CTU Presents

Grounding & Bonding for the Little Pistol & Medium Gun

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Goals of the Session

- Understand “ground” and “bond”
- Appreciate the different requirements for ac safety, lightning protection, RF and audio
- Illustrate some techniques
- Show how a system approach works
- Point you at more comprehensive resources
Who Is This Talk For?

- Station builders…
  - Just starting out
  - Putting up a first tower
  - Expanding a station
  - In lightning country
  - Trying for better performance

- But not really for…
  - K3LR, W3LPL, KC1XX, NR5M, etc
Background References

- ARRL Handbook, ARRL Antenna Book
- Grounding and Bonding for the Radio Amateur
- NEC Handbook – at your library
- Standards and Guidelines for Communication Sites (Motorola R56) – available online
- Lightning Protection for the Amateur Station (Ron Block, NR2B – Jun/Jul/Aug 2002 QST) – ARRL website
- Power, Grounding, Bonding, and Audio for Amateur Radio and RFI, Ferrites, and Common Mode Chokes For Hams – available at k9yc.com/publish.htm
What IS “Ground” Anyway

- The right answer depends on what you are trying to do
- What you are trying to do depends on frequency, voltage, current
- Your safety depends on the right answer
- Your equipment depends on the right answer
What *IS* “Ground” Anyway

- The right answer depends on what you are trying to do
- What you are trying to do depends on frequency, voltage, current
- Your *safety* depends on the right answer
- Your *equipment* depends on the right answer
- Your *sanity* depends on the right answer
What IS “Ground” Anyway

- It can be a noun, verb, and adjective – *all at the same time*
- Noun - an “earth connection” (ac, lightning) or a *local* reference potential (circuits, RF)
- Verb - an action “to connect to the reference potential”
- Adjective - a type of connection, such as a “ground conductor” or “ground system”
What IS “Ground” Anyway

- Fuzzy definitions:
  - “RF ground” – ain’t no such thing
  - “Ground loops” – not the problem you think it is
  - “Single-point ground” – it depends…

- The Earth is NOT – a magic sink into which we can pour RF or lightning and expect it to magically and safely disappear
What IS “Bonding” Anyway

- A connection intended to keep two points at the same voltage
- Sounds expensive but it’s not
- Sounds hard but it’s not
- Requires the right connecting materials and hardware
- Works in your favor for ac safety, lightning protection, and RF management
What **IS** “Bonding” Anyway

- For bonding to work, it has to be...
  - Low-Z and “short” at the frequencies of interest
  - Heavy enough to carry the expected current
  - Sturdy enough to survive the environment

- Inside the ham station, use...
  - Strap (20 ga) or heavy wire (#14 or larger)
  - Flat-weave braid
    - Braid from old coax deteriorates
AC Safety Grounding

- Before we go any further…

SAFETY FIRST

- Don’t be the one to say, “I didn’t think it would happen to me…”
AC Safety Grounding

- And a friendly reminder from your AHJ*

**LOCAL CODE IS THE LAW**

- If you don’t have a local code, use the NEC

* - Authority Having Jurisdiction
AC Safety Grounding

- If you aren’t sure you know what you’re doing…get a how-to reference

- Or hire a professional electrician
AC Safety Grounding

- Grounding for ac safety has several names
  - “Equipment ground”, “third-wire ground”, “green-wire ground”

- Purpose is two-fold
  - Provides a path to ac common point for fault current (shorts, leakage)
  - Stabilizes the ac power voltage during faults or transients, such as lightning
AC Safety Grounding

Utility transformer

Grounded service conductor (neutral)

Neutral bus

Main bonding jumper

Grounding electrode conductor

Equipment grounding bus bonded to metal enclosure

Grounding electrode

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AC Safety Grounding

Clamps suitable for direct burial or exothermic weld

Not less than 6 ft

8 ft
AC Safety Grounding

Bond ALL earth connections together
Lightning Protection

- You can’t steer lightning, but…you can help lightning make “good decisions”
  - Heavy, low-impedance paths to the Earth
  - Inductance is more important than resistance
  - Paths should be outside your residence
  - Don’t make it easy for lightning to go through your station on its way to the Earth
Lightning Protection

- Ground paths should go around your station.
Lightning Protection

- Ground paths should go *around* your station
Lightning Protection

- Tower grounding
Lightning Protection

- Bond feed lines to the tower
- Spark gaps across insulators
Lightning Protection

- Single-point Ground Panel

Protected

Unprotected
Lightning Protection

- Single-point Ground Panel
Lightning Protection

- Single-point Ground Panel
Lightning Protection

- Single-point Ground Panel
Lightning Protection

- Single-point Ground Panel
Lightning Protection

- Protected Zones
  - Every line crossing the boundary must be protected
  - Must all have a common or bonded ground connection
  - Bond equipment within the station
Lightning Protection

- Bonding inside the shack

Diagram showing bonding inside the shack, with components labeled:
- Strap to SPGP
- RF Bonding Bus (1/2" Copper Pipe)
- Wire to Equipment Enclosure
- Ground Clamp
- Antenna Switch
- Transceiver
- Computer
- Keyer

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RF Management

- Everything in the station is an antenna
RF Management

- Everything!!
RF Management

- Everything in the station is an antenna
- Forget about an “RF ground”
- Concentrate instead on bonding
- Equalize voltage to minimize current
  - Eliminates “hot spots”
  - Reduces RFI from common-mode current
  - Reduces sensitivity to physical configuration
  - Minimizes audio “buzz” and hum

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RF Management

- Keep cables short
- Use a bonding bus
- Minimize loop area

Keep Cables Together
RF Management

- RF ground plane
- Sheet of metal
- Helps equalize voltage
- Run cables along the ground plane
- Bond to station ground system
Ground System

- Now for some good news…
Ground System

- “One system to rule them all”
- All currents flow on all wires
- A single, solid ground system made of short, heavy, direct connections satisfies all of the requirements for...
  - AC Safety
  - Lightning Protection
  - RF Management & Clean Audio
Ground System

[Diagram of a ground system with labels for various components such as Ground Rod, Perimeter ground, Antenna Cables, Heavy Bonding Conductor, SPGP, AC Power Panel, RF Bonding Bus, Ham Radio Equipment, Phone, Cable, AC Safety Ground, House Exterior, AC Power Service, Cable TV Service, Phone Service, Service Entrance Ground, Bond between the tower ground and perimeter ground, and Conductor Extends to All Earth Connections.]

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Ground System
Additional Resources

- Professional Associations and Companies
  - National Fire Protection Association (www.nfpa.org)
  - International Association of Electrical Inspectors (www.iaei.org)
  - Mike Holt Enterprises (www.mikeholt.com) — training and continuing education for electricians, many tutorials
  - Polyphaser (www.polyphaser.com/services/media-library/white-papers) — various papers and tutorials on lightning protection for communications facilities, including ham stations
  - Lightning Protection Institute (lightning.org/learn-more/library-of-resources) — papers and tutorials on lightning protection techniques
Additional Resources

- Standards
Additional Resources

- Books and Online Material
  - ARRL Technical Information Service sections
    - Electrical Safety — [www.arrl.org/electrical-safety](http://www.arrl.org/electrical-safety)
    - Grounding (various types and topics) — [www.arrl.org/grounding](http://www.arrl.org/grounding)
    - Lightning Protection - [www.arrl.org/lightning-protection](http://www.arrl.org/lightning-protection)
  - W8JI’s web pages on ground systems
    ([w8ji.com/ground_systems.htm](http://w8ji.com/ground_systems.htm))
ARE WE DONE YET?
THANKS!!