



# power quality in your home

h.e.l.p. sheet

## overview

*This brochure was created to help home owners to 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 home appliances.*

## Background

As families continue to improve their way of life by using state-of-the-art home appliances and electronics, they place new demands on their homes' wiring and electric service system. Most modern household appliances contain sophisticated electronic components. Personal computers, fax modems, VCRs, CD and DVD players and digital clocks are now commonplace. In the near future, we can expect electronically driven heat pumps, washing machines and advanced lighting systems. Even the most mundane household chores will be facilitated by electronic technologies. Clothing will be dried by microwaves, and family meals will be prepared in high-efficiency, all-electronic kitchens.

In past decades, toasters, lights and motors were very forgiving of disparities in a home's electrical system. The advanced electronic equipment that has brought efficiencies to offices and factories, and now to our homes, has introduced some problems as well. Much of this equipment is uncommonly sensitive to routine power line disturbances, and some household devices even create their own disturbances that feed back through the house's wiring to interfere with other appliances and other residences. 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 residence are:

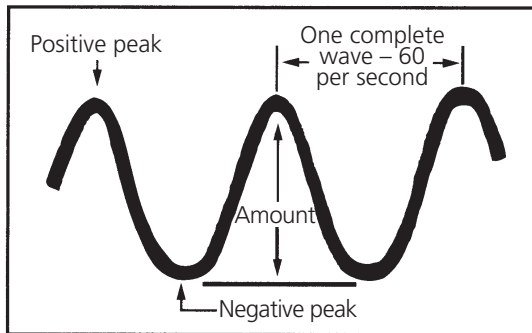
- flashing clocks
- noise on a radio or telephone
- flickering lights
- damaged appliances
- data loss or computer shutdowns

Although some symptoms may be obvious, a power quality problem can be complicated, involving the residence wiring, natural phenomena such as lightning, interacting home 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.

\* Words and phrases in italics are included in the glossary, page 11.

## 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 residence service panel. However, once electricity enters your home, appliances within the premises can distort it.

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



A recent customer survey indicated that customers are genuinely concerned about their electronic appliances and are beginning to understand that different appliances may have different levels of immunity to power quality problems. The same survey showed that appliance manufacturers tend to do what the market dictates. Any potential addition or extra feature can increase the cost of the appliance, which, in these economic times, can be the most important

purchasing factor. For example, adding an energy storage device to a digital clock to enable it to ride through momentary power interruptions may increase the cost of the clock by two dollars, making it uncompetitive with digital clocks that have no protection.

Certain appliance retailers that service the appliances that they sell have found that their early electronic-controlled systems malfunctioned and could be damaged under certain power quality conditions. Their present appliance design strategy includes new power quality testing. This strategy increases customer satisfaction, and reduces warranty and service contract expenses on dishwashers, microwave ovens and other major home appliances.

Unfortunately, at this time, available data on appliances is insufficient to fully characterize the power quality and residence compatibility performance of electronics-based appliances. Present studies indicate a wide range of performance among appliance manufacturers.

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

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

Once you have determined that you do have a power quality problem, look for clues that will help you to find a solution. A common symptom of a power quality problem is when any electronic appliance shuts down and then starts up 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 house 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 your home.

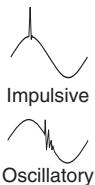







## Power quality problems

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 the utility 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's 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 (right) shows the most common electrical disturbances found in the electrical system of a typical residence and their causes.

- **Transients** (also called **surges** and **spikes**) are distortions of electricity caused by lightning, motors starting, routine utility activities and other appliances. These electrical disturbances can damage the components of electronic appliances, corrupt data on personal computers, and interfere with radio/TV/communications equipment.
- **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 service transformers, residence wiring, wiring in service 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 appliance 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.
- 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

Electrical Disturbance	Cause of Disturbance
 <p>Impulsive Transients (Surges or Spikes) Oscillatory</p>	<ul style="list-style-type: none"> <li>• motors in air conditioners, HVAC equipment, elevators, water coolers, fans</li> <li>• lightning</li> <li>• photocopiers and laser printers</li> <li>• static discharge</li> <li>• routine utility activity</li> <li>• electronic air ionizers</li> <li>• kitchen appliances</li> </ul>
 <p>Noise</p>	<ul style="list-style-type: none"> <li>• HVAC equipment</li> <li>• kitchen appliances</li> <li>• radiators, telephones</li> <li>• light dimmers</li> <li>• overhead lines</li> <li>• electronic lighting</li> <li>• building transformers</li> <li>• electronic air ionizers</li> <li>• vacuum cleaners</li> </ul>
 <p>Harmonic Distortion</p>	<ul style="list-style-type: none"> <li>• computers</li> <li>• televisions, video cassette recorders</li> <li>• electronic lighting</li> </ul>
 <p>Sag</p>	<ul style="list-style-type: none"> <li>• motors in air conditioners, HVAC equipment, elevators, water coolers, fans</li> <li>• photocopiers and laser printers</li> <li>• routine utility activities</li> </ul>
 <p>Swell</p>	<ul style="list-style-type: none"> <li>• motors in air conditioners, HVAC equipment, elevators, water coolers, fans</li> <li>• photocopiers and laser printers</li> </ul>
 <p>Undervoltage</p>	<ul style="list-style-type: none"> <li>• improper wiring and grounding</li> <li>• improper voltage tap adjustment</li> <li>• defective building transformer</li> </ul>
 <p>Overvoltage</p>	<ul style="list-style-type: none"> <li>• improper wiring and grounding</li> <li>• improper voltage tap adjustment</li> <li>• defective building transformer</li> <li>• crossed power lines</li> </ul>
 <p>Interruption</p>	<ul style="list-style-type: none"> <li>• lightning</li> <li>• tripped circuit breaker, blown fuse</li> <li>• downed power lines</li> </ul>

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 service 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 appliances and 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 residence is old. Other contributing factors include damaged or misapplied cables and inadequate shielding of appliances.

The **effects** of electrical disturbances on appliances range from relatively benign blinking clocks to overheated wires in the circuit breaker panel and air conditioning compressors, which can pose a fire hazard. However, the most common effect is upset – loss of timing/control sense 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 home. 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 home

The first and most important step in investigating a power quality problem is to walk through your home and record the location of each electronically operated 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 5 will help you record your observations (one example has been entered). Photocopy the table to make as many inventory tables as you need to conduct a comprehensive survey of your home. The users of residential 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 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 conducted and radiated noise

that can affect performance of communication appliances. For example, as you walk through your home, you may note that a television or 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 TVs and computers.

### 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 residence, turning off circuit breakers one at a time, and noting which electrical outlets lose power. (To facilitate the process, have a partner walk around your home 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 6, fill it in and tape it to the inside of the service panel door.

Another method to identify branch circuit outlets is to plug in 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 home.

### Step Three – Record all other appliance connections.

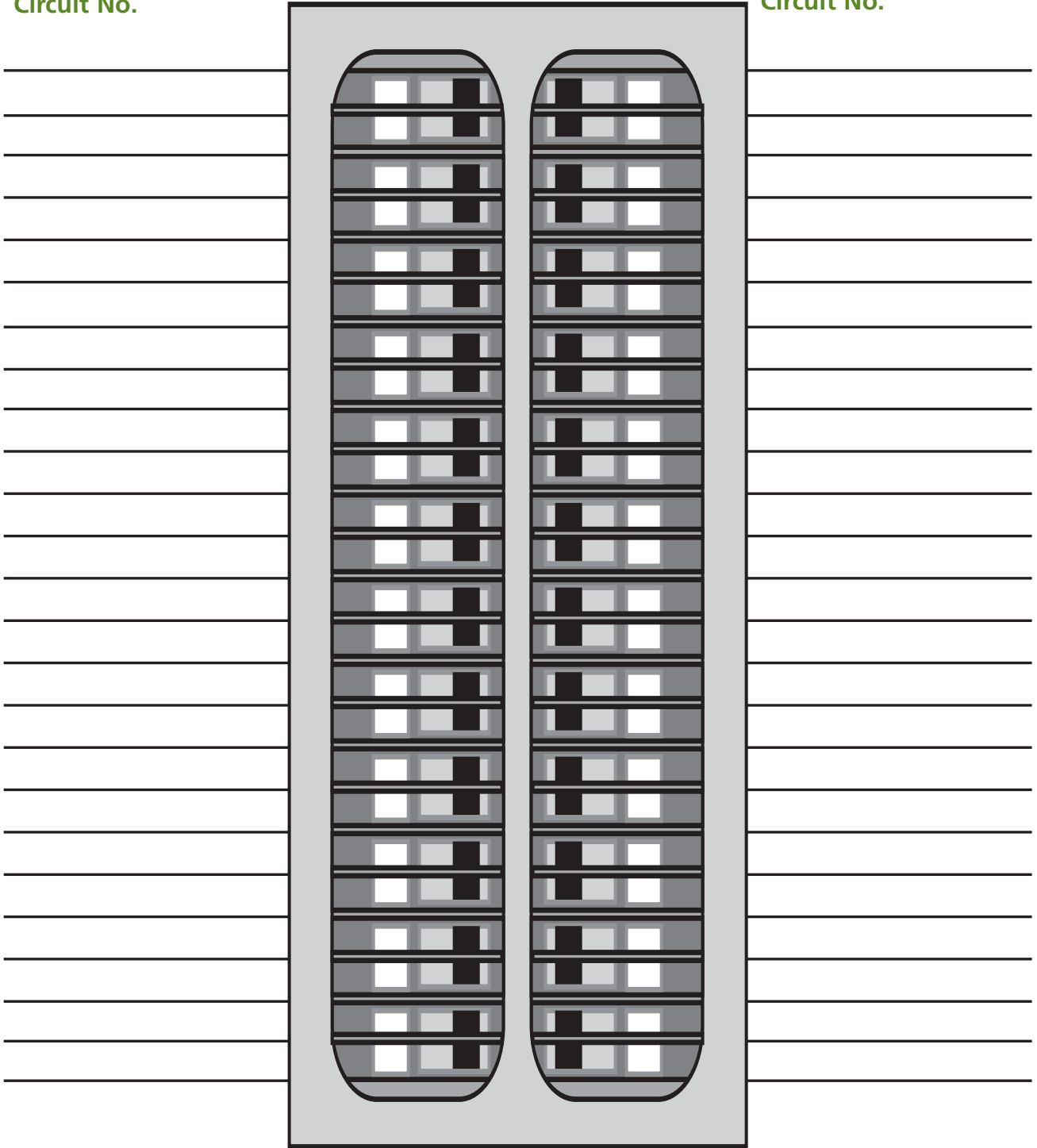
Look at each appliance carefully. Is it connected to another appliance (for example, a computer connected to a modem)? Is it connected to the telephone system? Cable system? A surge suppressor or other power quality device? Documenting such connections will help you solve data and signal problems, especially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



# Service Panel

Circuit No.

Circuit No.



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

Talk to other family members about the appliances they use, to determine a history of appliance performance. Have them 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 visible wiring, such as power cords, data cables, telephone cords, television cable and electrical power strips.**

Make sure they are safely tucked away and not wrapped around appliances. Damaged or ungrounded cables should be replaced or properly connected. You may also want to contract an electrician to inspect your home'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 home. The next section discusses solutions.

## **Solutions**

Now we have come to the most challenging part: solving the power quality problems in your home. Having completed your inventory table, you should have a record of symptoms of power quality problems for each appliance. The next step is to match symptoms to solutions by following the Problem-Solving Flowchart on the next page and the Problem-Solving Table at the end of this section.

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 extension cords. The wires in these extensions

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

- If you identify that circuits are connected to separate ground rods (called isolated grounds) at the service entrance, contact a licensed electrician for advice.
- If you identify that any metal conduit or piping is used as a ground, contact a licensed electrician for correction.
- For branch circuits feeding large appliances and equipment, such as electric ovens, air conditioners and furnaces, the electrical wires may not be adequate to handle the rush of electricity as the appliance starts. Undersized wiring can promote sags and can overheat because of harmonic distortion. A licensed electrician can determine whether conductors are sized correctly.
- Contact an electrician to check the voltage level at electrical outlets. If it is too high or too low, the electrician may be able to contact BC Hydro to discuss adjusting your service transformer and 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.

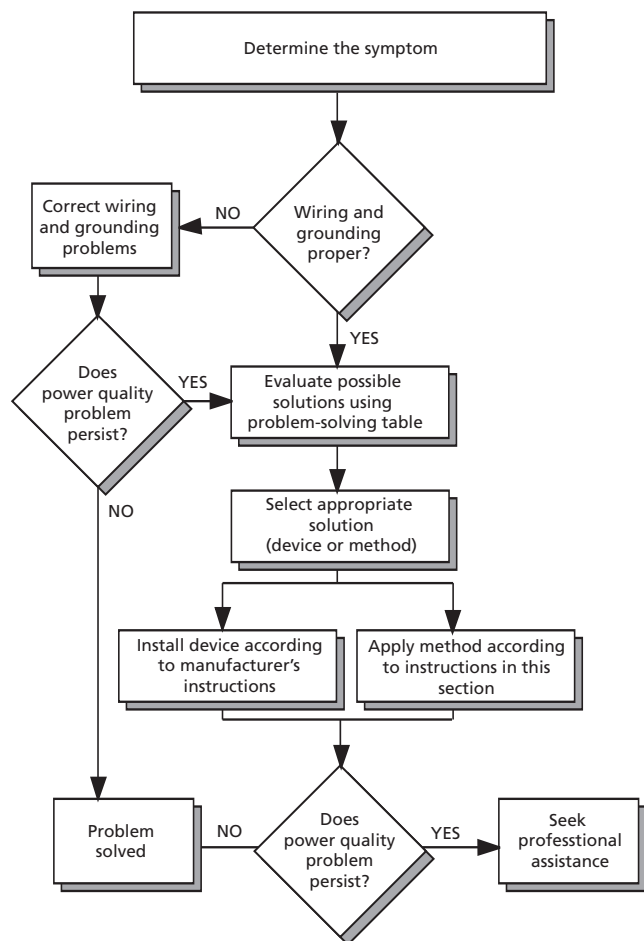
Once all contributing factors have been corrected, evaluate other possible solutions. In the Problem-Solving Table, solutions are listed by least to most expensive. Some solutions involve contacting a professional, which can increase the cost of the solution significantly. However, some power quality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

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

**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 (refrigerator) from a susceptible one (personal computer)
- To connect appliances that share a communication cable (computer and printer) to the same branch circuit.
- To remove an appliance (television) away from sources of radiated noise (electric mixer).

## Problem-solving flowchart



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) – limit the amount of electricity at the point of installation. Surge protectors can be installed at two locations: a plug-in device at the point of use of the electronic equipment, 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 electronic 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.

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.

**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 above) include a noise filter. They can be purchased at department stores and electronic 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. This is indicated as “True Line” or “Load-to-Load” isolation by some manufacturers. Power conditioners can be purchased through electronic suppliers.

A **UPS** (uninterruptible power supply), also called a battery backup system, 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/ULC approved. UPSs can be purchased at most office supply vendors.

## For further assistance

If, after following the procedures recommended in this brochure, power quality problems persist in your home, take the information about your home recorded in the inventory table to a qualified electrician.



# Problem-solving table

APPLIANCE	SYMPTOM	DISTURBANCE	CONTRIBUTING FACTORS	CAUSE OF DISTURBANCE	SOLUTIONS (Arranged by cost from lowest to highest)
Air conditioner	Compressor Overheating/early failure	<ul style="list-style-type: none"> <li>Harmonic distortion</li> <li>Undervoltage</li> </ul>	<ul style="list-style-type: none"> <li>Low voltage</li> <li>Faulty ground</li> <li>Undersized wiring</li> </ul>	<ul style="list-style-type: none"> <li>Computers, televisions, VCRs, electronic lighting</li> <li>Defective service transformer*</li> <li>Improper voltage tap adjustment*</li> </ul>	<ul style="list-style-type: none"> <li>Install harmonic filter at source or at air conditioner</li> <li>Install surge protector at surge source or at air conditioner</li> <li>Install surge suppressor at service panel</li> </ul>
Clock (digital)	Runs fast	<ul style="list-style-type: none"> <li>Transients (oscillatory)</li> </ul>		<ul style="list-style-type: none"> <li>Air ionizers, kitchen appliances</li> <li>Lightning, crossed power lines, routine utility activities</li> </ul>	<ul style="list-style-type: none"> <li>Discontinue using disturbance-causing appliance</li> <li>Replace with new clock</li> <li>Install surge protector with "sine wave tracking feature" at clock</li> </ul>
	Loses memory, blinks	<ul style="list-style-type: none"> <li>Sags</li> <li>Interruptions</li> </ul>	<ul style="list-style-type: none"> <li>Low voltage</li> </ul>	<ul style="list-style-type: none"> <li>Lightning, downed power line, routine utility activities</li> <li>Tripped circuit breakers, blown fuses</li> </ul>	<ul style="list-style-type: none"> <li>Install or replace backup battery</li> <li>Replace with model incorporating backup battery</li> </ul>
Compressor motors	Overheating, stalls, vibration/early failure	<ul style="list-style-type: none"> <li>Harmonic distortion</li> <li>Undervoltage</li> </ul>	<ul style="list-style-type: none"> <li>Low voltage</li> <li>Faulty ground</li> <li>Undersized wiring</li> </ul>	<ul style="list-style-type: none"> <li>Computers, televisions, VCRs, electronic lighting</li> <li>Defective service transformer*</li> <li>Improper voltage tap adjustment*</li> </ul>	<ul style="list-style-type: none"> <li>Relocate compressor motor to a different branch circuit</li> <li>Ask manufacturer for availability of heavier-duty model</li> </ul>
Computers & digital appliances (including networks, peripherals)	Resets/lockups	<ul style="list-style-type: none"> <li>Transients (impulsive)</li> <li>Transients (oscillatory)</li> <li>Sags, interruptions</li> <li>Noise</li> </ul>	<ul style="list-style-type: none"> <li>Faulty ground, loose wiring</li> <li>Defective data cables</li> <li>Mis-wired electrical outlet</li> <li>Low voltage</li> </ul>	<ul style="list-style-type: none"> <li>Equipment starting and stopping</li> <li>Lightning, crossed power lines, downed power lines, routine utility activities</li> <li>Photocopiers and laser printers</li> <li>Tripped circuit breakers, blown fuses</li> </ul>	<ul style="list-style-type: none"> <li>Relocate computer and peripherals or digital appliance to a different branch circuit.</li> <li>Install surge protector with data port at computer or appliance</li> <li>Install surge suppressor at service panel</li> <li>Install UPS at computer or digital appliance</li> </ul>
	Data errors	<ul style="list-style-type: none"> <li>Noise</li> <li>Transients (impulsive)</li> <li>Transients (oscillatory)</li> </ul>	<ul style="list-style-type: none"> <li>Faulty ground</li> <li>Mis-wired electrical outlet</li> <li>Low voltage</li> </ul>	<ul style="list-style-type: none"> <li>Overhead distribution lines, service transformer</li> <li>Motors in air conditioners, furnaces, refrigerators, fans</li> <li>Lightning, crossed power lines, routine utility activities</li> <li>Photocopiers and laser printers, static discharge</li> </ul>	<ul style="list-style-type: none"> <li>Connect computer and peripherals or digital appliance to the same branch circuit</li> <li>Relocate computer and peripherals or digital appliance to a different branch circuit</li> <li>Install surge protector with data port at computer or appliance</li> <li>Install power conditioner at computer or digital appliance</li> </ul>
Computer monitor	Wavy lines or noise on screen	<ul style="list-style-type: none"> <li>Noise (radiated)</li> </ul>	<ul style="list-style-type: none"> <li>Faulty ground</li> <li>Long branch circuit</li> </ul>	<ul style="list-style-type: none"> <li>Service transformer</li> <li>Electric heaters</li> <li>Overhead distribution lines</li> <li>Service panels</li> </ul>	<ul style="list-style-type: none"> <li>Relocate monitor away from source of noise</li> <li>Change monitor software scan rate (contact dealer)</li> <li>Relocate monitor and computer to a different branch circuit</li> </ul>
Doorbell (electronic)	Rings randomly	<ul style="list-style-type: none"> <li>Transients (impulsive)</li> <li>Transients (oscillatory)</li> </ul>		<ul style="list-style-type: none"> <li>Equipment and motors starting and stopping</li> <li>Photocopiers and laser printers</li> <li>Lightning, crossed power lines, routine utility activities</li> </ul>	<ul style="list-style-type: none"> <li>Request that the manufacturer modify doorbell</li> </ul>
Energy management system	Inoperative	<ul style="list-style-type: none"> <li>Direct interference</li> </ul>		<ul style="list-style-type: none"> <li>Electronic lighting</li> </ul>	<ul style="list-style-type: none"> <li>Change carrier signal of energy management system*</li> </ul>
Facsimile	Lost memory	<ul style="list-style-type: none"> <li>Sags</li> <li>Interruptions</li> </ul>	<ul style="list-style-type: none"> <li>Faulty ground</li> <li>Undersized wiring</li> <li>Mis-wired electrical outlet</li> </ul>	<ul style="list-style-type: none"> <li>Equipment and motors starting and stopping</li> <li>Lightning, downed power lines, routine utility activities</li> <li>Photocopiers and laser printers</li> <li>Tripped circuit breakers, blown fuses</li> </ul>	<ul style="list-style-type: none"> <li>Relocate facsimile to a different branch circuit</li> <li>Install UPS at facsimile</li> </ul>
	Faulty transmission	<ul style="list-style-type: none"> <li>Noise</li> <li>Transients (impulsive)</li> <li>Transients (oscillatory)</li> </ul>	<ul style="list-style-type: none"> <li>Faulty ground</li> <li>Loose wiring</li> <li>Mis-wired electrical outlet</li> </ul>	<ul style="list-style-type: none"> <li>Overhead distribution lines, service transformer</li> <li>Motors in air conditioners, furnaces, refrigerators, fans</li> <li>Lightning, crossed power lines, routine utility activities</li> <li>Photocopiers and laser printers</li> </ul>	<ul style="list-style-type: none"> <li>Relocate facsimile to a different branch circuit</li> <li>Install noise filter at intercom</li> <li>Install power conditioner at facsimile</li> </ul>
Fans, furnaces	Overheating, stalls, vibration/early failure	<ul style="list-style-type: none"> <li>Harmonic distortion</li> <li>Undervoltage</li> </ul>	<ul style="list-style-type: none"> <li>Low voltage</li> <li>Faulty ground</li> <li>Undersized wiring</li> </ul>	<ul style="list-style-type: none"> <li>Computers, televisions, VCRs, electronic lighting</li> <li>Defective service transformer*</li> <li>Improper voltage tap adjustment</li> </ul>	<ul style="list-style-type: none"> <li>Relocate fan or furnace to a different branch circuit</li> <li>Ask manufacturer for availability of heavier-duty model</li> </ul>
Intercom	Buzzes, hums	<ul style="list-style-type: none"> <li>Noise</li> </ul>	<ul style="list-style-type: none"> <li>Faulty ground</li> </ul>	<ul style="list-style-type: none"> <li>Motors in air conditioners, furnaces, refrigerators, fans</li> <li>Radios, televisions, video cassette recorders</li> </ul>	<ul style="list-style-type: none"> <li>Relocate noisy appliances to different branch circuit</li> <li>Install noise filter at intercom</li> <li>Install power conditioner at intercom</li> </ul>
Lighting (electronic)	Flickering	<ul style="list-style-type: none"> <li>Sags</li> </ul>	<ul style="list-style-type: none"> <li>Faulty ground</li> <li>Undersized wiring</li> </ul>	<ul style="list-style-type: none"> <li>Motors in air conditioners, furnaces, refrigerators, fans</li> <li>Photocopiers and laser printers</li> </ul>	<ul style="list-style-type: none"> <li>Connect lighting to a different branch circuit</li> <li>Install a soft-start kit on all sag-causing motors*</li> </ul>

\* Consult professional

## Problem-solving table

APPLIANCE	SYMPTOM	DISTURBANCE	CONTRIBUTING FACTORS	CAUSE OF DISTURBANCE	SOLUTIONS (Arranged by cost from lowest to highest)
Microwave oven	Loses memory, clock blinks	<ul style="list-style-type: none"> <li>Sags</li> <li>Interruptions</li> </ul>	<ul style="list-style-type: none"> <li>Low voltage</li> </ul>	<ul style="list-style-type: none"> <li>Lightning storms, downed power lines</li> <li>Tripped circuit breakers, blown fuses</li> </ul>	<ul style="list-style-type: none"> <li>Replace with model incorporating a built-in backup battery</li> </ul>
Modular home office panels	Overheating, fire	<ul style="list-style-type: none"> <li>Harmonic distortion</li> </ul>		<ul style="list-style-type: none"> <li>Computers, televisions, electronic lighting</li> </ul>	<ul style="list-style-type: none"> <li>Ask manufacturer to replace with model incorporating larger wires</li> <li>Reduce number of appliances connected to panel electrical outlets*</li> </ul>
Photocopier/laser printer	Data errors, lost memory	<ul style="list-style-type: none"> <li>Sags</li> <li>Transients (impulsive)</li> </ul>	<ul style="list-style-type: none"> <li>Mis-wired electrical outlet</li> <li>Faulty ground</li> <li>Defective data cables</li> <li>Low voltage</li> </ul>	<ul style="list-style-type: none"> <li>Equipment and motors starting and stopping</li> <li>Lightning, crossed power lines, routine utility activities</li> </ul>	<ul style="list-style-type: none"> <li>Relocate photocopier or laser printer to a different branch circuit</li> <li>Install surge protector at photocopier or surge protector with port at laser printer</li> <li>Install surge suppressor at service panel</li> </ul>
Radio	Static or buzz in speakers	<ul style="list-style-type: none"> <li>Noise</li> <li>Noise (radiated)</li> </ul>	<ul style="list-style-type: none"> <li>Mis-wired electrical outlet</li> <li>Faulty ground</li> </ul>	<ul style="list-style-type: none"> <li>Electronic lighting</li> <li>Kitchen appliances</li> <li>Equipment and motors starting and stopping</li> </ul>	<ul style="list-style-type: none"> <li>Relocate radio away from noisy appliances</li> <li>Install surge protector with noise filter at radio</li> </ul>
Scale (digital)	Faulty readout	<ul style="list-style-type: none"> <li>Noise</li> <li>Transients (impulsive)</li> </ul>	<ul style="list-style-type: none"> <li>Mis-wired electrical outlet</li> <li>Faulty ground</li> <li>Low voltage</li> </ul>	<ul style="list-style-type: none"> <li>Kitchen appliances, light dimmers</li> <li>Equipment and motors starting and stopping</li> <li>Photocopiers and laser printers</li> <li>Lightning, crossed power lines, routine utility activities</li> </ul>	<ul style="list-style-type: none"> <li>Relocate digital scale to a different branch circuit</li> <li>Install a surge protector with noise filter at digital scale</li> </ul>
Security/fire alarm	Random tripping and malfunction	<ul style="list-style-type: none"> <li>Noise</li> <li>Transients (impulsive)</li> </ul>	<ul style="list-style-type: none"> <li>Mis-wired electrical outlet</li> <li>Faulty ground</li> <li>Low voltage</li> </ul>	<ul style="list-style-type: none"> <li>Kitchen appliances, light dimmers</li> <li>Equipment and motors starting and stopping</li> <li>Photocopiers and laser printers</li> <li>Lightning, crossed power lines, routine utility activities</li> </ul>	<ul style="list-style-type: none"> <li>Relocate alarm system panel to a different branch circuit</li> <li>Install surge protector with noise filter at alarm system panel*</li> <li>Install power conditioner at alarm system panel</li> <li>Install UPS at alarm system panel</li> </ul>
Table saw	Overheating, stalls, vibration/early railure	<ul style="list-style-type: none"> <li>Harmonic distortion</li> <li>Undervoltage</li> </ul>	<ul style="list-style-type: none"> <li>Low voltage</li> <li>Faulty ground</li> <li>Undersized wiring</li> </ul>	<ul style="list-style-type: none"> <li>Computers, televisions, VCRs, electronic lighting</li> <li>Defective service transformer</li> <li>Improper voltage tap adjustment</li> </ul>	<ul style="list-style-type: none"> <li>Relocate table saw to a different branch circuit</li> <li>Ask manufacturer for availability of heavier-duty model</li> </ul>
Telephone	Static or buzz in receiver	<ul style="list-style-type: none"> <li>Noise</li> <li>Noise (radiated)</li> </ul>	<ul style="list-style-type: none"> <li>Mis-wired electrical outlet</li> <li>Faulty ground</li> </ul>	<ul style="list-style-type: none"> <li>Electronic lighting</li> <li>Kitchen appliances</li> <li>Equipment and motors starting and stopping</li> </ul>	<ul style="list-style-type: none"> <li>Relocate telephone away from noisy appliances</li> <li>Install a noise filter at telephone</li> <li>Install surge protector with telephone port at telephone</li> </ul>
Telephone answering machine	Loses calls	<ul style="list-style-type: none"> <li>Sags</li> <li>Interruptions</li> </ul>	<ul style="list-style-type: none"> <li>Low voltage</li> </ul>	<ul style="list-style-type: none"> <li>Lightning, downed power lines, routine utility activities</li> <li>Tripped circuit breakers, blown fuses</li> </ul>	<ul style="list-style-type: none"> <li>Install UPS at telephone system panel</li> </ul>
Telephone answering machine	Loses memory	<ul style="list-style-type: none"> <li>Sags</li> <li>Interruptions</li> </ul>	<ul style="list-style-type: none"> <li>Low voltage</li> </ul>	<ul style="list-style-type: none"> <li>Lightning, downed power lines, routine utility activities</li> <li>Tripped circuit breakers, blown fuses</li> </ul>	<ul style="list-style-type: none"> <li>Relocate answering machine to a different branch circuit</li> <li>Install UPS at answering machine</li> </ul>
Television	Wavy lines or noise on screen	<ul style="list-style-type: none"> <li>Noise</li> <li>Noise (radiated)</li> </ul>	<ul style="list-style-type: none"> <li>Mis-wired electrical outlet</li> <li>Faulty ground</li> <li>Long branch circuit</li> </ul>	<ul style="list-style-type: none"> <li>Kitchen appliances</li> <li>Equipment and motors starting and stopping</li> </ul>	<ul style="list-style-type: none"> <li>Relocate television to a different branch circuit</li> <li>Install a noise filter at television</li> <li>Install surge protector with cable port at television</li> </ul>
Television	Remote control does not work	<ul style="list-style-type: none"> <li>Direct interference</li> </ul>		<ul style="list-style-type: none"> <li>Electronic lighting</li> </ul>	<ul style="list-style-type: none"> <li>Replace television or lighting with different brands</li> </ul>
Video cassette recorder	Loses memory, clock blinks	<ul style="list-style-type: none"> <li>Sags</li> <li>Interruptions</li> </ul>	<ul style="list-style-type: none"> <li>Low voltage</li> </ul>	<ul style="list-style-type: none"> <li>Lightning storms, crossed power lines</li> <li>Defective service transformer</li> </ul>	<ul style="list-style-type: none"> <li>Relocate video cassette recorder to a different branch circuit</li> <li>Replace with model incorporating battery backup</li> </ul>
Video cassette recorder	Remote control does not work	<ul style="list-style-type: none"> <li>Direct interference</li> </ul>		<ul style="list-style-type: none"> <li>Electronic lighting</li> </ul>	<ul style="list-style-type: none"> <li>Replace video cassette recorder or lighting with different brands</li> </ul>
All	Appliance component damage	<ul style="list-style-type: none"> <li>Transients (impulsive)</li> <li>Transients (oscillatory)</li> <li>Undervoltages</li> <li>Overvoltages</li> <li>Sags</li> <li>Interruptions</li> </ul>	<ul style="list-style-type: none"> <li>Mis-wired electrical outlet</li> <li>Faulty ground</li> <li>Low voltage</li> </ul>	<ul style="list-style-type: none"> <li>Lightning storms, crossed power lines</li> <li>Defective service transformer</li> <li>Low voltage</li> </ul>	<ul style="list-style-type: none"> <li>Unplug appliance during lightning storms</li> <li>Install surge protector at appliances</li> <li>Install surge suppressor at service panel</li> <li>Adjust tap on service transformer to proper electricity level</li> </ul>

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

## Glossary

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

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

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

**harmonic filter** – device that can remove one or more harmonics of a complex wave.

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

**noise** – non-damaging distortion of electricity that interferes primarily with communication appliances – caused by other appliances and electronic lighting. *Radiated noise*, sometimes referred to as EMF or RFI noise by technicians, is emitted through the air instead of the electrical system (*conducted noise*) 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 in 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 a residence, 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, motors starting, utility operations and other appliances, that last a fraction of a second.

## Acknowledgement

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