

# Grounding and Bonding For Home Stations

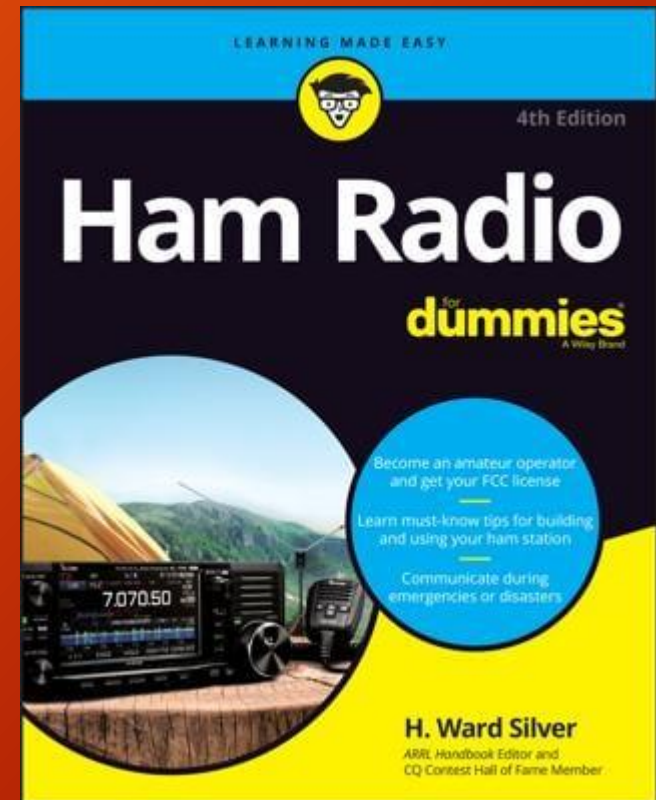
Ward Silver NØAX

Thanks to Contest University and Icom America

# Ham Radio for Dummies

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- A “desktop Elmer” for new and experienced hams
- Helps non-hams understand more about ham radio
- Not a license study guide
- Available as an audio book and as an eBook
- Now in the 4<sup>th</sup> edition!



# Goals of the Presentation

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

# Ham Radio References

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- *ARRL Handbook, ARRL Antenna Book*
- *Lightning Protection for the Amateur Station* (Jun/Jul/Aug 2002 QST - ARRL website) and *Lightning Protection - A Comprehensive Guide* (new) - Ron Block, NR2B -
- *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)
- W8JI website ([w8ji.com/ground\\_systems.htm](http://w8ji.com/ground_systems.htm)) and for mobile stations KØBG website ([k0bg.com](http://k0bg.com))

# Background References

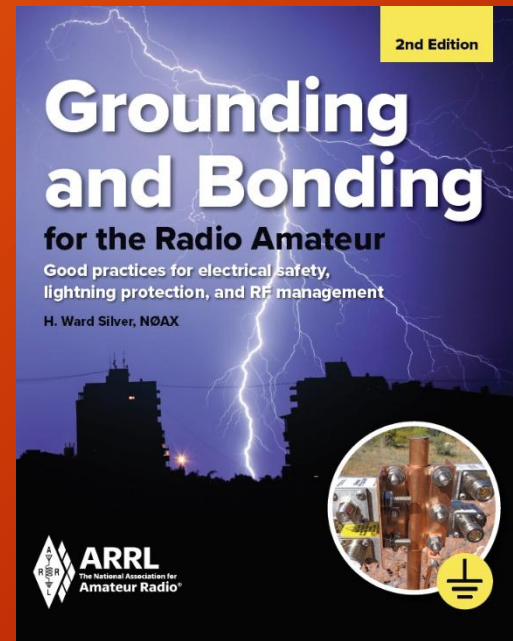
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## *Grounding and Bonding for the Radio Amateur*

Covers AC wiring,  
lightning protection, and  
RF management

Reviewed by a number of  
experts, including the  
ARRL Lab

Numerous examples for  
you to use - a “toolbox”



# What IS “Ground” Anyway

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- “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*
  - “I’m grounding the chassis to ground with a ground wire.”

# What IS “Ground” Anyway

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- The Earth is NOT - a magic sink into which we pour RF or lightning and it magically and safely disappears as zero volts
- Fuzzy definitions:
  - “RF ground” - ain’t no such thing, only local reference potential over limited frequency range
  - “Ground loops” - all stations have them, manage them
  - “Single-point ground” - depends on frequency
- Each set of requirements uses “ground” differently

# What IS “Bonding” Anyway

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- Bonding is 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
  - Limits current between devices caused by voltage differences from RF pickup

# What IS “Bonding” Anyway

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- For bonding to work, it has to be...
  - Low-Z and electrically “short” at the frequencies of interest
  - Heavy enough to carry the expected current
  - Sturdy enough to survive the environment
- In the ham station, use strap (20 ga) or heavy wire (#14)
  - Flat-weave, tinned braid if equipment moves around
    - Protect braid from moisture and chemicals
  - Exposed braid from old coax deteriorates - don't use it
- Works in your favor for ac safety, lightning protection, and RF management

# AC Safety Grounding

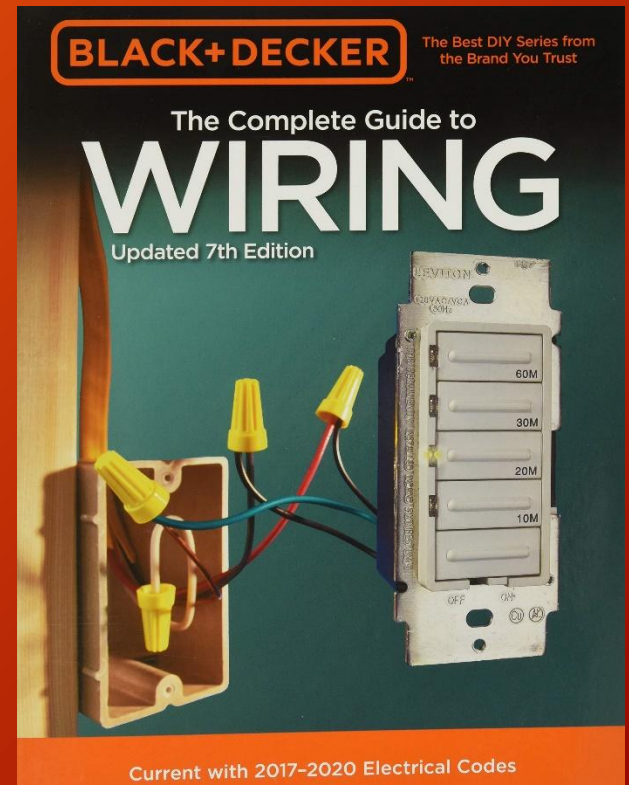
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- Grounding for ac safety has several names
  - “Equipment ground”, “third-wire ground”, “green-wire ground”
- Keep ground connections low-resistance
- Purpose is two-fold
  - Provides a path to ac common point for fault current (shorts, leakage)
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

# AC Safety Grounding

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



# Lightning Protection

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- You can't steer lightning, but...you *can* help lightning make “good decisions”
  - Heavy, direct paths to the Earth to dissipate charge in the ground
  - 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

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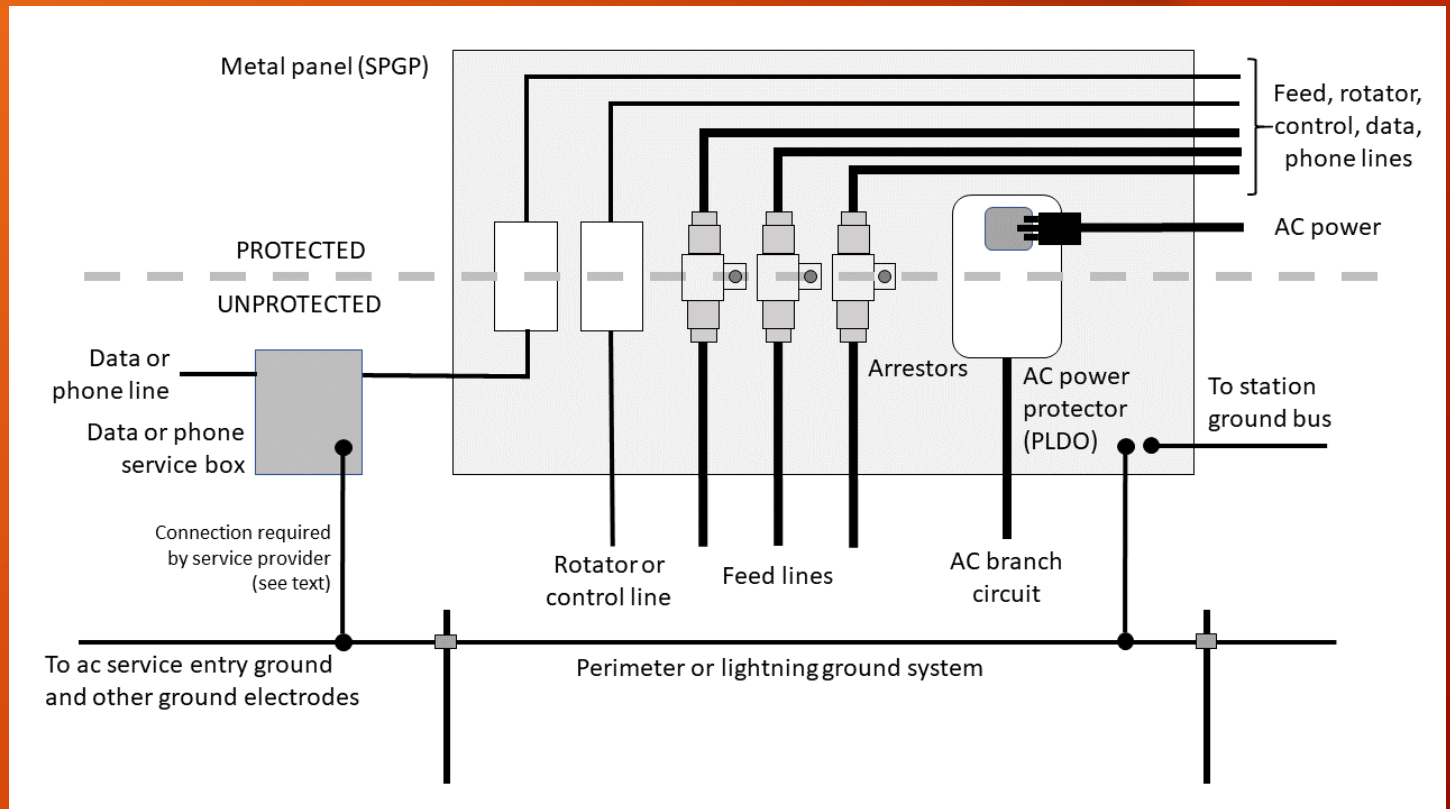
**In case there is any confusion...**

- Single-Point Ground Panels (SPGP)
  - Bonds grounds of all entry paths
    - Connected to perimeter ground
  - All protectors “fire” at the same time
    - Minimize voltage differences due to transient timing
  - Includes non-RF and AC power
  - Keep protected and unprotected cables separated

# Lightning Protection

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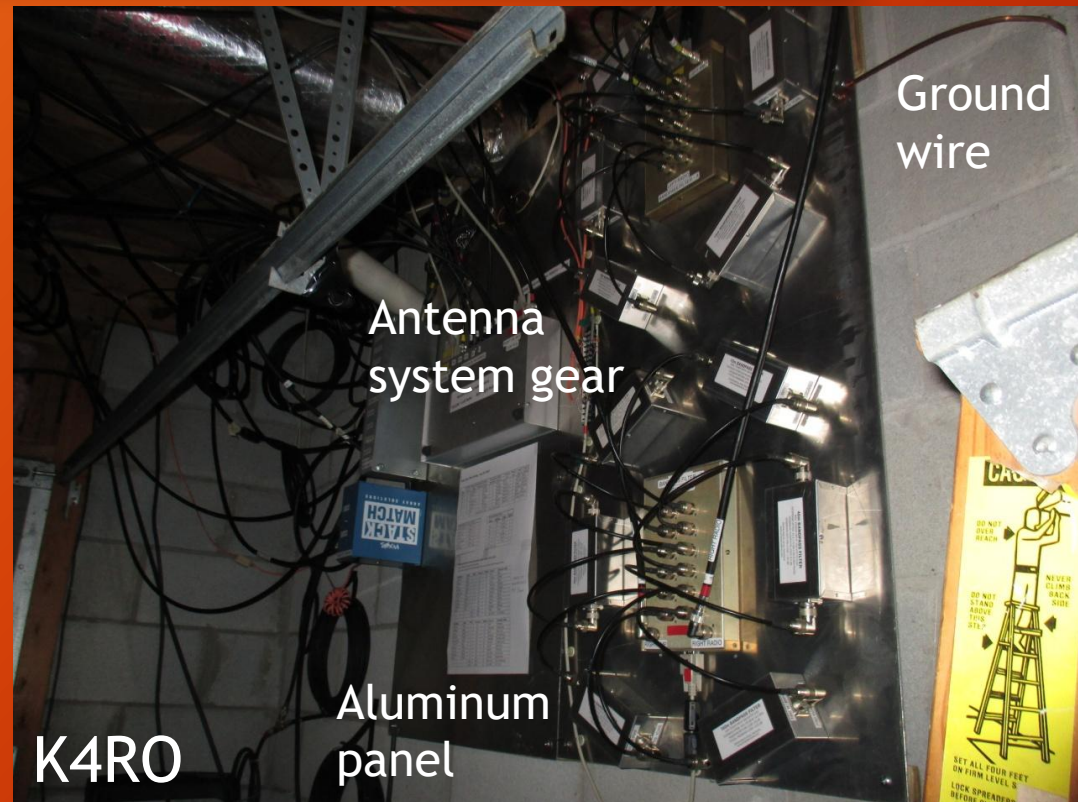
- Single-point Ground Panel (SPGP)



# Lightning Protection

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- Single-point Ground Panel (station entry)



Ground wire

Antenna system gear

Aluminum panel

K4RO

# Lightning Protection

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- Single-point Ground Panel (tower base)

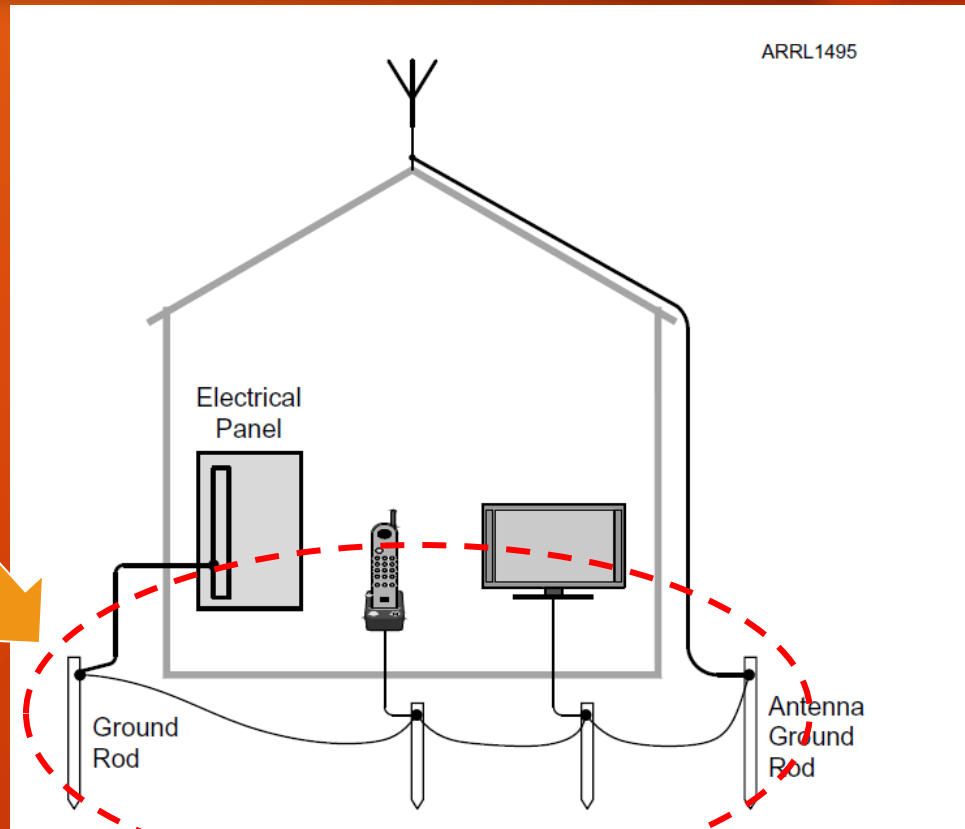


# Lightning Protection

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Bond ALL earth connections together - required!

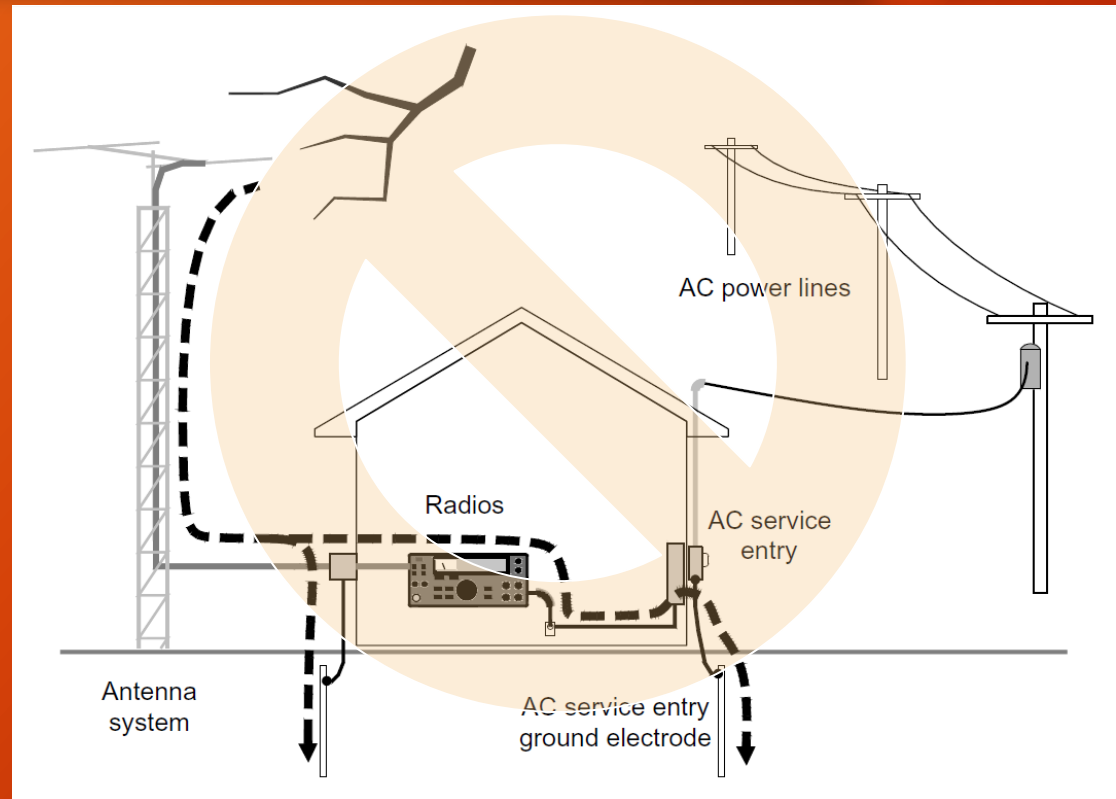
Perimeter Ground



# Lightning Protection

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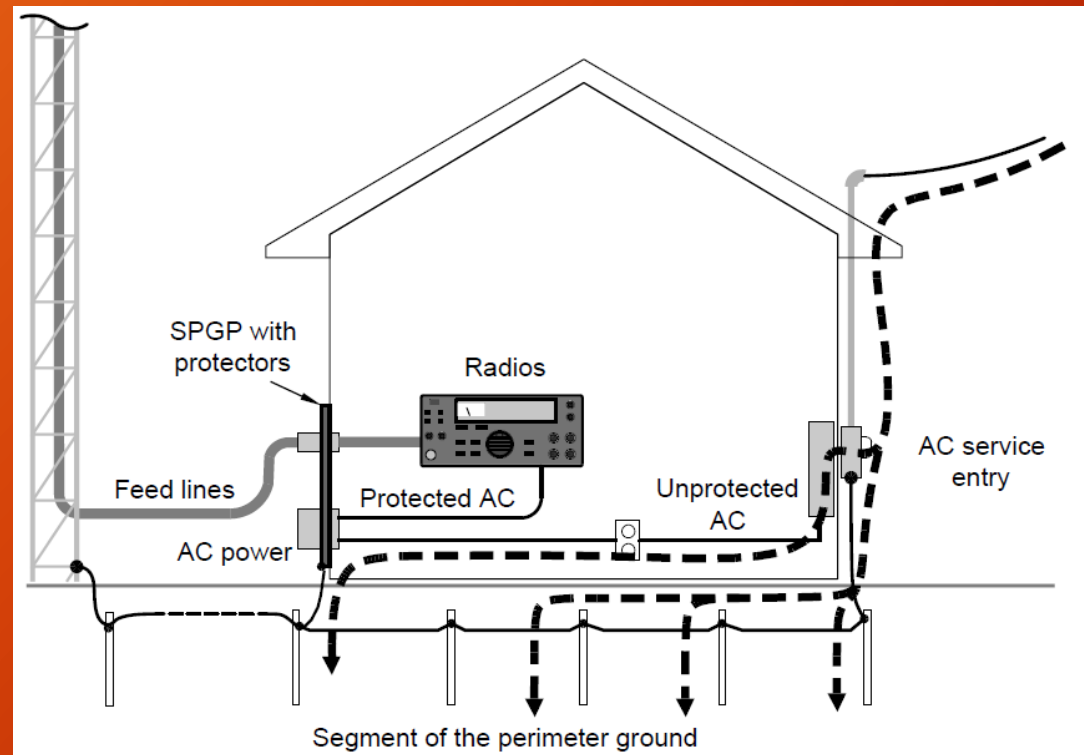
- Don't create low-impedance paths *through* your station



# Lightning Protection

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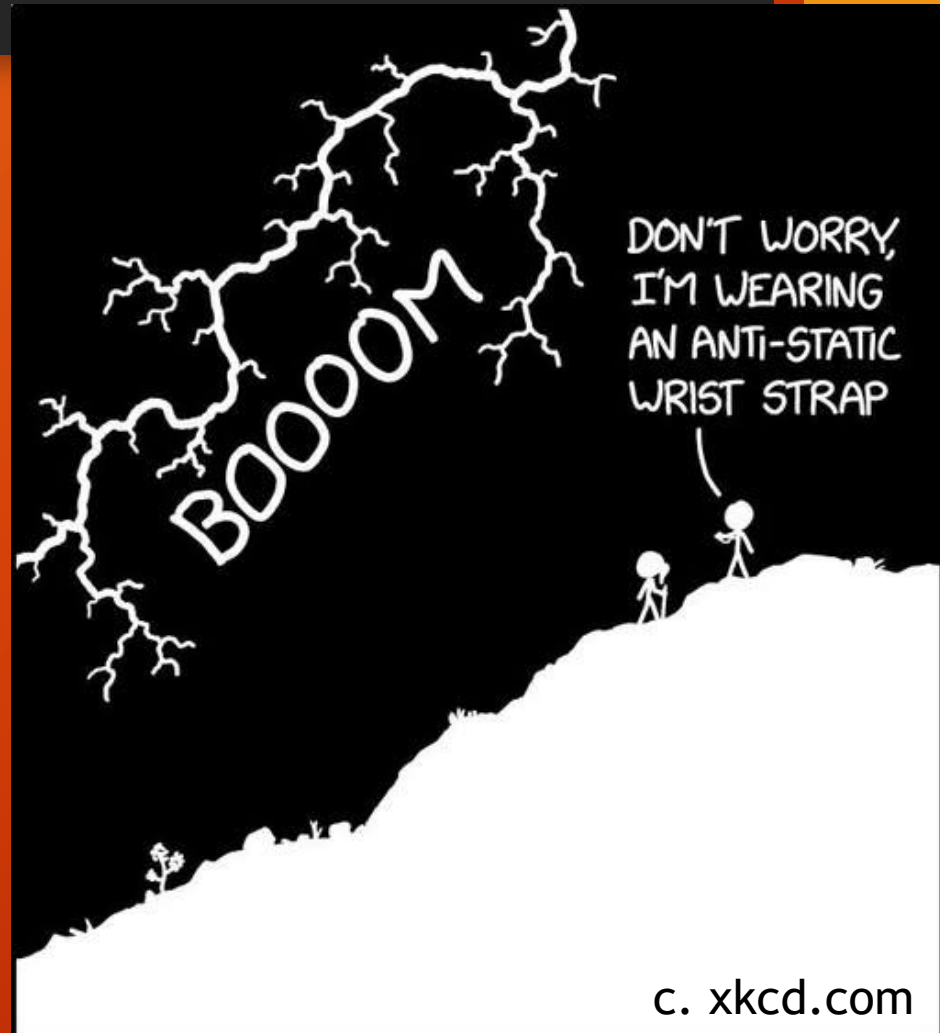
- Ground paths should go *around* your station



# Lightning Protection

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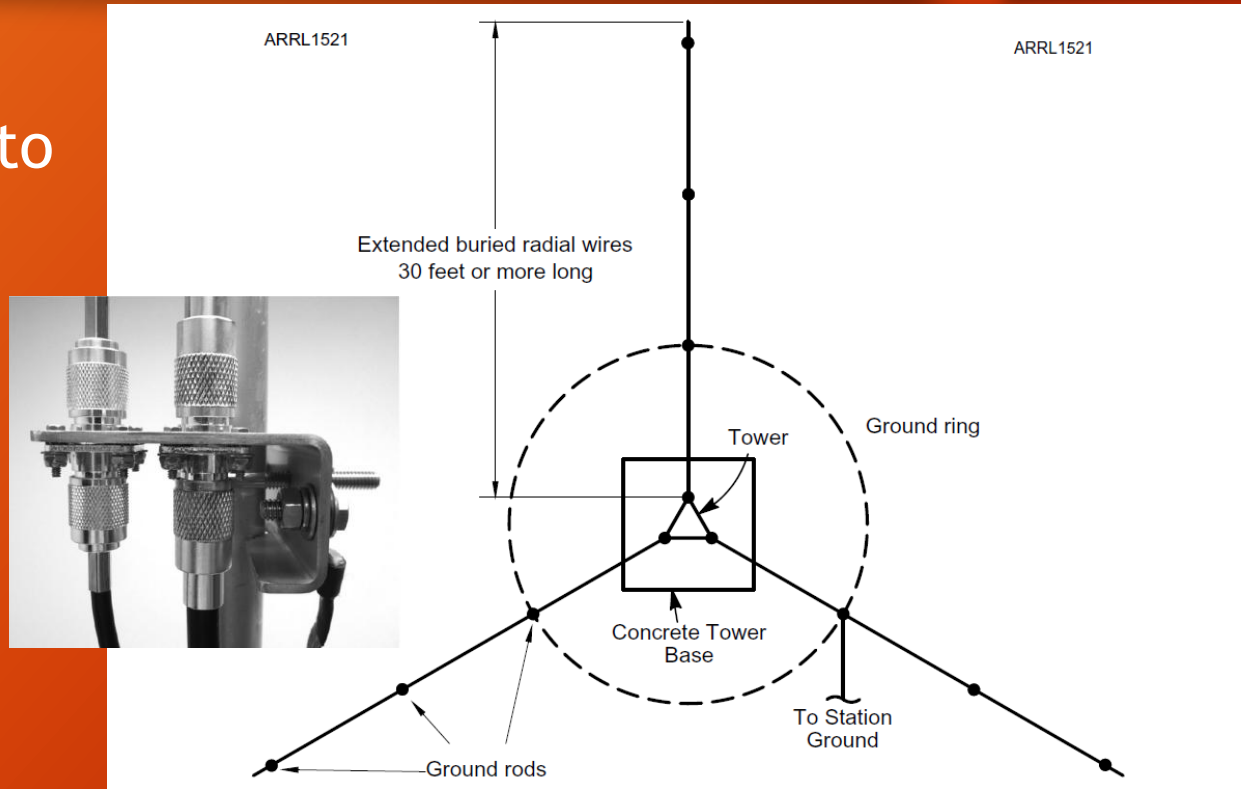
- Ground paths should also go around *YOU!*



# Lightning Protection

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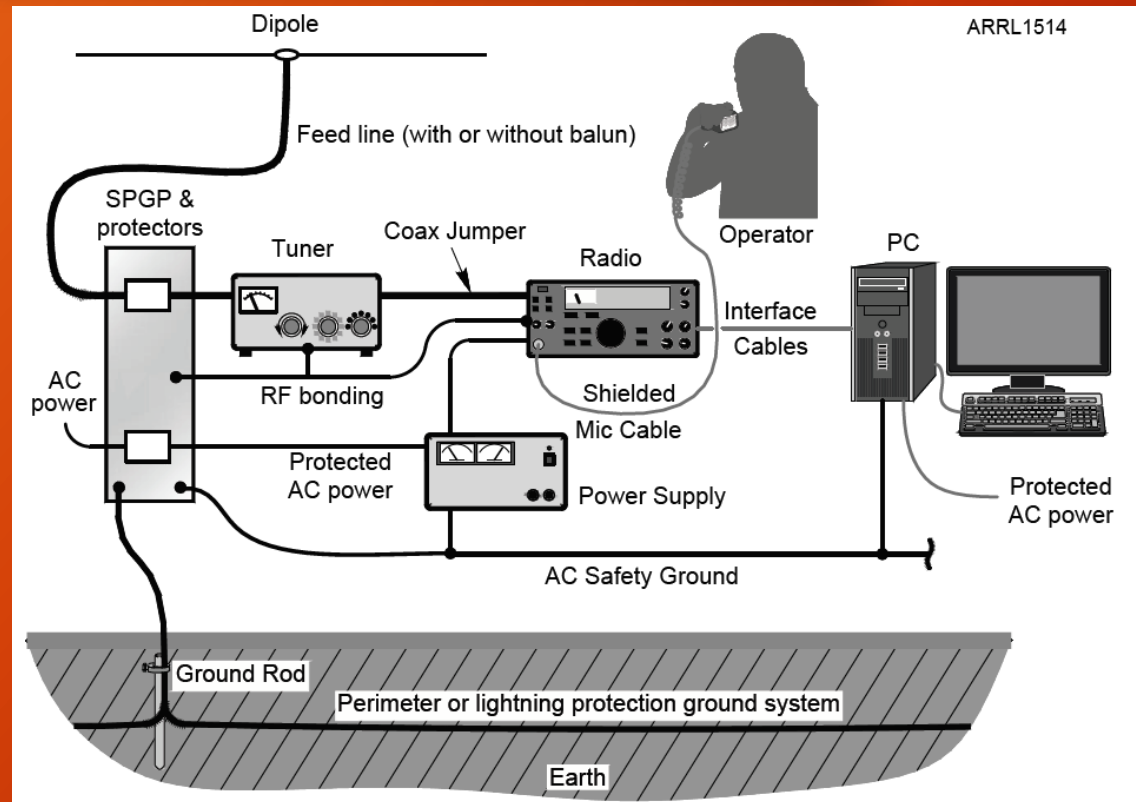
- Rods and radials
- Bond feed lines to the tower every 50 feet
- Spark gaps for insulated base towers



# RF Management

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- ***EVERYTHING IN THE STATION IS AN ANTENNA!***



# RF Management

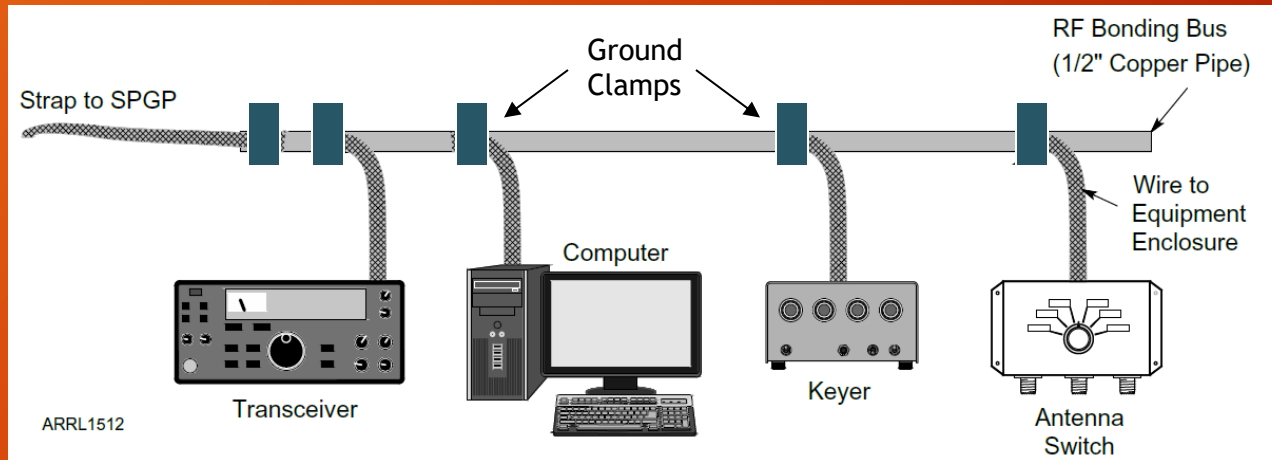
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- Forget about an all-band “RF ground”
  - Concentrate instead on bonding
  - Keep connections *electrically short*
  - Keep everything at the SAME voltage
- Amplifiers = high RF field strength
  - Requires extra attention to bonding
- Create common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

# RF Management

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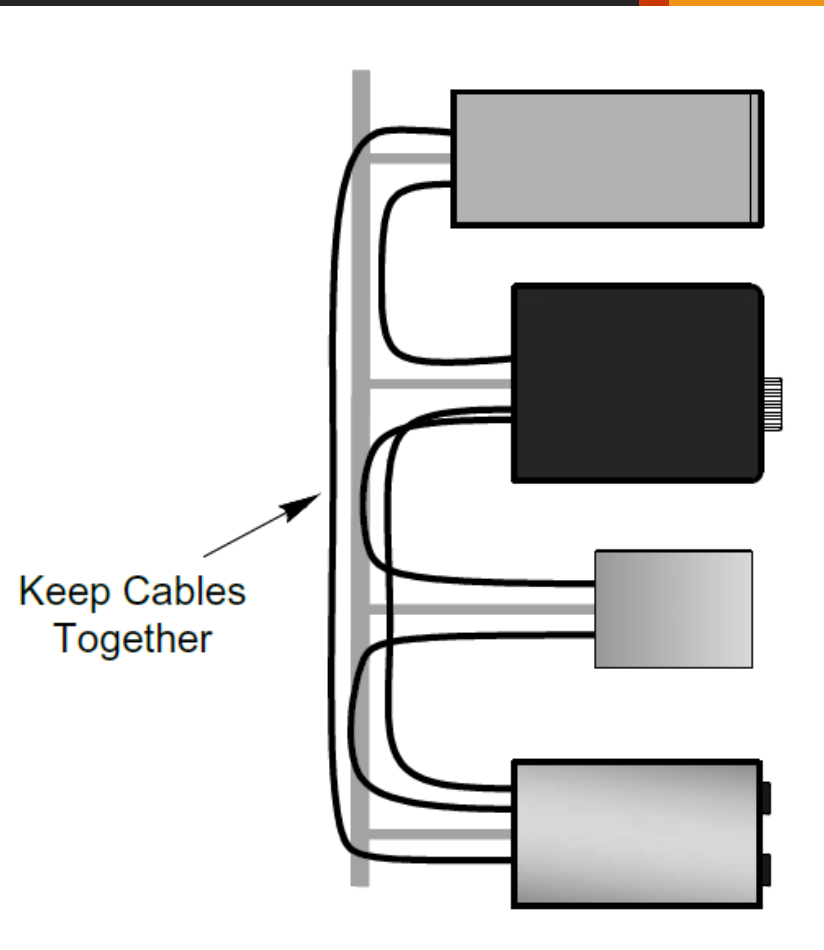
- Bonding inside the shack
  - Eliminates “hot spots”, reduces “buzz” and hum
  - Reduces RFI from common-mode current
  - Reduces sensitivity to physical configuration



# RF Management

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



# RF Management

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# RF Management

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# Ground System Review

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- A single, solid ground system made of short, heavy, direct connections can satisfy all of the requirements for...
  - AC Safety
  - Lightning Protection
  - RF Management & Clean Audio
- Bond all grounds, keep protectors together
- Perimeter ground helps keep lightning currents outside the building

# Additional Resources

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- 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/resources/white-papers](http://www.polyphaser.com/resources/white-papers)) — various papers and tutorials on lightning protection for communications facilities, including ham stations

# Additional Resources

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- 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

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- 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)

***THANKS!!***