Power Quality
in your Commercial Office

Introduction

Commercial office workers are becoming increasingly dependent on electronic appliances to facilitate or complete their tasks. Once a luxury, the personal computer is now as indispensable as pen and paper. Email has practically replaced the pink message slips that were commonplace in the pre-1990s workplace. Fax machines have taken the legwork out of delivering documents. As you look around the typical office environment, you are likely to see half a dozen or more electronic appliances. The lighting above, the telephone on your desk, and the elevator that transports you from floor to floor – all incorporate electronic technologies. Even an appliance as seemingly simple as a digital clock contains sophisticated electronic circuits. As useful as these electronic appliances are, however, they are particularly susceptible to ***power quality problems***.*

What is a power quality problem? It's any distortion of electricity that results in damage or mis-operation of electronic appliances or other electrical devices. Additionally, power quality problems extend beyond the electric power system, such as when electronic lighting interferes with the operation of a television remote control. Some common symptoms of power quality problems in a commercial office are:

- flashing clocks
- data loss or computer shutdowns
- noise on a radio or telephone
- flickering lights
- damaged appliances

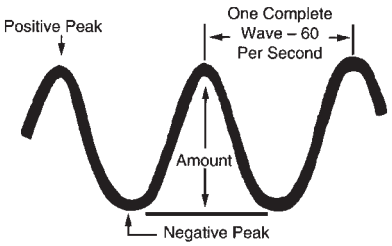
Although some symptoms may be obvious, a power quality problem can be complicated, involving the building wiring, natural phenomena such as lightning, interacting office appliances, and appliance connections to the electric power system. Most power quality problems involve electronic appliances, because such appliances are typically designed to operate with flawless electricity from the electric utility. However, many things can happen to electricity as it travels from the utility to an electronic appliance.

This brochure was created to help workers in a small commercial office understand and diagnose power quality problems. When used properly, it can help you avoid the costs of such problems, as well as ensuring the safety and reliability of your office appliances.

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

Power quality basics

Electricity is shaped like successive waves; that is, it alternates between positive and negative peaks, completing a cycle (measured from positive peak to positive peak) sixty times every second.



Electric utilities make every effort to ensure that your electricity meets strict standards set by the Canadian Standards Association, including delivering precisely shaped electricity to your building service panel. However, once electricity enters your building, appliances within the building can distort it.

Distorted electricity – in this brochure called ***electrical disturbances*** – can also be caused by equipment in neighbouring buildings or offices, as well as by events outside the office, such as lightning, downed power lines and routine utility activities. In fact, appliances and building wiring account for 80% of all power quality problems, which can be costly in terms of both worker frustration and money.

For example, assume that a typical commercial office has three personal computers and that the computer operators experience 20 lockups or reboots per year related to electrical disturbances. If each lockup or reboot costs $15 per computer in lost time and data, purchasing an uninterruptible power supply for each computer will pay for itself in one year (about $1,000). Additionally, the three office workers in our scenario will be more productive and more trusting of their computers.

How can you prevent and remedy costly power quality problems in your office? First, understand that an electronic appliance malfunction may be caused by something other than a power quality problem, such as:

- faulty appliance design
- manufacturing defects
- software errors
- operator errors
- using an appliance for something other than its intended purpose

Once you have determined that you indeed have a power quality problem, look for clues that will help you to determine a solution. A common symptom of a power quality problem is when a personal computer shuts down and reboots for no apparent reason. Some clues to the cause may be central air conditioning switching on before, flickering lights during, and blinking digital clocks after the shutdown. After identifying the problem and before employing a solution, you should correct any wiring and grounding problems, which can contribute significantly to a power quality problem. You can employ many solutions yourself, but solutions involving wiring and work at the service panel should be left to a professional.

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

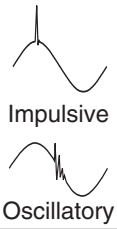
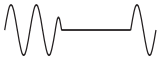
Power quality problems

Once you plug an appliance into an electrical outlet, it becomes part of the electric power system – a network of wires, appliances, equipment and devices. By plugging in an appliance, you are not only accessing electricity but also connecting your appliance to other appliances, other buildings and even BC Hydro's distribution system. This is why power quality problems can be so complex.

A power quality problem can be seen as consisting of four elements: an electrical disturbance, a cause of the disturbance, contributing factors and the effect of the electrical disturbance on an appliance. Most power quality problems are chain reactions. An initiating event causes an electrical disturbance, which is conducted by the building electrical system and aggravated by faulty wiring and grounding. The disturbance eventually reaches an electronic appliance, which can be upset or even damaged, depending upon the energy level of the disturbance and the tolerance level of the appliance.

An ***electrical disturbance*** is a type of distorted electricity. An initiating event will distort electricity by changing its shape or amount. The table below shows the most common electrical disturbances found in the electrical system of a typical office and their causes. Appliances directly interfering with each other, called **direct interference**, include electronic lighting and remote controls, and electronic lighting and energy management systems.

- ***Transients*** (also called **surges** and **spikes**) are distortions of electricity caused by lightning, large motors starting, routine utility activities and other appliances. These electrical disturbances can damage the components of electronic appliances, upset computer processes, and corrupt data.
- ***Noise*** can be transmitted either through the electrical system (**conducted**) or through the air (**radiated**). In this brochure, "noise" means the type transmitted through the electrical system, unless stated otherwise. Noise can be caused by communication appliances such as televisions and telephones, kitchen appliances, electronic lighting, vacuum cleaners and light dimmers, among others. Noise interferes with communication appliances and upsets some digital appliances, but does not typically damage them.
- ***Harmonic distortion*** is caused by the power supplies of certain electronic appliances, including televisions, fax machines, and especially personal computers. Harmonic distortion can overheat building transformers, building wiring, wiring in modular office panels, motors, and components in some appliances. This results in an increase in power consumption.
- A ***sag*** is a short (less than a second) decrease in the normal voltage level (measurement of electricity). Sags can be caused by motors starting, heaters in photocopiers and laser printers, and routine utility activities. Sags do not damage equipment, but can cause computers to restart or lock up, as well as causing digital clocks and other appliances to lose memory.

Electrical Disturbance	Cause of Disturbance
 Impulsive Transients (Surges or Spikes) Oscillatory	• 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

- A ***swell*** is a short (less than a second) increase in the normal voltage level. Mostly caused by motors stopping, swells generally do not upset or damage appliances but can initiate the failure of a stressed component in an electronic appliance.
- Much more rare than sags or swells, ***overvoltages*** and ***undervoltages*** are increases or decreases in the normal voltage level that last for seconds or minutes. These disturbances generally indicate a problem with the building's electrical system, such as an improperly adjusted ***building transformer***.
- Sometimes called a momentary or power outage, an ***interruption*** in electricity can last anywhere from fractions of a second to hours. Caused by lightning, downed power lines, tripped circuit breakers and blown fuses, interruptions disrupt computer processes, clocks and the memories of unprotected electronic devices.

A **cause** of an electrical disturbance is 1) any operation or activity – such as a motor starting or lightning – that distorts electricity enough to upset or damage an appliance, or 2) the normal operation of an appliance – such as electronic lighting – that directly interferes with the operation of another appliance – such as a cordless telephone.

Contributing factors are elements within the electrical system – such as faulty or overloaded electrical wiring – that enable or help an electrical disturbance to upset or damage appliances. Most contributing factors involve incorrect and sometimes unsafe wiring and grounding practices, or wiring and grounding not up to standards because the building is old. Other contributing factors include damaged or misapplied data cables and inadequate shielding of appliances.

The **effects** of electrical disturbances on appliances range from relatively benign blinking clocks to overheated wires in modular office panels and air conditioning compressors, which pose a fire hazard. However, the most common effect is upset – loss of data or computer lockups – which may not pose a physical threat but can be costly.

What is the solution? To solve a power quality problem, first conduct a thorough and precise survey of your office. The next section will help you investigate power quality problems and includes an appliance inventory table for recording and tracking power quality problems.

Surveying your office

The first and most important step in investigating a power quality problem is to walk through your office and record the location of each office appliance, the branch circuit to which each appliance is connected, and other appliance connections, such as data cables and telephone lines. The Inventory Table on page 6 will help you record your observations (an example has been entered). Photocopy the table to make as many inventory tables as you need to conduct a comprehensive survey of your office. The users of office appliances are the best sources of information, especially when you are trying to trace the history of power quality symptoms. Use the following five-step approach to record the environment and history of each office appliance on your inventory table:

1) Record the physical location of each appliance.
2) Record the branch circuit to which each appliance is connected.
3) Record all other appliance connections (including communication cables and power quality devices such as surge protectors).
4) Record any symptoms of power quality problems for each appliance, as well as when the symptoms were observed.
5) Inspect all visible electrical wiring.

Step One – Record the physical location of each appliance.

Knowing the physical location can be useful when you are trying to determine sources of radiated noise that can affect the performance of communication appliances. For example, as you walk through your office, you may note that a computer monitor is located close to the service panel. If your monitor screen wiggles, it's a good bet that the service panel is generating radiated noise (in this case, a magnetic field) that is interfering with your monitor.

WARNING: Before proceeding to Step Two, turn off all computers.

WARNING: Only an electrician or equally qualified person should switch off large breakers that feed heating, ventilation and air conditioning (HVAC) equipment, which should be labelled on the service panel.

Step Two – Record the branch circuit to which each appliance is connected.

Perhaps the most difficult and disruptive part of the investigation, this step is very important in identifying disturbing and susceptible appliances connected to the same branch circuit. You can determine which branch circuit feeds an appliance by turning on all lamps and appliances such as televisions and radios, locating the ***service panel*** for your office, turning off circuit breakers one at a time, and noting which electrical outlets lose power. (To facilitate the process, have a partner walk around the office looking for appliances that have lost power, while you stand at the service panel.) Each circuit breaker 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 appliance that loses power. 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 7, fill it in and tape it to the inside of the service panel door.

Another method to identify branch circuit outlets is to connect the base of a cordless phone to each electrical outlet without connecting the telephone line. Then, at the service panel, with the receiver in your hand and turned on, as you switch off the circuits 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 other appliance connections.

Look at each appliance carefully. Is it connected to another appliance (for example, a computer connected to a modem)? Is it connected to the telephone system? Cable system? A surge suppressor or other power quality device? Documenting such connections will help you solve data and signal problems, especially for appliances such as computers, telephones, fax machines and televisions, all of which can be damaged because of their multiple connections.

Step Four – Record the symptoms of power quality problems associated with each appliance.

Talk to office workers about the appliances they use, to determine a history of appliance performance. Have the staff individually record events and symptoms such as lightning and flickering lights that occur during and after the event. Be especially diligent in recording dates and times of symptoms, because they may coincide with lightning storms locally or elsewhere or routine utility activities, which are well documented.

Step Five – Finally, inspect all electrical wiring.

Inspect all power cords, data cables, telephone cords, television cable and electrical power strips. 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's electrical system, including the electrical outlets and service panel.

After you have completed your inventory sheet, you are ready to solve power quality problems in your office. The next section discusses solutions, their applications and their costs.

Solutions

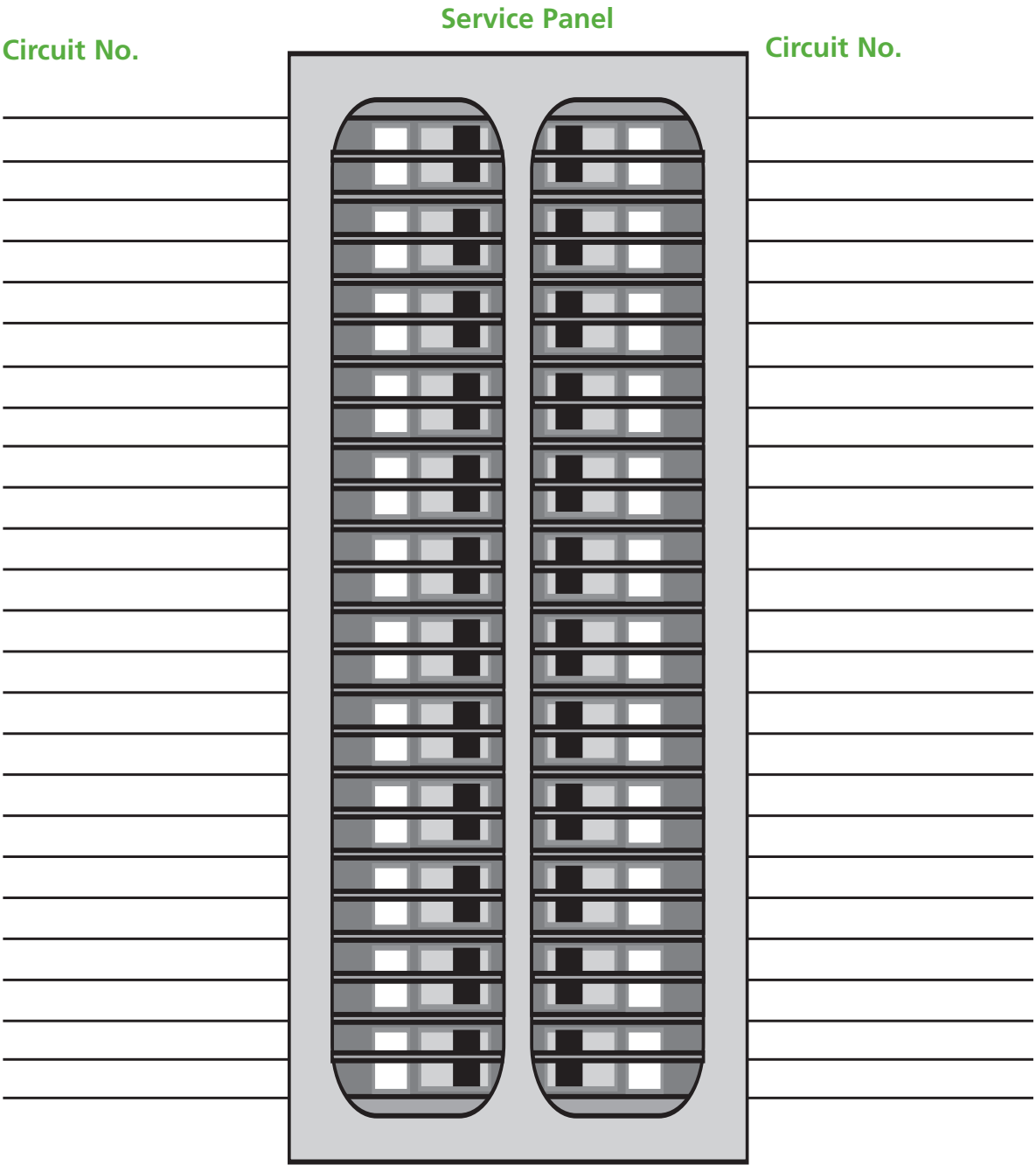
Now we have come to the most challenging part: solving the power quality problems in your office. Having completed your inventory table, you

Inventory Table

Appliance	Physical Location	Branch Circuit	Other Connections	Symptoms	Date/Time
Example: Computer	Last office left, next to service panel	13	Computer, surge protector	Screen wiggles	Intermittent

should have a record of symptoms of power quality problems for each office appliance. The next step is to match symptoms to solutions by following the Problem-Solving Flowchart on page 8 and the Problem-Solving Table on pages 10 and 11.

First, eliminate all contributing factors, especially wiring and grounding problems. For example, inspect the electrical outlet to which an appliance with 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 appliances, such as fans and digital clocks, do not require a connection to the grounding slot, but appliances such as computers and telephone equipment often use a ground to transmit data. (For such appliances, worn or incorrectly connected data cables or phone lines can be contributing factors.) Additionally, a ground is needed to meet safety standards, because some appliances may otherwise be shock hazards. In any event, outlets without grounds should be upgraded by a licensed electrician.

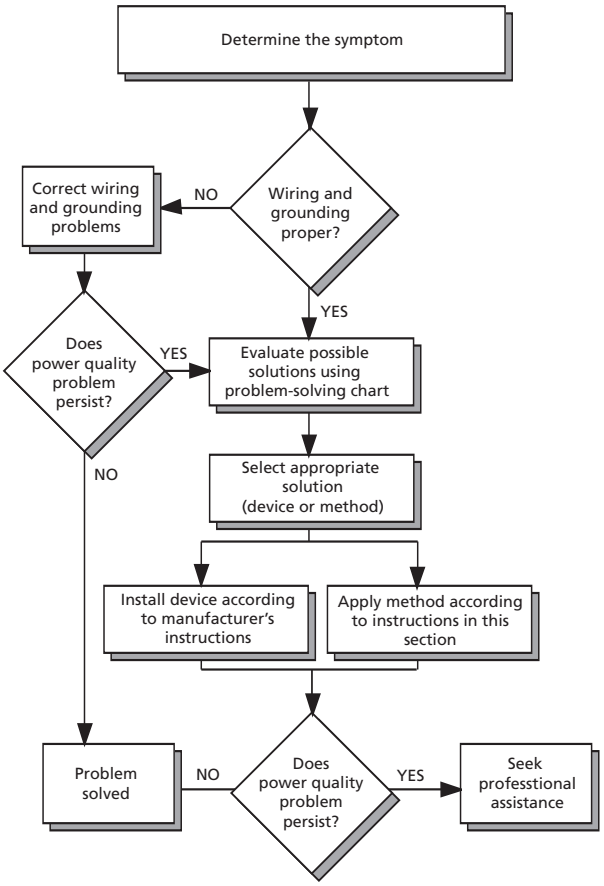
Here are some tips to help you identify and correct common contributing factors:

- Eliminate long branch circuits created by connecting successive modular office panels or extension cords. The wires in these

extensions may overheat and pose a fire hazard. Additionally, long branch circuits increase the effects of sags.

- If you identify that any circuits are connected to separate ground rods (called isolated grounds) at the service entrance, contract a licensed electrician for advice.
- If you identify that any metal conduit or piping is used as a ground, contract a licensed electrician for correction.
- For branch circuits feeding large appliances and equipment such as elevators and HVAC equipment, the electrical conductors may not be large enough to handle the rush of electricity as the motors start. Undersized wiring can promote sags and can overheat because of harmonic distortion. A licensed electrician can determine whether conductors are sized correctly.

Problem-solving flowchart



- Contract an electrician to check the voltage level at electrical outlets. If it is too high or too low, the electrician may be able to adjust the building transformer to achieve the proper voltage levels.

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 an appliance. The solutions in the Problem-Solving Table are explained below in alphabetical order.

WARNING: Always follow manufacturer's instructions when installing any of the devices discussed in this brochure.

Fibre-optic cables – If your office computers are connected to a local area network (LAN) and you are experiencing data errors and lockups, this option may be most effective, as it eliminates the electrical connections between computers. Suppliers of fibre-optic equipment can provide you with details about installation and cost.

Harmonic filter – A harmonic filter is a device that removes harmonic distortion on the service supply, thereby improving the power quality. However before you consider applying a harmonic filter, try to mitigate harmonic distortion in your office wiring by spreading harmonic distortion-causing appliances (especially computers) across as many branch circuits as possible. Additionally, appliances with the ENERGY STAR® label produce significantly less harmonic distortion, because they power down when not in use. Should your electrician decide that you need to install a harmonic filter to further reduce distortion, then contact an electrical design consultant.

Noise filters – A noise filter plugs into any electrical outlet and reduces noise caused by the connected appliances. They are most widely used for televisions to reduce noise that interferes with signal reception. Many plug-in surge protectors (see below) include a noise filter. They can be purchased at electronics and department stores.

Power conditioners – A power conditioner is a device that reduces or eliminates noise transmitted through the electrical system, thereby improving the power quality to the appliance. Should this be required, install a power conditioner between the susceptible appliance and the electrical outlet. Some power conditioners include surge protection and voltage regulation, but make sure that the power conditioner you purchase has an isolation feature, which is indicated as "True Line" or "Load-to-Load" isolation by some manufacturers. Power conditioners can be purchased through electronics suppliers and cost from $200 to $800.

Relocation – may be the most expedient and least expensive solution to a power quality problem. You may want to relocate an appliance to a different branch circuit or different physical location for a number of reasons:

- To separate a disturbing appliance (photocopier) from a susceptible one (fax machine).
- To connect appliances that share a communication cable (computer and printer) to the same branch circuit.
- To remove an appliance (computer monitor) away from sources of radiated noise (service panel).

One way to determine the source of noise is to turn off circuit breakers one at a time until the noise is gone. This procedure will limit the source to appliances connected to a particular branch circuit. If you have noise on a telephone and cannot find the source, call your telephone company for assistance.

Surge protectors – Also known as surge suppressors, surge arresters and TVSSs (transient voltage surge suppressors), these limit the amount of electricity at the point of installation.

Surge protectors can be installed at three locations: at the source of surges (an appliance), at the susceptible appliance and at the service panel. Most surge protectors are designed to plug into an electrical outlet and can be purchased at department stores or any vendor that carries electronics supplies. Features of the plug-in type of surge protector include noise filtering, indicator lights to let you know that the protector is working, and connections for telephone lines, television cables or data cables. Make sure that the model you purchase has three-way protection and is CSA approved. Prices for this type of surge protector can range from $25 to $75.

Surge protectors that mount at the service panel protect appliances from surges caused by lightning and crossed power lines and are called whole-home protectors or surge arresters. Most mount on the outside of the service panel; a few mount on the inside of the panel like a circuit breaker. Surge protectors designed to mount at the service panel can be purchased from vendors that carry electrical supplies; prices range from $50 to $300.

UPS (uninterruptible power supply) – Also called a battery backup system, this supplies an appliance with electricity during long sags and short interruptions. UPSs are connected between an appliance and the electrical outlet. Avoid connecting laser printers and photocopiers to a UPS, because their heaters may use more electricity than the UPS rating and cause it to malfunction. UPSs generally include surge protection; some models also include noise filtering. Make sure that the UPS you purchase is CSA approved. UPSs can be purchased at most office supply vendors and cost between $150 and $1,000.

For further assistance

If, after following the procedures recommended in this brochure, power quality problems persist in your office, contact a qualified electrician. Provide your electrician with the information about your office recorded in the inventory table.

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

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

building transformer – a customer-owned electrical device for changing the voltage from a high level to a low level.

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

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

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

momentary – *see* interruption.

noise – non-damaging distortion of electricity, which interferes primarily with communications appliances, caused by other appliances 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 communication appliances.

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

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 appliance, resulting is mis-operation or damage.

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

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

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

transients – sharp changes in voltage, caused by lightning, large motors starting, utility operations and other appliances, that last a fraction of a second.

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