

6 Meter BBQ Presents

Grounding & Bonding

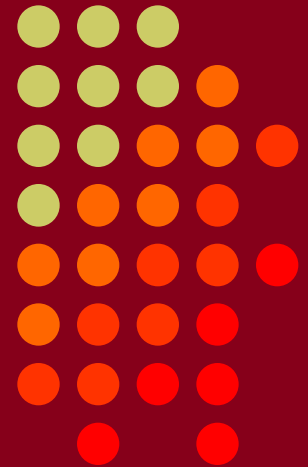
For VHF Shacks

Tim Duffy K3LR

With credit to Ward, N0AX

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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

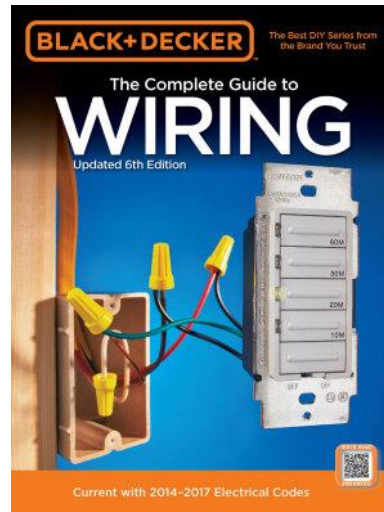
- If you don't have a local code, use the NEC

* - Authority Having Jurisdiction

AC Safety Grounding



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



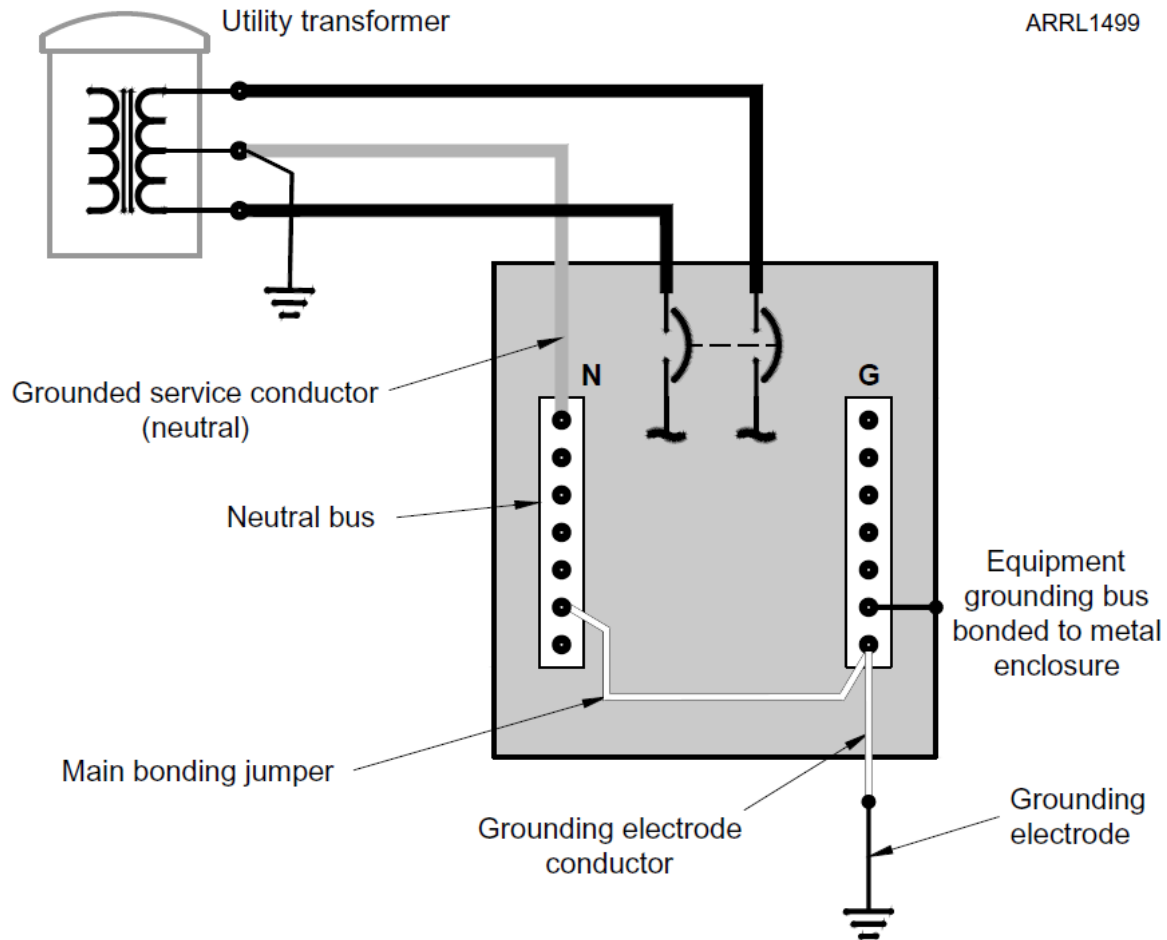
- Or hire a professional electrician

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

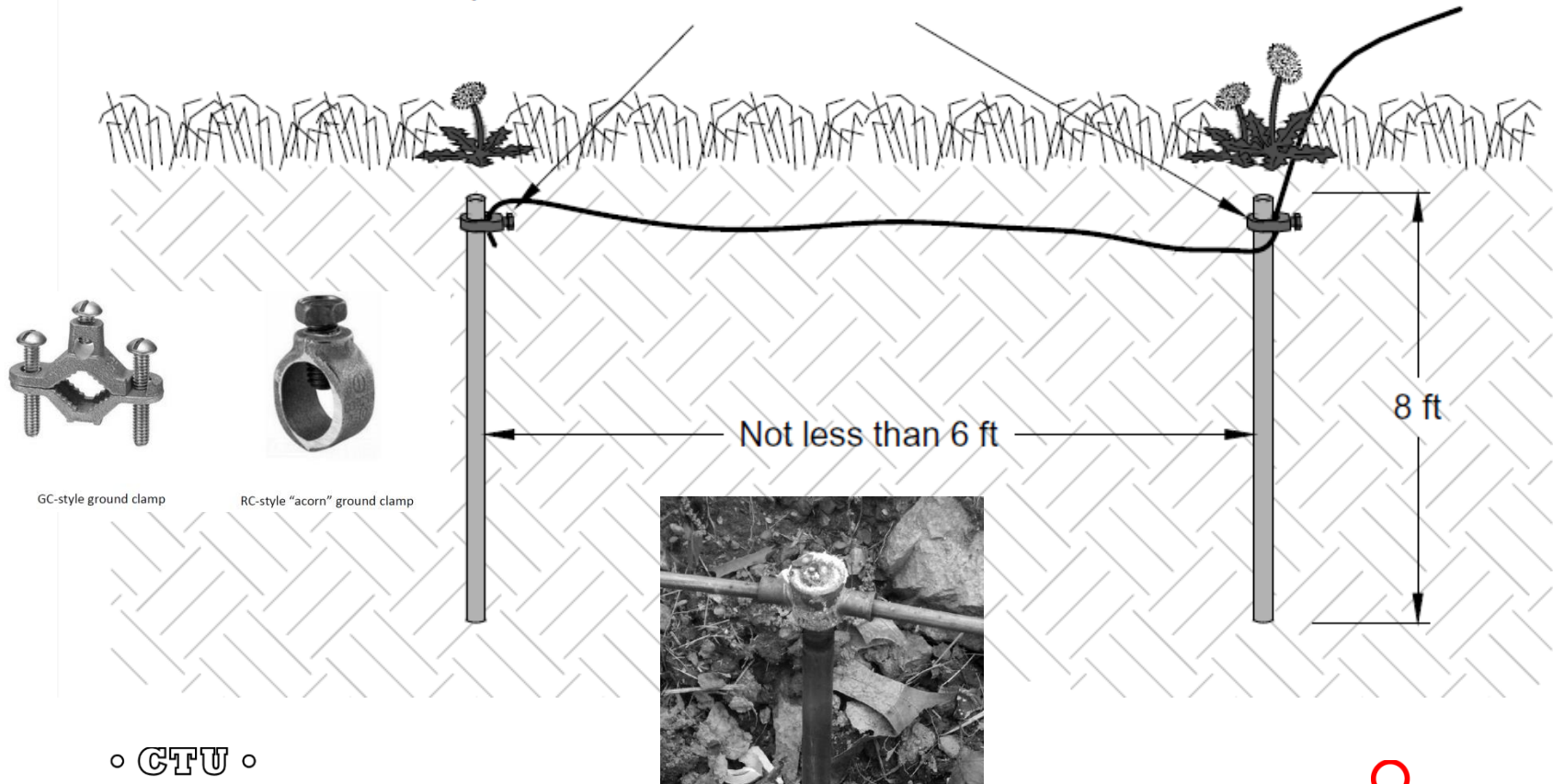
AC Safety Grounding



AC Safety Grounding



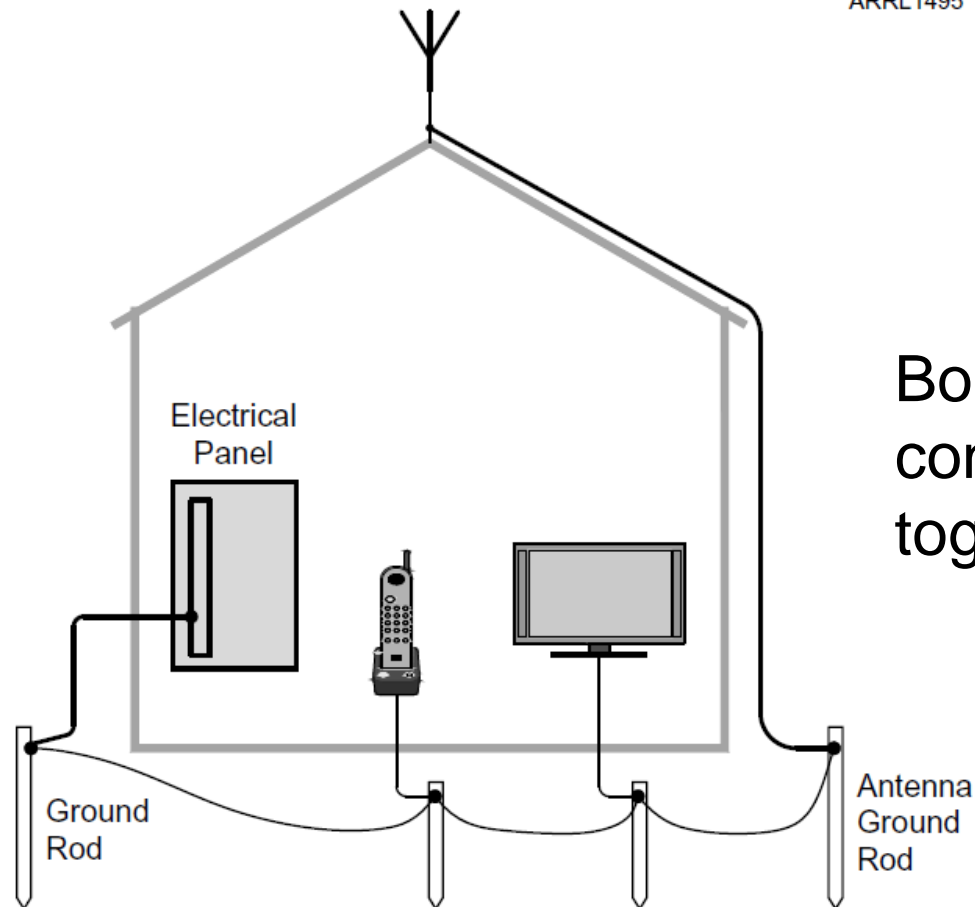
Clamps suitable for direct burial or exothermic weld



AC Safety Grounding



ARRL1495



Lightning Protection

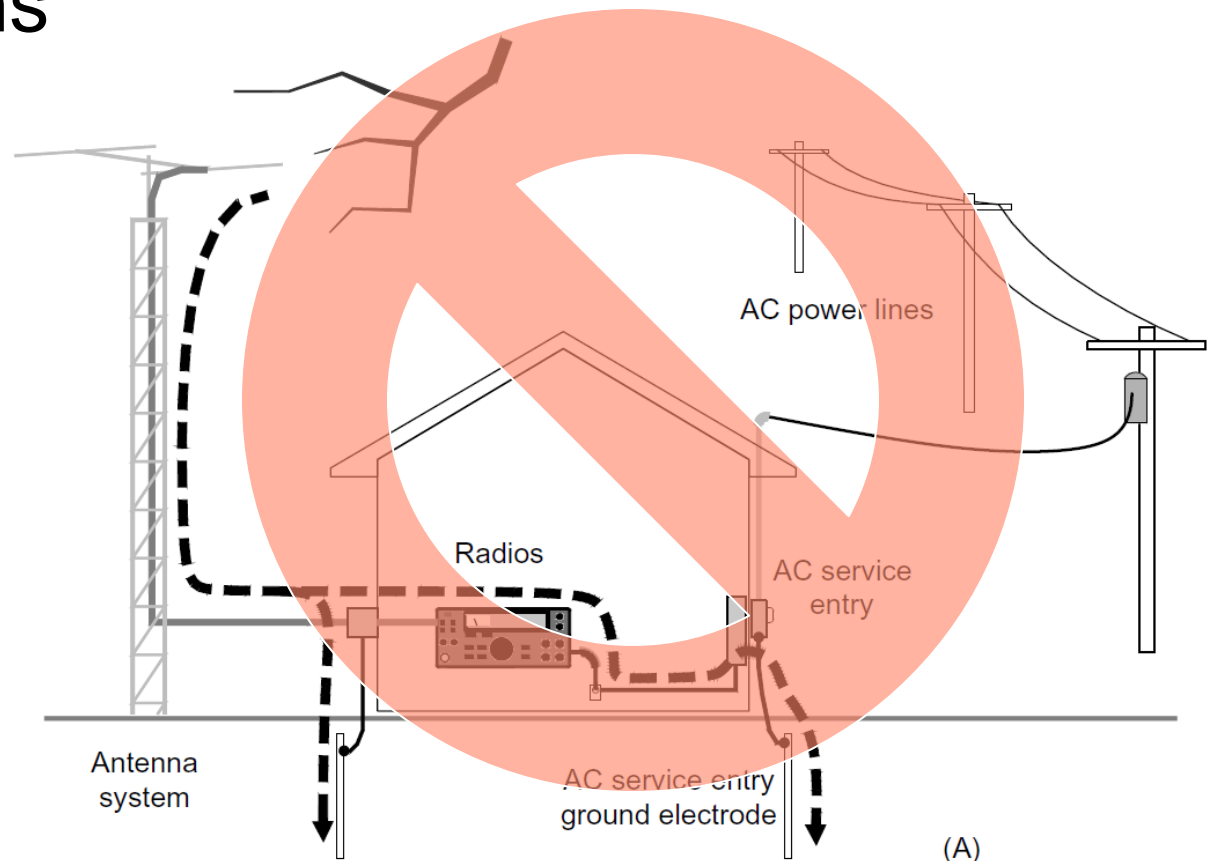


- You can't steer lightning, but...you *can* help lightning make “good decisions”
 - Heavy, low-impedance paths to the Earth
 - Inductance is more important than resistance
 - Paths should be *outside* your residence
 - Don't make it easy for lightning to go through your station on its way to the Earth

Lightning Protection



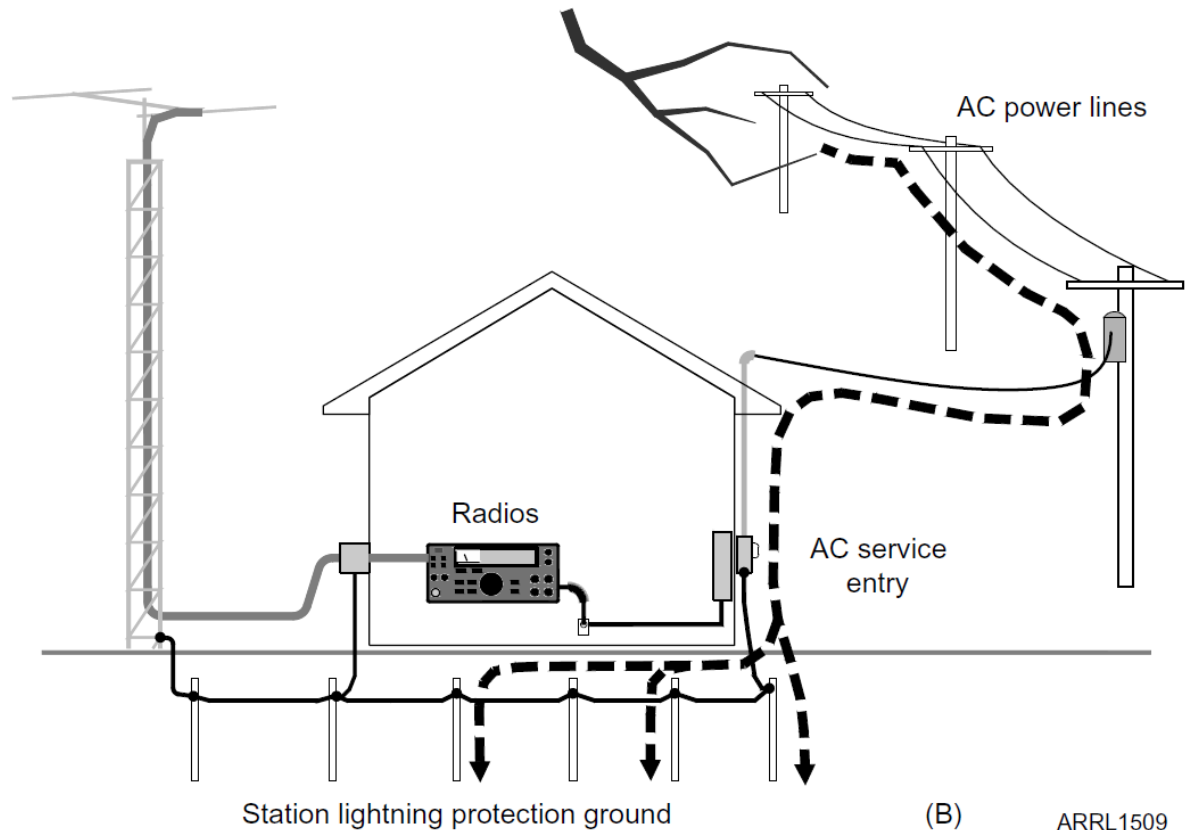
- Ground paths should go *around* your station



Lightning Protection



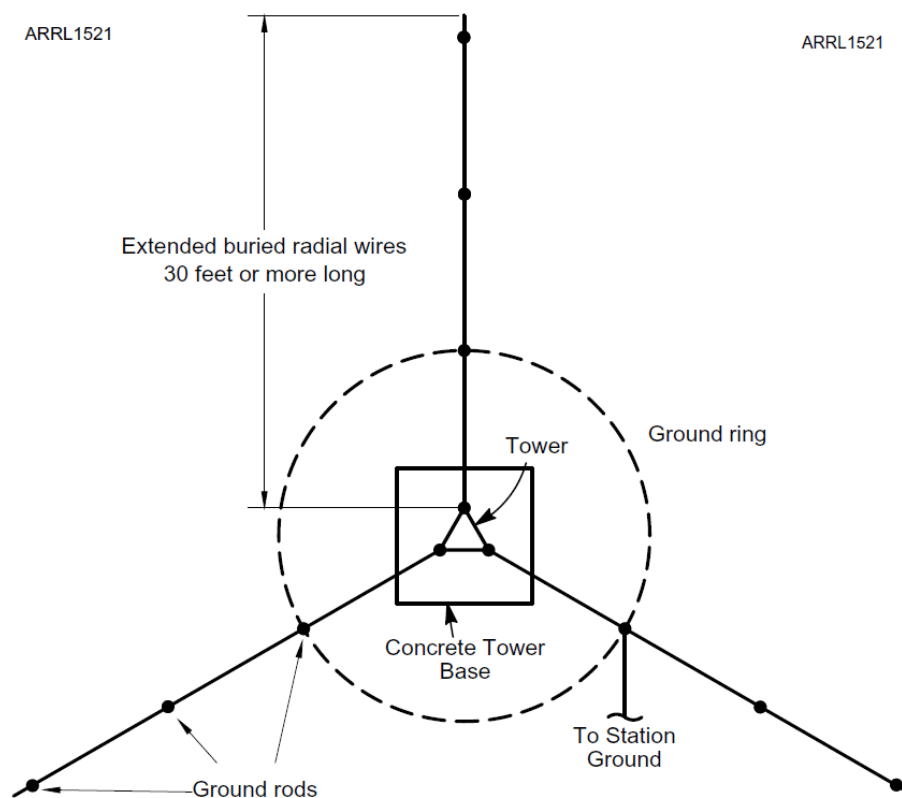
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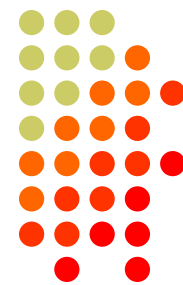
Lightning Protection



- Tower grounding



Lightning Protection



- Bond feed lines to the tower



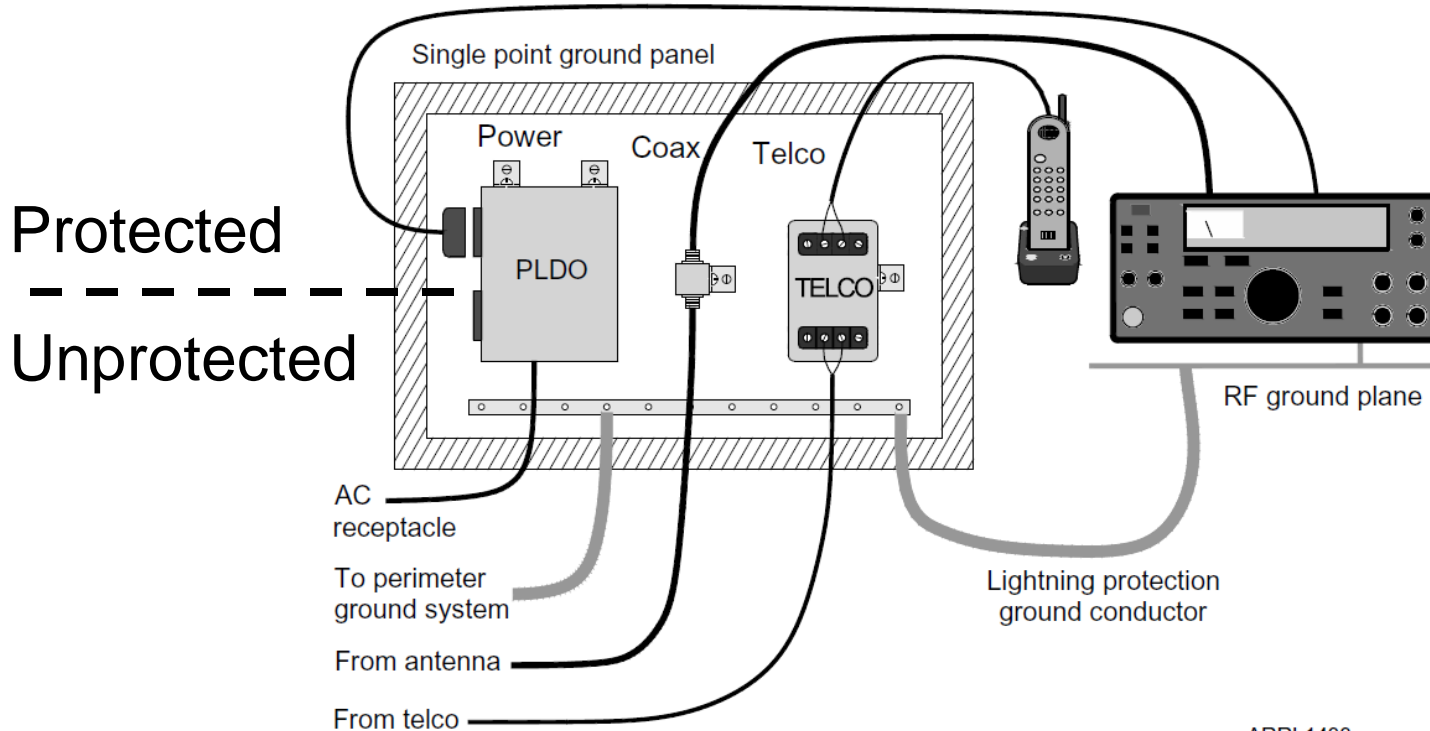
- Spark gaps across insulators



Lightning Protection



- Single-point Ground Panel

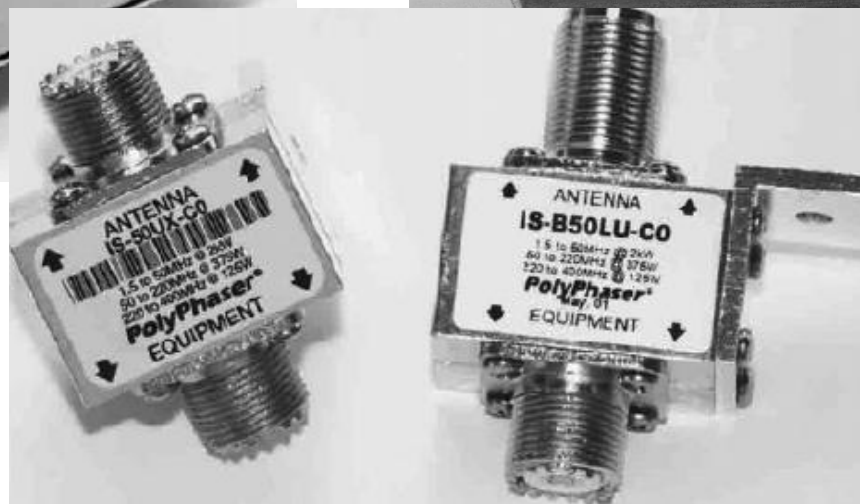
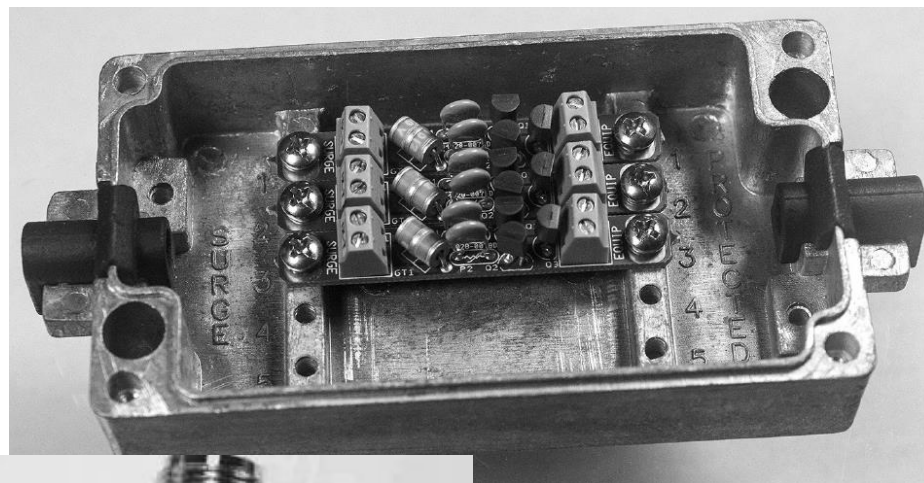
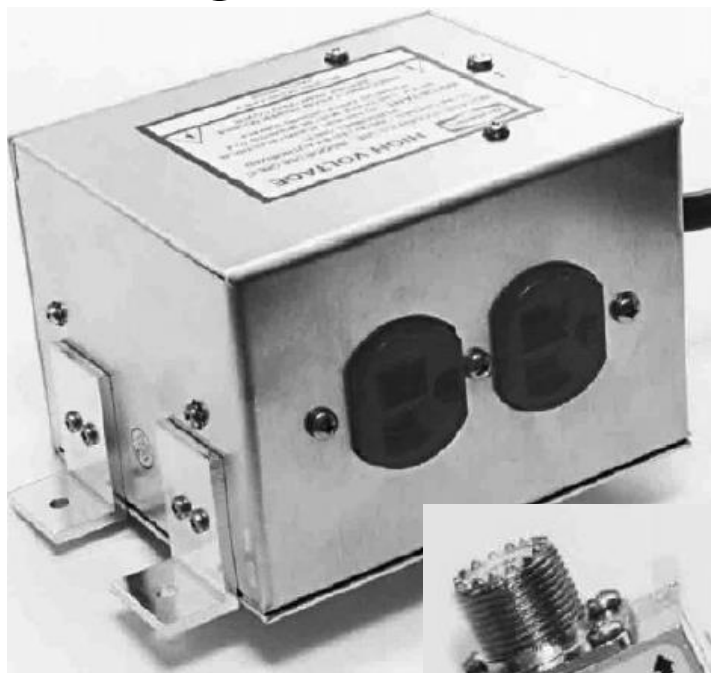


ARRL1433

Lightning Protection

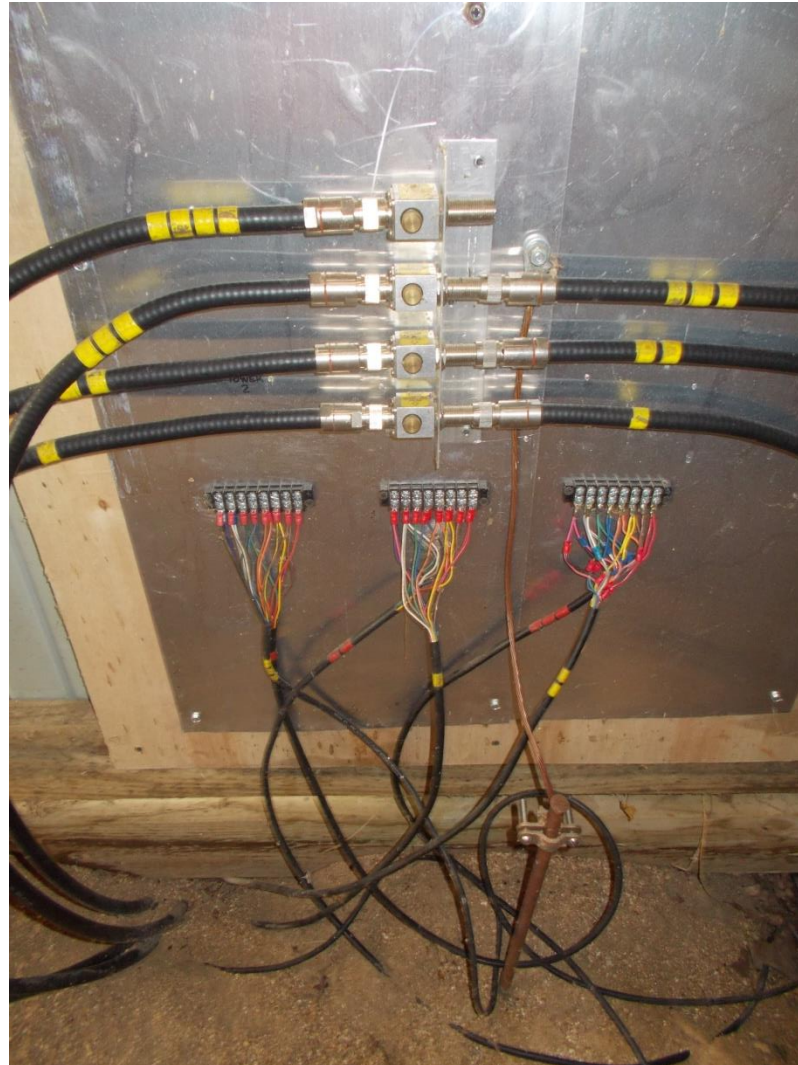


- Single-point Ground Panel



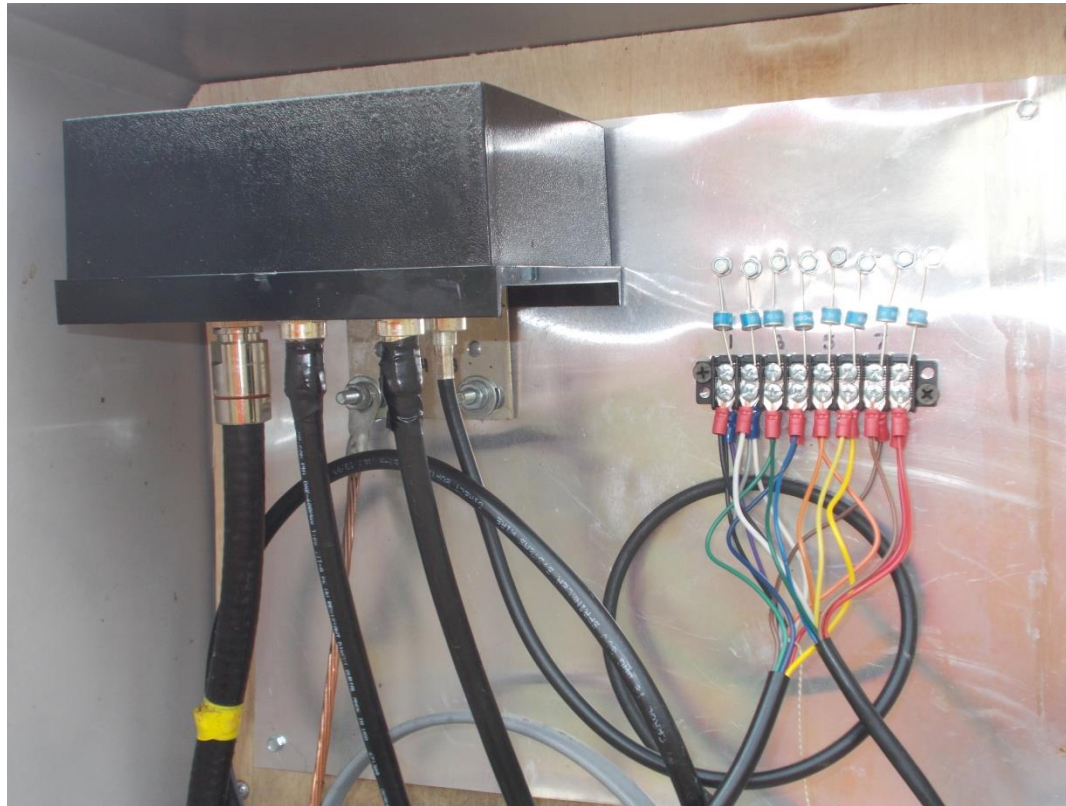
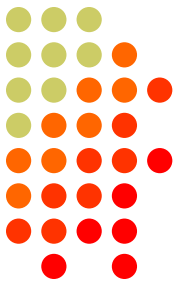
Lightning Protection

- Single-point Ground Panel



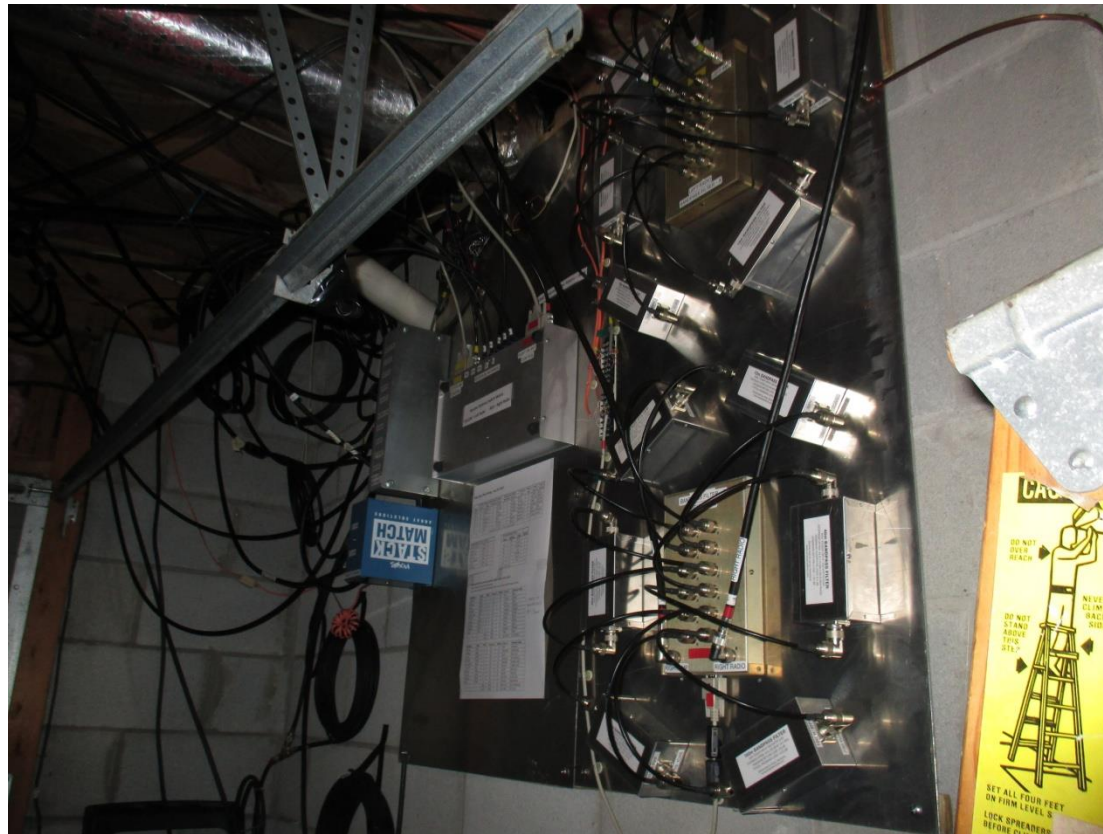
Lightning Protection

- Single-point Ground Panel



Lightning Protection

- Single-point Ground Panel

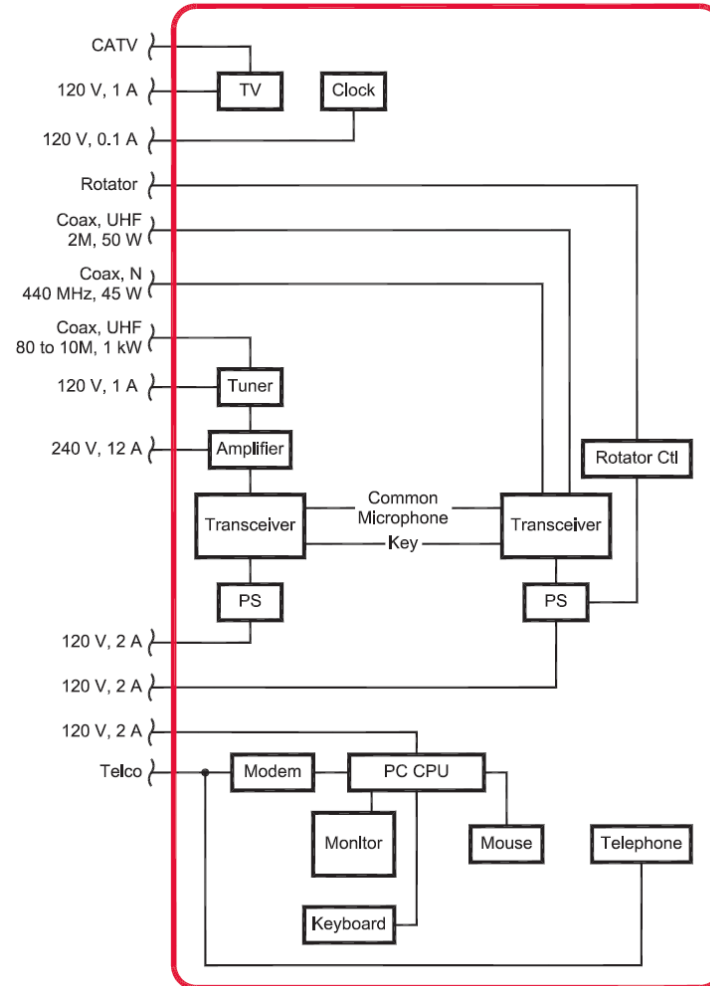


Lightning Protection



- Protected Zones

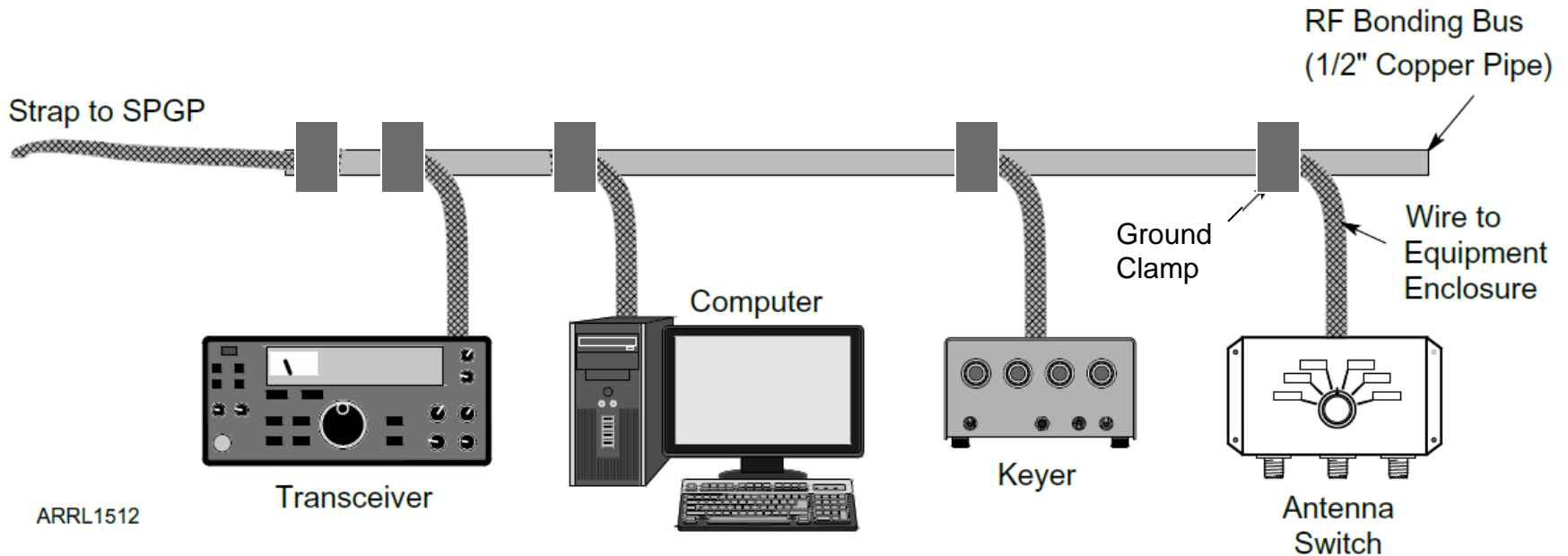
- Every line crossing the boundary must be protected
- Must all have a common or bonded ground connection
- Bond equipment within the station



Lightning Protection



- Bonding inside the shack



RF Management

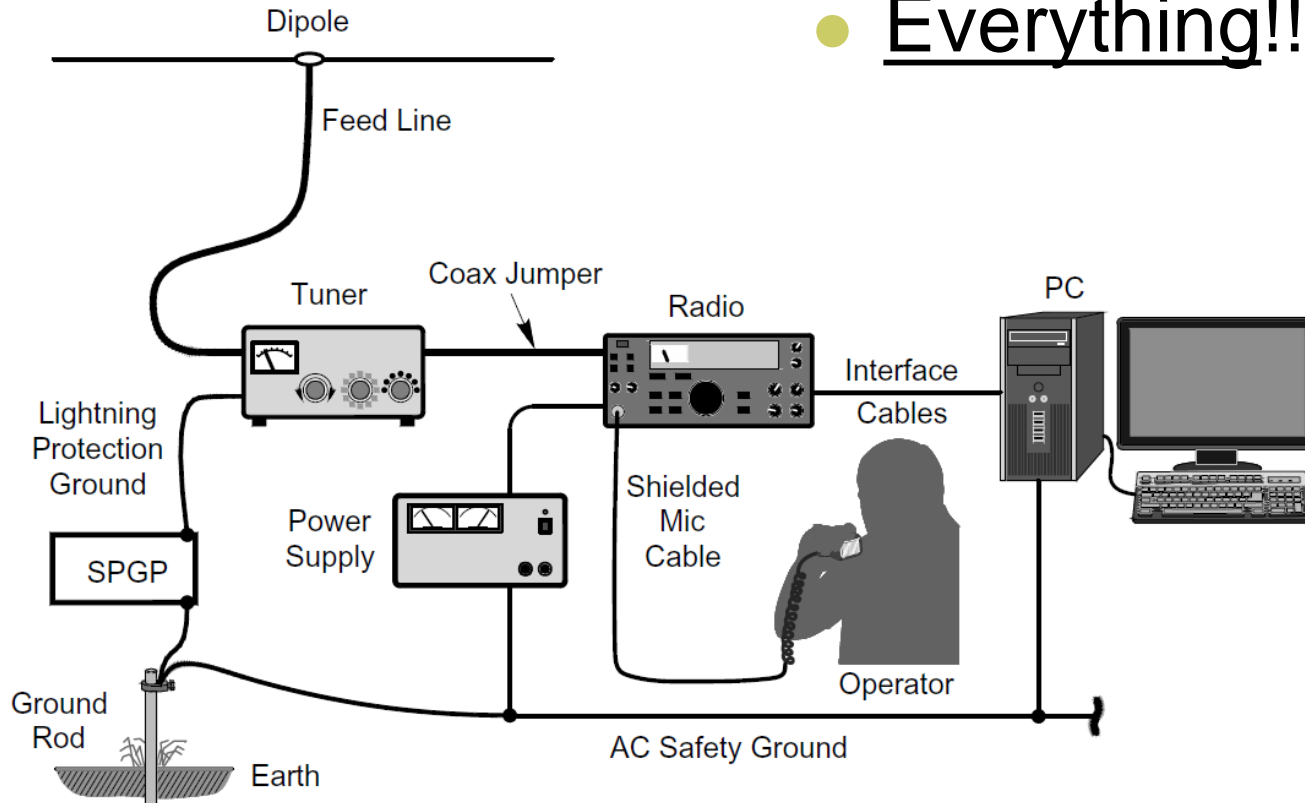


- Everything in the station is an antenna

RF Management



● Everything!!



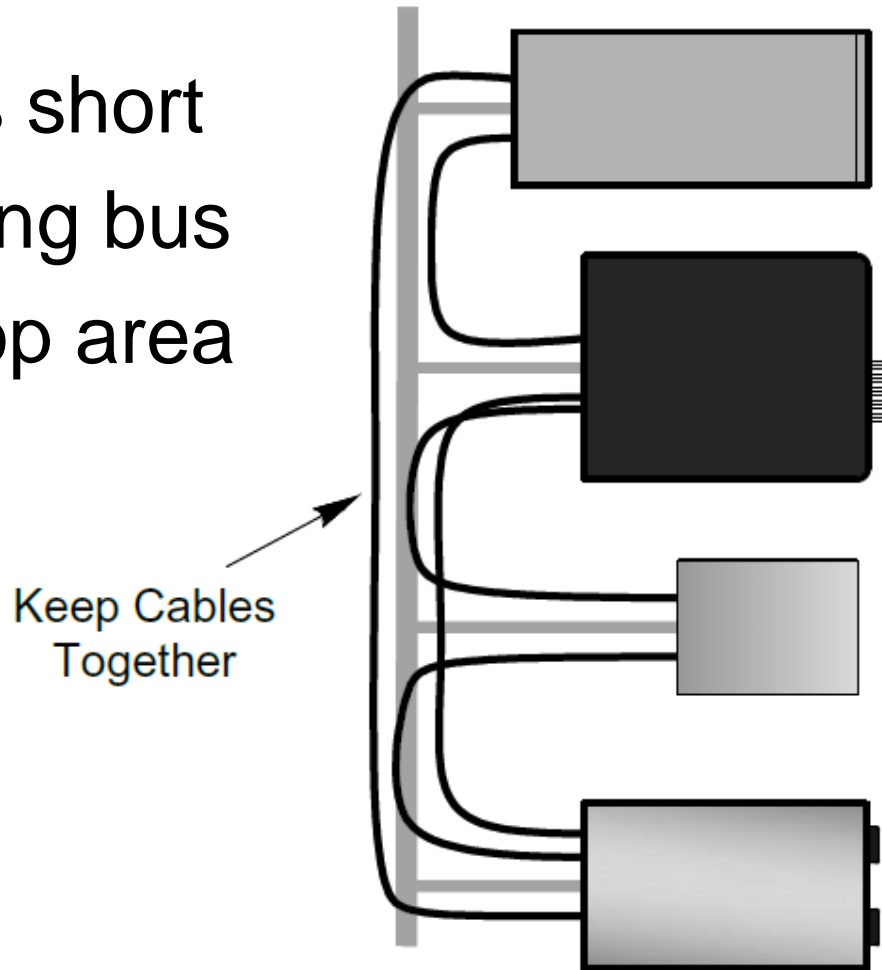
RF Management



- 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

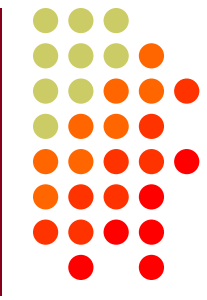


RF Management

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



Ground System



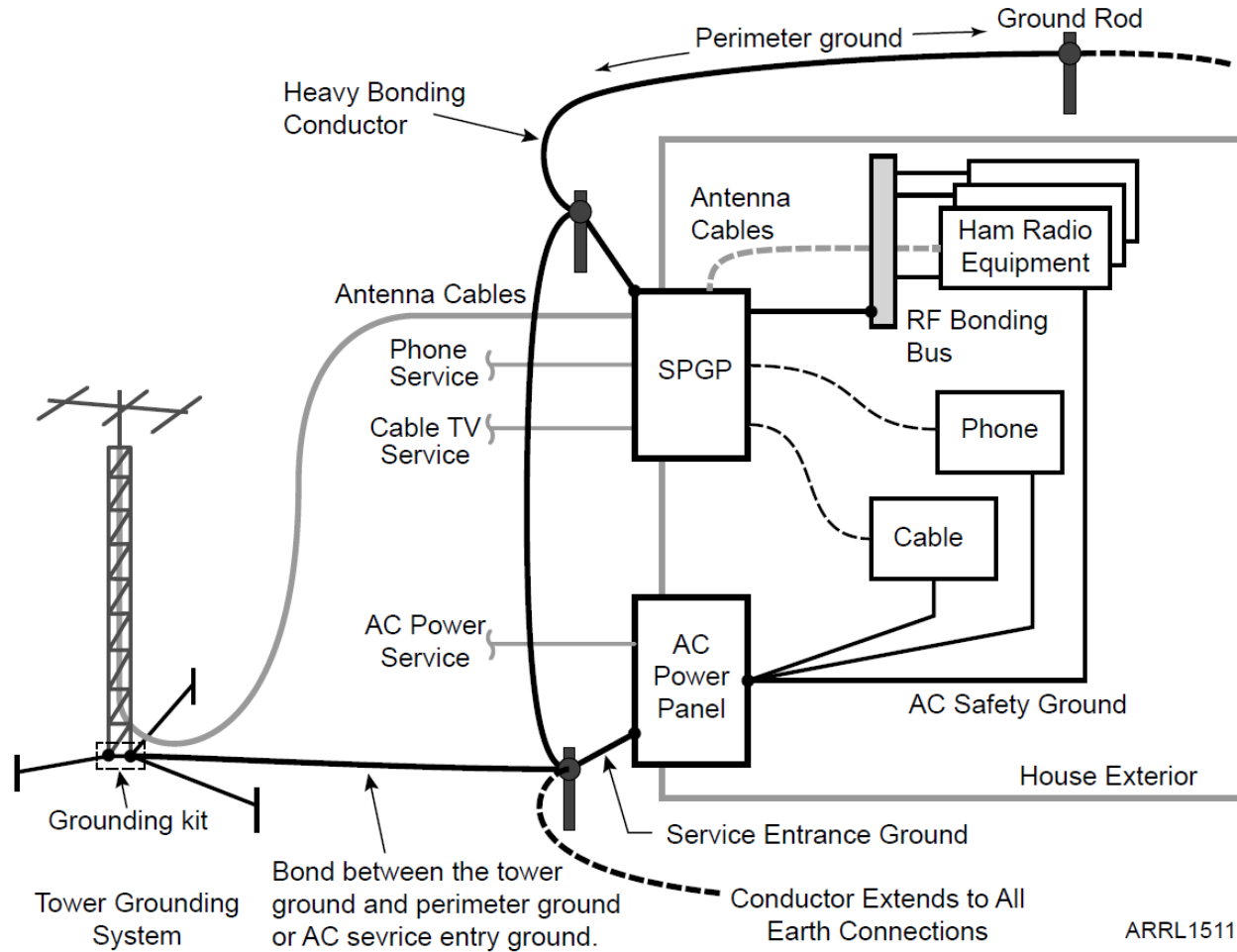
- Now for some good news...

Ground System

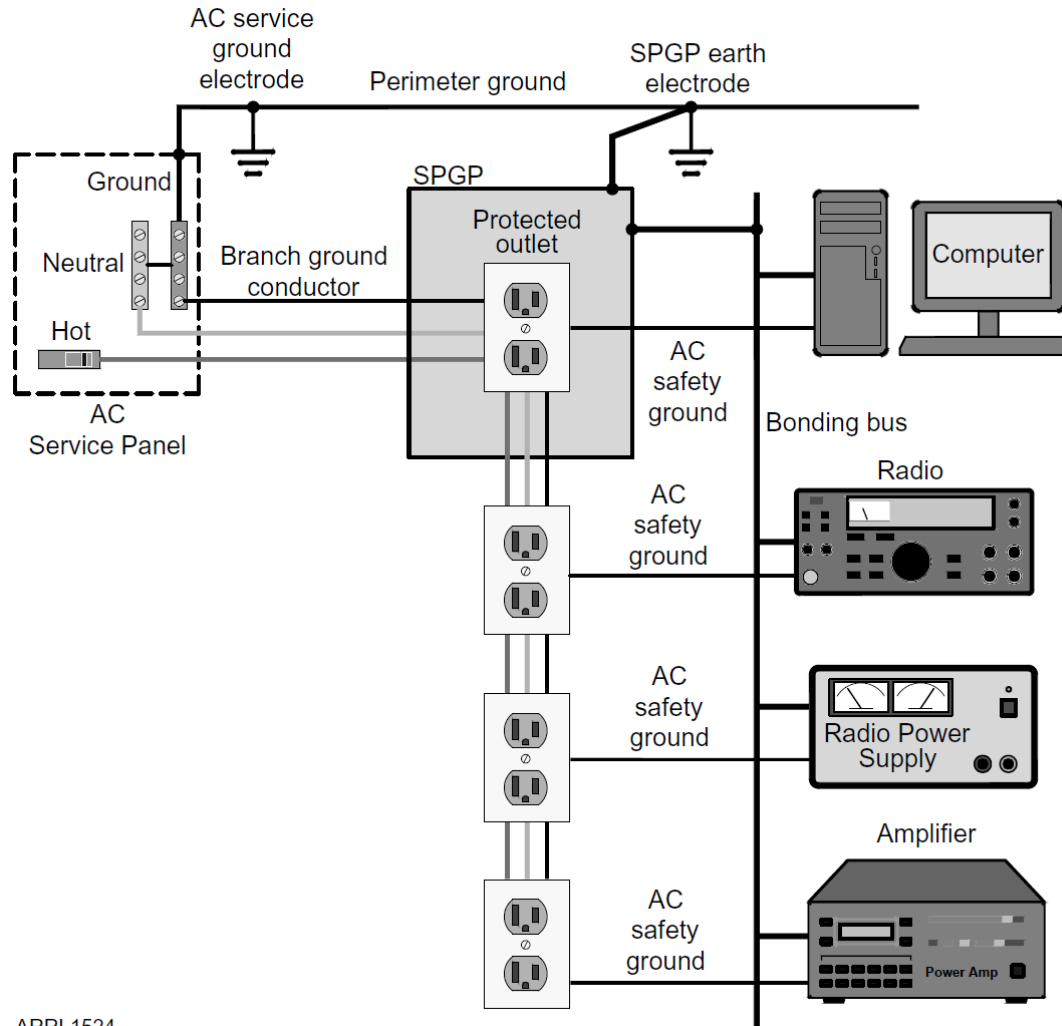


- “One system to rule them all”
- All currents flow on all wires
- A single, solid ground system made of short, heavy, direct connections satisfies all of the requirements for...
 - AC Safety
 - Lightning Protection
 - RF Management & Clean Audio

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)