

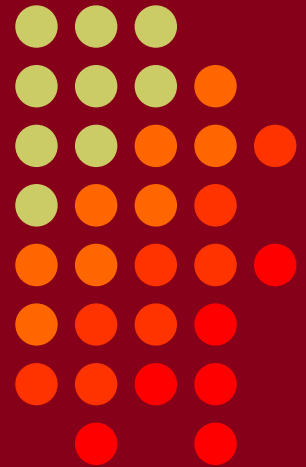
Grounding and Bonding For Home HF Stations

Presented Courtesy of
Contest University (CTU) &
Icom America

Ward Silver, NØAX

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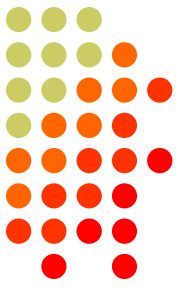


Goals of the Session



- Understand “ground” and “bond”
- Appreciate the different requirements for ac safety, lightning protection, RF and audio
- Discuss issues and techniques for home stations using HF
- Illustrate the system approach
- Provide comprehensive resources

Who Is This Talk For?



- HF station owners...
 - Building a new station
 - Upgrading a small station
 - Adding an amp
 - In lightning country
 - Trying for better performance

Background References

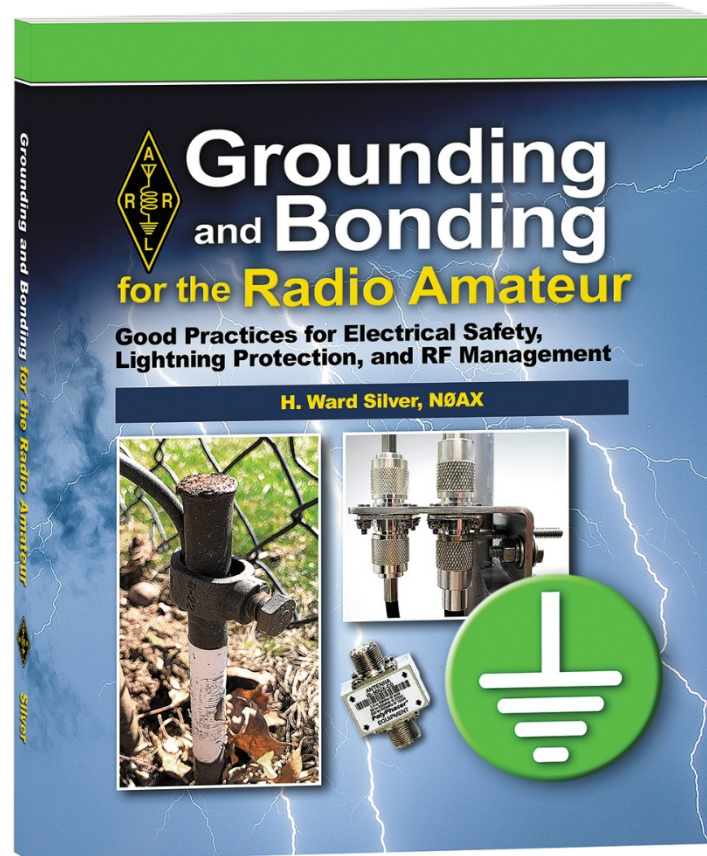


- *ARRL Handbook, ARRL Antenna Book*
- *NEC Handbook* – at your library
- *Standards and Guidelines for Communication Sites* (Motorola R56) – available online
- *Lightning Protection for the Amateur Station* (Ron Block, NR2B – Jun/Jul/Aug 2002 QST) – ARRL website
- *Power, Grounding, Bonding, and Audio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

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
- Your **sanity** depends on the right answer

What IS “Ground” Anyway



- “Ground” has different meanings
 - 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”
- It can mean *all of these things at the same time:*

What IS “Ground” Anyway



- The Earth is NOT – a magic sink into which we can pour RF or lightning and expect it to magically and safely disappear
- Fuzzy definitions:
 - “RF ground” – ain’t no such thing
 - “Ground loops” – not the problem you think it is
 - “Single-point ground” – it depends...

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

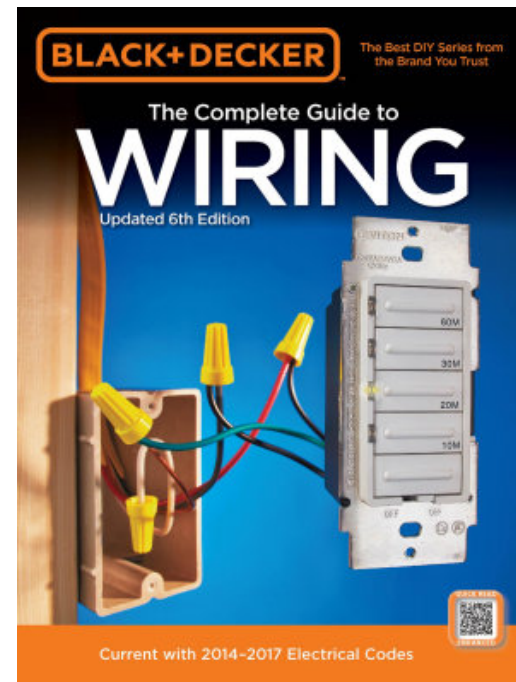


- Grounding for ac safety has several names
 - “Equipment ground”, “third-wire ground”, “green-wire ground”
- Keep ground connections low-resistance
- Purpose is two-fold
 - Provides a path to ac common point for fault current (shorts, leakage)
 - Stabilizes the ac power voltage during faults or transients, such as lightning

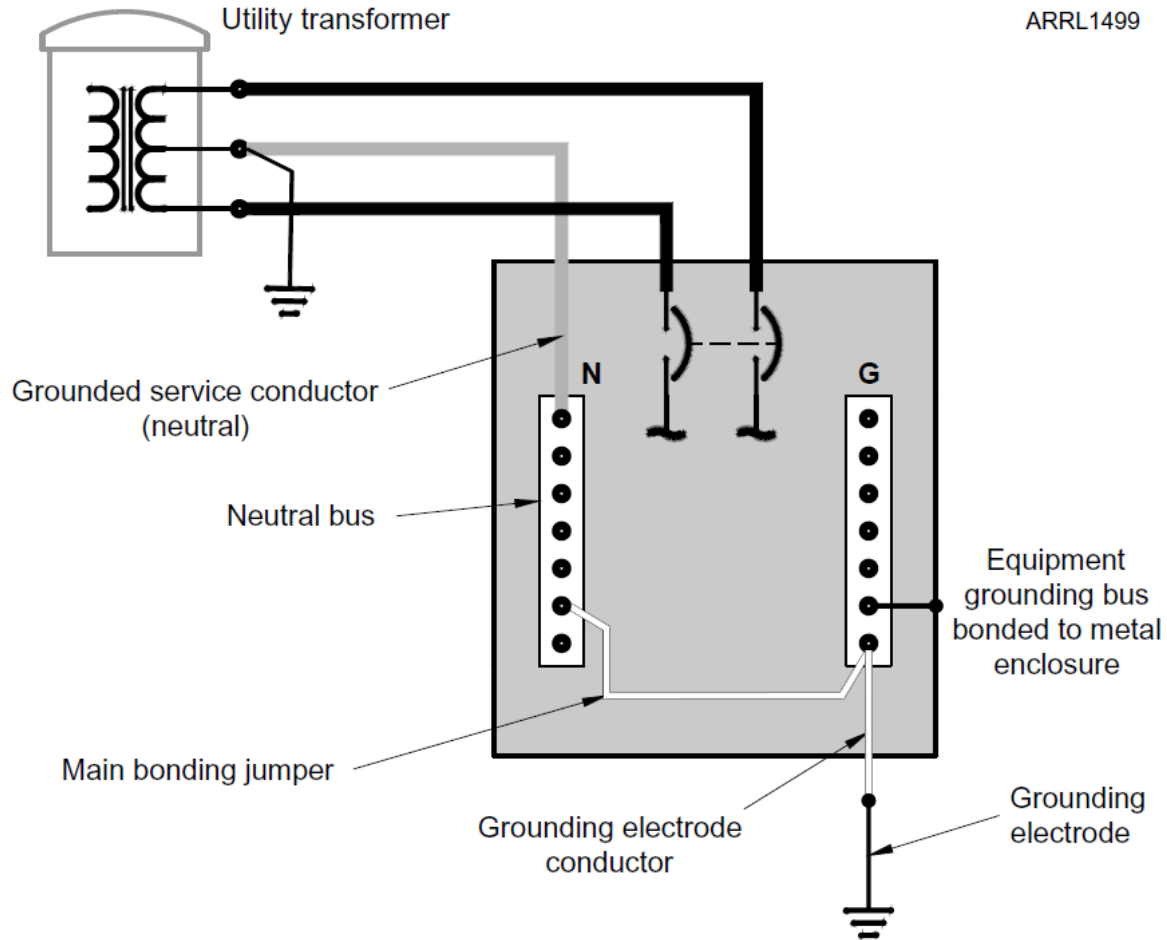
AC Safety Grounding



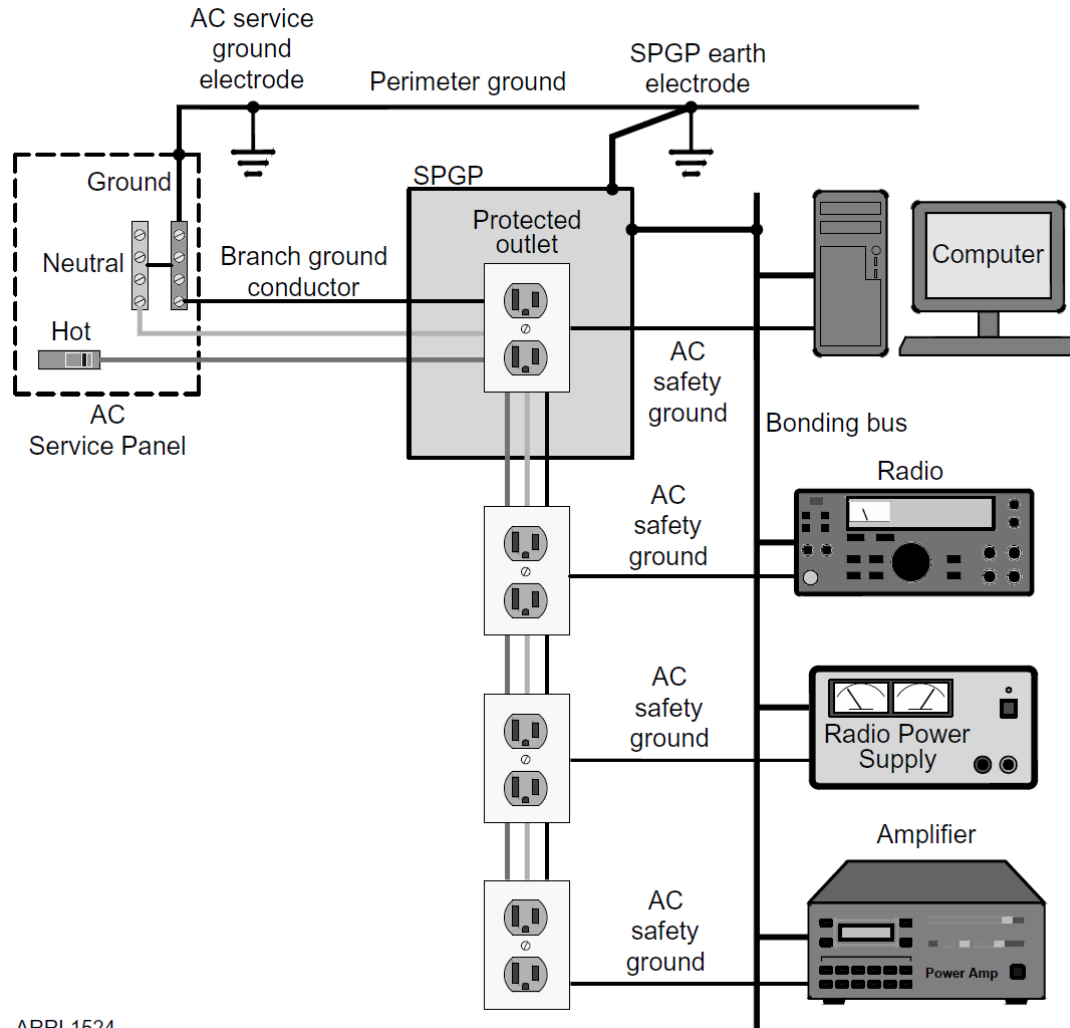
- If you aren't sure you know what you're doing...get a how-to reference
- Or hire a professional electrician
- Local code is the law



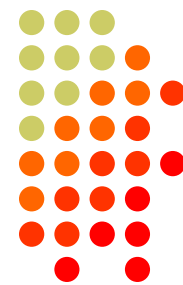
AC Safety Grounding



AC Safety Ground System



Lightning Protection

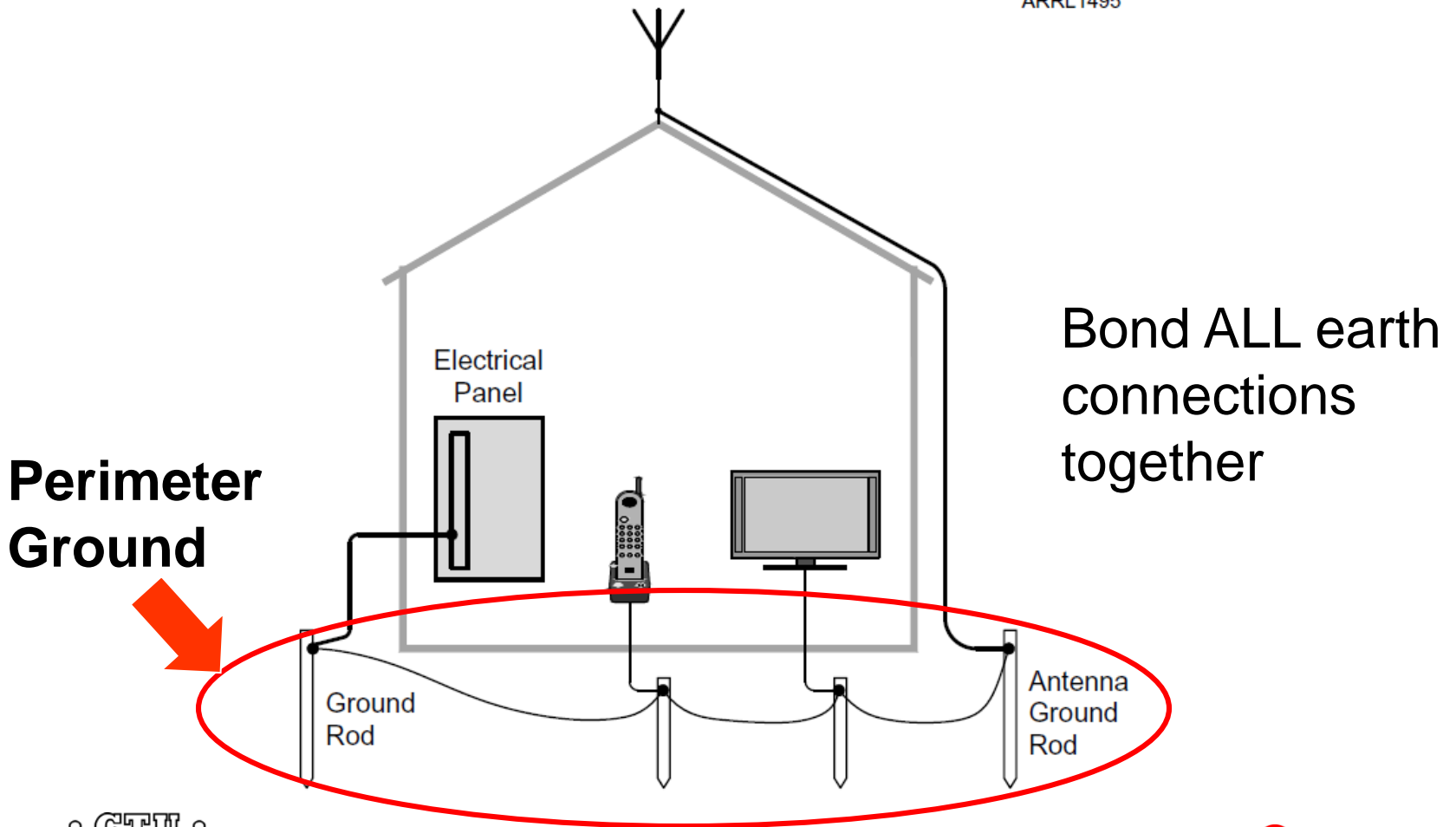


- You can't steer lightning, but...you *can* help lightning make “good decisions”
 - Heavy, direct paths to the Earth dissipate charge
 - Inductance is more important than resistance
 - Paths should be *outside* your residence
 - Don't make it easy for lightning to go through your station on its way to the Earth

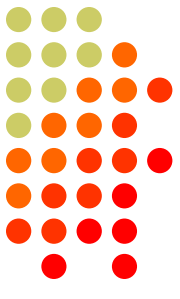
Lightning Protection



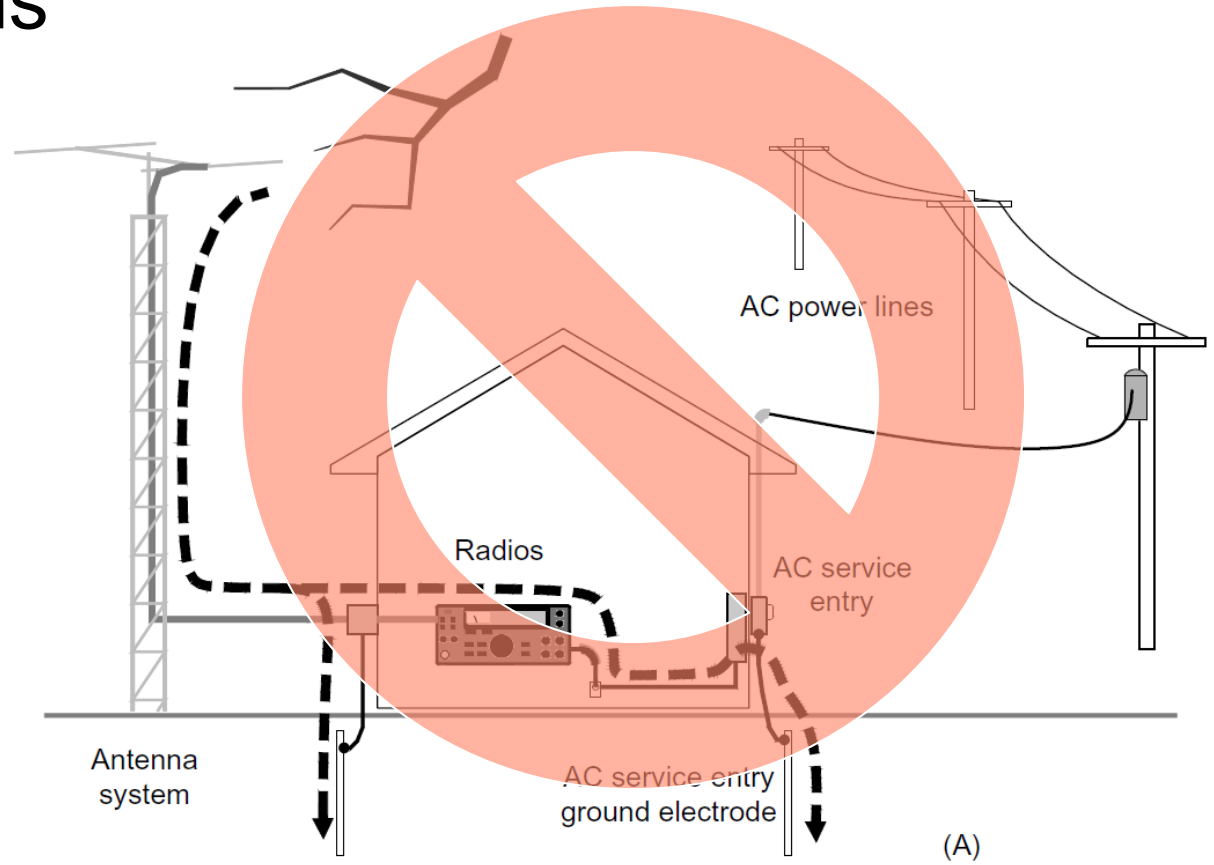
ARRL1495



Lightning Protection



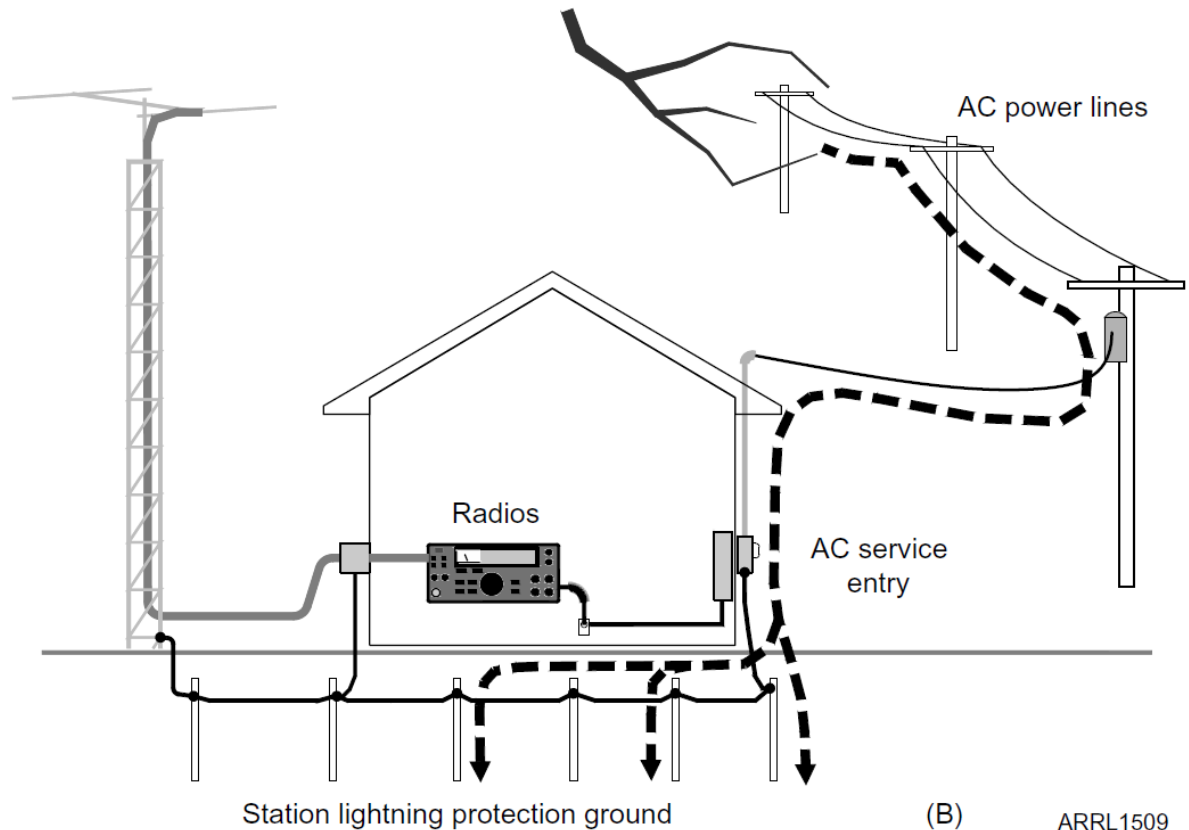
- Ground paths should go *around* your station



Lightning Protection



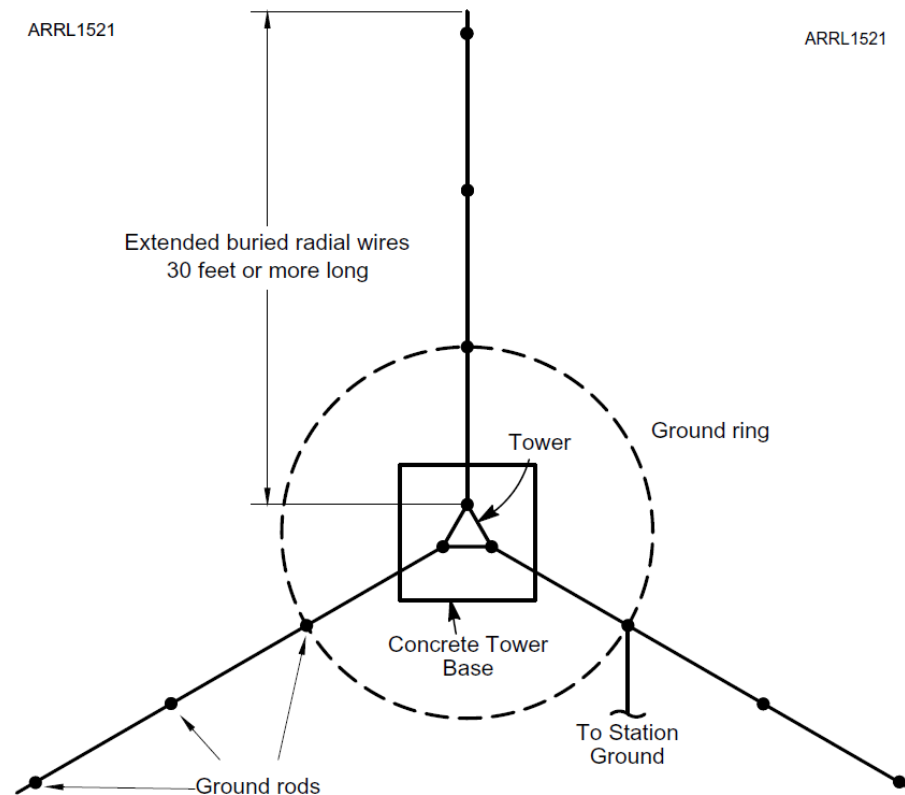
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Lightning Protection



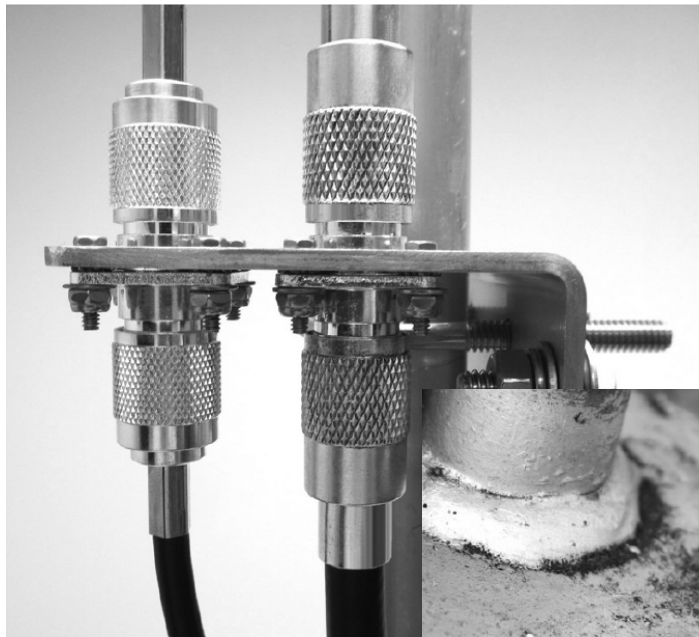
- Tower grounding



Lightning Protection



- Bond feed lines to the tower



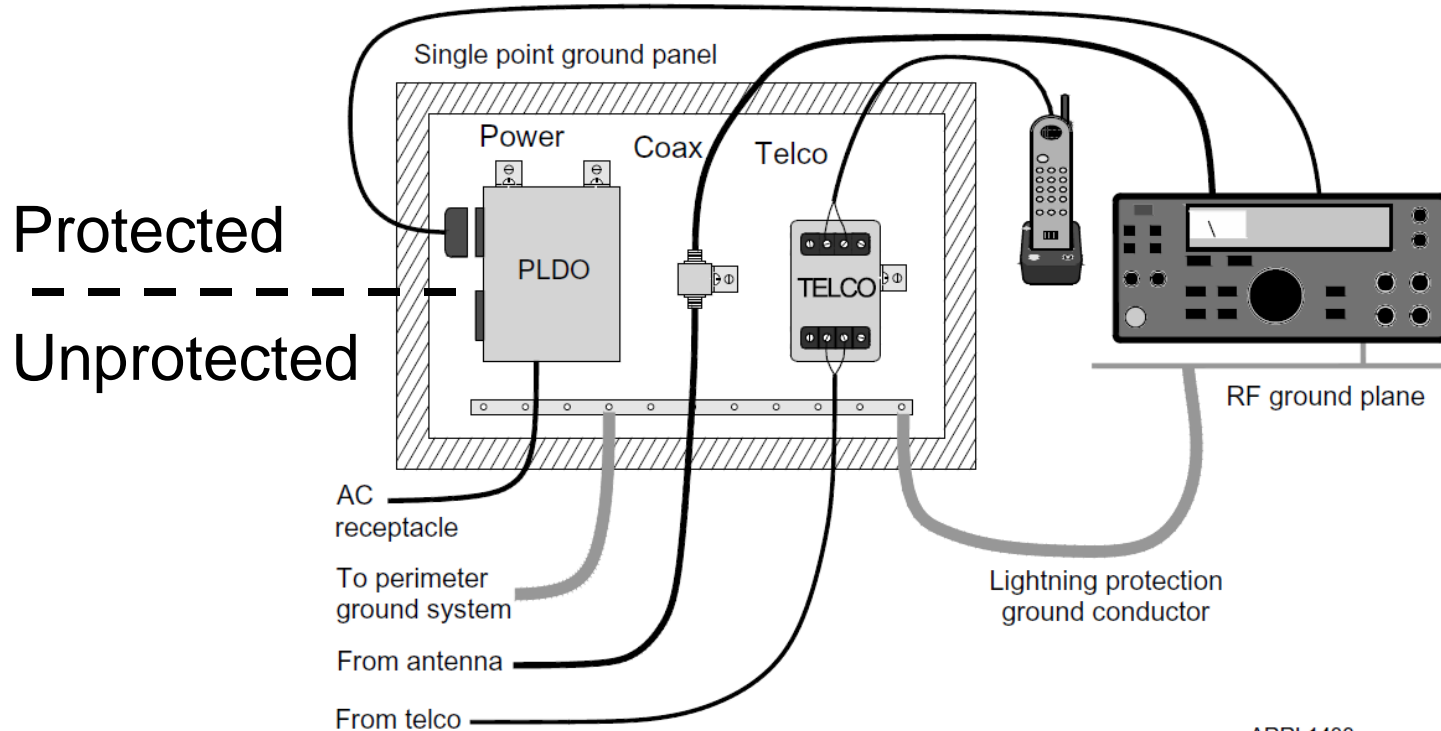
- Spark gaps



Lightning Protection



- Single-point Ground Panel (station entry)

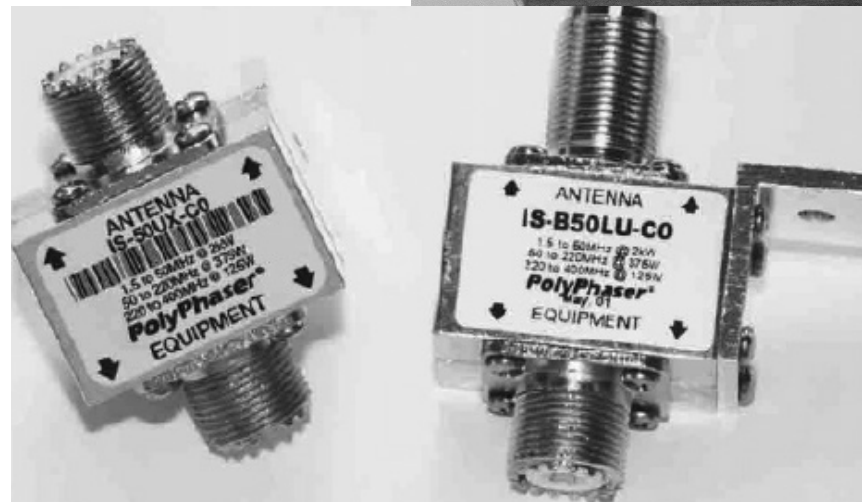
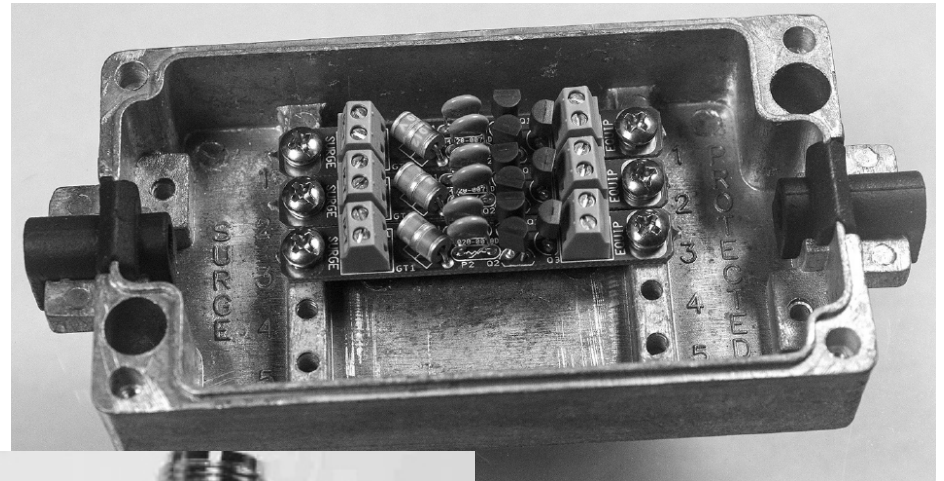


ARRL1433

Lightning Protection



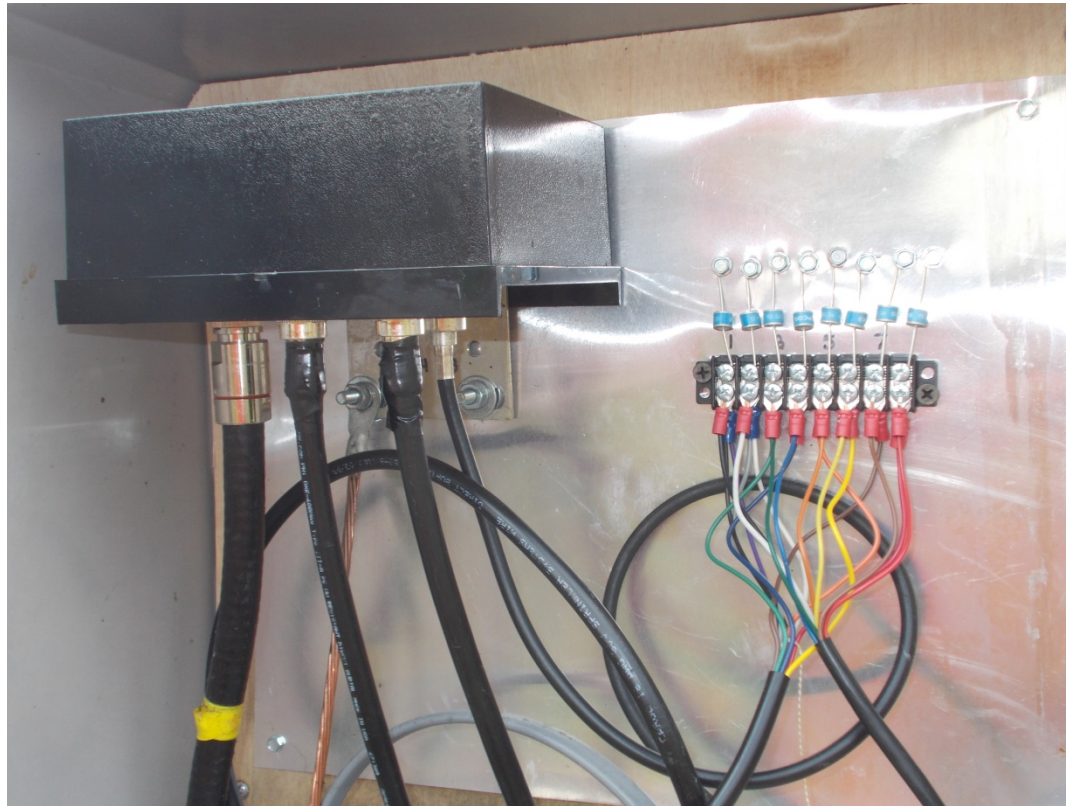
- Single-point Ground Panel



Lightning Protection



- Single-point Ground Panel (tower base)



Lightning Protection

- Single-point Ground Panel (station entry)



Lightning Protection



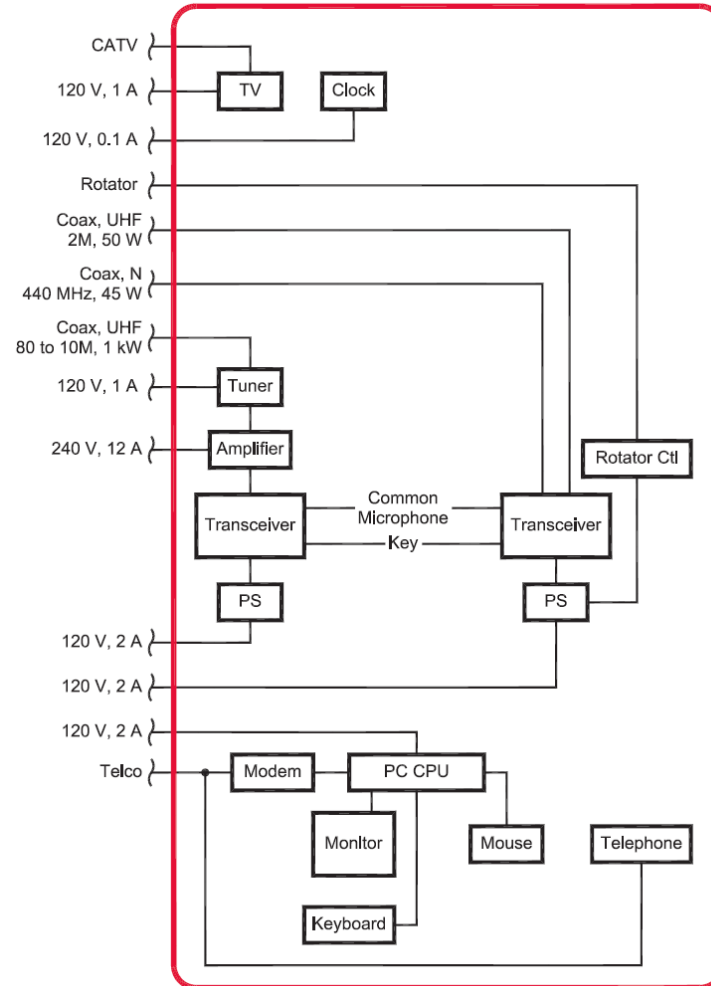
- Single-point Ground Panel (in station)





Lightning Protection

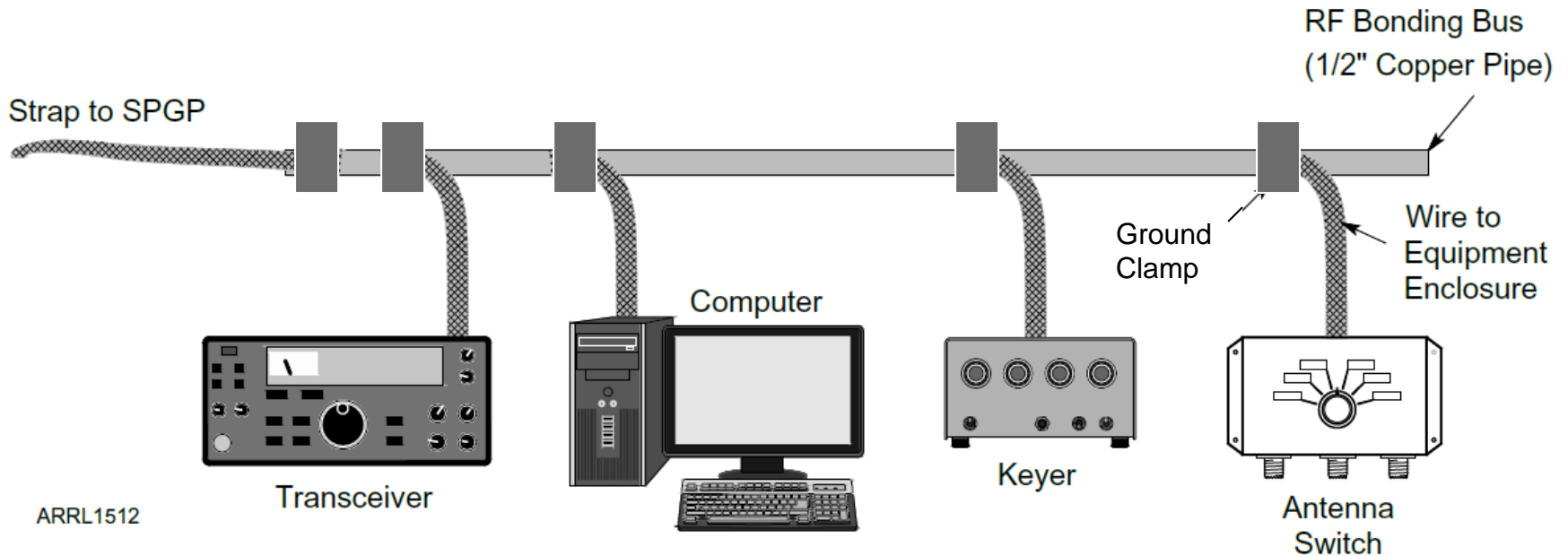
- Protected Zones
 - Every line crossing the boundary **must** be protected by a common or bonded ground connection
 - Bond equipment within the station
- Ron Block QST articles (ARRL TIS)



Lightning Protection



- Bonding inside the shack



RF Management

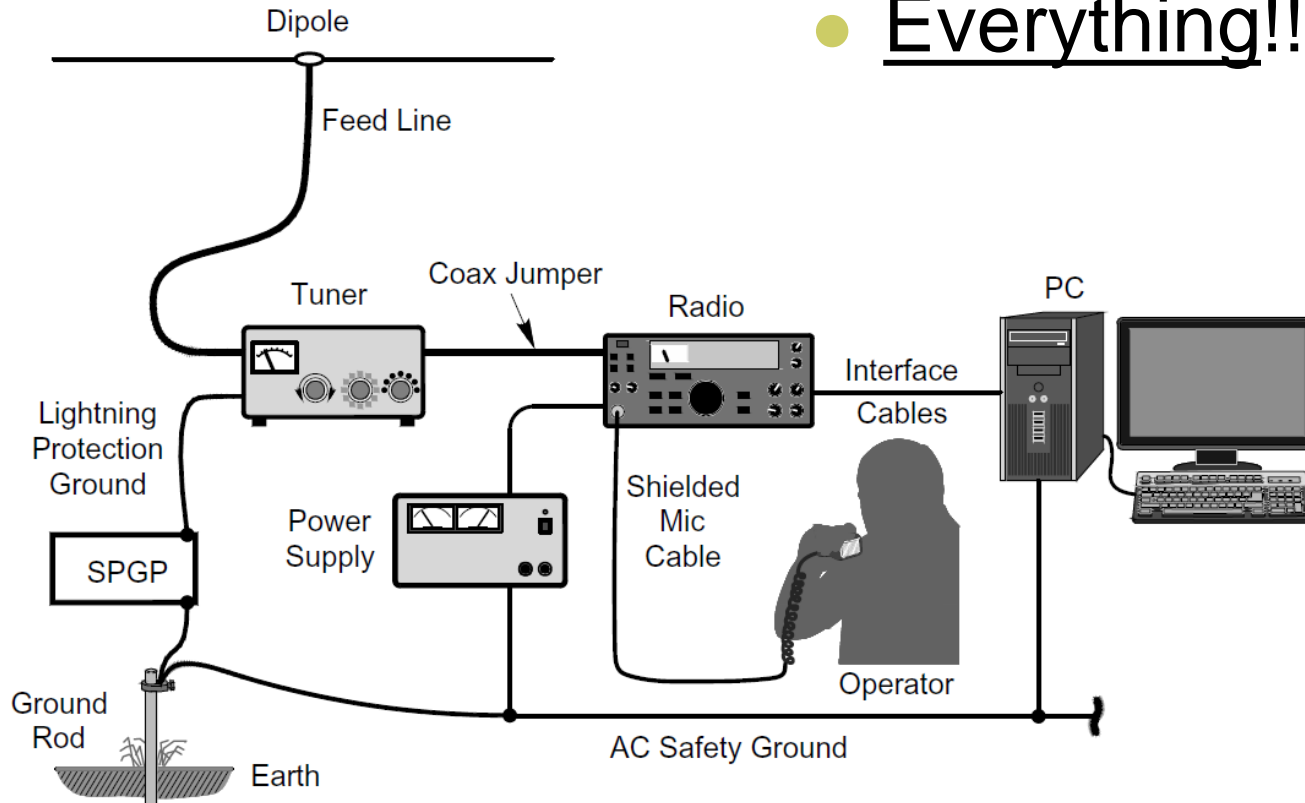


- Everything in the station is an antenna

RF Management



● Everything!!



RF Management



- Everything in the station is an antenna
- Concentrate on bonding
- Amplifiers result in high RF field strength
 - Requires extra attention to bonding
- Create common reference plane and/or bus
- Long connections can be **no** connection
 - Keep connections *electrically short*

RF Management



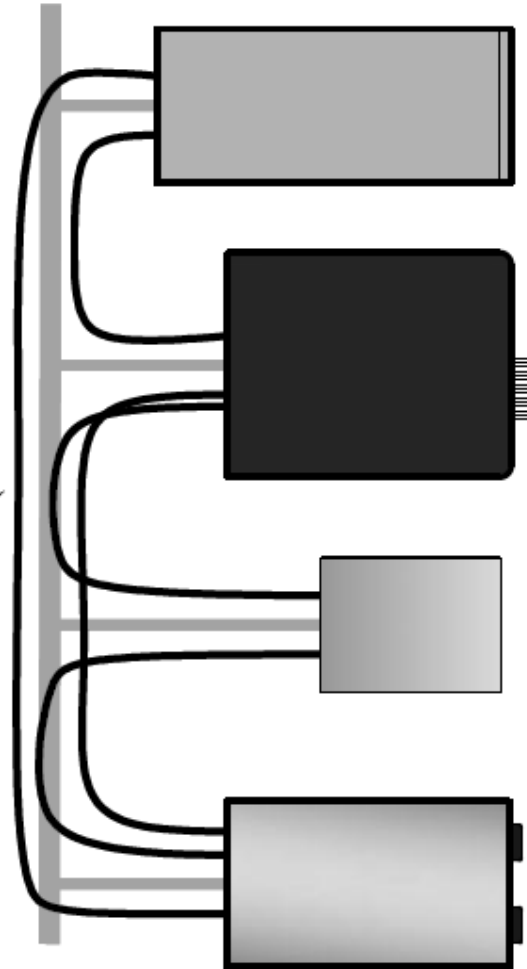
- Equalize voltage to minimize current
 - Eliminates “hot spots”
 - Reduces RFI from common-mode current
 - Reduces sensitivity to physical configuration
 - Minimizes audio “buzz” and hum
- Tie everything to a common plane or bus
- Keep cables short or coiled
- Heavy, direct connection to SPGP

RF Management



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

Keep Cables Together



RF Management



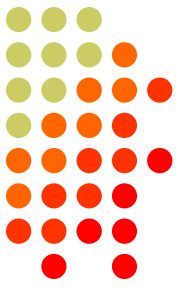
- RF ground plane
- Sheet of metal
- Helps equalize voltage
- Run cables along the ground plane
- Bond to station ground system



RF Management

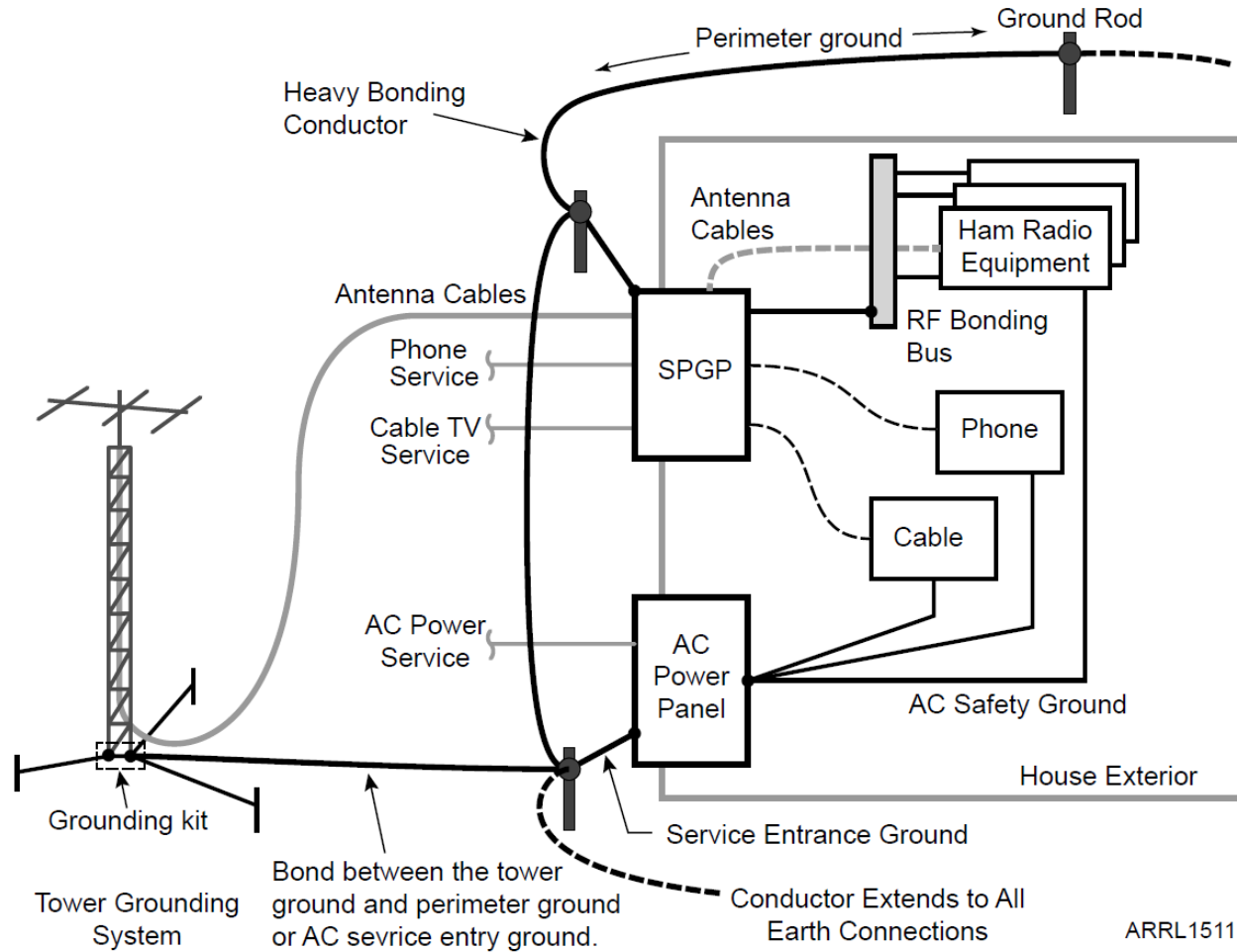


Ground System



- “One system rules 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



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

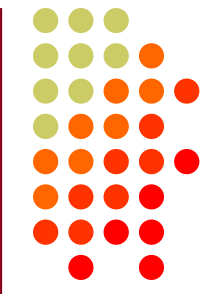


- Standards
 - FAA Document on Practices and Procedures for Lightning Protection, Grounding, Bonding, and Shielding Implementation — www.faa.gov/documentLibrary/media/Order/6950.19A.pdf
 - IEEE Std 1100 – 2006 “IEEE Recommended Practices for Powering and Grounding Electronic Equipment” — www.ieee.org (available from most libraries)
 - MIL-HDBK-419A – Grounding, Bonding, and Shielding for Electronic Equipments and Facilities (Vol 1 and 2) — www.uscg.mil/petaluma/TPF/ET/_SMS/Mil-STDs/MILHDBK419.pdf

Additional Resources



- Books and Online Material
 - Block, R. R., The “Grounds” for Lightning and EMP Protection, Second Edition, PolyPhaser Corporation, 1993.
 - Rand, K. A., Lightning Protection and Grounding Solutions for Communications Sites, PolyPhaser Corporation, 2000.
 - ARRL Technical Information Service sections
 - Electrical Safety — www.arrl.org/electrical-safety
 - Grounding (various types and topics) — www.arrl.org/grounding
 - Lightning Protection - www.arrl.org/lightning-protection
 - W8JI’s web pages on ground systems (w8ji.com/ground_systems.htm)



ARE WE DONE YET?



THANKS!!