Grounding & Bonding

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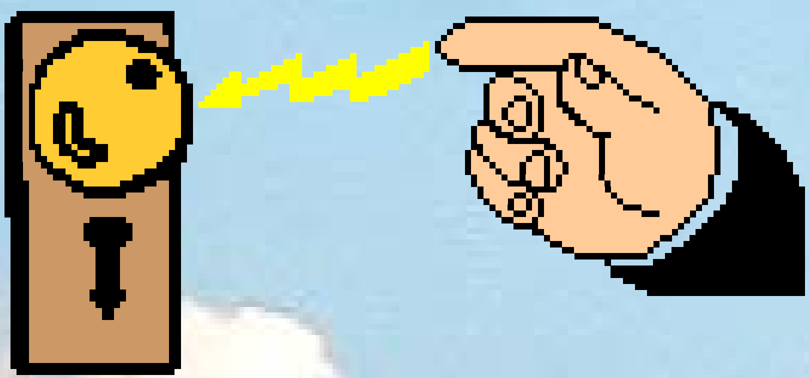
Grounding & Bonding

Reasons for Grounding

- Personnel safety
- Protection from high voltages
  - Lightning
  - Power faults
- Dissipate electrostatic charges
- Provide a zero volt reference
- Protection of electronic equipment
- Reduction of noise and interference

- Even though damage is not usually visible with electrostatic discharge, it is the leading cause of electronic equipment failure.
- Humidity and temperature can help control electrostatic energy, but protection must also be deployed to prevent damage.

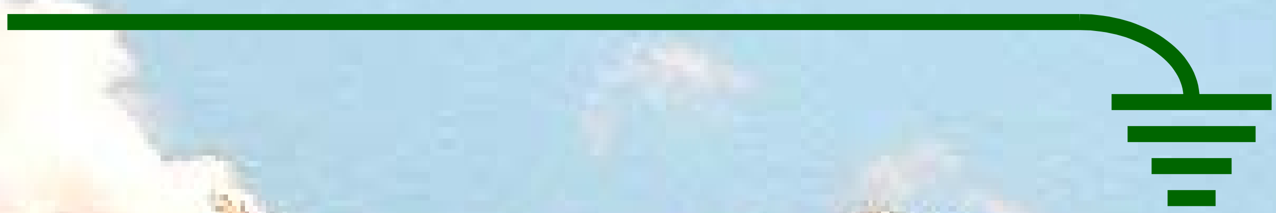
Electrostatic Discharge



- Caused when current passes from one object to another.
- Usually high voltage, but low current.
- A typical 1 cm electrostatic arc from a finger to a doorknob is around 19,000 Volts!

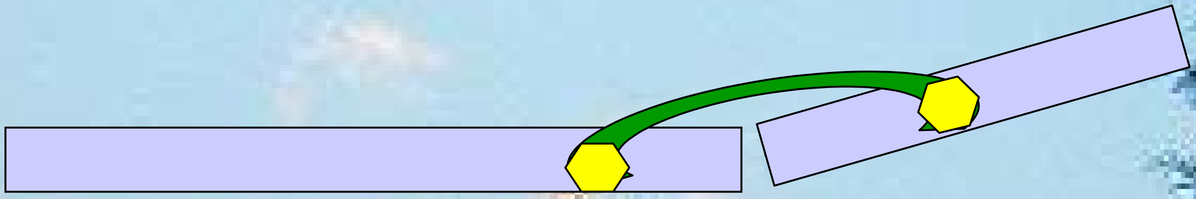
Grounding & Bonding

- "Ground: A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth."



Grounding & Bonding

- “Bonding (Bonded). The permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed.”
- Effective bonding helps equalize potentials.



Grounding & Bonding

- Grounding in a cabling installation refers to connecting non-current carrying metal parts of conduits, raceways, conductors and electrical equipment to a building's system ground.

Ground Resistance Objectives

National Electric Code (USA):

25 Ohms (Safety)

Equipment Manufacturers:

< 5 Ohms (Usually)

Conductor Surface Area

The most effective material for a ground system is copper strap. Copper as a metal is a good electrical conductor, only moderately attacked by ground and air borne acids, and should have a life-span measured in years.

Since lightning has a large portion of its energy in the LF range, it will behave like an RF signal. That means the energy will only be conducted on the skin of the conductor (skin effect). Such currents following a round-member conductor will not make extensive use of its large cross sectional area. With a 1-1/2 inch (38 mm) or larger flat strap of at least 26 gauge (0.41 mm), both surfaces will conduct the surge.

Soil Doping

The earth is a conductor because of the number of ionic salts present in the soil. Conductivity can be improved by adding more ions to the soil.

Soil doping can be done by either adding water or a saline solution to the soil around the grounding system. If the soil already has a sufficient amount of naturally occurring salts, adding water will free the ions and improve conductivity.

If few natural ions are available, salts, such as Epsom salts, can be added to the soil to increase the conductivity.

Depending on the amount of rainfall, doping the ground system radials with 10 kg of salt per per rod may last approximately two years.

Grounding & Bonding

Grounding System Components

The two areas of grounding that pertain to telecommunications equipment are the:

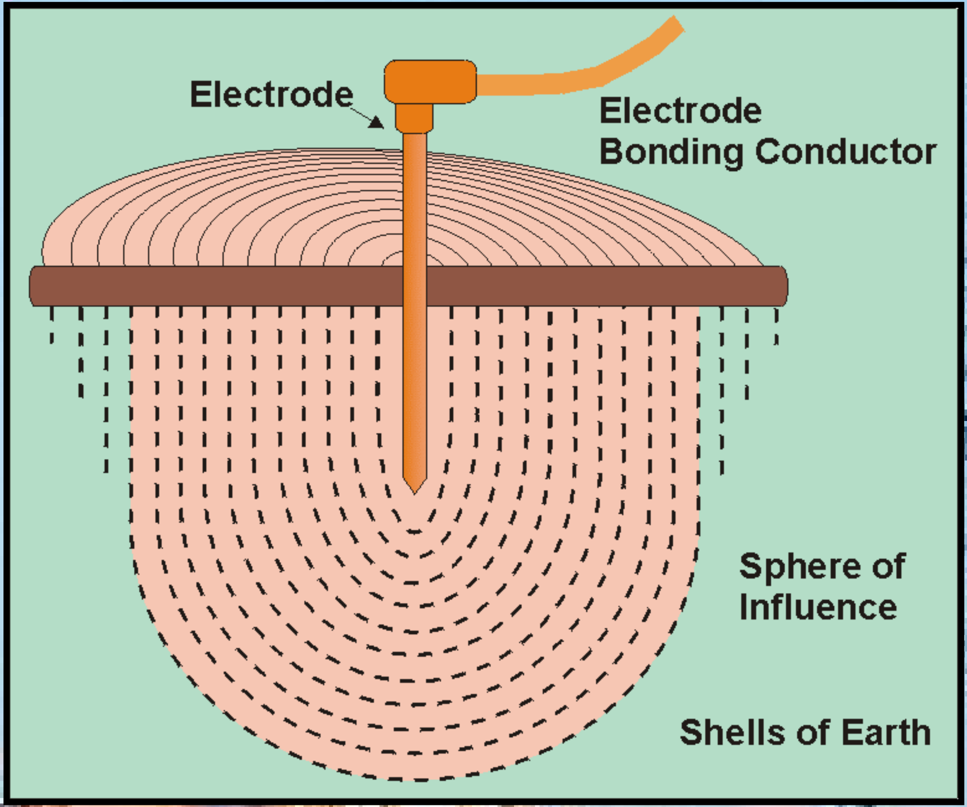
- Grounding electrode system (earthing system)
- Equipment grounding system (safety ground)

Grounding & Bonding

Grounding System Components

The grounding electrode system consists of a:

- Grounding field (earth)
- Grounding electrode
- Grounding electrode conductor



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Grounding System Components

Every building has several electrical protection systems:

- Lightning protection systems
- Grounding electrode systems
- Electrical bonding and grounding systems
- Electrical power protection systems
- Surge protection devices
- Telecommunications bonding and grounding systems
- Telecommunications circuit protectors

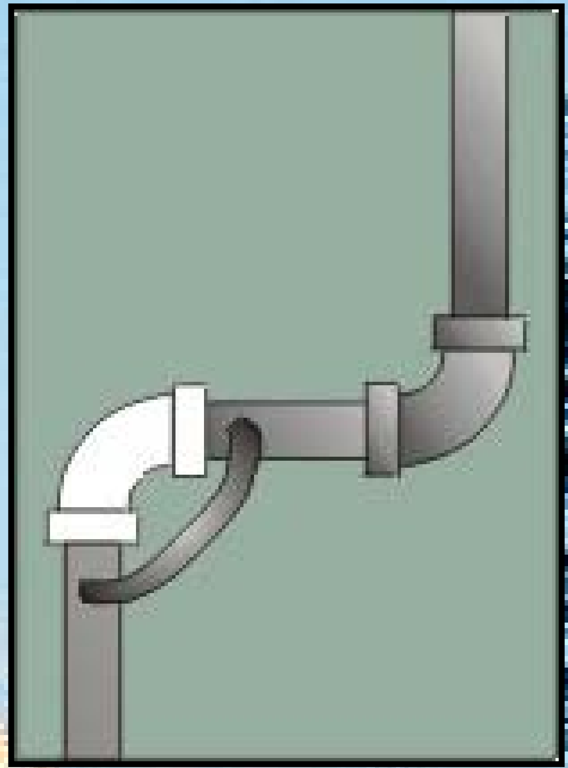
ONE AVERAGE LIGHTNING STRIKE

Instantaneous Power	Over one Megawatt
Total Energy	Over 250 Kilojoules
Sound Pressure	90 Atmospheres at 500m away
Temperature	30,000°K+ (5 times Sun Surface)
Rise Time	0.1 to 5 Microseconds
Average Current	30 kA
Duration	300 Microseconds + Repeats
Channel Length	5 km

Grounding & Bonding

Cold Water Pipes

- Historically the first choice
- Provides low resistance to earth
- Must be
  - In direct contact with 10 ft of earth
    - Bonded within 5 ft of entrance
  - Electrically continuous
    - No plastic pipes or couplers—bond across discontinuities
  - Bonded to a second electrode type



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Cold Water Pipes

Advantages:

- Most homes have water?
  - If they don't, establishing a ground is the least of our concerns!
- Easily accessible
- Usually less than 3 Ω resistance to earth

Grounding & Bonding

Cold Water Pipes

Disadvantages:

- Future repairs may be plastic
- Many cities use PVC
- Bonding causes electrolysis of the installed metallic pipes, causing reduced expected life span
  - Many cities are installing isolation joints made of PVC to separate their systems

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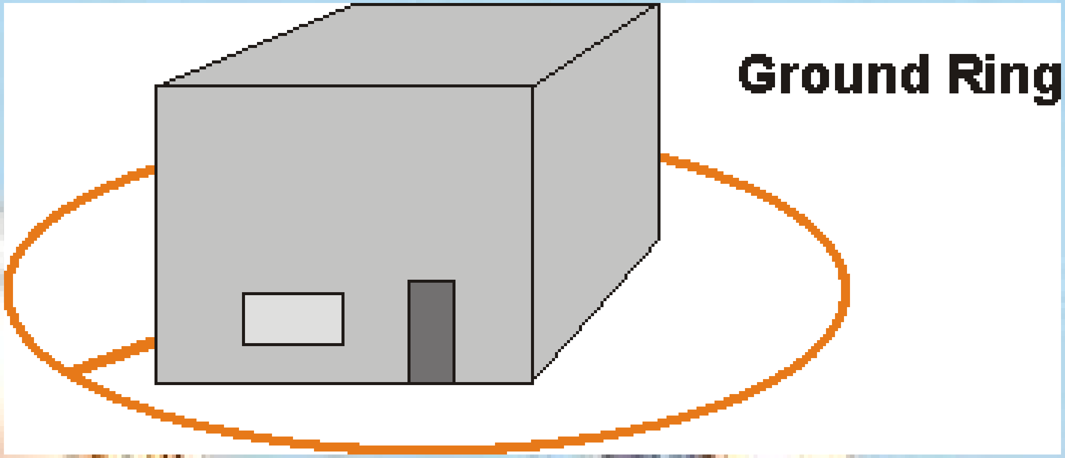
Installing a Ground Ring

Non-insulated conductors buried in the shape of a ring:

- Buried a minimum depth of 76 cm
- Minimum size 2 AWG (7.91 mm) and 6 m in length



Ground Radials

Radials are the most cost effective grounding technique considering system impedance, material cost, and installation labor. If one radial gives “X” resistance, then two will deliver an equivalent “parallel rule” plus 10%.

Radials do have a limit on their effective length. If the surge energy has not been launched into the soil within

the first 22 m, the inductance of the radial will prevent any further effective prorogation. Therefore, as a general rule of thumb, all radials should be at least 15 m long and no longer than 23 m.

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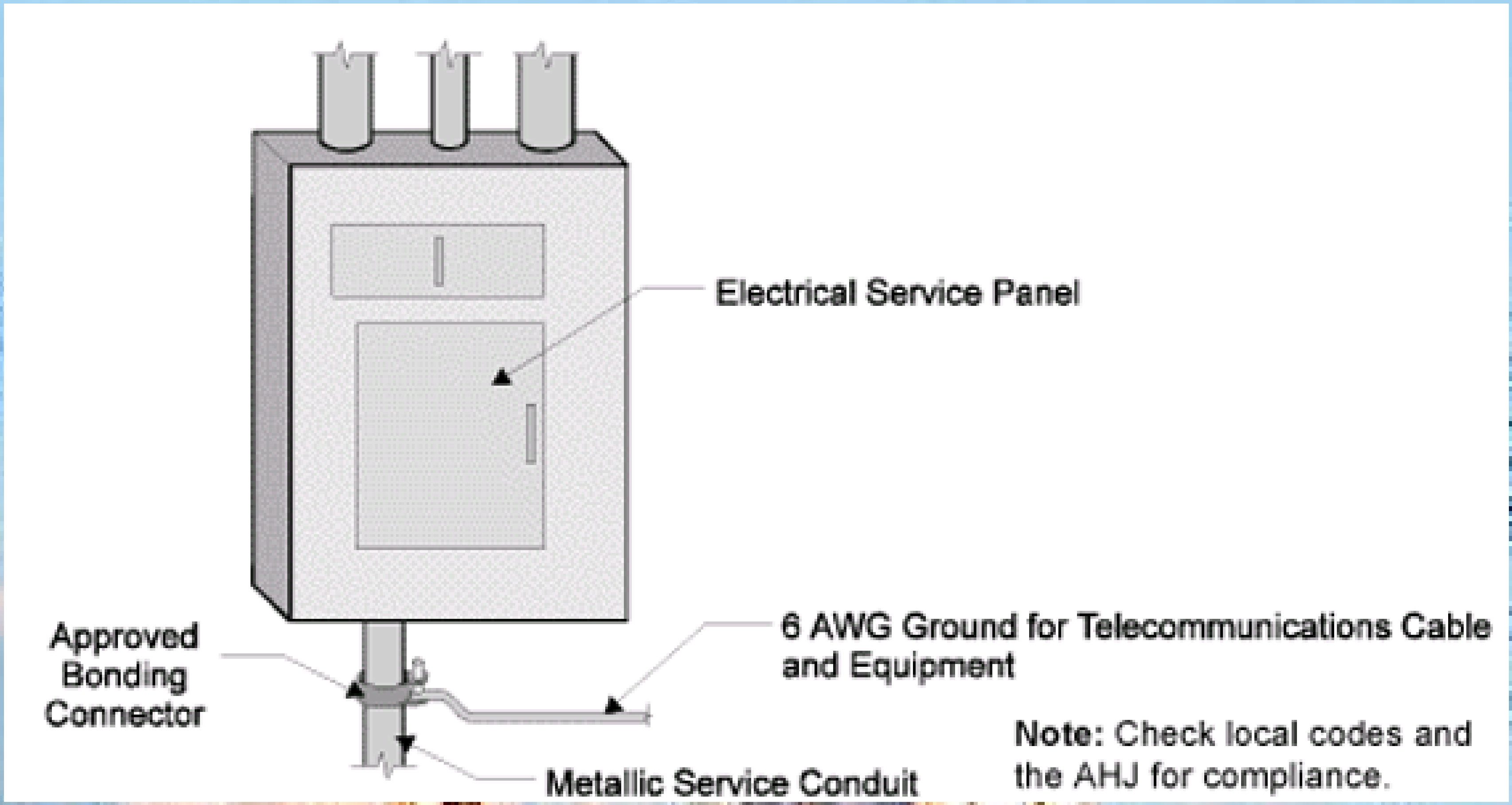

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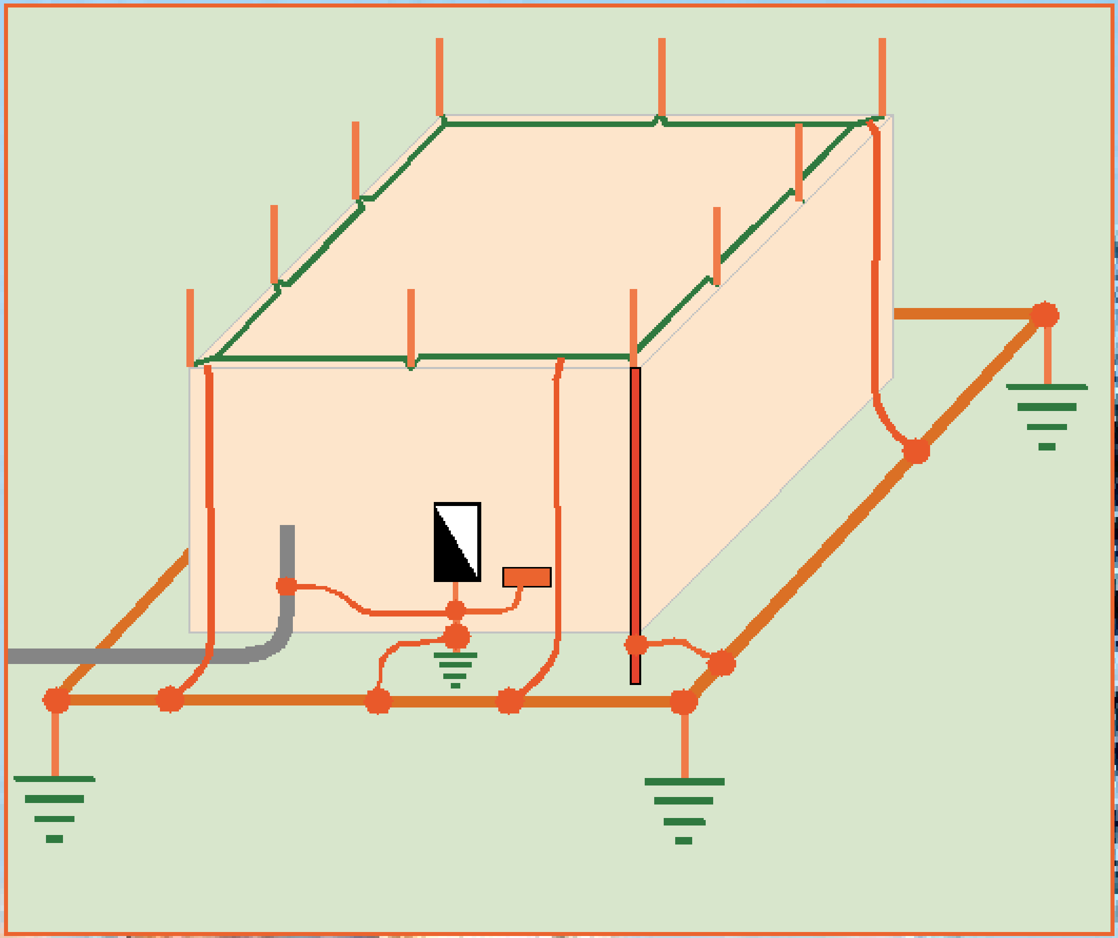
Safety

All systems bonded

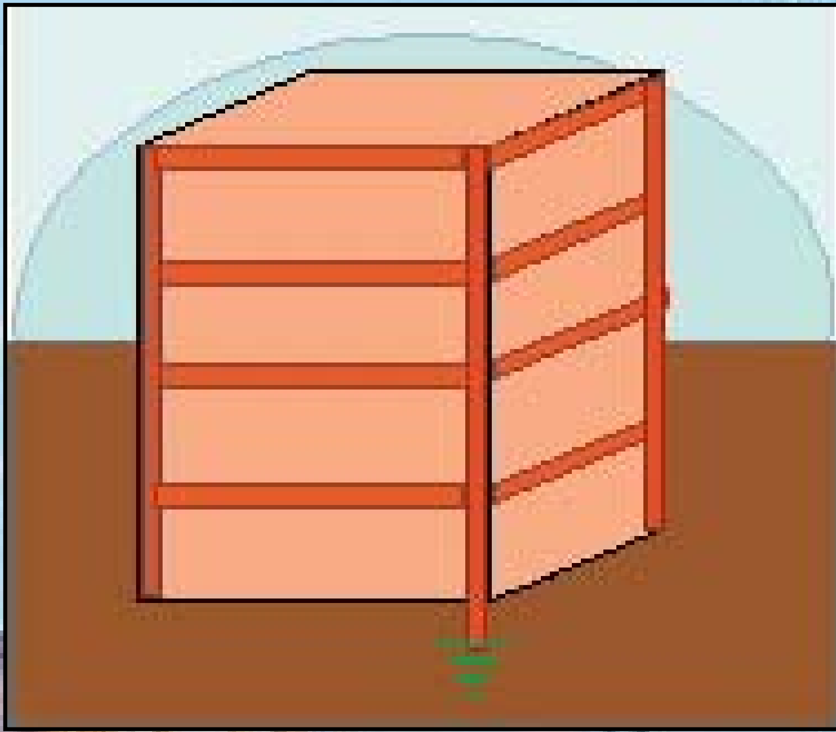


Grounding & Bonding

Building Steel

Usually a very good electrode

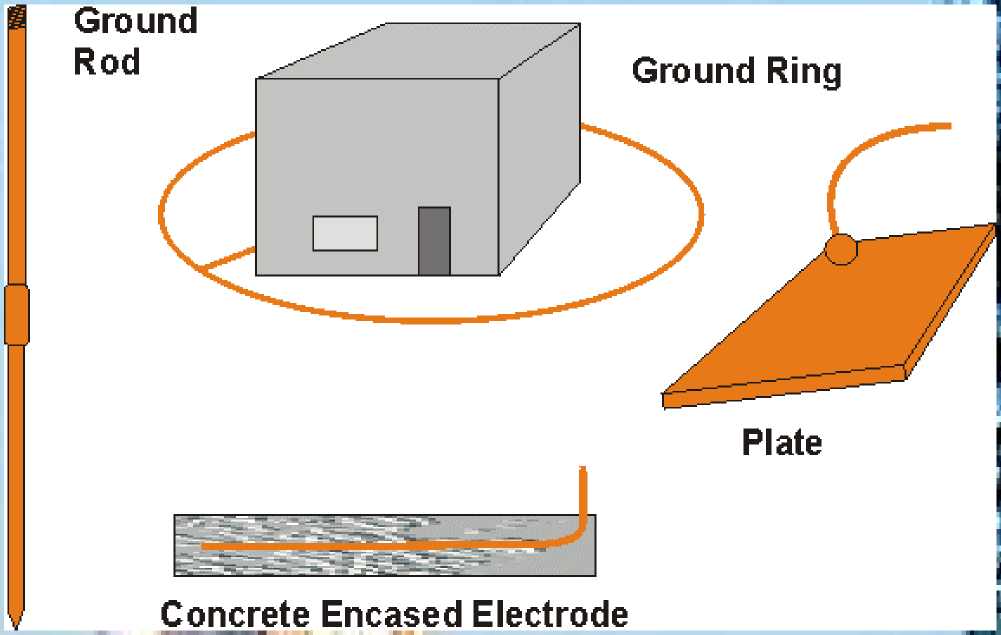
- Large physical size provides low impedance to earth
- Not always bonded together



Grounding & Bonding

Electrodes specifically designed and installed for grounding:

- Buried ground rods
- Buried ground rings
- Buried metal plates
- Concrete encased electrodes
- Chemical ground rods



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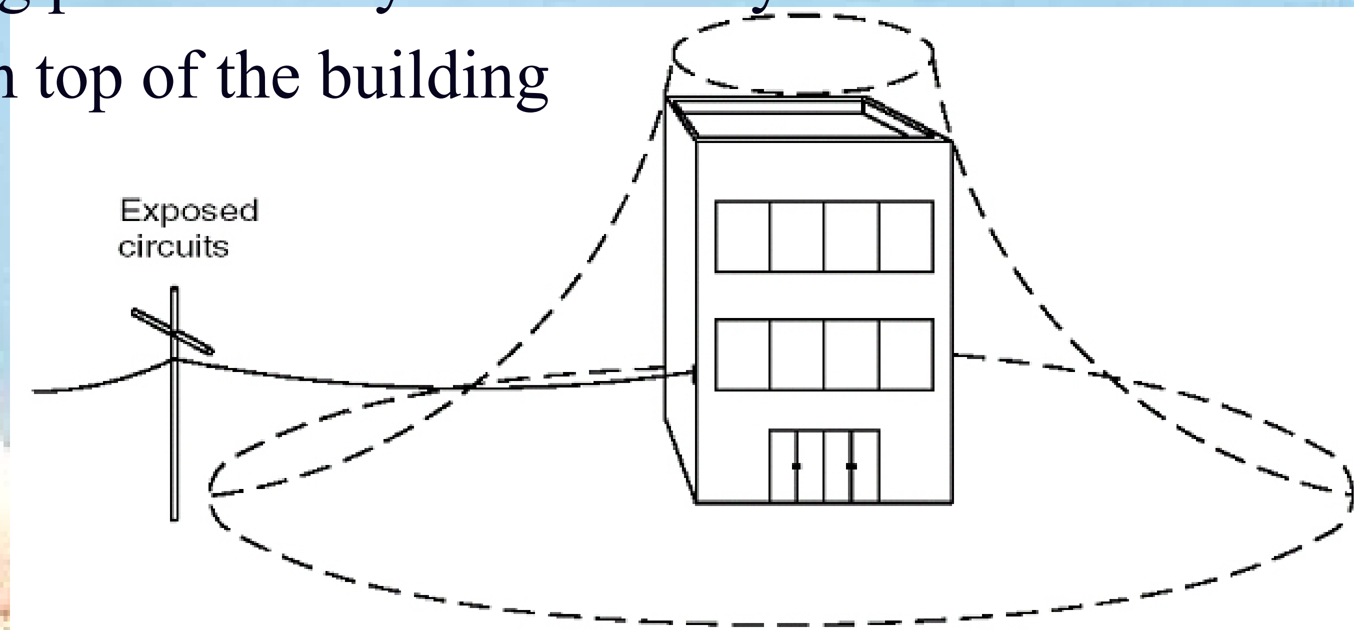
Zone of Protection

- An area under or nearly under a lightning protection system
- Lightning protection systems usually have metal spikes on top of the building



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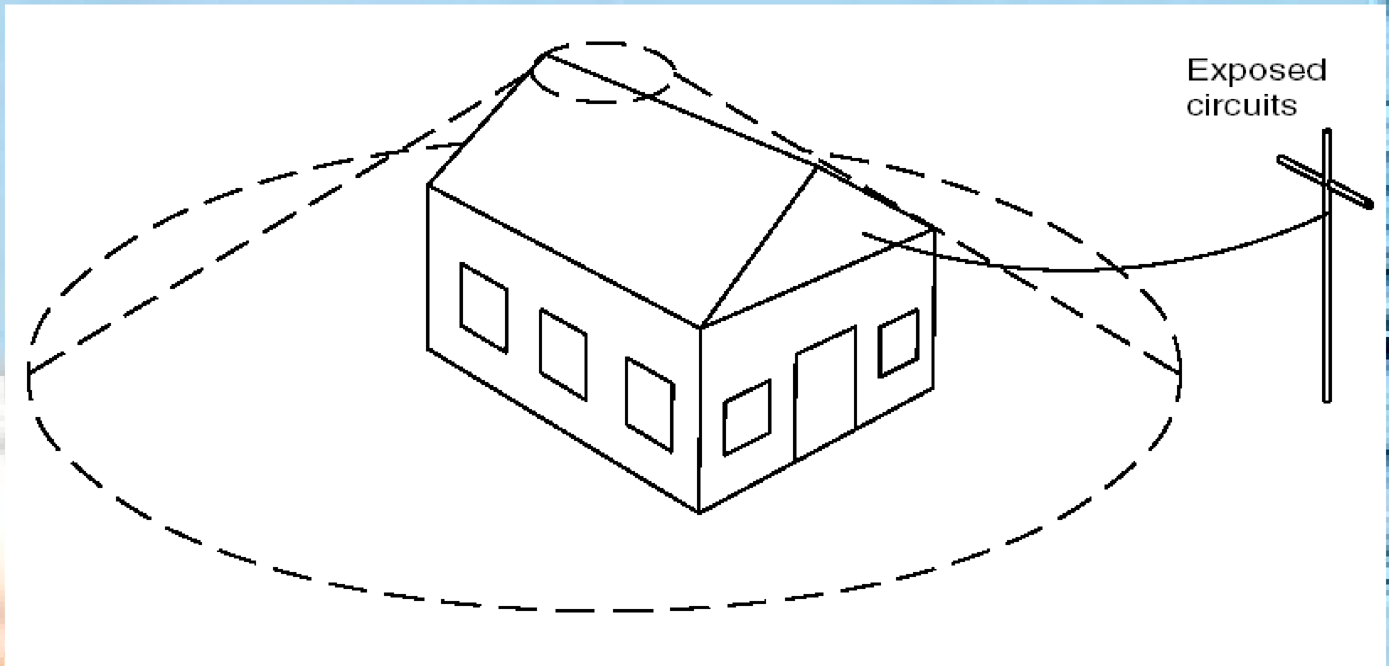
- Zone of protection used with small buildings



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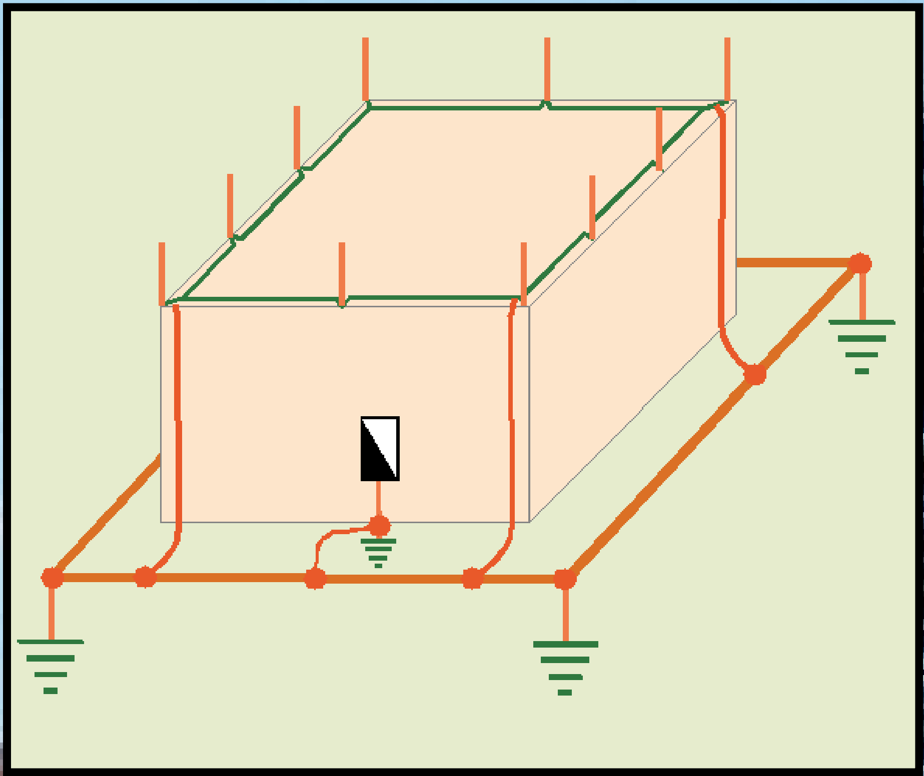
Protection Systems

Lightning Protection System

- Multiple rooftop air (lightning) terminals
- Down conductors
- Equalizing conductors
- Air terminals that surround a building for the exclusive purpose of intercepting, diverting, and dissipating direct lightning strikes



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Electrical Power Systems

- Electrical power is distributed throughout the building on individual branch circuits to operate appliances, lighting, and equipment
- Most telecommunications grounding systems establish the ground reference by bonding to the electrical service ground

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Grounding Electrode System

Grounding Electrode:

- Metallic conductor (e.g., rod, pipe, plate, ring, or other metallic object) in contact with the earth used to establish a low resistance current path to earth

Grounding Electrode System:

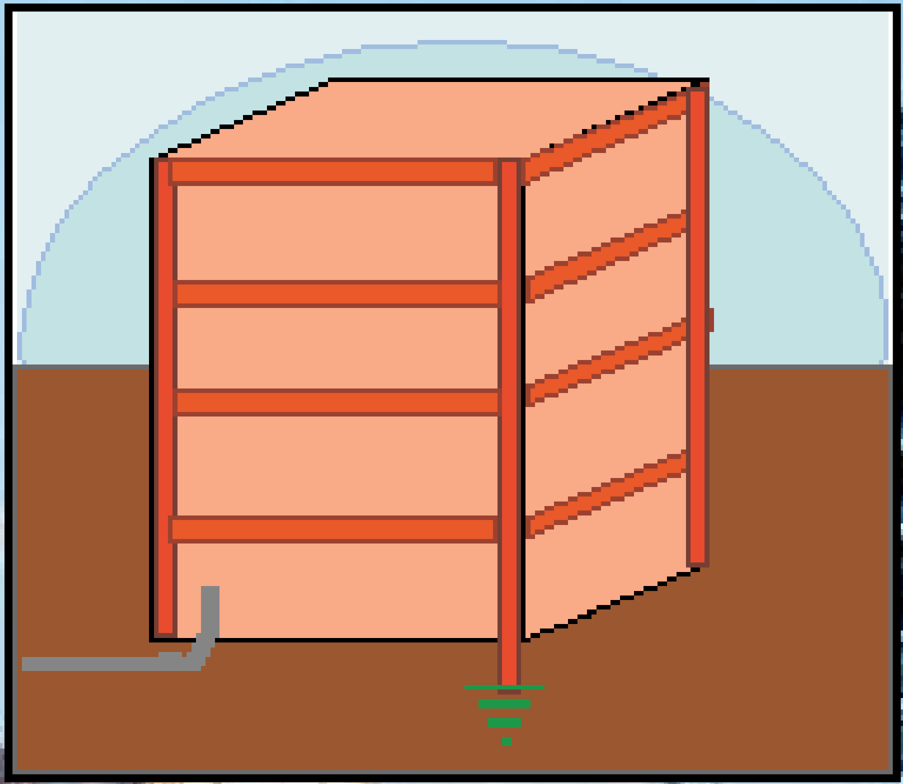
- Network of electrically connected ground electrodes used to achieve an improved low resistance to earth

Grounding & Bonding

Ground electrodes are divided into two groups:

Metal structures installed for purposes other than grounding:

- Metal building framework
- Underground piping systems



Grounding & Bonding

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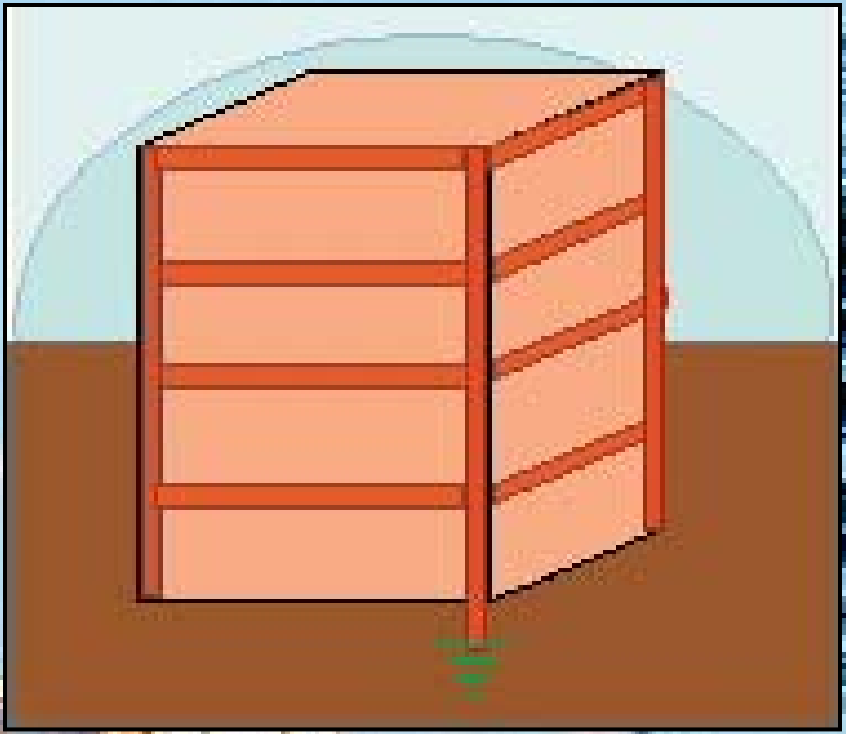

Grounding & Bonding

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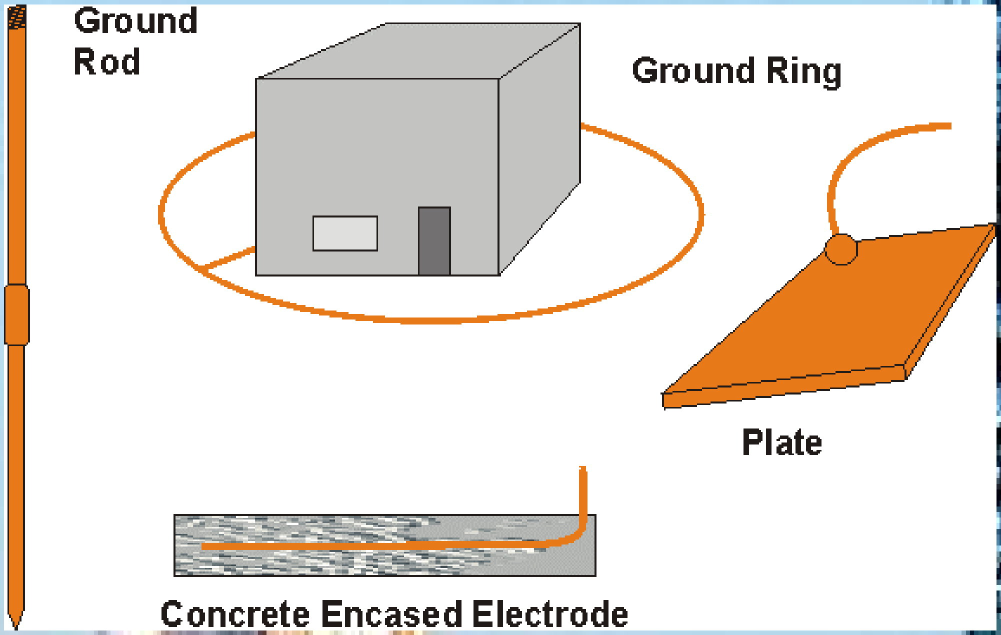

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- Continuous metallic underground water pipes as well as metal structural frames of buildings should provide a ground resistance not exceeding 3 ohm.
- Hot water pipes are often electrically not continuous and therefore ill suited for grounding.

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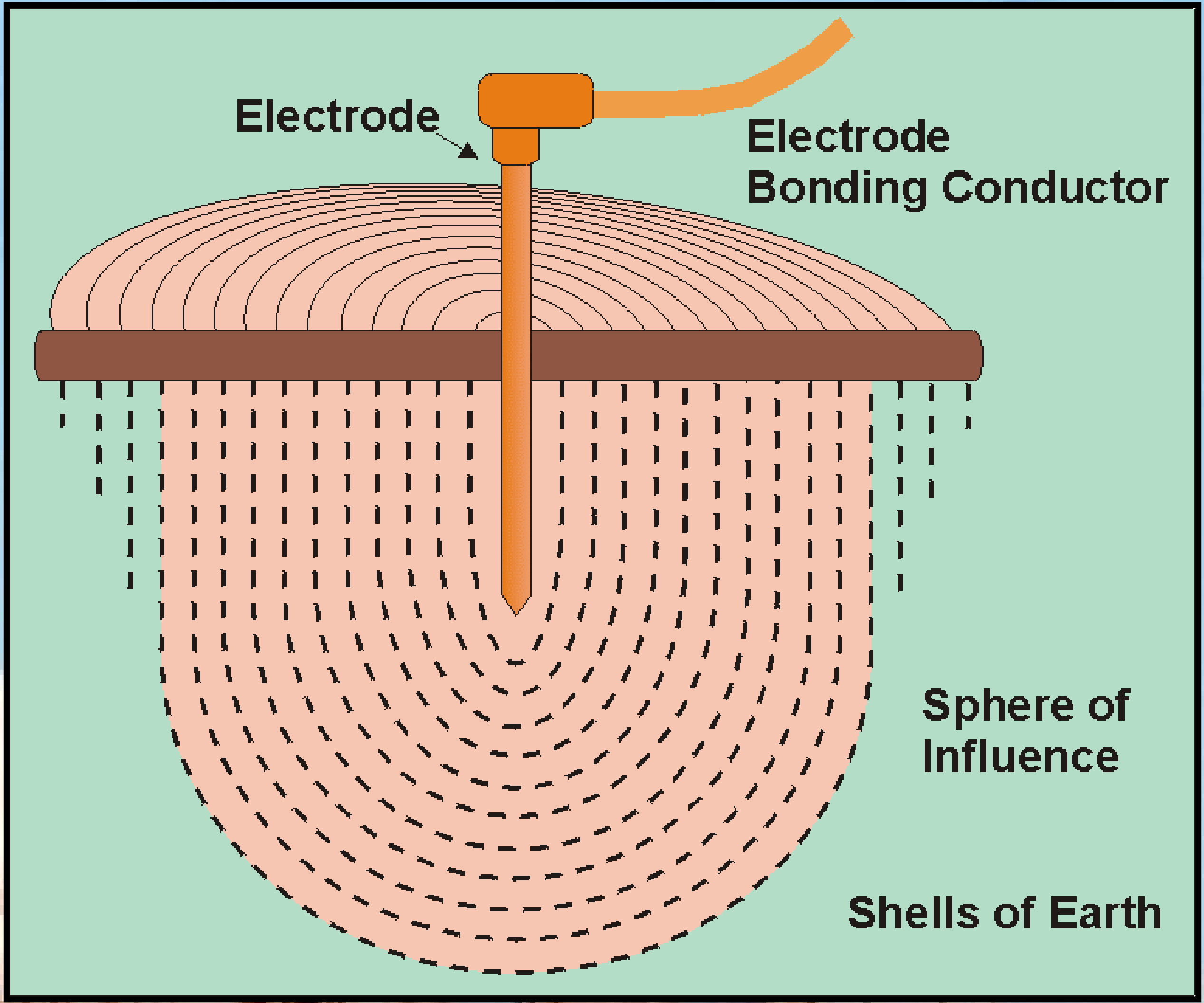
- Generally speaking, "earth resistance" is the resistance of soil to the passage of electrical current
- The earth is a relatively poor conductor of electricity compared to normal conductors like copper wire. But, if the path for current is large enough, the resistance can be quite low and earth can be a good conductor

Grounding & Bonding

Earth resistance is measured in two ways for two important fields of use:

- Determining the effectiveness of installed “ground” grids, installed electrode systems, and their connections
- Prospecting for good (low resistance) “ground” locations, or obtaining measured resistance values

Grounding & Bonding



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The resistance of the surrounding earth will be the largest of the three components making up the resistance of a ground connection.

Grounding & Bonding

Several factors can affect the resistance:

- Moisture content of the soil
- Quantity of electrolytes
- Type of electrolytes
- Adjacent conductors
- Temperature
- Electrode depth
- Electrode diameter
- Electrode(s) spacing distance

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Resistivities of Different Soils

Soil	Resistivity Ohm-CM (Range)
Surface soils, loam, etc...........................	100 - 5,000
Clay..	200 - 10,000
Sand and gravel..................................	5,000 - 100,000
Surface limestone................................	10,000 - 1,000,000
Limestones...	500 - 400,000
Shales...	500 - 10,000
Sandstone...	2,000 - 200,000
Granites, basalts, etc............................	100,000
Decomposed gneisses...............................	5,000 - 50,000
Slates, etc...	1,000 - 10,000

* Evershed & Vignoles Bulletin 245

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Improving Earth Conductance

There are several ways to improve the earth conductance:

- Use multiple electrodes bonded together.
- Treat the soil.
- Lengthen the earth electrode into the earth.

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Effect of the rod size

There are two factors in size:

- Length: Driving a rod deeper decreases its resistance
  - Doubling the rod length reduces the resistance by about 40%
- Diameter: Increasing the diameter has little effect
  - Doubling a rod's diameter will reduce resistance by only 10%

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Use of Multiple Rods

Two well-spaced rods driven into the earth provide parallel paths

The resistance of the original rod will be lowered by a total of:

- 40% for second rod
- 60% for third rod
- 66% for fourth rod

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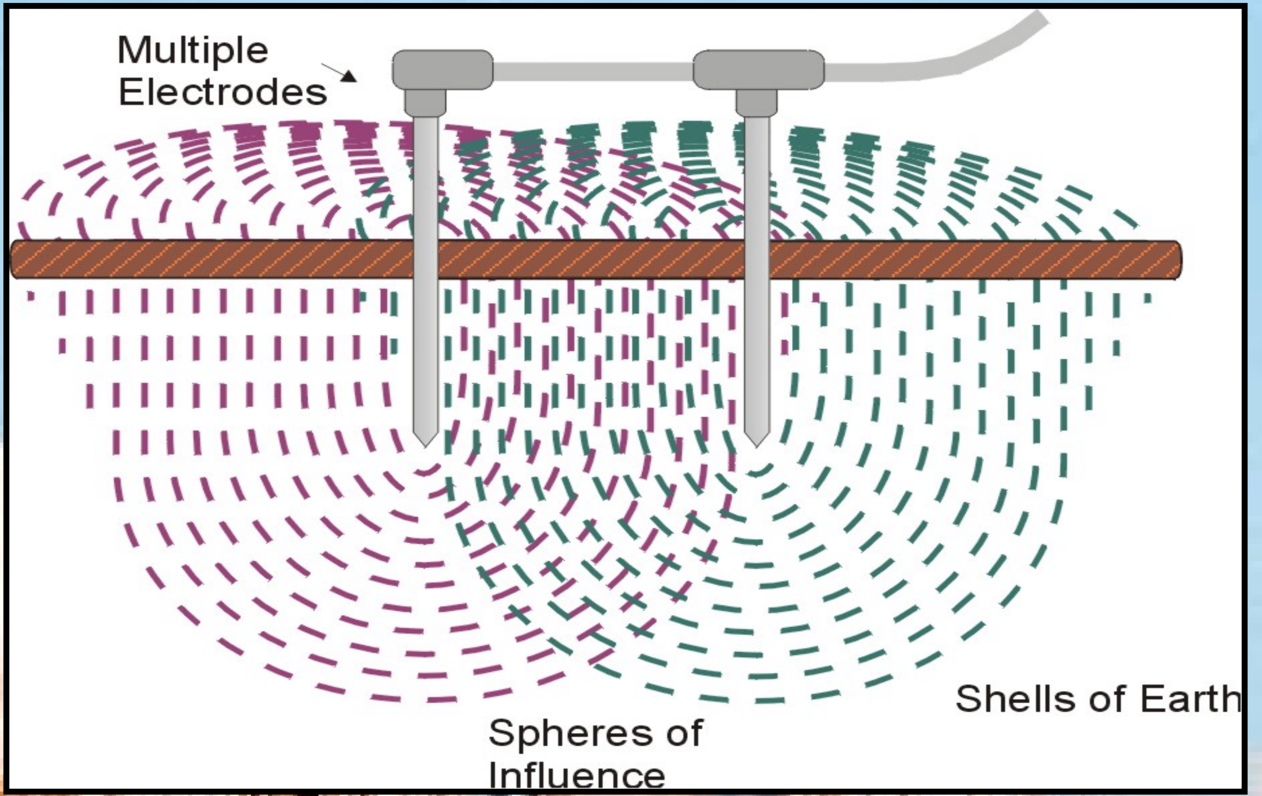
Earth Resistance Poor Rod Placement



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When using multiple rods, they must be spaced apart further than the length of their depth. This will maximize each rod's sphere of influence, thus lowering the total resistance.

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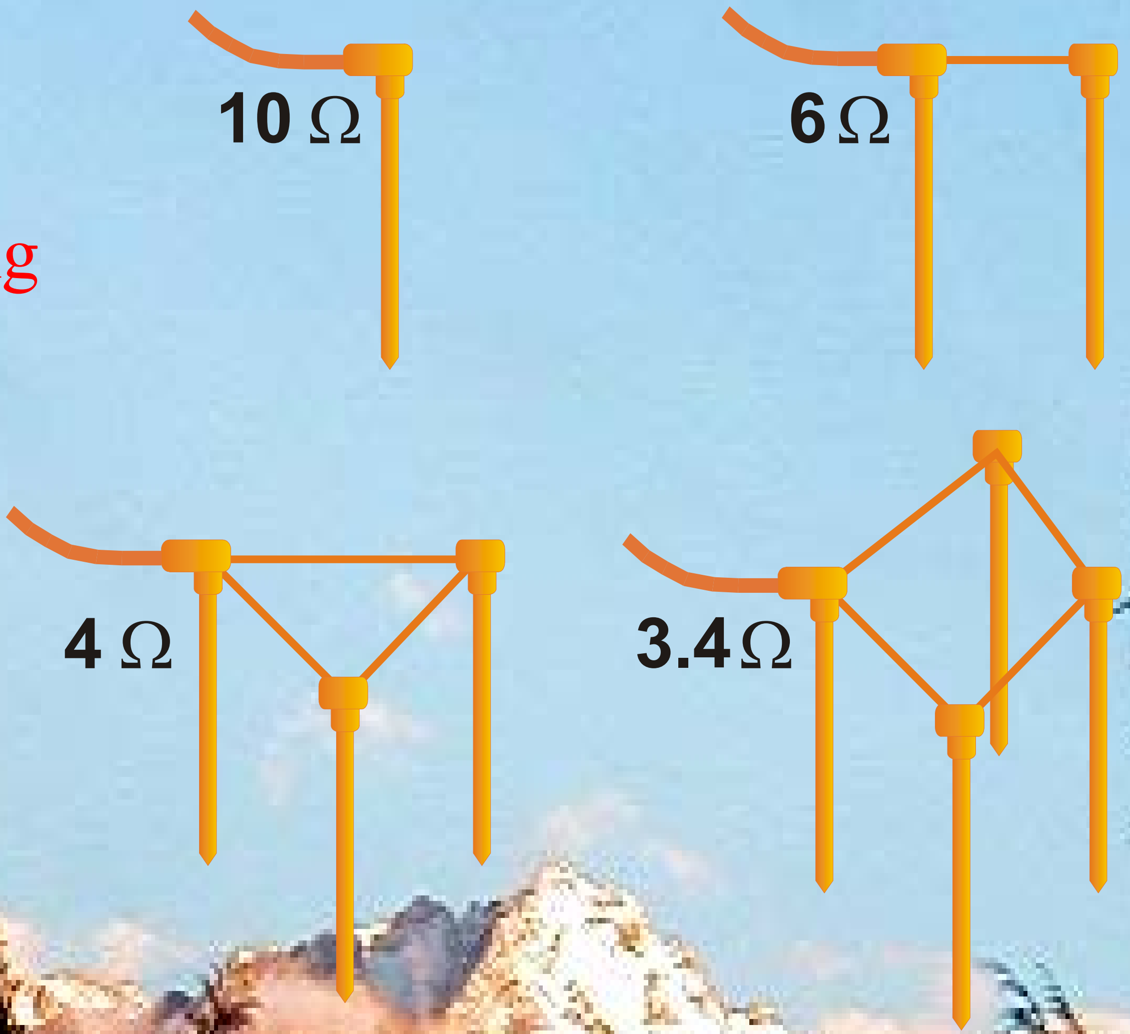
Multiple Rods

- Equal depth
- Proper spacing



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Chemically Treated Electrodes

"Made" Rods and Plates

Externally treated with electrolyte enhancing chemicals

- Used to improve earth resistivity
- Electrodes are designed to lose their outer coatings
- Chemicals leach into surrounding soil
- Electrode has shortened expected life span

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Hollow Electrodes and Plates

Hollow electrodes filled with electrolyte enhancing chemicals

- Used to improve earth resistivity
- Large amount of chemicals leach into soil
- Greater area treated at electrode
- Often used to augment solid electrodes
- Electrode has shortened expected life span

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Treat the Soil

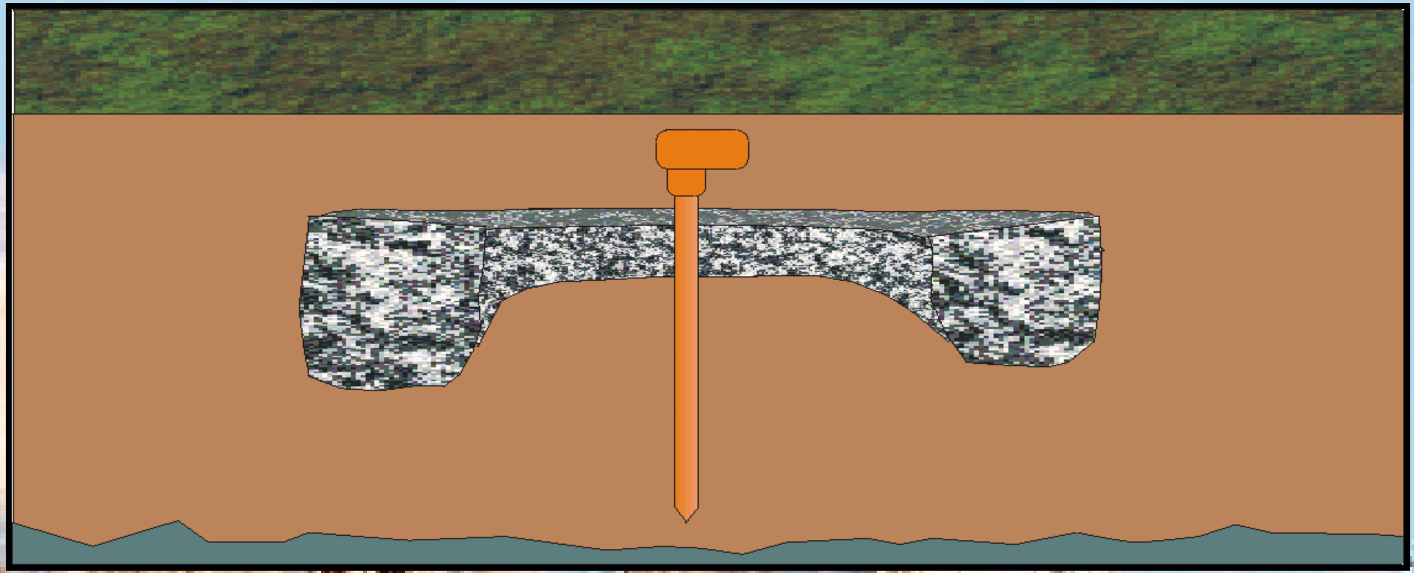
Chemical treatment of the soil is a way to improve earth-electrode resistance when longer rods cannot be driven into the soil because of rock beds.

Provides a uniform ground through seasonal changes.

Grounding & Bonding

Chemical treatment of the soil

- Used when longer rods can't be installed—bedrock
- Provides uniform ground through seasonal changes



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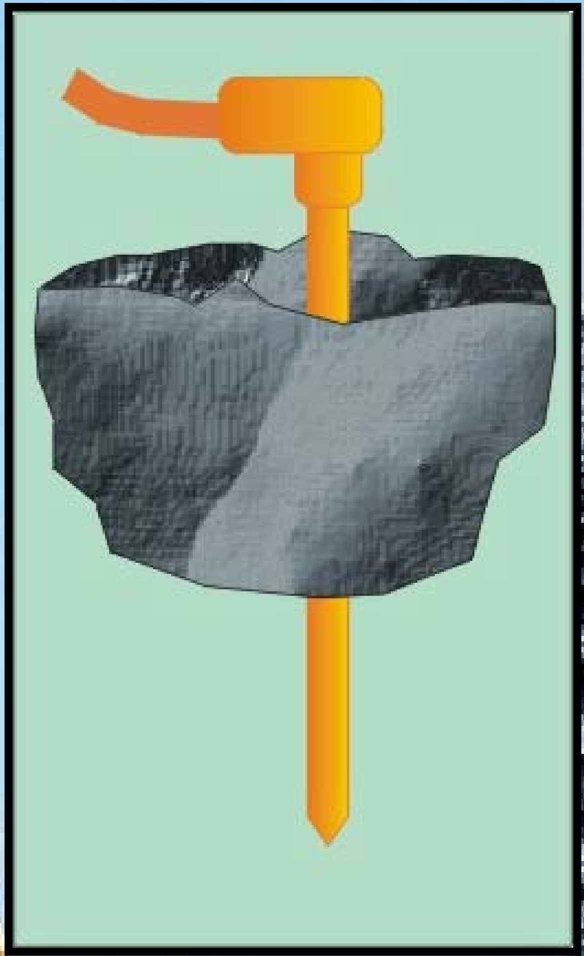
Soil Treatment Alternatives

Ground enhancement material

- Cement-like compound
- Non-corrosive
- Extremely conductive
- Installed around the electrode
- Easy installation
- Permanent



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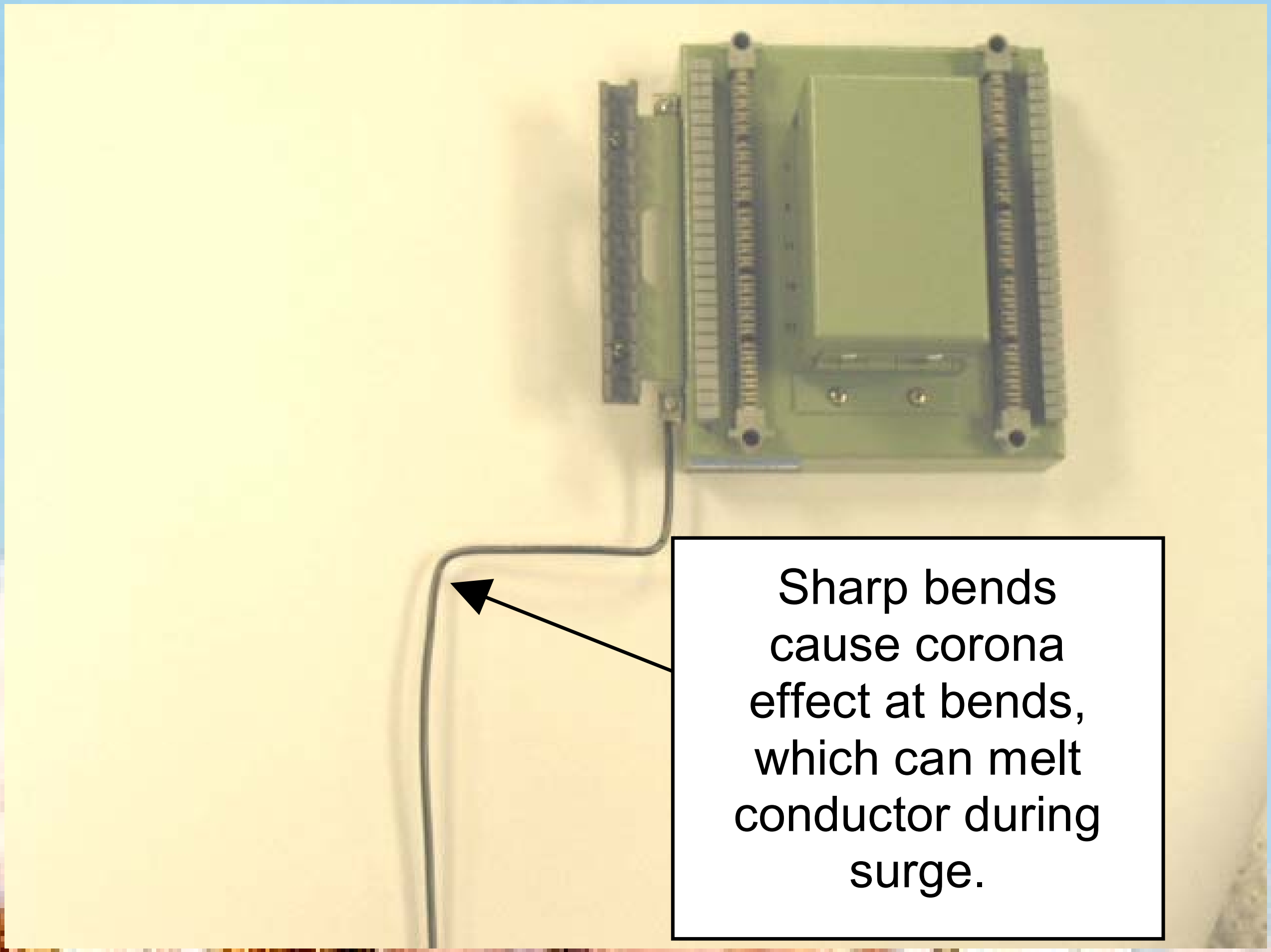
Disadvantages are:

- Chemicals concentrated around electrodes will cause corrosion
- Chemicals leach through the soil and dissipate
- Scheduled replenishment may be required
- May be prohibited because they may contaminate the water table

Ground Coils and Pigtails

- Coils and pigtails introduce an inductance to the ground path.
- Inductance doesn't like changes in current.
- Inductance is similar to pushing a heavy object on wheels. It takes a lot of force to get it to move. Once in motion, little force is required. But, it requires a lot of force to make it stop again.
- If there is inductance, then a surge might find it easier to go through the equipment versus the now restrictive ground path.

- Avoid sharp bends. Corona effect at the bends will cause the wire to heat and melt.



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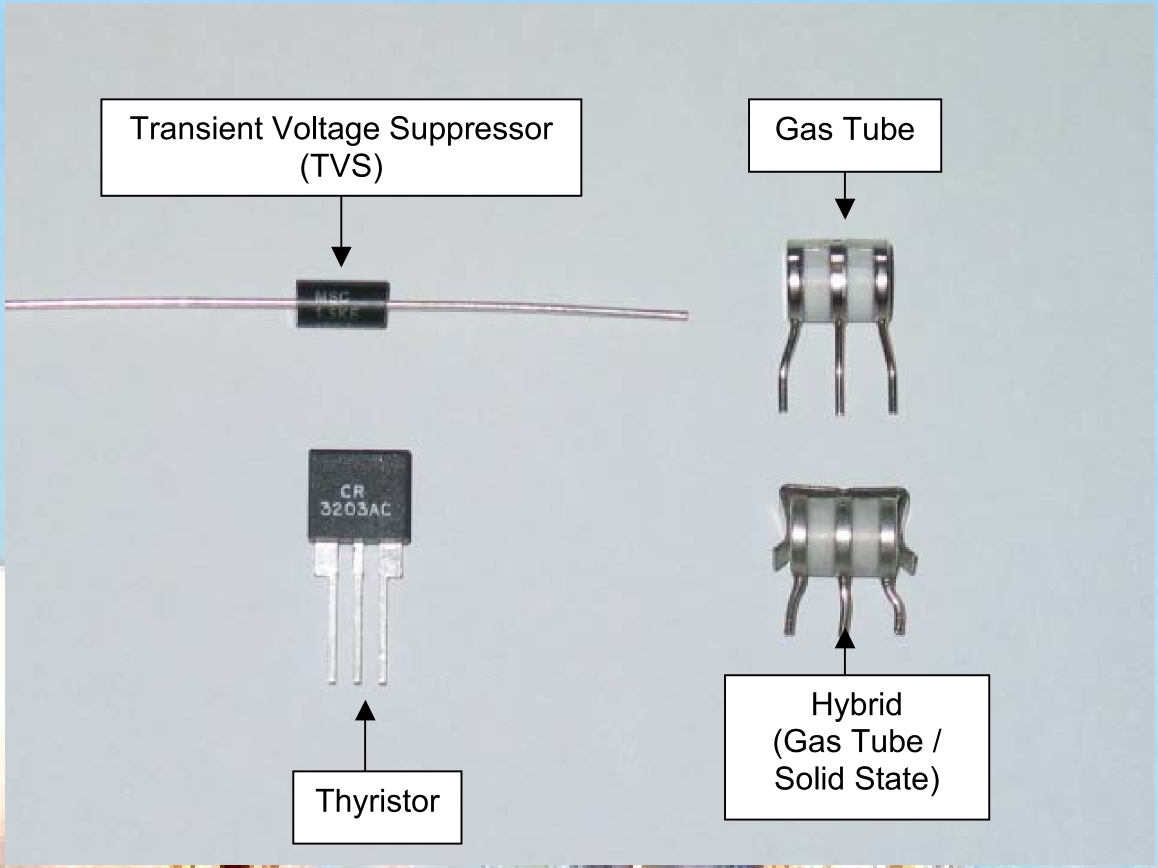
An alternative to chemical treatments is the use of a noncorrosive but conductive compound used between the electrode and the soil.

Advantages include:

- Ease of installation
- Remains permanent

Arrestor Components



Which module is better?

- No easy answer. It depends on your application.
- Gas tube handles repeated high current surges, but cannot react to fast surges. Low cost solution.
- Solid state cannot handle repeated high current surges, but can react to fast surges. Medium cost solution.
- Hybrid utilizes both gas tube and solid state, so it has the best of both worlds. High cost solution.
- Compromise: Performance versus cost.

Grounding & Bonding

Types of Electrical System Faults

- Phase-to-phase faults
- Phase-to-neutral faults
- Phase-to-ground
  - Greater than 90% of electrical system faults will be phase-to-ground faults
  - A phase-to-phase or phase-to-neutral fault will almost always trip the overcurrent device

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A phase-to-ground fault will not trip the overcurrent device if the impedance of the equipment grounding system is too high.

- The following factors govern equipment grounding conductor impedance:
  - Tightness of connections
  - Length
  - Proximity to circuit conductors during fault conditions
  - Number of bends and bend radius

Grounding & Bonding

Bonding Conductors:

- Must be copper
- Should be green or identified as green
- Shall be insulated (green)
- Keep as short and straight as possible
- Have a bend radius of at least 8 times their diameter
- Should not be spliced

Dissimilar Metals

Copper should never touch galvanized material directly without proper joint protection. Water shedding

from the copper contains ions that will wash away the galvanized (zinc) tower covering. Stainless steel

can be used as a buffer material. However, be aware that stainless steel is not a very good conductor. If

it is used as a buffer between copper and galvanized metals, the surface area of the contact should be

large and the stainless steel should be thin. Joint compound should also be used to cover the connection

so water can not bridge between the dissimilar metals.