



# Grounding & Bonding for Home HF Stations

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*Thanks to Contest University and Icom America for supporting the original presentation*

# Ward Silver, NØAX

- Licensed since 1972 as WNØGQP, then NØAX in 1975
  - Mostly HF operating, enjoying more VHF today
  - Interests are technical, radiosport, public service
- Electrical engineer – instrumentation and medical devices
- Second career as teacher and writer, beginning in 2001
- Author of *QST* column “Hands-On Radio” (2003-2018)
  - Tremendous interest in columns on RF ground
  - Suggested book on grounding and bonding
  - First edition released in 2017



# Goals of the Talk

- Understand “ground” and “bond”
- Appreciate the different requirements for ac safety, lightning protection, and RF
- Discuss issues and techniques for home stations using HF
- Common system to satisfy all of these requirements
- Provide comprehensive resources



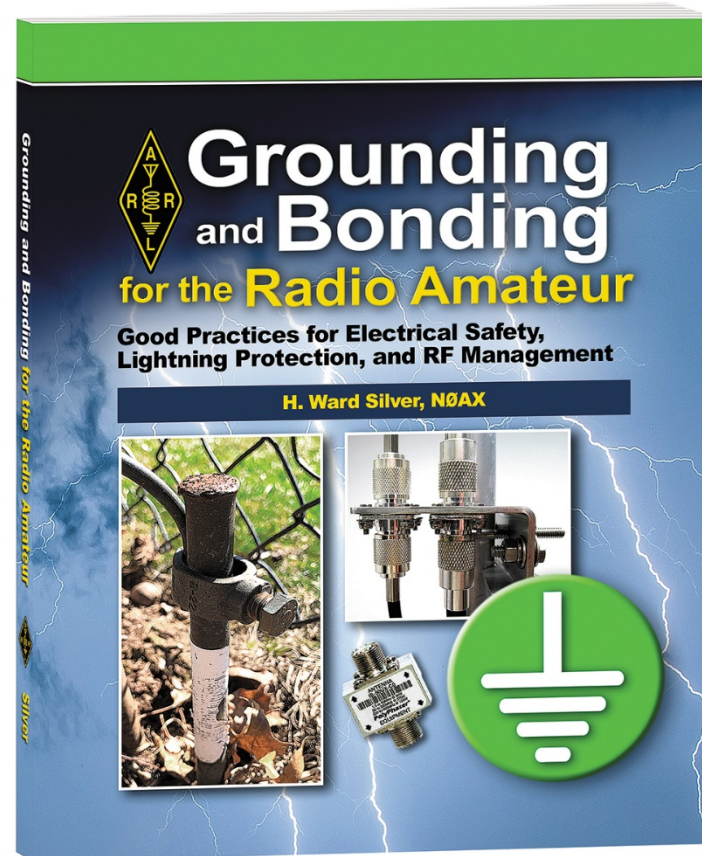
# Ham Radio References

- *ARRL Handbook, ARRL Antenna Book*
- *NEC Handbook* – at your library, any recent edition
- *Lightning Protection for the Amateur Station* (Ron Block, NR2B – Jun/Jul/Aug 2002 QST) – ARRL website, available to the public not just members
- *Power, Grounding, Bonding, and Audio for Amateur Radio and RFI, Ferrites, and Common Mode Chokes For Hams* – ([k9yc.com/publish.htm](http://k9yc.com/publish.htm))
- W8JI's web pages on ground systems ([w8ji.com/ground\\_systems.htm](http://w8ji.com/ground_systems.htm))



# Grounding & Bonding Book

- Covers AC wiring, lightning protection, and RF management
- Reviewed by a number of experts, including the ARRL Lab
- Numerous examples for you to use
- Not a cookbook – more of a toolbox



# 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, a “ground conductor” or “ground system”
- It can mean *all of these things at the same time*
  - “I’m grounding the chassis to ground with a ground wire.”
- 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
  - Everything goes up and down **TOGETHER**
  - Prevents shock hazards from voltage differences
  - Prevents destructive voltage differences caused by lightning surges
  - Limit current between devices caused by voltage differences from RF pickup (current causes RFI)



# What IS “Bonding” Anyway

- Sounds hard and expensive but it’s not
- Works in your favor for ac safety, lightning protection, and RF management
- 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 if equipment moves around
    - Exposed braid from old coax deteriorates





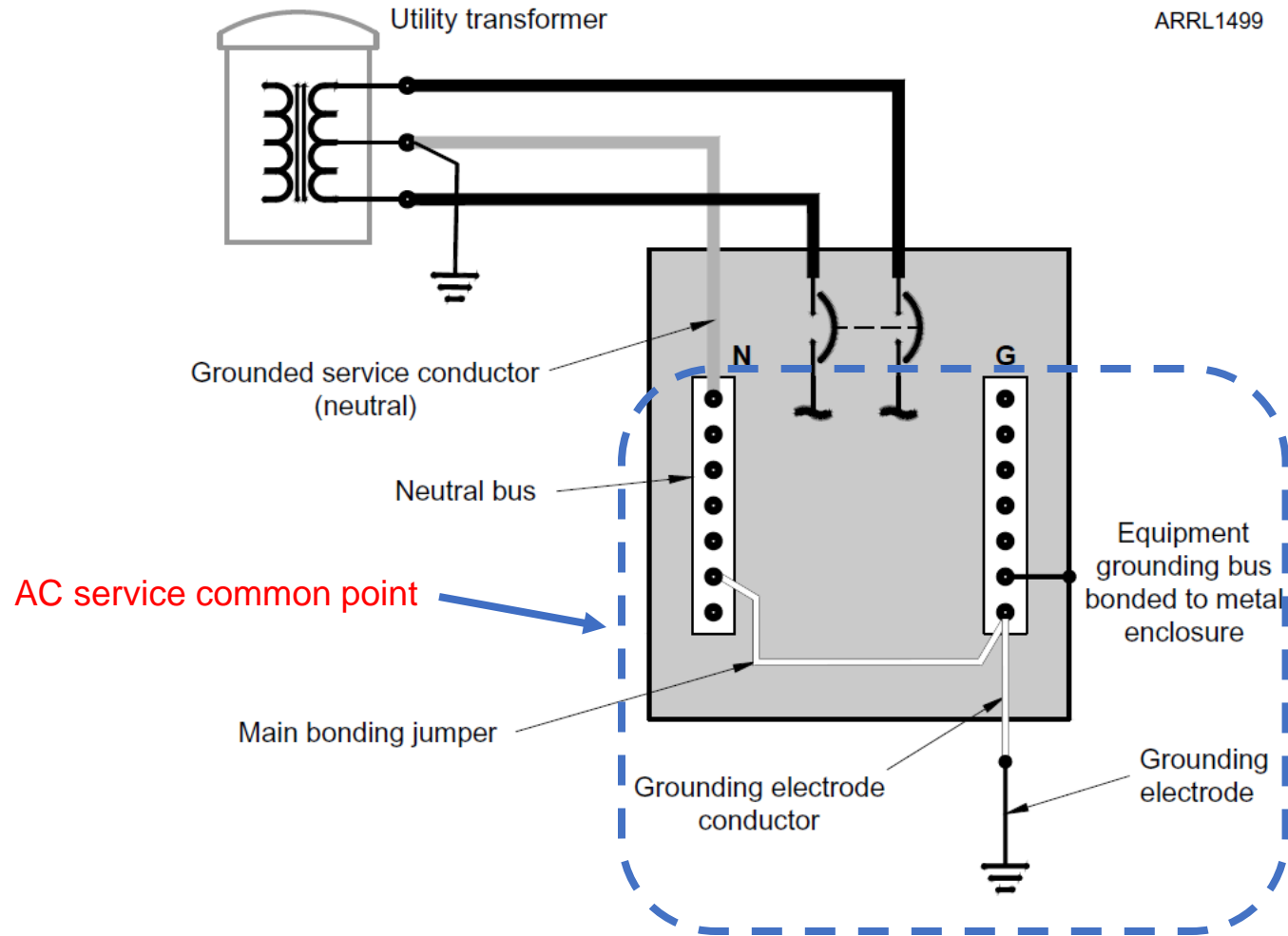
# AC Safety Grounding

- 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 system voltage during faults or transients, such as lightning



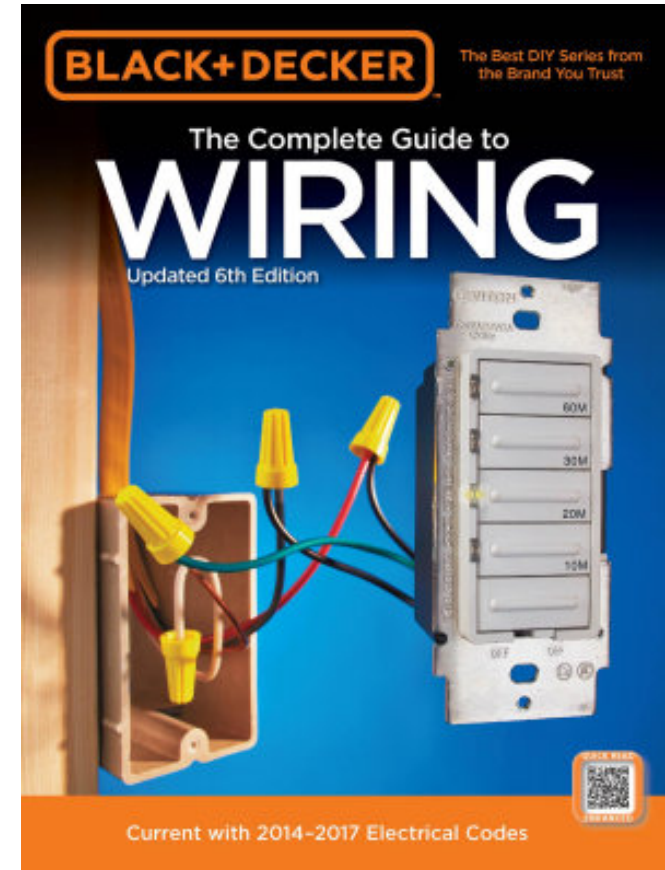
# AC Safety Grounding

ARRL1499



# AC Safety Grounding

- If you aren't sure you know what you're doing...get a how-to reference
- Follow rules for sub-panels and outbuildings
- Hire a pro electrician to do the work or inspect yours
- Local code is the law



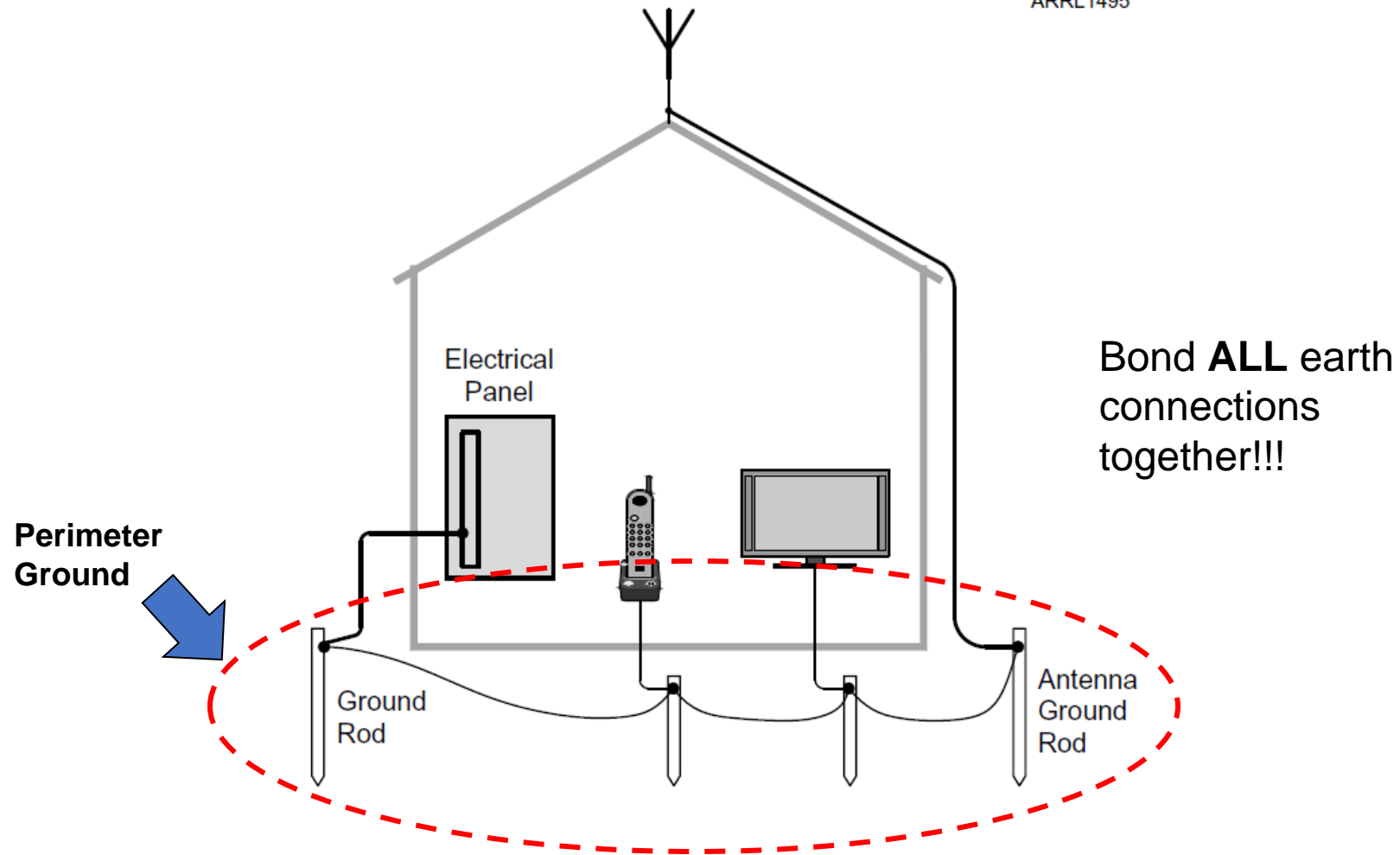
# Lightning Protection

- 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



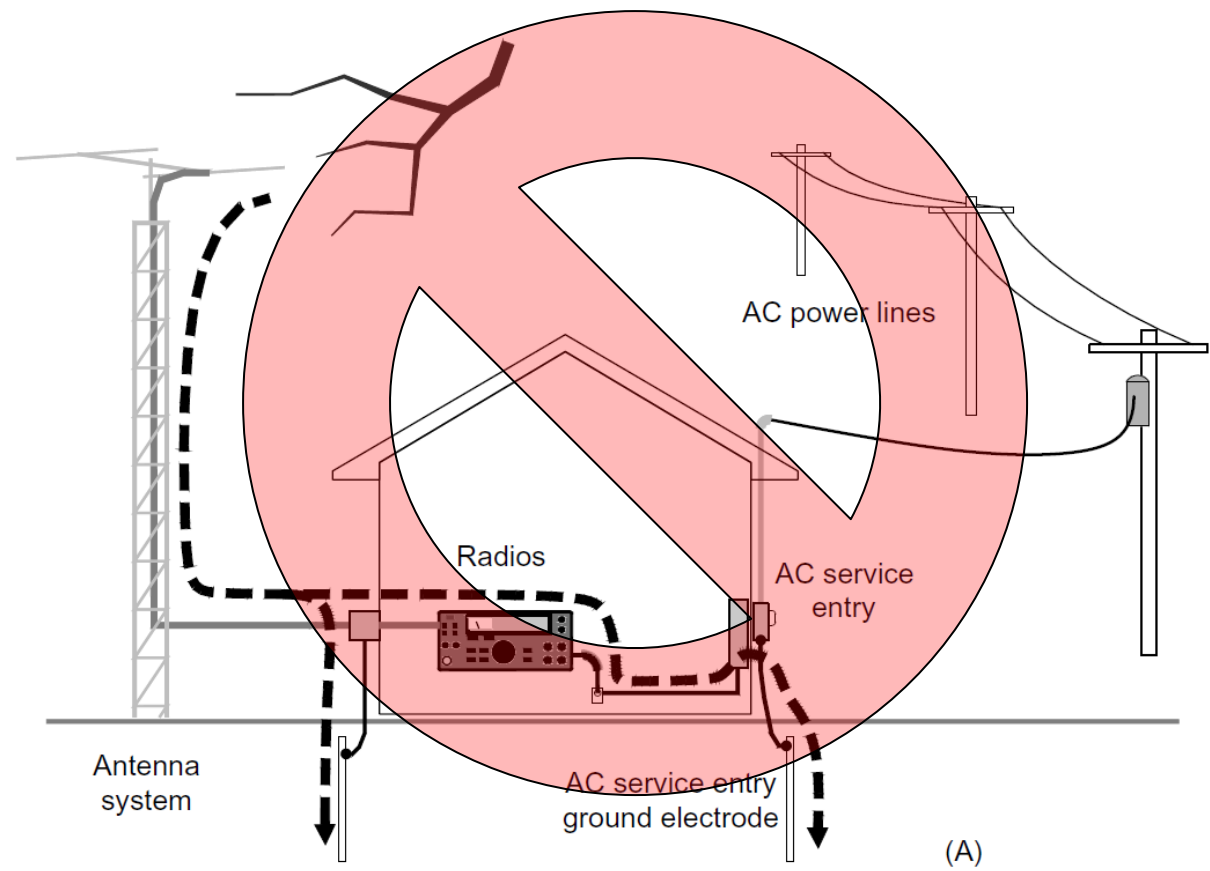
# Lightning Protection

ARRL1495



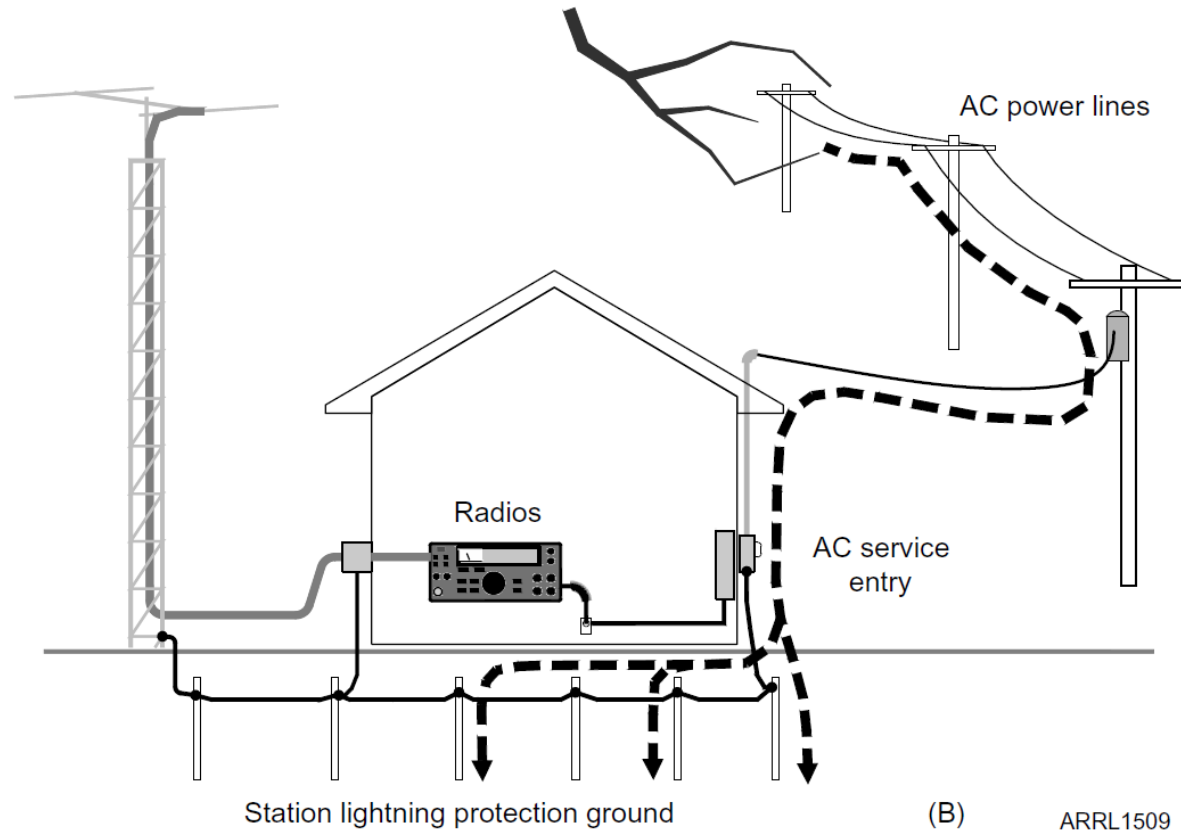
# Lightning Protection

- Ground paths should go *around* your station



# Lightning Protection

- Ground paths should go *around* your station



(B) ARRL1509

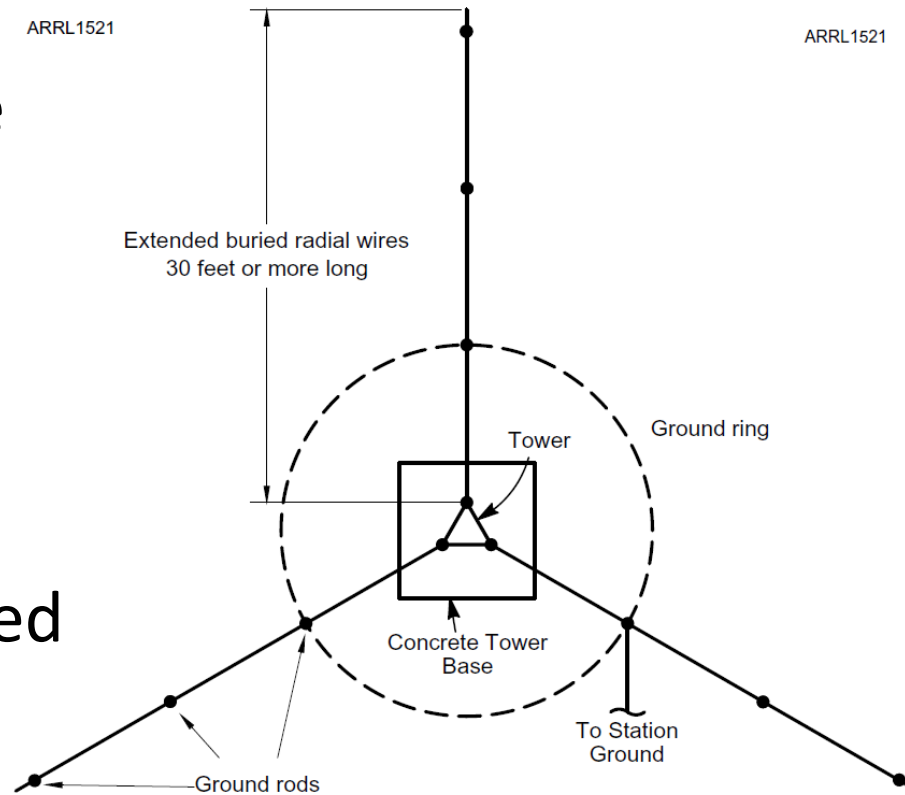


# Lightning Protection

- Rods and radials
- Bond feed lines to the tower every 50 feet



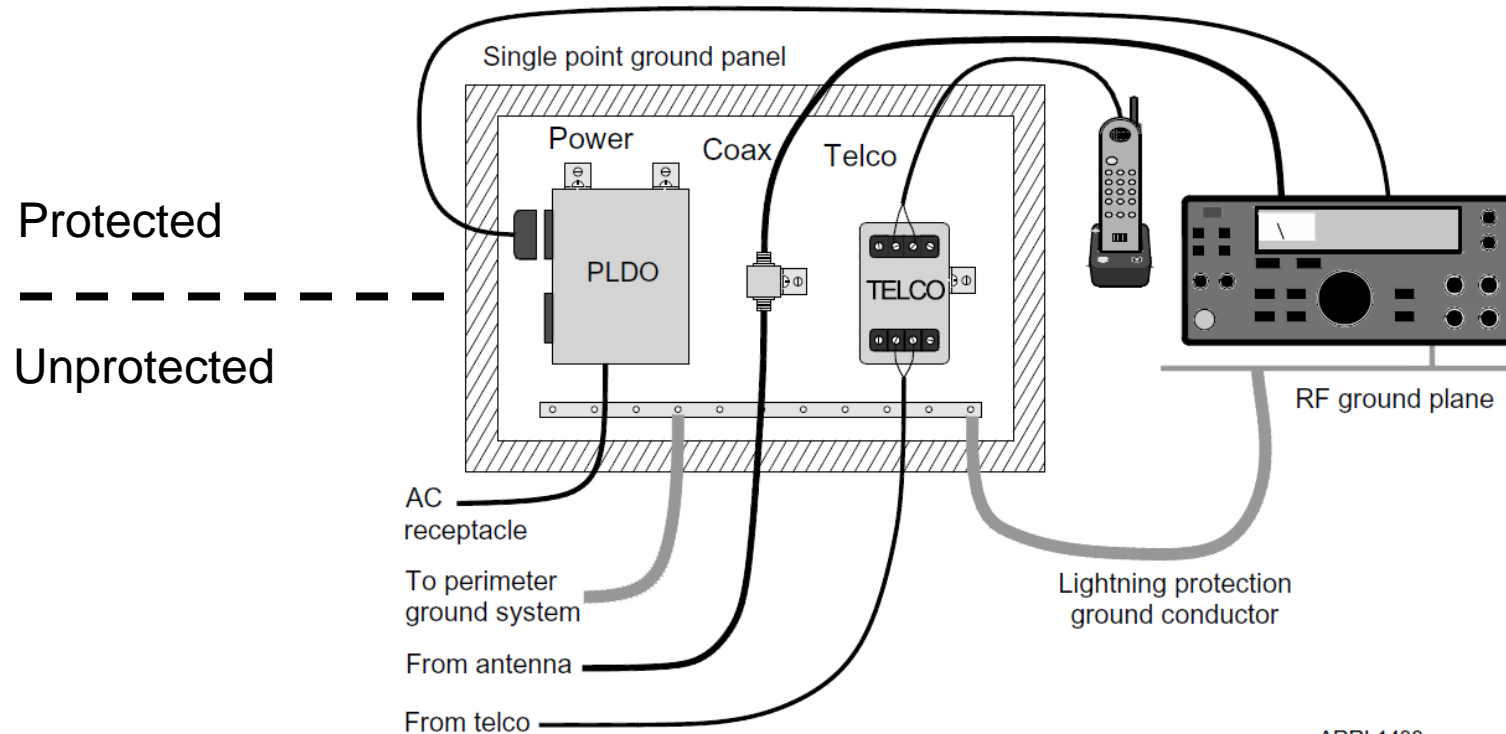
- Spark gaps for insulated base towers





# Lightning Protection

- Single-point Ground Panel (station entry)

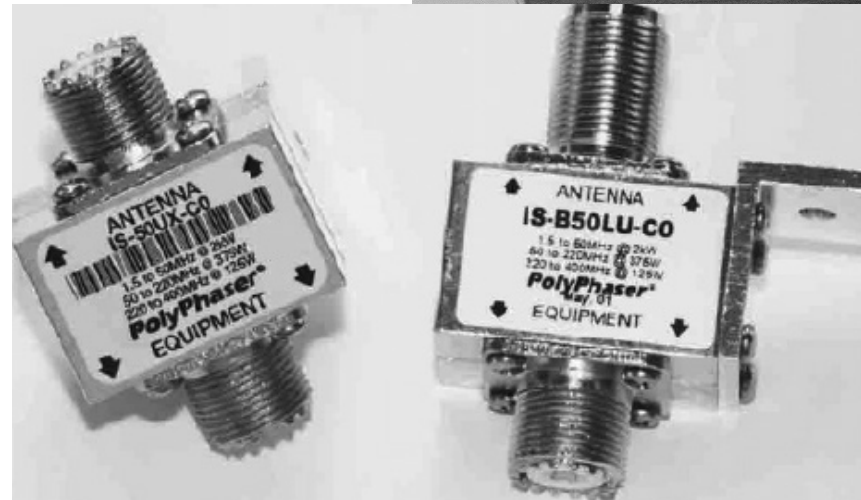
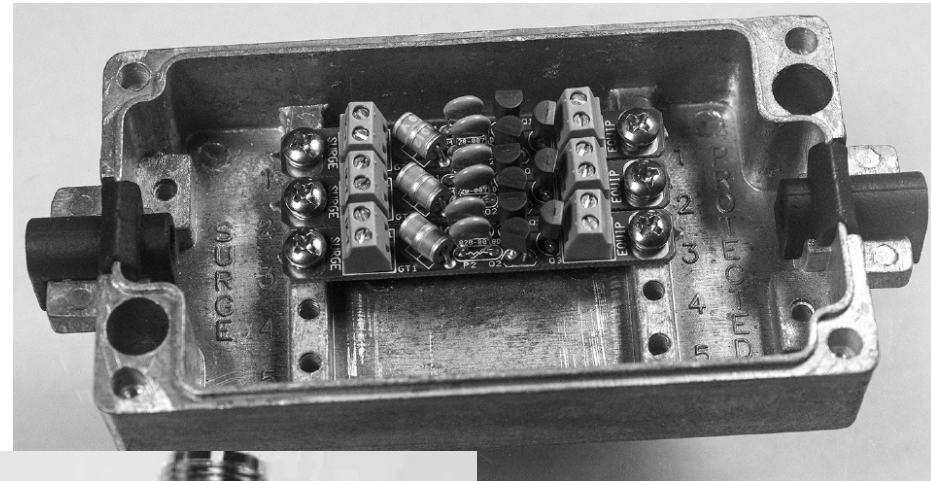


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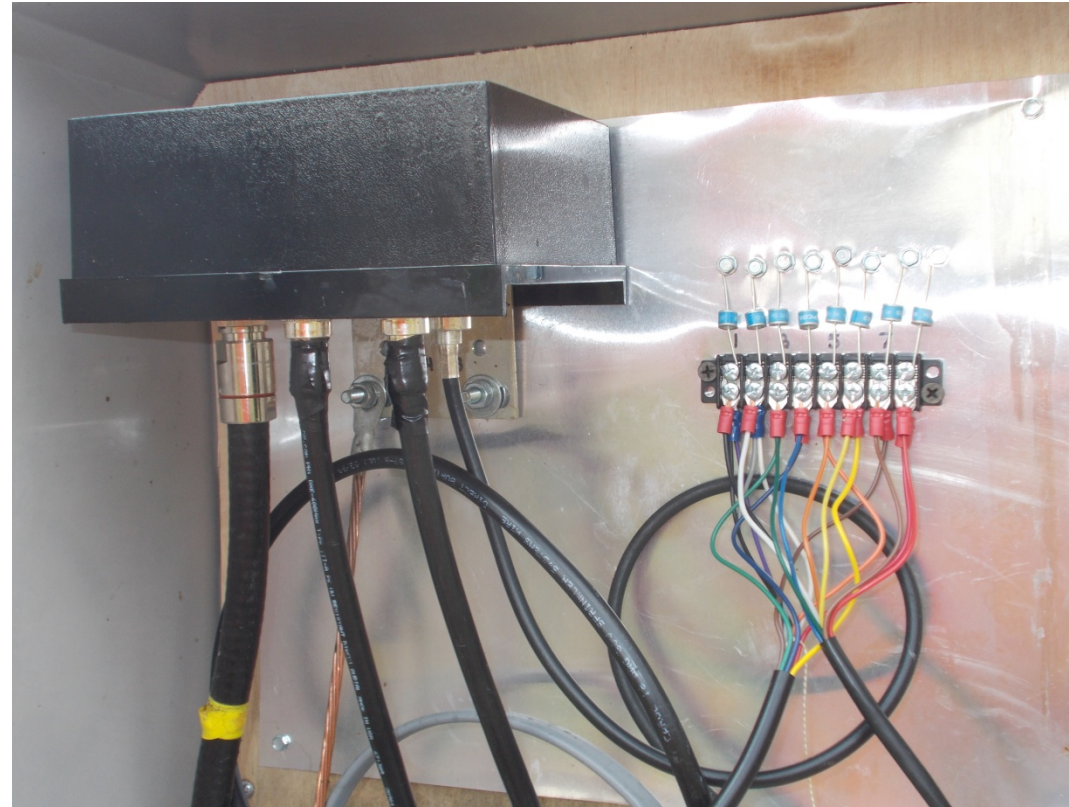
# Lightning Protection

- Single-point Ground Panel



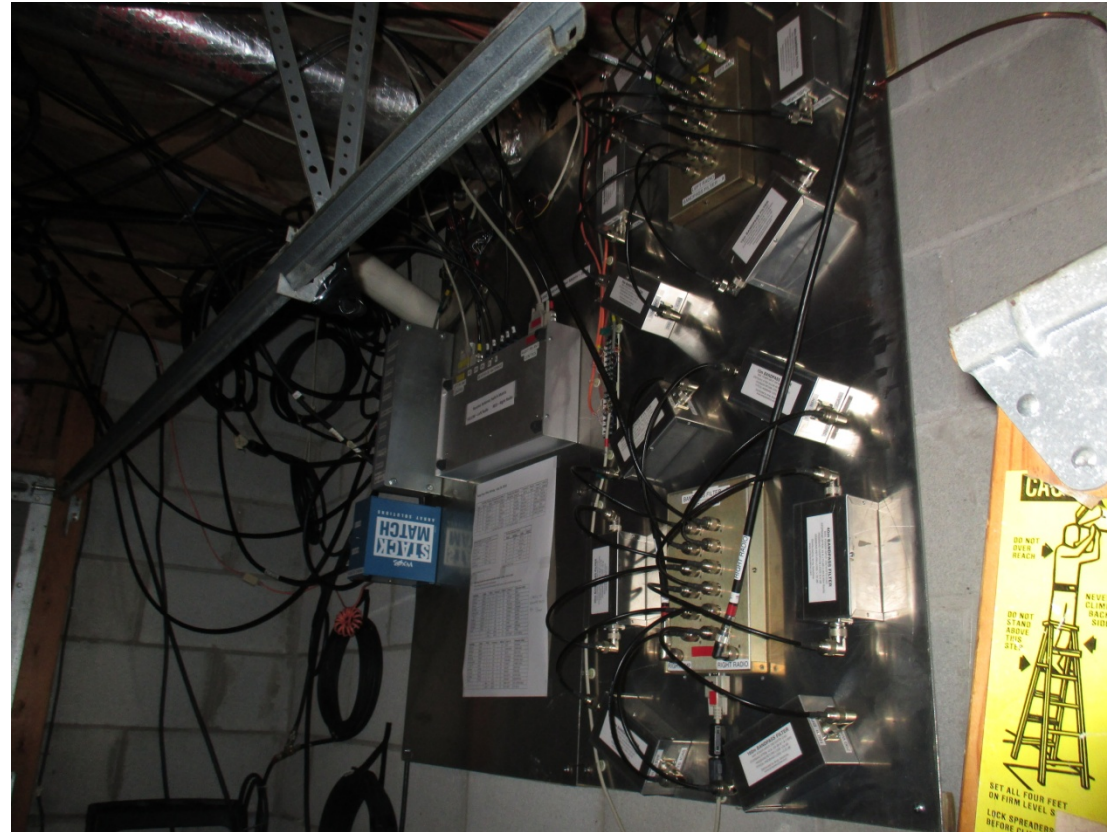
# Lightning Protection

- Single-point Ground Panel (tower base)



# Lightning Protection

- Single-point Ground Panel (station entry)



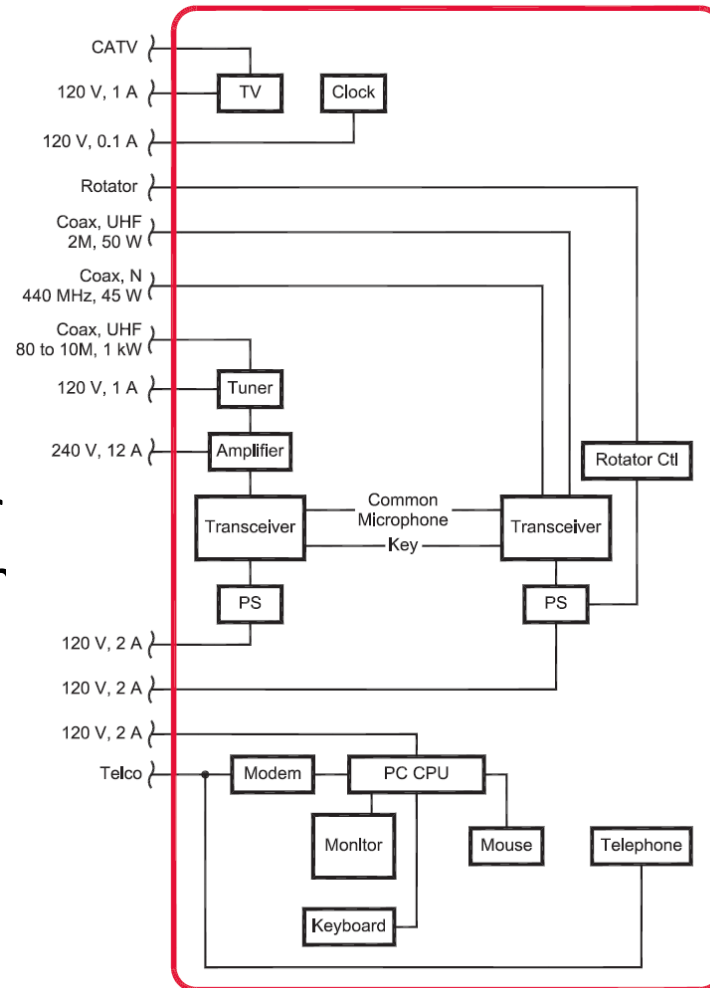
# Lightning Protection

- Single-point Ground Panel (in station)



# Lightning Protection

- Ron Block NR2B's 2002 *QST* articles
- Protected Zones
  - Every line crossing the boundary **must** be protected by a common or bonded ground connector
  - Bond equipment within the station



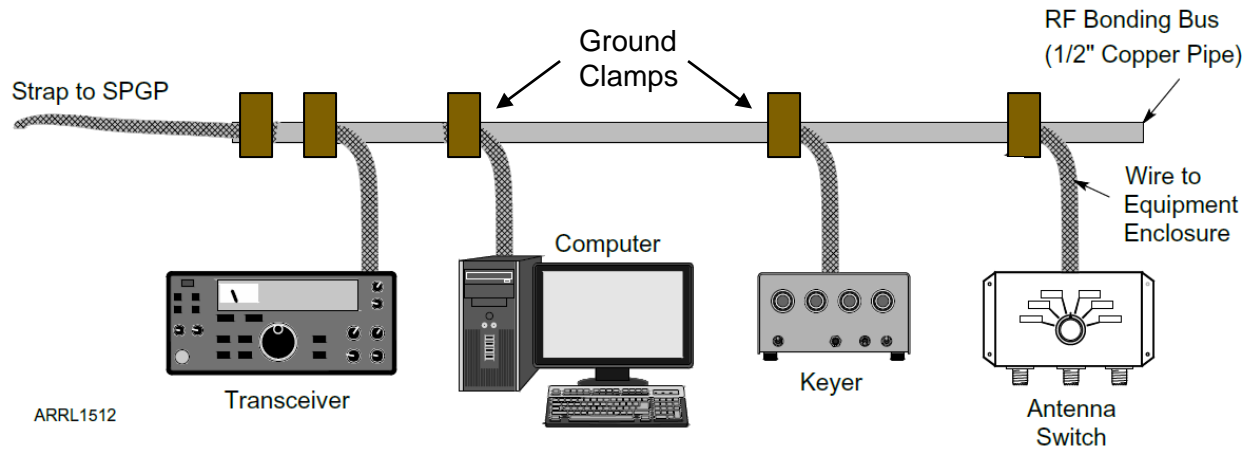
# RF Management

- Everything in the station is an antenna
- Forget about an “RF ground”
  - Concentrate instead on bonding
  - Keep connections *electrically short*
  - Keep everything at the SAME voltage
- Amplifiers = high RF field strength
  - Requires extra attention to bonding
- Create common reference plane and/or bus



# RF Management

- Bonding inside the shack
  - Eliminates “hot spots”, reduces “buzz” and hum
  - Reduces RFI from common-mode current
  - Reduces sensitivity to physical configuration

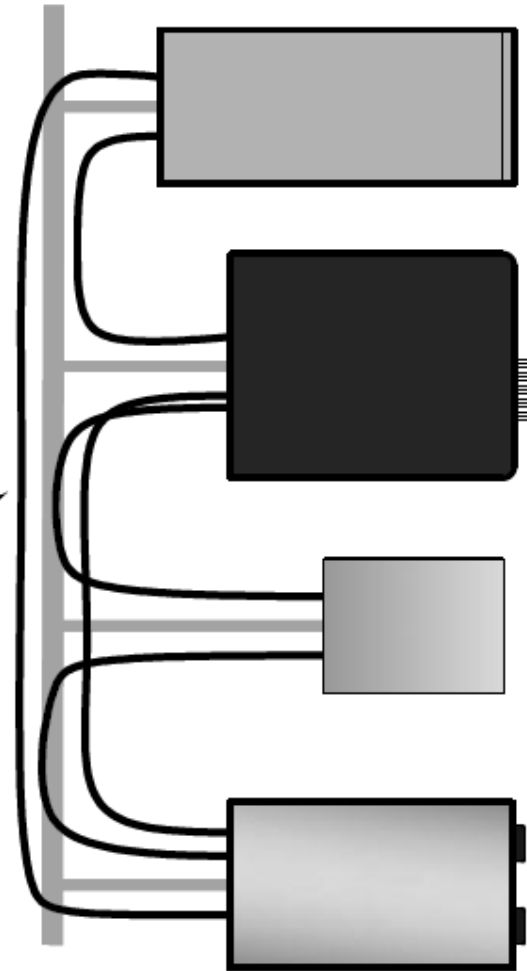




# RF Management

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

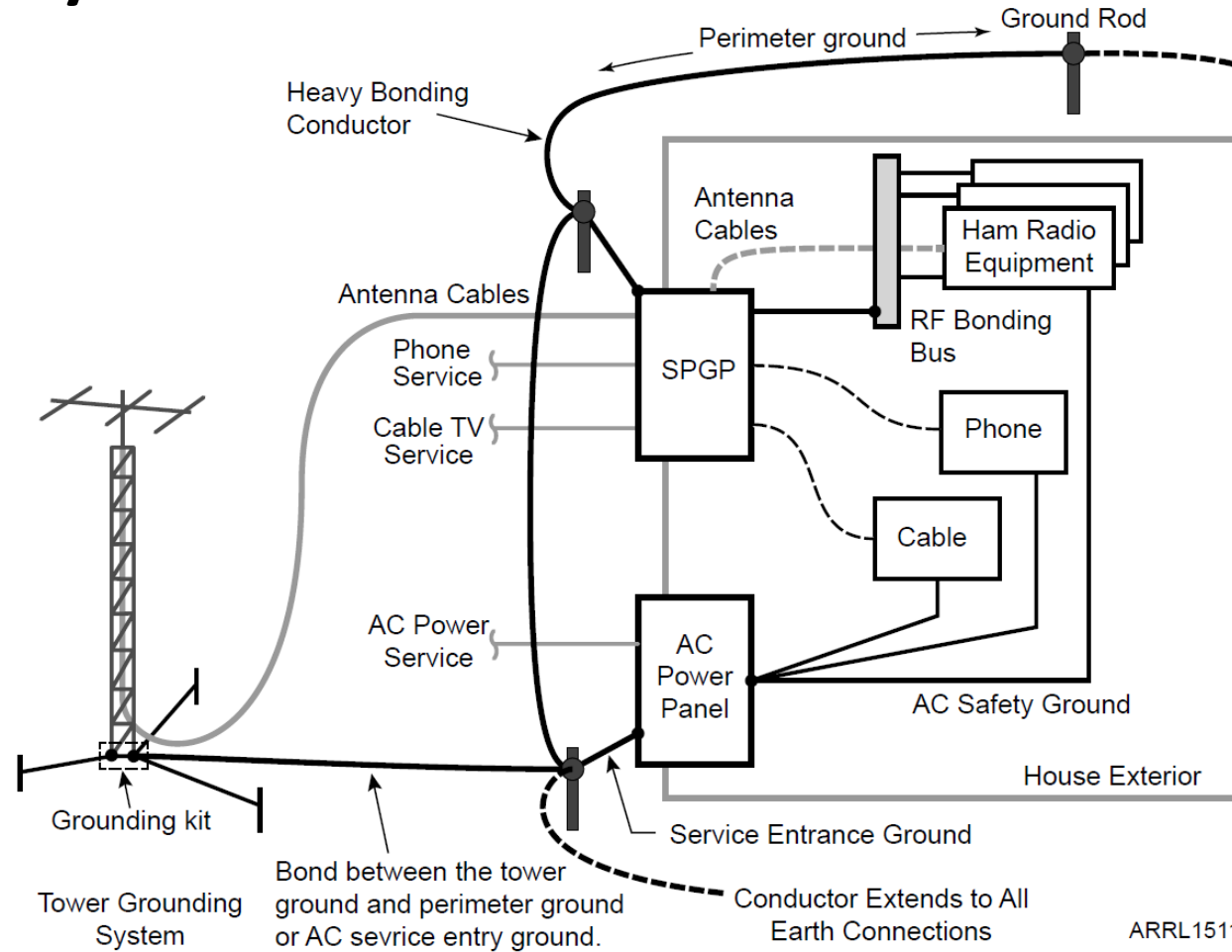
Keep Cables  
Together



# RF Management



# Ground System





**Q&A**

# Additional Resources

- Professional Associations and Companies
  - National Fire Protection Association ([www.nfpa.org](http://www.nfpa.org))
  - International Association of Electrical Inspectors ([www.iaei.org](http://www.iaei.org))
  - Mike Holt Enterprises ([www.mikeholt.com](http://www.mikeholt.com)) — training and continuing education for electricians, many tutorials
  - Polyphaser ([www.polyphaser.com/services/media-library/white-papers](http://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](http://lightning.org/learn-more/library-of-resources)) — papers and tutorials on lightning protection techniques



# Additional Resources

- Standards
  - *Standards and Guidelines for Communication Sites* (Motorola R56) – available online
  - *FAA Document on Practices and Procedures for Lightning Protection, Grounding, Bonding, and Shielding Implementation* — [www.faa.gov/documentLibrary/media/Order/6950.19A.pdf](http://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](http://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](http://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](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)

