



*LIGHTNING:
How Does It Work?
What Can You Do About It?*

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What We Will Look At

- ◆ Lightning Protection and Prevention
- ◆ Transient Voltage Surge Suppression
- ◆ Achieving Low-resistance Grounding

Proactively Prevent Lightning-related Failures of our Sensitive Equipment!



What Is Lightning?

- ◆ Complex AC Surge with a Typical Frequency of about 20-500 Khz.
- ◆ IEEE “Standard” Strike is defined as a 8 us Rise Time by 20 us Fall Time.
 - 50-125 Khz
- ◆ Average Current is 18,000 Amps for the first stroke, and half that for the Second and Third Strokes.
- ◆ Average Strike is 3-4 Strokes.



Strike Frequency

- ◆ Does Lightning ever strike the same place twice?
- ◆ Absolutely! The Strike Frequency goes up as the square of the height over average terrain!
- ◆ AND - Nothing can be done to totally prevent a strike!



Strike Current

- ◆ 50% of ALL strikes have a 1st strike of at least 18kA (kilo-amps).
- ◆ 10% will exceed 65kA.
- ◆ 1% will exceed 140kA.

The largest strike ever recorded
was almost 400kA!!!



Power Lines

Power Line Voltage Anomalies are the Greatest Source of Destructive and Disruptive Phenomena that Electrical and Electronic Equipment Experiences in Day-to-Day operation.



Power Line Voltage Anomalies

Four Basic Sources

- ◆ Lightning
- ◆ The Local Utility
- ◆ Your Neighbors
- ◆ Your Own Equipment

Of These, Lightning is the Greatest Normal Threat.

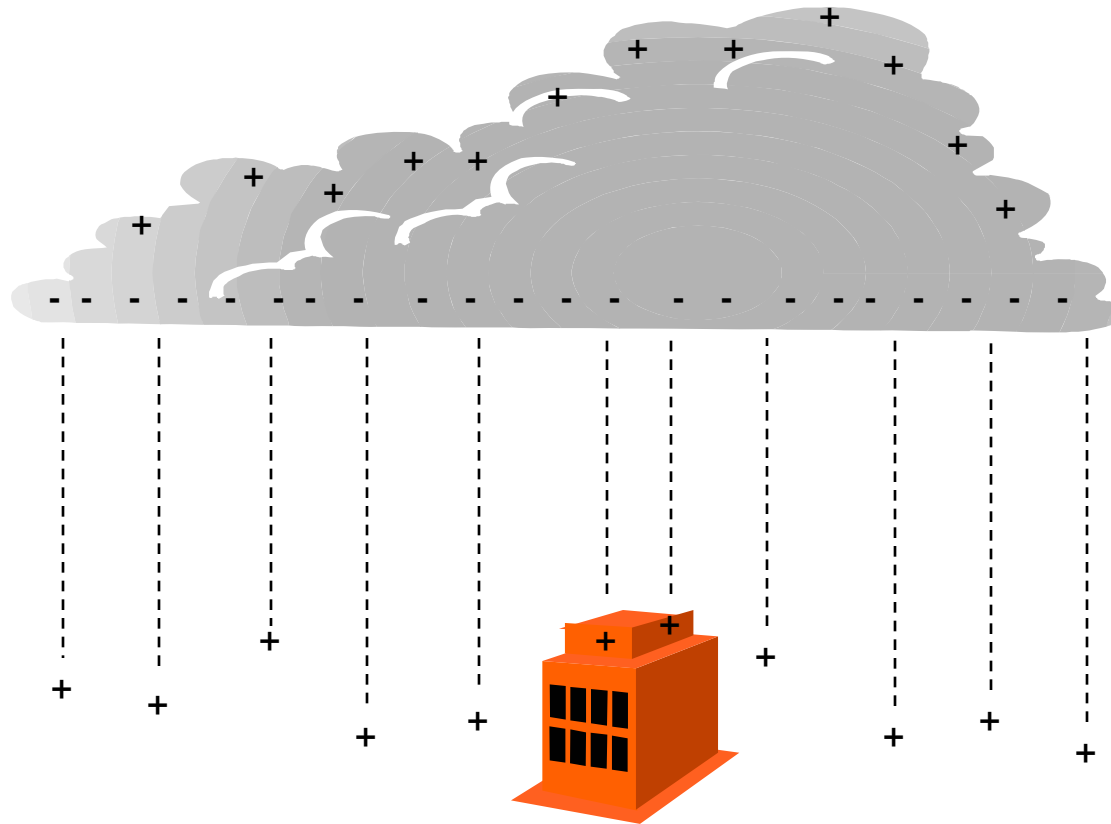


Mechanics of the Strike

- ◆ Charge Separation at the Base of the Cloud causes a Potential at the Cloud Base of about 100 Million Volts!
 - Base of Cloud is Typically Negatively Charged
 - Similar Charge of Opposite Polarity on the Earth
 - Resulting Electrostatic Field of 10kV/meter



Charge Separation





Breakdown

- ◆ Charge Separation Continues until the Air between the Cloud and Earth can no longer Act as an Insulator.



Mechanics of the Strike (Cont.)

- ◆ Step Leaders (low intensity sparks) move from the Base of the Cloud Toward the Earth.
 - Steps are about Equal Length
 - Length is Related to the Charge in the Storm Cell.
- ◆ Steps Vary in Length from about 10 Meters to over 160 Meters.
- ◆ At about One Step-distance from the Earth (or Earthbound Object), a Strike Zone is Established.

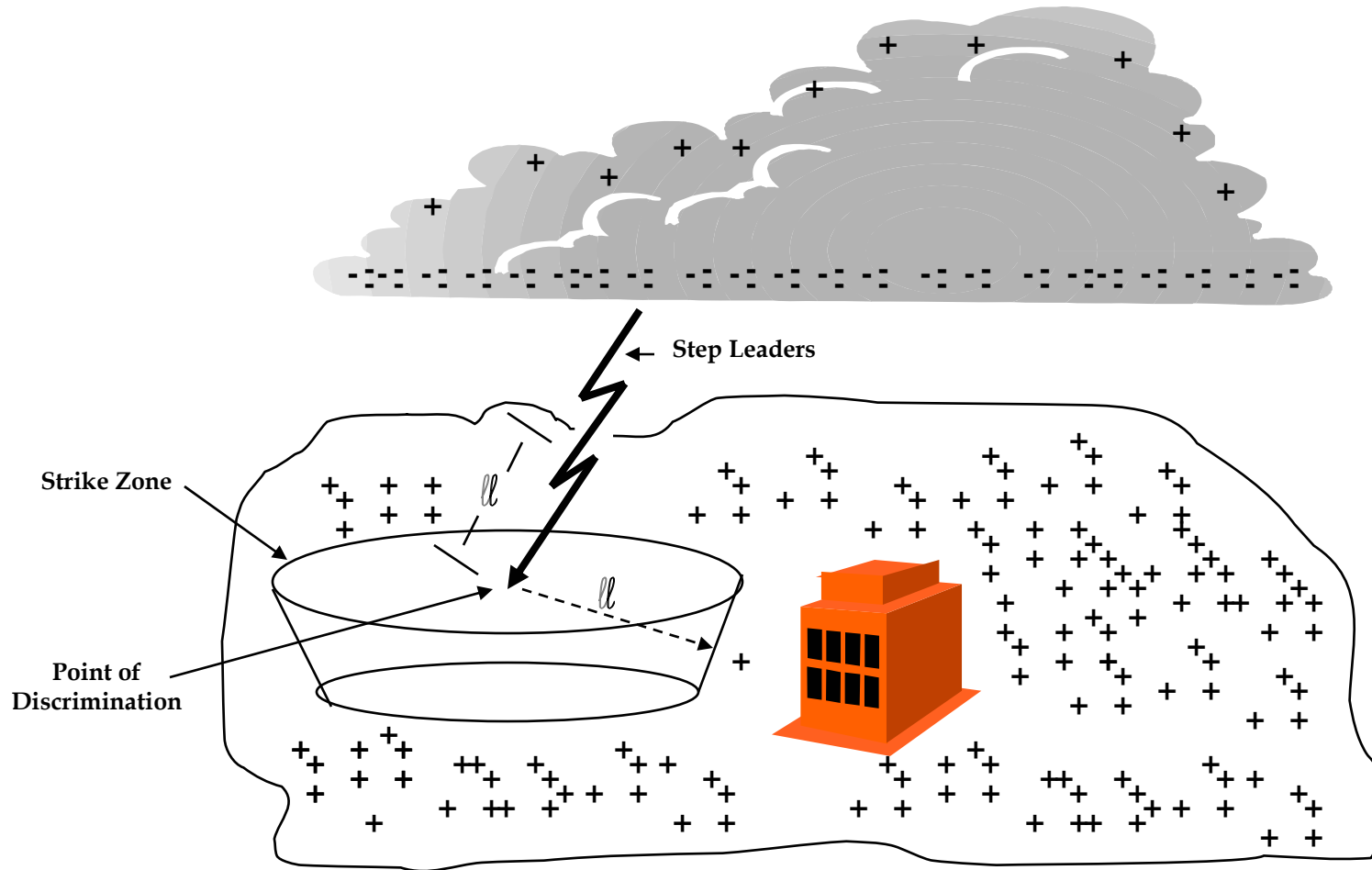


The Strike Zone

- ◆ Hemispherical in Shape
- ◆ Radius Equal to One Step-Length
- ◆ Electric Field within the Strike Zone is so High that it Creates Upward Moving Streamers from Earthbound Objects.
- ◆ The First Streamer that Reaches the Step Leader Closes the Circuit and Starts the Charge Neutralization Process.



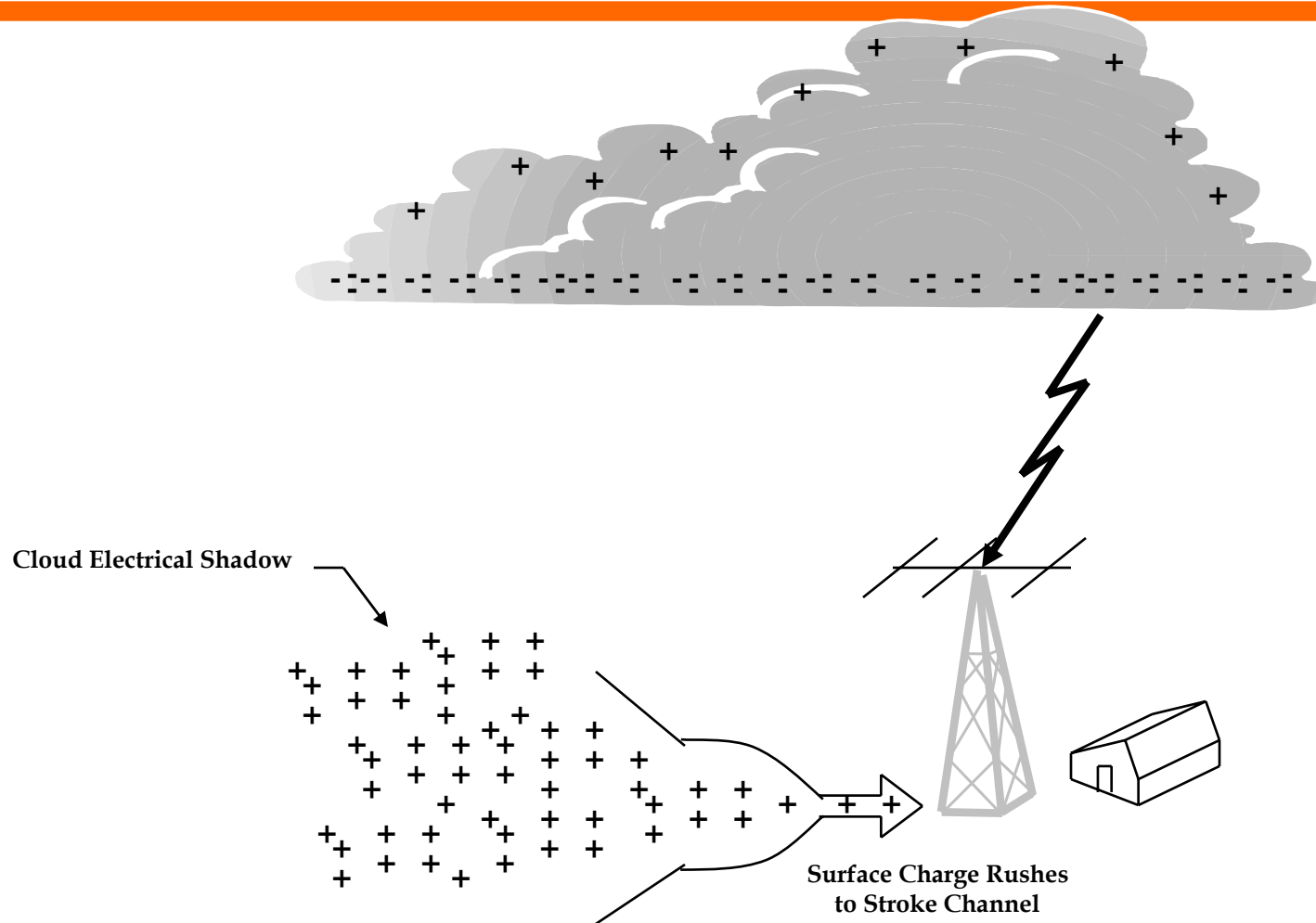
The Strike Zone



AD5X Charge Neutralization (the “Strike”)

- ◆ Caused by the Flow of Electrons from One Body (Earth or Earthbound Objects) to Another (the Cloud).
- ◆ Same Effect as Shorting Out the Terminals of a Battery.

Charge Neutralization





Direct Effects

- ◆ Destruction Due to the Lightning Bolt
- ◆ Exposure to the Stroke Channel
- ◆ Heating Effect of the Lightning Strike



Secondary Effects

- ◆ Electromagnetic Pulse
- ◆ Electrostatic Pulse
- ◆ Earth Currents



What Can You Do About It?

- ◆ Pray?
- ◆ Block it!
- ◆ Provide Alternative Path to Ground.



Blocking

- ◆ The inductance of your feedline “impedes” the higher frequencies.
- ◆ Energy is not lost, but is given back over a longer period of time.
- ◆ This results in the energy presented to your equipment being at a low frequency.
- ◆ Most radios have “protection” inductors across their inputs.
- ◆ Since the lightning frequency is low, it is difficult to build up the voltage necessary to fire a gas discharge tube.



Blocking (Cont.)

- ◆ The proper value of a series blocking capacitor can help.
- ◆ Voltage builds up across the capacitor and fires the gas discharge tube.
- ◆ That's fine - But what do you do with all this lightning energy?
- ◆ You must send it to ground!



Surviving the Lightning Strike

The Primary Rule:

- ◆ All Equipment Elements must be connected to a single low impedance ground.
- ◆ This includes:
 - Antenna(s)
 - Antenna Supports
 - Input & Output Protectors



The Ground System

Lightning energy can enter your shack in one of two ways:

- ◆ A distant strike coming in on the telephone and power lines.
- ◆ A direct strike to your antenna.

You must use high quality protectors to dump the energy into a good ground system.



The Ground System (Cont.)

- ◆ A Single Point ground for your system should be located no more than 10 feet from a very good earth ground.
- ◆ The sooner your ground system can spread out the energy, the better are the chances of preventing it from getting to your equipment.
- ◆ Your ground system should be formed by a set of ground rods interconnected below ground level with bare radials.



The Ground System (Cont.)

- ◆ Radials are the most cost effective grounding technique.
- ◆ Radials should be made of copper strap (most preferable), or stranded copper wire.
- ◆ If one radial gives “X” ohms of ground resistance, then two radials gives approximately 0.90 (X/2) ohms.
- ◆ To cut this in half again requires FOUR radials.



The Ground System (Cont.)

- ◆ If surge energy has not been launched into the soil in the first 75 feet, the radial inductance will prevent effective grounding.
 - Therefore, radials should be at least 50 feet long, and no longer than 75 feet long.
- ◆ Ground rods should be placed along the entire length of the radial.
 - Spaced at “2 X Radial Length” apart.



Rules of Thumb

- ◆ Try to avoid high, single sharp points on your antenna system.
- ◆ Nothing placed in the soil will last forever.
 - Must Maintain your Ground System.
 - Check annually.
- ◆ Copper is the best, and most robust, grounding material.
- ◆ Don't mix dissimilar metals in your grounding system.
 - Don't even mix bare copper and tinned copper wire.



Rules of Thumb (Cont.)

- ◆ Copper joint compound should be used in mechanical compression joints.
- ◆ Cool exothermic connections slowly to prevent stress corrosion.
- ◆ Ground rod lengths in excess of 8 feet don't buy you much.
- ◆ Ground rod diameter is unimportant.
 - Though larger diameter rods will last longer.



Conclusion

- ◆ No one can guarantee that they won't be hit by lightning.
- ◆ The best you can do is provide the best ground you can to redistribute lightning energy (and its effects) so that it causes minimal damage.