High Headroom or How to Prevent Premature SPD Death

Low headroom can spell death for a surge protection device; knowing where to set headroom is the first step in protecting an SPD investment.

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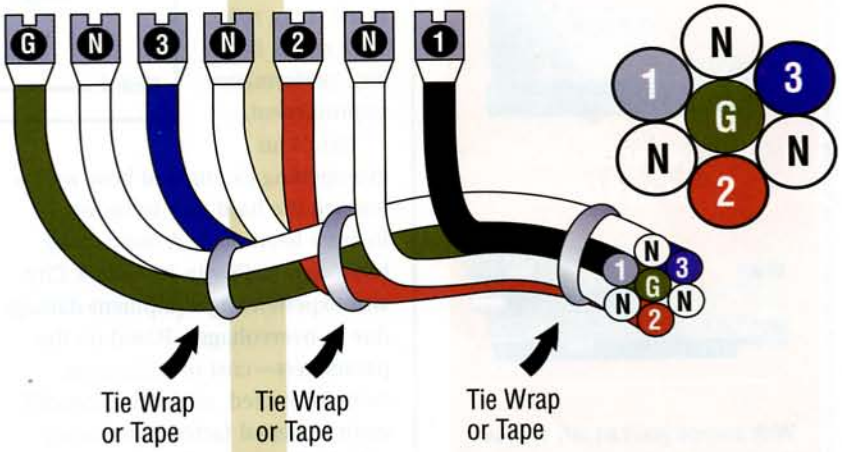
Low headroom can be uncomfortable in a vehicle, but in a surge protection device (SPD), it can result in the destruction of the protector. Knowing where to set headroom in terms of a protector's turn-on point is the first step in protecting one's investment.

The specified clamping voltage of SPDs should be as close to the value of the AC input power as possible. While it's logical to think that a protective device should derail overvoltages as soon as the input exceeds specified levels, actually, it turns out not to be the case. Real life power, as supplied by most utility companies, routinely varies from the nominal value, and in some cases, exceeds 15% variation above and below.

How does a well-designed SPD compensate for real world power variations? Recognizing the need for adequate headroom is a good place to start.



Axial power cabling approach forces magnetic field cancellation within this cable. This results in a correspondingly low inductive voltage drop along the cable length.

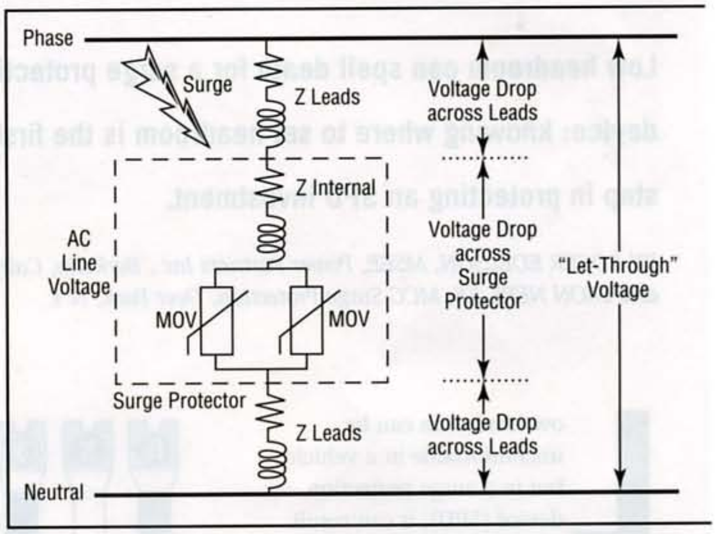
Headroom is the difference in voltage between the peak of the sine wave and a higher threshold voltage level where the protective components in SPDs—metal oxide varistors (MOVs)—start to turn on. If the headroom spread is too small, the MOV may conduct more frequently, resulting in a shorter MOV life. Under unremarkable conditions, MOV life ratings are conservatively estimated to exceed 30 years. Designed-in headroom margins of 15% and greater address this issue with virtually no effect on suppressor performance. Prudent design requires higher clamp voltage MOVs.

Clamp voltage is the measured maximum voltage appearing across a surge protector when a standard waveform (simulating a lightning strike) is applied to the surge protector. Some manufacturers, to gain a slightly lower clamping voltage, will narrow the headroom spread by using lower voltage MOVs. This approach is marketing thinking—not engineering thinking. Lower voltage MOVs greatly increase the likelihood of protector failure in the field. All in all, a big risk for a small, if any, performance improvement.

Here's an eye-opening example of how we learned the hard way to factor in extra headroom. A multi-story broadcast facility in New York City was experiencing equipment damage due to overvoltages. Based on the parameters—cost of equipment being protected, utility fluctuations, environmental factors (frequency of lightning storms), and 277-volt line—we recommended a 277/480 volt AC, 3-phase, 4-wire and ground main service panel protector with an Ip of 160,000 amps—more than adequate protection. The unit contained 320-volt AC MOVs.

On paper, it's perfect. In reality, the utility fed the line with X amount of excess voltage, far exceeding the tight clamp traditionally believed to be optimal. The protector's MOV modules were damaged and, as a result, the protector was taken offline, leaving the facility unprotected. No equipment was damaged, but picking up pieces of a blackened surge protector is not the way to stay in business, and we had to rethink our design and how we specified.

This is the problem. The difference between the peak voltage of the sinusoidal input power and the minimum specified clamping voltage is often referred to as headroom or safety margin, but really should be called line voltage variation allowance (LVVA), as this is more descriptive of the actual design parameter. While many surge protection units set the LVVA at 15% above the nominal input power value, we know that the line voltage can exceed this value under non-surge conditions—not as a fluke, but regularly.



Cases are documented where the input power has approached a 20% overvoltage value for over one minute, and this condition is considered to be within power company specifications. When this level of line voltage occurs, SPDs with a design LVVA of +15% will trigger into "protection mode," which can result in a permanent shorted condition. A permanent shorted condition means protectors are finished and require replacement.

While most electronic equipment is designed to withstand voltage excursions of +/-15% (and even a little more), if this level of peak voltage is sufficient to cause the surge suppressor to enter its protection mode, the permanent short will mimic a failure of the "protected" unit.

An aside: An external circuit breaker whose function is to disconnect a permanently shorted surge suppressor, removing it from the power line, is recommended. The circuit breaker is essentially transparent to surges, but its primary function is to safely disconnect shorted equipment from the power line. Using a protector with sufficient headroom ensures that protector circuit breaker operation is a rare occurrence. What good is a protector if it keeps taking itself out of the game?

As voltage spikes (or surge voltage generated by nearby lightning strikes or inductive switching) greatly exceed the +20% LVVA specification, no equipment protection is sacrificed by using surge protection units with a designed LVVA of +30% (an additional 10% is added to allow for variations in MOV actual clamping voltage vs. their nominal specification). In fact, providing this increased headroom enhances the lifetime and reliability of the surge protection units.

A user's primary concern is the tightest protection possible. It's the supplier's problem to figure out how to provide it without sacrificing close clamp voltage. True, the user wants the sharpest knife in the drawer, but also the most reliable. A reliable SPD is one that works again and again.

Only an SPD that allows for real-world voltage variations offers this premium reliability.

How does an SPD achieve perfect protection without allowing let-through voltage sully its stats?

Sensitive equipment located downstream on the AC power lines will be exposed to the clamp voltage of the surge protector while it is diverting the transient to ground. It is always desirable to limit let-through voltage. Careful design is required to minimize additional overvoltage supplied to the protected equipment due to external line drops.

For example, the use of standard methods of line power wiring can produce almost 500 volts of additional stress to protected equipment than if a low-inductance technique is used. (This comparison is based on using #6 wire size vs. low-impedance specialty cable.) A typical low inductance wiring technique results when the power, neutral (return) and ground lines are incorporated into a wiring bundle as shown on Page 23. Additionally, the surge suppressor circuit board should be designed for minimum inductance in the connection to the power line.

Failure to use low-Z boards can expose equipment to additional overvoltage conditions—low-impedance construction will yield approximately 50% less voltage drop in the suppression unit than standard construction. The diagram on Page 24 shows the factors that contribute to the "let-through" voltage stress.

The proliferation of SPDs is due to the recognition of the high cost of equipment downtime and failures. These failures can stop computer networks, ATMs, processing, medical functions, and manufacturing operations, resulting in loss of income, which in most cases, is not recoverable. In addition, there is the cost and annoyance of repair and reinstallation. Avoiding failures is a top priority.

Overall system reliability is greatly increased by using surge suppressors with an LVAA that can withstand a 20% overvoltage condition. Remember, too close clamping is not the best way to go. Further, surge suppression design should include low inductance cable as pioneered in the cable design shown, to reduce the voltage formed on the connection cable during a transient event. Adopting these simple guidelines will help prevent costly downtime by ensuring that your equipment or facility is reliably protected. END

A Surge Protector Primer

There are two types of protectors:

Series-installed protectors are typically used at the equipment level, either right in front of, or within the equipment they are protecting. These protectors have an "input" and an "output" whereas parallel protectors do not. A common example is a surge-protected strip. Because they are connected in series with the equipment, they conduct load current. It is also common for a series AC protector to contain a EMI/RFI noise filter to filter out noise generated by other loads.

Parallel protectors do not conduct load current and simply "tap" into the power system via a circuit breaker. Parallel protectors are commonly used where large surge energies exist. They're used on service entrance panels and switchgear, plus branch and local panels. There are a number of reasons why parallel protectors are very popular. They have proven reliable and are easy to install. And since parallel connected protectors do not have to support system load currents, they are relatively small and not costly.