LIGHTNING AND SURGE PROTECTION

Lightning has long fascinated the technical community. Ben Franklin studied lightning's electrical nature over two centuries ago and Charles R Steinmetz generated artificial lightning in his General Electric laboratory in the 1920's. As someone concerned with premises data communications you need to consider lightning. Here will elaborate on why, where and when you should take care lightning and discuss how to get protection from it.

1. Why consider the lightning?

It is unfortunate, but a fact of life, that computers, computer-related products and process control equipment found in premises data communications environments can be damaged by high-voltage surges and spikes. Such power surges and spikes are most often caused by lightning strikes. However, there are occasions when the surges and spikes result from any one of a variety of other causes. These causes may include direct contact with power or lightning circuits, static buildup on cables and components, high energy transients coupled into equipment from cables in close proximity, potential differences between grounds to which different equipment's are connected, mis-wired systems and even human users who have accumulated large static electricity charge build-ups on their clothing. In fact, electrostatic discharges from a person can produce peak Voltages up to 15 kV with currents of tens of Amperes in less than 10 microseconds.

A manufacturing environment is particularly susceptible to such surges because of the presence of motors and other high voltage equipment. The essential point to remember is, the effects of surges due to these other sources are no different than those due to lightning. Hence, protection from one will also protect from the other. When a lightning-induced power surge is coupled into your computer equipment any one of a number of harmful events may occur.

2. What is the "hard failures"?

Semiconductors are prevalent in such equipment. A lightning induced surge will almost always surpass the voltage rating of these devices causing them to fail. Specifically, lightning induced surges usually alter the electrical characteristics of semiconductor devices so that they no longer function effectively. In a few cases, a surge may destroy the semiconductor device. These are called "hard failures." Computer equipment having a hard failure will no longer function at all. It must be repaired with the resulting expense of "downtime" or the expense of a standby unit to take its place.
In several instances, a lightning-derived surge may destroy the printed traces in the printed circuit boards of the computer equipment also resulting in hard failures.

Along with the voltage source, lightning can cause a current surge and a resultant induced magnetic field. If the computer contains a magnetic disk then this interfering magnetic field might overwrite and destroy data stored in the disk. Furthermore, the aberrant magnetic field may energize the head when it should be quiescent. To you, the user, such behavior will be viewed as the "disk crashing." Some computer equipment may have magnetic relays. The same aberrant magnetic fields which cause disk crashes may activate relays when they shouldn't be activated, causing unpredictable, unacceptable performance.

Finally, there is the effect of lightning on program logic controllers (PLCS) which are found in the manufacturing environment. Many of these PLCs use programs stored in ROMS. A lightning-induced surge can alter the contents of the ROM causing aberrant operation by the PLC.

So these are some of the unhappy things which happen when a computer experiences lightning. But you may say, "Come on, equipment hit by lightning, that's like winning the lottery. It has never happened and I doubt that it ever will." This is a typical reaction and unfortunately it is based on ignorance. True, people may never, or rarely, experience, direct lightning strikes on exposed, in-building cable feeding into their equipment. However, it is not uncommon to find computer equipment being fed by buried cable. In this

environment, a lightning strike, even several miles away, can induce voltage/current surges which travel through the ground and induce surges along the cable, ultimately causing equipment failure. The equipment user is undoubtedly aware of these failures but usually does not relate them to the occurrence of lightning during thunderstorm activity since the user does not experience a direct strike.
In a way, such induced surges are analogous to chronic high blood pressure in a person; they are "silent killers." In the manufacturing environment, long cable runs are often found connecting sensors, PLCs and computers. These cables are particularly vulnerable to induced surges.

3. When consider the lightning?

This question primarily relates to the geographical location of computer equipment end-users. When other interfering phenomena which can cause a deterioration of performance is considered, it matters little where the equipment is geographically located.
When do you have to worry during a thunderstorm? Typically, thunderstorms are characterized as intense individual rain cells or showers embedded in a broad area of light rain. These intense cells are only over a fixed location for a few minutes. They are on average, several miles in each direction. The speed at which the thunderstorm cell moves is generally 30 knots (approximately 34.4 statute miles per hour).

4. Lightning protection.

Coming right down to it, a lot can be done as far as protection is concerned. However, it is best to begin by describing the magnitude of the threat from which you need protection.
The first stroke of lightning during a thunderstorm can produce peak currents ranging from 1,000 to 100,000 Amperes with rise times of 1 microsecond. It is hard to conceive of, let alone protect against, such enormous magnitudes. Fortunately, such threats only apply to direct hits on overhead lines. Hopefully, this is a rare phenomenon. More common is the induced surge on a buried cable. In one test, lightning-induced voltages caused by strokes in ground flashes at distances of about 5 km were measured at both ends of a 448 meter long, unenergized power distribution line.
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Conceptually, lightning protection devices are switches to ground. Once a threatening surge is detected, a lightning protection device grounds the incoming signal connection point of the equipment being protected. Thus, redirecting the threatening surge on a path-of-least resistance (impedance) to ground where it is absorbed.

5. Lightning Protection Unit Function

Any lightning protection device must be composed of two "subsystems," a switch which is essentially some type of switching circuitry and a good ground connection-to allow dissipation of the surge energy. The switch, of course, dominates the design and the cost. Yet, the need for a good ground connection can not be emphasized enough. Computer equipment has been damaged by lightning, not because of the absence of a protection device, but because inadequate attention was paid to grounding the device properly.
The basic elements used as protective switches are: gas tubes, metal oxide varistors and silicon avalanche diodes (transorbs). Each has certain advantages and disadvantages.
Because they can withstand many kilovolts and hundreds of Amperes, gas tubes have traditionally been used to suppress lightning surges on telecommunications lines. This is just what is needed to protect against a direct strike. Because gas tubes have a relatively slow response time, this slowness lets enough energy to pass to destroy typical solid state circuits.
Metal oxide varistors (MOVS) provide an improvement over the response time problem of gas tubes. But, operational life is a drawback. MOVs protection characteristic decays and fails completely when subjected to prolonged over voltages.
Silicon avalanche diodes have proven to be the most effective means of protecting computer equipment against over voltage transients. Silicon avalanche diodes are able to withstand thousands of high voltage, high current and transient surges without failure. While they can not deal with the surge peaks that gas tubes can, silicon avalanche diodes do provide the fastest response time. Thus, depending upon the

principal threat being protected against, devices can be found employing gas tubes, MOVS, or silicon avalanche diodes. This may be awkward, since the threat is never really known in advance. Ideally, the protection device selected should be robust, using all three basic circuit breaker elements. The architecture of such as device is illustrated in Figure 20. This indicates triple stage protection and incorporates gas tubes, MOVs and silicon avalanche diodes as well as various coupling components and a good ground.
With the architecture shown in Figure 20 a lightning strike surge will travel, along the line until it reaches a gas tube. The gas tube dumps extremely high amounts of surge energy directly to earth ground. However, the surge rises very rapidly and the gas tube needs several microseconds to fire.
As a consequence, a delay element is used to slow the propagation of the leading edge wavefront, thereby maximizing the effect of the gas tube. For a 90 Volt gas tube, the rapid rise of the surge will result in its firing at about 650 Volts. The delayed surge pulse, now of reduced amplitude, is impressed on the avalanche diode which responds in about one nanosecond or less and can dissipate 1,500 Watts while limiting the voltage to 18 Volts for EIA-232 circuits. This 18 Volt level is then resistively coupled to the MOV which clamps to 27 Volts. The MOV is additional protection if the avalanche diode capability is exceeded.
As previously mentioned, the connection to earth ground can not be over emphasized. The best earth ground is undoubtedly a cold water pipe. However, other pipes and building power grounds can also be used. While cold water pipes are good candidates you should even be careful here. A plumber may replace sections of corroded metal pipe with plastic. This would render the pipe useless as a ground.

6. Block Function for the Lightning Protection Units