

UNDERSTANDING AND AVOIDING COMMERCIAL POWER DISTURBANCES



Electric utilities utilize projected video to monitor system reliability.

How to guard computers and sensitive electronic equipment from expensive downtime and unscheduled maintenance.



***Pacific Gas and
Electric Company™***

A SENSITIVE ISSUE

"Businesses rely on all forms of energy. Constant supplies can be critical to the services they provide and the products they manufacture or distribute. Electricity is particularly important since, regardless of the type of business, everyone uses it to different degrees.

"In the last decade, commercial electric customers have become increasingly interested in the relative 'quality' of the power they purchase. Although it may be difficult to imagine that some supplies of electricity can be better than others, variations in flow or voltage can actually damage and disrupt sensitive electronics, computers and microprocessors. As businesses rely more heavily on modern high-tech processes, power quality will become even more important.

"This publication has been developed as a manual for commercial and industrial electric customers. It describes the most significant power disturbances and offers practical and cost-effective solutions to assure the life and reliability of sensitive equipment."

Carl Goeckeler, author

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SERVICE QUALITY

Utilities produce and deliver electricity using vast networks of generators, transformers and thousands of miles of wire. Although it's difficult to imagine that systems so complex could operate reliably, we deliver electricity when and where it's needed more than 99.95 percent of the time. That measure of service quality is called reliability.

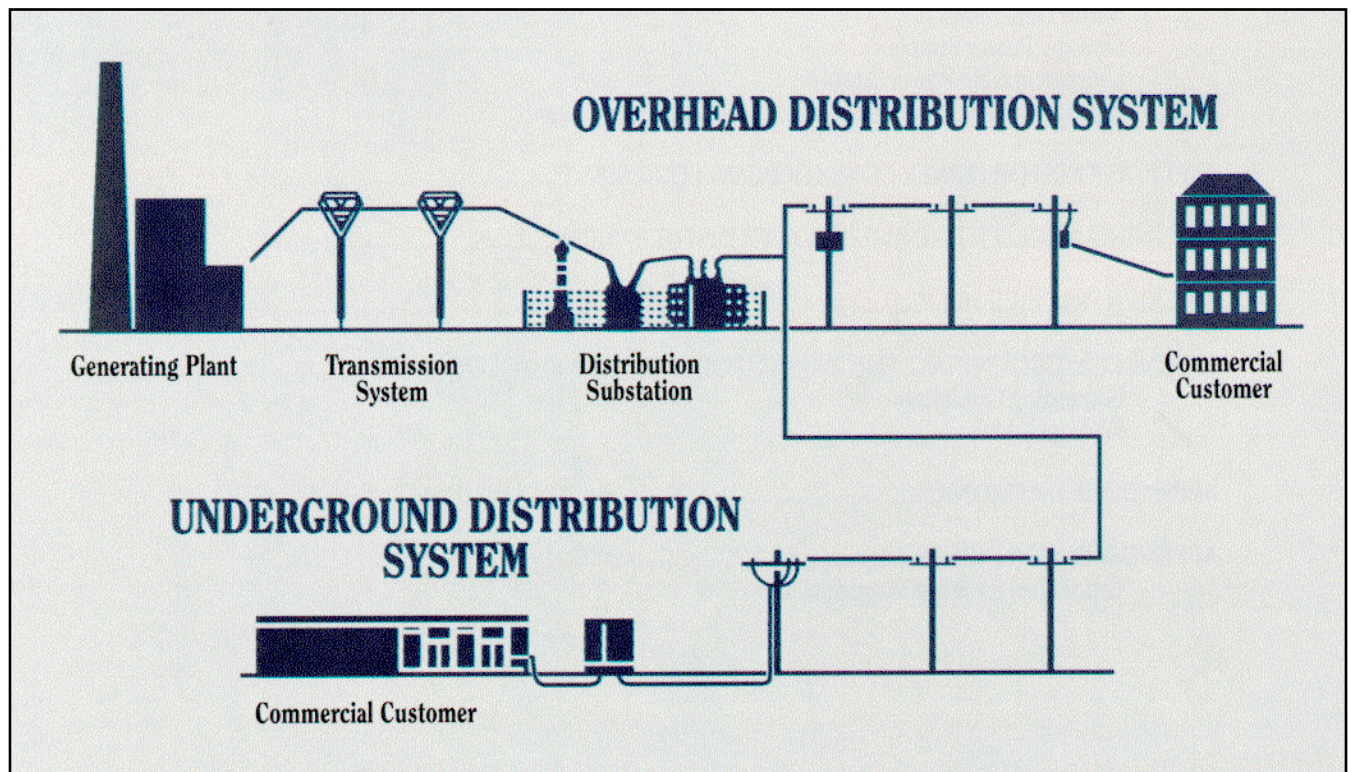
Since a continuous supply of electricity is what most customers demand, utilities have systems in place that practically eliminate the possibility of service outages. Regular trimming and clearing of trees around overhead lines, infra-red scanning and routine preventive maintenance are just a few of the ways we're protecting and improving your service reliability.

Unfortunately, there are circumstances beyond your utility's control. Things like severe weather, accidents involving electric lines, equipment failure, and vandalism can cause power disturbances. These can create problems for sensitive equipment if:

- o the equipment is designed to operate within narrow voltage limits, or
- o the equipment does not have adequate buffering systems or *ride-through* capabilities to filter out fluctuations in the electrical supply.

Short circuits or faults cause power disturbances within utility distribution lines, undermining service quality to customers within the area. Even though service is automatically restored following a fault, utility protective equipment may automatically turn power off and on several times, for several seconds each time, in an attempt to clear the faulted circuit. This is called a "momentary" power interruption.

When longer outages or permanent faults occur on the primary circuits serving an area, all power is interrupted until the cause of the fault can be isolated and corrected. The following illustration should help you understand the circuits and facilities which comprise an electrical service network.



POWER QUALITY

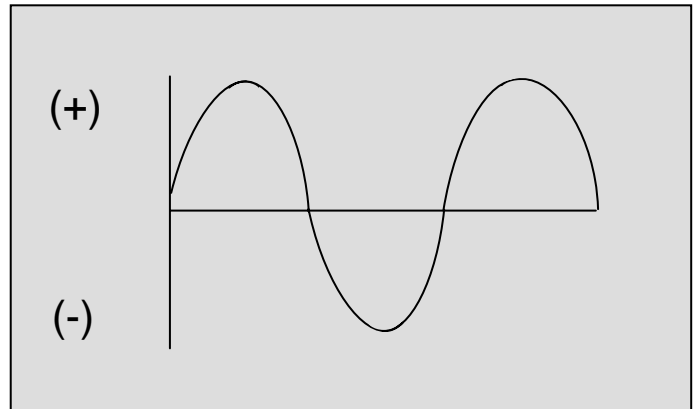
When generating plants create commercial electric power, the voltage is in the form of a 60 hertz (Hz) alternating current (AC) sine wave as shown at right:

Sensitive electronic equipment requires a constant 60 Hz supply like this one to operate correctly. Once service is delivered at the proper voltage, systems you use to distribute electricity within your own facility can affect voltage reliability. This "end use" quality is called power quality, and it depends both on your utility and you.

Electronic equipment is common in commercial and industrial locations. These digital electronics process information by operating simple on/off switches. Information can be processed more rapidly by increasing the speed of this switching.

Electronics have power supplies which change the power from alternating current to a steady direct current (DC) of much smaller value. They switch this small voltage (usually 5 volts or less) on and off at speeds in excess of 100 megahertz (MHz) as shown below.

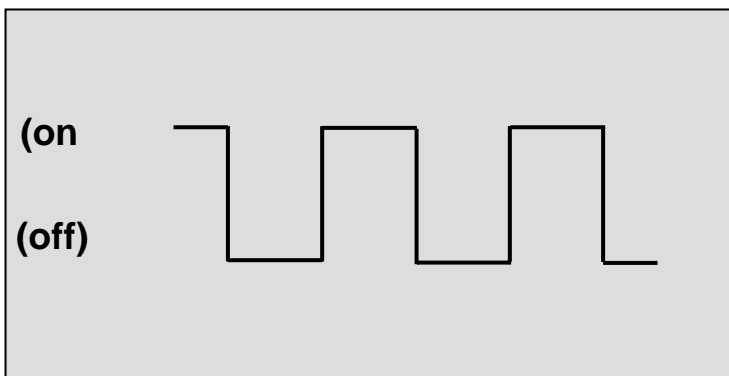
Electronic devices are designed to be operated from a uniform "clean" sine wave. If the AC wave becomes disturbed or distorted, electronics may send false signals, and this conversion process becomes disoriented, disrupted or even damaged.



60 Hz alternating current (AC) sine wave is used for electrical equipment.

Electrical disturbances can result from problems within your facility, even though your supply voltage is constant. These disturbances can occur frequently and appear severe because the sensitive equipment is close to the disturbance source. For example, any load, such as an air conditioner which starts and stops, can cause problems for sensitive electronics. Therefore, achieving power quality requires a combined effort between your utility and you, the customer.

Examples of electrical voltage with power quality problems appear on Pages 6/7. This publication will describe the most significant power disturbances and offer solutions to enhance the life and reliability of sensitive electronic equipment.



Electronics use choppy, low voltage, high speed on/off power.

VOLTAGE RANGES

Electric service voltages vary slightly during the day. This is because almost every customer draws different amounts of power from hour to hour and day to day. To counter the problem, utilities have operating and design standards which limit the range of service voltage variance. The American National Standard Institute (ANSI) has developed Standard C84.1 which recommends the following voltage ranges for utilities and their customers:

VOLTAGE RANGES (ANSI C84.1 Standard)			
Nominal Service Voltage	¹ Minimum Utilization Voltage	² Favorable Service Voltage (Range A)	³ Tolerable Service Voltage (Range B)
120	108	114-126	110-127
208	187	197-218	191-220
240	216	228-252	220-254
277	249	263-291	254-293
480	432	456-504	440-508

¹American National Standard Institute's C84.1 for comparison. This represents the minimum root mean squared (rms) voltage at the line terminals of the utilization equipment for circuits not supplying lighting loads.

²Favorable Voltage - The preferred range of voltage operation includes a range 5% below and 5% above nominal. Both this and the tolerable voltage range at right are rms voltages at the service entrance, outside the customer's facility.

³Tolerable Voltage - The service voltage falls outside the favorable range and includes a range of 8.33% below and 5.83% above nominal. This is considered an undesirable voltage but not low enough to cause equipment damage. Efforts should be initiated to move the voltage into the favorable range in the near future. If the voltage falls outside the tolerable range, this condition is assigned a very high priority and efforts should begin immediately to correct the voltage to an improved range.

SENSITIVE ELECTRONICS

Americans are becoming increasingly dependent on electronic equipment. The revolution started in the early 80's with the advent of the personal computer.

Some examples of sensitive electronic equipment which require quality power are shown below.

Sensitive Electronic Equipment

- o Answering Machines
- o Electronic Cash Registers
- o Electronic Clocks
- o Hospital Monitors
- o Personal and Mainframe Computers
- o Process Controls
- o Robotics and Automation
- o Security Systems
- o Telecommunications
- o VCRs

You may not have noticed power variations in the past because traditional electrical equipment such as motors, solenoids and electromechanical controls do not react to short-term disturbances. Some examples of problems resulting from power quality disturbances are:

- o Automatic Resets
- o Data Errors
- o Equipment Failure
- o Loss of Circuit Boards
- o Loss of Memory
- o Power Supply Problems
- o System Lockout

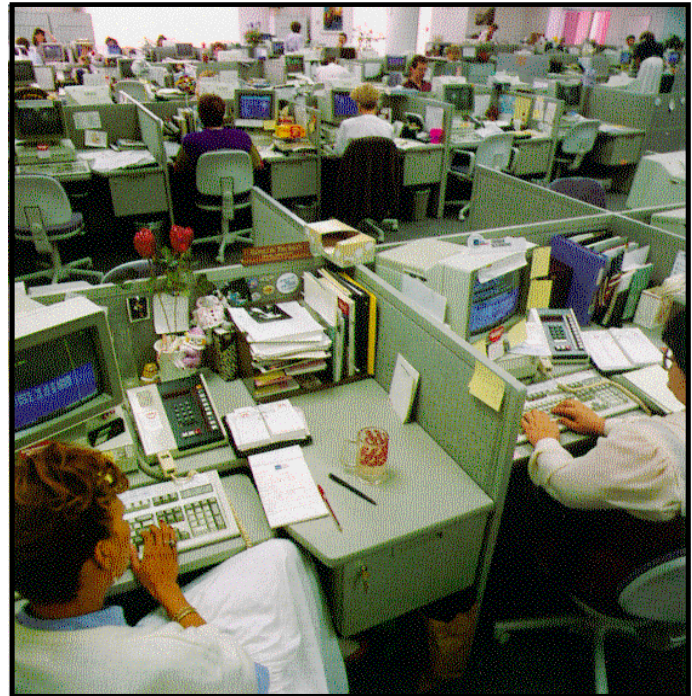
Although sources of distorted power may be found on utility systems, some are initiated within your facility. The following is a list of equipment which can contribute to power quality problems, especially if the grounding and wiring is inadequate within the facility. EPRI states that approximately 80 percent of all power quality problems may actually result from inadequate wiring or grounding on the customer's premises, or from interactions with other on-site loads.

Common Sources of Power Quality Problems

- o Adjustable Speed Drives
- o Air Conditioners and Compressors
- o Arc Welders
- o Battery Chargers
- o Circuit Breaker Switching
- o Copy Machines/ Printers
- o Electronic Power Supplies
- o Elevators
- o Fluorescent Lights (Electronic Ballasts)

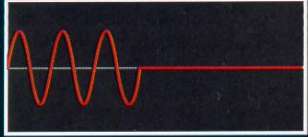
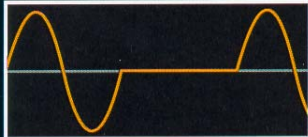
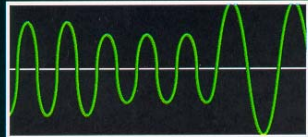
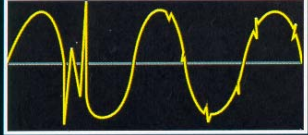
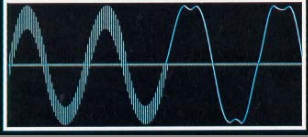
- o Induction Machinery
- o Motor Start-ups
- o Personal or Mainframe Computers
- o Silicon-Controlled Rectifier Drives
- o X-Ray Equipment

Your sensitive equipment can actually generate electrical disturbances which can adversely affect other equipment within your facility. The increasing dependence upon electronic equipment has heightened awareness for quality power.



During the last decade, new computer technologies have become the standard for businesses of every size. (Photo courtesy of Sprint)

MATCHING POWER SYSTEM PROBLEMS WITH SOLUTIONS

PROBLEM	DESCRIPTION	DURATION	CAUSE	EFFECT	POSSIBLE SOLUTION
<p>TEMPORARY INTERRUPTION/ LONG-TERM OUTAGE</p> 	<p>Planned or accidental total loss of power in a localized area of community</p>	<p>Temporary (2 sec.-2 min.) Long-term (over 2 min.)</p>	<p>Equipment failure, weather, animals, human error (auto accidents, kites, etc.)</p>	<p>Systems shut down</p>	<ul style="list-style-type: none"> o Uninterruptible power supply o Uninterruptible power supply with generator
<p>MOMENTARY INTERRUPTION</p> 	<p>Very short planned or accidental power loss</p>	<p>Milliseconds to a second or two</p>	<p>Switching operations attempting to isolate an electrical problem and maintain power to your area</p>	<p>Equipment trips off, programming is lost, disc drive crashes</p>	<ul style="list-style-type: none"> o Uninterruptible power supply o Motor generator o Standby power supply
<p>SAG/SWELL</p> 	<p>Decrease (sag) or increase (swell) in voltage</p>	<p>Milliseconds to a few seconds (sags or swells longer than a few seconds are called undervoltages or overvoltages)</p>	<ul style="list-style-type: none"> o Major equipment start-up or shutdown o Short circuits (faults) o Undersized electrical circuit 	<p>Memory loss, data errors, dim or bright lights, shrinking display screens, equipment shutdown</p>	<ul style="list-style-type: none"> o Relocate computer to a different electrical circuit o Voltage regulator o Power Conditioner o Uninterruptible power supply o Motor generator
<p>TRANSIENT/NOTCH</p> 	<p>A transient is a sudden change in voltage up to several thousand volts (also called impulse or spike). A notch is a disturbance of opposite polarity from the waveform.</p>	<p>Microseconds</p>	<p>Utility switching operations, starting and stopping heavy equipment or office machinery, elevators, welding equipment static discharges, and lightning</p>	<p>Processing errors, data loss, burned circuit boards</p>	<ul style="list-style-type: none"> o Surge suppressor (for transients) o Power conditioner o Motor generator
<p>NOISE/HARMONIC DISTORTION</p> 	<p>Noise is an unwanted electrical signal of high frequency from other equipment. Harmonic distortion is alteration of the pure sine wave due to non-linear loads on the power supply.</p>	<p>Sporadic</p>	<p>Noise is caused by electromagnetic interference from appliances, microwave and radar transmissions, radio and TV broadcasts, arc welding, heaters, laser printers, thermostats, loose wiring, or improper grounding. Harmonic distortion is caused by non-linear loads.</p>	<p>Noise disturbs sensitive electronic equipment but is usually not destructive. It can cause processing errors and data loss. Harmonic distortion causes motors, transformers and wiring to overheat.</p>	<ul style="list-style-type: none"> o Electrically separate non-linear loads and wire per Appendix A to limit harmonic distortion o Isolation transformer o Power conditioner o Uninterruptible power supply o Motor generator

ELECTRICAL DISTURBANCE LOG

Often, identifying the cause of a power quality problem is like solving a mystery. It is important to get as many clues as possible to reach a conclusion. A power disturbance log helps to systematically and quickly uncover important information.

Times of Occurrence

What was the date and time of each electrical disturbance?

Equipment Affected

What equipment was adversely affected, and what were the consequences? Note any equipment failures or data losses.

Length of Outage

Document the length of the outage in one of three ways: shorter than two seconds, two to 120 seconds or longer than two minutes. This will help identify what type of electrical disturbance occurred.

Weather Conditions

Note temperature and any special weather conditions such as wind, lightning or rain.

BASIC INVESTIGATION

A thorough investigation can help identify many power quality problems. A typical electrical disturbance log is shown on Page 9.

The data from the log can be used to identify any patterns. In addition, it is important to consider any recent changes in your operation and what is happening within your facility at the time of the problem. Consider the following:

- o Has any electrical equipment been added or changed?
- o Has any work been done on the electrical system?
- o Does the problem occur regularly?
- o What else was happening at the time of the problem?
 - Were any large loads switched on?
 - Were the lights flickering?
 - Were there any power outages?
- o What other equipment was affected?
 - Is it on the same circuit?
 - Is it made by the same manufacturer?



Broadcast engineers create video magic using digital editing equipment

ELECTRICAL DISTURBANCE LOG

Customer Name _____ Address _____ Utility Contact _____ Utility Phone _____

Date	Time	a.m. p.m.	Equipment Affected and Description (State Any Equipment Failures or Data Loss)	Length of Outage			Weather Conditions	Reported By
				Under 2 Sec.	2-120 Sec.	Over 2 Min.		

This log is designed to help identify the causes of the equipment malfunctions. Please record the above information as soon as possible after a disturbance. Accurate information will provide valuable clues toward a solution. We appreciate your efforts and share a mutual interest in your success.

THE POWER QUALITY SURVEY

Planning the Survey

A power quality survey should be initiated prior to any major electrical changes or power conditioning equipment purchases. Many common power quality problems can be identified and resolved by conclusions drawn from the basic investigation.

If the solution seems unclear or confusing, a comprehensive power quality survey could prove helpful. The procedure recommended by the National Electrical Contractors Association in their publication "Diagnosing Power Quality Problems" is described on Pages 10-12. This process will be aided by developing a professional power quality team to share information and efficiently identify problems. It should consist of the following:

- Electrical specialists (electrical contractors, engineers, and power conditioning vendors)
- The supplier of your sensitive electronic equipment
- Your utility commercial and industrial customer service representative

A comprehensive plan should augment a power quality survey. Specific survey objectives are listed below in the order of priority:

- Determine the condition and adequacy of the wiring and grounding system
- Determine the quality of the AC voltage at the utilization point
- Determine sources of power disturbances and their effects on equipment performance
- Analyze findings to determine immediate and near-term cost-effective solutions

Survey Instruments

It is important to conduct a detailed site survey of your building wiring and grounding as soon as possible. This survey should be conducted by a qualified electrician, possibly in cooperation with an electrical engineer or other parties suitably trained to perform such surveys. The survey should include a thorough inspection of the building wiring and grounding. Voltage and current readings should be taken to identify any problems. The following instruments are recommended:

- Use a multimeter to measure voltage, current and resistance. It is important that the meter specification states "true rms" so that nonlinear loads will be accurately registered. Attachments are available on many multimeters to allow various ranges of current to be measured with good resolution.
- Use a circuit/ impedance tester to check wiring polarity at the receptacles. This device checks for wiring and equipment grounding problems in low voltage power distribution systems. Some circuit testers also measure circuit impedance. Tests from this device need to be augmented with a physical wiring inspection.
- An earth-ground resistance tester will determine the integrity of the earth connection.
- Use an oscilloscope to analyze the waveshape of voltage. Attachments allow the current waveform to be changed to a voltage waveform for more detailed analysis. Some oscilloscopes designed especially for this purpose are light, portable and battery-operated
- An infrared scanner can detect overheating of electrical switchgear, transformers, circuit breakers and electrical connections. A digital display indicates the temperature rise above ambient.
- A power disturbance monitor may be set after the building wiring and grounding have been positively verified. These monitors capture very short-term disturbances and report these results in great detail (see Pages 11 and 12).

Again, the Electric Power Research Institute has found or reported that approximately 80 percent of all power quality problems may actually result from inadequate wiring or grounding on the customer's premises, or from interactions with other on-site loads.

Performing the Survey

Begin your inspection at the main building service panel or supply transformer. Use an earth-ground tester to measure the resistance of the grounding system. Voltage and current readings should also be taken and recorded. From this point, each panel in the power distribution system serving the affected equipment should be tested or verified.

It is also necessary to verify all branch circuits which supply the sensitive equipment. Verification tests should include voltages and proper conductor termination, as well as measurement of ground and neutral impedance levels. Neutral and ground bonds and isolated grounds must be installed as recommended in the *National Electrical Code*.

We recommend a visual inspection of the electrical system and grounding before acquiring power-monitoring equipment. In addition, correct any problems discovered before beginning your monitoring activities.

Usually, the previously described instruments, along with the wiring inspection, are sufficient to identify the cause of a power quality problem. If these steps fail to resolve the problem, power monitoring may be required to help identify it.

Monitoring is typically performed using a power disturbance analyzer. They're both accurate and capable of constant voltage and current monitoring, providing a detailed record when measurements fall outside pre-set limits. Some reports show a summary of disturbances in tabular or graphic form, while other reports display a picture of the voltage waveform at the time of the disturbance. The graphs can be printed to thermal paper or stored on a floppy disk for further analysis on a computer.

Power disturbance analyzers can be set to monitor the following general categories: high frequency events such as impulses and noise, voltage events (sags, swells, undervoltage, overvoltage and outages), distortions and frequencies. The devices can be rented, leased or purchased from various electronic equipment suppliers.

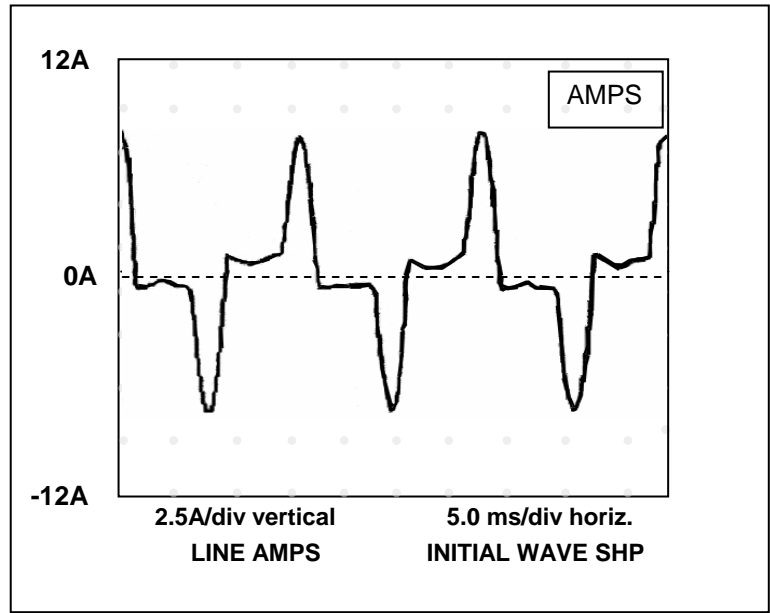


A power quality engineer reviews data gathered from power disturbance analyses

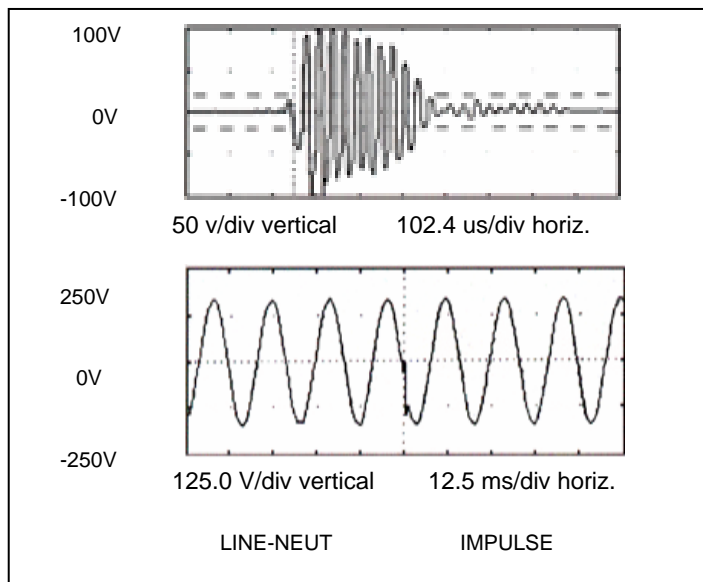
Analyzing to Reach Solutions

Once the power quality survey has been performed, the next step is to analyze the collected information. Close follow-up during the first few days of monitoring is important to selecting proper data thresholds. In this analysis, look for unusual or severe power events. It is important to review all information gathered up to this stage. Monitored events can be compared to the electrical disturbance log to determine any correlation. For example, a hard disk crash on a computer may be attributed to an impulse, power outage or overvoltage. Grouping key events into general categories such as impulses, voltage events or distortions will clarify the cause and effect and provide data to reach a successful solution.

These examples of current and voltage waveform graphs illustrate what power disturbance analyzers record and print out.



Current Waveform Graph



Voltage Waveform Graph

Different types of microcomputer or electronic equipment may have different tolerances for power line disturbances. The solution for one piece of equipment may be only a partial solution for another type.

Pages 13-16 show practical solutions for a building's wiring and grounding problems, as well as more complex solutions which include power conditioning equipment.

When the power quality survey is completed, prepare a proposed list of recommendations for the individual with the authority to initiate renovations. The decision to implement the recommendations should be based on a combination of facts, the economics and the effect of the sensitive electronics on your business operation.

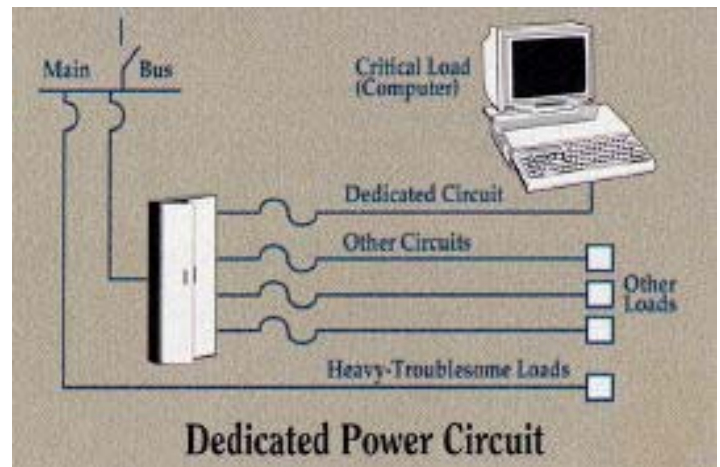
PRACTICAL SOLUTIONS

Many power quality problems can be resolved with practical, low-cost solutions. These solutions include preventive maintenance, equipment application or electrical rewiring. The following steps should be followed prior to the application of power conditioning equipment. A qualified electrician may be needed to perform some of these functions.

1. If you suspect a service quality problem, call your utility.
2. If the problem is intermittent, begin an electrical disturbance log to identify any patterns. (See Pages 8 and 9.). Check facility operation. Switching high current loads or loads on very lengthy building circuits can cause voltage sags.
3. If there are any suspected faulty electrical components, replace them. Also inspect the wiring for proper sizing and good condition. Check all wiring connections for proper tightness and clearance.
4. If the problem is related to hardware or software, contact the vendor or manufacturer.
5. If the voltage serving the equipment is not within manufacturer's specifications, and there is no service quality problem, contact a qualified electrician. Check to see that any auxiliary dry-type transformers are set for the proper tap.
6. Too much current to one conductor may cause a voltage imbalance to sensitive equipment. Ask your electrician about balancing loads to equalize your voltage.
7. If the disturbance is caused by other equipment on the same circuit, isolate sensitive equipment or move it to a dedicated circuit. (See diagram.)
8. Have a qualified electrician determine whether your installation complies with the latest edition of the National Electrical Code (NEC), Article 250. Single point, proper grounding is essential to the successful operation of your sensitive electronic equipment.
[\(See Power Note on "Performance Grounding and Wiring for Sensitive Equipment."\)](#)
9. Monitor ambient temperature and humidity to ensure compliance with computer manufacturers' recommendations.
10. If you have intermittent problems, consider static electricity. Static electricity can cause loss of data or damage to your computer. Anti-static sprays and mats are available to reduce the effect of static electricity. Static electricity can be minimized by maintaining at least 50 percent relative humidity or installing computer grade carpeting.

11. If noise and other high frequency interference are causing the problem, move the equipment to an alternate location in your building.
12. If the voltage waveform is distorted, consider the effects of harmonics. Symptoms of excessive harmonics include high neutral currents and excessive heating of motors and transformers. [\(See Power Note on Power System Harmonics\).](#)

If the problem persists, contact a power conditioning specialist. Should you decide to install power conditioning equipment, make sure the equipment is compatible with the sensitive equipment it will protect. Incompatible equipment may result in a new set of problems



POWER CONDITIONING EQUIPMENT

Solutions to power quality problems must include an economic evaluation plus intangible considerations. A properly designed and justified power conditioning system could be a good investment. Many users report payback periods of less than a year.

Various types of power conditioning equipment are available for protecting your sensitive equipment. The two categories of power conditioning equipment are "power enhancers" and "power synthesizers." There are various types of power conditioning equipment within these two categories. Power enhancers provide a way to improve the utility voltage and make it more suitable for computer loads; however, they provide no help for loss of power during a power outage. Power synthesizers are capable of not only enhancing the incoming power, but also providing auxiliary power during utility outages.

Some manufacturers and suppliers loosely apply the terms "power conditioner" and "line conditioner." A power conditioner could be either a power enhancer or a power synthesizer, and could also provide more than one mode of protection in a package. It is important to refer to the product specifications to understand a power conditioner's function.



Examples of power conditioning equipment include surge arresters, transient voltage surge suppressors, voltage regulators and uninterruptible power supplies. A wide variety of brands and models are available.

The rationale for choosing power synthesis over power enhancement may not be obvious. Severe power disturbances usually occur less frequently and the total cost of disruption is difficult to quantify. Power synthesizers are more complex and costly than power enhancers. In addition, power synthesizers are usually less efficient and require more maintenance.

In order to achieve positive results, power conditioning equipment must be properly understood, installed and maintained. The availability of proper maintenance and unit cost are other factors to consider in the selection of power conditioning equipment.

Power Enhancers

Surge Suppressors

Surge and transient or spike suppressors are the simplest, least expensive way to condition power. They reduce the size of spikes to levels that are safe for your electronics. High energy surge suppressors are installed at the service entrance. Transient voltage surge suppressors (TVSS) also are installed at the terminals of the sensitive electronic load. They provide protection against lower energy spikes which occur very abruptly. The service entrance suppressor is considered a minimum protection level, even if other power conditioners are employed. There are different levels of TVSS equipment. Their performance specifications vary widely and may depend on price. ([See Power Note on Surge Suppressors.](#))

Voltage Regulators

Voltage regulators maintain voltage output within a desired limit despite wide fluctuations in the input. They might provide protection against spikes or noise and limited or no protection from fast voltage changes depending upon the response time of the regulator. Voltage regulators respond best to slow changes in voltage.

Isolation Transformers

Isolation transformers protect sensitive electronic equipment by buffering electrical noise. They effectively reject *common mode* line-to-ground noise, but are limited in their rejection of *normal mode* line-to-line or line-to-neutral noise. Isolation transformers do provide a "separately derived" power source and permit single point grounding.

Power Synthesizers

Motor Generators

Motor generators consist of an electric motor driving a generator. They convert incoming electrical energy into mechanical energy and back again into electrical energy. The mechanical shaft isolates the electrical load from incoming disturbances such as voltage impulses, surges and sags. The motor generator rides through many short "momentary interruptions" but will not protect against sustained outages.

Standby Power Supply

For problems with power supply interruptions, use a

standby power supply (SPS) or an off-line uninterruptible power supply (UPS). This device switches to a battery supply upon loss of utility power. Some designs include a transfer during certain power disturbances.

The SPS is effective only when the equipment being protected can withstand the transfer time, usually a number of milliseconds. When voltage is normal, the transfer switch returns to the normal utility feed. Standby power supplies are typically available only in small personal computer sizes.

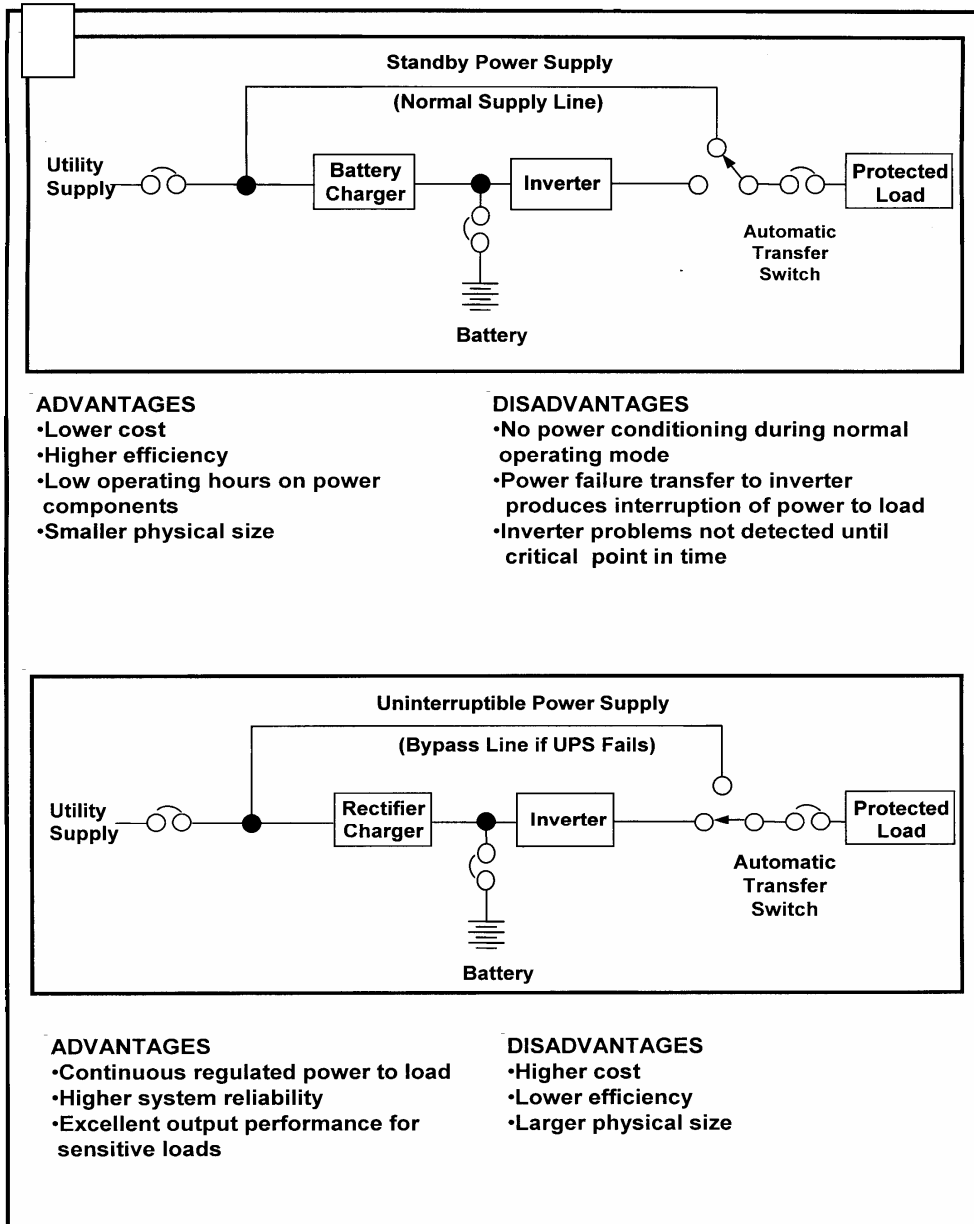
Uninterruptible Power Supply

Uninterruptible power supply (UPS) devices provide power to critical loads at all times. The two classifications of UPS systems are "rotary" and "static." A rotary UPS uses some form of a motor generator to provide uninterruptible power, while a static UPS has no moving parts and typically uses power semiconductors.

A static UPS system includes a rectifier/charger, a battery bank, a static inverter and an automatic transfer switch. Direct current power feeds an inverter from either the rectifier or battery and is converted to conditioned AC power which serves the sensitive electronic equipment. A direct utility feed powers the on-line UPS. A DC bus backed by a battery provides conditioned power. An on-line UPS typically has a solid-state transfer switch for switching directly to utility power if an internal element fails within the UPS.

Uninterruptible Power Supply with Auxiliary Generator

An uninterruptible power supply plus an auxiliary generator provides in even better supply system. This kind of system allows computers, for instance, to operate during lengthy utility outages. The generator starts automatically upon loss of utility power, and the source to the UPS will automatically transfer to the generator. Generators are available that utilize different fuels including gasoline, natural gas, propane or diesel.



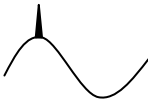

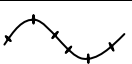
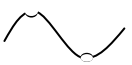




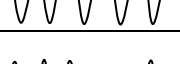


Standby Power Supply versus Uninterruptible Power Supply. (See Power Note on "Uninterruptible Power Supply")

APPLICATIONS FOR POWER CONDITIONING EQUIPMENT

The following table illustrates the effectiveness of various power conditioning equipment. Proper selection and application of the equipment requires an understanding of the type of disturbances

likely to affect specific equipment. For example, without proper conditioning sags, momentaries or transients could adversely affect the performance of your sensitive equipment.

SUMMARY OF PERFORMANCE FEATURES FOR VARIOUS TYPES OF POWER CONDITIONING EQUIPMENT

POWER QUALITY CONDITION			Power Conditioning Technology								
			Transient Voltage Surge Suppressor	EMI/RFI Filter	Isolation Transformer	Voltage Regulator (Electronic)	Voltage Regulator (Ferroresonant)	Motor Generator	Standby Power System	Uninterruptible Power Supply	Standby Engine Generator
	Transient	Common Mode									
	Voltage Surge	Normal Mode									
	Noise	Common Mode									
		Normal Mode									
	Notches										
	Voltage Distortion										
	Sag										
	Swell										
	Undervoltage										
	Overvoltage										
	Momentary Interruption										
	Long-term Interruption										
	Frequency Variation										



It is reasonable to expect that the indicated condition will be corrected by the indicated power conditioning technology.



There is significant variation in power conditioning product performance. The indicated condition may or may not be fully correctable by the indicated technology.

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PLANNING AHEAD TO MINIMIZE POWER DISTURBANCES

Here are some things that can minimize or prevent inconveniences caused by momentary power disturbances.

- When purchasing clock-driven electronic equipment for time-controlled manufacturing processes, make sure it is equipped with a backup battery or capacitor. This will allow the electrical device to retain settings whenever momentary power disturbances occur.
- To prevent loss of information on personal computers, "back up" or "save" files periodically. If retention of data is critical, consider adding power conditioning equipment.
- If you are designing a new work location, implement practical design considerations, such as dedicated electrical circuits, enhanced grounding, or humidity and temperature controls.
- Evaluate the importance of your mainframe computer and its data relative to your business. If critical, have backup equipment and data to protect against malfunctions. In such cases, power-conditioning equipment can be very helpful.
- Develop a preventive maintenance program for both your electronic equipment and the building's supply circuitry.



Computer-driven robotics spot-weld truck bodies on Ford's Clayco, Missouri assembly line.

WHERE TO RECEIVE HELP

- Your computer or sensitive electronic equipment suppliers should be your main source for technical information, such as voltage tolerance ranges. Review any recorded field data measurements to resolve whether the supply power is appropriate for the equipment. Suppliers also should be consulted when building a new installation.
- Secure a knowledgeable, qualified electrical contractor to perform your electrical survey and wiring. The National Electrical Contractors Association offers several helpful publications, including "*The Power Quality Reference Guide*," "*Diagnosing Power Quality Problems*," "*Effective Grounding of Electronic Equipment*" and "*Design to Improve Power Quality*." They can be purchased from The National Electrical Contractors Association, 7315 Wisconsin Ave., Bethesda, Maryland 20814.
- For a listing of companies that can assist you with computer design and application, consult your *Yellow Pages* under "Computer Rooms-Installation and Equipment."
- The Institute of Electrical and Electronics Engineers (IEEE) offers a collection of books for engineers who need extensive data on implementing power systems. This collection, called the "*IEEE Color Book Series*," was specifically developed for engineers involved with all facets of industrial and commercial power systems, and includes a comprehensive set of guidelines. The *Emerald Book* should prove particularly helpful. It contains IEEE Standard 1100 on "*Recommended Practice for Powering and Grounding of Sensitive Electronic Equipment*." These books can be purchased from IEEE Press, 445 Hoes Lane, P.O. Box 1331, Piscataway, New Jersey 08855-1331.
- For additional technical information, consult FIPS PUB 94 "*Guidelines on Electrical Power for ADP Installations*" published by the U.S. Department of Commerce, National Bureau of Standards. To obtain a copy, write to National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161.
- Your utility staffs commercial and industrial customer service representatives who are available to discuss power quality with you. They understand the growing dependency upon electricity to power sensitive electronic loads in your business or home.



Long-distance calls from around the world are handled in Sprint's digital switching centers.