Surge Suppressors – Hidden Dangers

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Abstract – We discuss the mechanisms and dangers of surge suppressors. We note that the ZnO varistor is the most common building block of most surge suppressors. From investigations done both in the lab and at the site of fires caused by surge suppressors, we note (1) that surge suppressors work well against transient voltages, even very high voltage spikes, but create problems if there is a moderate increase in steady-state voltage; (2) that surge suppressors can be a fire hazard in a damp (not wet) environment; and (3) that surge suppressors can cause electrocution and fires if used in conjunction with generators or any non-standard wiring scheme.

Keywords: surge suppressors, electrical fires, MOV (metal oxide varistor), surge protector, voltage spikes.

Introduction

Surge suppressors (aka power surge suppressors and aka surge protectors) are often used in the home to control voltage spikes and current spikes. Modern appliances that deal in intelligence (for example, a computer, a TV, a phone) often require a surge suppressor for general protection in order to behave in their proper fashion. The surge suppressor blocks large changes in power in order to protect the fragile electronics that is used in intelligence processing. By contrast, heavy duty appliances (a washer, dryer, fridge, etc.) can work very nicely in almost any power environment, no matter how noisy the electric power becomes [1].

We should clarify some points at the outset. Power strips are multiple electric outlets. They often have a fuse and an indicator light. They are not surge suppressors, but they MIGHT be. To add to this confusion, many surge suppressors are called power strips, even though the name is inaccurate. Surge suppressors are NOT power regulators. A surge suppressor using conventional technologies handles steady-state excess power very poorly. As an example, a voltage spike of 10,000 volts that lasts 10 microseconds is easy for a surge suppressor to regulate. However if a suppressor is built to operate at 120 volts AC RMS and if it operates in an environment of a steady voltage of 180 volts AC RMS, it will break after a very short time (about a week). If it operates at a higher steady voltage of 200, it will die within minutes. At 240 volts, the surge suppressor’s lifetime can be measured in seconds. This has been verified by us in the lab by “killing” 120 volt surge suppressors with the voltages quoted above. The surge suppressors tested were from a variety of sources – Radio Shack, Best Buy, Sears, etc.

Power surge suppressors protect the intelligence necessary to run a modern home. But there are dangers. In general, electric power has four major dangers that it can inflict: (1) corrupting intelligence, (2) shocking or killing a human, (3) causing a fire, and (4) unexpected machine operation. The 4th danger occurs (for example) if a power saw is switched off by the home owner, and then it turns back on unexpectedly, due to a malfunction in its control circuitry. We know of no cases where surges or surge suppression can cause or aggravate this 4th danger, since the appliances

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that demonstrate this behavior are generally rugged – they are more likely to be corrupted by defects in their control circuitry. Hence, we do not focus on this danger here.

Power surge suppressors can provide an excellent way to save data on a computer and to provide worry free communication for phone and TV. But many cases of fires caused by surge suppressors have been reported. Cases of shock and death are less common, but they too are growing in number. We report here on 2 fires and one near-death, and this “near-death” was prevented by “luck”.

**Analysis**

We analyze 2 accidents with surge suppressors. We also report on independent testing done by us in the lab on a host of surge suppressors.

**Case I**

A homeowner bought 3 surge suppressors to power his large home aquarium. Labels on the strips said that they were not to be used in a wet environment. He figured they would be okay, since NO water was ever spilled on them, nor was possible spillage from the aquarium anywhere near where they would be located. In fact, the surge suppressors were located in a small open closet and wires from them led to the aquarium that stood in the center of a small room. There were 2 problems here. There was no need for these devices. The appliances they powered were filters and heaters and lights. Voltage spikes were not a problem in the proper running of the aquarium. The more serious problem was that the water from the aquarium caused the room to be rich in vapor. This water vapor tended to congregate in the closet, since there was a small hole in the back of the closet that tended to draw the vapor into the closet and out of the house. This was much the same as a chimney draws smoke out of a room. Over time this water vapor settled on the power strips (surge suppressors). It caused a leakage resistance to form from the dirt/salts that were in the water vapor. A bridge of this dirt/salt shorted between the power lead and ground. No circuit breakers were tripped, since it is estimated that the current never got above 5 amps, and the breakers were set for 15. Initially, the salt and dirt bridges were of high resistance and the leakage current was small. When the leakage current reached about 5 amps, the heat from the current was enough to ignite the plastic (about 750 degrees-F). Once ignited, the plastic burned slowly, but since the homeowner was not at home, there was no one to notice. The good news is that the fire caused the aquarium to break and spill onto the fire – the home was NOT lost. The bad news is that smoke and water damage caused the homeowner about $100,000 for cleanup.

We ran tests in the lab, and showed that somewhere close to 5 amps, there is a thermal runaway effect that kicks in and causes most common plastics to ignite and burn. The surge suppressor is not able to fix the problems of steady-state leakage. These are best left to fuses or regulators that handle steady-state leakage problems. Figure 1 shows the burn through a complete power strip due to leakage. Note: suppose that the environment around the surge suppressor was not just damp but wet. This would have been safe – a wet surge suppressor would have almost no resistance, it would draw many hundreds of amps for a brief time, and it would trip the circuit breakers off. The result would be no fire ever getting started.
Case II

A homeowner lost power due to a major storm. He hooked up a generator to power his home. The TV and other appliances seemed to act “funny”. He was not sure what the problem was. He figured that a surge suppressor would cure the problem, and for a time it did.

The homeowner had switched off the power lead-in wires from the utility company. However, in the process he had also killed the ground connection to his house. He then compounded the problem by mis-wiring the generator. His neutral was at zero volts, and this was okay. His hot wire was at 120 volts (AC RMS) and this was okay. But his ground wire was at minus-120 volts. He had 2 TV’s plugged in to surge suppressors, and both were 2 wire devices. With no ground wire, there was no problem in the TV’s. However, he also had his refrigerator plugged into one surge suppressor. This meant that the metal cabinet of the fridge was NOT at ground potential but at -120 volts. Someone could have been killed if they went to open the refrigerator door. Luckily, no one was killed. The reason – fire. The surge suppressors were built to handle 120 volts in the steady-state. Adding -120 to the ground pin caused a steady-state voltage of 240 volts in each surge suppressor. Within an hour, all 3 caught fire. The fires were brought under control without doing any structural damage to the home, but the smoke and water damage approached $200,000. See Figure 2.
Test Run

Tests run by us in the lab on a number of surge protectors shows that they generally obey a rule-of-3 for steady-state voltages. Each component of a surge protector is rated at 3 times its steady-state value for voltage stress. More details of this rating can be found in several places [2]. The MOV (metal oxide varistor) is the component of choice for use in suppressing voltage surges. Generally, it fabricated as a pressed granular product. It is a “clamp” device (similar to a diode). As voltage increases, the current through the MOV increases, but it increases at a faster rate. “Crowbar” devices are also used in surge suppressors, but these are far less common – for example, an SCR [3]. Also, the most prolific of the MOV devices is polycrystalline ZnO [4].

Common surge suppressors have a simple architecture that can be viewed in 2 entirely different ways. Refer to Figure 3.

(i) Consider the 3 wire input to a surge suppressor: a hot wire of 120 volts, a neutral of zero volts, and a ground of zero volts. In the simplest case, a MOV is connected between the hot wire and ground. A second MOV is connected between the neutral and ground. There appears to be no need for the second MOV, since both the neutral and ground are at zero volts. Only the steady-state voltage across the hot wire and ground is important. If this is violated (see case 2 above), then there is a problem.

(ii) Consider a transient voltage or surge in voltage or voltage spike. This type of voltage can appear with equal probability on the hot line as well as on the neutral. Hence, the hot and the neutral can have the same voltage (albeit an unwanted or unexpected voltage) relative to ground. A balanced MOV arrangement is required for this transient case that was not required for the steady-state case noted in (i).

Conclusion

Surge suppressors are great appliances to have in a modern home. They clean up unwanted noise that effects modern communications.

But care must be taken with surge suppressors. Use them only for communications devices (TV, computers, and phone). Use them in a dry environment. And do not use them with any “odd” wiring arrangements (for example, a home generator), unless your use is certified by a qualified electrician.

References