frequency regimes. There are now microprocessors available that work in the 1–3 GHz range, and we lack information on the sensitivity of installed electronic equipment to EMI in that range. Utilities should do research to characterize EMI emissions from lines in substations in the range from 100 MHz to 10 GHz. This would complement information already developed about 15 years ago.

Mansoor: One of the biggest EMC problems is people getting boxed in by their own thinking. Designers and users of microprocessor-based controllers have little idea of the impact these devices can have on the electrical system. There needs to be more communication among equipment designers, utilities, and end users.

We also need more unified requirements in terms of standards. EMC requirements in the United States now differ from those in Europe. Also, industries should follow the lead of the semiconductor industry and adopt their own power quality standards.

Whisenant: While the Federal Communications Commission regulates emissions and frequency assignments, and the International Electrotechnical Commission has immunity standards, no one is regulating interference in the commercial and industrial environment. We need more standards development and different design specifications for equipment to help minimize EMI.

As we look to the future of EMC, it's important to remember our experience with voltage sags. It took time to understand them, but once we did, we started building equipment that could ride through sags. EMC can use the same model. We need to better understand what EMI is, where it comes from, and how it can cause problems. Then we can develop methods and standards that reduce the impacts of EMI. ■

New IEEE Standards: Continued from front

- IEEE Standard C62.45™ 2002—*Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits,* which shows how to perform reasonable, repeatable, and reliable surge testing.

New Focus

In developing the standards, IEEE focused on five key areas: transitions, temporary overvoltages, multiple-port equipment problems, scenarios, and harmonization. Because these factors can have significant impacts on hardware selection and specification, they were debated thoroughly by members of the working group and other interested parties before a consensus was reached. Fortunately, the IEEE standard format includes "normative" clauses, to emphasize important points, and "informative" annexes, to provide perspective on less definitive issues.

Transitions

Earlier versions of C62.41 offered the concept of "Location Categories" to help designers and users of equipment define surge threats by the general location of the equipment within a building. Location categories are based on the fact that the inherent inductance of the building wiring reduces *current* stress from an impinging surge as the distance from the service entrance increases, while *voltage* stress is not affected. According to this concept, SPDs can be expected to have less stress exposure as their point of use moves away from the service entrance.

While the earlier standards did not specify precise distances, they featured graphic representations with fine lines, or "boundaries," separating location categories. Because some users focused too narrowly on these boundaries, the updated guide now uses the concept of "Transitions" that connect rather than separate location categories, as the graphic shows. These transitions leave some flexibility for equipment manufacturers and users in selecting specific surge-withstand values.

Temporary Overvoltages

Although temporary overvoltages—which last seconds rather than the microseconds of surges—might be seen as outside the scope of the surge environment, their impact on SPDs can be devastating. For this reason, IEEE added a description of their occurrence and mechanism to the C62.41.1 guide.

Multiple-Port Equipment

Most of today's electronic equipment contains multiple ports, with connections to both the ac power supply and one or more additional systems that must have a ground reference, such as phone systems, television cable systems, and computer networks. Multiple-port equipment is now the most common victim of surges. A surge on any of the connected systems will cause a shift in ground reference potential to appear across the equipment ports. Guide C62.41.1 alerts the engineering community to this phenomenon—the most frequent source of insurance claims—and supports the standardization of SPDs. Furthermore, IEEE has just launched two projects for developing new standards addressing performance and test methods of multiple-port SPDs.

Scenarios

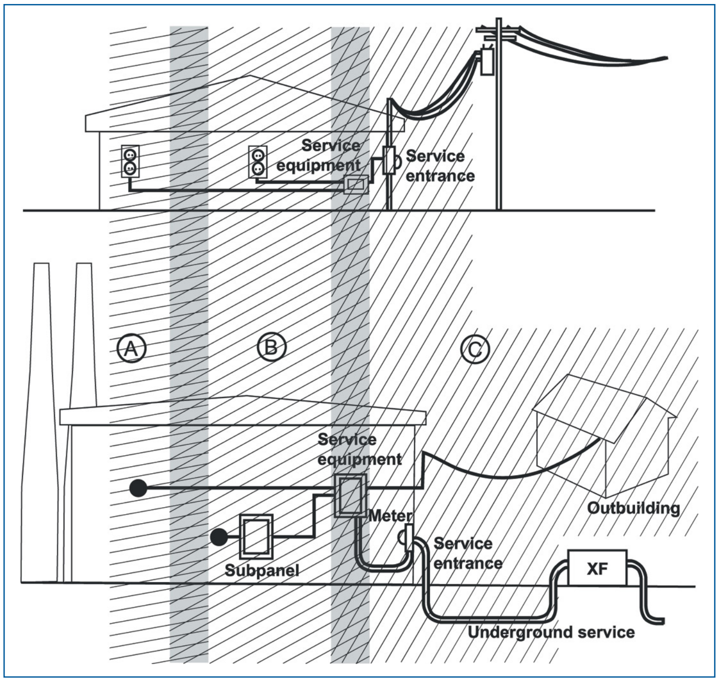
In an effort to organize and present information in a way that will be as useful and realistic as possible, the standards trilogy introduces the concept of "Scenarios," which distinguish between two types of surges. Scenario I describes surges coming from any source that *impinge* upon an installation or are generated within the installation by load switching. Scenario II covers surges that are associated with a rare but possible direct lightning flash to a building, and with surge current that *exits* the building via the service connection.

The concept of location categories applies only to surges in Scenario I—those impinging upon a building from the outside or being generated from within. These are considered to be the vast majority of surge events. Guide C62.41.1 provides a surge environment description that serves as the basis for defining the waveforms in Recommended Practice C62.41.2.

The more rare event of a direct flash to a building in Scenario II was considered to be a special case and not included in earlier documents. Given the increasing interest in the ramifications of such an event, the new standards address this situation. Definitions of appropriate parameters for this scenario did raise some discussion in gaining consensus, and therefore are proposed in an informative annex to allow case-by-case applications.

Harmonization

In keeping with the transnational aim of IEEE standards, the new standards were developed to harmonize with related documents from the International Electrotechnical Commission (IEC). The IEEE working groups established liaisons with



Derived from IEEE diagram

Overlaps between the lined areas represent "Transitions," which connect Location Categories A, B, and C. Stress levels imposed on end-use equipment, including surge protective devices, decrease from C to A for surges impinging upon the facility.

Exploring the Shores of Power Quality

The EPRI Power Quality Applications (PQA) 2003 North America Conference and Exhibit—"Exploring the Shores of Power Quality"—will provide firsthand customer experiences plus successful, forward-looking approaches to improving the interface between electricity supply and end-use devices. The exhibition will showcase innovative power quality equipment and solutions.

PQA 2003 will be held in Monterey, California on June 2-4, 2003. Room reservations can be made by calling the Monterey Plaza Hotel and Spa directly at 831-646-1700. To obtain the group rate of $195 (single or double), mention "EPRI PQA 2003." The room reservation deadline is May 19, 2003.

For questions or further information regarding conference logistics, contact Megan Wheeler at 415-455-9583 or mwheeler@epri.com. For exhibit information, contact Marsha Grossman at 650-855-2899 or mgrossma@epri.com.

IEC Technical Committees SC37A (Low-Voltage SPDs) and TC81 (Lightning Protection), as well as with other parties involved in lightning studies. These efforts will help to ensure greater credibility and worldwide acceptance of both IEEE and IEC standards.

Expanded Scope

In earlier versions of the standard, surge environment descriptions were limited to compilations of surge measurements in the field. The data were gathered either by systematic monitoring or through staged tests during equipment failure investigations. As development of Guide C62.41.1 progressed, it became clear that more information on the surge environment could be gained by incorporating other data. The standard now includes additional data from recordings of surge events in the field, numerical simulations and laboratory research, and inferences on the surge environment drawn from analysis of equipment failures.

The proposed waveforms and associated stress levels in Recommended Practice C62.41.2 required no major change during the updating process. The waveforms should not be construed as specifications—a misconception noted in the use of earlier versions of C62.41—but rather as a menu from which equipment manufacturers and users can select stress levels, as determined by the test waveform(s) and amplitude(s) best suited to their own applications. The menu offers a set of two standard waveforms for general applications and a set of two additional waveforms for special applications.

The first standard waveform, the "Ring Wave," was constructed in 1980 on the basis of the then-novel recognition that traditional test waveforms used in high-voltage laboratories might not provide accurate representations of the environment in low-voltage ac power circuits. The second standard waveform, the "Combination Wave," defines two stress types. It is used for subjecting equipment to voltage stress, when the equipment presents a high impedance, or to current stress, when the equipment presents a low impedance.

The additional waveforms are the "Electrical Fast Transient Burst," first developed within IEC for electromagnetic compatibility purposes and adopted by IEEE in 1991, and the "Long Wave," which reflects field observations of surge occurrences. The 1991 version of C62.41 also included a 5-kHz ring wave to emulate capacitor-switching surges. This wave was removed from the menu, as data on the wide range of capacitor-switching surges made it clear that only case-by-case applications would be reasonable.

Equipped with these waveforms, Recommended Practice C62.45 provides information on instrumentation, considerations on tolerances in the output of surge generators, and descriptions of test procedures, including coupling of surges into test circuits. This enhanced version addresses issues raised by the shift from analog to digital instruments as well as the possible effects of aliasing, insufficient resolution, and transducer saturation. It also includes precautions for avoiding artifacts.

With the implementation of the new IEEE standards trilogy, designers and users of next-generation devices will be well equipped to tackle the surge environment of the future in low-voltage ac power circuits. Among the benefits they will realize are more cost-effective use of resources and greater reliability of electrical and electronic equipment. ■

François Martzloff is an Electronics Engineer at the National Institute of Standards and Technology (NIST) (www.nist.gov) in Gaithersburg, Maryland. He has been at NIST since 1985, after 29 years at General Electric, and has contributed to the development of IEEE and IEC standards since the late 1960s. He can be reached at f.martzloff@ieee.org.

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staff to troubleshoot and get the hydrogen compressor back on-line in a fraction of the time it would have taken without it.

Honest Answers

Use of the monitoring system also fostered clear answers at the refinery. During taproot investigations, system data indicated that plant personnel had accidentally shut down equipment. The shutdowns could no longer be blamed on phantom power disturbances. It turned out that the errors were due primarily to ambiguous steps in procedures, vague labeling, or missing information on one-line diagrams—all of which were easily corrected.

Power monitoring and control systems have come of age as valuable forensic tools. Their output and capabilities can now provide customers with the answers they need to preempt failures, reduce energy costs, and better utilize their equipment. ■

Larry Ray, P.E., is Manager, Power Systems Engineering at Square D Company (www.squared.com) in Raleigh, North Carolina. His team performs power systems design, testing, and troubleshooting in industrial and commercial facilities. Larry is past-chair of the IEEE Standards Coordinating Committee on Power Quality, and the IEEE Recommended Practice for Monitoring Electric Power Quality.

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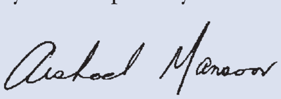
electrical environment, and are ensuring that power quality and reliability are integral to their grid-planning process. They are working with key industries—such as automotive, foods, and plastics—to promote development of industry power quality standards, like the SEMI F47 curve recently established by the semiconductor industry.

As failure analysis and electromagnetic compatibility (EMC) investigations become more central to SC, new entities will emerge. Companies engaged in failure analysis—a mature field in other failure modes, such as vibration—can contribute valuable knowledge to power quality efforts. Consumer sectors, such as healthcare, that are in the forefront of managing EMC issues, and equipment manufacturers and standards organizations can build solid partnerships with utilities and EPRI. Together, we can achieve our ultimate goal of system compatibility.



Arshad Mansoor, Ph.D.
EPRI PEAC Corporation

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systems made up of an ASD, PLC, control transformer, and motor—and performed surge testing in the EPRI PEAC laboratory to evaluate the failure mode of these systems.

The researchers began their investigation by applying surges to the three-phase ac power port of a system engaged in a cyclical routine. They initially used surges with a 500-volt peak and incrementally reached 6 kV in 500-volt steps. One brand failed at 2.5 kV with a surge applied line-to-line, while others tolerated the same scenario up to 6 kV without failure.

They followed up by testing the communication ports on the interconnected PLC and ASD. While the system was running a routine, they applied surges individually to each shielded cable in the test sample. Interestingly, one unit failed at 500 volts, while others survived up to the maximum of 6 kV under the same test conditions. The next step will be to analyze the failed samples to extract clues about the damaged components, and to attempt to explain the wide range of susceptibility of the tested systems.

The failure analysis initiative will provide invaluable information on how and why equipment failures occur, and on what can be done to prevent them in the future. At PSE&G we look forward to using this information to provide better customer service and more definitive answers when our customers experience equipment failures. With this increased knowledge and understanding, we expect to reduce the costs associated with investigating damage claims, while enhancing customer satisfaction with our power quality performance. ■

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R&D Corner

The EPRI System Compatibility Project was recently expanded to include a program in the area of electrical equipment failure and forensic analysis. By replicating certain failure modes, details regarding the cause of customer equipment failure can be obtained and studied.

The EPRI Forensic and Failure Analysis of Electrical Equipment Initiative is establishing a knowledge base of component and equipment failures through equipment testing and development of failure investigation methodologies, test protocols, and information guides. Components such as power supplies, surge protective devices, printed circuit boards, motors, and fuses are being tested for loads including appliances, heat pumps, air conditioners, electronic ballasts, motors and drives, programmable logic controllers, and motion controllers.

This multi-year program, which began in 2002, uses both base funding and Tailored Collaboration sources. For more information, contact Rick Langley at (865) 218-8016 or rlangley@epri-peac.com.

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