Power Quality
for your Local Area Network (LAN)

Introduction

The value of information is often in our ability to share it with others. Commercial offices are becoming increasingly dependent on electronic systems to facilitate the exchange of information. Computers, printers, facsimile servers and communication gateways all may benefit from being connected through a system of low-voltage data/communications interconnections referred to as local area networks (LANs). LANs are the staple of most office environments, integrating people and machines, enhancing productivity and communications.

This brochure will walk you through typical power quality problems affecting LAN systems, potential sources for these problems and basic methods for solution.

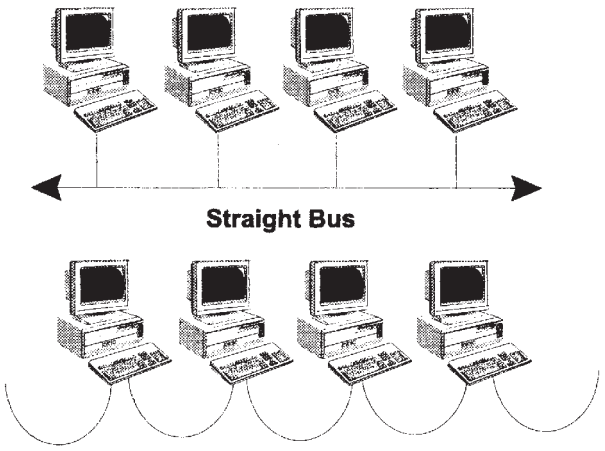
Power quality is characterized by any distortion of the electricity (often referred to as a power disturbance) that results in damage or the mis-operation of electronic equipment.

This brochure was created to help LAN managers and users understand and diagnose power quality problems that affect LAN systems. When used properly, it can help you avoid the costs of such problems, as well as ensuring the safety and reliability of your network equipment.

Network topologies

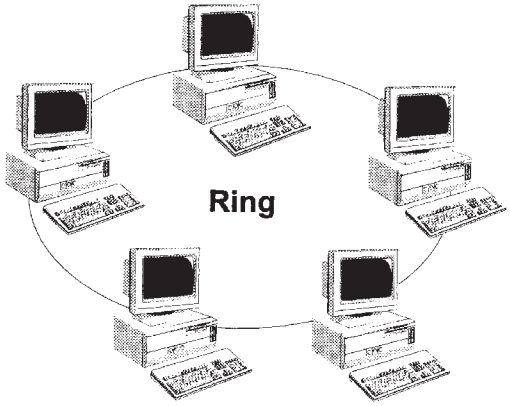
There are three basic topologies, or patterns, for interconnecting computers. These basic network topologies are bus, ring and star.

Bus – This method uses a single cable to connect adjoining computers, either in a daisy-chain or tap approach. If a single wire gets disconnected anywhere along the bus, the entire chain of computers can no longer talk to the network.

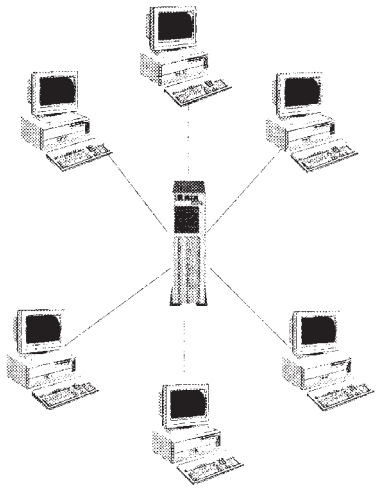


BC hydro
POWER SMART

Ring – This topology is seldom used to lay out LAN cabling. This is actually a daisy-chain layout, with the first and last computer connected. This method is vulnerable to cable breaks and disconnects.



Star – In this method every computer connects to a server or a network hub. Since computers are not connected to each other in this topology, removing one computer does not affect the others.



Star with Server or Hub

Basic network types

The type of network technology you select for your network will affect the performance, flexibility and expansion capability of your network. The following are the basic network technologies and their pros and cons.

ARCnet – This technology is normally run on star topologies. It works by passing a token around from computer to computer. Only the computer that holds the token can send data. The token holder broadcasts its message to the entire network, but only the computer to which it is sending the message will respond. After the computer has finished sending its message, it passes the token on to the next computer. ARCnets are inexpensive and quite common, so support is readily available. It is also the slowest of all common network types.

Ethernet – This technology works by a carrier sense, multiple access, collision detect scheme, abbreviated CSMA/CD. Carrier sense means that all computers on the network are always listening to the cable and can tell when another computer is sending a message. No computer is allowed to send a message if another is already doing so. Multiple access means that it's possible for more than one PC to detect a quiet cable and send data at the same time. This results in a collision. Each computer can detect a collision when it occurs, then wait and transmit its data at another time. An Ethernet system can lay out in either a star or bus configuration. Ethernet is well understood and flexible, but not always the fastest network system. It has limitations on cable lengths, which, if exceeded, will affect performance.

Token ring – This technology also uses a token method. Once the computer with the token has sent out data, the sender does not relinquish the token until its message gets to the intended receiver. Every computer gets the same chance at sending data. A token ring cannot become over-whelmed by traffic. It can also run on all three topologies. This technology is the fastest and can easily handle heavy traffic, but it is also the most expensive and the most complicated to install and maintain.

FDDI – Fibre Distributed Data Interface technology uses a token method on a ring topology. The difference is that it uses two rings and two tokens, one in one direction on one of the rings and the other in the opposite direction on the other ring. It is usually used as a high-

speed link between networks and utilizes fibre optic cable (there is a version that uses coaxial cable, CDDI). This technology is 40 times faster than ARCnet, up to 10 times faster than Ethernet's fasted rated speed, and 6 to 12 times faster than token ring. The cabling method used can run much longer distances, but it is the most expensive method and requires professional installation.

LAN operating symptoms

As useful as LANs are, however, they are particularly susceptible to power quality problems. As indicated, a LAN is made up of a network of computers, which can be sensitive to power disturbances, interconnected by way of LAN communications cabling and equipment, which can also be susceptible to power disturbances, and in many cases they tie together (by way of data cabling) equipment served by different electrical circuits, creating ground loops. Ground loops allow unwanted current to flow on the ground system between individual computers, often distributing these disturbances throughout a network.

Some common symptoms of power quality problems in a LAN are:

- slow network data communications rates
- shut-down of the network file server
- lock-up of individual network terminals
- data/communications component failures
- lost or erroneous data communications

Although some symptoms may be obvious, a power quality problem affecting a LAN can be complicated, involving building wiring, natural phenomena such as lightning, interacting equipment, and currents flowing through ground loops. Most power quality problems involve electronic equipment, because this equipment has typically been designed to operate with relatively precise electrical service. However, many things can happen to the electricity as it travels from the utility to an electronic device.

The next three sections will help you recognize and deal with most power quality problems encountered in a LAN.

Power quality problems

Once you connect a terminal into a LAN system, it becomes part of both the electrical system and a network of communications cabling. This also means that this terminal is interconnected with other pieces of electrical equipment through both the power system and the communications network. This is why power quality problems can be so complex.

There are four elements to a ***power quality problem****: an electrical disturbance, an initiating event that caused the electrical disturbance, contributing factors that allow the disturbance to travel to multiple locations, and the effect of the electrical disturbance on a LAN system component, as determined by the components' sensitivity to the disturbance. Most power quality problems occur like chain reactions, starting with an initiating event and eventually resulting in upset or even damage.

An ***electrical disturbance***, caused by an initiating event, will distort electricity by changing its shape or amount. The table on the next page shows the most common electrical disturbances found to affect the performance of local area network systems and their causes.

- ***Transients*** (also called **surges** and **spikes**) are distortions of electricity caused by lightning, the turning off or on of any electrical equipment, or any switching operations that may be part of the normal operation of office equipment (e.g., copy machines and laser printers). These disturbances can damage electronic components, upset computer or LAN processes and corrupt data.
- ***Noise*** can be transmitted either through the electrical system or through the air (**radiated**). Noise is caused by communication equipment (radios, televisions, phones, etc.), lighting systems and controls, and motors. Noise is a common issue for LAN systems, since it will interfere with data communications and cause errors.

* Words and phrases in italics are included in the glossary.

- ***Harmonic distortion*** is caused by the power supplies contained in today's modern electronic equipment, such as computers, fax machines, and other office equipment. Harmonic distortion affects electrical system components and can cause overheating of transformers, building wiring and temporary wiring such as office partition wiring. This results in an increase in power consumption.

- ***Voltage sags*** are very short (less than a second) decreases in the normal supply voltage level. Sags can be caused by the starting of motor-based equipment or the start-up of heaters in copy machines and laser printers. Sags will not normally damage equipment, but they can halt its operation or cause a restart of equipment or the loss of memory.

Electrical Disturbance	Cause of Disturbance
 Impulsive  Oscillatory Transients (Surges or Spikes)	• motors in air conditioners, HVAC equipment, elevators, water coolers, fans • lightning • photocopiers and laser printers • static discharge • routine utility activity • electronic air ionizers • kitchen appliances
 Noise	• HVAC equipment • kitchen appliances • radios, telephones • light dimmers • overhead lines • electronic lighting • building transformers • electronic air ionizers • vacuum cleaners
 Harmonic Distortion	• computers • televisions, video cassette recorders • electronic lighting
 Sag	• motors in air conditioners, HVAC equipment, elevators, water coolers, fans • photocopiers and laser printers • routine utility activities
 Swell	• motors in air conditioners, HVAC equipment, elevators, water coolers, fans • photocopiers and laser printers
 Undervoltage	• improper wiring and grounding • improper voltage tap adjustment • defective building transformer
 Overvoltage	• improper wiring and grounding • improper voltage tap adjustment • defective building transformer • crossed power lines
 Interruption	• lightning • tripped circuit breaker, blown fuse • downed power lines

- ***Voltage swells*** are very short (less than a second) increases in the normal supply voltage level. These are mostly caused by motor-based systems that are turned off, but continue to turn. Swells can cause damage to equipment and components.
- ***Overvoltages*** and ***undervoltages*** are increases or decreases in the normal supply voltage level, lasting for seconds or minutes. These kinds of disturbances occur far less frequently than sags and swells. These generally indicate a problem with building wiring or power system components such as transformers. The impacts of these disturbances are very similar to those of sags and swells.
- ***Interruptions*** (also referred to as a **momentary** or **power outage**) are disruptions in electrical supply that can last anywhere from fractions of a second to hours. These are caused by lightning, downed power lines, tripped circuit breakers and blown fuses. Interruptions will disrupt equipment operation and cause the loss of data and memory for unprotected equipment.

Some of these disturbances can actually travel between sensitive devices on LAN system cabling and components (transients and noise, for example). Other disturbances will normally affect several devices that may be interconnected by LAN cabling or components (sags, swells, under-voltages and overvoltages or interruptions, for example). Harmonic distortion is one type of disturbance, which is really a by-product of the concentration of computer equipment represented by LAN systems. The effect of this disturbance is directed to the power system and power system components (heating and thermal breakdown).

Contributing factors are those aspects of an installed LAN system that allow or enable a disturbance to access and upset or damage an electronic device. For LAN systems, contributing factors will fall into one of two broad categories: incorrect or unsafe wiring and grounding practices, or the design and method of installation of the actual LAN system data communications cabling.

The effect of electrical disturbances on equipment ranges from relatively benign (blinking clocks) to severe (overheating of wires, posing a fire hazard). The most common effect is upset – the loss of data or LAN system operating capability – which may not pose a physical threat, but can be very costly.

What is the solution? To solve a power quality problem it is important to first know how all of your critical equipment is interconnected. This can be determined through a process of surveying your LAN system and office. The next section will help you investigate power quality problems. It includes an equipment inventory, electrical panel schedule, data cabling interconnect log and basic survey methods.

Surveying your LAN system

The first and most important step in investigating a power quality problem with a LAN is to walk through your office to identify and record the location of all LAN system equipment, the electrical branch circuit to which each device is connected, the interconnecting data cable run for each device and any other connections, such as phone line or modem connections. The Inventory Table on page 7 will help you record your observations. Photocopy the table to make as many inventory tables as you need to conduct a comprehensive survey of your LAN system. The users of the LAN system are often the best sources of information, especially when you are trying to trace the history of power quality symptoms.

Use the following six-step approach to record the environment and history of each LAN system component on your inventory table, as described on the next pages.

The six-step survey approach

1) Record the physical location of the device.
2) Record the electrical circuit serving each device.
3) Record the nature and routing of any data communications cable connections.
4) Record any other connections to the device (including communications cables and power quality devices such as surge suppressors).

5) Record any symptoms of power quality problems for each device, as well as when the symptoms were observed.
6) Inspect all visible electrical wiring and data cabling.

Step One – Record the physical location.

Record the physical location of each LAN device (including servers, terminals, modems, routers, hubs, concentrators, etc.). Knowing the physical location can be useful when you are trying to determine sources of radiated noise that can affect the performance of LAN systems. For example, as you walk through your office, you may note that a LAN server is located close to a lighting control panel. If your data transfer rates on the network appear to be slower than expected, it is possible that radiated noise from panels like this is coupling to the data cabling, slowing down transfer rates due to error checks and re-transmissions.

WARNING: Before proceeding to Step Two, shut down the network in an orderly fashion.

WARNING: Only an electrician should switch off large breakers that feed heating, ventilation or air conditioning equipment, which should be labelled on the service panel.

Step Two – Record the circuit serving each device.

Perhaps the most difficult and disruptive part of the investigation, this step is very important in identifying disturbing and susceptible equipment connected to the same circuit. You can determine which circuit feeds a device by simply turning on all non-critical equipment (lamps, radios, etc.), locating the electrical ***service panel*** serving the LAN, turning off the breakers in this panel one at a time, and noting which outlets lose power. **Make sure that your LAN has been safely shut down and that all critical LAN equipment is replaced for this exercise with non-critical equipment, such as lamps, radios, heaters, etc.** (To facilitate the process, have a partner walk around the office looking for equipment that has lost power while you stand at the service panel.) Each circuit breaker in the panel feeds one circuit and is usually numbered from left to right.

Start by turning off circuit breaker 1 and recording a "1" in the "Branch Circuit" column for each device that loses power with this action. Then turn circuit breaker 1 back on. Repeat the procedure for the remaining circuit breakers. So that you will have an accurate record for future use, you may want to copy the service panel chart on page 8, fill it in and tape it to the inside of the service panel door.

Another way to identify branch circuits is to connect the base of a cordless phone to each electrical outlet without connecting the telephone line. Then, with the receiver in your hand and turned on, listen for the receiver to change from noise to silence, which indicates that the base has lost power. No matter which method you use, the job can be tedious, but your diligence will pay off when it comes time to solve power quality problems in your office.

Step Three – Record all LAN data cable connections.

Look at each device carefully. Is it connected to the LAN? Carefully documenting this connection will help you solve data transmission problems and I/O port damage problems caused by these interconnections. Some LAN systems are installed with some form of data cabling system documentation (a print or map). If this is available it will expedite this particular step.

There are three possible methods for cable identification. For each method, assign a "label" to each data cable (possibly a letter code or colour code), and record that label in your inventory table for the device you are documenting. Next you will need to trace the data cable to the next device in the system. Record this same label for the device at the other end of the cable run. The three ways to accomplish this are:

- visual inspection of the cabling run
- using specifically designed data cable test instruments
- using a simple continuity tester in a trial-and-error process

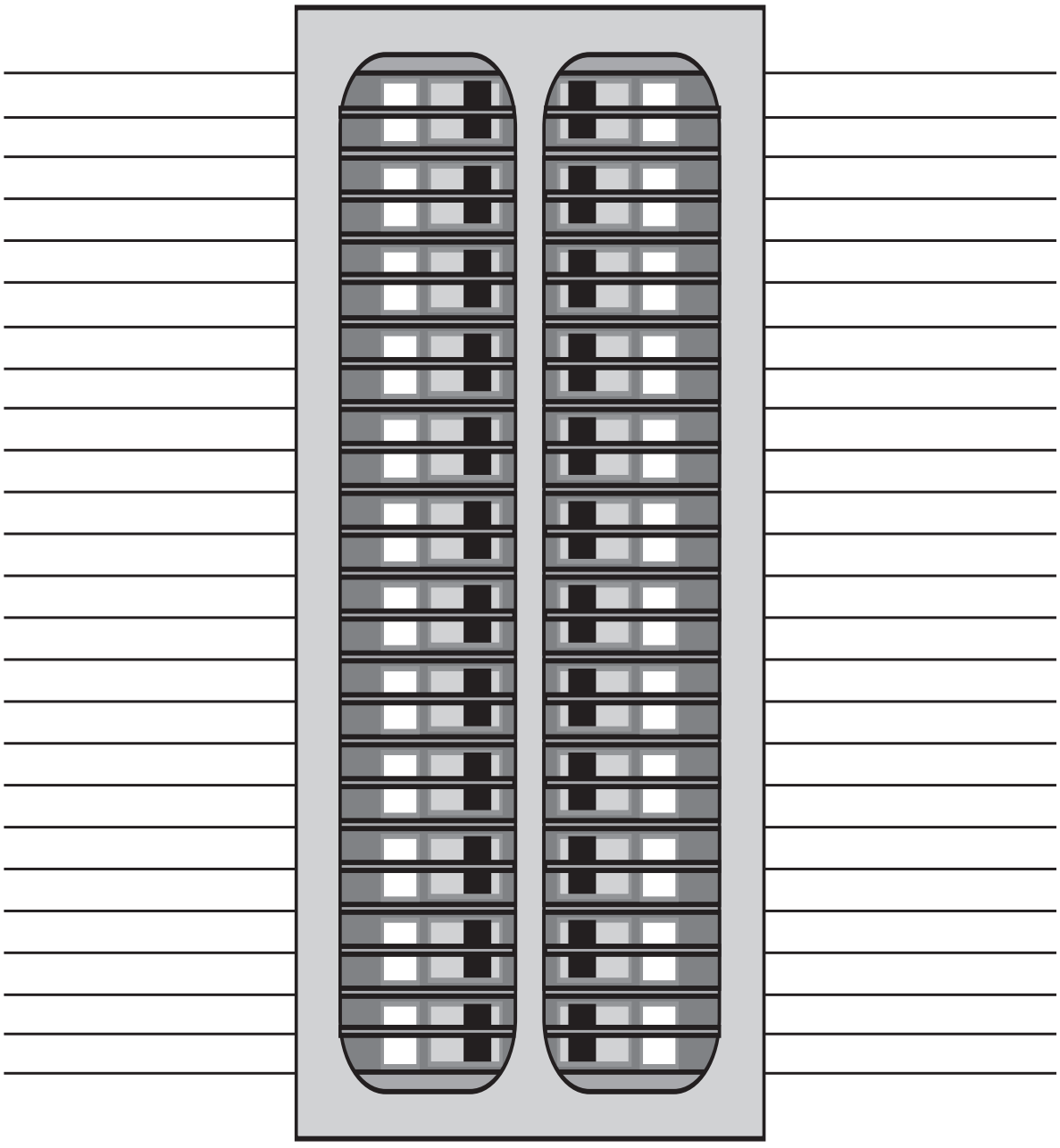
Inventory Table

LAN Device	Physical Location	Branch Circuit	Other Connections	Symptoms	Date/Time

Service Panel

Circuit No.

Circuit No.



Visual inspections should cover the general condition of the cable run, specifically the drop cords to the individual devices, and damaged connectors or terminations. Ensure the proper grade of cabling (always look for data grade cabling). Any unacceptable condition should be corrected. There are a number of alternative methods that can be used to evaluate the condition of data cabling.

Hand-held LAN diagnostic instruments, available through instrument suppliers, can trace and report a great deal about LAN cable routing and condition. These tools do require an investment of several hundreds of dollars.

Another method is quite simple and inexpensive. On disconnected cable runs, first short-circuit one end of the cable run by using a small jumper wire with alligator clips. At the suspected other end of the cable run, use a simple and inexpensive continuity tester (a two probe device with a light that illuminates when a complete circuit is detected), checking between cable leads to find one that shows continuity. This signifies the other end of the cable in question.

Step Four – Record all other equipment connections.

Look at each LAN device carefully. Is it connected to another device, for example, a modem? Is it connected to the telephone system? Cable TV system? A surge suppressor or other power quality device? Documenting such connections will help you solve LAN operating problems, since modems, suppressors and cable TV systems may all connect into a LAN and may also provide a path for disturbances to access the LAN system.

Step Five – Record the symptoms.

Record the symptoms of any power quality problems associated with each LAN device. Talk to the LAN users about these devices to determine a history of LAN performance. Have the staff individually record symptoms and events such as lightning and flickering lights that occur before, during and after they observe a LAN performance symptom. Be especially diligent in recording dates and times of symptoms, because they may coincide with other operating activities that are well documented.

Step Six – Inspect all visible electrical wiring.

Inspect all visible wiring, such as power cords and power strips, as well as all communication/LAN cabling. Make sure that they are safely tucked away and not wrapped around equipment. Damaged or ungrounded cables should be replaced or properly connected. You may also want to contract an electrician to inspect your building electrical systems, including the electrical outlets and service panels.

After you have completed your inventory sheets, you are ready to look at solutions to the power quality problems in your LAN. The next section discusses solutions, their applications and their costs.

Solutions

Now we have come to the most challenging part of this brochure: solving the power quality problems in your LAN system. Having completed your inventory table, you should have a record of symptoms of power quality problems for each LAN system device. The next step is to match symptoms to solutions by following the Problem-Solving Flowchart on the next page and the Problem-Solving Table on pages 12 and 13.

First, you should deal with all contributing factors, especially wiring and grounding problems and data cabling issues. For example, inspect the electrical outlet to which a LAN system device experiencing power quality symptoms is connected. The outlet should have two receptacles, each with three slots: two side-by-side vertical slots, and one semicircular slot. If the outlet has only two vertical slots, you have a grounding problem. Some devices do not require a connection to the grounding slot, but others (computers, telephone systems, etc.) use this ground as a data or voice communications reference. Additionally, a ground is needed to meet safety standards, because some equipment might otherwise pose a shock hazard. In either case, outlets without grounds should be upgraded by a licensed electrician.

As another example, if your LAN system communicates with terminals over a large space, or more than one floor in a building, and your inspection of visible wiring identifies more than one electrical panel serving your space, and if

you have utilized a data cabling method that uses grounded terminations at each end of the individual cable runs, it is possible that your LAN system is suffering from ground loop issues. Ground loops allow unwanted and disturbing currents to flow around your LAN from device to device, sometimes causing disruption. Ground loops should be minimized as much as possible.

The following tips will help you identify and correct common contributing factors for LAN systems:

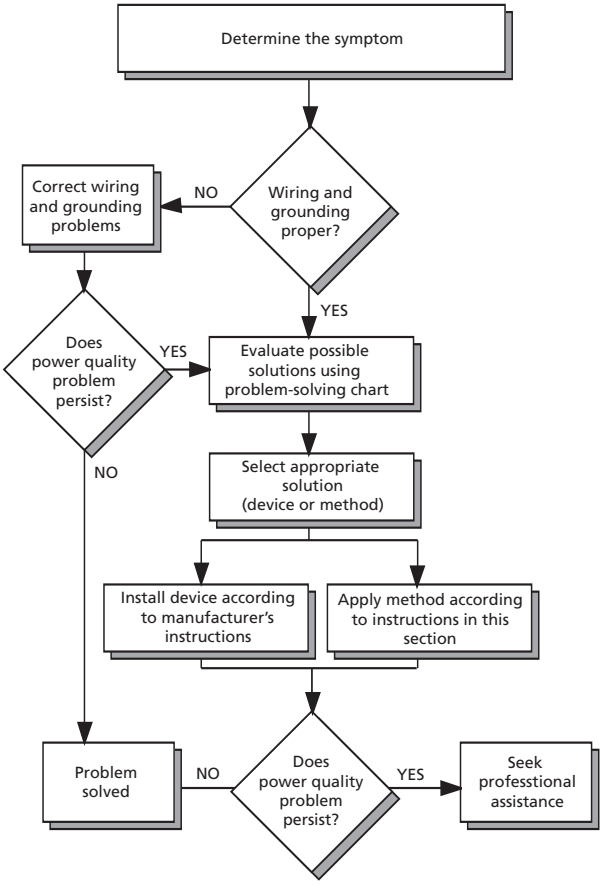
- Eliminate long branch circuits created by connecting successive modular office panels or extension cords (or both) together. The wires in these extensions may overheat and pose a fire hazard. Additionally, long branch circuits increase the effects of sags and contribute to unwanted noise currents, which flow in ground loops.
- Minimize the length of individual data cable runs between LAN system devices as much as possible and avoid routing these cables near things like fluorescent lighting fixtures, motors, antennas, and other communications equipment.
- Use an isolated ground receptacle for all branch circuits that support LAN equipment. If isolated ground receptacles are not in place, a licensed electrician should be retained to make this modification.
- As much as possible, make sure that all of your LAN system equipment is served by branch circuits from the same electrical panel.
- Large electrical equipment, such as motors, HVAC equipment or elevators, should not be served from the same electrical panels that serve LAN system equipment. If these types of devices are now served from LAN system electrical panels, they should be relocated to a different panel by a licensed electrician.

If contributing factors are not corrected, a power quality problem may persist even if you have installed devices to correct the problem.

Once all contributing factors have been corrected, evaluate other possible solutions. In the Problem-Solving Table, solutions are listed by least to most expensive. Some solutions involve contracting a professional, which can increase the cost of the solution significantly. However, some power quality problems can be solved simply by relocating a device. The solutions in the Problem-Solving Table are explained below, in alphabetical order.

WARNING: Always follow manufacturers' instructions when installing any of the devices discussed in this manual.

Problem-solving flowchart



Fibre-optic solutions (optical cable or isolators) can be a very expensive, highly effective option. If data errors and terminal lock-up problems appear to be associated with ground loops through data cabling grounds, this option may be the most effective, because it eliminates the electrical connections between terminals through the data system and breaks the ground loop. The

cost of this solution method can be minimized if it is only used for key data runs (like hub-to-hub runs or very long runs). Suppliers of fibre optic equipment can give you details about installation and cost.

Filter solutions can help to reduce the level of interfering electrical noise that mixes with the desired data transmission signals on some local area networks, causing errors and reduced transmission rates. Filters are available configured for application at data cabling terminations. The specific frequencies to be restricted must be known in order to ensure the proper application of these filters. These components are not expensive and it is possible to find the proper frequency range through a trial-and-error process using different filters. Much like the fibre optic solutions comment, these devices should be installed only at key locations. These devices can be purchased at most electronic supply stores.

For further assistance

If, after following the procedures recommended in this brochure, power quality problems persist for your LAN, a network specialist or electrician may be able to provide further assistance.

Sample trouble log format

Date	Time	Event Sympton	Operator	Duration	Impact to Process	Action Taken	Result

Appliance	Symptom	Disturbance	Contributing factors		Cause of disturbance	Solutions (arranged by cost from lowest to highest)
Air conditioner	Compressor overheating/early failure	• Harmonic distortion • Undervoltage	• Low voltage • Faulty ground • Undersized wiring		• Computers, televisions, VCRs, electronic lighting • Defective building transformer* • Improper voltage tap adjustment *	• Install harmonic filter at source or at air conditioner • Install surge protector at surge source or at air conditioner • Install surge suppressor at service panel
Clock (digital)	Runs fast	• Transients (oscillatory)			• Air ionizers, kitchen appliances • Lightning, crossed power lines, routine utility activities	• Discontinue using disturbance-causing appliance • Replace with new clock • Install surge protector with "sine wave tracking feature" at clock
	Loses memory, blinks	• Sags • Interruptions	• Low voltage		• Lightning, downed power lines, routine utility activities • Tripped circuit breakers, blown fuses	• Install or replace backup battery • Replace with model incorporating backup battery
Computer (including networks, peripherals)	Computer locks up	• Transients (impulsive) • Transients (oscillatory) • Sags • Noise	• Faulty ground • Defective data cables • Mis-wired electrical outlet		• HVAC equipment starting and stopping • Lightning, crossed power lines, routine utility activities • Photocopiers and laser printers	• Install surge protector with data port at computer • Install surge suppressor at service panel • Use fibre-optic cables to link communication peripherals to computer
	Computer resets (reboots)	• Sags • Interruptions	• Faulty ground • Loose wiring • Mis-wired electrical outlet • Low voltage		• HVAC equipment starting and stopping • Lightning, downed power lines, routine utility activities • Photocopiers and laser printers • Tripped circuit breakers, blown fuses	• Relocate computer and peripherals to a different branch circuit • Install UPS at computer
	Data errors	• Noise • Transients (impulsive) • Transients (oscillatory)	• Faulty ground		• Overhead distribution lines, building transformers • Motors in air conditioners, HVAC equipment, elevators, water coolers, fans • Lightning, crossed power lines, routine utility activities • Photocopiers and laser printers, static discharge	• Connect computer and peripherals to the same branch circuit • Relocate computer and peripherals to a different branch circuit • Install surge protector with data port at computer • Install power conditioner at computer • Use fibre-optic cables to link communication peripherals to computer
Computer monitor	Wavy lines or noise on screen	• Noise (radiated)	• Faulty ground • Long branch circuit		• Building transformer • Electric heaters • Overhead distribution lines • Service panels	• Relocate monitor away from source of noise • Change monitor software scan rate (contact dealer) • Relocate monitor and computer to a different branch circuit
Doorbell (electronic)	Rings randomly	• Transients (impulsive) • Transients (oscillatory)			• HVAC equipment and elevators starting and stopping • Photocopiers and laser printers • Lightning, crossed power lines, routine utility activities	• Request that the manufacturer modify doorbell
Energy management system	Inoperative	• Direct interference			• Electronic lighting	• Change carrier signal of energy management system*
Facsimile	Lost memory	• Sags • Interruptions	• Faulty ground • Undersized wiring • Mis-wired electrical outlet		• HVAC equipment and elevators starting and stopping • Lightning, downed power lines, routine utility activities • Photocopiers and laser printers • Tripped circuit breakers, blown fuses	• Relocate facsimile to a different branch circuit • Install UPS at facsimile
	Faulty transmission	• Noise • Transients (impulsive) • Transients (oscillatory)	• Faulty ground • Loose wiring • Mis-wired electrical outlet		• Overhead distribution lines, building transformers • Motors in air conditioners, HVAC equipment, elevators, water coolers, fans • Lightning, crossed power lines, routine utility activities • Photocopiers and laser printers	• Relocate facsimile to a different branch circuit • Install surge protector with telephone port at facsimile • Install power conditioner at facsimile
Hearing aid	Buzzes, hums	• Noise (radiated)			• Electronic lighting	• Request that manufacturer modify or replace hearing aid
Intercom	Buzzes, hums	• Noise	• Faulty ground		• Motors in air conditioners, HVAC equipment, elevators, water coolers, fans • Radios, televisions, video cassette recorders	• Relocate noisy appliances to different branch circuit • Install noise filter at intercom • Install power conditioner at intercom
Lighting (electronic)	Flickering	• Sags	• Faulty ground • Undersized wiring		• Motors in air conditioners, HVAC equipment, elevators, water coolers, fans • Photocopiers and laser printers	• Connect lighting to a different branch circuit* • Install a soft-start kit on all sag-causing motors*
Microwave oven	Loses memory, clock blinks	• Sags • Interruptions	• Low voltage		• Lightning storms, downed power lines • Tripped circuit breakers, blown fuses	• Replace with model incorporating a built-in backup battery

*Consult professional.

Appliance	Symptom	Disturbance	Contributing factors		Cause of disturbance	Solutions (arranged by cost from lowest to highest)
Modular office panels	Overheating, fire	• Harmonic distortion			• Computers, televisions, electronic lighting	• Ask manufacturer to replace with model incorporating larger wires • Reduce number of appliances connected to panel electrical outlets*
Photocopier/laser printer	Data errors, lost memory	• Sags • Transients (impulsive)	• Mis-wired electrical outlet • Faulty ground • Defective data cables • Low voltage		• HVAC equipment and elevators starting and stopping • Lightning, crossed power lines, routine utility activities	• Relocate photocopier or laser printer and computer to a different branch circuit • Install surge protector at photocopier or surge protector with data port at laser printer and computer • Install surge suppressor at service panel
Postage machine	Faulty readout	• Noise • Transients (impulsive)	• Mis-wired electrical outlet • Faulty ground • Low voltage		• Kitchen appliances, light dimmers • HVAC equipment and elevators starting and stopping • Photocopiers and laser printers • Lightning, crossed power lines, routine utility activities	• Relocate postage machine to a different branch circuit • Install surge protector with noise filter at postage machine
Radio	Static or buzz in speakers	• Noise • Noise (radiated)	• Mis-wired electrical outlet • Faulty ground		• Electronic lighting • Kitchen appliances • HVAC equipment	• Relocate radio away from noisy appliances • Install a noise filter at radio
Scale (digital)	Faulty readout	• Noise • Transients (impulsive)	• Mis-wired electrical outlet • Faulty ground • Low voltage		• Kitchen appliances, light dimmers • HVAC equipment and elevators starting and stopping • Photocopiers and laser printers • Lightning, crossed power lines, routine utility activities	• Relocate digital scale to a different branch circuit • Install surge protector with noise filter at digital scale
Security/fire alarm system	Random tripping and malfunction	• Noise • Transients (impulsive)	• Mis-wired electrical outlet • Faulty ground • Low voltage		• Kitchen appliances, light dimmers • HVAC equipment and elevators starting and stopping • Photocopiers and laser printers • Lightning, crossed power lines, routine utility activities	• Relocate alarm system panel to a different branch circuit • Install surge protector with noise filter at digital scale • Install power conditioner at alarm system panel • Install UPS at alarm system panel
Telephone	Static or buzz in receiver	• Noise • Noise (radiated)	• Mis-wired electrical outlet • Faulty ground		• Electronic lighting • Kitchen appliances • HVAC equipment	• Relocate telephone away from noisy appliances • Install a noise filter at telephone • Install surge protector with telephone port and noise filter at telephone
	Loses calls	• Sags • Interruptions	• Low voltage		• Lightning, downed power lines, routine utility activities • Tripped circuit breakers, blown fuses	• Install UPS at PBX telephone system panel
Telephone answering machine	Loses memory	• Sags • Interruptions	• Low voltage		• Lightning, downed power lines, routine utility activities • Tripped circuit breakers, blown fuses	• Relocate answering machine to a different branch circuit • Install UPS at answering machine
Television	Wavy lines or noise on screen	• Noise • Noise (radiated)	• Mis-wired electrical outlet • Faulty ground • Long branch circuit		• Electronic lighting • Kitchen appliances • HVAC equipment	• Relocate television to a different branch circuit • Install a noise filter at television • Install surge protector with cable port and noise filter at television
	Remote control does not work	• Direct interference			• Electronic lighting	• Replace television or lighting with different brands
Video cassette recorder	Loses memory, clock blinks	• Sags • Interruptions	• Low voltage		• Lightning, downed power lines, routine utility activities • Tripped circuit breakers, blown fuses	• Relocate video cassette recorder to a different branch circuit • Replace with model incorporating battery backup
	Remote control does not work	• Direct interference			• Electronic lighting	• Replace video cassette recorder or lighting with different brand
All	Appliance component damage	• Transients (impulsive) • Transients (oscillatory) • Undervoltages • Overvoltages	• Mis-wired electrical outlet • Faulty ground • Low voltage		• Lightning storms, crossed power lines • Defective building transformer • Low voltage	• Unplug appliance during lightning storms • Install surge protector at appliance • Install surge suppressor at service panel • Adjust tap on building transformer to proper electricity level

*Unless the number of appliances connected to the panel outlets is minimized, the undersized wiring in the panels may still overheat.

Glossary

10Base2 – cheaper net, Thin Net, or Thin Ethernet; 10 Mbps speed; maximum cable segment length of 200 metres.

10Base5 – thick Ethernet, the cable system specified by DEC and Xerox; 10 Mbps speed; maximum cable segment length of 500 metres.

10Base-T – twisted pair Ethernet; 10 Mbps speed. Very popular.

ANSI – American National Standards Institute.

ARCNET – Datapoint Corporation's long-standing network system.

balun – BALanced, UNbalanced. An impedance matching device, which allows networks that are intended to run over coax to run over twisted pair. Also provides filtering benefit.

bit – the smallest unit or number in a digital computer.

BNC connector – a twist connector, used to connect coax cables.

boot – the process the computer goes through to load the operating system.

branch circuit – an individually protected electrical circuit originating at the service panel and ending at the electrical outlets.

bridge – a device that connects two networks at the Link Layer, sometimes called a MAC - Layer Bridge in LANs.

building transformer – a customer-owned electrical device for changing the voltage (i.e., from a high level to a low level).

byte – eight bits, the smallest unit of data moved about in a computer.

client-server architecture – method of organizing interconnected computers in which a client process or device makes a request of another application or device for services.

CMOS – Complementary Metal Oxide Semiconductor chips, used to store information with battery backup.

communications server – a device designed to provide communications services to network users.

CPU – central processing unit.

crash – an abrupt, abnormal end to a process, whether caused by hardware or software failure.

crosstalk – interference on one set of wires from another.

CSA – Canadian Standards Association.

down – file server console command that closes out the server before turning it off.

electrical disturbance – electricity distorted by electrical equipment connected to the electrical system or by events outside the building.

external bridge – a bridge or router external to the file server.

external router – a NetWare router external to the file server.

FDDI – Fibre Distributed Data Interface. A fibre optic ring running at 100 Mbps.

file server – computer running the network operating system.

gateway – a device that allows one type of network to talk to a different type of network.

harmonic distortion – distorted electricity caused by the power supplies of certain electronic equipment.

IEEE – Institute of Electrical and Electronic Engineers.

interrupt – interrupts break in on the CPU's internal operations to ask for attention from the CPU.

interruption (also called *power outage* or *momentary*) – a complete stop in the flow of electricity, lasting from a fraction of a second to hours.

internal bridge – a bridge inside of the file server.

I/O, input/output – process by which the computer communicates with the external world.

LAN – local area network

logic – a name for the internal parts of the computer that perform functions defined by the rules of logic.

MB – megabytes, or 1 million bytes of memory.

media – a name for the physical channel of communication (i.e., floppy disk, hard disk, CD ROM, etc.).

microprocessor – the chip that executes instructions and manipulates information, also called the CPU.

momentary – *see interruption*.

network interface card – a card installed in the computer that talks to the network.

node – a location where something is physically connected to the network (servers, workstations and other devices).

noise – non-damaging distortion of electricity, which interferes primarily with communications equipment, caused by other equipment and electronic lighting. Radiated noise, sometimes referred to as EMF or RFI noise by engineers, is emitted through the air instead of the electrical system and is received by televisions, hearing aids, computer monitors and other communications equipment.

overvoltage (undervoltage) – an increase (decrease) in the normal voltage level lasting for seconds or minutes.

packet – contents of a message between one Network Layer entity and another.

power quality problem – the difference between the quality of electricity at an electrical outlet and the quality of the electricity required to reliably operate an electrical device, resulting in mis-operation or damage.

protocol – the rules for communication.

router – device used to route packets. It allows connection of several small networks into a larger, efficient network.

sag – a decrease of the normal voltage level lasting less than a second.

server – a special-purpose computer on a network that provides the other workstations with file storage service, printing services or communication services.

service panel – a cabinet that houses all circuit breakers or fuses for an office, suite or building.

state – condition, as in ON - OFF or HIGH - LOW.

swell – an increase in the normal voltage level lasting for less than a second.

token – an electronic message that is passed from station to station.

topology – the way the nodes in a network are connected.

transient – sharp changes in voltage, caused by lightning, large motors starting, utility operations and other equipment, that lasts for a fraction of a second.

twisted pair – wiring arranged in pairs twisted around one another to reduce interference.

WAN – wide area network.

workstation – the user's computer.

Acknowledgement

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