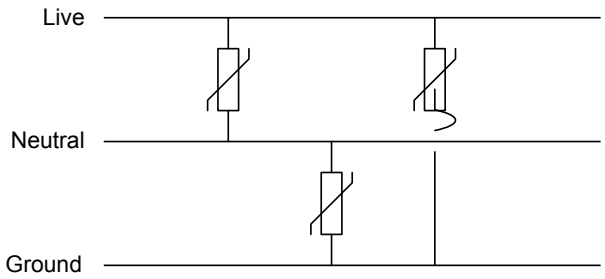
SurgeX Advanced Series Mode®

By Andy Benton, Engineering and Power Consultant

Abstract

Today's electronic equipment relies on embedded computers – microprocessors, digital signal processors, and memory chips – each containing millions of transistors. Lightning surges and transients generated within buildings pose a hazard to these sensitive, nano-meter scale components. Starting with a historical review of electronic equipment, this paper discusses power conditioning options currently available to systems designers and installers.

Traditional Shunt Mode Protection Using MOVs



First Light

Ever since one of the first electric grids lit up lights in New York City in 1882, engineers have realized that, because lightning is attracted to long copper wires, a good path to ground must be maintained at all times if the electrical service is to be safe. When solid-state electronic equipment became commercially available in the 1960s, a new problem emerged – transistors were much more sensitive to transients and surges than the older and more rugged vacuum tubes. In response to this new threat, basic surge suppressors were developed, chiefly using metal-oxide varistors (MOVs), which had originally been developed to suppress arcing on relay contacts.

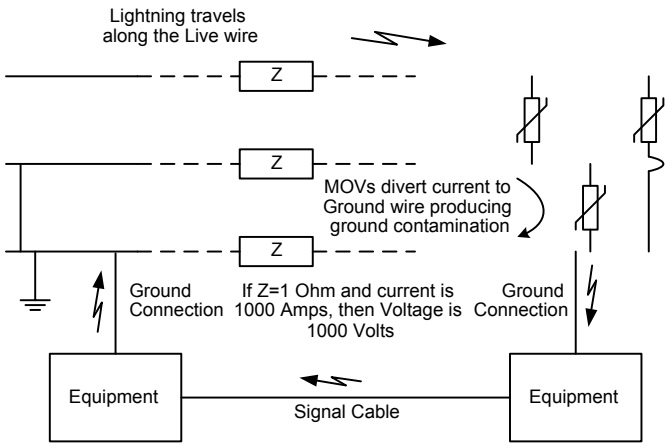
These early surge suppressors functioned by simply diverting surge energy to the ground wire – following the traditional electrical mindset of providing a path to ground. This offered a measure of protection, but electronic components rapidly became smaller and more sensitive, and integrated circuits came into common use in the 1970s along with early microprocessors – the precursors of the "digital age". These new electronic components were more sensitive to transients and surges, plus another problem emerged: a small transient which would not necessarily damage components could disrupt the program running on a microprocessor or corrupt data stored in a memory chip.

The Bad Old Days

Before the introduction of SurgeX power conditioners in 1996, installers and end users had no other option but to use unreliable surge suppressors that utilized MOVs. These products were not dependable, plus a substantial amount of surge voltage still made it through to the connected equipment. This is known as the "let-through voltage", and the amount of energy that made its way through to the connected equipment depended on the quality of the individual product.

When these MOV-based surge suppressors did work, they diverted thousands of amps of surge current to the ground wire, thus causing ground contamination. This is a relatively new problem born out of increasingly complex, interconnected systems. The audio/video system ground is the same as the electrical safety ground, and contaminating the electrical ground also means contaminating the A/V system ground. As the diagram below shows, when surges and transients are diverted to the ground wire, that energy can travel anywhere – even along signal cables – potentially damaging a sensitive preamplifier, causing equipment lock-up, phantom gear issues and downtime. Not only were MOV-based surge suppressors not up to the task of adequately protecting modern A/V systems, they were now actually causing a problem!

Multiple Paths To Ground Caused By Ground Contamination



The Task At Hand

Although lightning strikes have been measured as large as 200,000 amps, a more typical strike is on the order of 20,000 amps. However, even the smaller lightning strikes still pack a tremendous amount of energy into a very small timeframe. Common-sense tells us that no surge protection device could withstand a direct lightning strike but, fortunately, we don't need to: evaluations of surge energy inside buildings performed back in the 1970s set upper limits on surge voltage and energy. That pioneering work was published in 1980 by the IEEE in their C62.41 document.

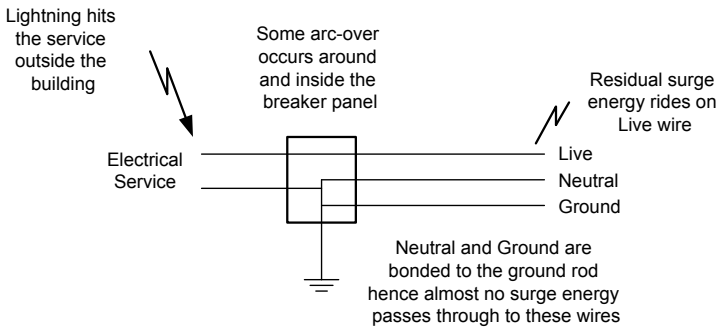
Due to arc-over at the electrical service entrance and within the building wiring, equipment plugged into a 120V or 240V outlet does not get hit with millions of volts and tens of thousands of amps. IEEE C62.41 characterizes the maximum properties of surges within a building as:

- 6,000 Volts
- 3,000 Amps
- 90 Joules of Energy

This might not sound like a lot compared to a lightning strike but, if we do the math for a typical 20 micro-second surge, the peak power works out to be 4.5 Mega-Watts! It is precisely because the surge energy is packed into such a narrow window of time that equipment blows up.

IEEE C62.41 became the design standard for SurgeX. The goal was to design surge protection technology which could withstand worst-case surges as defined by this document an unlimited number of times, with no degradation, no damage or interruption to connected equipment, and no unwanted side effects.

Lightning Strike Hits Electrical Service



SurgeX To The Rescue

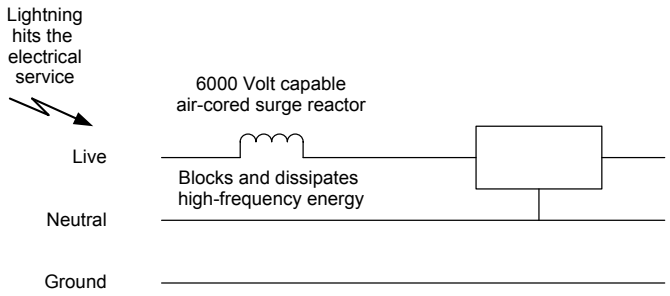
Seeing that the traditional diversionary surge suppressors, which shunt surge energy to ground, no longer provided adequate protection for modern digital electronics, as well as causing other problems by contaminating the system ground, inventors started looking at a totally different approach. Instead of trying to shunt thousands of amps of surge energy to ground through building wiring, the idea was to block and contain the surge energy – more difficult and more expensive to produce but, ultimately, much more effective and reliable.

While trying to decide how to design a surge protector which was 100% reliable under all conditions of use and which also did not contaminate the system ground, the inventors realized that surges and transients are very short-lived events, and that most of the damaging energy was up around 100KHz to 1MHz. (Keep in mind that the audio band is generally considered to be from 20Hz to 20KHz.) So, if an AC power filter could be designed that would withstand repeated hits of 6,000 Volts, then most of the surge energy would be blocked. An analogy would be a speaker crossover filter – in this case, like a subwoofer crossover that allows the 60Hz AC mains to pass through unimpeded, but blocks the much higher surge and transient frequencies.

In order to make this idea a reality, the inventors had to design a special kind of inductor called a surge reactor which was able to withstand 6,000 Volts and also had specific magnetic characteristics which keep the let-through voltage at a very low level – below anything that could potentially damage or disrupt equipment. Low-pass filters always have both a series element and a parallel element. In this case, the surge reactor was the series element. The parallel element was designed to complement the surge reactor and mitigate any residual surge energy using sensing circuitry, triacs and storage capacitors. That residual energy is then safely dissipated internally.

Thus, SurgeX Series Mode was born!

SurgeX Blocks and Contains Surge Energy

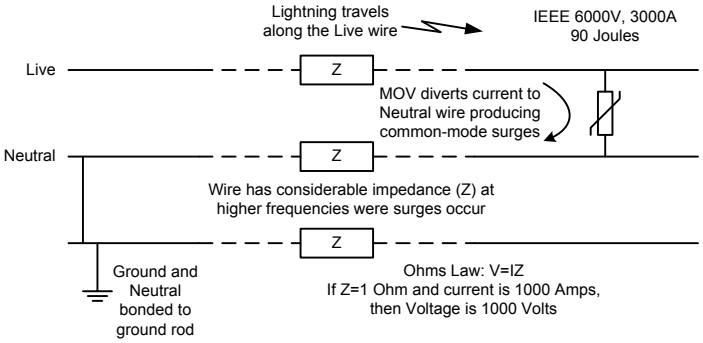


The Empire Strikes Back

Recognizing the seriousness of the ground contamination issue raised by SurgeX, manufacturers of MOV-based surge suppressors began to release products which did not have any MOVs connected to ground – only between live and neutral – known as "normal mode" suppressors. This overcame the problem of ground contamination but, because their products do not block and contain the surge energy like SurgeX, that energy has to go somewhere. In the case of these new product offerings, that energy went back down the neutral wire instead of the ground wire. The technical term for this is "mode conversion". In other words, these products were simply converting normal-mode surges into common-mode surges. Common-mode surges normally only exist on building wiring at levels orders of magnitude less than normal-mode surges. However, these line-to-neutral-only MOV surge suppressors were now producing common-mode surges at levels never before seen on the AC mains.

Electronic power supplies naturally have some immunity to common-mode surges, but their tolerance before damage occurs can only go so far. Once again, the MOV-based surge suppressors were actually causing a problem that didn't exist before. Leaving AV systems vulnerable to malfunction and unnecessary service calls.

Normal-Mode MOV Protection On A Branch Circuit



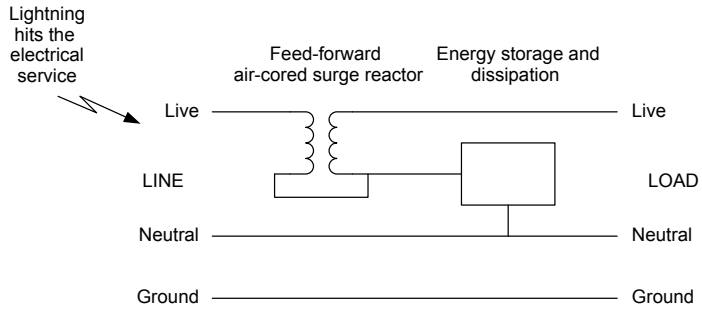
And Then Came Advanced Series Mode

Ongoing development at SurgeX resulted in the release of the first Advanced Series Mode products in 2005. In developing Advanced Series Mode, engineers improved the technology to the point where there was no measurable let-through voltage at all – zero let-though – thus achieving total surge elimination!

In order to accomplish this feat, engineers added an extra winding to the surge reactor, essentially making it a transformer, and improved the control board so that the two work seamlessly together to eliminate all disturbances on the AC mains – from the largest 6000 Volt lightning surges to smaller transients generated within the building which can disrupt a microprocessor, DSP, or memory chip.

As well as providing catastrophic surge elimination, SurgeX ASM also includes filtering for EMI and RFI (electromagnetic and radio frequency interference). In a class of its own, the SurgeX filter set includes both normal-mode filtering (from line to neutral) and common-mode filtering (line + neutral to ground). And all this without contaminating the system ground or producing common-mode surges. In fact, SurgeX does not require a solid ground for its protection to work (unlike diversionary MOV-based surge suppressors) because it blocks and contains surge energy instead of dumping it onto the ground or neutral wire. The electrical ground must, of course, always meet building codes for safety reasons.

Advanced Series Mode Technology Completely Eliminates Surges



What's in it for you?

In a word: peace of mind. Because SurgeX was designed for worst-case conditions, you can simply smile and relax when you see (or your customers see) a flash of lightning in a window or hear a rumble in the distance. You never have to worry about whether SurgeX will protect your expensive installation. SurgeX products are the only power conditioners servicing the AV industry with a lifetime warranty.

But, SurgeX is not just the best surge protector on the planet, the unique, patented Advanced Series Mode technology combined with SurgeX Impedance-Tolerant EMI/RFI filtering offer you a complete power conditioning solution which also captures transients and radio interference so that nothing – absolutely nothing – can disrupt your installation or cause equipment freezes, re-boots or loss of memory.

Do you like to gamble, or do you prefer a "sure thing"? When you insist on SurgeX, you don't have to wonder, will that power conditioner which claims to be as good as SurgeX, or even, "Just like SurgeX!", protect my mission-critical gear. There is a reason it was cheaper than SurgeX and doesn't feel as heavy. How much let-through voltage is actually OK for some of today's sensitive electronics? When you include SurgeX zero let-through technology in your installation, that is a redundant question. Sometimes you really do get what you pay for.

Still like to gamble? When you insist on SurgeX, you don't have to wonder, "Are my surge protection devices still OK?" because SurgeX ASM doesn't use any components that degrade – never has, never will! The manufacturers of MOV-based surge suppressors won't tell you that MOVs have a certain fixed lifetime. Just like a sacrificial metal anode, each time an MOV takes a hit from a large surge or a small transient, it gives up some of its useful life. The semiconductor manufacturers which make MOVS, however, do disclose lifetime ratings for their products. You only need Google, "MOV lifetime ratings" to find these.

Offering service contracts? If so, and you're not insisting that SurgeX is included in every one of your systems, then you're giving money away. As well as preventing catastrophic damage from lightning, SurgeX also extends equipment life by blocking the larger transients that gradually degrade semiconductors, and reduces hassles by filtering out the smaller transients which can cause equipment hang-ups and loss of setup information. You can immediately increase your profitability by insisting that every system be protected by SurgeX.

Oh, by the way, did I mention customer satisfaction and your reputation? How important is that to your company? Every piece of equipment that you spec into a design or include in an installation says something about your company. And the reliability of each one of those pieces and its ability to do its job, adds to or detracts from your reputation. We don't need to mention SurgeX again, do we?

How much is each one of these points worth to you?

Nothing provides cleaner AC power than SurgeX Advanced Series Mode.

It truly has redefined power quality.