# Grounding and Bonding For Home Stations

Ward Silver NØAX

Thanks to Contest University and Icom America

# Goals of the Presentation



- 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



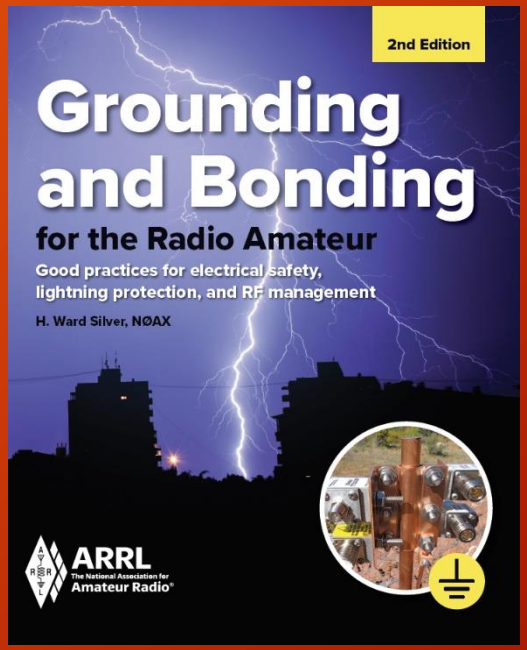
- *ARRL Handbook, ARRL Antenna Book*
- *Lightning Protection for the Amateur Station* (Ron Block, NR2B – Jun/Jul/Aug 2002 *QST*) – ARRL website
- *Power, Grounding, Bonding, and Audio for Amateur Radio* and *RFI, Ferrites, and Common Mode Chokes For Hams* – available at **k9yc.com/publish.htm**
- W8JI website (**w8ji.com/ground_systems.htm**) and for mobile stations KØBG website (**k0bg.com**)

# 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 – 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, 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



- The Earth is NOT – a magic sink into which we can pour RF or lightning and expect it to magically and safely disappear (same for the vehicle body)
- Fuzzy definitions:
  - “RF ground” – ain’t no such thing, only local reference potential
  - “Ground loops” – not the problem you think they are
  - “Single-point ground” – depends on frequency
- Each set of requirements uses “ground” differently

# What *IS* “Bonding” Anyway



- 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



- 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

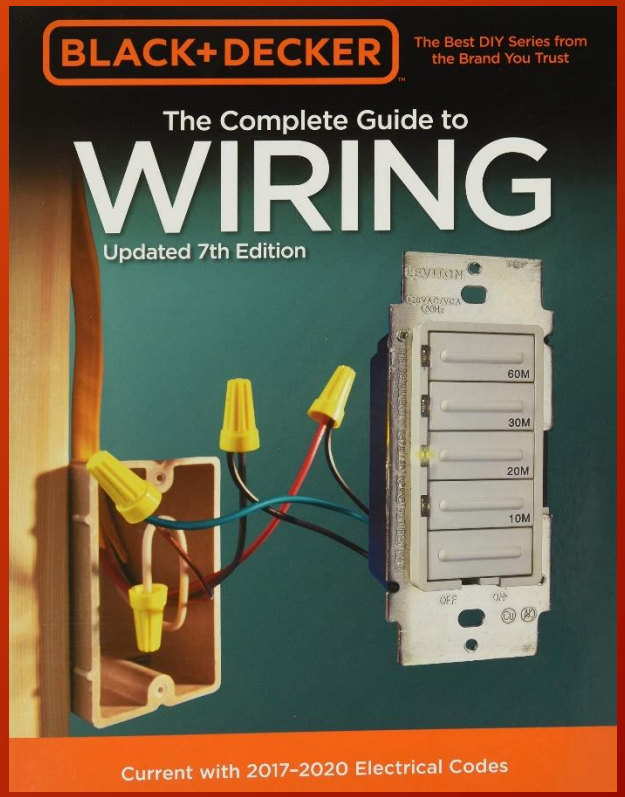


- Grounding for ac safety has several names
  - “Equipment ground”, “third-wire ground”, “green-wire ground”
- Keep ground connections low-resistance
- Purpose is two-fold
  - Provides a path to ac common point for fault current (shorts, leakage)
  - Earth connections stabilize the ac power system voltage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

# AC Safety Grounding



- 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



- 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

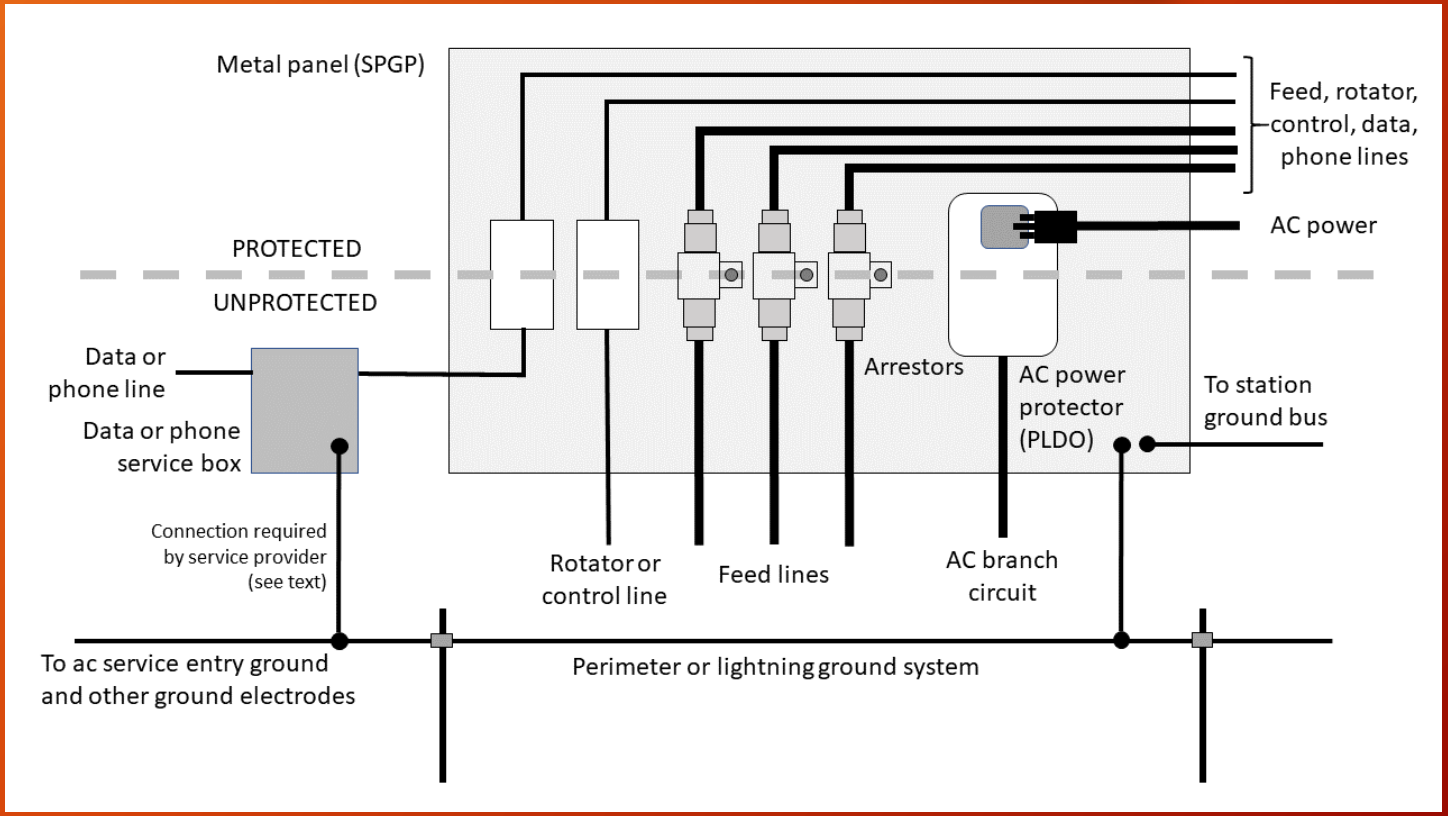


- Single-Point Ground Panels (SPGP)
  - Bonds grounds of all entry paths
    - Connected to perimeter ground
  - All protectors “fire” at the same time
    - Minimize voltage differences due to transient timing
  - Includes non-RF and AC power
  - Keep protected and unprotected cables separated

# Lightning Protection



- Single-point Ground Panel (SPGP)



# Lightning Protection



- Single-point Ground Panel (station entry)

# Lightning Protection

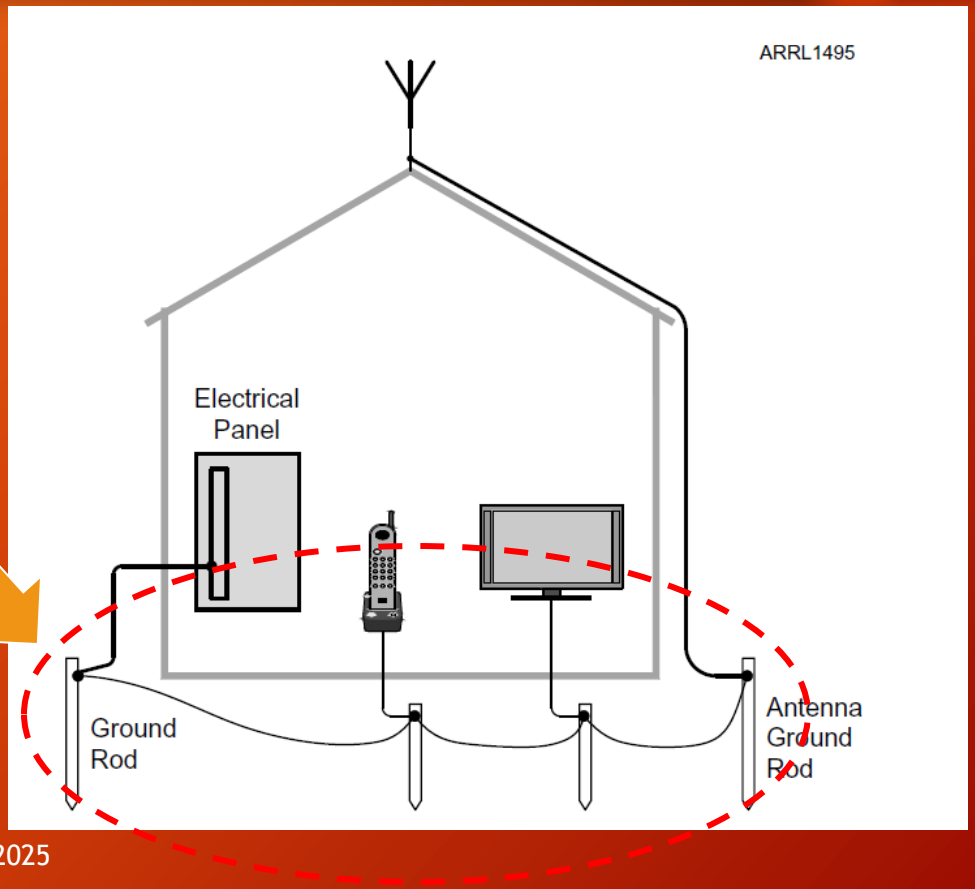


- Single-point Ground Panel (tower base)

# Lightning Protection



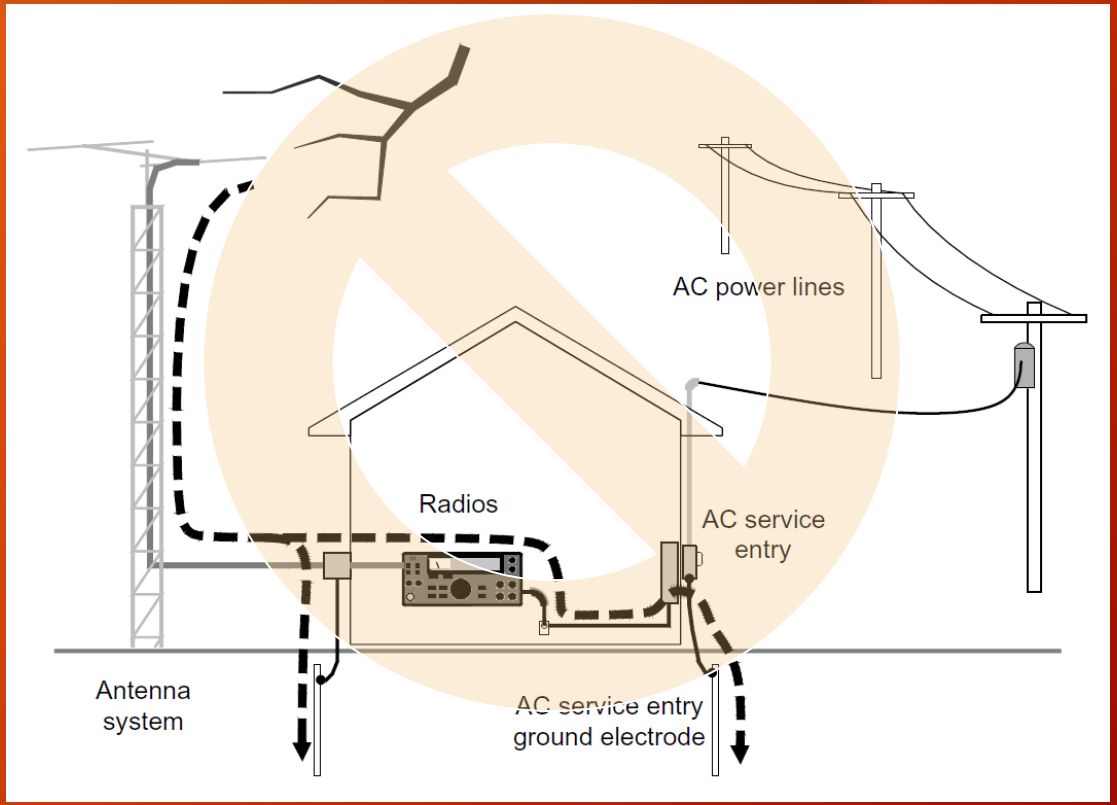
Bond ALL earth connections together – required!



# Lightning Protection



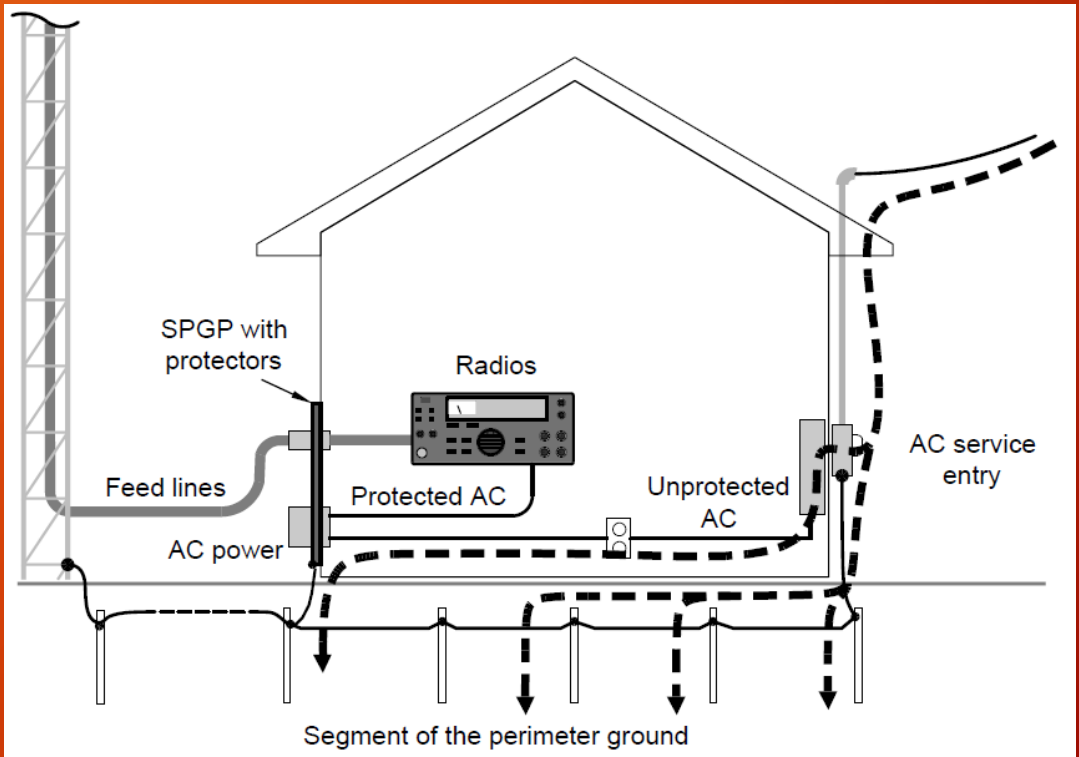
- Don’t create low-impedance paths *through* your station



# Lightning Protection



- Ground paths should go *around* your station



# Lightning Protection

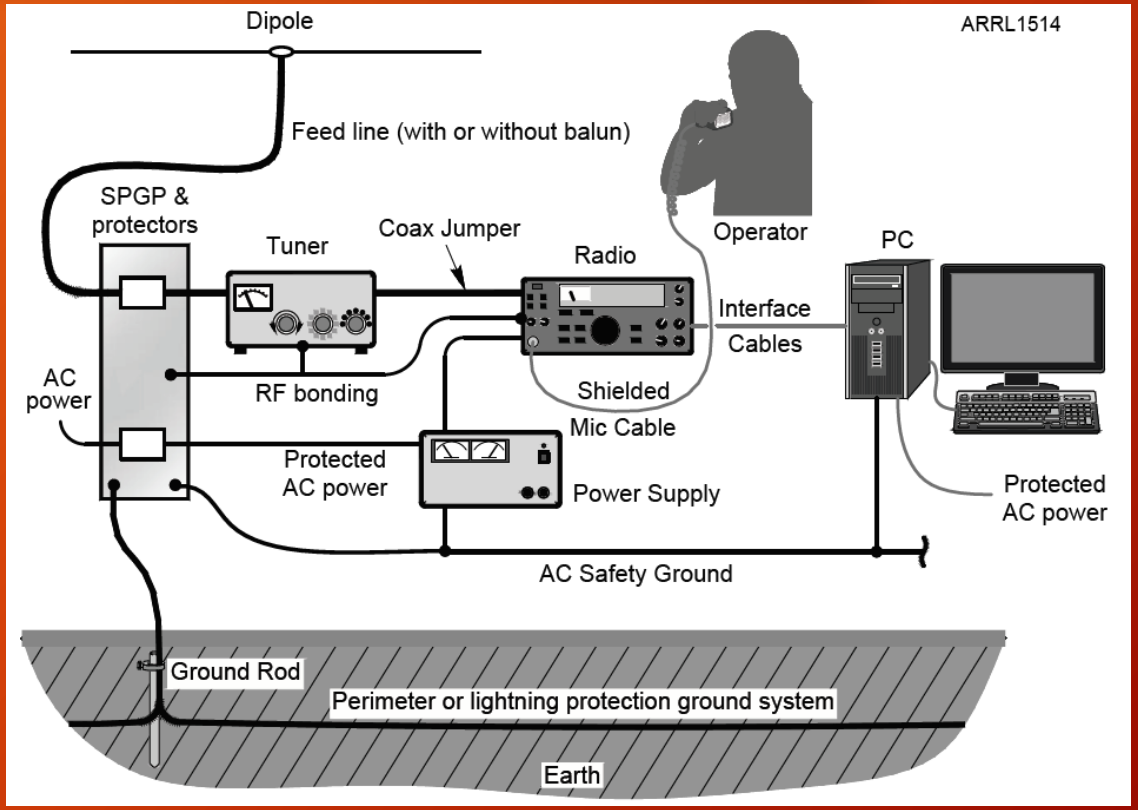


- Rods and radials
- Bond feed lines to the tower every 50 feet
- Spark gaps for insulated base towers

# RF Management



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



# RF Management

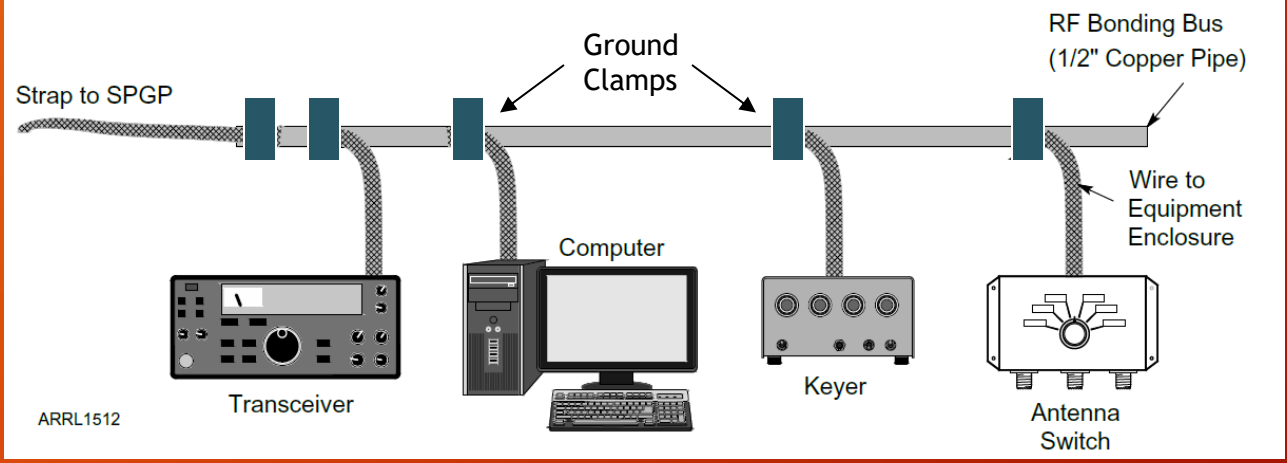


- Forget about an all-band “RF ground”
  - Concentrate instead on bonding
  - Keep connections *electrically short*
  - Keep everything at the SAME voltage
- Amplifiers = high RF field strength
  - Requires extra attention to bonding
- Create common reference plane and/or bus

# RF Management



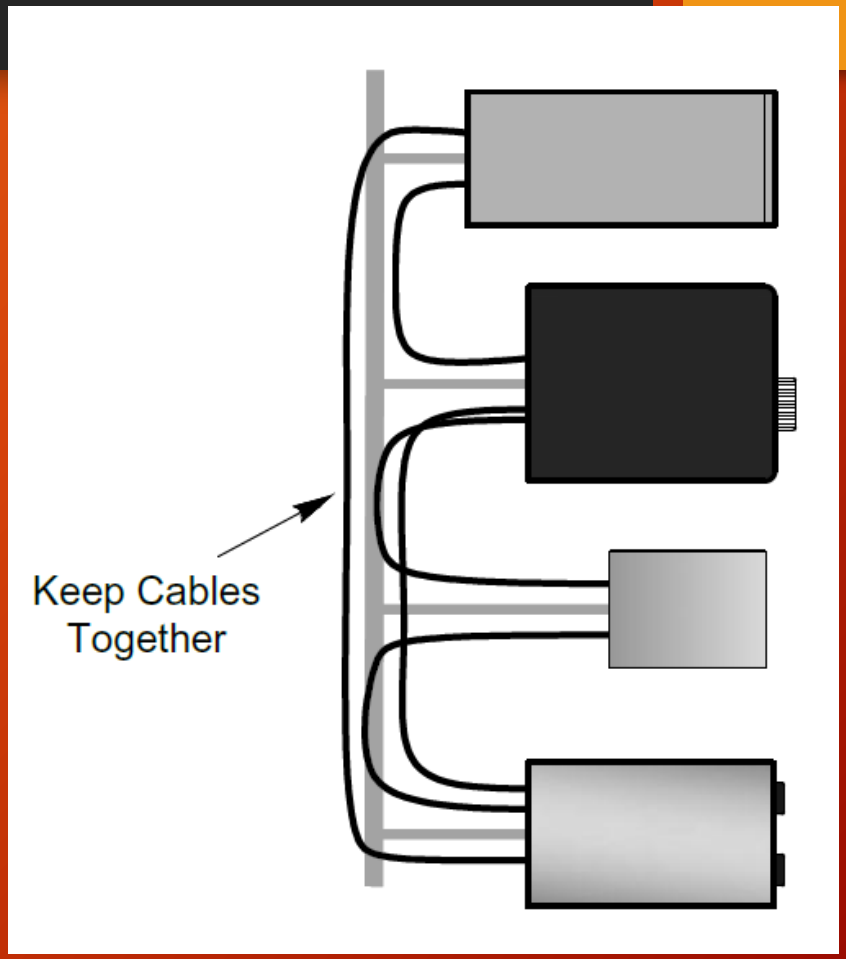
- Bonding inside the shack
  - Eliminates “hot spots”, reduces “buzz” and hum
  - Reduces RFI from common-mode current
  - Reduces sensitivity to physical configuration



# RF Management

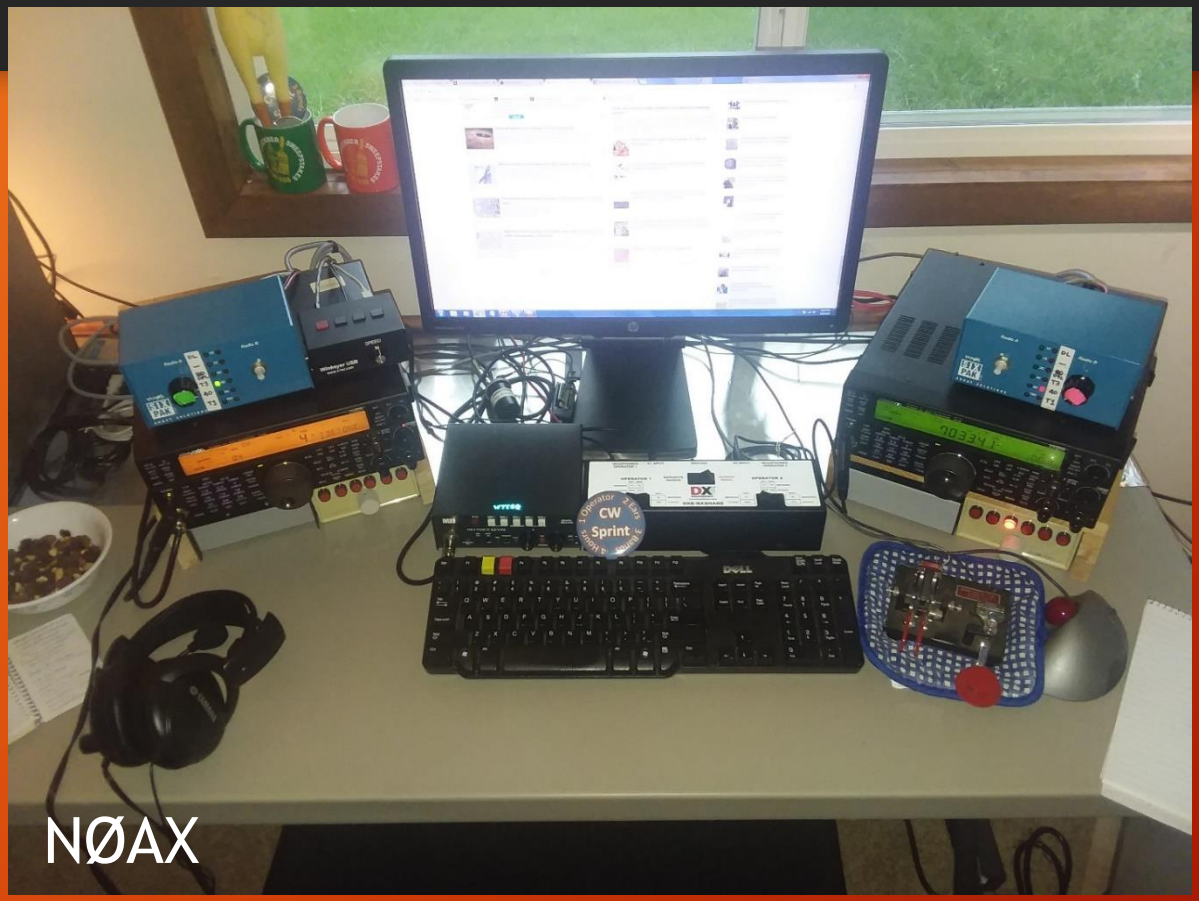


- Minimize loop area and cable length
- Short or coiled cables
- Use a bonding bus and reference plane
- Use shielded cables
- Short straps or wires



# RF Management



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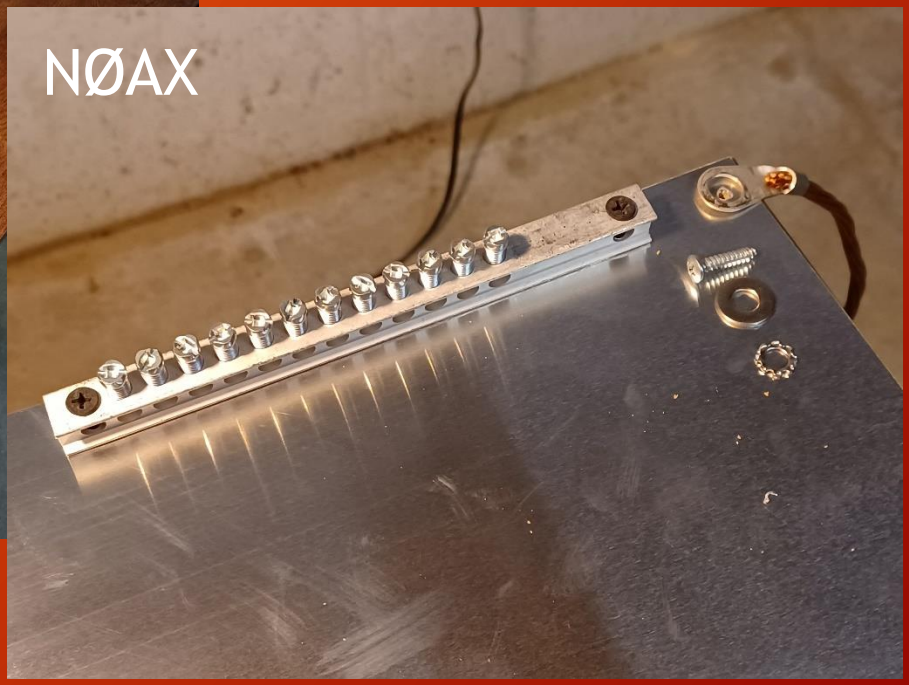
# RF Management





# Ground System Review



- 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



- 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/resources/white-papers**) — various papers and tutorials on lightning protection for communications facilities, including ham stations

# 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**
  - 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**

# *THANKS!!*