Grounding & Bonding for Home HF Stations

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THANKS TO CONTEST UNIVERSITY AND ICOM AMERICA FOR SUPPORTING THE ORIGINAL PRESENTATION

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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

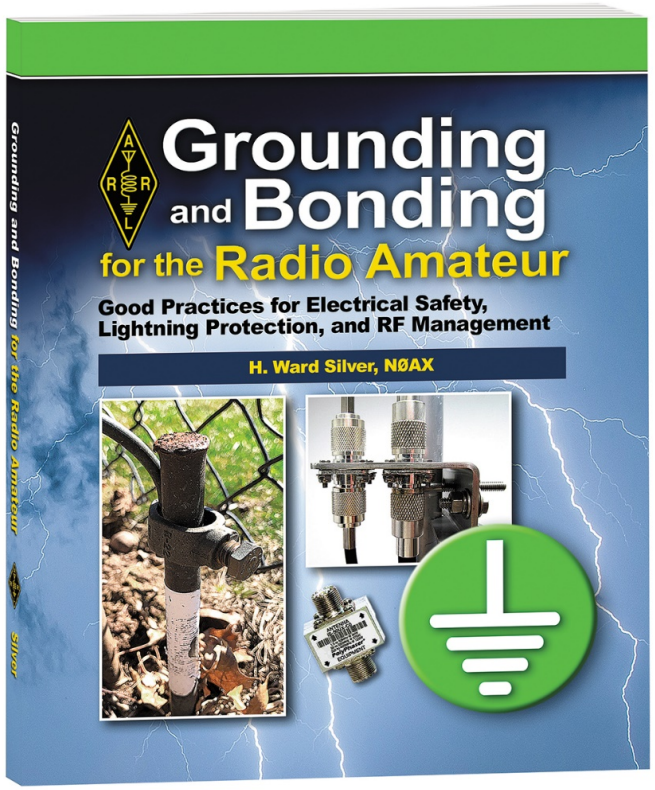
Lightning Protection for the Amateur Station (Ron Block, NR2B – Jun/Jul/Aug 2002 *QST*) – ARRL website, available to the public not just members

Power, Grounding, Bonding, and Audio for Amateur Radio and *RFI, Ferrites, and Common Mode Chokes For Hams* – (**k9yc.com/publish.htm**)

W8JI's web pages on ground systems (**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

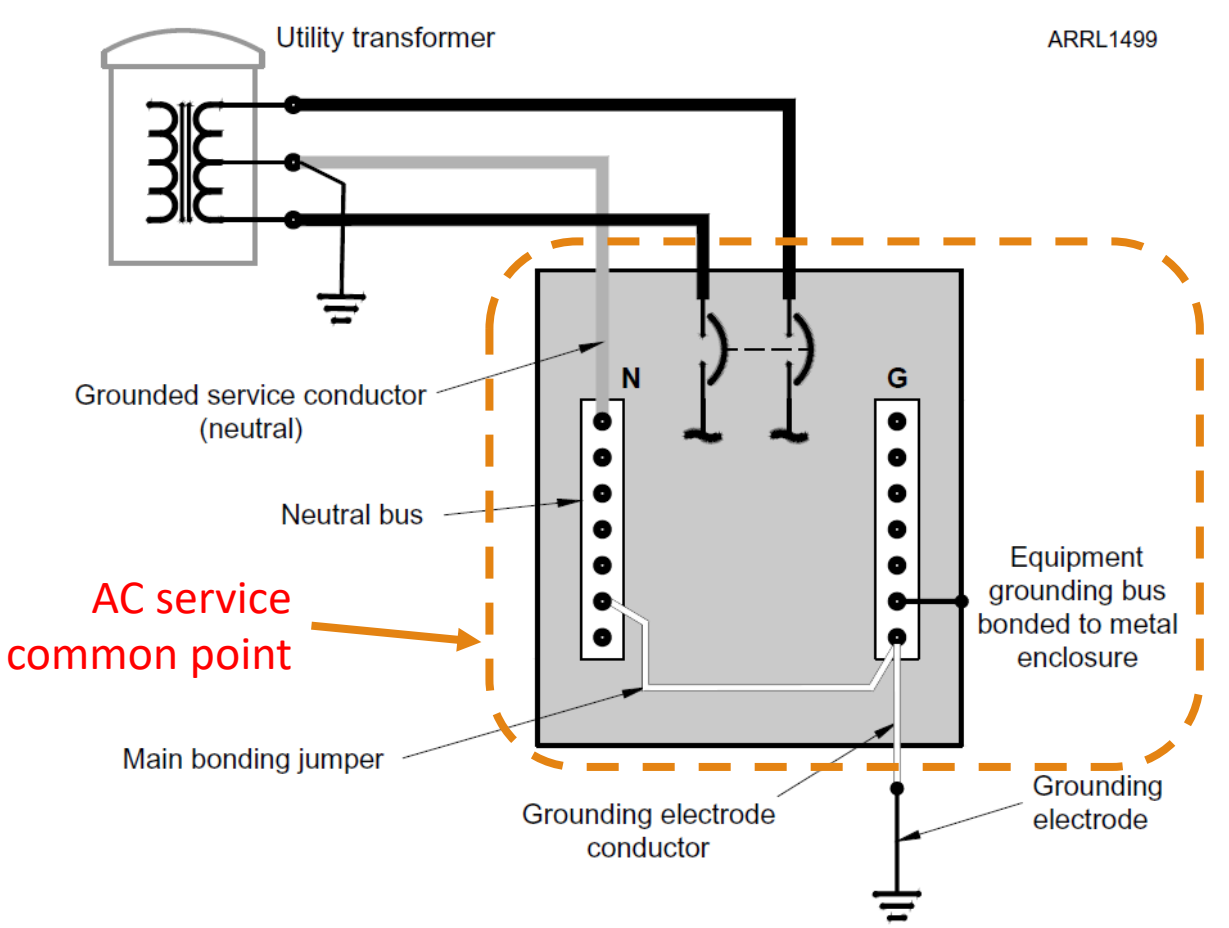
- “Equipment ground”, “third-wire ground”, “green-wire ground”

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



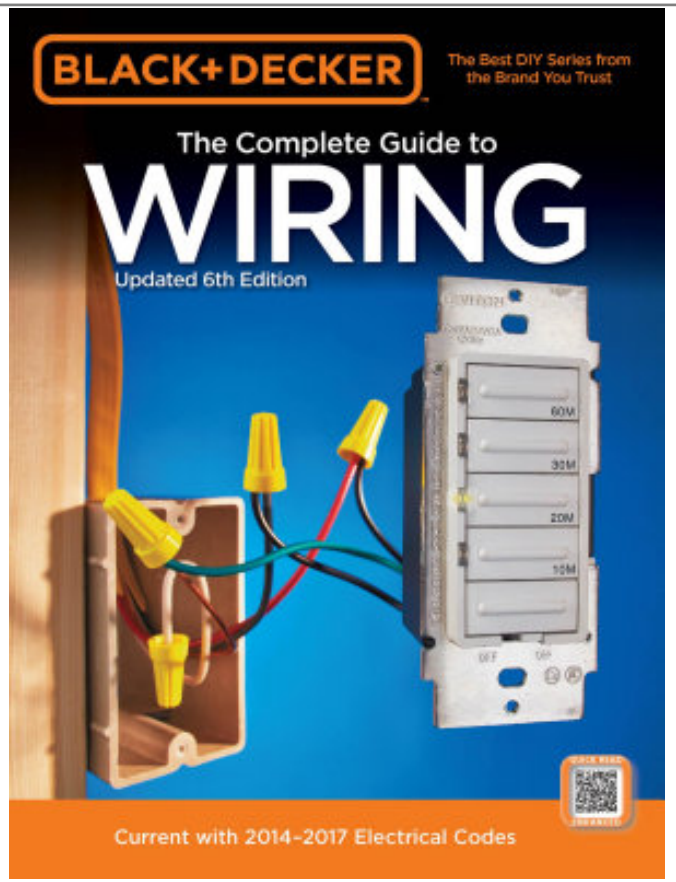
AC Safety Grounding

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

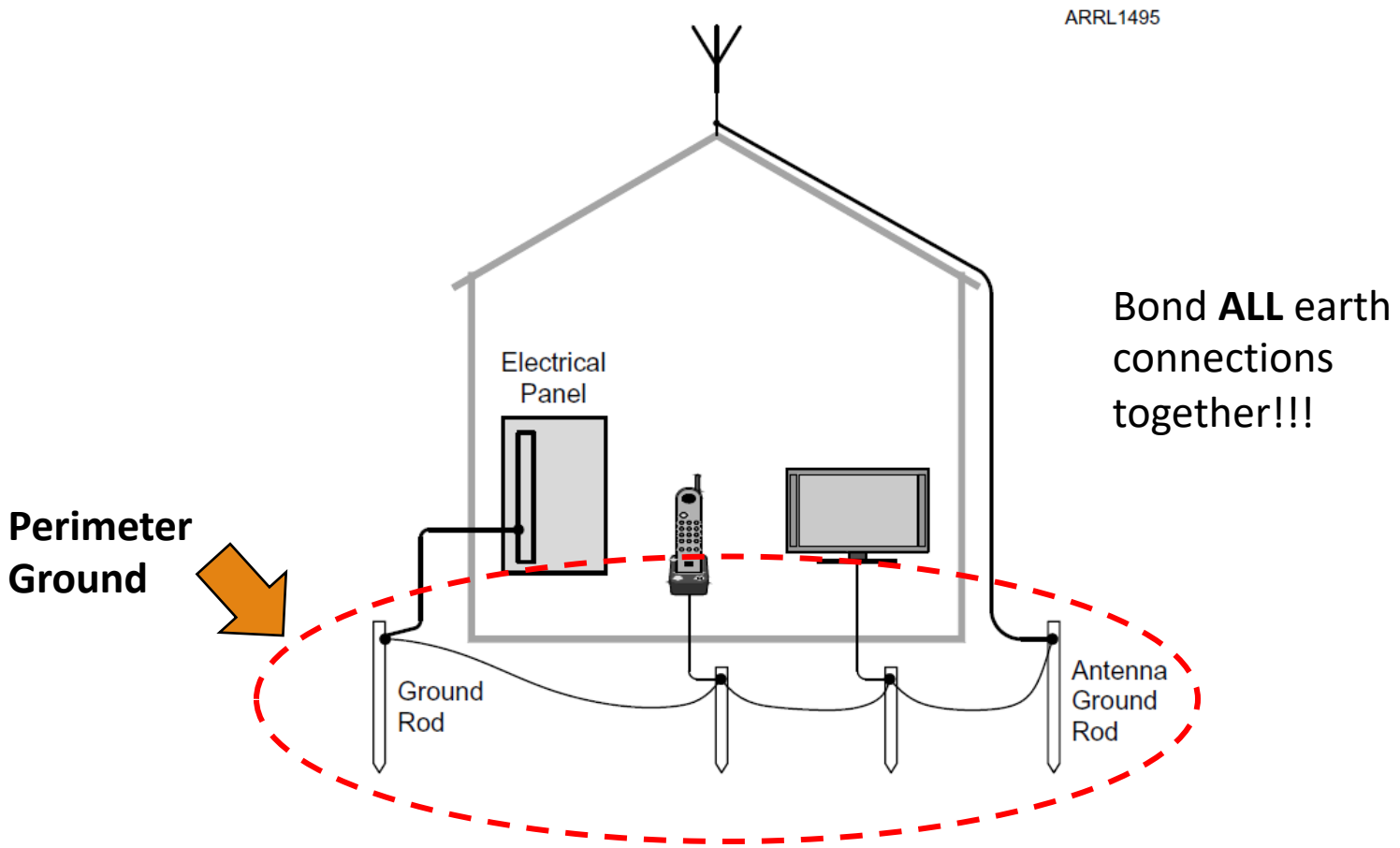


Lightning Protection

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 <u>through</u> your station on its way to the Earth

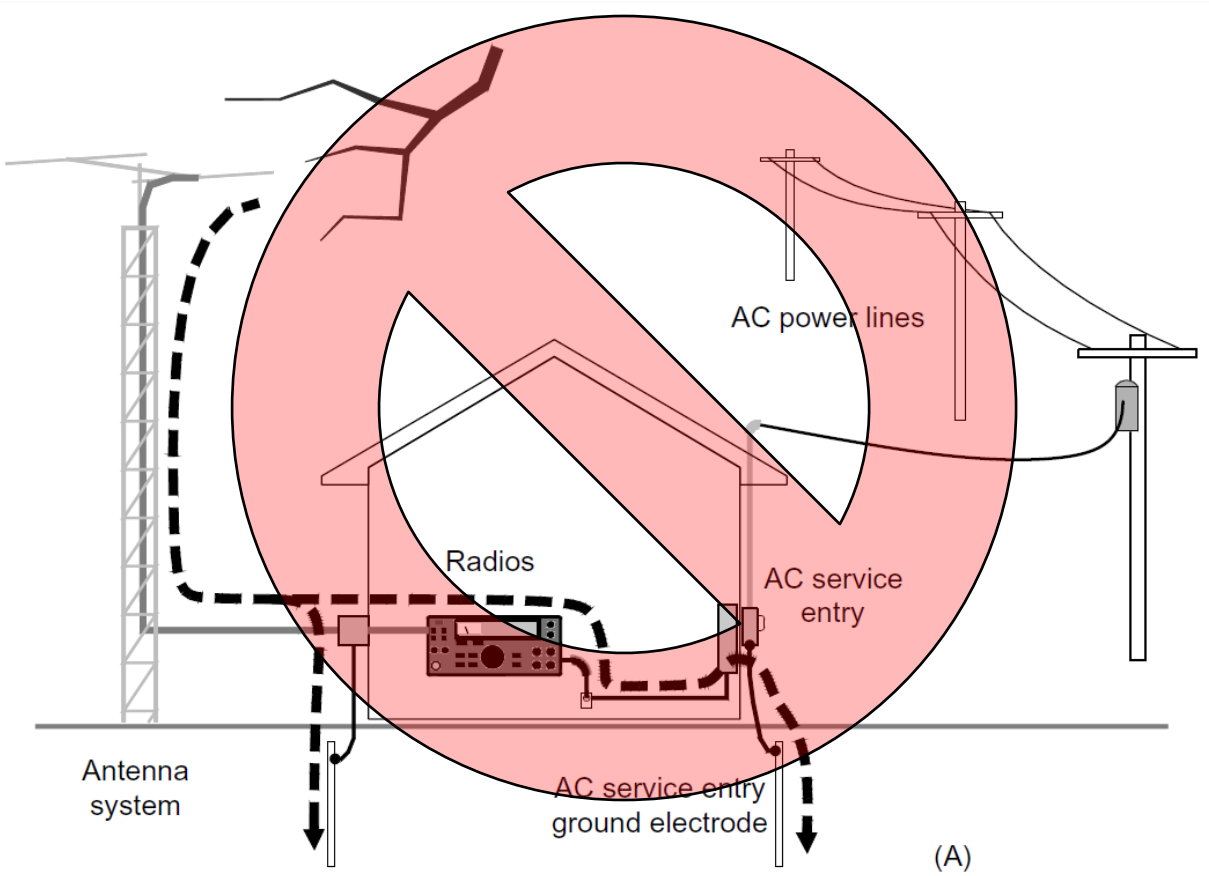
Lightning Protection



Bond **ALL** earth connections together!!!

Lightning Protection

Ground paths should go *around* your station



Lightning Protection

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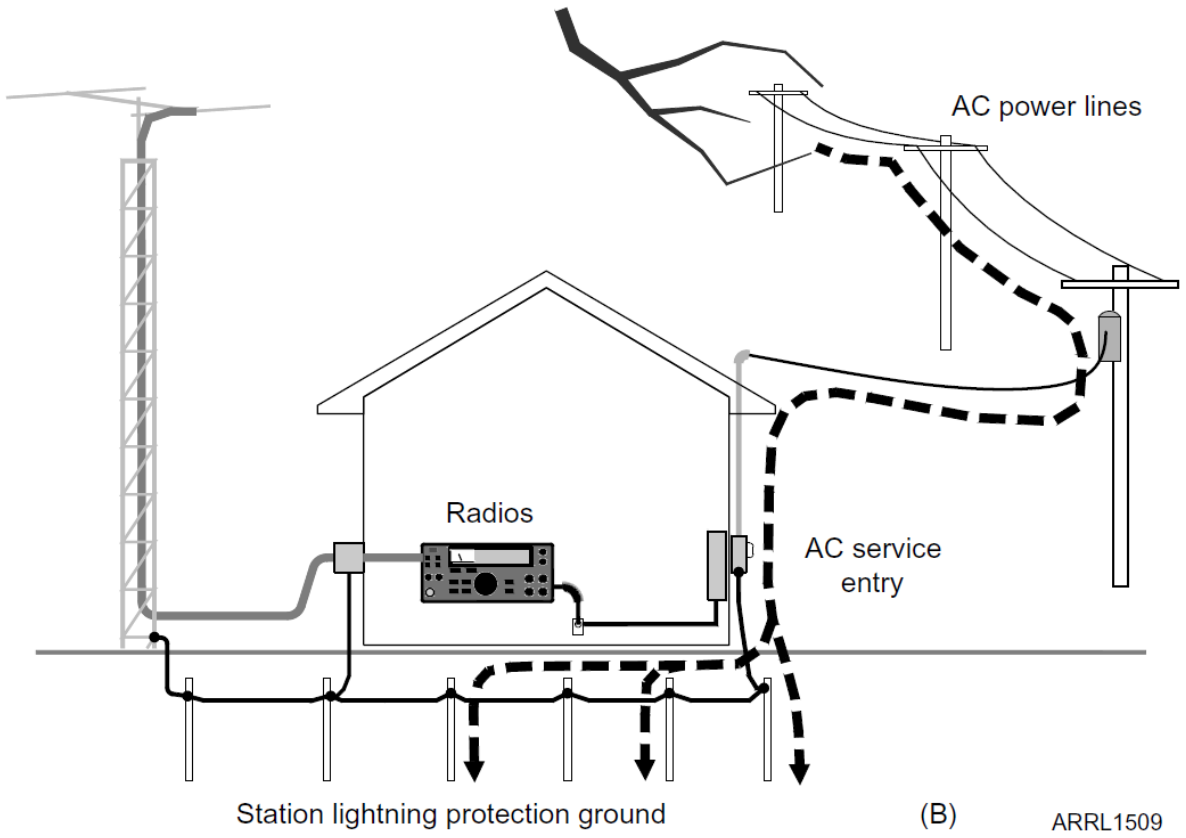
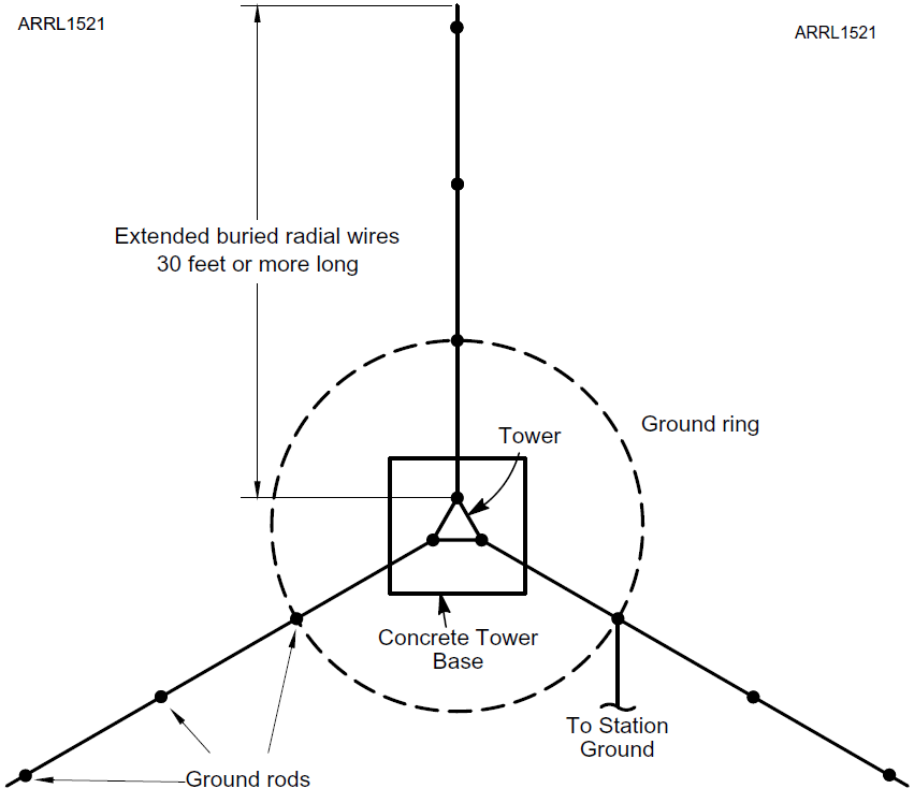


Lightning Protection

Rods and radials

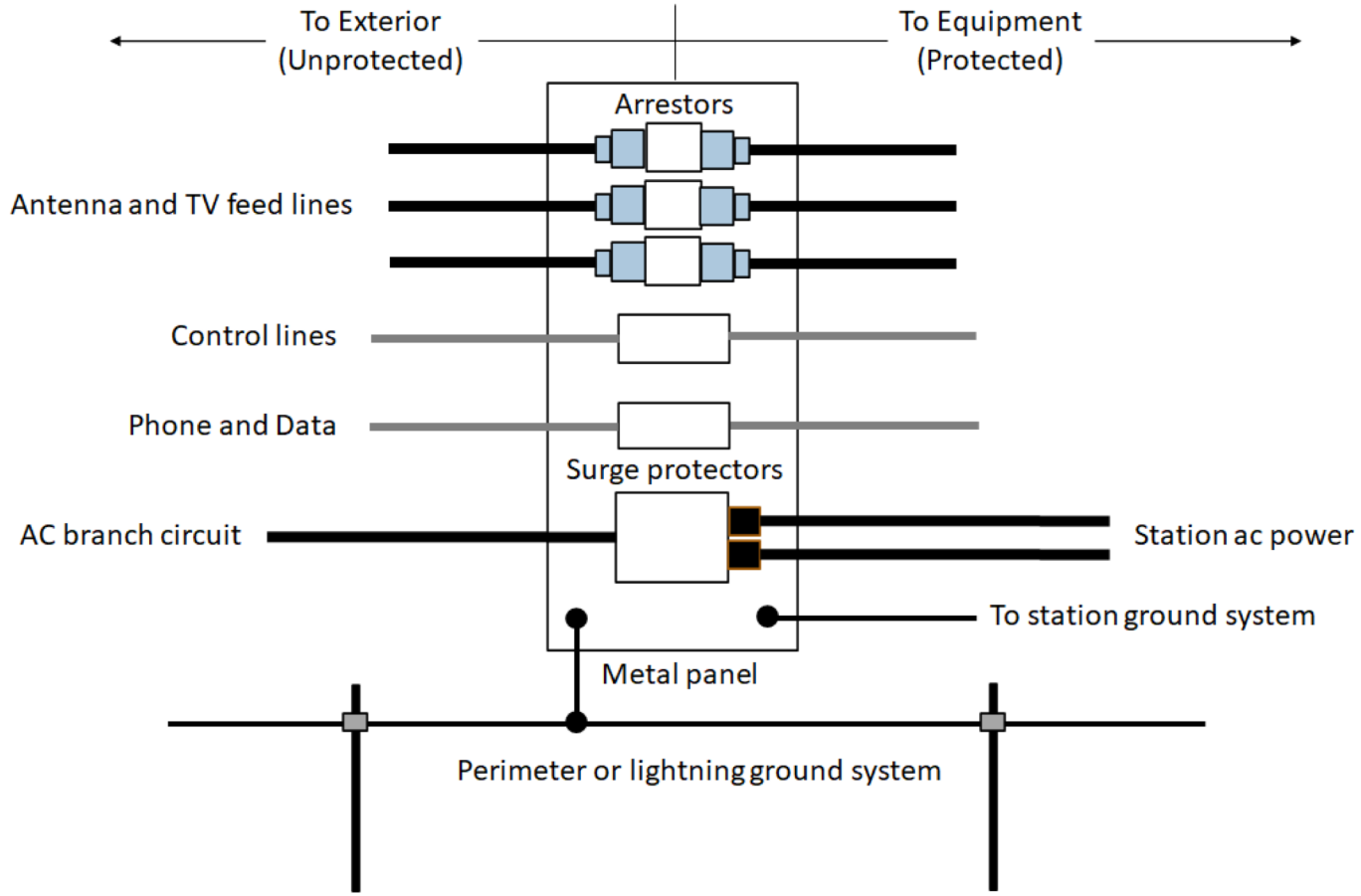
Bond feed lines to the tower every 50 feet

Spark gaps for insulated base towers



Lightning Protection

Single-point Ground Panel (station entry)



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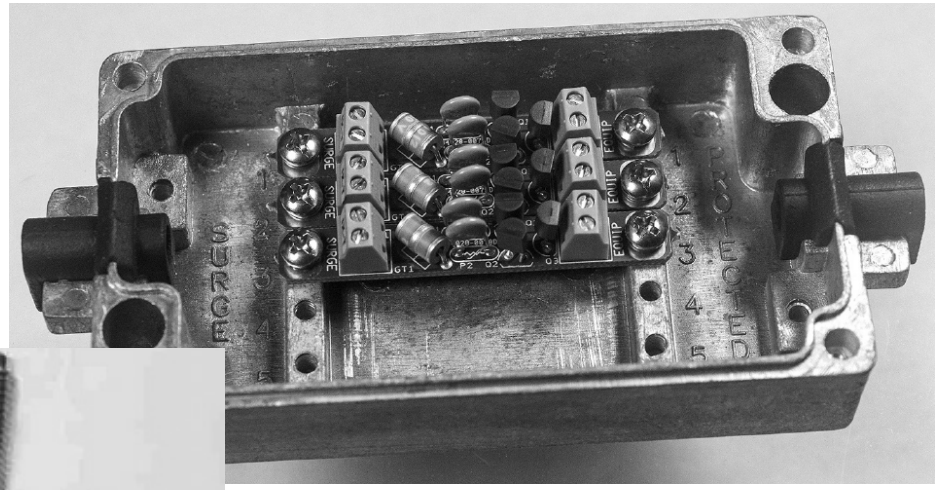
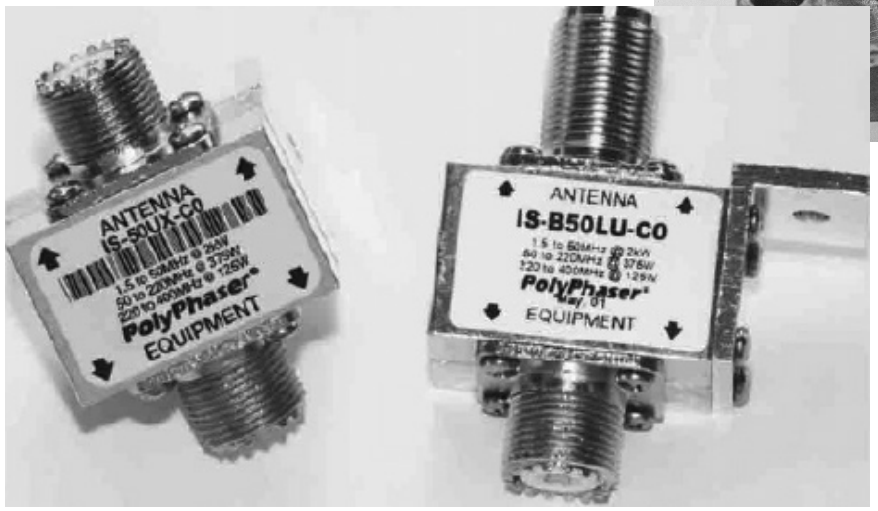
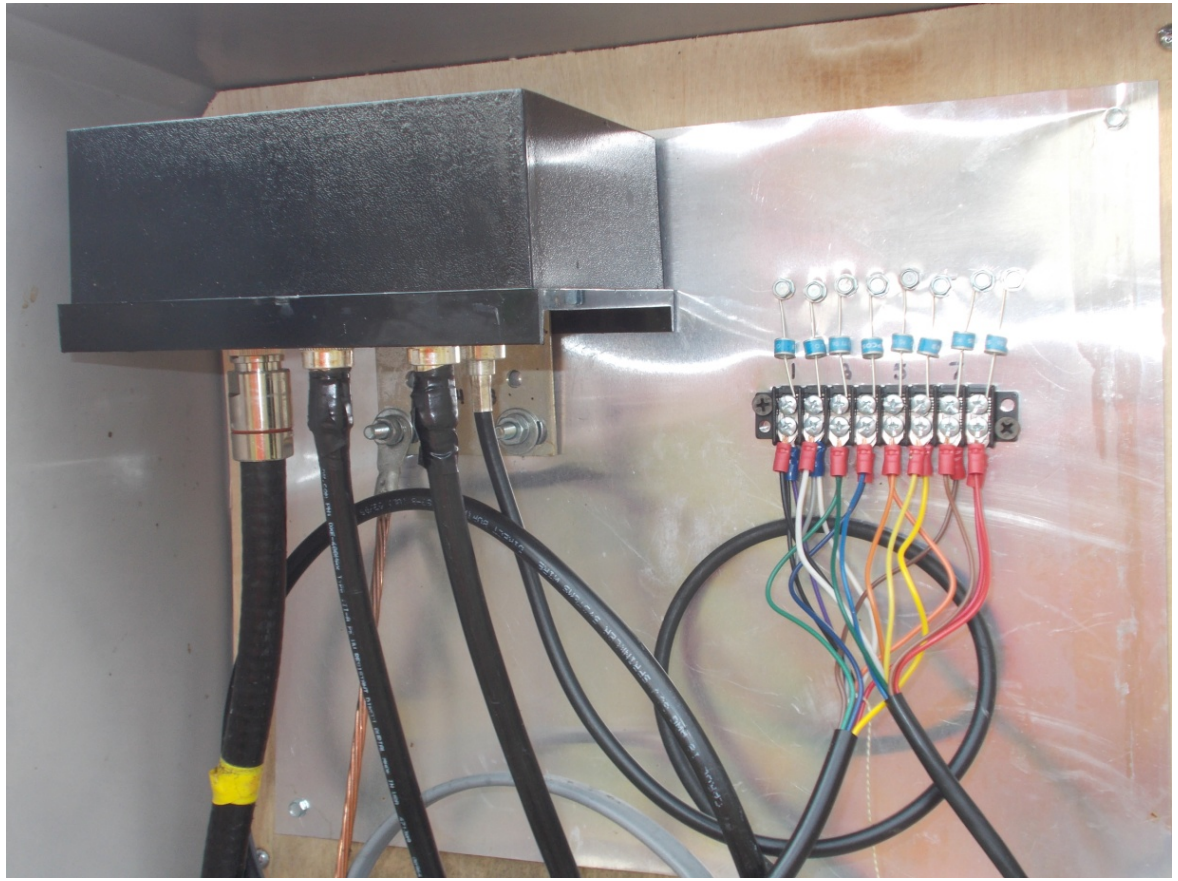




Lightning Protection

Single-point Ground Panel (tower base)

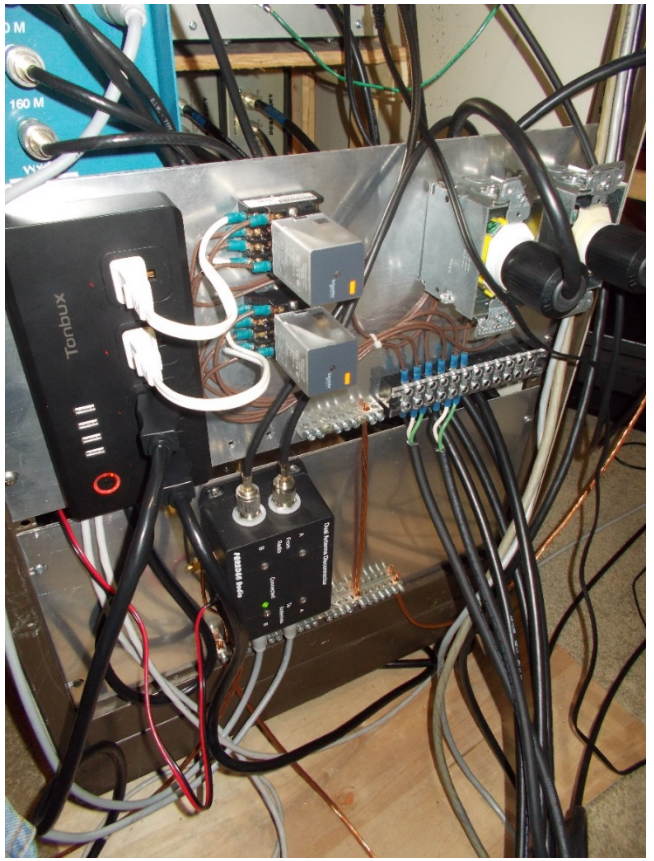


Lightning Protection

Single-point Ground Panel
(station entry)

Lightning Protection

Single-point Ground Panel (in station)

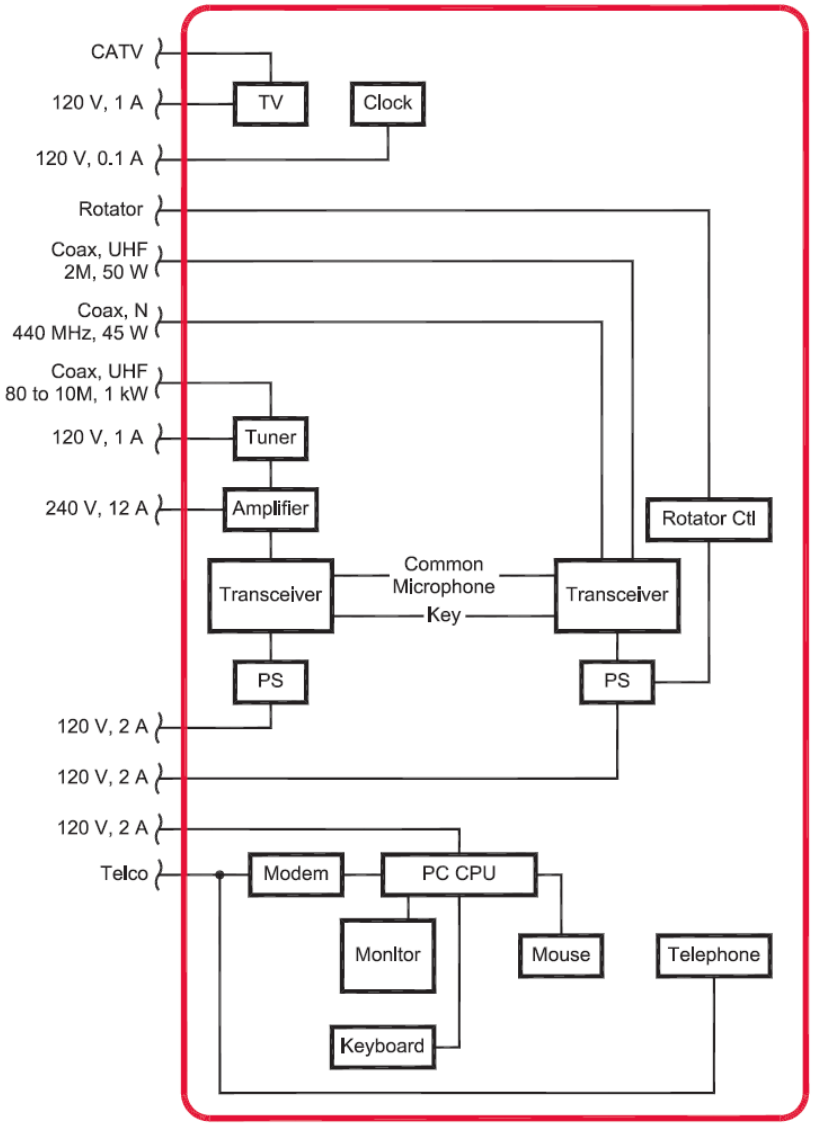


Lightning Protection

Ron Block NR2B's 2002 *QST* articles

Protected Zones

- Every line crossing the boundary ***must*** be protected by a common or bonded ground connection
- 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

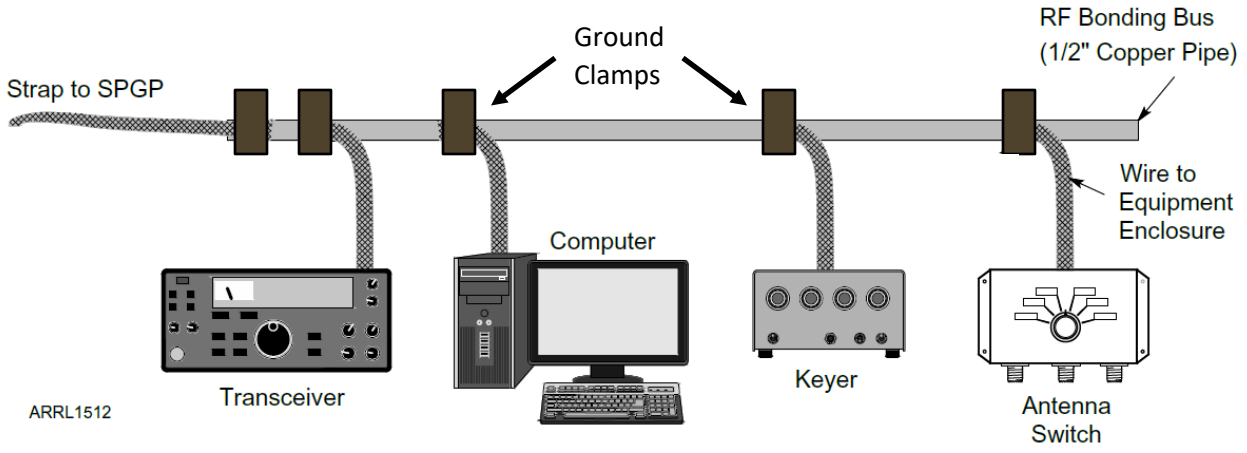
- Requires extra attention to bonding

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

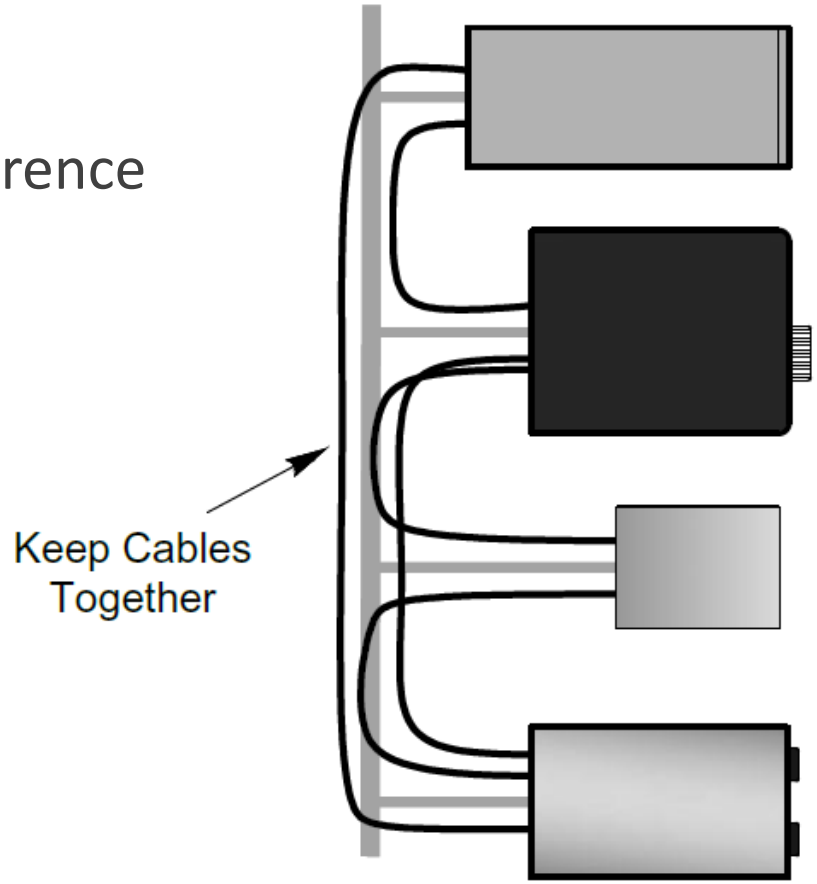
Short or coiled cables

Use a bonding bus and reference plane

Minimize loop area

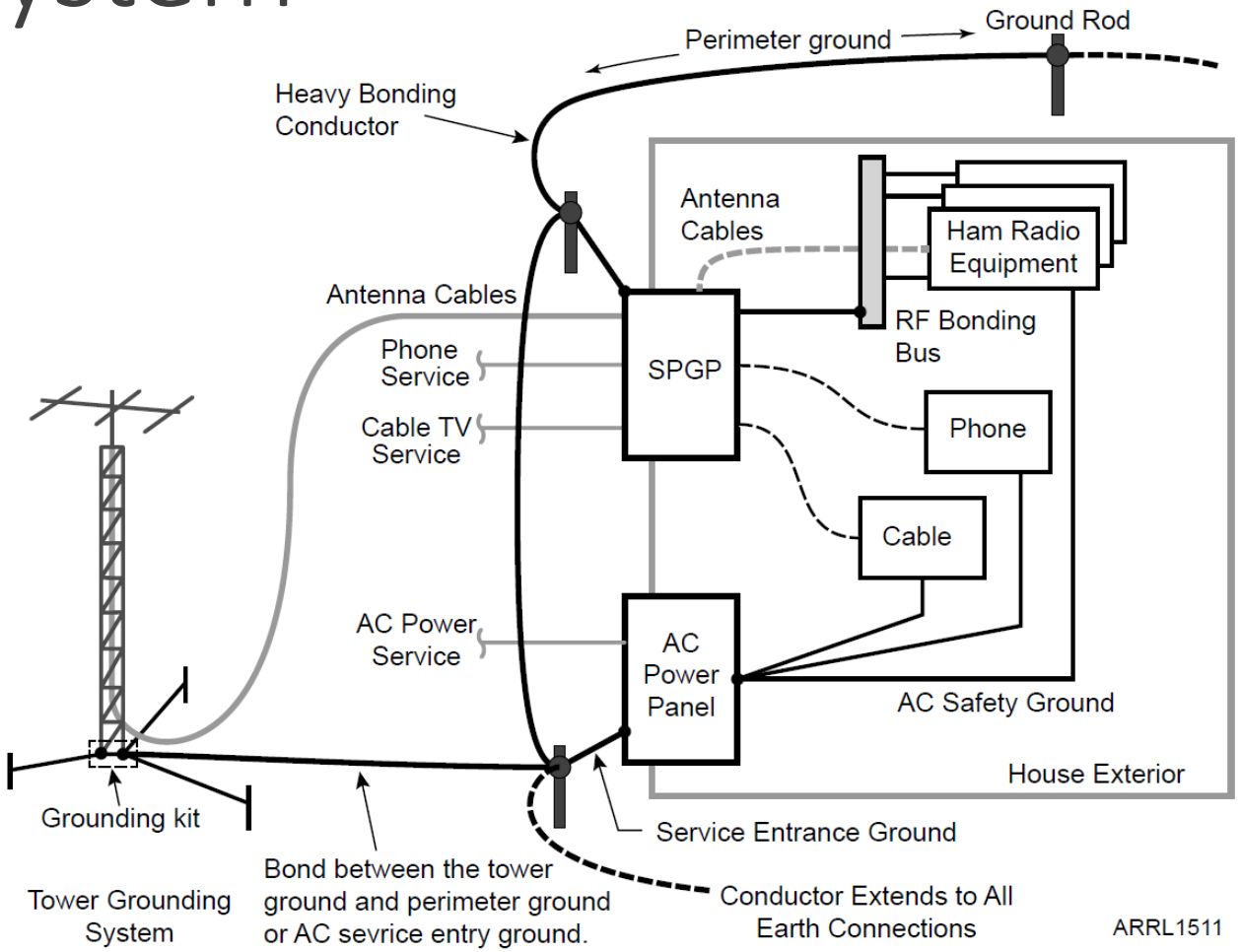
Use shielded cables

Short straps or wires



RF Management

Ground System



Q&A!

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

- *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**