

GROUNDING

What is it?

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Disclaimer

Disclamier

- Mechanical Engineer with some electrical background
- My primary reference is...

References

UP THE TOWER

The Complete Guide to Tower Construction

By

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SUBJECTS TO DISCUSS

- Grounding- Definitions
- Why should I ground my station
 - ▣ Lightning Induced surges
 - ▣ Power system transients (surges)
- How do I ground my station

Definitions

- Multiple Definitions
 - All Valid
 - However, they have led to:
 - Confusion
 - Misunderstanding
 - Bad advice

Definitions

□ Earth Ground –

- A connection to earth
- Sole purpose is electrical safety.
- It provides a discharge path for:
 - Lighting
 - Voltage and current transients in the power system

Definitions

□ Power System Ground –

- The connection of **one conductor of the power system mains** to ground (neutral)
- Serves as the return for mains power
- Must be made at one and **only one point** in any power system
- Bond
 - Can be defined as a low impedance connection that is mechanically and electrically robust
 - **At frequencies above a few hundred hertz, the impedance of virtually any conductor is dominated by inductance, not resistance**
 - Bonding conductors should be beefy so that they do not melt and are as short as possible to minimize impedance
 - A system ground must be made at the first breaker panel within the premises
 - Virtually all breaker panels include a large screw called a bonding jumper to make this connection
 - More than one bonding jumper on the same system is illegal

Definitions

□ Reference Ground–

- A “reference plane” against which electrical potential is measured
 - Can be a “circuit common” in a piece of electronic gear
 - Can be the chassis of an automobile or aircraft
- Viewing a reference plane as a single point
 - Is convenient
 - But, dangerous
 - Because all circuit wiring has some finite length, and thus it also has some inductance and resistance
 - There is also capacitance between the signal wiring and common
 - The combination of the signal wiring and the circuit common
 - Forms an inductive loop
 - May form resonances
 - Behaves as a transmission line at some frequencies

Misconceptions

- Misconception #1a – Grounding is necessary to prevent Radio Frequency Interference (RFI), spurious signals and noise
 - A connection to earth ground is neither necessary or useful in preventing RFI spurious signals or noise

Misconceptions

- Misconception #1b – Cable shield is Grounding
 - Use of cable shielding is not grounding – it is shielding
 - Shields **do not** need to be grounded, but they **do need to be continuous**, and all wiring that penetrates the shield needs to be RF bypassed to the shield

Misconceptions

- Misconception #2 – A connection to earth ground makes an antenna work better
 - Antennas do not need to be connected to earth ground to work better
 - A study of virtually any text on antennas shows that earth grounding of antennas does not improve antenna performance

Misconceptions

- Certain types of antennas, notably most verticals, need a conductive plane to
 - serve as the return of the antennas electrical and magnetic field
 - and to complete the electrical circuit
- The earths surface is typically a poor conductor and except for salt water, serves this purpose poorly
- Any current flowing in lousy earth will cause power to be lost as heat

Grounding - Misconceptions

- A vertical antenna can be made effective by placing a highly conductive plane (such as a radial system) under it
- Such a system would then provide a low resistance return for the antennas electrical and magnetic field and the electrical current

Why Ground

- Lightning strike
 - ▣ Lighting is the most obvious transient disturbance from which we want to protect ourselves
 - Fifty percent of all lightning strikes will have a first strike current of 18,000 amps
 - Ten percent will exceed 65,000 amps
 - **Lighting is not just DC**
 - Most of the energy in a lightning strike is in the MF spectrum (300 KHz – 3 MHz)
 - When designing a ground system for lighting we need to **avoid inductance**

Why Ground

- Lightning Induced surges
 - ▣ Lightning current induced directly into our antenna (tower) is only a small part of the problem
 - ▣ Chances of a direct or near direct hit may be small
 - ▣ It is common for destructive transient spikes caused by lightning miles away.
 - When current flows, resistance in the conductor will cause voltage drop
 - Lightning will induce current in a wire
 - Lightning will induce current in any closed loop

Why Ground

- Other Power system transients (surges)
 - ▣ Voltage and current spikes caused by the connection and disconnection of large electrical loads
 - ▣ This includes transmission lines

Surges

- Current surges whether lightning induced or power system induced flow along the lines that enter your house.
 - Power lines
 - Telephone lines
 - Cable TV lines
 - Any other conductor that enters your house

Earth Electrode

- Definition – Any electrical connection to the soil
 - Intentional – i.e. ground rod
 - Structural steel
 - Conductive water pipe
 - Conductive gas pipe

 - Unintentional
 - Structural steel
 - Conductive water pipe
 - Conductive gas pipe
 - You

Earth Electrode

- To Increase Performance- Reduce the Impedance
 - ▣ Increasing surface area in contact with soil decreases the impedance
 - Doubling diameter –
 - decreases impedance by 10%
 - Doubling length –
 - decreases impedance by 40%
 - Up to about 10 feet in depth
 - Multiple Ground Rods
 - Space approximately 2.2 times the length of the rod
 - However, Inductance of connection wire reduces the performance

Bonding Earth Electrodes

- An effective ground system has two key elements
 - ▣ Most obvious is the earth electrode(s)
 - ▣ However, the most important is how the earth electrodes are bonded together
- Minimize difference in potential(voltage) between points in our ground system
 - ▣ It is these differences in potential that cause the damage

My Basic Rule of Thumb

- Keep transient currents and voltages out of the house
- If it gets in - Balance the differences in potential

SPGS – Single Point Ground System

- Some variation of a single point ground system is the best approach
- All tower and antenna
 - cable shields
 - Control wires
 - Earth electrodes

To a single point before entry into the building
- This SPGS should be bonded to the Mains Power system and protectors for the telephone lines, cable TV etc.
- Minimize potential differences

Ground Rods

- Preferred material is Copper clad Steel
 - ▣ Copper coating is more for corrosion resistance than conductivity
 - ▣ Best way to install is with weighted slide hammer
 - ▣ Fence post driver or rotary hammer also works
 - ▣ Don't use a water jet – it will result in a higher resistance to ground

Ground Rods

- Corrosivity of soil
 - Acidic soil (most of eastern US) use galvanized rods
 - Acetic soil will attack copper
 - Alkaline soils
 - Avoid galvanized, tin or aluminum rods

Making Bonding Connections Outdoors

- There is only two acceptable methods
 1. Mechanical compression or crimp joint
 - Use industrial type crimper with sufficient force to cause the joining metals to exchange materials and bond under pressure
 - Use bolted mechanical compression
- Don't forget the antioxidant
- Don't use dissimilar metals

Making Bonding Connections Outdoors

2. The second and best method is an exothermic process

- Uses a heat and chemical reaction to produce a permanent bond
 - Somewhat expensive
 - Requires a mold, copper oxide and aluminum powder and ignition source
 - Extremely reliable joint
 - Avoids dissimilar metals problem
 - Results in larger cross section and lower resistance on joint

Making Bonding Connections Outdoors

- ❑ Don't use hose clamps on a ground rod
- ❑ Don't use silver solder it will melt in a lightning strike

Dissimilar Metals

ANODIC END

Magnesium

Zinc

Galvanized steel

Mild Steel

Iron

50-50 lead tin solder

Stainless Steel

Tin

Nickel (active)

Brass

Aluminum-Bronze

Copper

Nickel (passive)

Silver

Gold

CATHODIC END

Cable to Tower Grounding

- First at the top of the tower
- Second at the bottom of the tower before it turns horizontal
- Third just prior to entering the building

Surge Suppressors

- Designed to prevent damage to equipment
- Two fundamental types
 - Shunt mode
 - Looks like an open circuit at low voltage
 - Looks like a conductor at some higher threshold voltage
 - Diverts current away from protected equipment via equipment ground
 - Disadvantage
 - Can increase potential differences between inter connected equipment
 - Will conduct noise spikes to the equipment ground radiating it to the antenna system
 - Advantages
 - Cheaper than Series mode
 - Only practical method for whole house suppressors at the service entrance
 - Series mode
 - Adds a high reactive impedance (an inductor) in series with the current path
 - Stores energy surge and the releases it slowly (harmlessly) back into the system
 - Disadvantage

Surge Suppressors

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 - ▣ Series mode
 - Adds a high reactive impedance (an inductor) in series with the current path
 - Stores energy surge and the releases in slowly (harmlessly) back into the system
 - ▣ Disadvantage
 - Larger and more expensive
 - Not practical for capacities larger than 30 amps
 - ▣ Advantages
 - Reliably protects equipment on branch circuits

Recommended Strategy

- Install shunt whole house suppressor at service entrance.
 - ▣ This will protect against surges coming in to the building on the power lines etc.
- Use series mode devices on branch circuits (between the breaker panel and the equipment)
 - ▣ This will protect you from induced currents on the wiring within the house
 - ▣ Demonstration



Questions?