GROUNDING

What is it

Disclaimer??????????????????

Disclaimer

- Mechanical Engineer with some electrical background

- My primary reference is:

References

UP THE TOWER

The Complete Guide to Tower Construction

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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 lighting strikes will have a first strike current of 18,000 amps
    - Ten percent will exceed 65,000 amps
    - **Lightning 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 oblivious 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 that 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

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

Making Bonding Connections Outdoors

There are 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 power 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

Aluminum

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

1. 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

Surge Suppressors

2. 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