All Together Now – Grounding and Bonding For Contest Stations

Presented Courtesy of Contest University (CTU) & Icom America

Ward Silver, NØAX
Goals of the Session

- Understand “ground” and “bond”
- Appreciate the different requirements for ac safety, lightning protection, RF and audio
- Discuss issues and techniques for contest stations
- Illustrate the system approach
- Provide comprehensive resources
Who Is This Talk For?

- Station builders…
  - Building a competitive station
  - Adding an amp
  - In lightning country
  - Trying for better performance
- But not really for…
  - K3LR, W3LPL, KC1XX, NR5M, etc
Background References

- **ARRL Handbook, ARRL Antenna Book**
- **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](http://k9yc.com/publish.htm)
Background References

- Grounding and Bonding for the Radio Amateur
  - Covers AC wiring, lightning protection, and RF management
  - Reviewed by a number of experts, including the ARRL Lab
  - Numerous examples for you to use
What *IS* “Ground” Anyway

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

- What you are trying to do depends on frequency & wavelength, 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…
  - Long connections can be *no* connection

- 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

- 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
- Equipment grounding bus bonded to metal enclosure
- Grounding electrode conductor
- Grounding electrode
AC Safety Grounding

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

- Or hire a professional electrician
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

Bond ALL earth connections together
Lightning Protection

- Ground paths should go around your station
Lightning Protection

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

- Tower grounding

![Diagram showing tower grounding system with extended buried radial wires, ground rods, concrete tower base, and connections to ground ring and station ground](image)
Lightning Protection

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

- Single-point Ground Panel
Lightning Protection

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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

Strap to SPGP

RF Bonding Bus
(1/2" Copper Pipe)

Ground Clamp

Wire to Equipment Enclosure

ARRL1512

Transceiver

Computer

Keyer

Antenna Switch

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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
- Contest stations = high RF field strength
- Requires extra attention to bonding
- Create common reference plane and/or bus
RF Management

- Equalize voltage to minimize current
  - Eliminates “hot spots”
  - Reduces RFI from common-mode current
  - Reduces sensitivity to physical configuration
  - Minimizes audio “buzz” and hum
- Tie everything to a common plane or bus
- Keep cables short or coiled
- Heavy, direct connection to SPGP
RF Management

- Keep cables short
- Use a bonding bus and reference plane
- Minimize loop area
- Use shielded cables
- Short straps or wires
RF Management

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

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RF Management
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
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
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!!