

6 Meter BBQ Presents

Grounding & Bonding

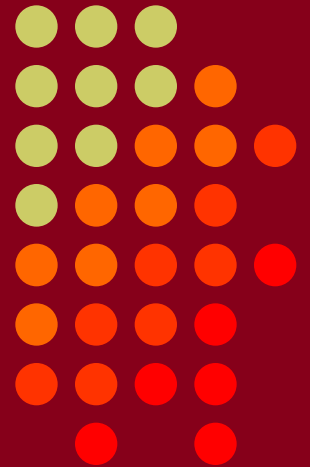
For VHF Shacks

Tim Duffy K3LR

With credit to Ward, N0AX

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CONTEST
UNIVERSITY

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Goals of the Session



- Understand “ground” and “bond”
- Appreciate the different requirements for ac safety, lightning protection, RF and audio
- Illustrate some techniques
- Show how a system approach works
- Point you at more comprehensive resources

Who Is This Talk For?



- Station builders...
 - Just starting out
 - Putting up a first tower
 - Expanding a station
 - In lightning country
 - Trying for better performance

Background References



- *ARRL Handbook, ARRL Antenna Book*
- *Grounding and Bonding for the Radio Amateur*
- *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

What IS “Ground” Anyway



- The right answer depends on what you are trying to do
- What you are trying to do depends on frequency, voltage, current
- Your **safety** depends on the right answer
- Your **equipment** depends on the right answer

What IS “Ground” Anyway



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- 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...
- 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 – Tinned Copper Braid - wide
 - Braid from old coax deteriorates

AC Safety Grounding



- Before we go any further...

SAFETY FIRST

- Don't be the one to say, "I didn't think it would happen to me..."

AC Safety Grounding



- And a friendly reminder from your AHJ*

LOCAL CODE IS THE LAW

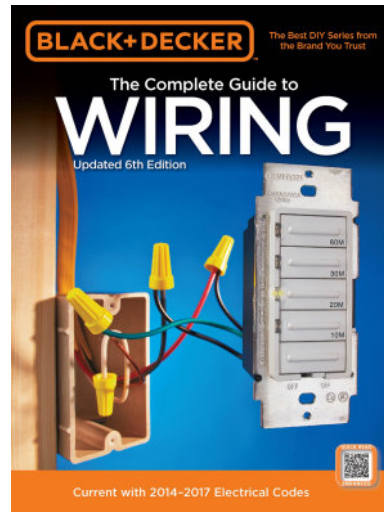
- If you don't have a local code, use the NEC

* - Authority Having Jurisdiction

AC Safety Grounding



- If you aren't sure you know what you're doing...get a how-to reference



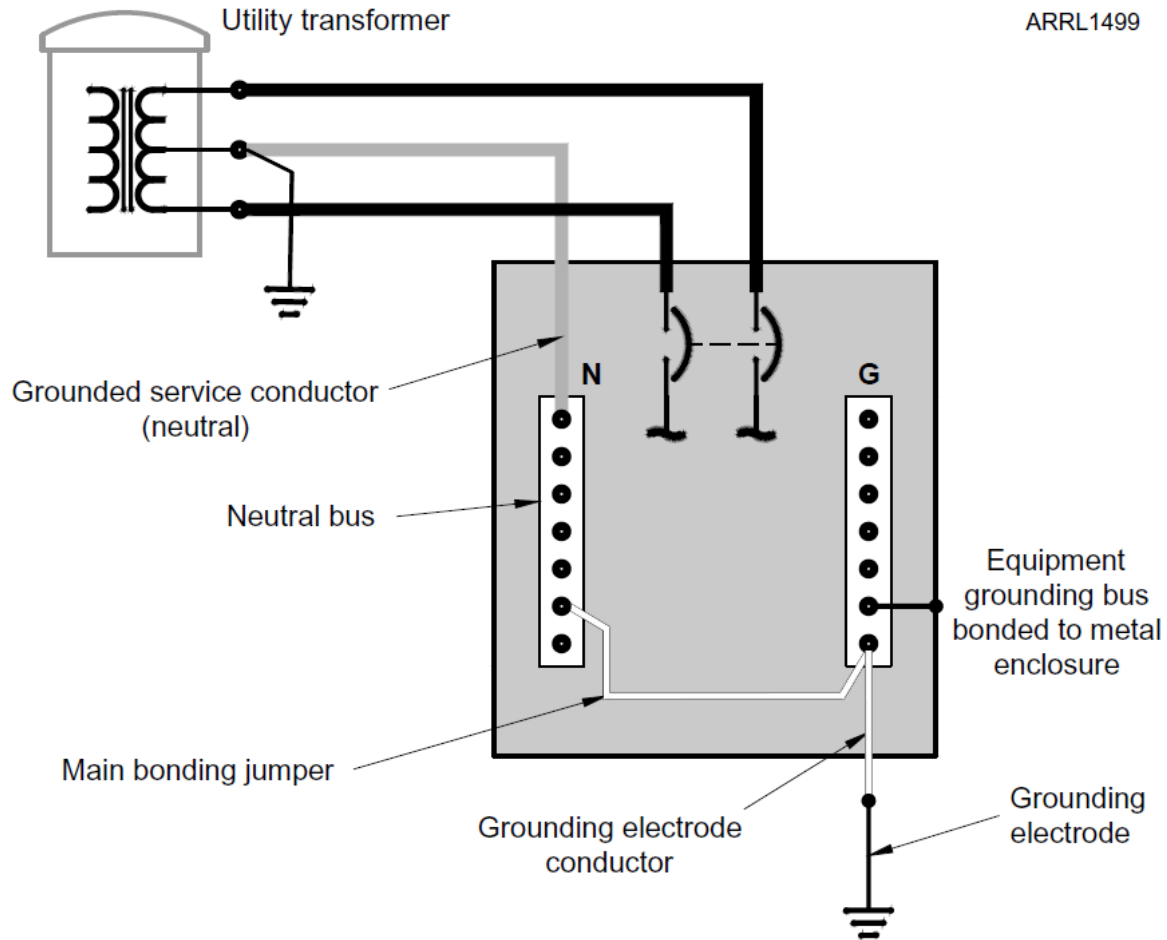
- Or hire a professional electrician

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

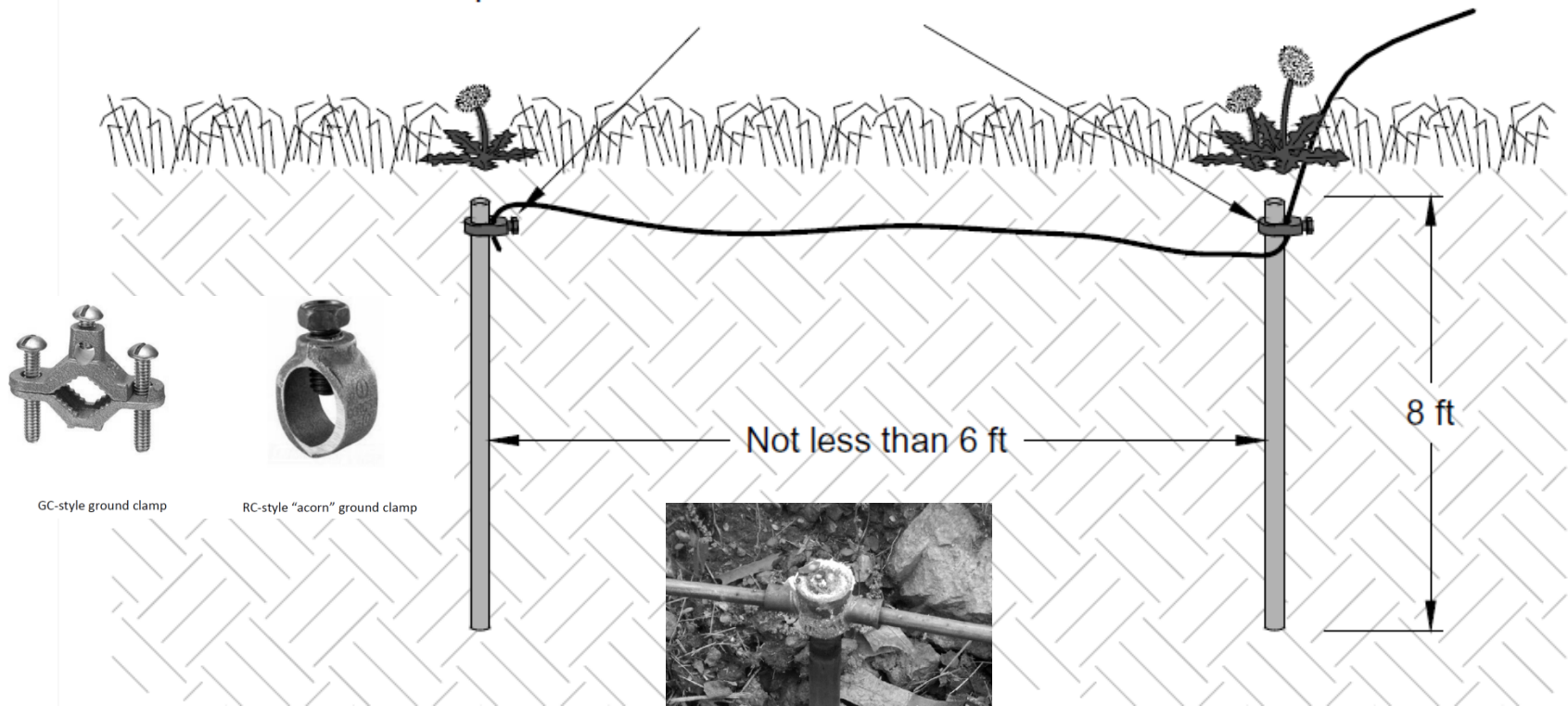
AC Safety Grounding



AC Safety Grounding



Clamps suitable for direct burial or exothermic weld



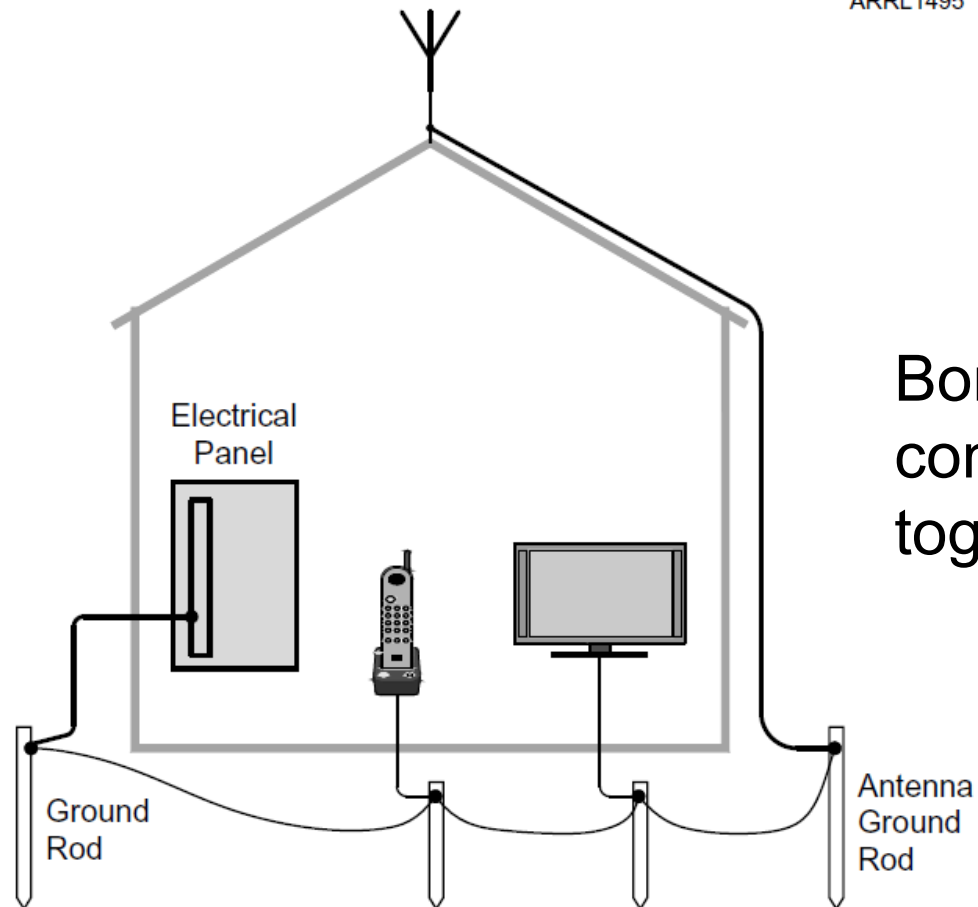
GC-style ground clamp

RC-style "acorn" ground clamp

AC Safety Grounding



ARRL1495



Bond ALL earth connections together

Lightning Protection

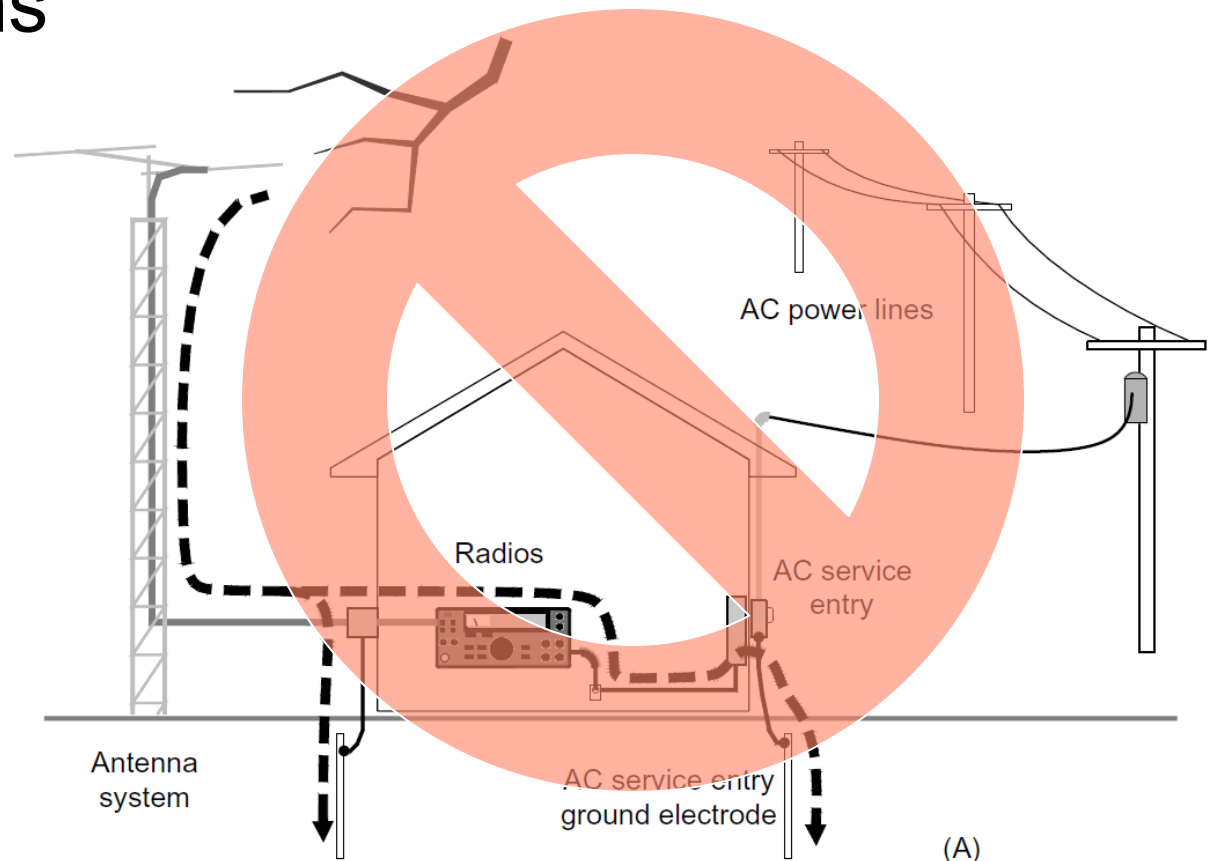


- You can't steer lightning, but...you *can* help lightning make “good decisions”
 - Heavy, low-impedance paths to the Earth
 - Inductance is more important than resistance
 - Paths should be *outside* your residence
 - Don't make it easy for lightning to go through your station on its way to the Earth

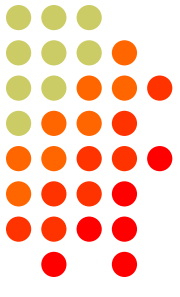
Lightning Protection



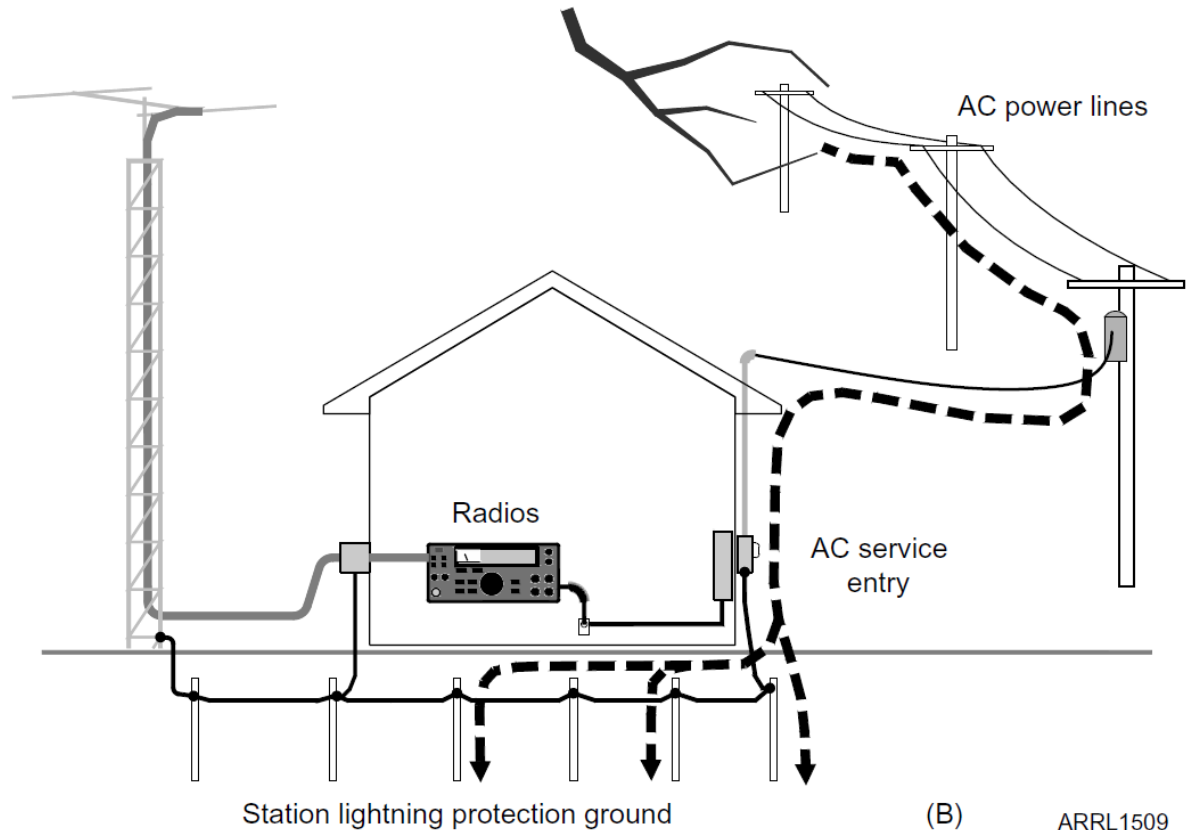
- Ground paths should go *around* your station



Lightning Protection



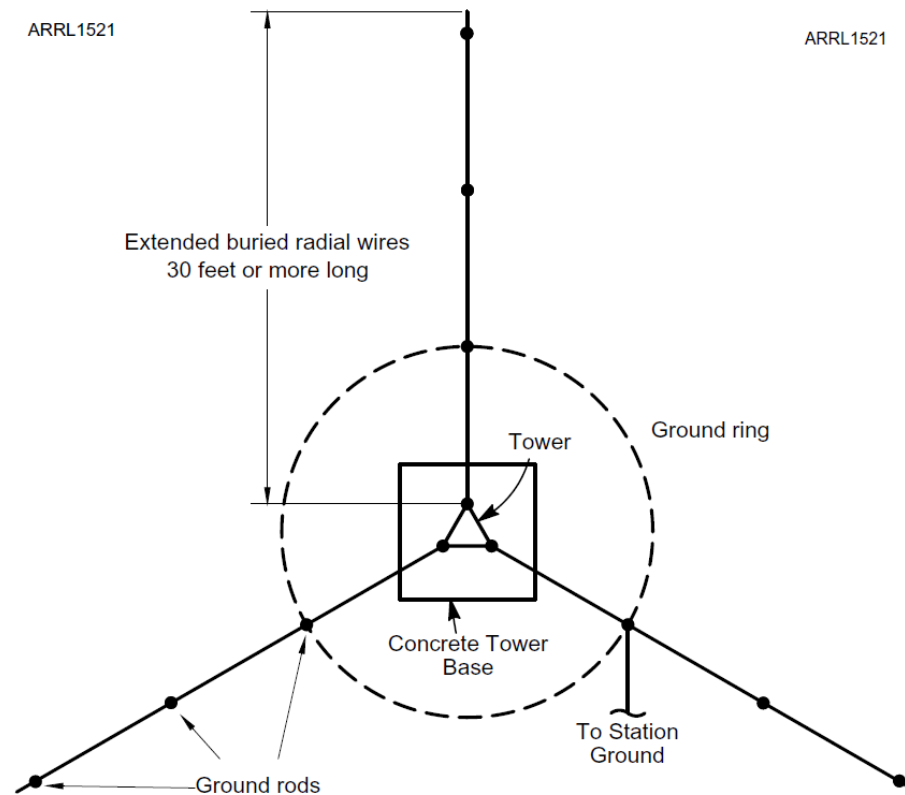
- Ground paths should go *around* your station



Lightning Protection



- Tower grounding



Lightning Protection



- Bond feed lines to the tower



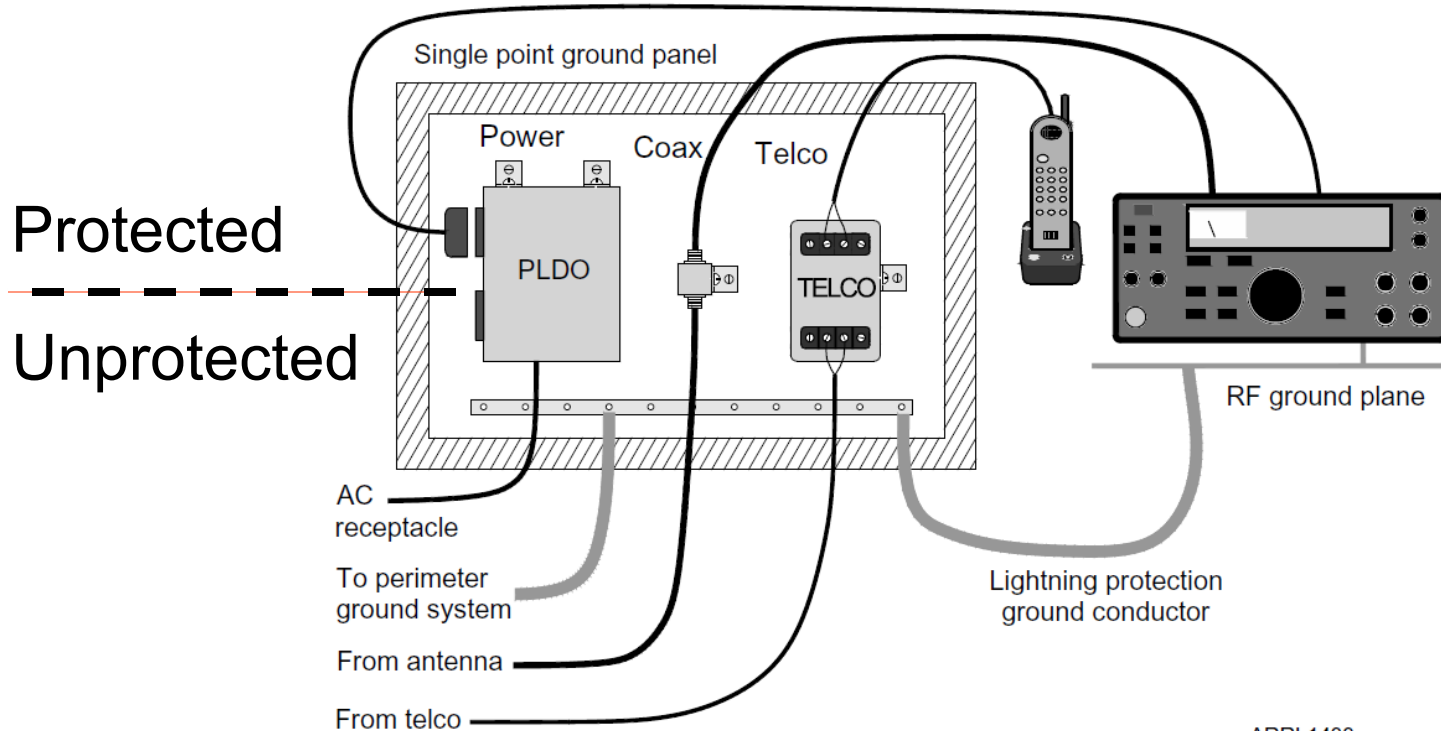
- Spark gaps across insulators



Lightning Protection



- Single-point Ground Panel

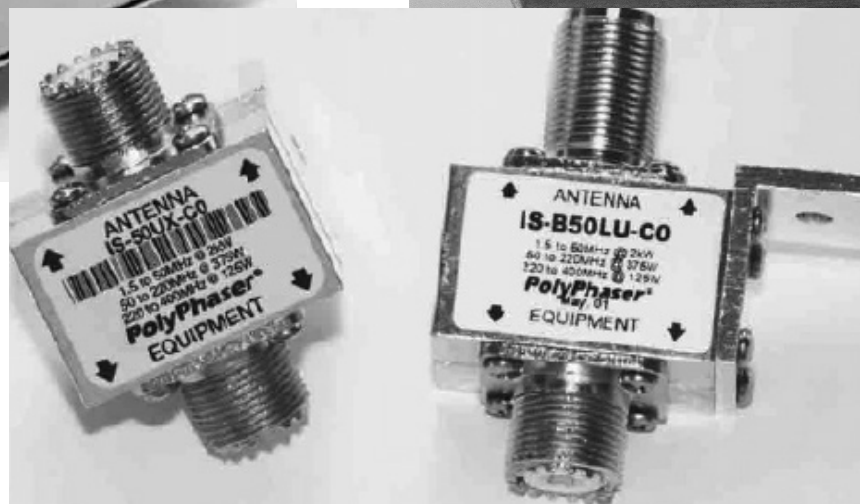
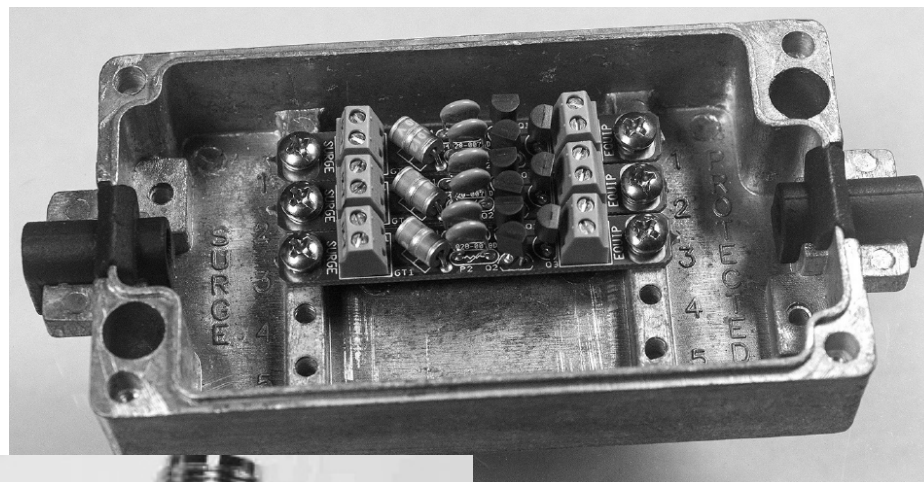
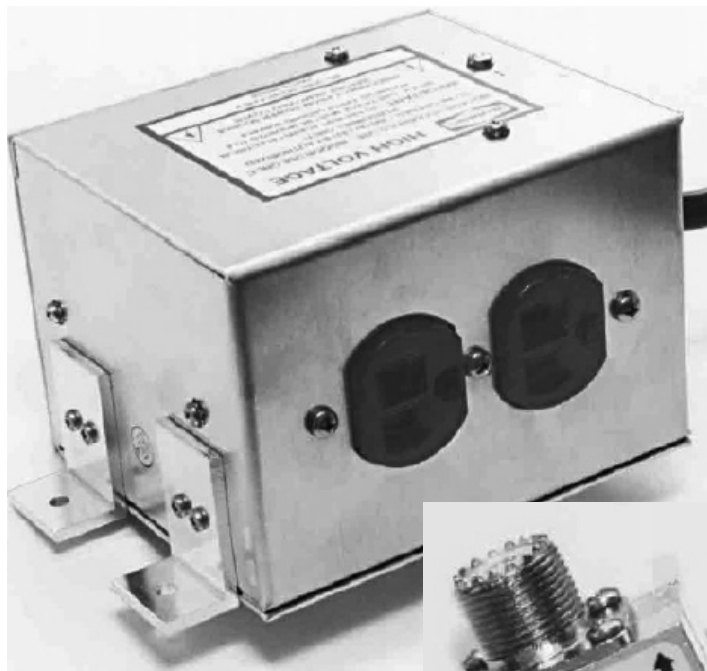


ARRL1433

Lightning Protection

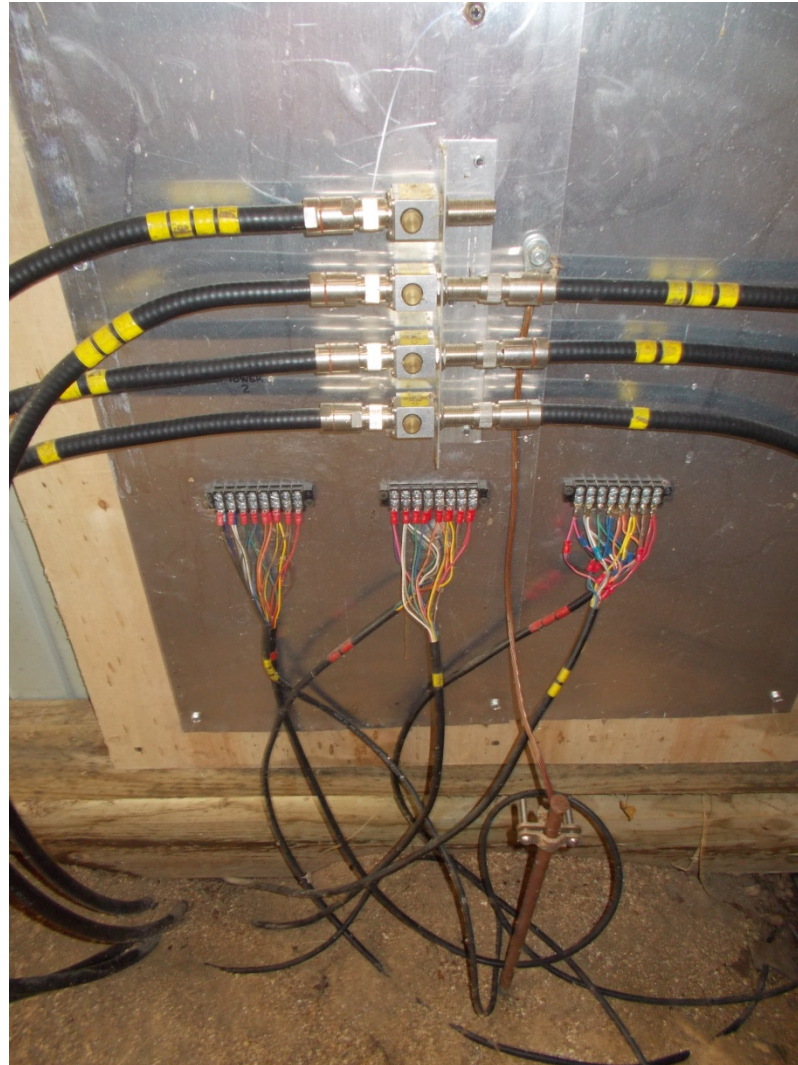


- Single-point Ground Panel



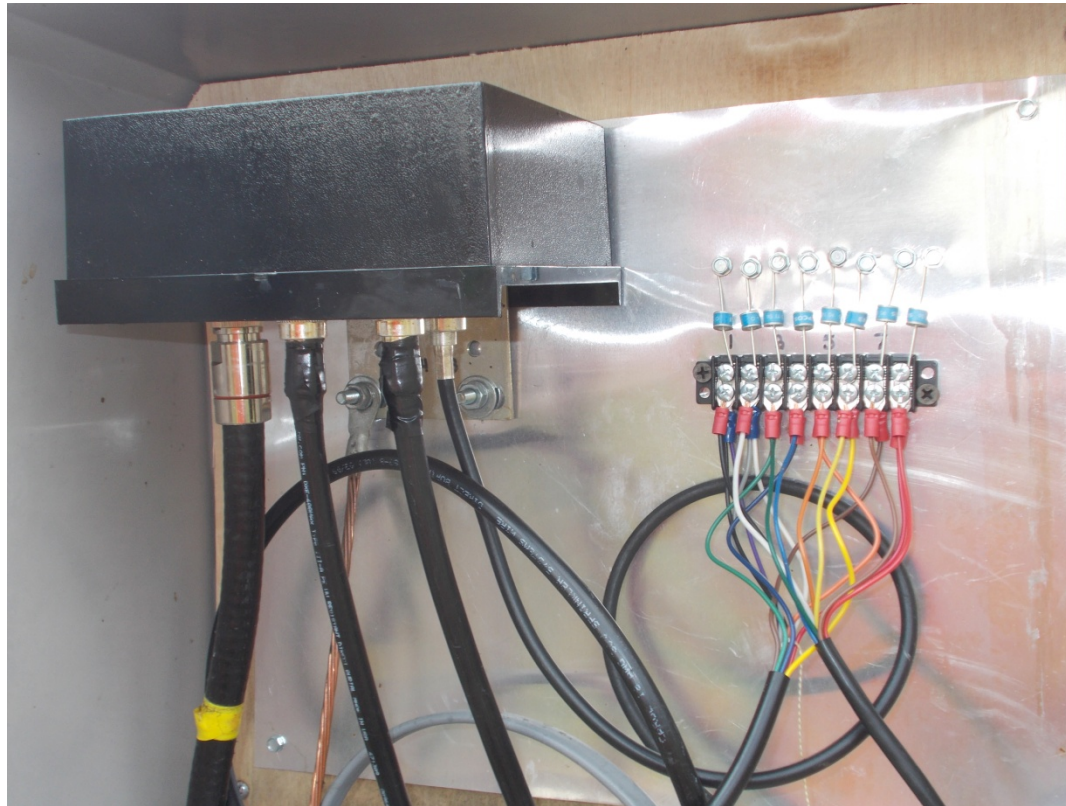
Lightning Protection

- Single-point Ground Panel



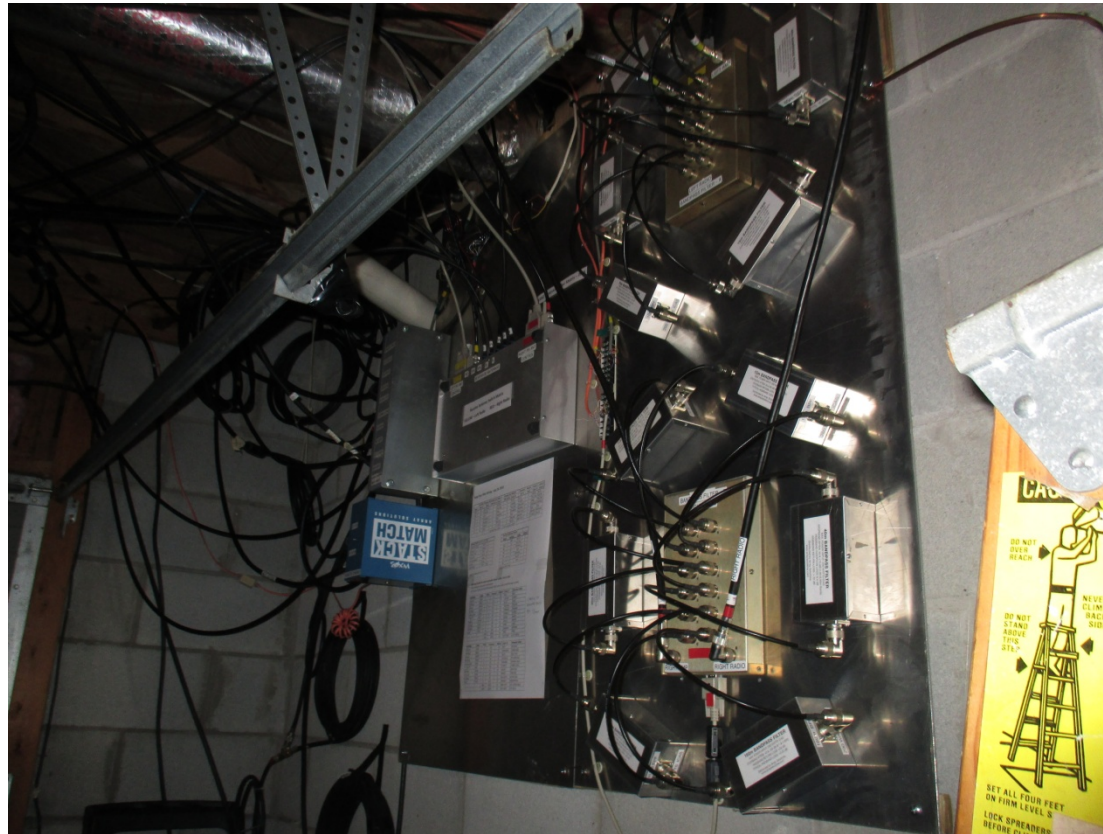
Lightning Protection

- Single-point Ground Panel



Lightning Protection

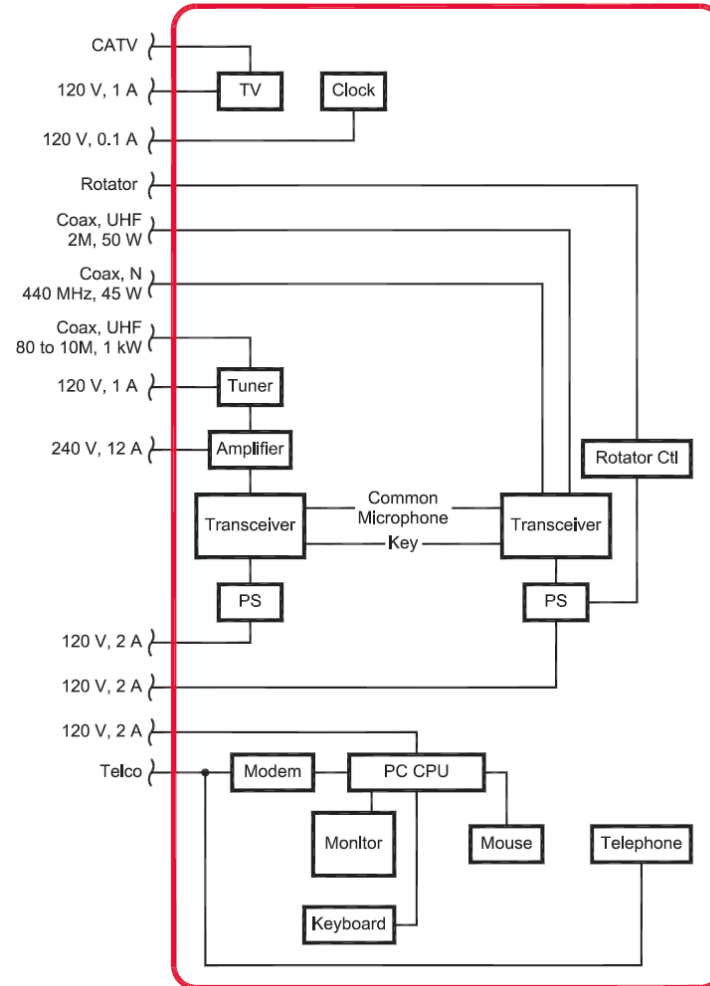
- Single-point Ground Panel





Lightning Protection

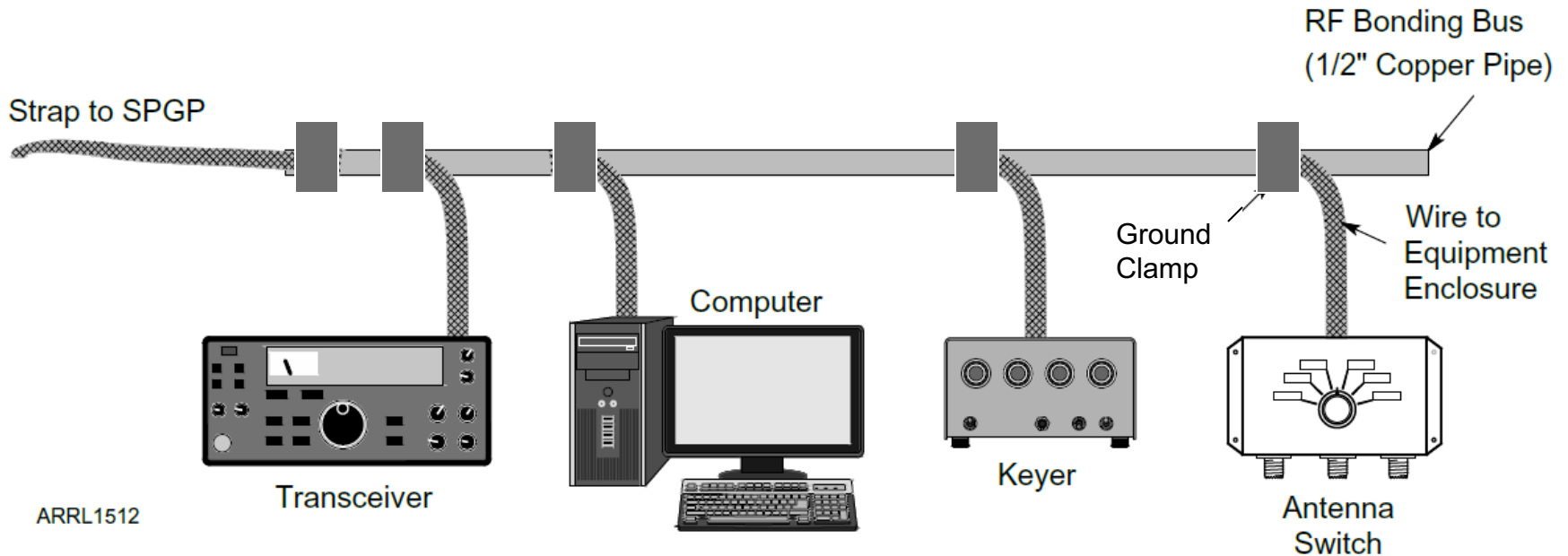
- Protected Zones
 - Every line crossing the boundary must be protected
 - Must all have a common or bonded ground connection
 - Bond equipment within the station



Lightning Protection



- Bonding inside the shack



RF Management

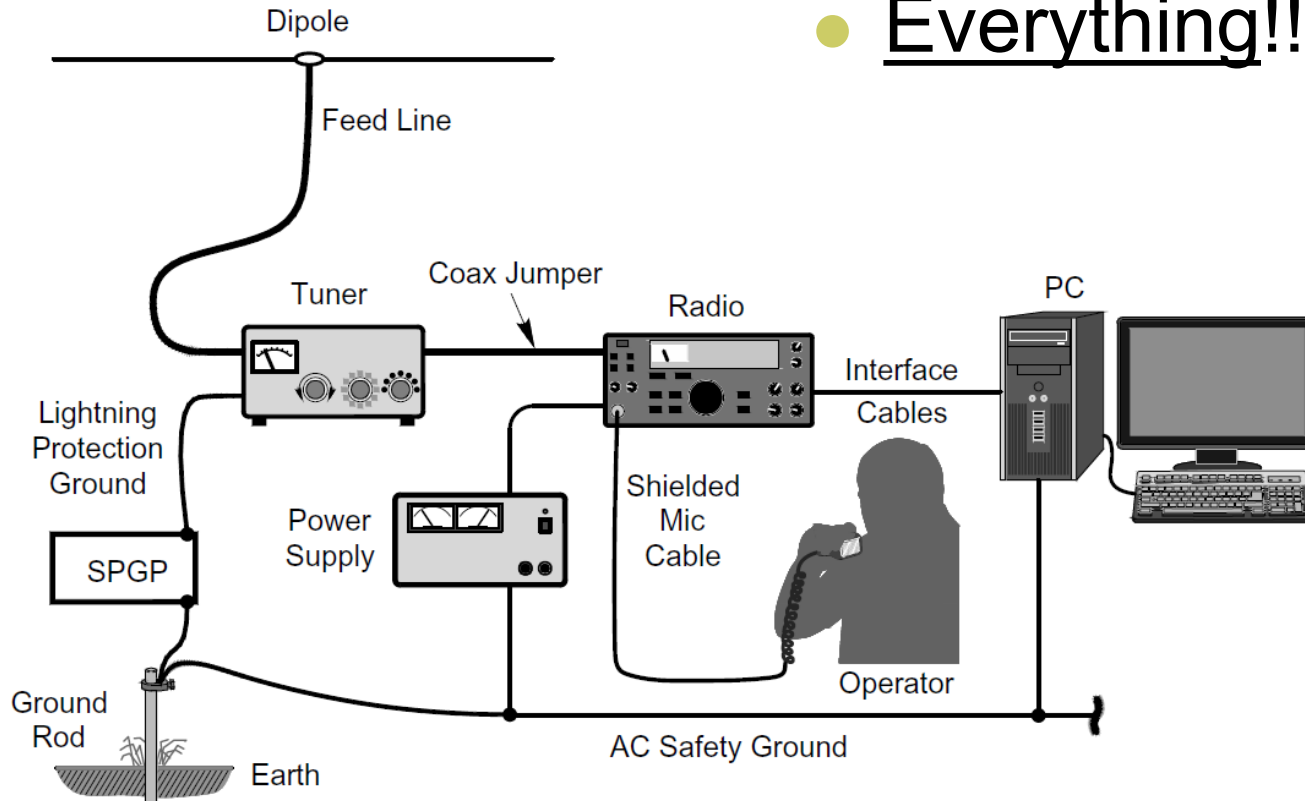


- Everything in the station is an antenna

RF Management



● Everything!!



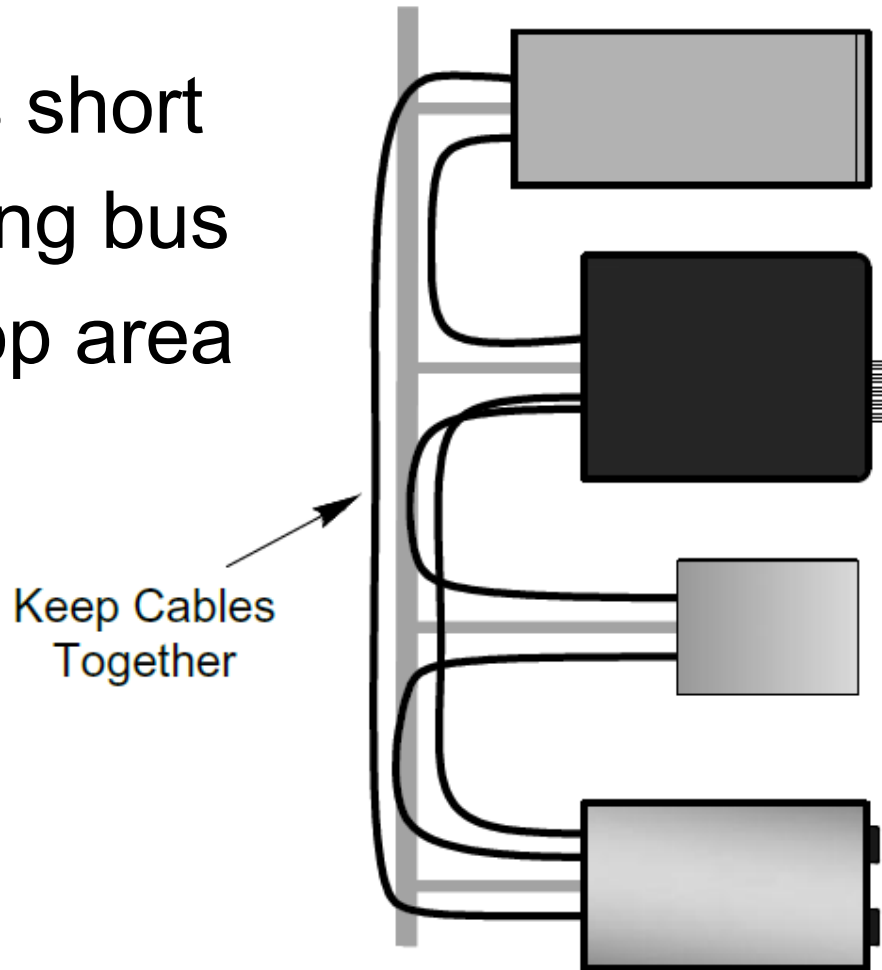
RF Management



- Everything in the station is an antenna
- Forget about an “RF ground”
- Concentrate instead on bonding
- Equalize voltage to minimize current
 - Eliminates “hot spots”
 - Reduces RFI from common-mode current
 - Reduces sensitivity to physical configuration
 - Minimizes audio “buzz” and hum

RF Management

- Keep cables short
- Use a bonding bus
- Minimize loop area

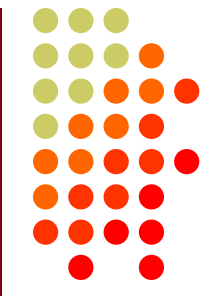


RF Management

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



Ground System



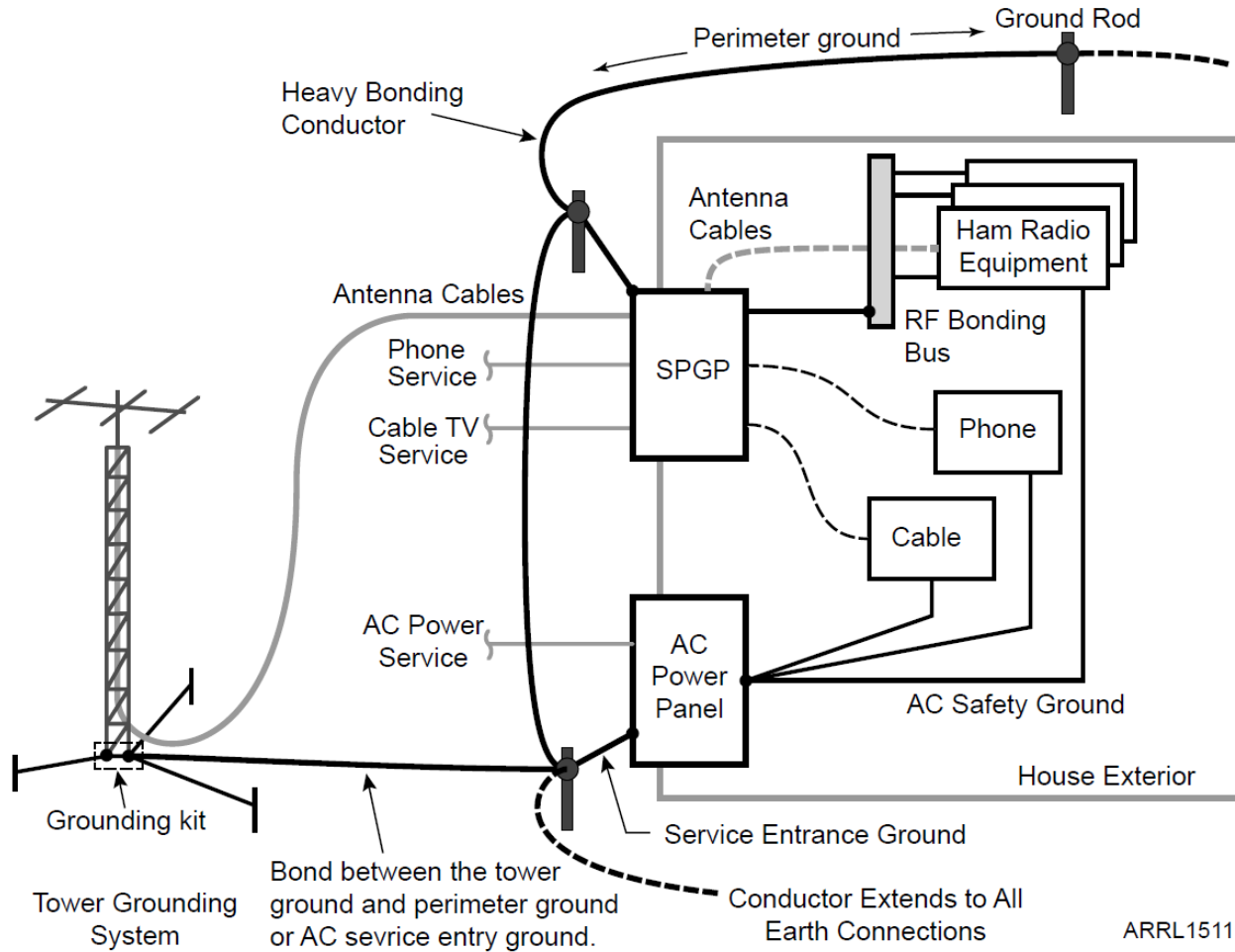
- Now for some good news...

Ground System

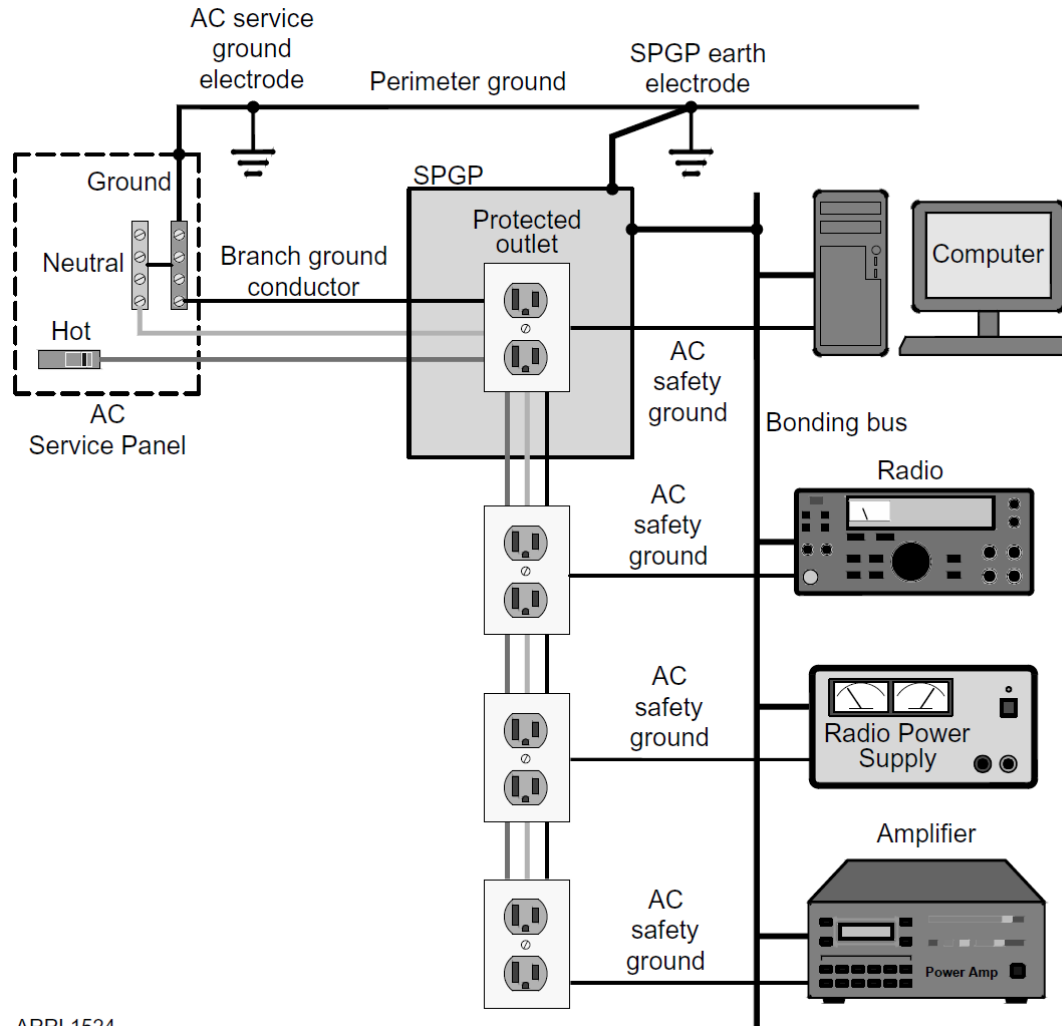


- “One system to rule them all”
- All currents flow on all wires
- A single, solid ground system made of short, heavy, direct connections satisfies all of the requirements for...
 - AC Safety
 - Lightning Protection
 - RF Management & Clean Audio

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

- 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)