EPRI

SIGNATURE™

FALL 1997 • VOLUME 7 • NUMBER 4

A POWER QUALITY NEWSLETTER

Point of View

Deregulation has put power quality in the spotlight. In fact, until power quality and power reliability issues are properly addressed, utilities will have difficulty establishing price plans for an open energy market.

At PQA '97, the recent EPRI-sponsored conference on power quality, Joe Craven of Kimberly-Clark presented the customer side of the situation. He described power quality as a common denominator to his company's management goals of profitability, productivity—and peace of mind. As he sees it, quality power allows company equipment to operate efficiently, manufacturing processes to go uninterrupted, products to ship on time, and profits to accrue. Peace of mind, indeed!

To achieve these goals on a sustained level, customers might consider adding power quality assessment procedures to routine activities such as equipment purchasing and maintenance. At the same time, utilities might take measures to better understand and meet the needs of their various customers. With this in mind, the EPRI Power Quality Business Area—in collaboration with Salt River Project, Texas Utilities Electric, Duke Energy, and First Energy (formerly Centerior Energy and Ohio Edison)—has developed a series of workshops

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Power Quality Perspectives in the Semiconductor Industry

by C. Rinn Cleavelin, Ph.D., Texas Instruments, Inc.

In the highly automated setting of a semiconductor fabrication facility, a voltage sag—even within American National Standards Institute limits—can shut down the ultrasensitive equipment and control systems used in the production of semiconductor devices. A sag to about 80% of nominal voltage for a few cycles can interrupt the microprocessors running production, potentially resulting in thousands of dollars in scrap material and more than $500,000 a day in lost production.

In addition, loss of production during equipment restabilization —which ranges from hours for less sensitive equipment to days in more severe cases—can result in significant potential revenue losses, as the table shows on page 7. To determine potential revenue loss, Texas Instruments uses a profit and fixed cost model that takes into account fixed production costs, such as depreciation and facility cost, and loss of profit due to lost production time. Based on this model, the company's real financial loss is typically in the range of $500,000 to $2 million per event, depending on the severity of the interruption.

Changing Parameters

In early 1999, Texas Instruments will begin producing 300-mm wafers, which will double the surface area and potential production and revenue losses of today's 200-mm wafers. In addition, the continued miniaturization of chips multiplies the number of chips per wafer, heightening potential losses. And, the increasingly complex integrated circuit designs of the smaller chips put tremendous demands on the stability of the fabrication process. These factors place even more emphasis on the need for quality power in the semiconductor industry.

Technicians develop manufacturing processes for digital signal processors (DSPs), the specialized chips used in cellular telephones, personal computers, and other high-tech products. Utilities may also find applications for DSPs in their power quality efforts.

Until as recently as 10 years ago, operating assumptions at Texas Instruments included a tolerance for voltage sags and momentary interruptions of three to five seconds. However, this assumption is no longer acceptable, and new mitigation techniques and technologies actually allow us to operate without interruption. With these considerations in mind, we are collaborating with our serving utilities worldwide to meet an aggressive power quality goal: no electrical downtime from preventable causes, with no or minimal increase in cost per kWh (see *TU Electric Aims for Total Reliability* on page 3). We need to be able to assume that our facilities will operate 24 hours a day, 365 days a year, without interruption. To accomplish this goal, we are pursuing solutions on both sides of the meter.

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Semiconductor Tool Mitigation Options

by Mark Stephens, EPRI PEAC

Following is Part I of a two-part series on semiconductor tool tests at PEAC. Part II will run in *Signature* in 1998.

Crashing robotic arms, lost controller memory, and damaged wafers are just some of the tolls a voltage sag or momentary interruption can take on a semiconductor fabrication plant. These and other costly production problems could be mitigated if manufacturing tools were able to ride through minor power disturbances.

Semiconductor facilities, like other industrial power users, experience a range of voltage fluctuations in their electrical supply. However, testing of 25 semiconductor manufacturing tools and subsystems by the EPRI Power Electronics Applications Center (PEAC) shows that disturbances lasting as few as three cycles and dipping to just 93% of nominal voltage can affect the complex tools used in the semiconductor industry. Analysis also reveals that the majority of sags impacting the tools are in the range of five to 10 cycles, with dips to between 90 and 50% of nominal.

Problem Areas

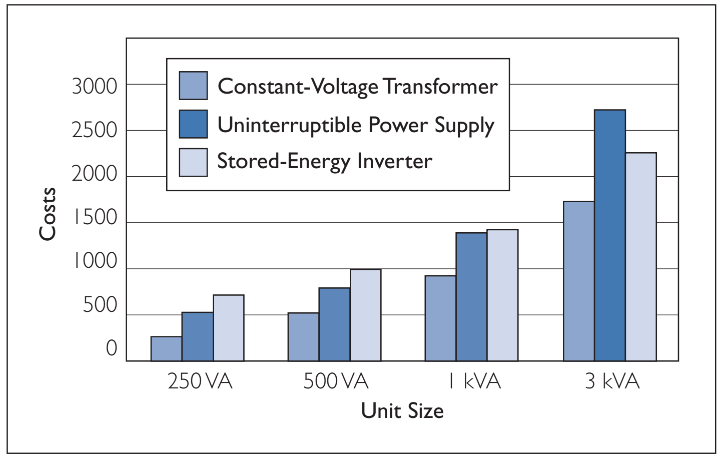
PEAC research has uncovered several shared weak links in semiconductor tools, the most common being the emergency-off (EMO) safety circuits. These circuits are designed to stop power to the tool when an operator presses a button or when a safety interlock is violated. They rely on standard relays and contactors to perform their function. PEAC has found EMO circuits that will shut down a tool for voltage sags to 80% of nominal for one cycle. More robust relays and contactors could be selected if these components were tested by tool suppliers prior to their use in tool designs.

Another weak link is the switch-mode dc power supply to the tool. This device powers operator-interface computers and programmable controllers and also supplies input/output power. Some of these units have been found to shut down for voltage sags to 85% of nominal for five cycles. This is due to a design topology that senses the state of incoming power rather than internal dc-link bus voltage when making shutdown decisions.

A third area of sensitivity is in use of phase-monitoring relays on a tool's incoming power. When used as an interlock in the EMO circuit, these devices can shut down the tool in response to minor voltage sags. As a result, some semiconductor manufacturers and tool suppliers have removed phase-monitoring relays from the interlock circuits of delivered tools.

Mitigating Devices

Three off-the-shelf power conditioning technologies—the constant-voltage transformer (CVT), uninterruptible power supply (UPS), and stored-energy inverter—have been applied with success to mitigate the effects of power disturbances on semiconductor tools. When properly installed to support "weak link" components on a tool, these technologies have proven to be very effective. The costs of the devices, as the graph shows, are significantly lower than potential production losses due to downtime, which can average $500,000 per occurrence.



Careful application of power conditioning technology in semiconductor fabrication plants offers a low-cost alternative to more expensive facility-wide power conditioning solutions.

Each device has a distinct design for providing protection from power disturbances. The CVT—also known as a ferro-resonant transformer—regulates power without switching to an alternate source. Because it contains no stored energy, the CVT is only effective during voltage sags and not during momentary interruptions. Also, the CVT needs to be applied with care, since an inrush current load that is too high can cause the output voltage to collapse.

The UPS uses batteries and a switching circuit to provide power to critical tool circuits during voltage sags and interruptions lasting several minutes. The stored-energy inverter also provides an alternate source of power during sags and interruptions of one to three seconds. However, it uses capacitors instead of batteries for its stored energy, which typically lasts up to one second at rated load.

One Case Study

An etcher at a semiconductor facility continued to shut down due to voltage sags, even though the tool supplier had installed a 2-kVA UPS on the perceived critical loads. To assess the problem, PEAC used the EPRI Process Ride-Through Evaluation System—known as the "Porto-Sag"—to inject voltage sags into the main ac power supply feeding the EMO circuit, etcher, heat exchanger, and vacuum pump system. Results revealed that the vacuum-pump control circuits were shutting down for line-to-line voltage sags of 80% of nominal. The etcher's on-board EMO circuit was dropping out for line-to-line voltage sags of 75% of nominal.

PEAC determined that the UPS application was ineffective because UPS output was interlocked with the on-board EMO circuit. Once the EMO circuit dropped out, UPS output became irrelevant. After moving the EMO circuit power to the load side of the UPS and applying a stored-energy inverter to the vacuum-pump and main tool

Semiconductor Tool: *Continued on back page*

TU Electric Aims for Total Reliability

by John Soward, TU Electric, a Texas Utilities Company

Fifteen years ago, an eight-second electrical interruption would have had little impact on the manufacturing processes of most semiconductor fabrication facilities around the world. Today, however, a power disturbance of *eight milliseconds* can be devastating to these same facilities, resulting in production losses in the hundreds of thousands of dollars, and potential revenue losses into the millions.

Two factors, in particular, have contributed to such heightened production and cost factors. First, as in many other industries, today's manufacturing tools are embedded with sensitive microprocessor circuits. While these circuits provide precision control and greater flexibility, they are also more susceptible to power disturbances. Second, the wafers used in the semiconductor fabrication process are now larger in size, while individual circuits on the wafer are continually being made smaller. This creates a higher dollar value per wafer and greater revenue losses when power disturbances result in product damage and/or production downtime.

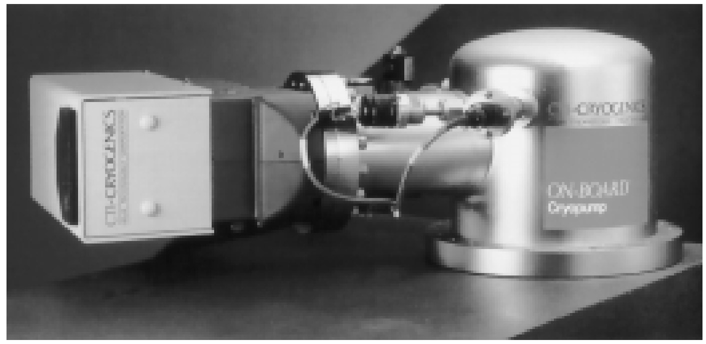
Customer Teamwork

Texas Instruments, a worldwide manufacturer of semiconductor products, operates four large fabrication facilities in the north Texas service area of TU Electric. Over the years, the company and utility have formed numerous working-level teams to solve specific problems. These efforts have enhanced their long-term working relationship.

In 1984, in an effort to reduce electricity costs and better control the quality of power supply, Texas Instruments purchased the TU Electric substation serving its Dallas facility. This fostered a closer collaboration between the company and utility on power quality- and energy-related issues. As a result, Texas Instruments has established high-voltage operations and maintenance expertise, while TU Electric has strengthened its commitment to customer service.

In 1989, based on the recommendations of a working-level team, TU Electric began an eight-year project to replace 86, 138-kV grounding switches in the north Dallas area with SF6 fault-interrupting devices. The grounding switches had been found to produce disturbances that could significantly impact production at the company's main manufacturing site in Dallas.

In 1993, following an unusually high number of lightning-induced electrical disturbances, Texas Instruments and TU Electric formally established an Excellence Team to explore innovative solutions to power quality concerns. The initial objective of the team was to reduce the frequency and duration of power disturbances at the Dallas site. Between 1992 and 1995, implementation of the team's recommended improvements to the TU Electric system, combined with the ongoing grounding switch replacement program, reduced the number of production loss events due to faults at the site from 25 to three.



Courtesy of CTI-Cryogenics/Helix Technology Corporation

Power disturbances can impact the operation of the cryo-pump, one of the most critical tools in the semiconductor fabrication process.

Expanded Collaboration

When the Excellence Team recognized in 1995 that investments in electrical system improvements were offering diminishing returns, they directed their attention to finding solutions inside the manufacturing facility. This required the involvement of CTI-Cryogenics, the manufacturer of cryo-pumps used in the manufacturing process. Texas Instruments considered the cryo-pump, which maintains a vacuum within semiconductor production chambers, one of the tools most critical to the fabrication process. The company identified it as one of the more susceptible tools to power disturbances, and noted that after an interruption, a pump could require as many as eight hours to regenerate the vacuum.

A team was formed of representatives from Texas Instruments, TU Electric, CTI-Cryogenics, and the EPRI Power Electronics Applications Center to address the vulnerability of cryo-pumps to power disturbances. One possible solution was to replace older cryo-pumps with newer models incorporating intelligent vacuum-regenerating capabilities. However, the cost and invasive nature of this solution made it impractical. Following an extensive evaluation of cryo-pump systems, the problem was solved by optimizing control settings and taking advantage of available auto-restart capability.

In March 1997, Texas Instruments presented TU Electric with its *Supplier Excellence Award*, the first such award given to a utility by the company. The award recognizes the utility's efforts to fine-tune the quality of electric power supply as well as its assistance with expanding the capacity of the substation. Power quality improvements recommended by the Excellence Team have reduced company production losses by more than $1 million.

The Excellence Team continues to meet regularly, identifying opportunities for enhancing the management of operating costs, production cycle time, and product quality at the Texas Instruments facilities. TU Electric has used the knowledge gained from its work with the company to establish Excellence Teams with other semiconductor and high-tech manufacturers in its service area. ■

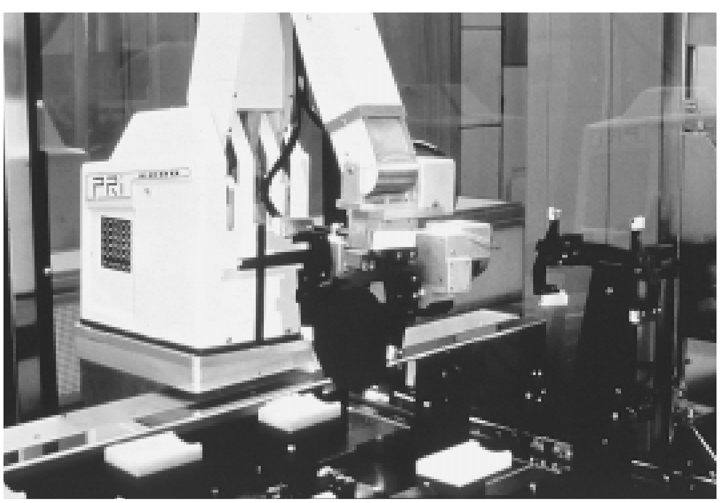
Collective Intelligence Is Key to Power Quality Solutions

by Gary Emmett, EMRO, Inc., Scottsdale, Arizona

While the stakeholders of the $100 billion semiconductor industry historically have been at odds over power quality issues, they readily concede that quality of power has a significant impact on business productivity and profitability. The most cost-effective and technically viable solution for mitigating power quality problems and improving the bottom line is uncertain at this point. What is clear, however, is that finding the solution will require the earnest efforts of individuals with diverse perspectives.

The manager of a wafer fabrication plant, for example, sees quality power as essential to running a high-efficiency operation and producing wafers with zero defects. The electrical engineer at the plant looks for guarantees that manufacturing tools and systems will not be affected by electrical variations originating on- or off-site. The semiconductor tool supplier characterizes power quality as no events at the power connection that could cause the tool to misprocess, shut down, or fail. The utility engineer describes power quality in reliability terms, or the allowable number of disturbances not exceeding the maximum per year. And, the consulting design engineer defines it as no negative feedback from the client regarding power distribution system design.

To effectively abate costly power quality problems, should the utility be expected to build an electrical system that eliminates all voltage variations or at least compensates for them? Or, should the semiconductor manufacturer install an uninterruptible power supply to back up sensitive equipment? Perhaps it would it be more advantageous for the tool supplier to embed solutions into the tool design to reduce sensitivity.



Semiconductor processing equipment, such as this robotic wafer handler, can shut down due to slight variations in electrical supply.

Actually, each party owns a piece of the pie and none bears the entire responsibility. The solution lies in incorporating the varied and salient viewpoints of all stakeholders into a comprehensive, collective power quality approach.

Industry Background

Most semiconductor fabrication plants operate 24 hours a day, 365 days a year, with load factors typically greater than 85%. Under these circumstances, the impacts of a total loss of voltage due to a power interruption are dramatic. Wafers will be damaged beyond rework recovery, and manufacturing downtime will be incurred to recertify tools for production. Revenue lost can reach upwards of a million dollars for a single interruption.

The impacts of voltage sags are less apparent. Sags lasting five to 10 cycles and falling to 85% of nominal are very difficult, if not impossible, for utilities to eliminate on their transmission and distribution systems. These types of sags can cause some semiconductor equipment to stop processing, which can ruin wafers in process and result in tool downtime to recertify for manufacturing. Because such events fall within the traditionally accepted voltage-tolerance envelope, or CBEMA curve, that utilities and some tool suppliers use as their standard, semiconductor manufacturing tools and systems need to be able to ride through these relatively low-level disturbances.

Most tool suppliers have not been aware of sag impacts, having received little feedback from tool owners. However, they have been very willing to retrofit and redesign tools to be more robust, as long as the owner is willing to pay.

Current Scenarios

The following case studies describe typical power quality problems impacting the semiconductor industry today. Such problems range from disturbances that barely flicker fluorescent lights but shut down tools, to semiconductor equipment that introduces disturbances into the plant power distribution system.

- At a semiconductor plant in Arizona, a newly installed wafer laser scribe with a large nonlinear power supply was causing photolithography stepper tools to misprocess and experience computer-processor lockup. Investigation by plant engineers revealed that the laser scribe was being fed from the same 208-V, three-phase, 400-A panelboard feeding the steppers. Removing the laser scribe feed from the panel and reconnecting it to the plant's heating, ventilating, and air conditioning (HVAC) load panel solved the problem, with no adverse effects on the HVAC air handlers.
- Due to the soft-impedance characteristics of a 115-kV utility transmission system serving a large semiconductor plant in New Mexico, faults originating 25 miles away resulted in voltage sags to 80% of nominal for eight to 12 cycles. These disturbances

caused some of the chemical vapor deposition tools at the plant to shut down. Analysis of the tool design by tool manufacturing and plant engineers showed an undervoltage relay connected to the 115-V ac control circuit. The magnetic properties of the relay's ac coil prohibited any ride-through capability. Plant technicians replaced the relay with a dc-type and connected it to the dc-load side of the tool power supply, taking advantage of the power supply's inherent ride-through capabilities.

- Two automated assembled-device testing systems were installed and connected to one distribution panelboard at a semiconductor plant in Arizona. During initial operation, one of the test systems locked up and shut down when the main breaker of the other unit was turned off. An investigation by engineers representing both the test system manufacturer and the plant confirmed that turning one tester off caused enough of a transient to trip the second tester. The test system manufacturer, who was unaware of the problem, solved it by installing line conditioners at both testers, which provided a buffering impedence between the two units.

Collaborative Possibilities

Today, the impacts of such scenarios are financially too great for semiconductor manufacturers to sustain. Collective resolution efforts by all stakeholders could reduce the effects of power disturbances and distortions to an acceptable risk.

In an effort to bring the various stakeholders together, EPRI is sponsoring a series of workshops focusing on power quality in the semiconductor industry (see *EPRI R&D Corner* on this page). As a result of the most recent gathering in September, EPRI will draft a power quality specification for semiconductor manufacturing tools, which will be reviewed at the next workshop in Spring 1998. The intent of this specification is to describe minimum ride-through characteristics that a tool must exhibit when subjected to minor power disturbances. In support of the effort, the EPRI Power Electronics Applications Center is conducting disturbance testing of the tools to determine their ride-through characteristics (see *Semiconductor Tool Mitigation Options* on page 2).

These efforts by EPRI are a good start. Perhaps by teaming together, the stakeholders could go even further to contribute to other power quality solutions. One undertaking that could improve the ride-through characteristics of semiconductor plants would be the development of architect/engineer guidelines for facility design, including such requirements as automatic-transfer switches and power distribution load assignments. These types of guidelines have the potential to reduce the money spent on power quality mitigation and backup equipment, while subjecting plant power distribution equipment to fewer electrical stresses.

EPRI R&D Corner

Semiconductor wafer manufacturers, fabrication plant and equipment designers, facility and process engineers, tool manufacturers, standards-making organizations, and electric power providers agree: Power quality is key to productivity and profitability in the semiconductor industry. Two new EPRI activities target the specific needs of the industry stakeholders.

A task under the System Compatibility Research Project of the EPRI Power Electronics Applications Center (PEAC) characterizes the electrical susceptibility of critical semiconductor fabrication processes and tools. Based on task findings, PEAC can recommend power conditioning options to utilities and their semiconductor customers for mitigating power quality problems. The task also includes development of performance criteria and test protocols for use in establishing baseline compatibility standards for semiconductor manufacturing tools.

The EPRI Power Quality Initiative for the Semiconductor Industry combines the experience and expertise of PEAC, Salt River Project, and Texas Utilities Electric. The initiative aims to engage all industry stakeholders through an ongoing series of workshops, where individuals can work together to resolve electric power reliability issues and collectively leverage their resources to expedite power quality solutions. In 1997, a total of 300 participants gathered at two workshops to identify system compatibility gaps and establish priorities for action. Next year, workshops are slated for the spring in Texas and fall in Arizona.

The semiconductor initiative serves as a model for two recently launched EPRI Power Quality Initiatives addressing the chemicals and petroleum, and plastics and polymers industries. These initiatives are designed to help member utilities expand their industrial business bases, enhance customer relations, and mitigate the power quality problems unique to each industry.

For more information, contact Tom Key at 423-974-8336 or *tkey@pqac.com* by e-mail.

Plant engineers could also start requiring all motor starters to be designed and manufactured with a 20-cycle ride-through capability at 50% of nominal voltage. Tool suppliers could design power-sensing on the dc side of the power supply and design with standard equipment and component grounding practices.

Finally, a revision of the CBEMA curve for tighter performance tolerance could have a significant impact on the productivity and profitability of the semiconductor industry. Because it is not possible for utilities to eliminate all power disturbances, however, facility equipment and manufacturing tool suppliers need to design their products to ride through disturbances in the range of 10 cycles at 80% of nominal voltage. ■

Standards Update

by Tom Key, EPRI PEAC

This column serves as an open forum on power quality standards activities and developments. Please send your comments to *tkey@pqac.com* by e-mail.

The relatively new semiconductor industry is on the fast track to development of useful power quality standards. The industry needs new standards to address utility service and semiconductor facility electrical design as well as the immunity and emissions of manufacturing tools and support equipment.

All parties involved in semiconductor plant design and operations agree that premium utility power systems and manufacturing equipment are necessary to maintain productivity and profitability. The bottom line is that timely and appropriate power quality standards can minimize electrical incompatibilities and reduce production and revenue losses.

Plant Power System

The Institute of Electrical and Electronics Engineers (IEEE) presently offers several standards that may be useful in semiconductor plant power system design (see *Signature*, Spring 1996, *Standards Update*). These include the *IEEE Red, Green, Orange, and Emerald Color Books*. Of particular interest are the recommended practices for powering and grounding sensitive electronic equipment in the *Emerald Book*, and those on emergency and standby power systems in the *Orange Book*.

IEEE is currently developing a new color book, "Design of Clean Room Electrical Systems," with significant input from the semiconductor industry. The first edition of this book—whose color is yet to be determined—will not be a mandatory code, fully developed standard, or specification. Rather, it will contain specific guidance for use in designing clean rooms with appropriate electrical systems. About 75% complete, the book includes chapters on clean room concepts, power, electromagnetic compatibility (EMC), backup power and power conditioning, hazardous areas, lighting, and life safety systems. Before final approval, which is expected next year, the book will be coordinated with other complementary standards such as Institute of Environmental Sciences and Technology (IEST) Recommended Practice-12, "Considerations in Clean Room Design."

Process Equipment

Beyond enhanced facility design, the semiconductor industry needs better power quality performance from manufacturing tools and support equipment. It has become clear that a standard like the CBEMA curve, which is included in the *IEEE Emerald Book*, does not assure sufficient performance to avoid disruption from typical power disturbances.

Another standards source, the International Electrotechnical Commission (IEC), offers a comprehensive series of generic EMC standards (see *Signature*, Summer 1995, *Standards Update*). However, because of their generic nature, these standards do not address the unique compatibility issues of the high-tech, high-stakes semiconductor industry. Although IEC has provisions for industry-specific standards, which set tougher performance criteria, none presently meets the industry's special power quality requirements. There is a real need for standards development from inside the industry.

Industry Involvement

Semiconductor Equipment and Materials International (SEMI)—an international trade association representing semiconductor equipment and materials suppliers—has developed several equipment interface and compatibility standards. Related to IEEE and IEC standards by reference only, the industry-specific SEMI standards form the basis for electrical performance of manufacturing tools and equipment. Three standards addressing electrical compatibility are

- SEMI E6-96, "Facilities Interface Specifications Guideline and Format;"
- SEMI E33-94, "Specification for Semiconductor Manufacturing Facility EMC;" and
- SEMI E51-95, "Guide for Typical Facilities Services and Termination Matrix."

Like IEC compatibility standards, the SEMI standards do not yet demand immunity levels that will prevent routine upsets. Probably the largest compatibility issue not addressed in any of the SEMI standards is the inevitable power system short-circuit, which often upsets semiconductor plant processes.

Responding to this issue, a SEMI task force on Power Quality and Equipment Ride Through composed of semiconductor manufacturers, tool suppliers, and electric utilities will begin deliberations before the end of the year to develop a new standard. The task force has been charged to deliver by July 1998 a set of performance criteria, specifications, and test methods for determining ride through of semiconductor fabrication processing tools and support equipment during power disturbances. Upon delivery of the standard, the task force will begin work on a performance specification for power supplied to semiconductor plants, along with a guide for plant power conditioning.

When completed, this SEMI standard may be one of the most significant ride-through criteria to be established since the computer industry introduced the CBEMA curve in 1979. By focusing on industry-specific power quality needs, this standard will help optimize the fabrication process and lower production costs. The standard's stringent performance criteria will make semiconductor tools among the most robust equipment available in industry, perhaps saving millions of dollars in power conditioning hardware. ■

For more information on IEST Recommended Practice-12, call IEST at 847-255-1561. Individuals interested in contributing to the new IEEE Clean Room Standard (Project 1429) and other color books, contact Brian Rener, IEEE P1429 chairman, at 312-616-7445, or call IEEE at 800-678-4333.

PQ Perspectives: Continued from page 1

On-Site Mitigation Options

To reconcile the strict power requirements of automated processes with the realities of the electrical environment, we and other semiconductor manufacturers are investing significant capital to protect fabrication equipment from power disturbances. At Texas Instruments, we are evaluating power monitoring software, modifications to tool controls, and power conditioning equipment.

For selected tools and equipment, we are currently using static transfer switches that have two possible utility sources, or a utility source and an emergency generator or power conditioner. The fast-transfer capability of these switches helps protect critical systems and manufacturing processes from power source failures such as faults, breaker trips, transformer failures, and feeder losses. Some static switch systems are sensitive enough to transfer for voltage sags and other low-voltage conditions. The ability to transfer between two independent sources, in effect, increases the overall reliability of the power supply to the tools and equipment.

We are also investigating the application of static switches between feeders from independent 13.8-kV substations to avoid annual maintenance shutdowns of 24 to 28 hours and to improve immunity to voltage sags. The subject switches are solid-state, silicon-controlled rectifier devices capable of automatically transferring load between different sources. Through the use of digital signal processors (DSPs)—real-time, programmable signal analyzers—a load transfer can be made in one-quarter cycle, or four milliseconds, without interruption to fabrication equipment. As a result, maintenance becomes transparent to the facility, since it can be done during normal working hours.

Utility-Side Options

Utilities have had success in reducing the exposure of semiconductor facilities to power disturbances by supplying higher service voltage levels, limiting the length of distribution feeders, and decreasing the number of other industrial customers connected to the same distribution lines. Electric service redundancy is another power quality option that has been implemented at Texas Instruments. The utility has supplied our facilities with multiple sources, which allow us to switch between sources to maintain power during prolonged interruptions.

Utilities might also consider using DSP technology in their power quality efforts. DSPs have the capability to gather and assess the knowledge-based, radio-frequency signal of incoming power and make needed corrections within the first cycle. In the case of a voltage sag, they could analyze the power signal, detect the sag, and make a correction before the sag becomes detrimental to a manufacturing facility.

Cost Impact Estimate for State-of-the-Art Semiconductor Fabrication

	Memory Wafer	Logic Wafer	Unit
Assumptions	800	800	Wafers/Day
	$1300	$2500	$/Wafer
	300	100	Chips/Wafer
	$9	$300	$/Chip
Production Cost	$1.04 million	$2 million	$/Day*
	$43,000	$83,000	$/Hour
Potential Revenue Loss	$90,000	$1 million	$/Hour

*Assumes 24-hour operation

Potential revenue losses due to a disrupting voltage sag or momentary interruption on a typical 200-mm wafer production line can be as high as $1 million an hour. Actual losses depend on device technology, such as Memory or Logic; production line output; and average chip cost.

New Tool Specifications

While the Information Technology Industry Council provides ample specifications—including the CBEMA curve—for the immunity of information technology equipment, there currently is not a standard that specifically addresses the immunity of fabrication tools. Presently, if we operate a tool within the range of the CBEMA curve, we can assume that the tool's computer component will function properly. However, there is no guarantee that other tool components—such as the temperature and wafer-handling control systems, heating element, and radio-frequency generators—will meet the CBEMA requirements. These components need to comply with the curve as well.

For the semiconductor tool supplier, the key issue is the cost of compliance. Testing expenses correlate directly with the cost of a tool and, therefore, with the tool's marketability. This issue must be resolved before tool suppliers will agree to comply with the CBEMA curve or any other power quality specification.

As users of electric power and fabrication tools, semiconductor manufacturers are in a position to orchestrate the efforts of tool suppliers with those of utilities. Semiconductor Equipment and Materials International (SEMI)—the international trade association representing semiconductor tool suppliers—could do a real service to the industry by developing a general semiconductor tool specification for meeting input voltage requirements that uses the voltage-tolerance envelope of the CBEMA curve.

System compatibility has become a shared responsibility, requiring a team effort by semiconductor manufacturers, tool suppliers, and electric utilities. By working together to increase tool immunity, develop and implement power conditioning technologies, and determine utility-side options, we can all enhance our levels of productivity and profitability. ■

Point of View: *Continued from page 1*

as part of its Power Quality Initiatives for the semiconductor, chemicals and petroleum, and plastics and polymers industries. The well-attended workshops have resulted in lively discussions and served as a bridge between utilities, customers, and equipment suppliers. The workshops have made it clear that cooperation is a prerequisite to success in a deregulated market.

The power quality business at EPRI will continue to provide opportunities for collaboration, which should lead to mutually beneficial power quality contracts between utilities and key industrial customers. It will also promote profitable alliances and business partnerships between utilities and other organizations. In addition to helping resolve technical issues, this kind of cooperation should certainly result in peace of mind for all involved.

Marek Samotyj

Marek Samotyj, Manager
Power Quality Business Area

Semiconductor Tool: *Continued from page 2*

EMO circuits, PEAC retested the etcher. Immunity of the subject circuits on the tool improved 25%, surviving a three-phase, 50% of nominal, one-second sag.

After these tolerance improvements were made, two other etcher components—a single-phase, turbopump controller and the heat-exchanger EMO circuit—were found to be susceptible to voltage sags. PEAC recommended supplying these components from the stored-energy inverter. With these changes, the entire tool should be able to withstand three-phase voltage sags to 50% of nominal, lasting up to one second. Tests to confirm this are scheduled at PEAC for January 1998.

Analysis of tool designs and sag testing continue to reveal weak links in the complex control systems of semiconductor tools. Looking to the future, PEAC will begin voltage sag testing on prototype 300-mm tools before year's end. Also, in a key element of the EPRI Semiconductor Initiative, PEAC, Sematech, Semiconductor Equipment and Materials International, the International 300-mm Initiative, and numerous semiconductor manufacturers, tool suppliers, and utilities are working together to develop a standard specification for tool immunity. ■

EPRI End-Use Awards for BGE and TVA

Congratulations to Power Quality Business Area winners in the EPRI Customer Systems Group End-Use Awards Program. The awards acknowledge member utilities and personnel who have encouraged the application of EPRI end-use technologies, services, and planning tools.

Baltimore Gas & Electric Company (BGE) is the recipient of the *EPRI End-Use Leadership Award*, recognizing significant member programs. Through comprehensive use of EPRI products and services, the BGE Premium Power Program has consistently met customer needs and dramatically increased its revenues over the last five years. The utility relies on test data from the EPRI Power Electronics Applications Center (PEAC) to, among other activities, select and market uninterruptible power supplies and power conditioners to its industrial and commercial customers. BGE engineers, technicians, and customers also attend hands-on power quality training courses at PEAC.

James Rossman at Tennessee Valley Authority (TVA) received the *EPRI End-Use Product Champion Award*, which salutes outstanding individual contributions. Rossman's award acknowledges his involvement in two important projects. He implemented a large-scale power quality monitoring system at TVA, incorporating measurement modules from the EPRI Power Quality Diagnostic System. The monitoring system enables near real-time dissemination of power quality information to TVA engineers via the corporate intranet. Rossman also championed development of next-generation monitoring technology for utility distribution substations. The new monitoring system will provide measurement data on all aspects of power quality and quantity, completely characterizing the delivery performance of utility distribution systems.

Look for detailed project descriptions in future issues of *Signature*.

Signature is a publication of the EPRI Power Quality Business Area, Customer Systems and Power Delivery Groups.

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Palo Alto, California 94303
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Printed with soy inks on recycled paper (50% recycled fiber, including 10% postconsumer waste) in the United States of America.

NL-109718