The Power Sheet

Consulting Engineer Edition

SURGE SUPPRESSION

INTRODUCTION

A transient voltage is an irregular or abnormal electrical event. Specifically, transients are defined as an over voltage (or under voltage) condition with a duration of less than half cycle of the normal voltage waveform of either polarity.

Transient voltages have two causes: lighting strikes traveling into a facility through electrical lines and switching generated transients. Common causes of switching transients are the toggling of heavy loads, controlled rectifier devices (such as variable frequency drives), and current limiting fuses all of which chop the AC wave.

The electric utility industry estimates that electronic equipment (computers, lighting ballasts, drives, PLCs, telecommunications equipment) accounts for 60% of the generated electrical load. Electronic equipment is highly susceptible to damage from voltage surge. Because fuses and breakers cannot react fast enough to protect the electronic equipment from a surge, a surge suppressor is used to divert the voltage spike.

RING WAVE vs. COMBINATION WAVE

The two types of surge waves forms are ring waves and combination waves. A combination wave is a pulse and is typically higher in amplitude than a ring wave, but is a single, instantaneous spike. These waves are associated with lighting strikes. Figure 1 shows a combination wave.

A ring wave is lower in amplitude when compared to a combination wave, however the ring wave is oscillating. These waves generally are generated from within a facility caused by electric motors, drives, and UPS systems. Figure 2 shows a ring wave.

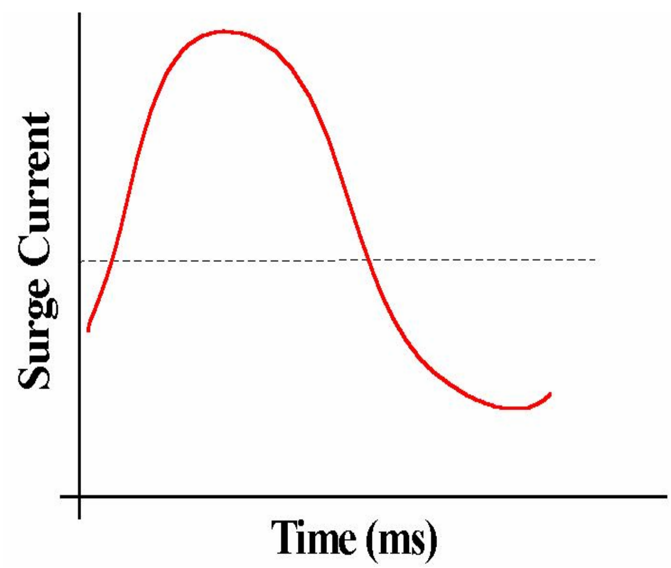

FIGURE 1 - COMBINATION WAVE

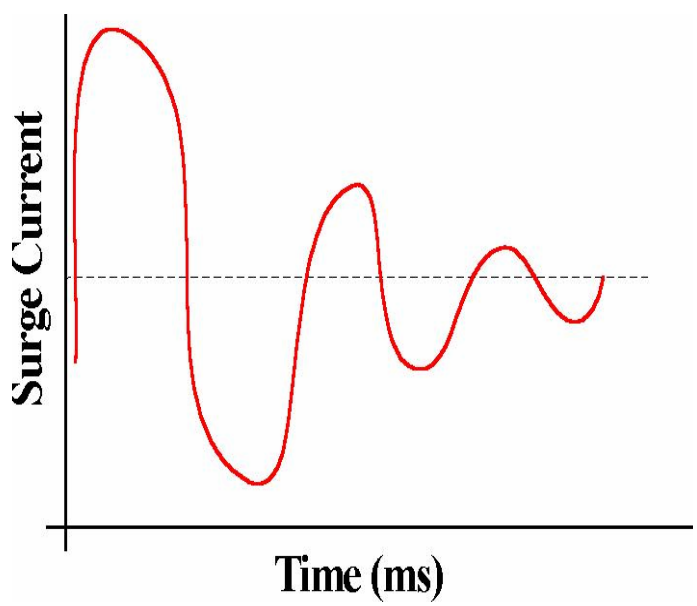

FIGURE 2—RING WAVE

Look to Eaton Electrical for Protection of Your Critical Power

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SURGE CLASSIFICATIONS

IEEE has three classifications based on location within the facility and the size of the surge. These classifications determine the level of surge protection needed. The following are descriptions of the three categories:

CATEGORY A - Outlets and long branch circuits
- All outlets at more that 10 m (30 ft) from Category B
- All outlets at more than 20 m (60 ft) from Category C

CATEGORY B - Feeders and short branch circuits
- Distribution panel devices
- Bus and feeder distribution
- Heavy appliance outlets with "short" connections to service entrance
- Lightning systems in large buildings

CATEGORY C - Outside and service entrances
- Service drops from pole to building
- Runs between meter and panel
- Overhead lines to detached building
- Underground lines to well pump

ARRESTOR vs. SUPPRESSOR

Surge arrestors are typically used by an electric utility for protection of the distribution power lines. The standard for surge arrestor operation is intended to protect the wire insulation from a lighting strike. Therefore, the let-through voltage is higher when compared to a surge suppressor. The basic impulse level (BIL) is a reference specifying insulation strength and indicates the highest crest voltage that can be withstood by cable insulation without breaking down.

Surge suppressors are intended to protect electronic devices within a facility. Small voltage surges will damage electronic equipment. Therefore, the let-through voltage is much less than a surge arrestor. IEEE recommends reducing a 20 kV lighting disturbance to below two-times the nominal voltage.

For example, the nominal voltage for a 240 volt system is 170 volts ($240 \div \sqrt{2}$). Two times this nominal voltage is 340 volts. For a surge suppressor, the standard peak let-though voltage in this application is 340 volts. In comparison, IEEE recommends that surge arrestors allow a let-though voltage of 1200 volts on a 120-volt system, based on a 20kV, 10kA lighting strike. In addition, a surge suppressor reacts much fasted than a surge arrestor.

SYSTEM DESIGN CONSIDERATIONS

IEEE recommends a two stage design approach. The first stage is located at the service entrance and protects the facility from combination waves. The second stage is located at branch panels feeding sensitive loads, such as computer rooms. This second stage protects downstream devices from transients generated from within the facility. Typically, these internal transients are ring waves. Figure 3 shows this two stage approach.

Cutler-Hammer recommends a maximum surge suppression rating of 250kA per phase. Suppressors rated above 250kA do not provide any additional protection for the following reason. When lighting strikes a power line, the charge follows the path of least resistance. Therefore, most of the energy is shunted to ground by the electric utility's surge arrestors.

As explained above, the surge arrestor reduces the line surge to a level below the distribution cable BIL rating, thus limiting the available transient voltage at the service entrance. The remaining energy enters the facility as inductive or capacitate load. This creates a transient impulse less that one half of a cycle.

Per IEEE, less that 5% of lighting strikes are greater than 100kA and less than .2% of strikes are above 220kA. Again, these value are before the utility surge arrestors shunt the voltage to ground, so the energy entering the facility is far lower.

In general, sizing a surge suppressor above 250kA provides no greater system protection.

WHY DO SURGE DEVICES FAIL?

A common myth as to why surge protection devices fail is due to surge events. This is not the case!

Over 90% of surge fails are due to "temporary over voltages" (TOV). The most common cause of TOVs are the following:

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- Improper Installation
- Loss of the Neutral on 4 Wire Systems
- Elevated System Voltage

Improper installation failure can include long conductor leads, improperly terminated phases, and improperly terminated neutrals. For this reason as well as reduced installation costs, **integrated TVSS** guarantees proper installation.

The loss of neutral, although rare, occurs either from improper installation or field damage where the neutral connection is broken. Again, **integrated TVSS** greatly eliminated these possibilities.

Elevated voltages are the most common reason a TVSS will fail. An improperly tapped transformer provides a system voltage above design voltage. A slight, constant overvoltage (greater that 5%) electrically flexes the MOVs within the TVSS. Therefore, the MOVs are constantly shunting a small amount of voltage and, simply stated, wear out.

INTEGRATED DESIGN

Historically, surge suppression devices were purchased as stand-alone devices and installed next to a panelboard, switchboard or motor control center by an electrical contractor. In 1995 gear manufacturers began integrating Surge Protection Devices (SPD) into electrical distribution equipment to increase the level of protection provided against surge and noise disturbances.

Directly connecting the surge suppressor to the bus bar of electrical distribution equipment results in the best possible level of protection. Compared to side mounted devices, connecting the surge protection device (SPD) unit to the bus bar eliminates the need for lead wires and reduces the let-through voltage up to 50 percent.

Given that surges are high frequency disturbances, the inductance of the insulation of cable wiring increases the let-through voltage of the protective device. The effect of installation lead length on let-through voltage, shows that for every inch of lead length, the let-through voltage is increased by an additional 15V to 25V above the manufacturers stated suppression performance.

Lead length has the greatest effect on the actual level of protection realized. Twisting of the installation wires is the second most important installation consideration. By twisting the installation wires, the area between wires is reduced and the mutual inductance affect minimized.

Increasing the diameter of the installation wires is of negligible benefit. Inductance is a “skin effect”, meaning surge currents discharge only on the outer surface of conductors. Since only a marginal reduction in inductance is achieved when the diameter of the installation conductors is increased, the use of large diameter wire results in only minimal improvement. Figure 3 shows the let-through voltage of side mounted verses bus connected TVSS.

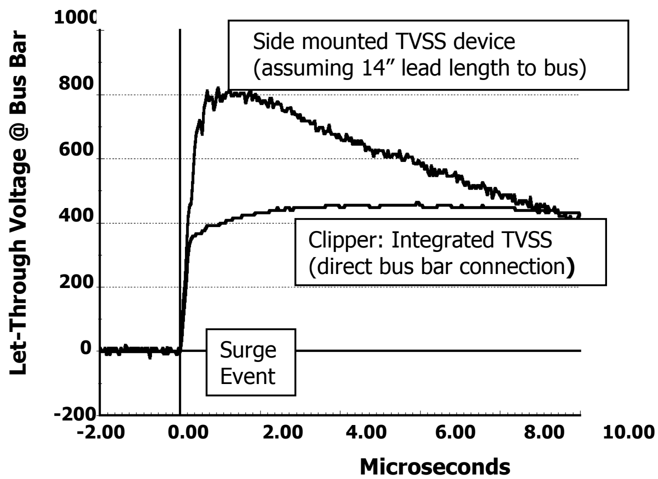

FIGURE 3—INTEGRAL verses SIDE-MOUNTED TVSS

COMPETITIVE COMPARISON

✓ **SURGE PLANE TECHNOLOGY** - The Eaton Electrical Visor TVSS is the first design to utilize the benefits of ground plane technology in the construction of suppressors. The electrical foundation of all our Visor suppressors employing a multi-layer, low impedance surge plane. The surge plane design provides the largest possible conducting area without the drawbacks of heavy gauge wire.

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Many TVSS designs use MOVs arranged in line, meaning the MOVs shunt the surge voltage similar to dominos arranged in a straight row. The first MOV in the line will shunt the greatest amount of voltage, the second MOV shunts the second greatest and so on. Figure 4 is a graphical representation of the Eaton Electrical **Surge Plane** Technology.

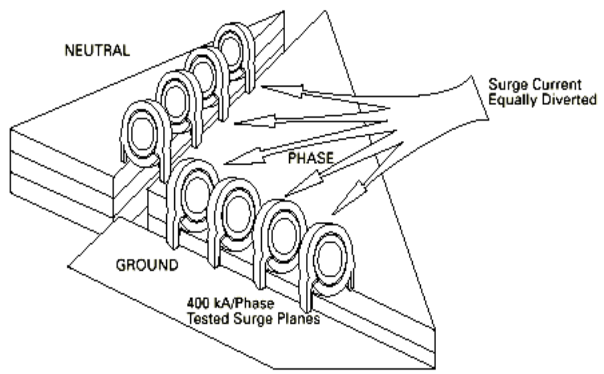

FIGURE 4 — SURGE PLANE TECHNOLOGY

The disadvantage to the linear arrangement is unequal loading of the MOVs; where MOVs at the front of the line take more of the wear and tear those in line after. The Eaton Electrical design distributes the shunted voltage equally over all MOVs. This leads to greater surge unit life and greatly reduces the likelihood of thermal run away.

✓ **THERMAL RUN AWAY**—Catastrophic TVSS failure is caused by MOVs overheating and burning. This is named “thermal run-away”. and results from a prolonged overvoltage condition.

The Eaton Electrical Visor TVSS is designed where individual **MOVs will mechanically disconnect** from the surge plane in the event of an overheating event.

Simply, overheating of MOVs that result in TVSS meld-downs are eliminated because over-heated MOVs are mechanically removed from the surge plane.

✓ **DIAGNOSTICS**— Eaton Electrical has the following surge monitoring and diagnostic packages that provide both diagnostics and metering :

ADVISOR

- **Form C, Audible Alarm**
- **Red/Green LED**
- **Alarm Enable/Disable Feature**
- **Remote Mountable**

SUPERVISOR

- **Multifunction counter**
- **Voltage, Surge, Sag, Swell, Outage**
- **2x16 LCD Display**
- **Remote Mountable**

NETVISOR

- **Voltage&Duration Values for Surge, Sag, Swell, Outage**
- **Percent MOV's Remaining**
- **% THD**
- **User Define Setpoints**
- **Ethernet&Modbus Comm.**

EATON ELECTRICAL TVSS