SURGES HAPPEN!
How to protect the appliances in your home

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Significance
Part 6: Tutorials, Textbooks, and Reviews

In contrast to most of the publications included in the SPD Anthology that were written for an engineering audience, this 22-page booklet was developed for the general public as a recommended practice, with reader-friendly illustrations rather than circuit diagrams or oscillograms.

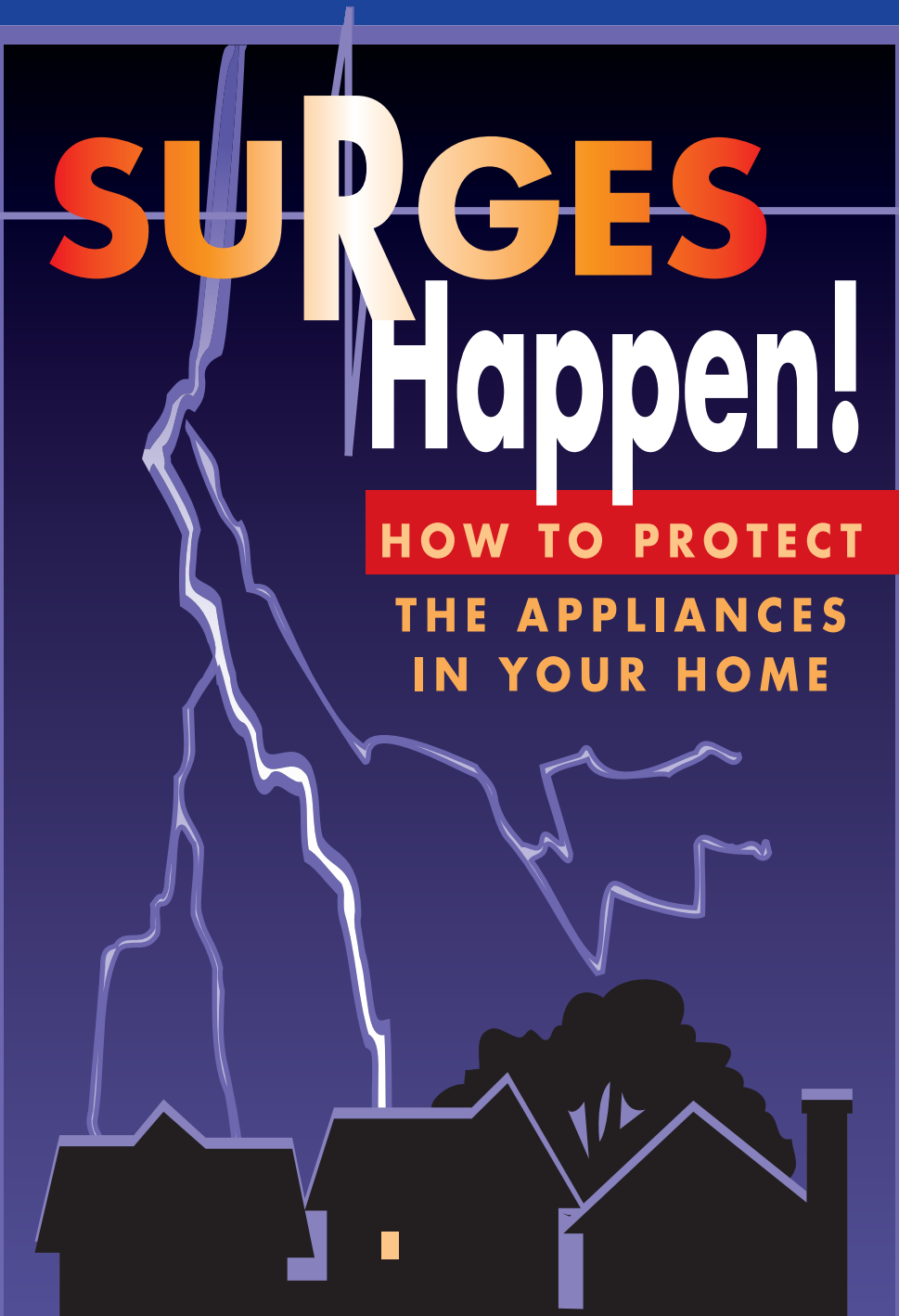
Note: A hard copy of the booklet can be obtained by sending a request for SP 960-6 to: inquiries@nist.gov.

practice guide

NIST recommended

SURGES Happen!

HOW TO PROTECT THE APPLIANCES IN YOUR HOME



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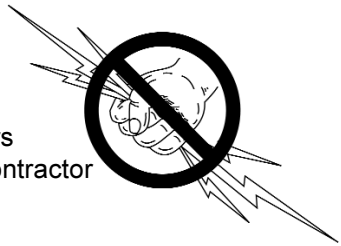
ABOUT THIS BOOKLET ....

This booklet has been prepared to help home dwellers, owners, contractors, insurance agents and all parties interested in reducing the number of cases and severity of equipment damage caused by the unavoidable surges that occur in the electrical systems. It is offered as a public service without any commercial intentions.

The information offered here is the result of collective efforts by several experts on the subject, but presented in a simple format with practical hints on what to avoid and what to do. General principles are explained, but specific brand names are not discussed or mentioned as the technology and packaging techniques are constantly evolving.

- The need for protection – What is a “surge”
- A few words about other power problems
- Source of surges – Lightning and other
- How tough are today’s appliances
- Protection for the whole house
- Protection at the outlet
- Good and bad installations
- Where and how to get help
- Common questions and answers
- A few hints for your electrical contractor



HOW TO PROTECT THE APPLIANCES IN YOUR HOME

What's a surge ?

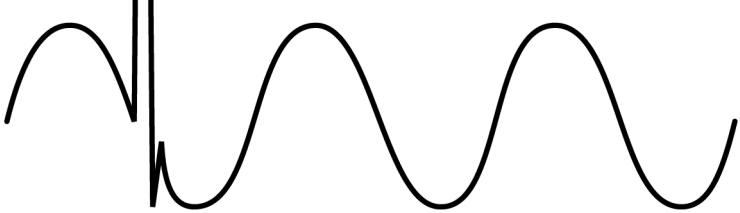
The power you get from the wall outlet is known as "120 volts AC power." It can be represented by a sine wave of voltage, as shown at the bottom of this page. The power companies try to keep that voltage uniform. Lightning, short-circuits, poles knocked down by cars, or some other accident can make the voltage jump to hundreds, even thousands of volts.

The voltage spike shown on the left of this page is what engineers call a "surge." A surge will last only a few millionths of one second (the "blink of an eye" is thousands of times longer than the typical surge). It is enough to destroy or to upset your appliances.

What can a surge do to your appliances ?

Your appliances are designed to run on the normal 120 volts AC supply, with some tolerance for more or less, but they can be damaged, or their controls can be upset by surges. The result is then frustration and repair bills, and even a fire in rare cases.

See the next pages for a discussion of how sensitive your appliances can be to these surges.



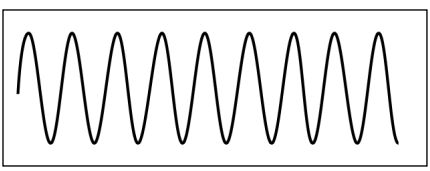
Don't give up !

You can do something about it, your electrician can help and even the power company can offer help, as this booklet will show you – the why's and how's.

◆ Other disturbances . . .

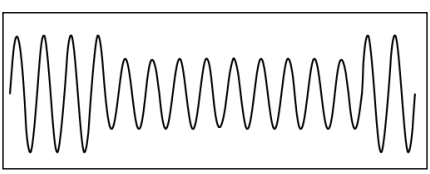
.... and what they can do to your appliances

In the normal operation of a power system, unavoidable disturbances other than surges also happen. They can upset electronic appliances, but are unlikely to cause permanent damage. This booklet is concerned with surges and how to protect your appliances against surges. However, just to give you an idea of what these other disturbances can be, the graphs and words below will give you the right words when you want to discuss a problem with your power company, your electrician, and (hopefully, not any longer) an electronics repair shop.



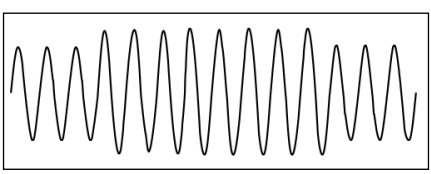
Normal line voltage

This is the voltage that we all take for granted, every second of the minute, every minute of the hour, every hour of the day, every day of the year. But occasionally, for a short time ....



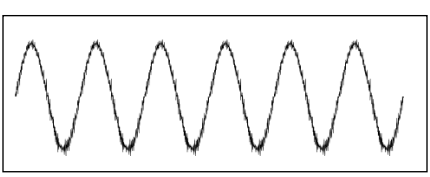
Sag

The voltage falls below normal: a **sag**. Sags are unlikely to damage most appliances, but they can make a computer crash, confuse some digital clocks and cause VCRs to forget their settings.



Swell

The reverse of a sag is called a **swell**: a short duration increase in the line voltage. This disturbance might upset sensitive appliances, and damage them if it is a very large or very long swell.



Noise

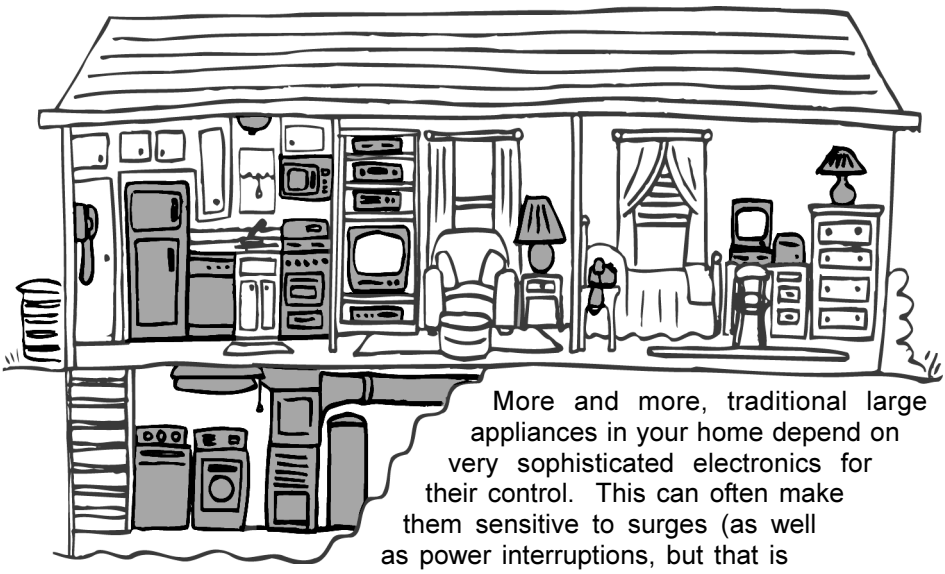
Noise is a catch word sometimes used to describe very small and persistent disturbances. These do not have damaging effects but can be a nuisance.

There is, of course, the ultimate disturbance: an **outage** – no voltage at all !

These disturbances are different from surges, but they should be mentioned because the remedies are generally different. As we will see later, some available devices can help overcome both.

Sensitive appliances in your home ◆

Your home contains all sorts, types or kinds of appliances. By "appliances," understand not only the traditional household helpers, but also the entertainment electronics, the family's computer(s), smart telephones, control systems (thermostats, garage door, etc.), and all the new things to come.



More and more, traditional large appliances in your home depend on very sophisticated electronics for their control. This can often make them sensitive to surges (as well as power interruptions, but that is another story ...).

To help sort out which types of your appliances might be damaged or upset, you can describe them in general terms depending on their connections: power, telephone, cable, or antennas. Each of these connections offers a path for a surge to come in, something that might be overlooked when the cause of damage is explained as a "power surge."

The first type includes electronics that are connected only to the power, such as a computer with no modem, a TV set with rabbit ears, a VCR not connected to cable TV, a table-top radio, a microwave oven, etc. Surge protection of these is not particularly difficult, and quite often it is already built-in by the manufacturer.

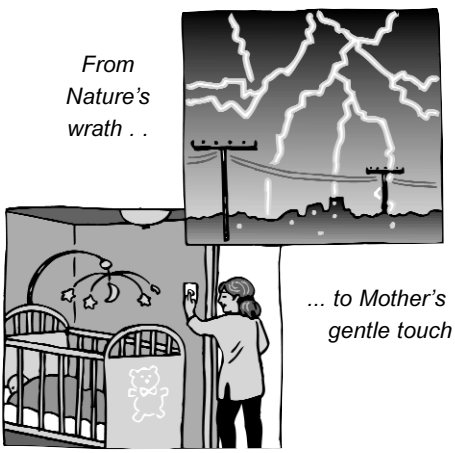
The second type, for which more protection might be needed, includes electronics that are powered, of course, from your power receptacles but also connected to an external communications system: telephone, cable TV, satellite receiver. A slightly different but similar situation, which also needs attention, is that of appliances connected to a household control system such as garage door opener, intrusion or fire alarm, automatic sprinklers, or intercom.

We will see later why the two kinds of appliances face different risks of being damaged and consequently might require different protection methods.

◆ Where do surges come from?

There are two origins for the surges that occur in your power system: l***ightning surges*** and ***switching surges***. A few words about these will help you better understand what can be done to protect against them, and make good decisions on risks versus economics.

Lightning surges, occur when a lightning bolt strikes between a cloud and objects on earth. The effect can be *direct* - injection of the lightning current into the object, or *indirect* - inducing a voltage into electrical circuits.



We will look at ways of protecting your appliances against lightning surges that come by way of the wires - power, telephone, cable, etc. Protection of the house against the direct effects of lightning is done by properly grounded lightning rods, a job to be done by professionals †. Note also that lightning rods are intended to protect the structure of the house and avoid fires. They do not prevent surges from happening in the wiring.

Direct lightning effects are limited to the object being struck and its surroundings, so that the occurrence is considered rare but it is nearly always deadly for persons or for trees. Well-protected electrical systems can survive a direct strike, perhaps with some momentary disturbances from which they recover (blinking lights and computers restarting during a lightning storm). The key word, of course, is *"well-protected"* and that is why this booklet is offered to help your home have a well-protected electrical system.

Indirect lightning effects are less dramatic than from a direct strike, but they reach further out, either by radiating around the strike, or by propagating along power lines, telephone system and cable TV. From the point of view of the home dweller, unwanted opening of the garage door, or a surge coming from the power company during a lightning storm, would be seen as indirect effects.

Switching surges occur when electrical loads are turned on or off (by "Mother's gentle touch" or by some appliance controls) within your home, as well as by the normal operations of the power company. An analogy often given is the "water hammer" that can occur in your piping if a faucet is turned off too quickly: the electric current flowing in the wires tries to flow for a short time after the switch has been opened, producing a surge in the wiring, just like the surge of pressure in the piping,

† *You might find useful information about lightning protection on the Web - see page 20.*

So, surges can and do happen !

These questions – how often do surges occur, how far do they travel before hitting your appliances, how severe are they – must be answered, as well as possible, so that you can proceed to the next step of taking calculated risks or making a reasonable investment by purchasing some additional protection. There are several ways of getting surge protection, from the simple purchase of a plug-in device from an electronic store (more on that later) to the installation of protective devices for the whole house, to be done by an electrician or the power company.

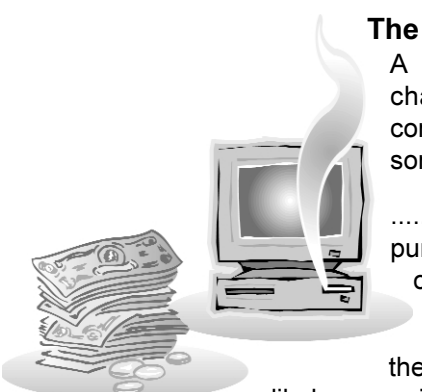
How often ?

You are probably best placed to answer that question if you have lived in your neighborhood for several years. Lightning is random but can strike more than one time at the same place. There are now sophisticated means to record the occurrence of individual lightning strikes; electric utilities and businesses seek the data to make decisions on the risks and needs for investing in protection schemes. The reason for mentioning "several years in your neighborhood" is that the frequency of lightning strikes varies over the years and the section of the country where you live †.

How far, how severe ?

The answers to these two questions are linked: a nearby lightning strike has more severe consequences than an equal strike occurring farther away. There is also a wide range in the severity of the strike itself, with the very severe or very mild being rare, the majority being in mid-range (a current of about 20,000 amperes for a short time) – but still much shorter than the blink of an eye.

Calculated risk or insurance ?



The trade off:

A large stack of dollar bills and some change to replace your unprotected computer, if and when a lightning or some other surge destroyed it .....

..... or use a small number of bills to purchase a "surge protector" for peace of mind and effective protection.

If you look at it from that point of view, the choice is probably easy and, most likely, you will be looking for one of those "surge protectors" – or some device with a similar name to do the same job, as explained next.

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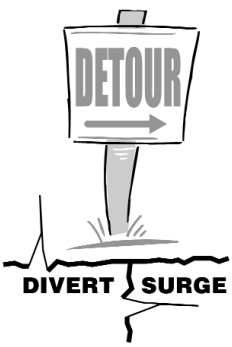
† *Look on page 20 for information about lightning by surfing the Web.*

◆ What's in a name ?

When you walk in the computer store or electronic supply store, you might ask for something to protect your appliances against surges, but what to call it ? The devices that can protect against surges are called "surge-protective devices" by engineers, but that sounds too much like jargon to some people.

One name that seems to stick is "surge suppressor" with a variety of trade-mark names. The Underwriter's Laboratories chose to call them "Transient Voltage Surge Suppressor" and you might find that name or the TVSS acronym next to the listing on the product. Always make sure that the product has been tested by a product safety testing organization, such as UL, ETL, or CSA, as indicated by their labels, as shown here:



You cannot really suppress a surge altogether, nor "arrest" it (although your utility uses devices they call "surge arresters" to protect their systems). What these protective devices do is neither suppress nor arrest a surge, but simply divert it to ground, where it can do no harm. So a name that makes sense would be "surge diverter" but it was not picked. So, for the rest of this booklet, we will stick with the more popular "surge protector" and that's what you want to ask for when you walk in the store.

Then, when you get to the aisle where the surge protectors are on display, you will most often find many brands, at different prices, so that the next question will be "Which should I buy ?" That's a more difficult question to answer because, while the principles and basic technology for these devices remain the same, manufacturers come up with variations and improvements in their packages and trade names. So, instead, there are some points to look for on the packages that will steer you in the right direction.

HOLD IT !

Before you run to the store and buy the most expensive surge protector – under the assumption that more money automatically gets you a better protection – look at your personal situation. Asking yourself some simple questions will help to decide how much surge protection you really need.

Surge protectors come in many shapes and forms for many purposes, not just the plug-in kind that you find in the electronic stores. There are several ways to install them on your power supply: plug and play, do-it-yourself, hire a licensed electrician to do it, or even call on your power company to do it. Here is a run down on your options, and who does it:

- Purchase one or more plug-in surge protectors
- Install a surge protector at the service entrance panel
- Have the power company install a surge protector next to the meter

Plug-in surge protectors

This is the easiest solution, and there is a wide variety of brands available in the stores (as we noted at the start of this booklet, we are not going to recommend brands). These come in two forms: a box that plugs directly into a wall receptacle, or a strip with a power cord and multiple outlets. Depending on the appliance, you will look for a simple AC power plug-in, or a more complex combined protector for AC power and telephone or cable – more on that later. However, before you purchase the right protector for the job, you should think about some details.

There is another decision to make, concerning how a surge protector will power your appliance if the protective element should fail under extreme cases of exposure to a large surge or large swell. Most surge protectors are provided internally with some kind of fuse that will disconnect in case of failure. However, this disconnect can operate in two different ways, depending on the design of the surge protector: some will completely cut-off the output power, others will disconnect the failed element but maintain the power output.

Quit and be protected or continue ?

For you, it is a matter of choice: would you want to maintain the output power to your appliance – but with no more surge protection ? Or would you rather maintain protection for sure – by having the circuit of the protector cut off the power supply to your appliance, if the protective function were to fail ? To make an intelligent decision, you must know which of the two possibilities are designed into the surge protector that you will be looking for.

What are the lights telling you ?

To help the consumer know what is going on inside the surge protector, many manufacturers provide some form of indication, generally by one or more pilot lights on the device. Unfortunately, these indications are not standardized, and the meaning might be confusing, between one, two – even three or four lights – where it is not always clear what their color means. Read the instructions !

◆ More decisions ...

So far, we have looked mostly at the plug-in surge protectors because they are the easiest to install and they do not require the services of an electrician. The two other possible locations for surge protectors are the service panel (breaker panel) and the meter socket.

Service-panel surge protectors

Instead of using several plug-in protectors – one for each sensitive appliance is sometimes recommended – you can install a protector at the service panel of the house (also called "service entrance" or "breaker box"). The idea is that with one device, all appliances in the house can be protected, perhaps with a few plug-in protectors next to the most sensitive appliances. There are two types of devices available: incorporated in the panel, or outside the panel.

Some breaker panel manufacturers also offer a snap-in surge protector, taking the space of two breakers (assuming that there are blank spaces available on the panel), and easily installed by the home owner or by an electrician. However, there are two limitations or conditions to that approach:

(1) The snap-in protectors generally fit only in a breaker panel from the same manufacturer – possibly down to the model or vintage of the panel.

(2) To install the snap-in protector, you must remove the front panel (do turn off the main breaker before you do that !). Most cities have codes allowing the home owner to do it, under some conditions. Check with your local authorities to find out if they allow you to do that, or hire a licensed electrician to do the installation for you.

There are other surge protectors packaged for wiring into the service panel, either within or next to the panel. That kind of installation is best left to a licensed electrician (as shown on page 19).

At the meter socket

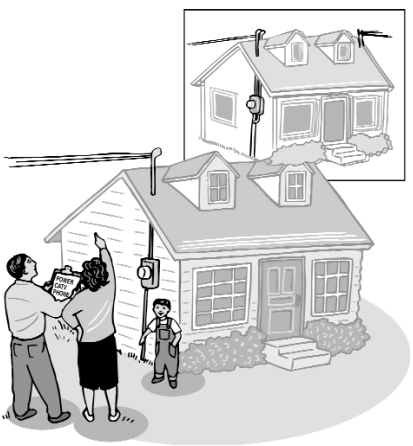
There might be a possibility that the power company in your area offers, as an option, to install a surge protector with a special adapter, fitting it between the meter and its socket (the dark band in the bubble of the picture). But that type of device and installation is out of the question as a do-it-yourself project, and will require cooperation from the power company, if they do offer the program.

Other types of outdoor surge protectors can be installed near the meter. That kind of installation must be done by a licensed electrician.

Before you decide which way you want to protect your appliances, there are other points to consider – perhaps this is a good time to make a check list. We have already mentioned the variation in lightning activity across the country: Florida is known for very high lightning activity, the West Coast for much lower (but not zero) activity. For a given area of the country, the type of your dwelling, and what kind of appliances are to be protected will influence which type of surge protectors you will be looking for.

Where do you live ?

This is an important question because the type of dwelling has some effect on how severe your surge problem might be. In a somewhat simplified way, consider three categories according to the arrangement of the utilities:



- Detached house with power and telephone and/or cable TV drops at opposite ends of the house – the worst possible arrangement of all. But do not fret, there is a way of compensating, even after the fact, for this unfortunate situation, as we will see.

- Detached house with all services (power, cable TV, phone) entering on the same side of the house. You can improve that situation further, as shown at the end of this booklet.

- Townhouse or apartment building with services entering the building at one point and fanned out to the different dwellings – about the same as the case of the detached house with all services on the same side.

The first of these three arrangements has often been found to be made worse by a violation (not intentional) of the prescriptions of the National Electrical Code that require that the two incoming services be properly bonded by a grounding conductor. Without going into fine details, the problem arises because typically the power company and the communications utilities do their own thing without enough coordination. Statistics of insurance companies show that one of the most frequent damage claims is for video equipment. A possible explanation is the uncoordinated grounding of the service connections by one of the utilities.

◆ What appliances are you using ?

From the surge protection point of view, there are four kinds of appliances, with examples listed below by order of increasing sensitivity to surges, either because of their nature or because of their exposure:

- Motor-driven and heating appliances
  Washers (dish and clothes), food processors, power tools, heating and ventilation motors, pumps, etc.
  Water heaters, space heaters, toasters, incandescent light bulbs
- Free-standing electronic appliances
  Computers without modem, table radios, TV sets with rabbit ears
  Compact fluorescent and modern tube-type fluorescent lamps
- Communications-connected appliances
  Computers with modem, TV with cable or satellite antenna
  Fax machines, telephone answering/recording machines
- Signal systems
  Intruder alarms, garage-door openers, sprinklers, intercom

Let's then take a quick look at each of these and see which might need some form of surge protection.

Motor-driven appliances and heating appliances

For each of these two categories, there can be two or more kinds, depending on the type of control used.

- Mechanical control (ON-OFF switch, rotary control, etc.), no sophisticated key pad or other electronic control
- Electronic control (programmable operation, key pad, display, etc.)

Appliances with mechanical controls are generally insensitive to surges and can be expected to withstand the typical surges that occur in a residence. Extreme cases, such as a direct lightning strike to the building, or one to the utility, very close, might cause damage.

Appliances with electronic controls can be more susceptible to damage than those with mechanical controls. Less traumatic but annoying can be upset memory in programmable appliances, although progress is being made in providing more built-in protection.

Another difference to be noted is that of appliances permanently connected, as opposed to those in intermittent use. The risk of a damaging surge happening at the time of intermittent use is much smaller than that of an appliance which is on all the time.

Electronic appliances

As soon as the word "electronic" is mentioned, your friends will tell war stories of surge damage that can raise justifiable concerns. But fear not; simple precautions and proper protective devices can go a long way to avoid problems and replace those concerns by confidence.

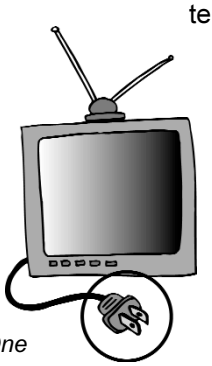
Power companies sometimes include as bill-stuffers the suggestion to disconnect your appliances when a severe lightning storm is approaching. But that is no help if you are not in the house at that time. If, on the other hand, you are in the house, pulling out the power cord of an appliance that remains connected to a telephone line or cable TV might not be the best idea: you would lose the grounding of the appliance normally done by the power cord – possibly a safety problem should a surge come upon the telephone or cable TV.

By showing you the basic principles of surge protection, this booklet should help you make the choices that fit your needs for protection, without overdoing it. To make the right choice, it is useful to note that there are two types of electronic appliances. For each of these types, a different type of surge protector might be needed. These types include:

- ♦ Simple, one link connection to power the system
- ♦ Dual connection to both power and communications

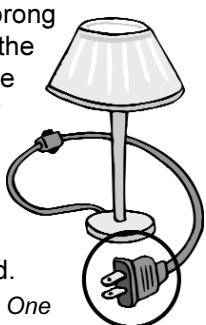
One-link connections

Examples of one-link connection of powered electronic appliances include a TV set with "rabbit ears" antenna, a portable radio receiver, a computer with no modem connection or remote printer, a compact fluorescent lamp, etc. In the category of one-link connection we also find an old-fashioned telephone connected only to the telephone system.



One cord only

Note that most of these have a two-prong plug, which is their sole connection to the power system. For the TV set, a simple AC plug-in surge protector on the power cord would be sufficient. For just the lamp, the cost of a surge protector would be greater than the cost of simply replacing the lamp, if damaged by a surge – and therefore not be justified.

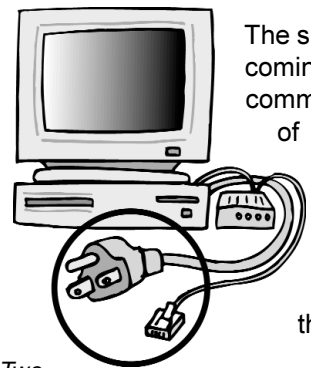


One cord only

◆ What kind of appliances ?

Two-link connections

This type of appliance is another matter. Typical of these would be a computer with a modem, a video system with cable or satellite link, a phone system directly powered from a receptacle (those with a large adapter plug and a thin cable with jack which goes to the appliance generally have sufficient internal isolation against surges).



Two cords

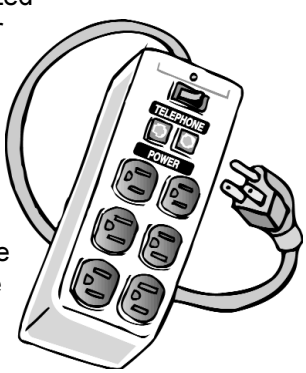
The surge problem with this type of appliance is that a surge coming in from one of the two systems – power or communications – can damage the appliance, because of a ***difference*** in the voltage between the two systems when the surge occurs. This can happen even when there are surge protectors on each of the systems. (For those of you interested in finding out why that is so, more on that subject on page 18.)

Fortunately, you can find a special type of surge protector against the problem, as described next.

Equalizing differences

A simple solution to the problem of voltage differences for two-link appliances is to install a special surge protector that incorporates, in the same package, a combination of input/output connections for the two systems. Each link, power and communications, is fed through the protector which is then inserted between the wall receptacles and the input of the appliance to be protected. This type of surge protector is readily available in computer and electronics stores, and the electrical section of home building stores.

In addition to words on the package, it can be recognized by the presence of either a pair of telephone jacks or video coax connectors in addition to the power receptacles. Some models might have all three in the same package. Do note a few words of caution:
(1) Read carefully the instructions or markings to find which is "in" and which is "out" for the telephone wires. It is important to note, before you buy the product, whether your wall receptacles are wired for three-prong power cords. Some of these combined protectors might not work very well if plugged into a 2-blade receptacle, using a "cheater" plug. (On some, an indicating light will signal that.)



Among other disturbances on the power lines, there was a brief mention of sags and outages on page 2. You are certainly and unhappily well-acquainted with outages that can occur for any number of reasons beyond the control of your utility. Sags – a brief decrease of the line voltage – can be more subtle and do occur more often than the complete outage. You will notice these when the lights dim momentarily, digital clocks or VCR controls blink, or your computer shuts down then reboots – possibly losing some data.

Industrial and commercial users, health-care facilities and other critical systems have for many years used a device called "uninterruptible power supply" (UPS) that provides continuous power across a sag, or for the first portion of an extended outage (an independent local power generator set can then kick in).

The aggravation of consumers caused by sags and outages has created a mass-market for consumer applications, making them affordable when looked at as protection against these annoying (but not damaging) disturbances – and with built-in surge protection as a bonus in many cases. These consumer-type UPSs have a small battery which is sufficient to ride through any sag and short outages. Some models even include the software to make a computer shut down in an orderly sequence in case of a long outage.

Surges in other systems

So far, we have looked at surges on the power line alone, or on a combination of power and communications lines. Surges of a slightly different kind can also happen in parts of other electrical systems that do not directly involve a power line. Examples of these are: the antenna for a remote garage door opener, the sensor wiring for an intrusion alarm system, the video signal part of a satellite dish receiver. Surges in these systems are caused by nearby lightning strikes.

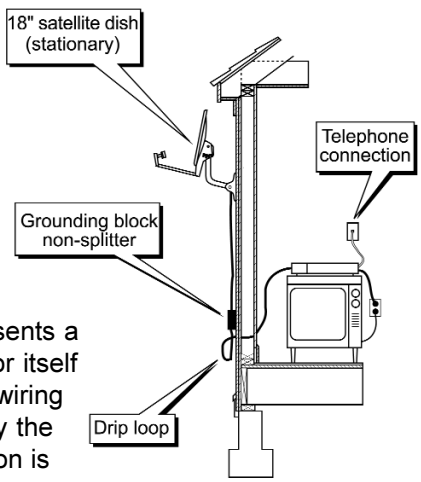
These other systems just mentioned have not been the subject of standards on surge protection as much as power and telephone systems. Furthermore, protective devices for these other systems are not as readily available to consumers. It is more difficult to offer well-defined guidance on surge protection for these systems. Applying preventive surge protection schemes to an existing system might be difficult when the sensitivity of such a system to surges is not known. When considering installation of a new system, it would be a good idea to ask pointed questions on that subject before signing the contract.

◆ Protection for other systems

Some codes or practices aimed at providing safety for persons, when they are correctly applied, can also provide some equipment protection.

For instance, the general practice of telephone companies is to provide a surge protector as part of their services at the point where the telephone line enters the house (in dense urban environments, the National Electrical Code allows an exception). This protector is known as the "Network Interface Device" (NID) and you will find it on the outside of your house (see the drawing on page 19).

Another example of code requirement is that of cable TV systems for which the National Electrical Code requires proper safety-oriented grounding practices. The problem, however, is that in some cases, the video equipment can still be damaged by voltage differences, as explained on page 12.



With the increasing popularity of small-dish satellite receivers, installation by the user as do-it-yourself has also increased. Typical instructions for installation show how to make the connections, for instance in the figure at right. What the figure does not show is the need to provide a combined protector for power, telephone, and cable.

A well pump installed outside the house presents a double challenge: protecting the pump motor itself against surges, and protecting the house wiring against surges that might enter the house by the line that powers the pump. The first protection is generally built-in for modern submersible pumps. The second protection should be provided by a surge protector installed at the point where the power line to the pump leaves the house, using protectors similar to those applied at the power line service entrance.

Intruder alarm systems using wires between sensors and their central control unit can be disturbed – and damaged in severe cases – by lightning striking close to the house. The wires necessary for this type of installation extend to all points of the house and act as an antenna system that collects energy from the field generated by the lightning strike, and protection should be included in the design of the system, rather than added later by the owner. Wireless systems are less sensitive than wired systems.

Questions .... and answers ◆

Among the questions often asked by consumers about surges, here is a selection of typical concerns and simple answers.

Q – ***When looking at the devices offered in the store, the packages show specifications and claims that puzzle me. Can you explain ?***

A's – Here are some typical specifications, and corresponding comments:

Joules – A (simplified) measure of the surge energy that the protector can dissipate without damage to itself. The higher the value, the more energy the protector can handle. Typical values range from about 100 joules, up to 1000 joules or more. Because this joule number is often based on the three combinations of the wiring, many specifications show the total joules rather than a breakdown among each of the three combinations. Maximum surge current (below) may give better information.

Clamping voltage – A measure of the voltage-limiting capability of the protector. An oversimplified perception might be that the lower, the better. Many specifications show 330 volts for this voltage. This number is embedded in the UL standard values, but it is not a requirement. Somewhat higher clamping voltages, such as 400 volts or more, may be sufficient for protecting electronic appliances, and will make the surge protector itself less susceptible to damage from "swells" (see page 2).

Maximum surge current – A measure of the ability of the protector to handle surge current without damage to itself. You will find a range of values from several hundred to several thousand amperes. Even the lower values offered by manufacturers are sufficient for most surges, but a higher value will give you (generally for a slightly higher price) a comfortable margin of peace of mind.

Speed of response – This specification appears on some packages, others do not even mention it. Since practically all protectors use the same kind of technology for the protective components, and their speed of response is inherently adequate for power-line surges, there is no need to emphasize a fast speed of response.

Internal protection – Some packages provide a description of what happens on the load side of the surge protector (cut-off or still powered), should the protective element be damaged by an exceptionally large surge or a long overvoltage. See on page 7 your choice, "Quit and be protected or continue" – but now unprotected. Some packages also provide a cut-off and reset feature in cases of large swells, protecting the protector itself as well as the load.

Indicating lights – See the discussion of their meaning on page 7. Be sure that you will remember the meaning after you have discarded the package. If a card with explanations is included in the package, save it because the meaning of the light - on or off, and what the difference there is among colors – is not always clear on the device itself. If the protector maintains power on the load side, how often will you look under or behind your desk to check and make sure that the "Protection on" light is still on ?

UL 1449 Second Edition – Some packages show “UL listed Second Edition” rather than the simple "UL Listed" found on others. It shows explicitly that the product has passed the most recent, improved tests for safety. Other standard symbols such as ETL or CSA might be present instead of UL. They all represent the latest testing for safety.

Guaranteed protection – A measure of the manufacturer's confidence in the actual performance of the product. As for all guarantees, do read the fine print.

◆ More questions and answers

***Q** – If I install one plug-in surge protector in one room, are the receptacles in other rooms also protected ?*

A – Yes, but only to some degree. The wiring in your house is split into several "branch circuits" originating from your service entrance panel. If a surge protector is installed on a particular branch circuit, the other receptacles on the same branch circuit might benefit from it, but that benefit is much less on other branch circuits. To be more relaxed about protection in other rooms, it would be a good idea to install a surge protector for each of the sensitive appliances in the house. This is especially true for the multi-link appliances because of the problem explained on page 12. (See the next Q&A on whole-house protection and Figure 3 on page 19.)

***Q** – Will a surge protector installed at the service entrance be sufficient for the whole house ?*

A – There are two answers to that question: **Yes** for one-link appliances, **No** for two-link appliances. Since most homes today have some kind of two-link appliances, the prudent answer to the question would be No – but that does not mean that a surge protector installed at the service entrance is useless. An important function of the service-entrance protector is to divert large surges coming on the power line, before they enter the house. A service-entrance surge protector makes the protection by plug-in protectors easier but, as discussed on page 8, installation at the service entrance generally requires an electrician, unless you are a do-it-yourself person and your city code allows it.

***Q** – Why single out two-link appliances as requiring special protection ?*

A – A first answer to that question is given on page 12, explaining the voltage difference problem for these two-link appliances. A more technical explanation is also given on page 18, intended for your electrician.

***Q** – I have heard about surge protectors degrading over time: What about it ?*

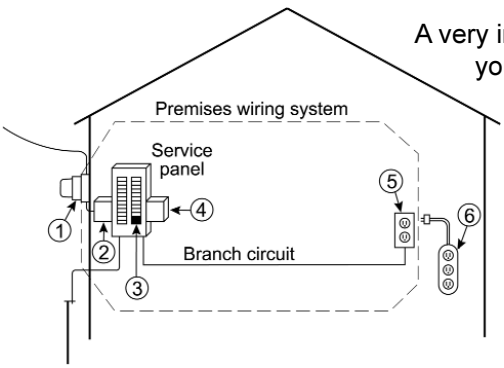
A – Many, if not all, electronic components will age and have a limited life. The question is really how long a useful life can a surge protector have. Today's well-designed surge protectors might reach their end of life prematurely if exposed to some exceptionally high and rare stress but, for those tested according to UL 1449 Second Edition, the way they fail should not be a hazard. The prevailing opinion among specialists on surge protection is that most of the observed (and quite rare) catastrophic failures of surge protectors are caused by excessively high line voltage that can occur when there is a fault on the power system. Failure from very large surges that might exceed the surge-handling capability of the protector is less likely than failure from high line voltage.

And now, the "bottom line" question:

***Q** – How much money should I spend on surge protection ?*

A – It depends on too many factors to give a simple answer. Technology can change, additional features beyond basic surge protection vary, stores offer "specials", and how much margin makes you feel comfortable is an intangible factor. This booklet is not oriented toward rating product performance or prices, but rather toward explaining the principles, so that you can make an informed decision that will give you confidence.

As discussed on pages 7 and 8, there are several locations in your power system where you can connect (install) a surge protector, depending on the type of protection you desire and your inclination toward do-it-yourself or hire someone. These possible locations are shown in the sketch below, with appropriate hints on how to go about the installation.



A very important point to keep in mind is that your surge protector will work by diverting the surges to ground (see "What's in a name" on page 6) The best surge protector in the world can be useless if grounding is not done properly.

① ***Meter-base adapter***
This is the most involved installation, requiring cooperation of the power company if they allow it to be done by a licensed electrician. They might also do it as part of their own program †.

② ***Service panel, upstream***
Also a job for a licensed electrician since the power cannot be turned off on this side of the service panel † ‡.

③ ***Service (breaker) panel, snap-in***
First opportunity as a do-it-yourself project, provided that the hardware is compatible and that local authorities allow the owner to do it.

④ ***Service panel, downstream***
Another possibility for do-it-yourself. The protector should be connected on the load side of a pair of dedicated (spare) breakers in the panel ‡.

⑤ ***Receptacle, built-in***
Provides same protection as a simple plug-in protector, but stays in place and cannot easily be moved to another receptacle, should that become desirable.

⑥ ***Plug-in (with cord or directly into receptacle)***
The easiest of all for anyone to do. The only question is "Which to choose ?" Pages 15 and 16 have given you some elements for making that choice.

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† *It would be a good idea, to ensure compatibility, to ask the electrician to look into the ratings of the device and the power system available fault current.*
‡ *The protector should be located close to the service panel (less than about 30 cm or one foot), otherwise the voltage-limiting effect will be degraded.*

FOR YOUR CONTRACTOR'S EYES ONLY

(But it's OK to take a peek)

The problem of shifting reference potentials

According to insurance company statistics, two kinds of appliances are at the top of the list as the most frequently damaged during a lightning storm: video systems (receivers and/or VCRs) and computers with a modem connection. There is at least one explanation for that very unhappy situation: if one of the two systems – power or communications – brings a surge to the house, the intended operation of surge protectors creates a difference in the potentials of the references across the two input connections of the appliance, causing failure.

In the set-up of Figure 1, a personal computer (PC) is connected to both the power system and the telephone system, and we assume that a surge is coming along the telephone wires. The surge current ("Surge I" in the figure) flows from the telephone system toward the common grounding point via the network protective device (NID) at the point of entry, and the grounding conductor mandated by the National Electrical Code (NEC ®). This current produces a magnetic field that couples into the loop formed by the power branch circuit, the telephone premises wiring lines to the PC, and the bonding conductors. A voltage (Vdiff) is induced in the loop and appears across the power input and telephone input of the PC, with upsetting or damaging consequences. The presence or absence of surge protection on the AC side (Arrester or SPD) has no effect on the coupling. One effective solution is to have the consumer install a combined protector, as explained on page 12.

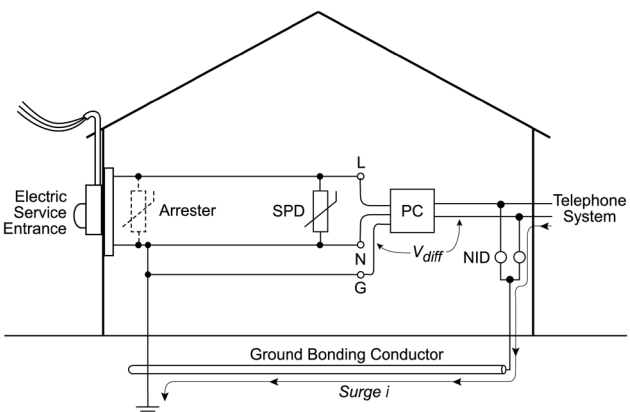

Figure 1
Shifting of reference potentials between power and telephone

Even though this installation complies with the NEC, the situation is made worse if the point of entry for power and the point of entry for communications are at opposite ends of the house, with a large loop separating the two cables. The 1999 NEC now limits the separation between points of entry to 20 feet (7 meters) for new installations. The situation is even worse yet when the incoming service, cable TV in particular is not bonded to the power service ground. That is a clear violation of the NEC but experience has shown that it is not so rare, and the result can be severe damage to the appliance.

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Recommended integrated bonding

The recommended bonding arrangement shown in Figure 2 is applicable for new construction or for existing homes where an opportunity occurs to relocate the point of entry of the cable TV or the telephone NID. It is compliant with the NEC minimum requirements for safety, and will reduce the problem of shifting reference potentials just described by inter-system bonding of all utilities serving a residence. The usual components for each service connection are simply installed next to each other.

Another possibility for reducing the shift in reference potentials is to install an integrated, multi-utility surge protection at the breaker panel, as shown in Figure 3. This device includes appropriate surge protection for all three services: AC power, telephone, and cable TV, with the minimum length for the bonding arrangement.

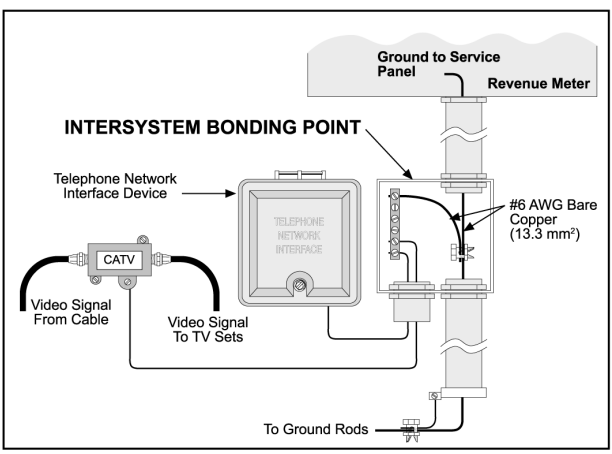

Figure 2 Recommended Inter-system bonding

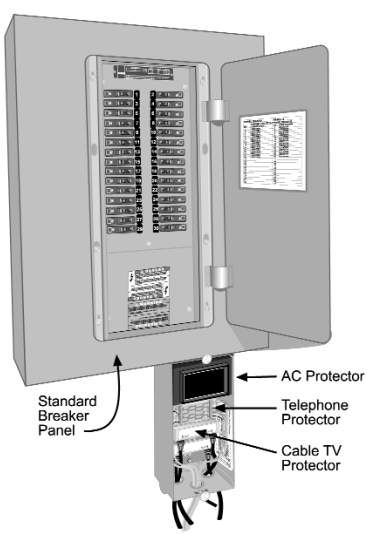

Figure 3 integrated multi-protection device for service panel installation

WHERE TO GET MORE HELP

There are many sources of information on surge protection, including codes, standards, handbooks, and many technical papers. Most of these are written for technically-oriented people rather than typical consumers, with the exceptions of the bill-stuffers from your utility, occasional consumer-oriented articles, or the present booklet.

On the other hand, with the popular and ever-increasing use of the Internet, useful information can be obtained on line.

The sources identified below are listed as a starting point for a Web search, but with the understanding that new ones can appear and existing ones can disappear. Furthermore, these sources include some commercial entities as well as non-profit organizations. Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology, nor is it intended to imply that these sources are necessarily the best available for the purpose.

Weather and lightning information:

- http://www.accuweather.com/wx/services
- http://www.lightningstorm.com
- http://www.lightningsafety.com
- http://www.nfpa.org

Surge-protective devices

- http://www.nema.org

Wiring practices

- http://www.necdirect.org

Power quality

(Surges, sags, and outages)

- http://www.epri-peac.com

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Donald L. Evans, Secretary
National Institute of Standards and Technology
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Illinois Power Company
State Farm Insurance Companies

Text by François Martzloff based on Special Publication 0545.R,
Recommended Practice for Protecting Residential Structures and Appliances Against Surges,
EPRI PEAC Corporation, Knoxville TN.
[Available at http://www.epri-peac.com]

Cover and illustrations by Susan Spangler

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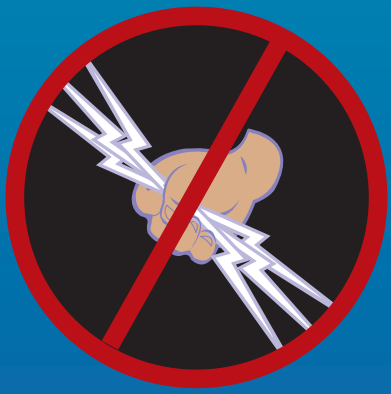

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