Pacific Gas and Electric Company

Surge Suppressors

What is Surge Protection

A surge suppressor can be the first and best defense against the instant or gradual destruction of electrical equipment. Compared to the replacement cost of a computer or the costly impact of data loss, surge suppressors are very inexpensive.

Surge protection is a defense against damage from extremely high voltages that can be caused by lightning strikes, short circuits somewhere on the line, or switching equipment on or off line.

Until the introduction of solid state devices, most AC powered equipment was too robust to be upset by surging power. However, modern electronic equipment such as computers, telecommunications equipment and controllers is vulnerable to surges and the damage they can cause.

Many people think of surge damage as caused by a single catastrophic event such as a lightning strike. While lightning is one of the most powerful and destructive surges, it does not occur frequently in our service territory. Small surges can occur several times a day or a hundred times an hour, ranging from several thousand volts to under 100 volts. These repeated smaller surges can eventually degrade electronic equipment.

Power surges can also be generated by equipment in your facility such as:

- Elevators
- Office machines
- HVAC equipment
- Electric motor starters

Utility operations such as switching may also cause surges that can be carried along utility lines. When the surge reaches an office, factory, or home, it may still have enough energy to jump across switches, even those that are turned off, and damage equipment.

An understanding of surges, noise and the serious problems they cause will help you protect valuable equipment from these invisible, extremely fast, and destructive forces.

Why Do We Need Protection

Solid state devices depend on consistent, high quality power. A single, powerful surge literally melts, welds, pits and burns its way through solid state circuits. Damage from surges can be classified into three categories:

1. **Hard failures** which cause permanent damage requiring repair or replacement of electronic components,
2. **Upsets** which are temporary malfunctions or glitches and usually do not cause permanent damage, and
3. **Latent failures** resulting from continuous exposure to smaller, non-catastrophic surges which erode equipment performance and eventually cause hard failure.

Surges also create noise which can upset sensitive electronic equipment as well as alter or completely destroy stored data. Noise interference is actually a series of low level surges, typically between 10 volts to less than a volt.

Types of Surge Suppressors

The most common type of suppressors are diverters. Diverters are connected in parallel between any two conductors. Generally, they are line to line, line to neutral, or neutral to ground. There are two basic forms of diverting devices: clamps and crowbars.

Clamps - Voltage-clamping devices simply limit the surge. However, these devices have a changing impedance depending on the current flowing through them or the voltage appearing across them. Metal-oxide varistors (MOV) and avalanche diode suppressors are examples of clamps.

Metal-oxide varistors (MOVs) operate in the nanosecond range and were originally designed to protect electric motors. The disadvantage here is a limited pulse life. Each time an MOV suppressor reacts to a surge, its performance ability lessens. Therefore, it is difficult to predict an MOV product's life. It depends primarily on the number and frequency of surges it experiences. Ultimately, it will fail. It is important to plan for replacement of the MOV components.

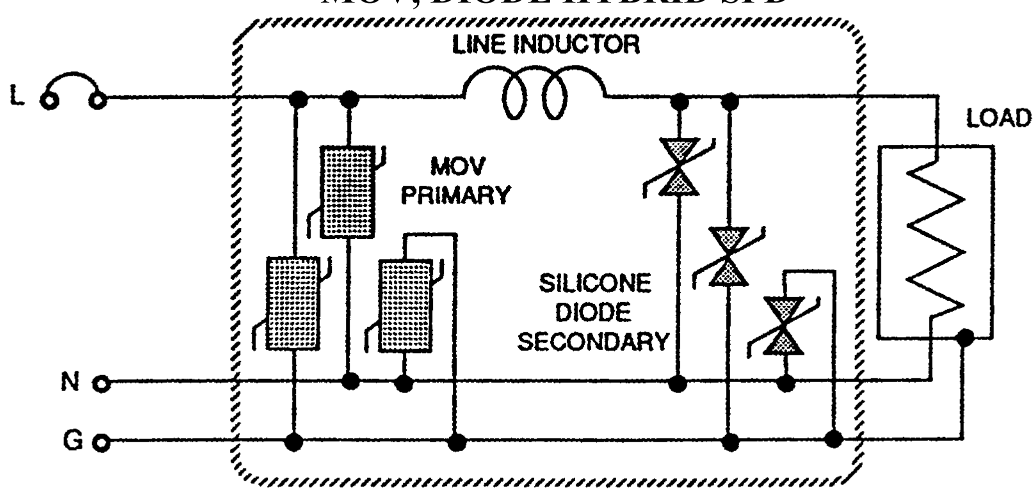
Silicon avalanche diodes respond within nano seconds to clamp excessive voltage but have low energy dissipation characteristics. Further, a surge that exceeds an avalanche suppressor's rating could get through to the equipment or destroy the surge suppressor. These are rarely used due to short life and limited use.

Crowbar - When an overvoltage occurs, the crowbar devices change from a high-impedance to a low-impedance state. This low-impedance state then offers a path to ground, shunting unwanted surges away from sensitive circuits. Gas discharge tubes are one currently available crowbar device. For radio and TV antennas, a spark gap device may be the principal lightning protection.

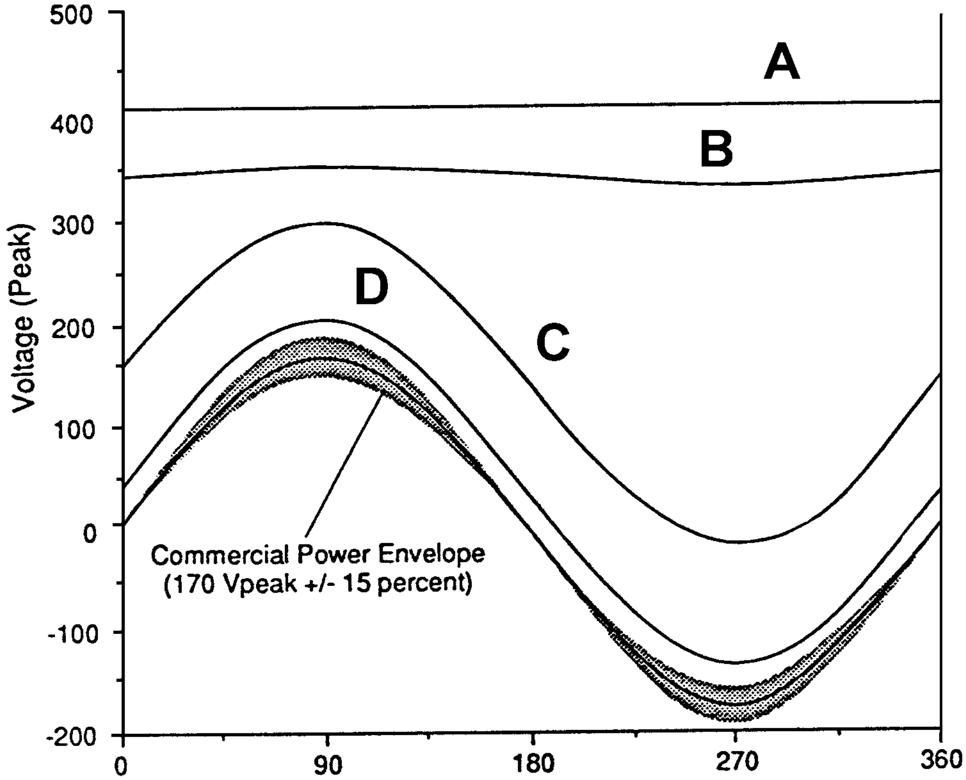
Gas discharge tubes offer a low resistance path for large currents to shunt high-current transients to ground and dissipate energy in the form of light and heat. The major advantage of a crowbar device is its ability to handle large surge currents without breaking down or overheating. However, unlike avalanche diodes, gas discharge tubes do not respond quickly to a surge. In some cases, the transient may occur faster than the device can respond to it. Gas tubes are rarely used today.

Most surge suppressors use a combination of these technologies in one product, referred to as **multistaging.** Such circuits, made up of different kinds of protectors separated by a suitable impedance, are referred to as **hybrids**. MOVs that divert surge current are the most common surge protection components for the first stage of protection. A gas discharge tube may provide the second stage of protection. It operates only when a surge exceeds the MOV's maximum current rating. The inductor tends to smooth out any rapid changes at higher frequencies. The capacitor acts as a short circuit to high frequency transients. Most manufacturers use one or more MOVs as the principal surge protection device. There is one manufacturer that uses a large inductor, several high frequency filtering capacitors and no MOVs. The diagram below illustrates a hybrid circuit of a Surge Protection Device (SPD).

MOV, DIODE HYBRID SPD



Sine wave tracking is a new technology that appears in high-end surge suppressors. This technology tracks the AC power sine wave, enabling instant response to minor spikes and transients that may pass through conventional protection. The diagram below illustrates one manufacturer's test data in four different SPD topologies. Curves A and B are from MOV based models. Curves C and D are higher performance models with sine wave tracking options.



PHASE ANGLE (Degrees)

Suppression Performance Data taken at Multiple Phase Angle positions via Keytek 587 Plus Surge Generator and Tektronix Digital Storage Oscilloscope per ANSI/IEEE C62.45-1980

Application of Surge Protection

Balance the cost of the surge suppressor with the importance and cost of the equipment to be protected. Different surge suppression units offer varying levels of protection, but all have the same basic job: to prevent damaging voltage spikes from reaching the device they are intended to protect. More sophisticated suppression units offer other kinds of protection such as noise filtering.

The following is a procedure you may want to go through in applying surge protection in your facility.

1. Identify the equipment to be protected.
2. Determine the amount of protection required. Decide what kind of surges will be encountered on which lines connected to your equipment. Then select the proper class of protection.

3. Determine the location for the protective devices. Devices can be located at the main service entrance, sub-panel, receptacle or even on the circuit boards themselves. It is generally recommended to use a service entrance device if lightning is common in your area, but this is rarely a problem in the PG&E service territory.
4. Determine whether hard wired or plug-in type units are appropriate. Hard wired units have multiple, large MOVs to divert excess current and absorb more energy at higher clamping levels than plug-in types.
5. Select the failure mode of the protection device. Decide on the level protection and if failure does occur, whether it is permissible to have an outage without protection.
6. MOVs and filter capacitors will fail over time so you need to plan on their replacement, either the total device or by components.
7. Panel mounted units, based on MOV technology, must have very short wiring leads to be effective, preferably <12 inches.

Things to Look for in a Surge Suppressor

Indicator Lights (LED) - Look for the indicator light on the surge suppressor and be aware of what it means. Some suppressors have both visual and audible alarms. Some suppressors also have circuit breakers or fuses to protect circuits from normal overload. It is critical to know if the protective components are still in working condition. Some SPDs have fuses to open when the MOVs fail.

UL 1449 Listed - Look for the UL 1449 listing, printed on the device not just UL 1449 tested or passed claims in the product literature. Under UL 1449, surge suppressors are required to pass three durability tests that determine the performance of the device. Under UL 1449, second edition, approved in 1998, there are further safety and performance standards. Besides many safety issue enhancements, a very important new parameter covered under the second edition listing is the ability to withstand an open neutral condition which results in a potential doubling of the voltage.

Energy Specifications - Make sure the maximum impulse energy the suppressor can withstand is specified on the suppressor in joules. The range will be from several kilojoules for small individual SPDs to 10-100 kilojoules for panel mounted units.

Noise Attenuation - Look for the type of noise attenuation capabilities of the device. For example, some devices have both transverse and common mode noise attenuation capabilities. This is not a primary function.

Clamping Voltage - Look for the clamping voltage on the surge suppressor. The range is from 330 volts up to 600 volts for 120 volt nominal. Four hundred volts is adequate. Sine wave tracking would be optional but the most costly.

Claims of Energy Savings SPDs have no apparent validity.

Claims of Harmonic Filtering SPDs have no apparent validity.

Revised: March 2000