How Surge Protectors Work

When you put together a computer system, a home entertainment center, or a digital satellite system, one piece of standard equipment you'll probably buy is a **surge protector**. Most designs serve one immediately obvious function -- they let you plug multiple components into one power outlet. With all of the different components that make up a computer system, this is definitely a useful device.

But the other function of a surge protector power strip -- protecting the electronics in your computer from surges in power -- is far more important. In this edition we'll look at surge protectors, also called surge suppressors, to find out what they do, when you need them, and how well they work. We'll also find out what levels of protection are available and see why you might not have all the protection you need, even if you do use a quality surge protector.

Surge Basics

The main job of a surge protector system is to protect electronic devices from "surges." So if you're wondering what a surge protector does, the first question is, "What are surges?" And then, "Why do electronics need to be protected from them?"

A power surge, or **transient voltage**, is an increase in voltage significantly above the designated level in a flow of electricity. In normal household and office wiring in the United States, the standard voltage is **120 volts**. If the voltage rises above 120 volts, there is a problem, and a surge protector helps to prevent that problem from destroying your computer.

To understand the problem, it is helpful to understand something about voltage. **Voltage** is a measure of a difference in **electric potential energy**. Electric current travels from point to point because there is a greater electric potential energy on one end of the wire than there is on the other end. This is the same sort of principle that makes water under pressure flow out of a hose -- higher pressure on one end of the hose pushes water toward an area of lower pressure. You can think of voltage as a measure of **electrical pressure**.

As we'll see later on, various factors can cause a brief increase in voltage.

- When the increase lasts three nanoseconds (billionths of a second) or more, it's called a **surge**.
- When it only lasts for one or two nanoseconds, it's called a **spike**.

If the surge or spike is high enough, it can inflict some heavy damage on a machine. The effect is very similar to applying too much water pressure to a hose. If there is too much water pressure, a hose will burst. Approximately the same thing happens when too much electrical pressure runs through a wire -- the wire "bursts." Actually, it heats up like the filament in a light bulb and burns, but it's the same idea. Even if increased voltage doesn't immediately break your machine, it may put extra strain on the components, wearing them down over time. In the next section, we'll look at what surge protectors do to prevent this from happening.

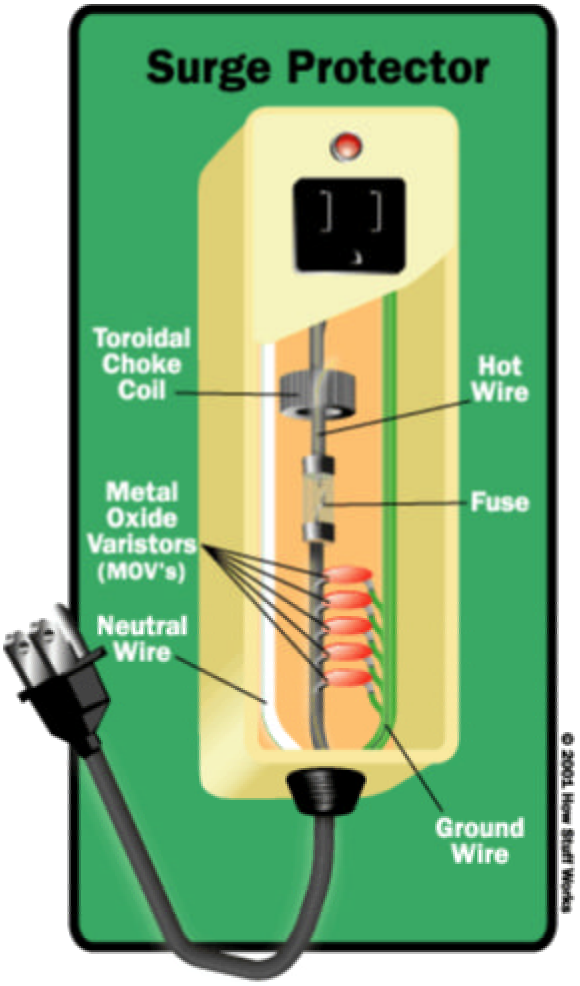
The Process of Protection

A standard surge protector passes the electrical current along from the outlet to a number of electrical and electronic devices plugged into the power strip. If the voltage from the outlet **surges or spikes** -- rises above the accepted level -- the surge protector diverts the extra electricity into the outlet's grounding wire.

In the most common type of surge protector, a component called a **metal oxide varistor**, or **MOV**, diverts the extra voltage. As you can see in the diagram below, an MOV forms a connection between the hot power line and the grounding line.

An MOV has three parts: a piece of **metal oxide** material in the middle, joined to the power and grounding line by **two semiconductors**.

These semiconductors have a **variable resistance** that is dependent on voltage. When voltage is below a certain level, the electrons in the semiconductors flow in such a way as to create a very high resistance. When the voltage exceeds that level, the electrons behave differently, creating a much lower resistance. When the voltage is correct, an MOV does nothing. When voltage is too high, an MOV can conduct a lot of current to eliminate the extra voltage.



A simple MOV surge protector with line conditioning and a fuse

As soon as the extra current is diverted into the MOV and to ground, the voltage in the hot line returns to a normal level, so the MOV's resistance shoots up again. In this way, the MOV only diverts the surge current, while allowing the standard current to continue powering whatever machines are connected to the surge protector. Metaphorically speaking, the MOV acts as a pressure-sensitive valve that only opens when there is too much pressure.

Other Systems

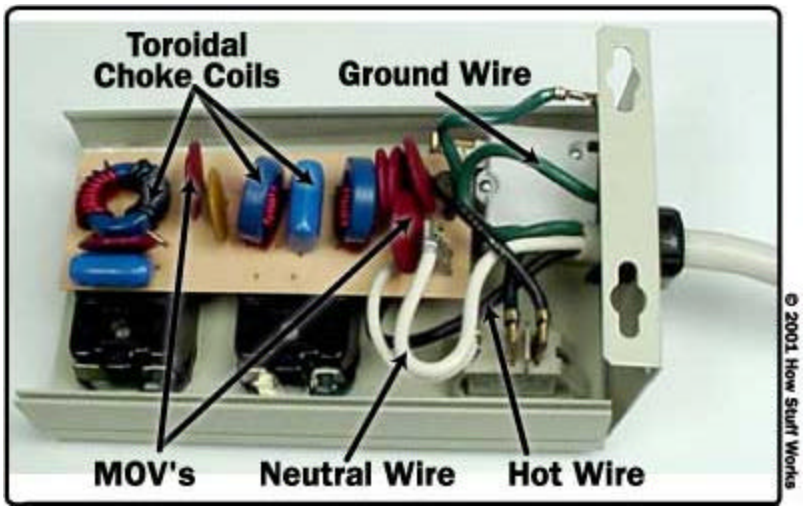
Another common surge protection device is a **gas discharge arrestor**, or gas tube. These tubes do the same job as an MOV -- they divert the extra current from the hot line to the ground line. They do this by using an inert gas as the conductor between the two lines.

When the voltage is at a certain level, the makeup of the gas is such that it is a poor conductor. When level, the voltage surges above that electrical power

is strong enough to **ionize the gas**, making it a very effective conductor. It passes on current to the ground line until the voltage reaches normal levels, and then becomes a poor conductor again.

Both of these methods have a **parallel circuit** design -- the extra voltage is fed away from the standard path to another circuit. A few surge protector products suppress surges with a **series circuit** design -- the extra electricity isn't shunted to another line, but instead is slowed on its way through the hot line. Basically, these suppressors detect when there is high voltage and then store the electricity, releasing it gradually. The companies that make this type of protector argue that the method offers better protection because it reacts more quickly and doesn't dump electricity in the ground line, possibly disrupting the building's electrical system.

As a backup, some surge protectors also have a **built-in fuse**. A fuse is a resistor that can easily conduct current as long as the current is below a certain level. If the current increases above the acceptable level, the heat caused by the resistance burns the fuse, thereby cutting off the circuit. If the MOV doesn't stop the power surge, the extra current will burn the fuse, saving the connected machine. This fuse only works once, as it is destroyed in the process.



Inside a surge protector with line-conditioning chokes

Some surge protectors have a **line-conditioning** system for filtering out "line noise," smaller fluctuations in electrical current. Basic surge protectors with line-conditioning use a fairly simple system. On its way to the power strip outlet, the hot wire passes through a **toroidal choke coil**. The choke is a just ring of magnetic material, wrapped with wire -- a basic electromagnet. The ups and downs of the passing current in the hot wire charge the electromagnet, causing it to emit electromagnetic forces that smooth out the

small increases and decreases in current. This "conditioned" current is more stable, and so easier on your computer (or other electronic device).

Surge Sources

Power surges occur when something boosts the electrical charge at some point in the power lines. This causes an increase in the electrical potential energy, which can increase the current flowing to your wall outlet. A number of different things can cause this to happen.

The most familiar source is probably **lightning**, though it's actually one of the least common causes. When lightning strikes near a power line, whether it's underground, in a building or running along poles, the electrical energy can boost electrical pressure by millions of volts. This causes an extremely large power surge that will overpower almost any surge protector. In a lightning storm, you should never rely on your surge protector to save your computer. The best protection is to unplug your computer.

A more common cause of power surges is the operation of **high-power electrical devices**, such as elevators, air conditioners and refrigerators. These high-powered pieces of equipment require a lot of energy to switch on and turn off components like compressors and motors. This switching creates sudden, brief demands for power, which upset the steady voltage flow in the electrical system. While these surges are nowhere near the intensity of a lightning surge, they can be severe enough to damage components, immediately or gradually, and they occur regularly in most building's electrical systems.

Other sources of power surges include faulty wiring, problems with the utility company's equipment, and downed power lines. The system of transformers and lines that brings electricity from a power generator to the outlets in our homes or offices is extraordinarily complex. There are dozens of possible points of failure, and many potential errors that can cause an uneven power flow. In today's system of electricity distribution, power surges are an unavoidable occurrence. In the next section, we'll see what this could mean to you.

Protecting Your Equipment

In the last section, we saw that power surges are a regular occurrence, unavoidable with our current system of providing electricity to homes and offices. This raises an interesting question: If power surges are an inherent part of our electrical system, why didn't we need surge protectors in our homes 50 years ago?

The answer is that a lot of the components in sophisticated modern electronic devices (such as computers, microwaves, DVD players) are much smaller and more delicate than components in older machines, and are therefore more sensitive to current increases. Microprocessors, which are an integral part of all computers as well as many home appliances, are particularly sensitive to surges. They only function properly when they receive stable current at the right voltage.

So whether or not you should get a surge protector depends on what sort of device you're hooking up to the power supply.

- There's no reason to hook up a light bulb to a surge protector because the worst that is likely to happen due to a power surge is that your light bulb will burn out.
- You should definitely use a surge protector with your computer. It is filled with voltage-sensitive components that a power surge could damage very easily. At the least, this damage will shorten the life of your computer, and it could very easily wipe out all of your saved data or destroy your system. Computers are very expensive items, and the data they hold is often irreplaceable, so it's only good economic sense to invest in a quality surge protector.
- It's a good idea to use surge protectors for other high-end electronic equipment, such as entertainment center components. A surge protector will generally extend the life of these devices, and there's always a chance that a big power surge will causes severe damage.

One problem with surge protectors is that the MOVs can burn out with one good surge. This is why it's good to get a protector with an **indicator light** that tells you whether or not it's functioning properly.

Even if you connect surge protectors to all of your outlets, your equipment might be exposed to damaging surges from other sources. Telephone and cable lines can also conduct high voltage -- for full protection, you should also guard against surges from your telephone or cable lines. Any lines carrying signals into your home can also carry a power surge, due to lightning or a number of other factors. If your computer is connected to the phone lines via a modem, you should get a surge protector that has a **phone-line input jack**. If you have a coaxial cable line hooked up to expensive equipment, consider a **cable surge protector**. If you have a digital satellite system, the surge protector should have a separate **digital**

satellite coax input connector. Surges on these lines can do just as much damage as surges over power lines.

Levels of Surge Protection

All surge protectors are not created equal. In fact, there is a tremendous range in both performance and price of protection systems.

- At one end, you have your basic $5 surge protector power strip, which will offer very little protection.
- On the other end you have systems costing hundreds of thousands of dollars, which will protect against pretty much everything short of lightning striking nearby.

This inexpensive, quality protector features basic MOV protection and line-conditioning systems.

Most systems have limitations of some sort; picking out a protector system that suits you is a matter of balancing the cost of the system with the cost of losing data or electronic equipment. As with insurance, you find the level of coverage you're comfortable with.

To protect your equipment from surges, you need individual surge protectors for each outlet. These power strips range a great deal in quality and capacity (as we'll see in the next section). There are three basic levels of power strip surge protectors:

- **Basic power strip** - These are basic extension cord units with five or six outlets. Generally, these models provide only basic protection.
- **Better power strip** - For $15 to $25 you can get a power strip surge protector with better ratings and extra features.

- **Surge station** - These large surge protectors fit under your computer or on the floor. They offer superior voltage protection and advanced line conditioning. Most models also have an input for a phone line, to protect your modem from power surges, and may feature built-in circuit breakers. You can get one of these units for as little $30, or you can spend upward of $100 for a more advanced model.
- **Uninterruptable Power Supply** (UPS) - Some units combine surge protection with a continuous UPS. The basic design of a continuous UPS is to convert AC power to DC power and store it on a battery. The UPS then converts the battery's DC power back to AC power and runs it to the AC outlets for your electronics. If the power goes out, your computer will continue to run, feeding off the stored battery power. This will give you a few minutes to save your work and shut down your computer. The conversion process also gets rid of most of the line noise coming from the AC outlet. These units tend to cost $150 or more.

An ordinary UPS WILL give you a high level of protection, but you should still use a surge protector. A UPS will stop most surges from reaching your computer, but it will probably suffer severe damage itself. It's a good idea to use a basic surge protector, if just to save your UPS.

Once you've decided what level of surge protection you need, it's time to shop around for a good unit. In the next section, we'll find out what you should look for when considering different models.

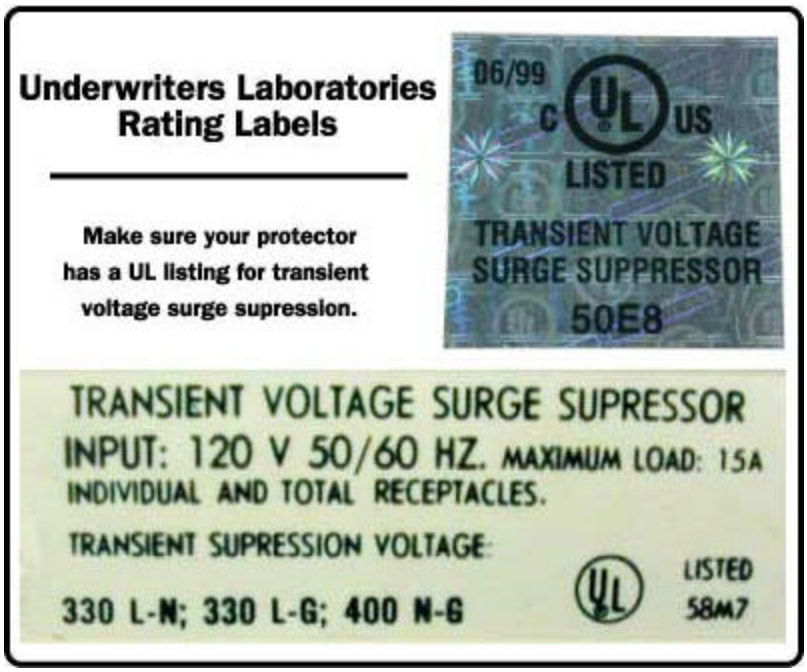
Picking the Right Surge Protector

Shopping for a surge protector is tricky business because there are a lot of nearly worthless products on the market. Research into a particular model is the best way to ensure good results, but you can get a good idea of a product's performance level by looking for a few signs of quality.

Of course, high price doesn't promise quality. To find out what the unit is capable of, you need to check out its **Underwriters Laboratories (UL) ratings**. UL is an independent, not-for-profit company that tests electric and electronic products for safety. If a protector doesn't have have a UL listing, it's probably junk; there's a good chance it doesn't have any protection components at all.

Many UL-listed products are also of inferior quality, of course, but you're at least guaranteed that they have some surge protection capabilities and meet a marginal safety standard. Be sure that the product is listed as a **transient voltage surge suppressor**. This means that it meets the criteria for **UL 1449**, UL's minimum performance standard for surge suppressors. There are a lot of

power strips listed by UL that have no surge protection components at all. They are listed only for their performance as extension cords.



On a listed surge protector, you should find a couple of ratings. Look for:

- **Clamping voltage** - This tells you what voltage will cause the MOVs to conduct electricity to the ground line. A lower clamping voltage indicates better protection. There are three levels of protection in the UL rating -- 330 V, 400 V and 500 V. Generally, a clamping voltage more than 400 V is too high.
- **Energy absorption/dissipation** - This rating, given in joules, tells you how much energy the surge protector can absorb before it fails. A higher number indicates greater protection. Look for a protector that is at least rated at 200 to 400 joules. For better protection, look for a rating of 600 joules or more.
- **Response time** - Surge protectors don't kick in immediately; there is a very slight delay as they respond to the power surge. A longer response time tells you that your computer (or other equipment) will be exposed to the surge for a greater amount of time. Look for a surge protector that responds in less than one nanosecond.

You should also look for a protector with an **indicator light** that tells you if the protection components are functioning. All MOVs will burn out after repeated power surges, but the protector will still function as a power strip. Without an indicator light, you have no way of knowing if your protector is still functioning properly.

A Belkin SurgeMaster II mid-range surge protector with connections for phone lines

Better surge protectors may come with some sort of guarantee of their performance. If you're shopping for more expensive units, look for a protector that comes with a guarantee on your computer. If the unit fails to protect your computer from a power surge, the company will actually replace your computer. This isn't total insurance, of course -- you'll still lose all the data on your hard drive, which could cost you plenty -- but it is a good indication of the manufacturer's confidence in their product.