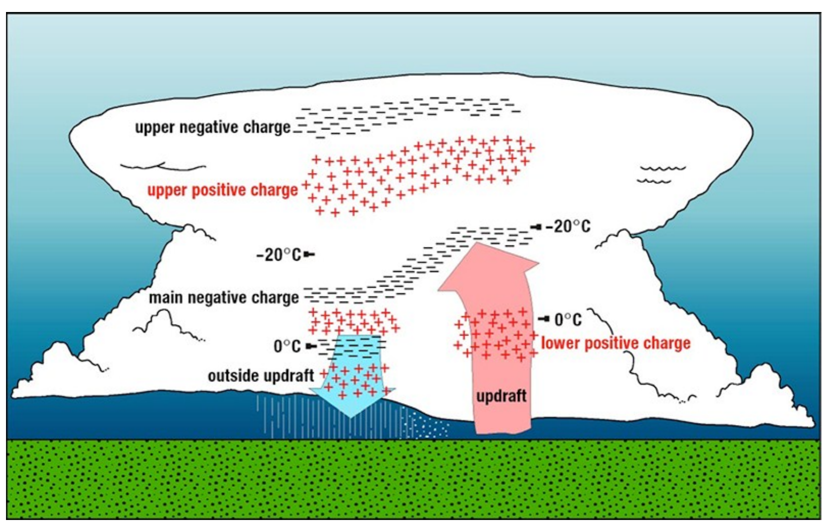
“It was a dark and stormy night, a night full of danger ...”   Sound familiar?

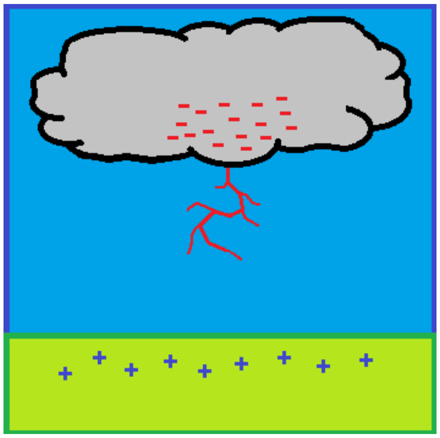
If you had picked up a new mystery novel and read that opening line you, like me, would most likely put it back down and walk away from it. In the real world, thunderstorms are scary, dark and dangerous, and do real damage. Besides the wind and rain, thunderstorms always generate lightning [1], which is dangerous not just to us, but the environment around us including electronic equipment. In the real world we do not always have the time or ability to get out of harms way, especially electronic equipment bolted to a pole outside as it must endure all weather conditions.

The Anatomy of a Lightning Strike

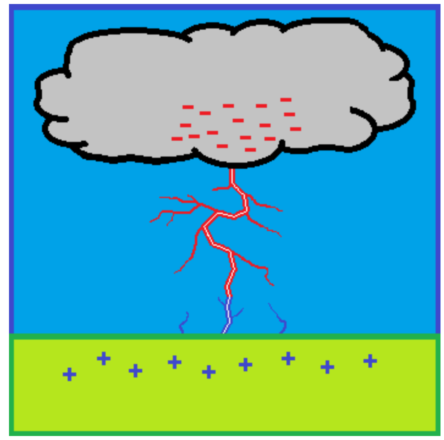


Lightning is described as a massive electrostatic discharge caused by an imbalance in electrical charges in the cloud, resulting in a strike. A lightning strike has many forms, mostly in or of the cloud itself, but we here are focusing on Cloud to Ground (CG).

Cloud to ground lightning (2nd most common) is a discharge between a cumulonimbus cloud and ground. The strike is initiated by a leader from the cloud to the ground, creating a channel for the much more energetic return strike from the ground to the cloud. The energy contained in a single electrostatic discharge is anywhere from 100 million to 1 billion volts, and from 20 to 100 kA, containing upwards of 1 terawatt of energy [1].



In the event of negative cloud to ground lightning, the ground is positive with respect to the charge built-up in the cloud. The initial strike (always taking the path of least resistance) creates a path using stepped leaders from the cloud to the ground (see figure on the left). As the cloud leaders approach the ground, ground leaders reach up seeking a path to complete the circuit (figure on the right).

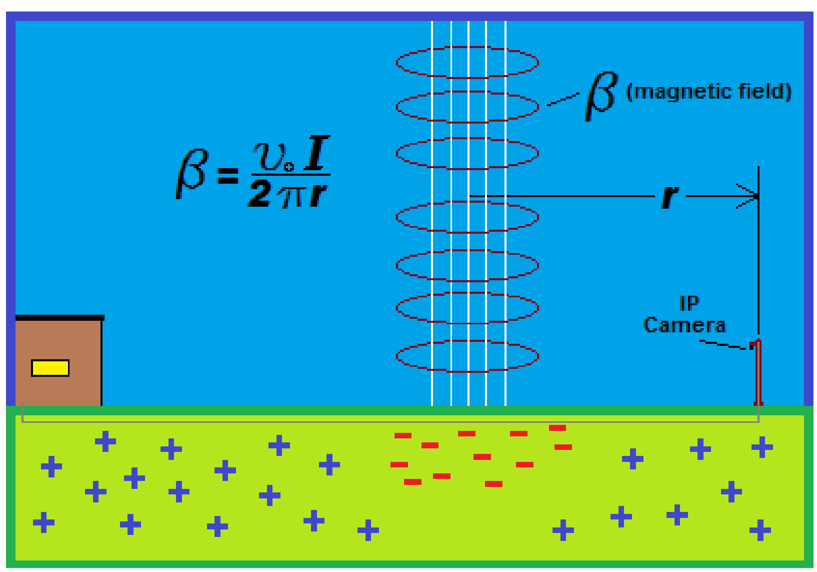


Once the circuit is closed, the full current (somewhere between 20,000 to 100,000 Amps) of the up-ward return strike flows, with a time duration between 20 and 90 micro seconds. Most of the energy of the strike is used in the creation of the pathway (between the cloud and the ground), heat energy and light. In the photo to the right, near the bottom, the ground leaders are visible, as-well-as the return strike.

The Surge

The dangers to electronic equipment can not be over stated, in fact, there is very little available that can with-stand a direct hit from a lightning strike. A lightning strike directly or indirectly induces a voltage/current rise (pulse) in a system. This pulse is commonly referred to as a transient, and is either coupled to a cable by capacitive or magnetic coupling.

In magnetic coupling, the lightning strike generates an EMP (electromagnetic pulse) whose strength can be calculated from the formula to the right. Where u_o = $4*pi*10^{-7}$ tesla*m/amp, **I** is peak current of the strike, and **r** (in meters) is the distance from the strike.

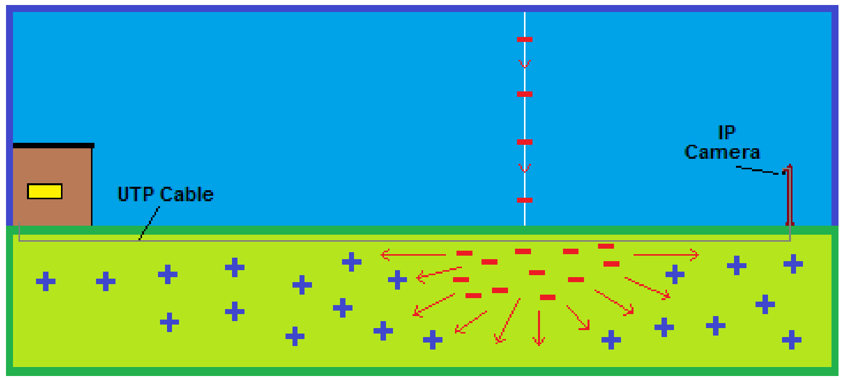


Example: If distance to camera is 5 meters, and a moderate energy strike of 25kA, what is the field strength at the camera and the vertical length of cable going up to it?

Answer: **B** = 0.0001 Wb/m^2 or 10G (gauss). Note that the Earth's magnetic field ranges from 0.25 to 0.65G.

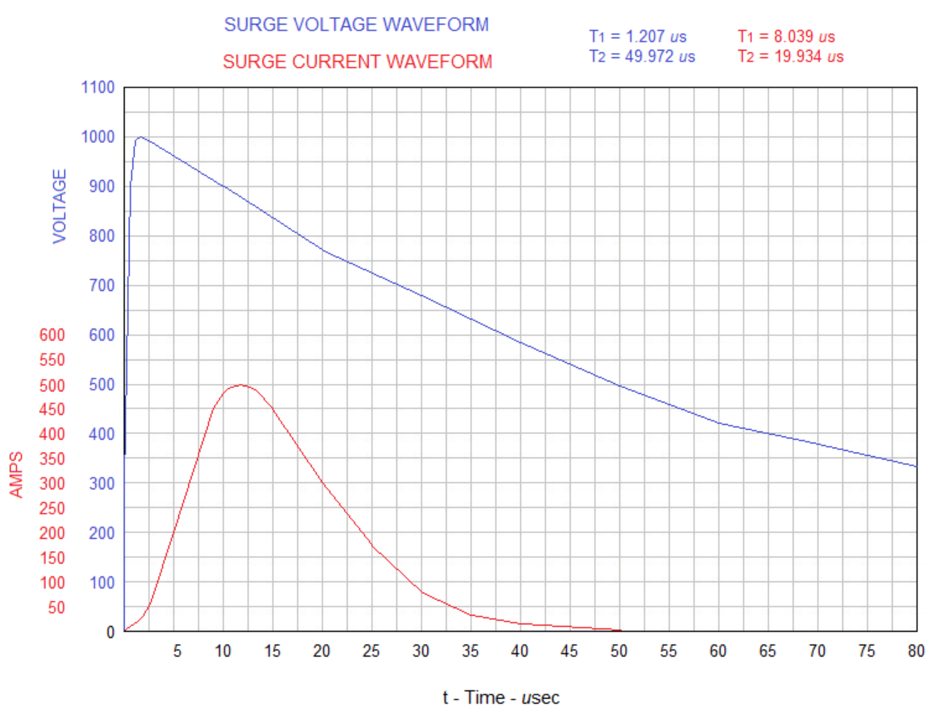
Lets continue to explore the case of a negative lightning, where a strike imparts a large amount of negative charge in a small area on the ground. The ground (Earth) at this instant in time is far more positive then what has just been deposited by the lightning strike. The newly formed charge will flow from the more negative to the more positive region, as the negative charge is mostly freed electrons (and are free to move about). The positive ions are relatively trapped in the ground, but can freely travel in a plasma or other less dense charged medium. It is the ground current from the lightning strike that is responsible for most of the lightning related deaths around the world [1].

Lets expand our image above, when we were discussing magnetic fields, and look at a simple building with a single IP camera mounted near the top of a pole. Since the strike is relatively far from the pole (5 meters), and the cable by design, resist EMI (electromagnetic interference) [2], the strength of the pulsed electromagnetic field is fairly weak.



On the other hand the current running next to and parallel to the UTP cable, is still very substantial, and can still impart a great amount of energy. This indirect strike can induce severe voltages and current in the cable.

There are two surge waveforms that are used in testing the typical energy that is coupled into a cable and is defined by the IEC Standard 61000-4-5. The transient as two waveforms are defined as either open-circuit voltage (1.2 x 50 us) or short-circuit current (8 x 20 us).



The chart (on the right) has the combined typical waveforms of both the Open-Circuit Voltage and the Short-Circuit Current from the Surge Generator, when set to a 1kV peak with a 2 Ohm source impedance. This threat to the equipment is greatest when the cabling is associated with an out-door application [3].

The surge spreading out from the lightning strike moves towards both the IP camera or other IP device and at the same time entering the building into what ever Head-end units are being used at the time. The circuitry in all devices, ie. PoE chips are not rated for voltages much higher then 80 volts, much-less 1000volts. Outdoor networks are also tested for a 1.5kV dielectric test to earth (IEEE802.3 requirement) [3].

IP Camera Systems

Outdoor IP camera installation is completed in one of two ways, either mounted on a pole or on the side of a building. A large facility can have dozens of cameras mounted in various locations using a variety of methods. We will be focusing on the pole type mounting for the outdoor cameras, as they are the most acceptable to damage from a surge.

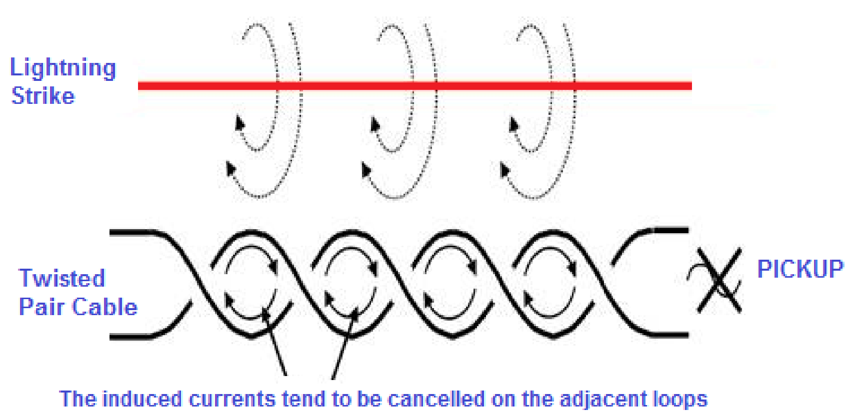
Regarding a lightning strike, the lightning will always seek the easiest path to its destination. This makes tall structures more likely to be hit, be it a pole or a building. Also any camera mounted away from the main facility will have many meters of shallow buried cables stretched out from the building to the IP device.

There are, on many pole installations, a small lightning rod with a cable attached running down the pole on the opposite side from where the UTP cable is located. In reference to the previous example, the lightning strike is now only about 0.2 meters from the UTP cable attached to the IP device. Using the same data with only the value for **r** changing, we get a magnetic field felt at the cable 500 times greater then the field generated by the earth.

A Quick Installation Review:

Lets say we have a moderate shipping facility, a single building located in the middle of a very large fenced-in parking lot, with entrances at the four cardinal directions. We would probably need multiple cameras at each entrance, either mounted on the corner of a guard shack or on a pole. There could be hundreds of feet between the fence entrances and the building, a dozen or so IP cameras on the outer perimeter. It sounds like we have everything covered, except for one thing, that's right … Surge. And unless we want to pay, on a routine basis every-time there is an electrical storm, we need to protect our equipment.

A complete IP camera system is not complete until matters are taken in hand by a means of securing the camera system itself is addressed. The cabling either twisted pair or coax is capable of rejecting outside EM Interference induced by a sudden large magnetic field [2]. The twist provides a means of maintaining a balance even in a harsh environment.



There is another factor to be considered, and that is the method of powering up and communicating with the IP device. These devices rely on PoE or PoE+ power, which is not referenced from earth ground, so the lines in a sense are floating. A device that protect and allows PoE power and Ethernet communication to pass through, but blocks/re-routes harmful voltages going to the camera or head-end is needed.

What we need are surge protectors that can be mounted with the IP camera for just that one device. Having a device designed to support multiple IP devices is size restrictive and costly for an out-side installation. The available surge protection devices provide a single-point ground for harmful voltages to be re-routed away from the equipment.

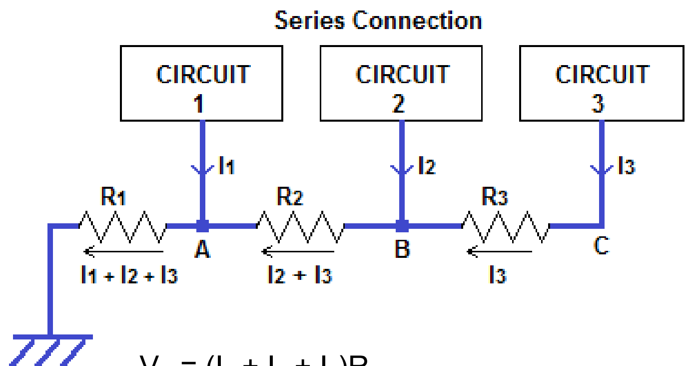
Single-Point Ground and Surge Arrestors

Single-point grounds are used to overcome several problems (high-impedance ground, large ground current, and noise sensitivity), by separating ground currents that are likely to interfere and forcing them to flow on different conductors [2]. The use of single-point grounding limits ground loops which can cause noise to circulate through-out the system.

There are basically two types of single-point grounds; a series connection and the parallel connection. The two figures to the right are representatives of the two types of single-point ground, and the resistors represent the impedance of the ground conductors, and I_1, I_2, and I_3 are ground currents of circuits 1, 2, and 3. [2]

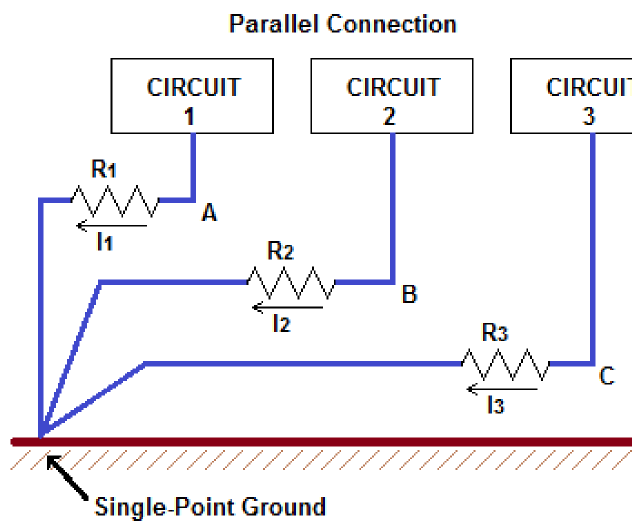
For the series connection the points A, B, and C are not at zero potential, and it should be noted that point A is at a lower potential then point B or C. The parallel connection single-point ground is more desirable, because there is no cross coupling between ground currents. [2]

Another advantage to single-point grounding is its ability to handle rising ground potentials. A lightning strike nearby can cause a rise or fall of the ground potential, since all the components potential's are tied to the same point, the components potential will rise and fall uniformly. It is this method that is used to protect against lightning [4]. This does not provide all the protection that is necessary in case of a strike.



$V_A = (I_1 + I_2 + I_3)R_1$

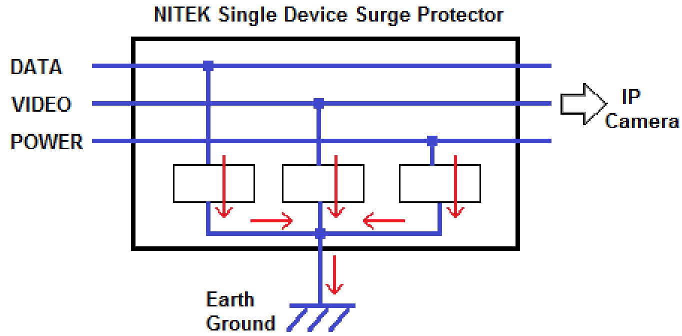
$V_C = (I_1 + I_2 + I_3)R_1 + (I_2 + I_3)R_2 + I_3R_3$



$V_A = I_1R_1$

$V_C = I_3R_3$

What NITEK can provide is a means of re-directing the coupled energy from the lightning away from the IP devices, both outside and inside. Initially, we'll look at the equipment mounted in the elements, where it's most likely to encounter dangerous voltages/currents. The image on the right depicts the basic surge protector provided by NITEK combines the functionality of a single-point ground with surge protection devices, which conduct only when a surge is present on the lines.

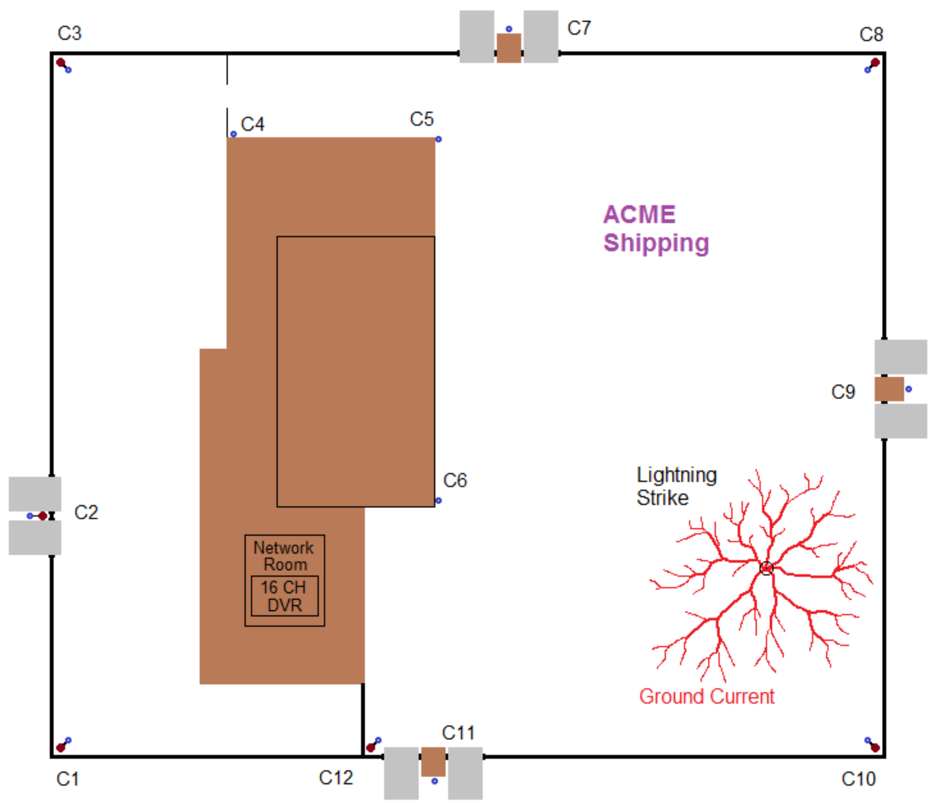


Network Systems and Surge Protection

Let us consider securing/monitoring a fenced-in shipping facility, which is open 18 hours a day receiving and transporting various goods. The fleet trucks are parked along the fence, and open areas in the NE & SE corners. There are, see reference diagram, 12 out-door IP cameras, some are mounted on poles while others are either mounted on guard shacks or on the building itself. The cabling, from the fence perimeter, is a few feet under ground, and is of various length (for example: distance from the Network room to camera C8 is set to 800 meters). Currently, there are no devices across the data line to protect the equipment from surges.

Next, during a thunderstorm a lightning strike takes place in the parking lot. The initial strike, and return strike produces both a large electromagnetic field and a very large ground surge current (ground current has been measured to penetrate several feet deep into the earth), and will travel out-wards in every direction.

Even though it is not a direct strike to any equipment it is likely that some of the energy will enter the IP devices, by coupled energy in the cabling. The cameras most likely to receive some of this energy are C9 and C10, and will be the first to be damaged.

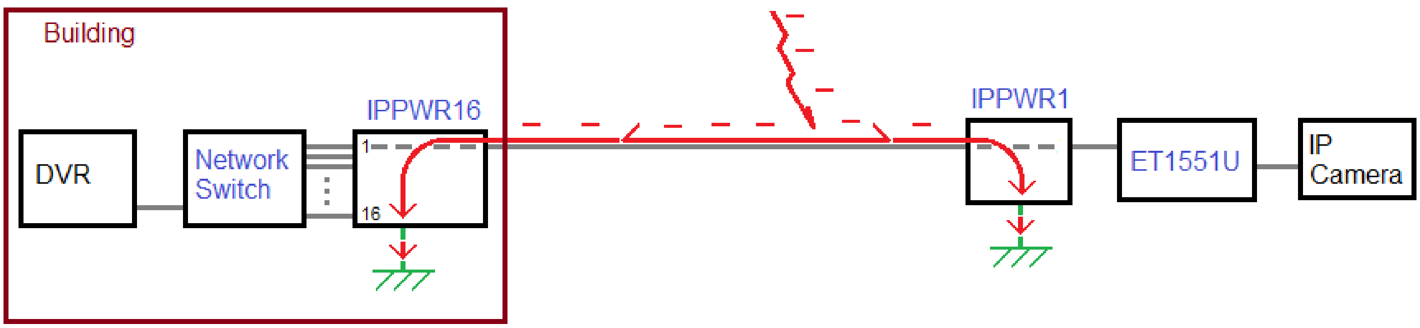


The strike will also travel through the cabling into the Network room and into the DVR, damaging that device. From a single strike both the out-side IP devices and the in-side Network device are damaged in less then 0.0001 seconds. The potential from cameras C9 and C10 will rise-up, placing them at different levels then the rest of the cameras (though cameras C6, C11 and C12 could also experience a slightly diminished surge on their lines). This means that our DVR has multiple potential levels on its various inputs, resulting in heavy current flow on equipment ground causing irreparable damage to that piece of equipment.

Surge Protection from ***NITEK***

In the last scenario, as expected, several expensive pieces of electronic equipment was damaged from a single lightning strike. This does not have to be, as there are ways to divert the surge energy moving towards an IP device (outside) or a network switch and/or DVR. In order to protect the individual IP camera we could have installed a single surge protector device between the network cable and the camera, and for the DVR, there are multi-channel surge protector units designed for rack installation.

Looking back to the lightning strike, the energy travels the length of the cable in both directions, towards the camera and towards the DVR. With surge protection circuitry at both ends of the cable, the energy coupled over from the strike will be diverted back to earth ground, avoiding the equipment at both ends.



As the lightning strikes the ground, a surge is built-up in the cabling and travels towards both the camera and the building. During normal operation, the surge protection allows the Data/PoE+ (58Vp-p) to pass through with-out affecting the data or power. But during a surge, a path to earth ground is created allowing the surge to be directed away from the other devices.

The surge protection devices from NITEK, provide a means of protecting the end user equipment from power surges while being transparent to the transmitted video signal. It is not enough to block/re-direct dangerous voltages, but also allow the Signal/PoE+ power to travel the full length of the recommended cable length of that particular system. For our example we relied on standard UTP cabling, but many existing systems use coax cabling which needs a different set of surge protectors.

NITEK Models for out-side/camera end installation

NITEK PN:	Description
IPPWR1	This is a single channel, in-line UTP 10/100/1000 Ethernet PoE+ surge protector. In addition to the network protection the IPPWR1 provides independent protection for 12 or 24 volt power. The IPPWR1 provides a heavy duty, single-point ground connection and is easy to install.
IPCOAX1	This is a single channel, in-line Ethernet PoE+ over Coax surge protector. In addition to the network protection the IPCOAX1 provides independent protection for 12 or 24 volt power. The IPCOAX1 provides a heavy duty, single-point ground connection and is easy to install.

NITEK Models for in-side/rack installation

NITEK PN: Description

IPPWR16

The IPPWR16 provides 16 channels of PoE+ Ethernet over UTP for network devices. The IPPWR16 is rack mounted in a standard 16 inch rack (2RU height). The IPPWR16 allows a surge to be routed to ground, by the use of a heavy duty single-point connection, and clamps the protected equipment video inputs to a minimum voltage.

IPCOAX16

The IPCOAX16 provides 16 channels of PoE+ Ethernet over coax for network devices. The IPCOAX16 is rack mounted in a standard 16 inch rack (2RU height). The IPCOAX16 allows a surge to be routed to ground, by the use of a heavy duty single-point connection, and clamps the protected equipment video inputs to a minimum voltage.

IPPTR12

The IPPTR12 provides 12 channels of Ethernet over single twisted pair for network devices. The IPPTR12 is rack mounted in a standard 16 inch rack (1RU height). The IPPT12 allows a surge to be routed to ground, by the use of a heavy duty single-point connection, and clamps the protected equipment video inputs to a minimum voltage.

For further information contact sales department at address below.

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