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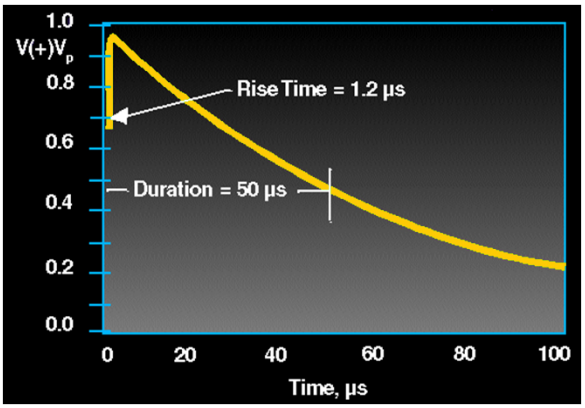
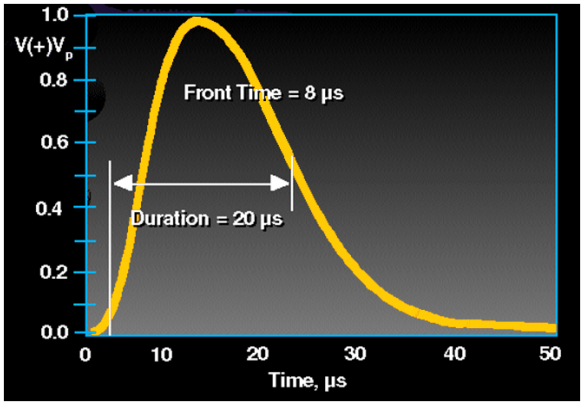
The Technology Behind
The Surge Suppression LLC
Surge Protective Devices

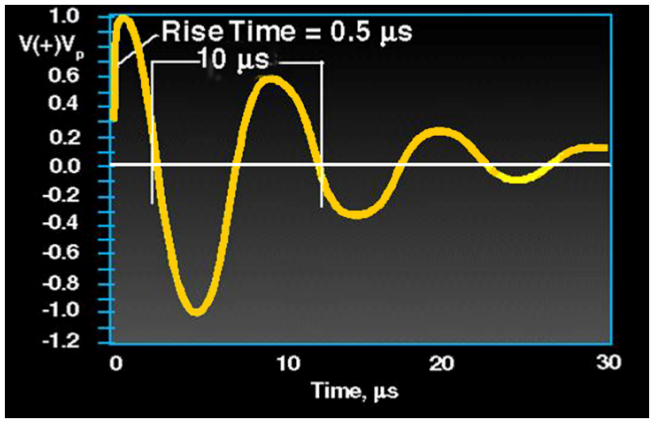
Two Basic Types of Surge

Surges have two basic shapes. The combination wave impulse, and the oscillatory ring wave.





With the combination wave impulse, the voltage and current rise to a peak and fall back to normal. It is a simple rise to a peak and fall back to normal. The impulse originates mainly from lightning and mechanical switching.



With the oscillatory ring wave, the voltage rises to a peak and then falls back past the zero line to an equal negative peak, then rings back and forth several times before damping out. The ring wave is caused primarily by electronic switching power supplies like your computer, and larger electronic equipment like variable frequency drives for elevators, HVAC, assembly line motors and overhead cranes in manufacturing plants.

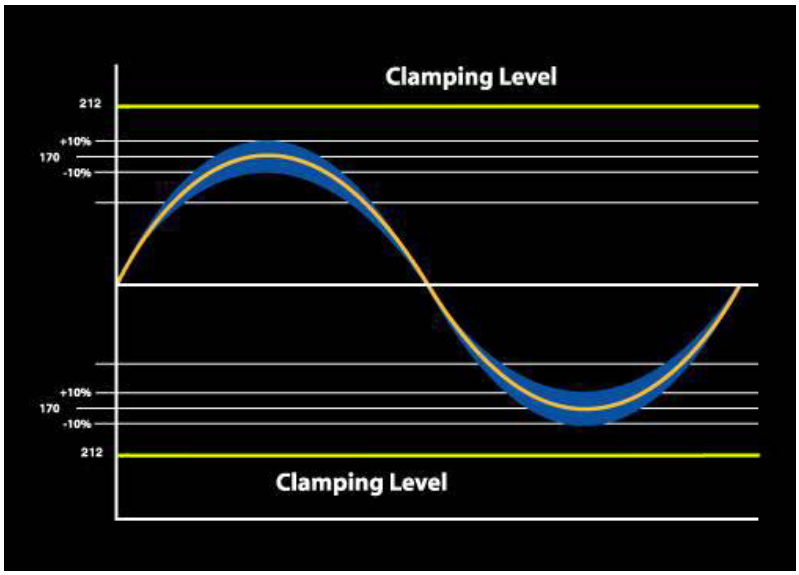
The Basic Two Types of Surge Protective Device Design

There are two distinct types of surge protection technology, the Voltage Responsive Circuitry and the Frequency Responsive Circuitry. Each one is designed to address a particular type surge.

Voltage Responsive Circuitry

Let's first look at the Voltage Responsive Circuitry, designed to address the impulse type surge created by lightning and mechanical switching:

- Requires that a transient exceed a preset voltage level above and below the power voltage sine wave before the components within the SPD begin to activate,
- Requires "headroom" above and below the peak voltage level to prevent the SPD from clamping the power frequency sine wave, and
- Commonly called Threshold, Standard, or Fixed Clamping.



The upper and lower yellow lines represent the positive and negative "clamping" points. You will notice that these lines are a constant or "fixed" distance from the zero line (center white line) of the sine wave. No matter where on the sine wave the surge is induced, it must reach the "threshold" level on the positive or negative side of the sine wave to activate the SPD circuitry. Thus, the term "threshold clamping". The threshold clamping circuit provides the best protection against high energy impulse transients.

Frequency Responsive Circuitry

Looking at the Frequency Responsive Circuitry:

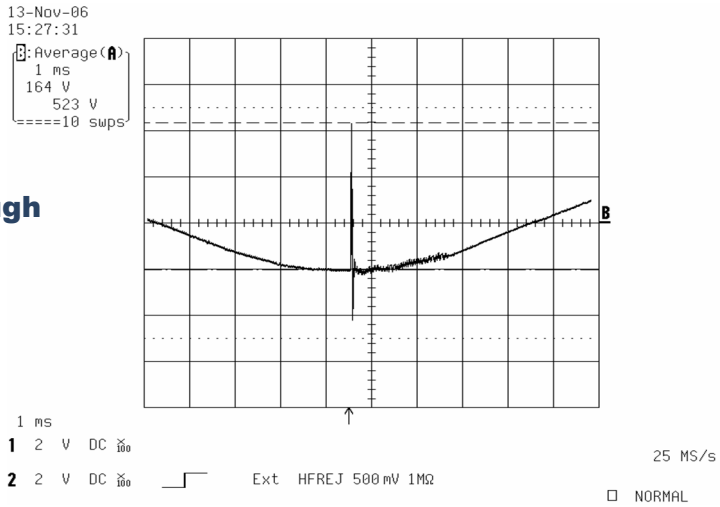
- Designed to address ring wave surges as they deviate from the power frequency sine wave without interaction with the applied power voltage sine wave.
- Unlike the *Voltage Responsive Circuitry*, "headroom" is not required for this type of circuitry to operate.
- Reacts to a change in frequency created by the surge.
- Operates independent of the voltage.

Power supplies for virtually all equipment with an electronic control or monitoring function convert the AC voltage to DC voltage to power the electronic circuits. The Frequency Responsive Circuitry is designed to address the oscillating ring wave surges that are created primarily by electronic switching. The Frequency Responsive Circuitry triggering on the high frequency oscillation, or ringing, of the surge, not the voltage. Remember, the Voltage Responsive Circuitry triggers when the impulse voltage exceeds a set level. With a ring wave, the surge oscillates back and forth across the normal waveform, decreasing each time until it damps out and returns to normal voltage. In reacting to the high

frequency ringing, the Frequency Responsive Circuitry SPD removes only the voltage present at that high frequency, allowing the voltage at the normal 60 Hz frequency to flow unabated.

Voltage Responsive Circuitry

Let-Through Voltage 523 Volts

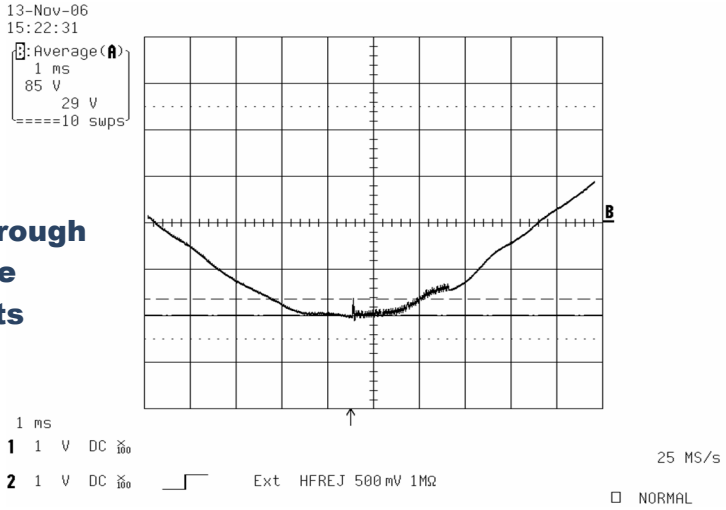


A1 Ring Wave,
2,000 volts,
67 amps,
270° phase angle

Frequency Responsive Circuitry

A1 Ring Wave,
2,000 volts,
67 amps,
270° phase angle

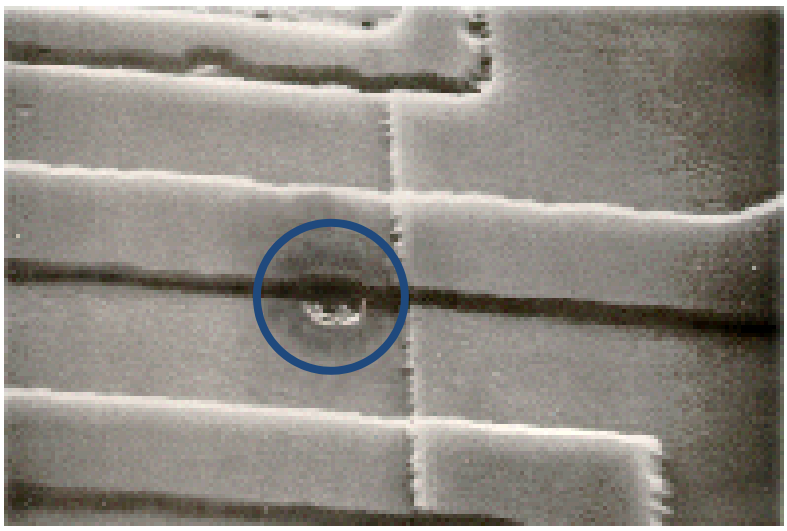
Let-Through Voltage 29 Volts



To illustrate the effectiveness of these two types of circuitry on a ring wave surge, note the preceding charts. Both types of circuitry are tested with the IEEE C62.41, 100 kHz Ring Wave surge of 2,000 volts 67 amperes, tested at the 270° phase angle on the sine wave. The "let-through voltage" of the "Voltage Responsive Circuitry" is 523 volts, over **one fourth** of the 2,000-volt ring wave. The "let-through voltage" of the "Frequency Responsive Circuitry" is **29 volts**. While a few other surge protection manufacturers provide frequency responsive circuitry in the Line-to-Neutral mode and Line-to-Neutral-to-Line connection, SSI is the **only** manufacturer to provide Frequency Responsive Circuitry as an option for every Advantage and SpecPRO series AC power model, in every voltage and every Peak Surge Current rating, reacting in every mode (L-N, L-G, N-G and L-L).

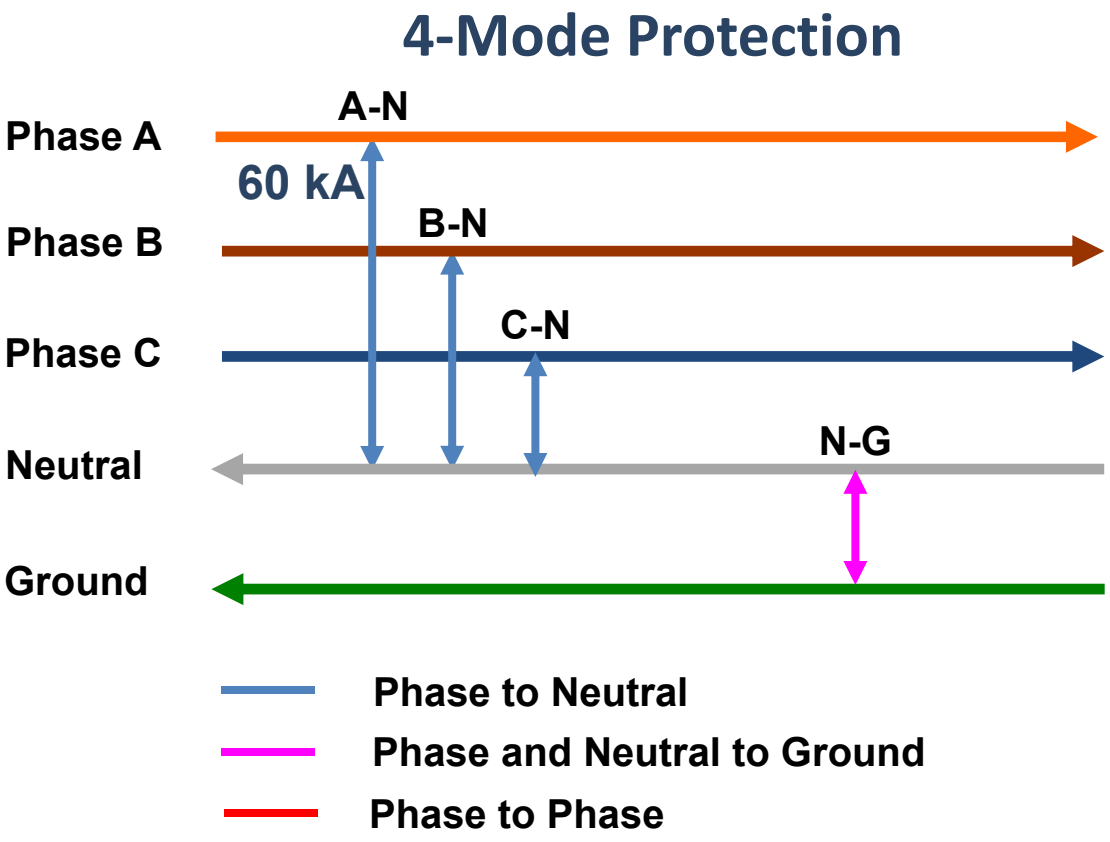
While impulse surges occur when constant speed motors, incandescent lights, and other mechanical electrical equipment is turned on or off, ring wave surges are occurring several times per cycle, 60 cycles per second. The switch-mode power supplies for the laptop, desktop computers, office printers and other electronic equipment, large and small variable frequency drive motor controls, electronic ballast and LED driver lighting and converting AC voltage to DC voltage to run the electronics or motor speed controls. They are doing this by drawing current in pulses, four to six times per cycle, or more. These current pulses create an inductive "kick" which create the voltage surges. This can be from 864,000 to 1,296,000 per hour. The good news is they are almost all below the 2,000-volt level. The bad news is

they are still excess, unusable over-voltage that will travel throughout the electrical distribution system until they find a point of resistance and convert to heat. Over time, these low-level, cumulative ring wave surges will build into “hot spots” that will deteriorate and degrade the processor circuits, motor winding insulation, electronic ballast and LED drivers, circuit boards and components, from the largest motor drive to the smallest piece of electronic office equipment.



This slide shows a blister that formed from transient activity on a processor chip. The blister grows from repeated, cumulative surge events, until it blocks or breaks the circuit and stops the flow of data down this path. When this happens, the chip shuts down, the board shuts down, the terminal shuts down and the computer shuts down. All this from a microscopic blister that is usually considered “normal wear and tear” on the equipment. This is preventable surge damage.

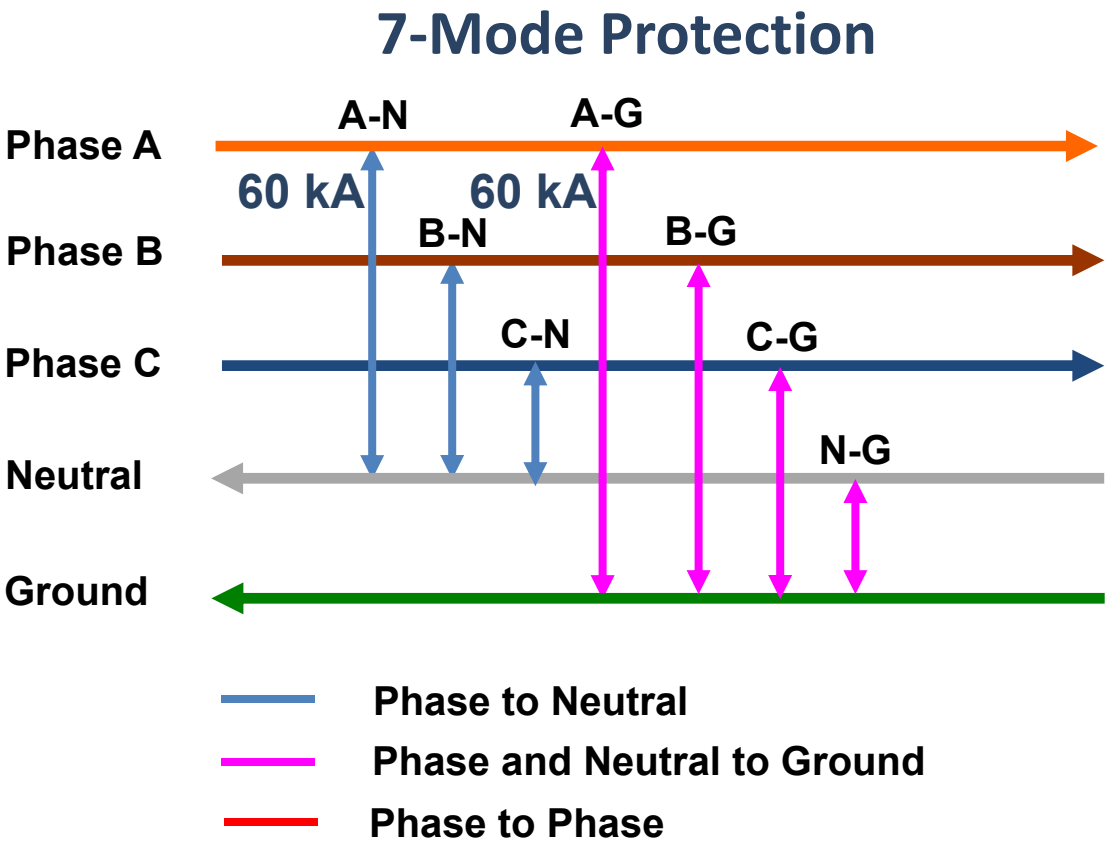
Modes of Protection



On a three-phase, four-wire system like a 120/208, or 277/480 V, four mode protection provides four sets of directly connected surge protection component paths (3 x L-N and 1 x N-G). There are six paths that do not have directly connected components (3 x L-G and 3 x L-L).

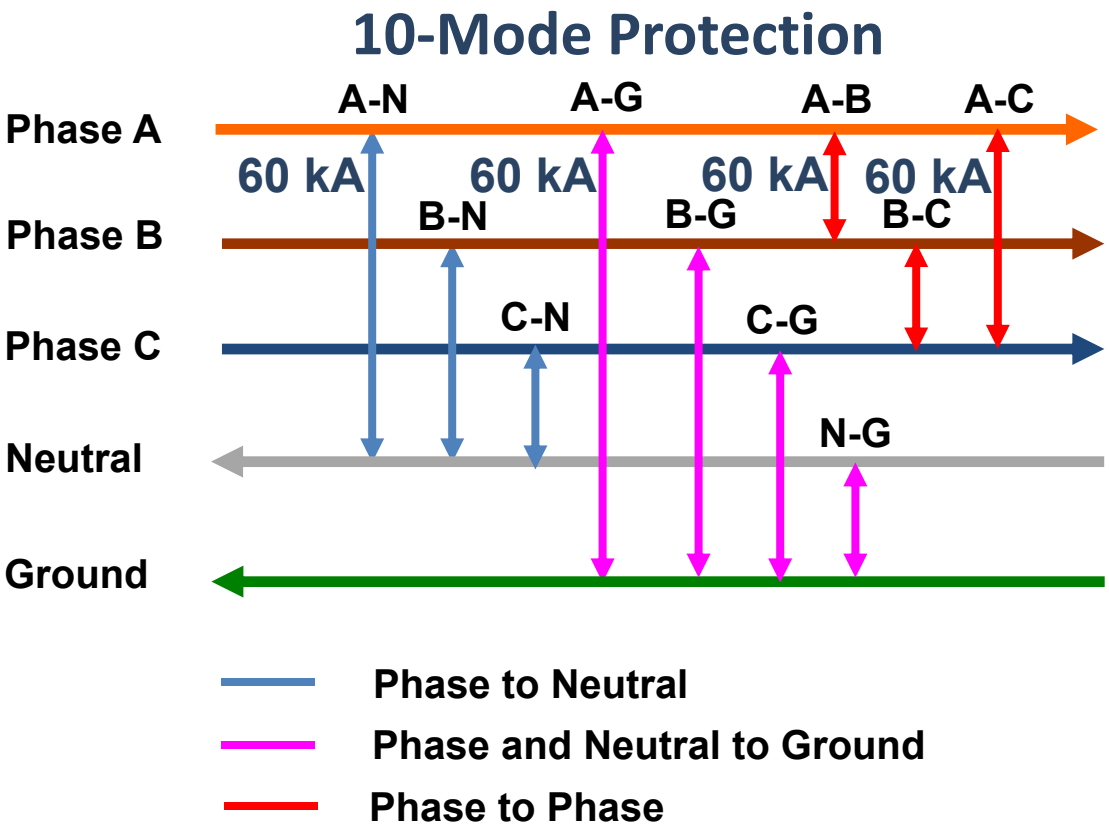
The per mode kA rating for a surge protective device represents the maximum strength from a single current pulse the components in that mode can absorb without failure.

If you have a 60 kA per mode SPD, you only have A-N mode on Phase A, therefore, the per Phase rating would also be 60 kA.



Seven mode protection provides seven directly connected paths (3 x L-N, 3 x L-G and 1 x N-G) There are three paths with no directly connected components (3 x L-L). There is an improvement in let-through voltage between the four mode and seven mode products.

On a 7 mode SPD, you have A-N and A-G modes at 60 kA each on Phase A, therefore you would have 120 kA per Phase peak surge current absorption capability.



Ten modes provide ten directly connected paths (3 x L-N, 3 x L-G, 1 x N-G and 3 x L-L). The let-through voltage is essentially the same between the seven and ten mode products.

On a 10 mode SPD, you have A-N, and A-G, and one of the phase-to-phase modes at 60 kA each. This would be a total of 180 kA per Phase for a 10 mode SPD.

The main difference between the three types of design are the number of surge protection components that are on-line for a given event and how much energy they can absorb.

Three Reasons for 10 Mode Protection

First, with a large surge on Phase A, and all mode protection (10 modes), you have A to N, A to G, A to B and A to C, providing 240 kA absorption capability. This doubles the paths of a 7 mode SPD for the surge to be dissipated, thereby increasing the probability that the surge will be absorbed by the surge suppression device.

Second, because there are more components available, the surge is spread out over more paths so that any one set of components sees less of the total surge and experiences less stress per event. This means longer life of the SPD.

And, third, more total paths and components means the let-through voltage is equalized between all the modes more effectively than with a 7-mode SPD that does not have discrete L to L components available. That means less surge stress and damage to the equipment down line. SSI is the **only** manufacturer that has dedicated surge protection components in every available mode of every Advantage series SPD, at every Peak Surge Current rating, and every voltage combination.

Hybrid Network Technology

- Multiple, redundant components,
- Multiple, redundant paths,
- Emphasize the strengths of each component,
- And their compatibility with each other, and
- Patented, board mounted over-current fusing on each phase.

The multiple components on multiple redundant paths emphasizes the strengths of each component. Their placement in the correct order, to take advantage of the unique benefits of each component, provides the strongest circuit with the most energy absorption possible. The patented, board mounted over-current fusing for each phase is non-replaceable. This reduces the resistance inherent in the normally seen replaceable fuses, fuse clips, fuse blocks, terminal connections, and wire runs between the fuse block and the circuit board, as well as the additional space requirements. If the SSI SPD should ever clear a fuse from a catastrophic surge, the entire SPD is replaced under warranty, any time during the full 25-year warranty period. SSI is the **only** surge protection manufacturer that has the board mounted over-current fusing.

Benefits of Electrochemical Design (Encapsulant)

- High dielectric strength of the encapsulant allows for more compact circuit designs,
- Extended life,
- Not effected by extreme environmental conditions,
- Protects against vibration and shock damage, and
- Environmentally friendly - HMIS value = 0 (non-toxic).

The encapsulant provides insulation between the components as well as the circuits on the board to eliminate arcing and preserve the integrity of the SPD during surge events. The encapsulation not only keeps the component connections secure to the circuit boards, it also protects against extreme environmental conditions, vibration and shock, extending the life of the SPD. A patented process provides for layering a fiberglass cloth over the encapsulated board and components and embedding it in the encapsulant around the edges and covering that with a fiberglass batting in the dead space remaining, to capture pieces and fine dust particles in case of a catastrophic surge event. **No other** surge protection manufacturer has this patented safety technology.

Size of the SPD and Lead Length

The size of an SPD is critical. The larger the SPD, the harder it is to find a desirable location to install the device that allows for short connection to the panel or equipment with short, straight leads.

The National Electrical Code:

Article 285 Surge-Protective Devices (SPDs), 1 kV or Less

II. Installation

285.12 Routing of Connections. *The conductors used to connect the **SPD** (surge arrester or TVSS) to the **line** or **bus** and to **ground shall not be any longer than necessary** and **shall avoid unnecessary bends**.*

This would apply to Type 1 and Type 2 SPDs

The IEEE Standard 1100-2005, Emerald Book, Section 8.6.2:

- Amount of external wire required to connect the SPD to the electrical system or equipment
- Recommended practice is for all leads to be short and straight
- Gently twist the phase leads to reduce impedance
- Avoid sharp bends in the conductors
- Short leads result in optimum performance; better equipment protection; AND lower let-through voltages

Warranty

With the ***"Advantage"*** series 25-year, unlimited replacement warranty for any electrical anomaly, ***including lightning***, and the "***SpecPRO"*** series 15-year Warranty for 7 mode models and 10-year Warranty for 4 mode models, ***including lightning,*** **Surge Suppression LLC** has the right surge protector for every application.