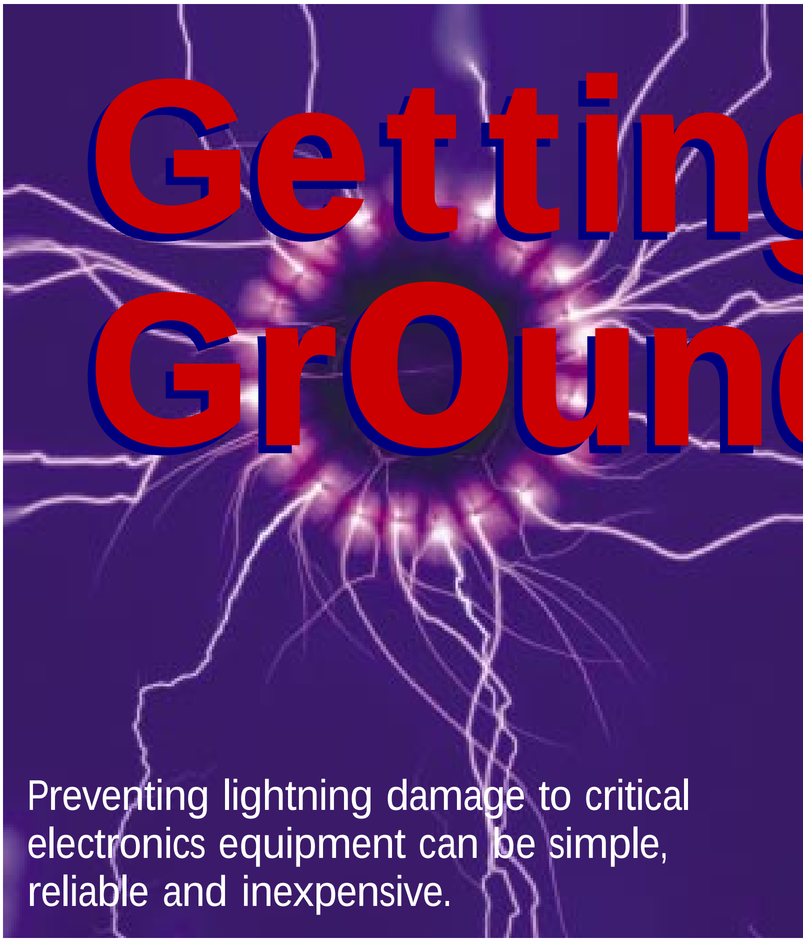
Getting GrOunded



Preventing lightning damage to critical electronics equipment can be simple, reliable and inexpensive.

By Ernest M. Duckworth Jr., P.E.

With more than 150 lightning strikes per second, damage to equipment brings losses exceeding $26 billion annually in North America and nearly three times that amount worldwide. Insurance payments for lightning damage claims total 6.5% of all property and casualty claims. Ironically, damage to equipment can be prevented.

Methods that prevent lightning damage are simple, reliable and inexpensive when compared to the cost of repair—not to mention possible injury or death. Remarkably, methods for lightning protection cannot be found in building codes such as the National Electrical Code or the National Electrical Safety Code. Yet, builders rely on these codes for practically all construction in the United States.

Electrical equipment damage from lightning usually can be blamed on one or two reasons: 1) improper or insufficient grounding and 2) no special protection from a ground potential rise (GPR). Improper or insufficient grounding allows equipment to be stressed or damaged by a difference in electrical potential from nearby equipment and metal objects as current flow is misdirected. A lack of special protection from a GPR allows equipment to be stressed because of its attachment to a remote ground through communications wire lines or power-supply wiring.

Standard protection for the termination of communications wireline services is the gas tube. Gas tubes are shunting devices that can be found on virtually every telephone pair terminated in homes and buildings. They are designed to shunt (connect to ground) "incoming energy," and thereby protect equipment and people from harm.

However, no shunting device protects electronic equipment from a GPR, or "outgoing energy." High outgoing current flow from a lightning strike effectively lifts electrical ground. During a GPR, the shunting devices are connected to an elevated ground and merely offer an additional current path from the site to a remote ground. In this unfortunate way, gas tubes guarantee a connection of the communications path in the reverse direction from which they were intended to operate when there is a GPR. (See Figure 1.)

Dangers from outgoing energy

The outgoing energy from a GPR places most telephone and power installations at risk for equipment damage and the people near them at risk for harm. One of the most dangerous locations for people is a 9-1-1 public safety answering point. The typical PSAP is a small building beneath a large radio tower. The tall tower supports radio communications antennas and forms a lightning target. Workers taking emergency calls must be at the PSAP phones constantly. They do not have the luxury of staying off the phone during lightning

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storms, which is recommended in virtually every telephone book.

The only effective method of protecting equipment connected to wireline communications from a GPR is through isolation—using optical isolators or isolation transformers. These devices prevent current flow. With no metallic path, there will not be outgoing current flow, equipment damage or risk of injury to workers. (See Figure 2.)

To control lightning-strike energy as it dissipates requires division. There is no substitute for division for successfully dissipating the energy because of the magnitude of the current and the resulting surge impedance of any single dissipation path. Using 10 radials connected to a ground ring that is bonded to an antenna divides lightning current into 10 smaller segments. This division helps to ensure that the lightning will follow the grounding conductors for dissipation into the earth. The improved dissipation also serves to reduce the resulting GPR to the adjacent equipment-building grounding system.

The copper wire grounding system can be greatly improved by placing conducting cement around the radials at the time of installation. The cement hardens into concrete, protecting the grounding system and giving it many more years of life. It also gives the system a lower ground resistance.

Tower location

Equipment buildings must be at least 30 feet from antenna towers. This is done to avoid damage caused to electronic circuits by the magnetic field associated with lightning. Magnetic field strength drops off as the square of the distance. If the real estate configuration prevents separating the building at least 30 feet from its antenna tower, consideration must be given to engineering a Faraday cage (wire mesh) around the interior of the building. Without a Faraday cage, equipment damage cannot be prevented no matter how well the equipment is grounded or isolated from remote ground.

Another reason to place equipment buildings or shelters at least 30 feet from antenna towers is to keep the lightning GPR at the tower base from saturating the building grounding system before most of the energy is dissipated in the earth. The grounding systems for the building and its tower must be bonded together at one single point, but a bond of 30 feet or more will significantly reduce the resulting

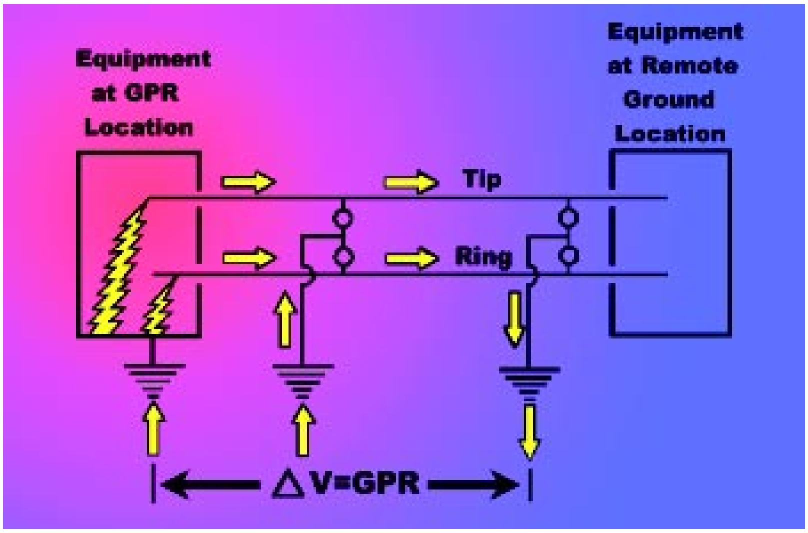

Figure 1. Communications without isolation protection.

GPR at the shelter because of the impedance of the lengthy bond. This is a rare exception in which a lengthy bond is an advantage in supporting a robust grounding system.

Single-point grounding (a "ground window") is absolutely necessary to prevent equipment damage because the GPR from lightning strikes is a wave of rising voltage or an energy surge that passes through a grounding system. The nature of the wave demands that all equipment should be bonded to the grounding system at one location to ensure that the electrical potential of every metallic object connected to it rises and falls together. (See Figure 3.)

Anyone using equipment susceptible to GPR must be protected by a single-point grounding system to guarantee that they won't be injured by touching different pieces of equipment that otherwise might have different and harmful electrical potentials when lightning strikes. This phenomenon is also known as "touch potential."

The use of a ground window (also called a bulkhead panel or

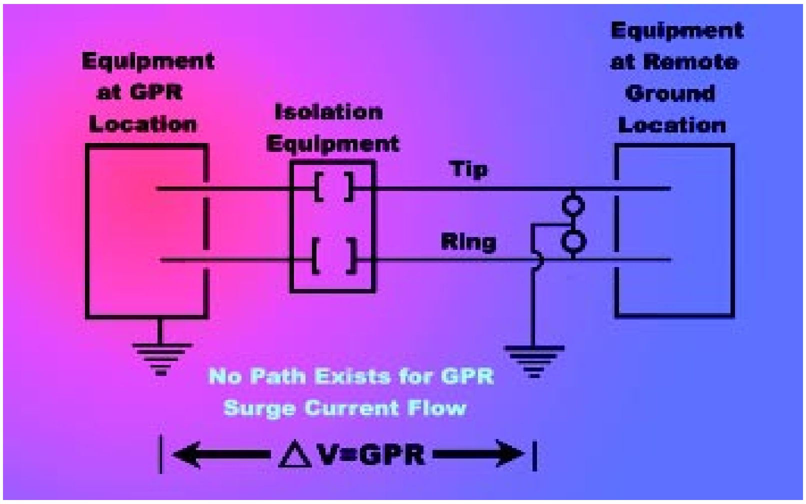

Figure 2. Communications with isolation protection.

waveguide hatch) where coax cables, waveguide and antenna wires penetrate the wall of the equipment building is indispensable. The bulkhead is made of solid copper. Its proper engineering design and installation will ensure that lightning energy does not enter the equipment building on cables from the antenna tower.

The bulkhead must be bonded to the building grounding system at the single-point grounding location—the same single point ground where the tower grounding system is bonded to the building grounding system.

Isolate wireline comms

A lightning strike to a grounding system produces an elevated ground or GPR. Any equipment bonded to the grounding system and also connected to wireline communications is likely to be damaged by outgoing current seeking remote ground. Individuals who may be working on equipment connected to the wire lines could be harmed because they would be in the path of the outgoing current.

An engineering design that protects this equipment isolates the wireline communications from the

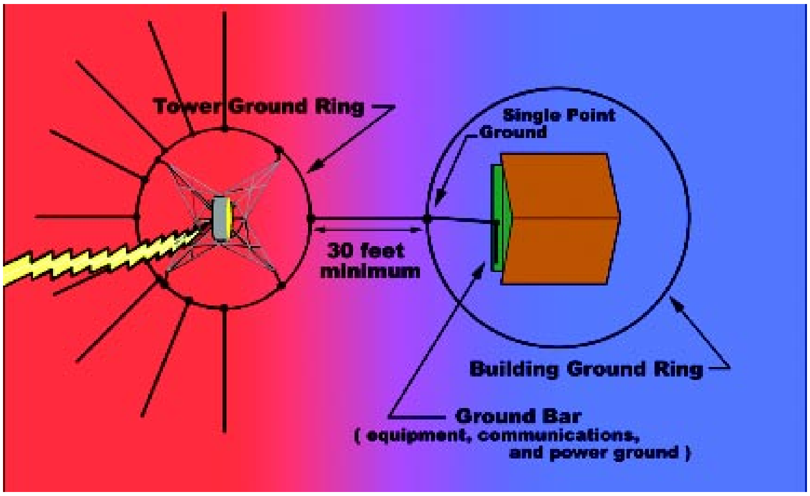

Figure 3. Ideal lightning dissipating single-point grounding system.

remote ground. Isolation is accomplished using optical isolators, isolation transformers or both. The isolation equipment, called the high-voltage interface, is housed together and mounted on a nonconducting surface in a nonconducting cabinet.

The HVI isolates the communications equipment during a GPR and prevents a current from flowing from the grounding system with higher electrical potential to a grounding system with a lower potential. The isolation completely protects equipment from damage and people from harm.

Simple lightning protection

Simple, reliable and inexpensive protection methods can prevent lightning damage to equipment. The three most important concepts are:

1) divide and control the lightning strike energy.
2) design a true single-point ground system.
3) isolate wire-line facilities from a remote ground.

A reliable, well engineered grounding design will all but completely eliminate lightning threats to equipment and people. ■