Surge protection of outdoor CAT5 equipment
The scope of this paper is to provide an overview of effective grounding and surge protection of outdoor deployed CAT5 connected communication systems.

The grounding issues and considerations discussed in this paper are solely limited to protection of electronic communication equipment, and do not address safety code requirements which are beyond the scope of this paper. Since electrical, safety, and building codes vary with locality, it is the responsibility of the system integrator to determine what is required for compliance wherever the system is being deployed.

System Grounding Considerations

Grounding and surge protection of a communications system depends on its deployment environment, it is important to remember that there is no “standard” set of instructions that is applicable to all systems. The important thing to remember is that all communication equipment at a given installation site must share a common earth ground system. This means that the tower, station, and halo ground systems must all be bonded together to a common earth ground. Unless all outdoor equipment, surge suppressors, and terminating equipment indoors are bonded to a common earth ground point, ground loop problems will result.

The presence of “ground loops” can cause unintended triggering of surge protection devices installed between the two terminating devices. When this happens, “loading down” of the power or signal circuits takes place, causing either inexplicable equipment reboots, or loss of ethernet connectivity or data link problems between the terminating equipment.

If these symptoms clear up when the surge protectors are removed, it is an indication that a ground loop exists between the chassis ground of both terminating equipment and the surge suppression device. Successful bonding of the three grounds to a common earth ground point will resolve the problem. This applies to all systems, whether tower, rooftop, light pole, or water tower mounted.

Typically most grounding problems involve tower mounted equipment, primarily due to the lack of proper tower grounding. Two or three 10-foot ground rods at the base of a tower do not constitute a proper or effective tower grounding system. Depending on soil conditions, locality, and tower height, several buried ground radials extending from the tower base, each with distributed ground rods attached, may be required to properly ground the tower. Unfortunately, there is no such thing as a “one size fits all” tower ground system. Each tower is unique.

The commercial power grid ground is designed to provide a safety return path for the 50/60 Hz energy in the event of a ground fault interruption, and generally not suitable for use as a communication ground system. The one exception is its use as the third terminal ground for AC line surge suppression devices like protective power strips and UPS systems.

Unless a communication system is provided a proper ground, equipment failures and other problems will result. For additional information please check out http://www.psihq.com/iread.
Lightning and Ground Potential Rise (GPR)

Lightning brings with it a special problem known as “ground potential rise,” due to its broadband energy distribution. The distribution of energy in lightning extends from about 10 KHz to well beyond 10 MHz.

This broadband energy distribution creates a problem when the inductive reactance in the ground conductor raises the effective ground impedance ten-fold with each decade of frequency increase. This is in addition to any DC resistance across the conductor.

This means that the same conductor to ground having 1 Ohm of reactive impedance at 10 KHz would represent 1000 Ohms of reactive impedance at 10 MHz. Apply some simple Ohms law, and you can see the problem with the ground system. This is why short low-inductance ground conductors are important, and tower mounted electronics can tend to be difficult to protect against lightning damage. Even the small inductance in huge self-supporting tower legs is sufficient to cause thousands of Volts of Voltage drop across their length (or ground path) when a lightning strike is involved.

A couple of great websites for additional information on lightning surge protection and grounding are: http://www.polyphaser.com/technical_notes.aspx and http://gpr-expert.com/

Application of Surge Protection

The application of surge suppression in a communication system depends on the characteristics of the equipment.

Equipment with metallic enclosures that are mounted onto a metallic structure should be properly grounded for safety reasons.

Equipment with outdoor enclosures that are electrically insulated by design, will typically not be grounded, but allowed to “float” with the power and signal levels references provided via the CAT5 cabling.

Since we know that the best ground system is the one having the lowest impedance to earth ground, and that reactive impedance is as important as DC impedance, the lower the inductance of the ground path the lower its reactive impedance. Generally, the larger the surface area of a conductor, the lower its reactive impedance tends to be.

For this reason, tower members (provided they are electrically bonded together by ground strap or welding), and building steel represent the best conductors to ground. This is of course provided that they in turn bonded to a proper earth ground.

Once the appropriate system ground buss has been identified, and implemented, the next decision is when and where to install surge suppressors.
Metal Enclosure Equipment

Since for safety reasons a local ground reference has been applied to a piece of equipment with a metallic enclosure, this same ground reference must be used for the related surge suppression device.

The surge suppressor should be installed as close to the equipment to be protected and in some cases directly onto it if possible. This will minimize and/or eliminate any differential ground reference problems between the surge suppressor and the protected equipment, since the surge clamping devices protecting the input power and signal interfaces will be referenced to the equipment chassis ground.

The equipment in turn should be grounded to the metallic mounting structure, whose sections should also be bonded together with short ground straps or by welding them together. The base of the mounting structure should then be bonded to a proper earth ground.

In addition, installation of a properly grounded surge suppression device at the building cable entrance point should also be implemented to protect equipment and personnel inside the building. The earth ground for both surge suppressors and both the outdoor and indoor equipment should be the same in order to avoid ground loop as shown in the drawing below.
Insulated Enclosure Equipment

When deploying insulated enclosure equipment such as the Tsunami 5012SUR, no specific equipment ground point is provided. This type of ground isolated equipment is referenced to the power, signal, and ground references provided by the connecting CAT5 cable. This provides a measure of surge protection in itself for the equipment since the power, power return, and signal levels all rise together whenever a Voltage spike is induced onto the CAT5 cable. In such an installation, the internal surge suppression circuitry within the unit in the insulated enclosure should be sufficient to avoid equipment damage, and an external suppressor is not required for the outdoor equipment.

However, installation of a properly grounded surge suppression device at the building cable entrance point should still be implemented to protect equipment and personnel inside the building. The earth ground for this surge suppressor needs to be the same as that of the station ground inside the building, to which the internal equipment chassis should be grounded as indicated in the drawing below. Doing so is important to avoid a ground loop between the surge suppressor and the terminating equipment in the building.
**Summary**

Surge protection begins with implementation of a proper earth ground system that must be broadband in nature. This is because the energy distribution in a lightning strike is broadband with many different frequency components involved. Unless the ground system represents a low impedance to all of the frequency components involved, it will be ineffective, and all of the potentially damaging energy will not be bypassed to ground through the ground system.

Simplistically, consider a 5-gallon bucket with a 2-inch diameter hole in the bottom representing the drain for any water that may be poured into it.

As long as the water from a 10-gallon bucket is poured into it at a low enough frequency (gallons per time interval), the drain hole will be effective, and keep the water level in the 5-gallon bucket from rising to the top and spilling over.

Now lets increase the “frequency” and quickly dump the contents of the 10-gallon bucket into the 5 gallon bucket.

Because the “impedance” of the “narrowband” 2-inch drain hole cannot cope with the “high frequency” of water input, it does not drain quickly enough, and the water level in the bucket rises quickly, such that a significant amount of it spills over the top of the 5-gallon bucket.

Next, lets “broadband” the drain system by knocking out the entire bottom of the 5-gallon bucket and repeating the last test. Because of the lower “impedance” of the “broadband” drain system, no matter how quickly we dump the 10-gallon bucket, the water level in the 5-gallon bucket does not rise sufficiently to spill over the top.

The 5-gallon bucket in the above analogy represents the surge suppressors, and the drain hole in the bottom of the bucket the earth ground.

It is important to always remember that the best surge suppression technology alone will not protect a system, unless it is has a proper “drain” or earth ground system.