Lightning Surge Suppression And Standard Grounding Practices

Background/Introduction: The secondary products of a lightning strike include:

- Electromagnetic Pulses
- Electrostatic Pulses
- Earth Current Transients

Electromagnetic Pulses are created by the strong magnetic field that is formed by the short term current flow taking place in the lightning strike. With current flows as high as 510kA per microsecond, these currents create very large magnetic fields. These short term magnetic fields then induce voltages onto wires and cables.

Electrostatic Pulses are created by electrostatic fields that accompany a thunderstorm. Any cable suspended above the earth during a thunderstorm is immersed in the electrostatic field and will be electrically charged. Quick changes in the charges stored in both the clouds and earth take place whenever there is a lightning strike. The charge on the cable must now be discharged or neutralized. Unable to find a path to ground (earth), it breaks down insulation and component in its efforts to return to earth.

Earth Current Transients are the direct result of the neutralization process that immediately follows the end of lightning strike. Neutralization is accomplished by the movement or redistribution of charge along or near the earth's surface, from all the points where the charge had been initially induced to the point where the lightning strike has just terminated. Earth Current Transients create a shift in potential across a ground plan, often called a "Ground Bounce".

Common Mode and Differential Mode Voltages: Assume for a moment that two insulated wires are run along the ground from one location to another. Neither wire is connected to ground or an electrical device. The two wires take a similar path as each other, but do not follow the exact the same path. At times they run very close to each other and other times there is a minor separation. When a lightning strike takes place in the area of the wires two basic types or forms of voltage are present on these conductors.

Common Mode Voltage: This voltage is measured between either of the two insulation wires and the earth. In almost all installations this is the higher voltage of the two types mentioned. Common Mode Voltage is created by the secondary forces related to lightning strikes. In one test, a lightning strike at a distance of almost 5 km from an installation induced an 80 volt (peak to peak) common mode spike on an insulated cable. This voltage is more than enough to damage most electronics.

Differential Mode Voltage: In addition to the common mode voltage that was induced by the lightning strike, a differential mode voltage is induced by a lightning strike. This is the difference in voltage between the two individual wires. It is detected by measuring the voltage between the two separate conductors. In the simple case provided, this would be created by the difference in the routing of the two wires. It can be created by other means.

Surge Suppression Techniques: Surge suppression components typically perform their suppression function by temporarily short circuiting the voltage between two wires, several devices or ground. This action takes place whenever the voltage between the two objects exceeds a predetermined value. Once this discharge is completed, the suppression component discontinues this function and normal circuit operation continues. Differential Mode Voltage surges are relatively easy to suppress for two reasons. The first reason being that this voltage is relatively low, when compared to the common mode voltage. The second reason is because there are numerous low cost devices available to help reduce this voltage. Most designers simply place a surge protection device (SPD) between the two conductors. This device quickly bleeds off the Differential Mode Voltage, when is exceeds a predefined level. Where there are multiple conductors in a multi-conductor cable, networks of low cost SPD's are used to discharge any voltage potential between the conductors. SPD component cost is lower when the device is rated at lower voltage and power levels. Common Mode Voltage can be far more difficult to suppress. These voltages are usually much larger than the Differential Mode Voltage. In addition, the power rating of this SPD device is usually higher, given the larger charges involved. To discharge this potential, SPDs are placed between the wire(s) and ground. Common Mode Voltage Suppression designs require a robust ground to effectively discharge the common mode voltage. This is because the Common Mode Voltage is the voltage between the wire and ground (earth). This voltage will destroy any component that cannot withstand this higher potential. Generally speaking, it is the Common Mode Voltage that most adversely affects product reliability. Poor grounding is the usually the root cause for this class of failures.

Grounding: Robust grounding is required to discharge Common Mode Voltages and prevent instrument damage. This is particularly true of networks of cables and devices placed over a distance. The greater the distance between devices, the greater the opportunity for surges. The larger or more complex the overall network, the greater the need for a robust grounding system. Surge currents can be additive. Without a robust grounding system, there is no way to effectively protect against the most fundamental of surges created by lightning. When systems and networks of components are combined, a good low-resistance ground, as part of a single grounding system is needed. Grounding straps or wires must be large to facilitate the discharge of all surge currents. High- resistance grounding systems typically fabricated of small gage wire are unable to effectively discharge the combined current created during a surge. It should never be assumed that a good grounding system simply exists when fabricating a network of individual electrical devices. Each individual device should provide a connection to the system's ground. A spike or rod of conducting material is driven into the earth to provide the single ground reference. The aforementioned grounding straps or wires are then connected to this rod.

How to Protect Your Ech2o Probes:
Probes have built in circuitry, which protect them against common surge conditions. Installations in lightning-prone areas, however, require special precautions, especially when probes are connected to a well-grounded CSI logger. As previously mentioned, a single ground point for the system should be established at the data logger using a ground rod. The ground rod should be made from a metal that will not tarnish or corrode such as stainless steel.

Rebar is sometimes used, but it can rust and provide high surface resistance to ground. Widely spaced sensors need a low resistance path to this central ground that is not through the sensors. By installing ground rods in the vicinity of sensors, and running a separate #6 AWG copper wire from that rod back to the central ground rod, earth current transients from nearby lightning strikes are minimized, so voltage spikes on sensors are reduced. The following figures show two configurations with appropriate grounding in lightning prone areas.

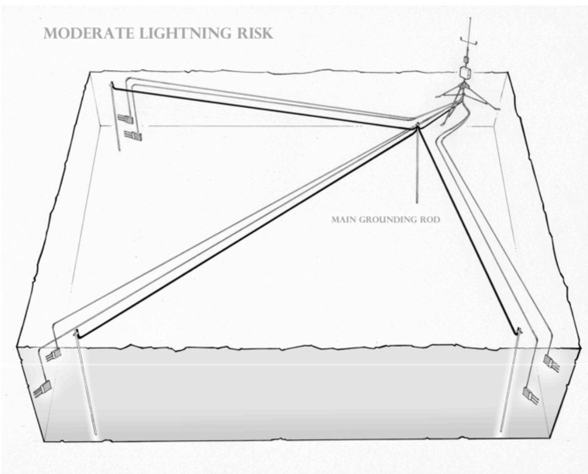

Figure 1. Ground rods in the general vicinity of groups of probes are connected back to a main grounding rod to which the logger is grounded. Ground rods should be driven 2 or more meters into the ground if possible and connected to the central ground through #6 AWG copper wire.

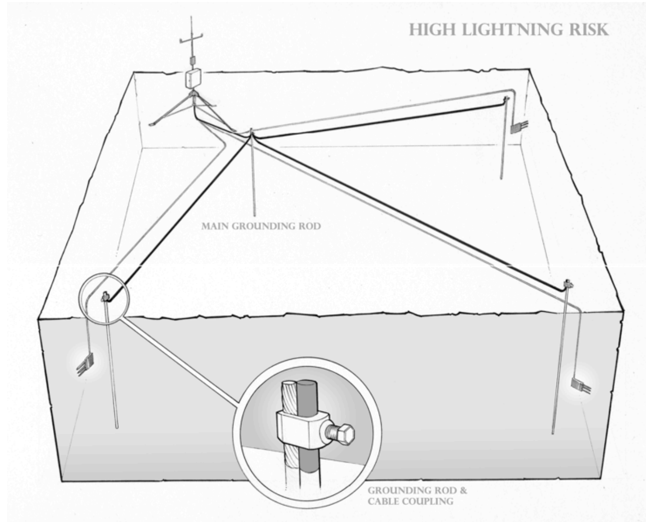

Figure 2. When lightning risk is high, ground rods may be required in the vicinity of each sensor location. As with the moderate lightning installation, #6 AWG copper wire connects each ground rod to the central rod, which is connected to the data logger.