

Grounding Considerations for Your Amateur Radio Station

Hamfesters – September, 6th 2019

Presented by
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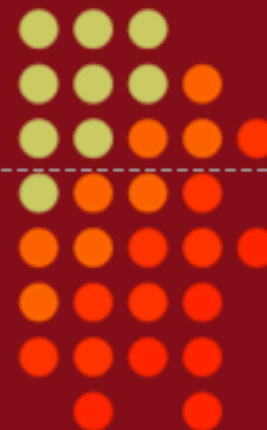


CTU Presents

Grounding & Bonding for the
Little Pistol & Medium Gun
Ward Silver, NØAX

• CTU •
CONTEST
UNIVERSITY

ICOM



Acknowledgements

Thanks to:

- **ICOM**
- **Contest University (CTU)**
- **And especially Ward Silver, NØAX**

for their permission to use their slides as a basis for our updated grounding presentation.

Overview

- What *is* **a “GROUND”**
- What *is* **“BONDING”**
- AC **Safety**
- Lightning **Protection**
- RF **Management**
- **Grounding Systems**
- Resources
- Questions



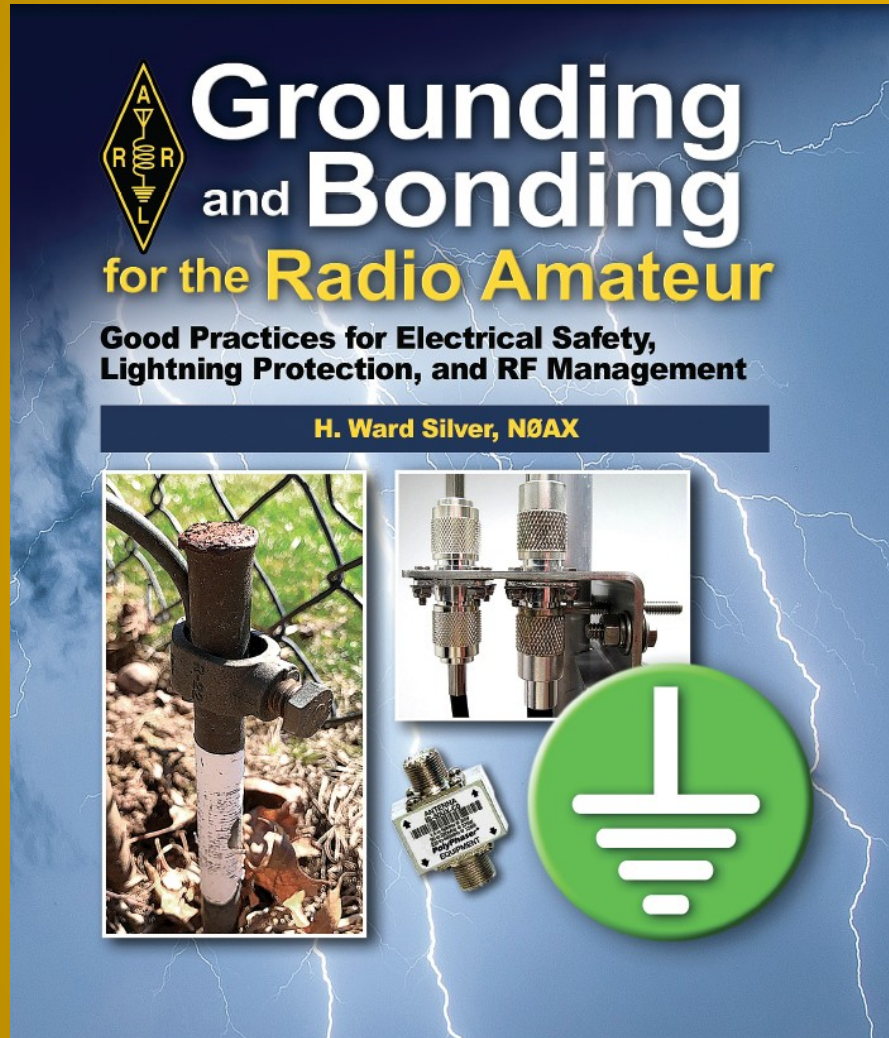
Goals of the Session

- Understand “**Grounding**” and “**Bonding**”
- Appreciate the different requirements for AC **grounds**
 - ✓ **Safety**
 - ✓ **lightning protection**
 - ✓ **RF**
 - ✓ **Audio**
- Illustrate various techniques for grounds
- Show how a system approach to grounding works
- Point you at more comprehensive resources for grounding

Who is this talk for

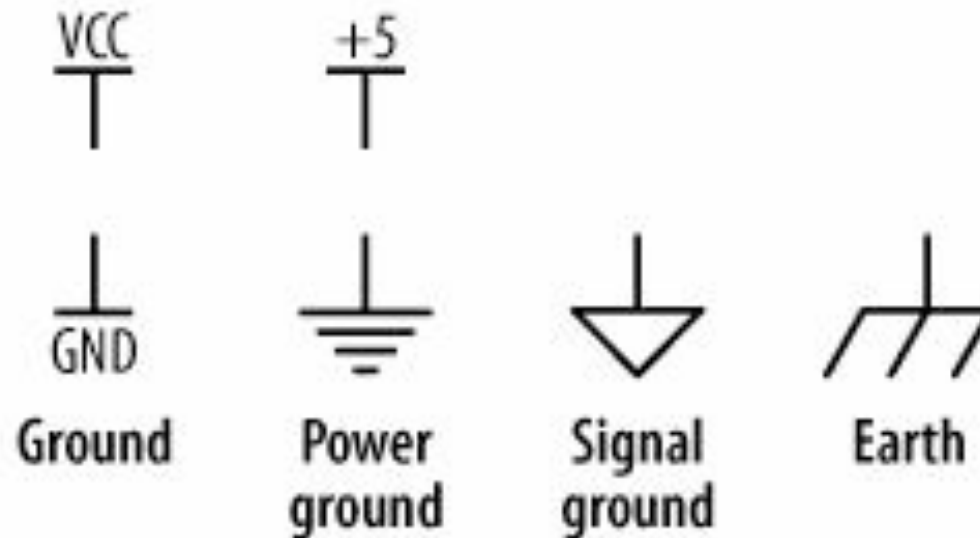
- Amateur Radio Station builders...
 - Just **starting out**
 - Putting up your **first tower**
 - **Expanding** your station
 - In **lightning** country
 - Trying for **better performance**
 - **But not really for super stations...**
K3LR, W3LPL, KC1XX, W9HLQ, K8UT, K9CT, etc

Background References



What is a “Ground” Anyway (1)

- 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 a “Ground” Anyway (2)

- It can be a **noun**, **verb**, and **adjective** or *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 a “Ground” Anyway (3)

- 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 (1)

- **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**
 - ✓ **RF management**

What is “Bonding” Anyway (2)

- 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...
 - *Copper Strap* (\geq **20 Gauge**) or heavy wire (\geq **12 Gauge**)
 - Flat-woven braid
 - **Don't use braid from old coax as it deteriorates too quickly.**

Checking that “Bond” (2a)



Good “Bonding” Information (2a)



Chiburban Radio Mobileers

Celebrating Over 60 Years of Ham Fellowship in Chicago South Region



◦ Welcome – Guest / Visitor

[Getting on 160 meters](#) » Grounding Information

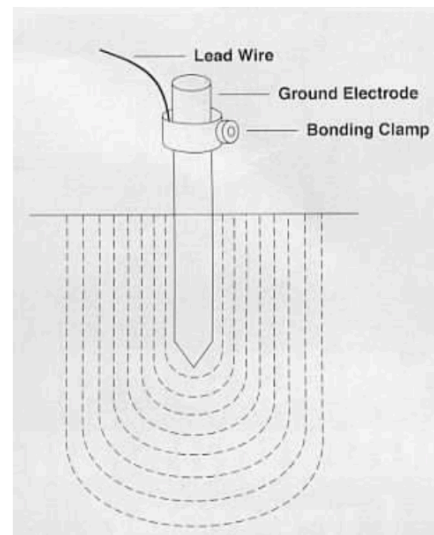
Mobileers

- Home
- Our Daily Radio Net (and QTH map)
- Weekly Brunch
- Our Momence Cook Out
- History & Comments
- ▾ Getting on 160 meters
 - Antennas for 160
 - Feed line Considerations
 - ▾ Grounding Information
 - **Ground Connection Tester**
 - Grounding Devices and Equipment
 - Lightning protection by Polyphaser
 - Installing Ground Radials
 - Measuring Ground Wire Current – A Case Study
 - Using your dipole on 160
 - A Simple Link Tuner for 160
 - Discussions on Baluns
- ▾ Photo Gallery
- Old Members List
- Reference Reading and Links
- Online Tube Manuals

Grounding Information

When we discuss grounding, we are not talking about a simple electrical ground provided by an eight foot pipe in the soil. When working with RF vertically oriented antennas, a robust RF ground **system** must be employed. This will include the necessary radial wire system discussed at this site.

Grounding Theory



When operating on 160 a single ground rod will **not** work. You need to install a **grounding system** consisting of many radials all tied to a common point. This will provide excellent ground for RF and also can be part of your lightning protection. (An exception to this rule is if you are able to install a dipole or similar antenna that does not work against ground as a vertical does). Refer to the manuals and hand books shown below for more details on building your ground system for 160 meters.

We feel proper grounding (actually a comprehensive ground system) is most important and most overlooked part of your 160 meter station. Hams often spend much time on their antenna and neglect their ground system. When working the higher frequency HF bands, the ground system may not be as essential as we find here on 160 meters. Thus hams become somewhat casual regarding the importance of a suitable ground system. It is fortunate that when working on your ground system you can work on the ground! Unlike some antenna system installations that may find you in a tree or up a tower.

AC **Safety** Grounding (1)

- 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 (2)

- And a friendly reminder from your AHJ*

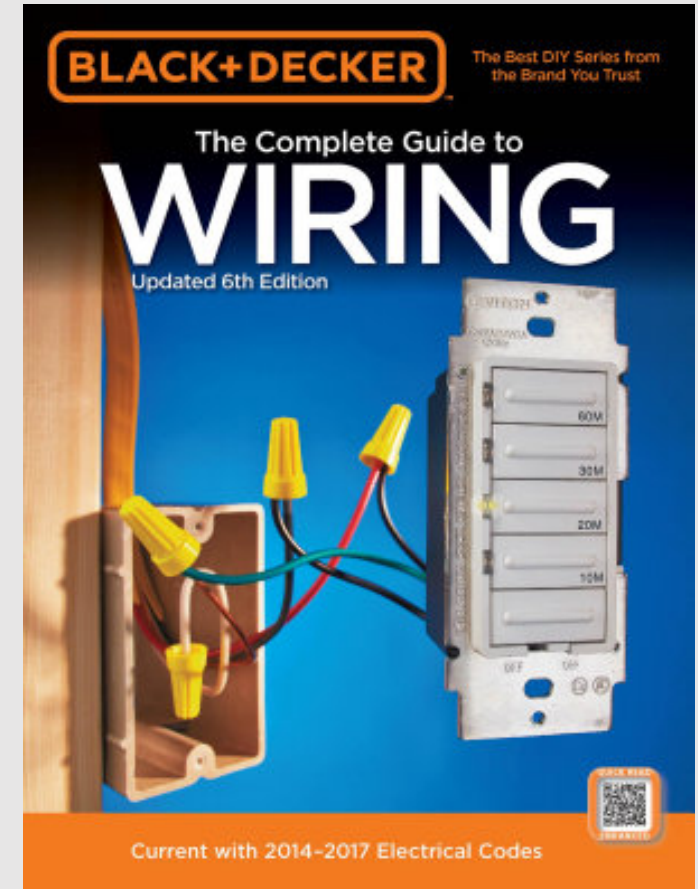
LOCAL CODE IS THE LAW

- If you don't have a local code,
use the National Electrical Code (NEC)

* The Authority Having Jurisdiction

AC Safety Grounding (3)

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

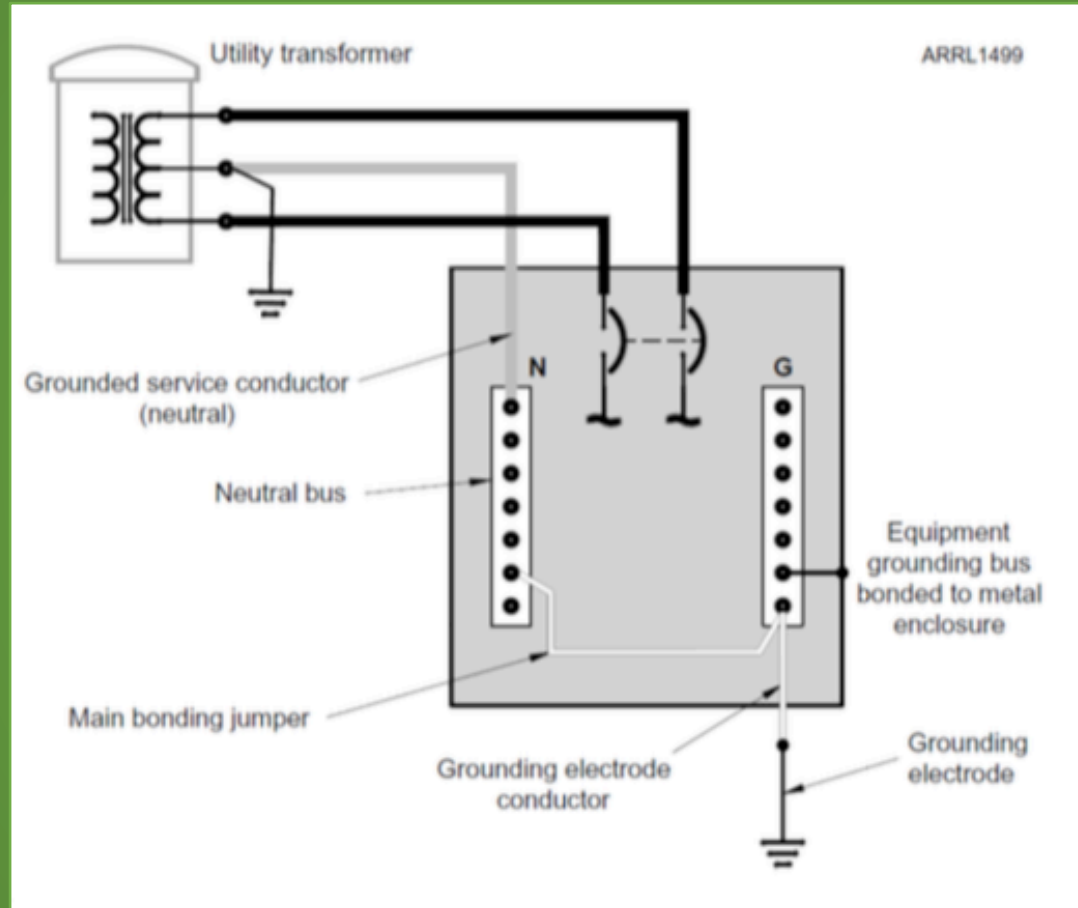


AC **Safety** Grounding (4)

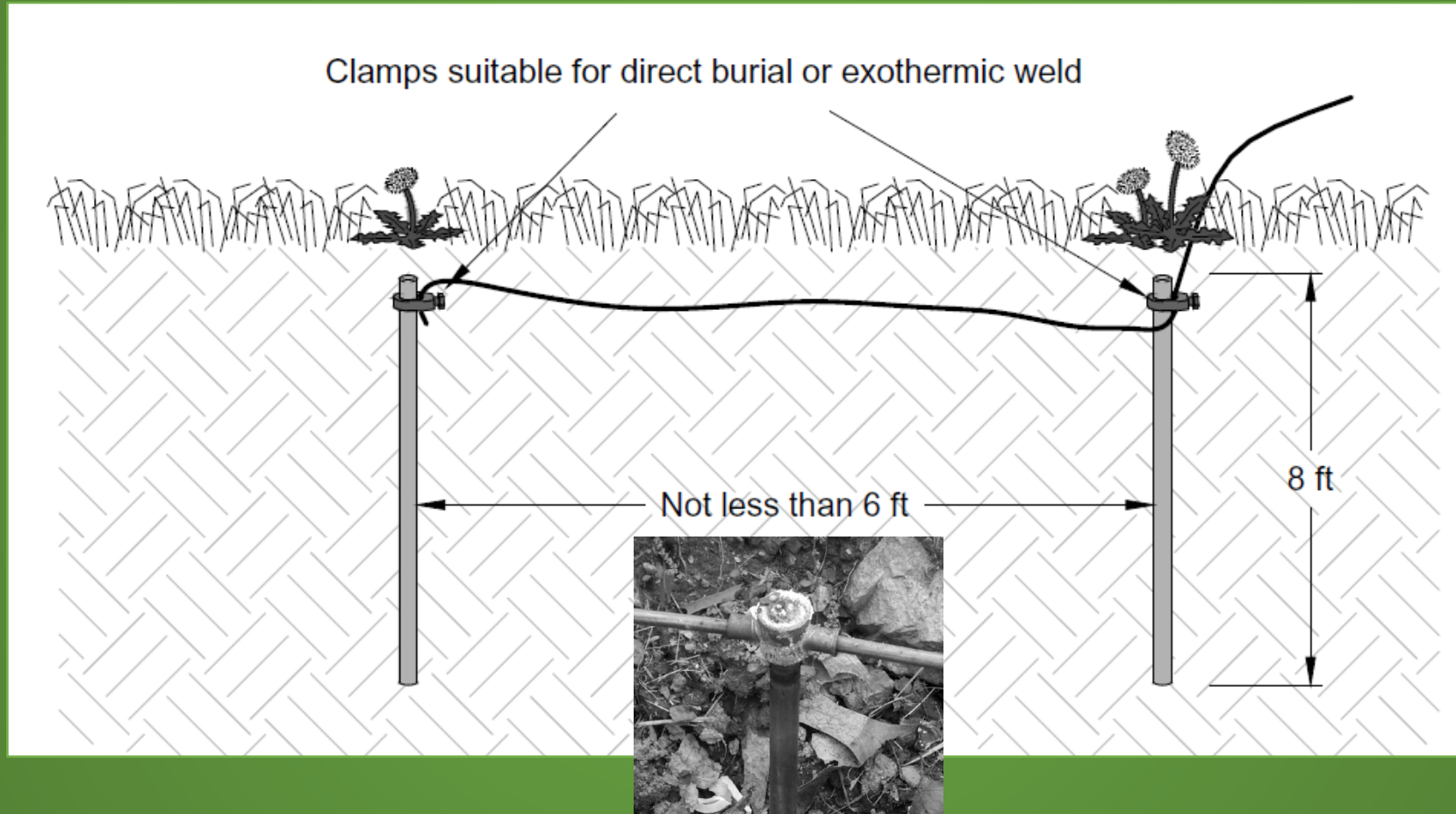
- **Grounding** for ac safety has several names:
 - ✓ “Equipment **ground**”
 - ✓ “third-wire **ground**”
 - ✓ “green-wire **ground**”
- The purpose is two-fold:
 - Provides a path to **AC** common point for **fault current** (shorts, leakage)
 - Stabilizes the **AC** power voltage during faults or transients, such as lightning



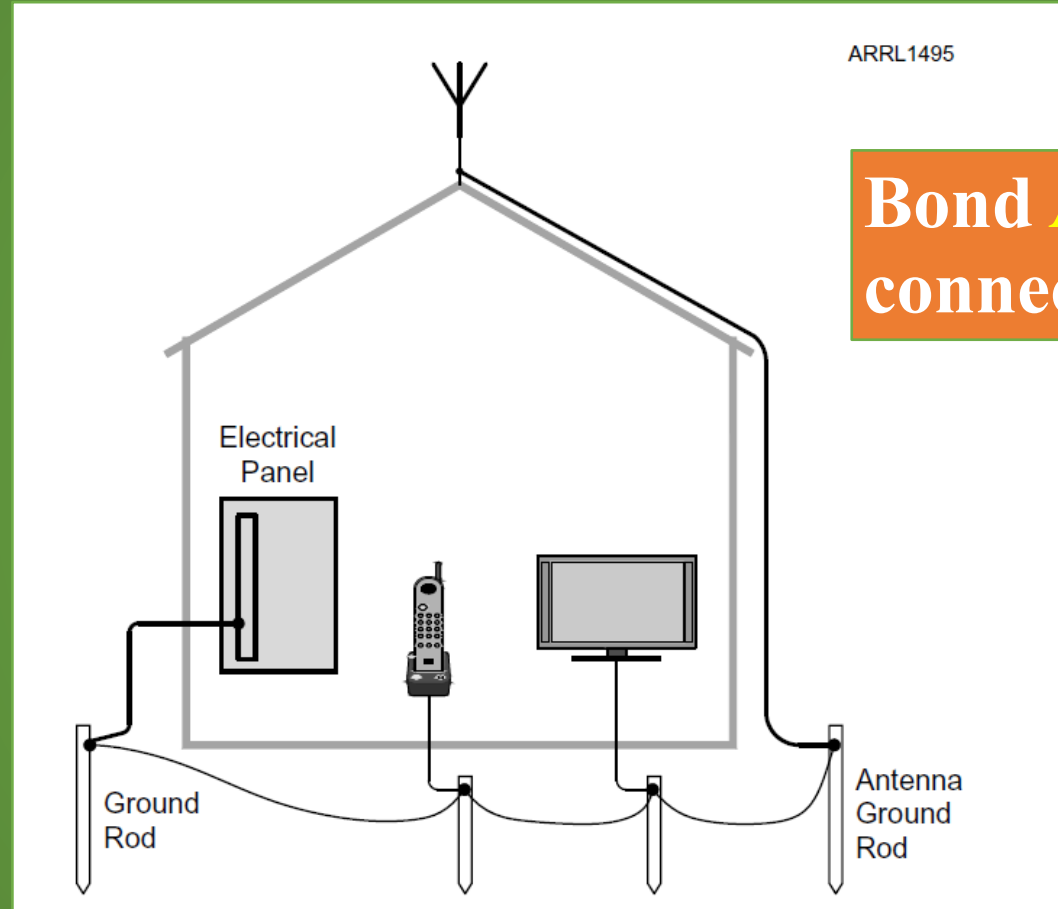
AC Safety Grounding (5)



AC Safety Grounding (6)



AC Safety Grounding (7)



Bond ALL earth connections together

AC **Safety** Grounding (8)

You can use **GROUND** wire with a **THHN** protective coating unless you are operating in an area where extreme heat or cold are a factor.

WIRE TYPE	THHN / THWN / THWN-2	XHHW / XHHW-2
Jacket	Polyvinylchloride (PVC)	Cross-linked Polyethylene (XLPE)
Wire Insulation	Thermoplastic	Thermoset
Minimum Installation Temp	-10° C / 14° F	-40° C / -40° F
Emergency Overload Temp	105° C / 221° F	130° C / 266° F
Maximum Short Circuit Temp	150° C / 302° F	250° C / 482° F

THHN: Thermoplastic High Heat Nylon (Water - PVC coating)

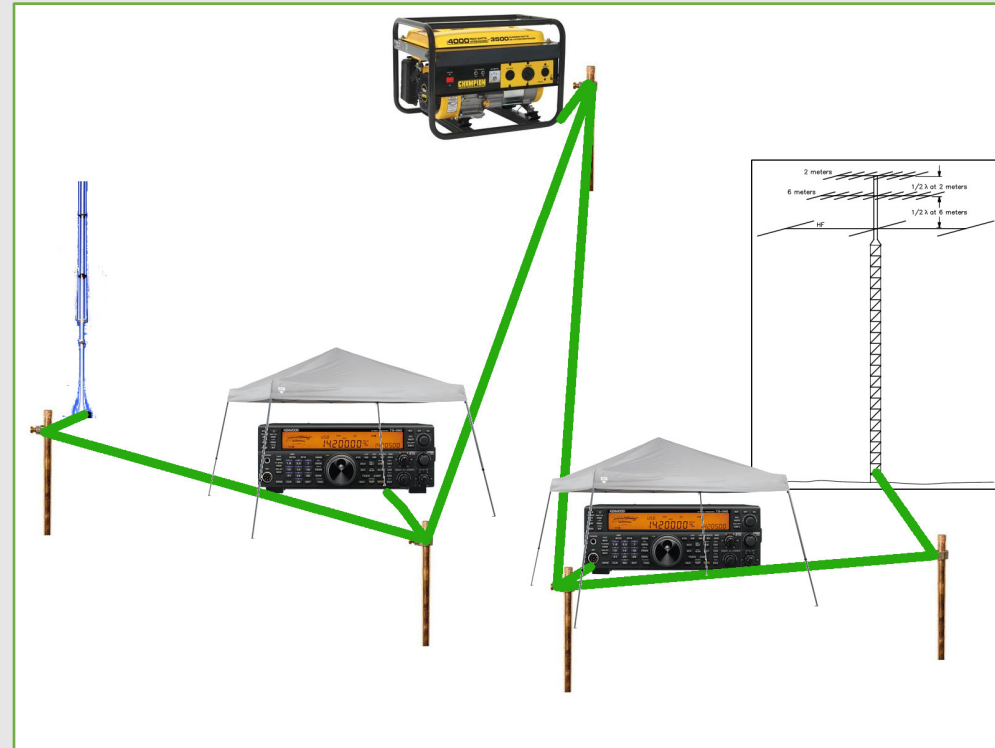
AC **Safety** Grounding (9)

Field Day and other temporary installations

- A ground rod at generator is not needed if the frame is connected to **green-wire GROUND** – **BUT it is still a very good idea**
- Ground Rods at stations are not required if the station equipment is **green-wire GROUNDed** at the generator.
- **BUT ...** the earth is a big resistor, so...
- Best practice: **GROUND RODS** at each station tied to gear & back to generator **GROUND**
- 12AWG **THHN** usually OK up to 100 ft (green!)
- 10AWG **THHN** is preferred for distances at or over 100 ft

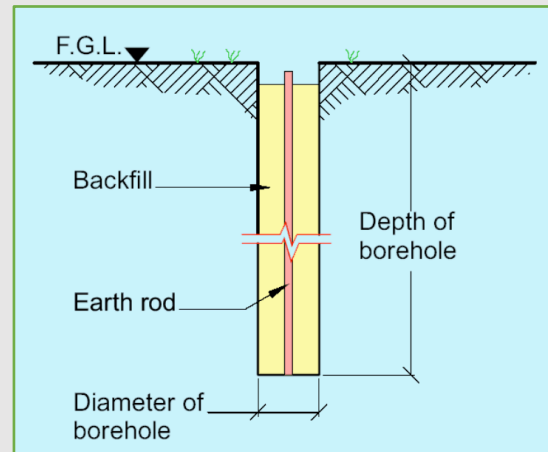
AC Safety Grounding (10)

Field Day and other temporary installations



AC Safety Grounding (11)

Bentonite is used to lower the resistance to earth by providing ground enhancement effectively reducing the resistance between the soil and earth electrode (such as copper earth rod) by retaining moisture. This inherent ability to absorb and retain rainwater increases the electrical conductivity of the earthing compound in positive correlation to local climatic conditions, specifically average rainfall levels.

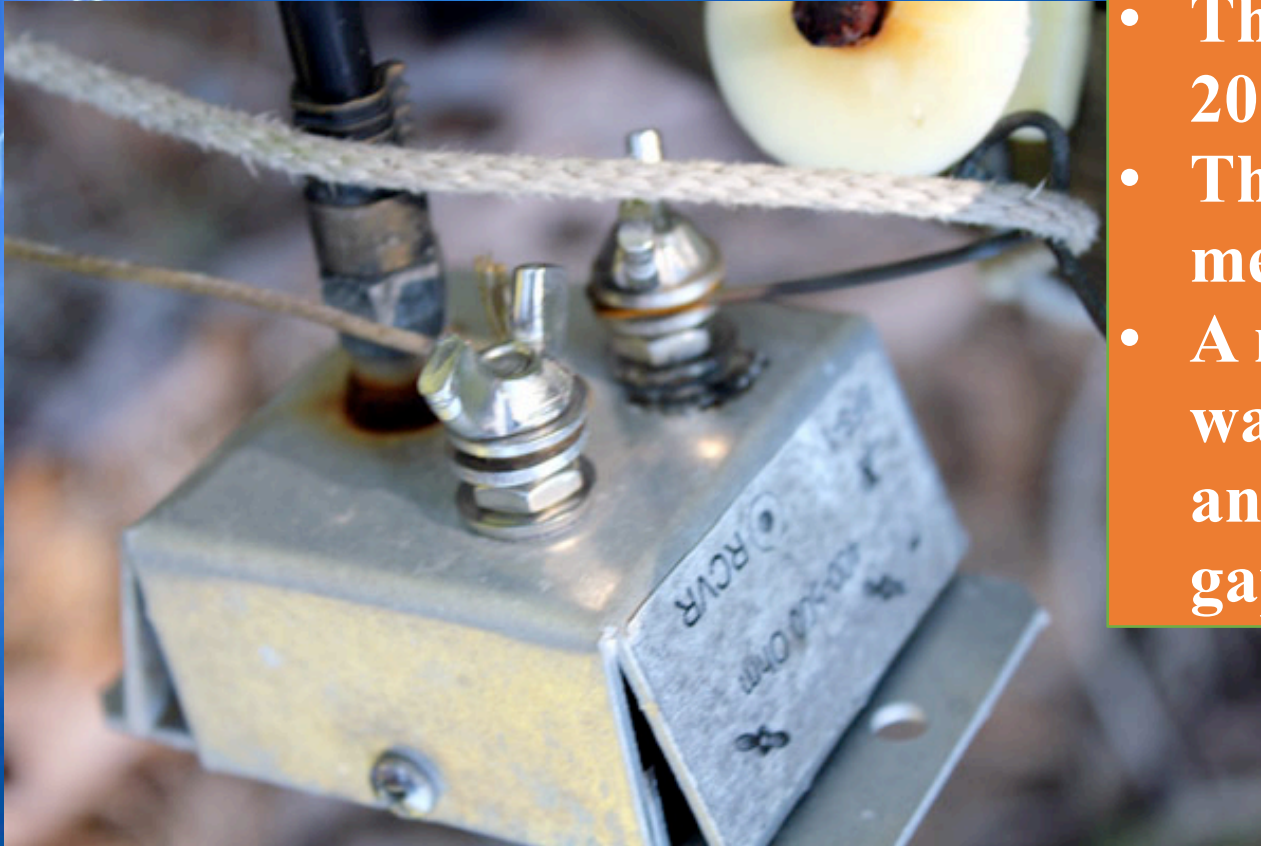


Lightning Protection (1)



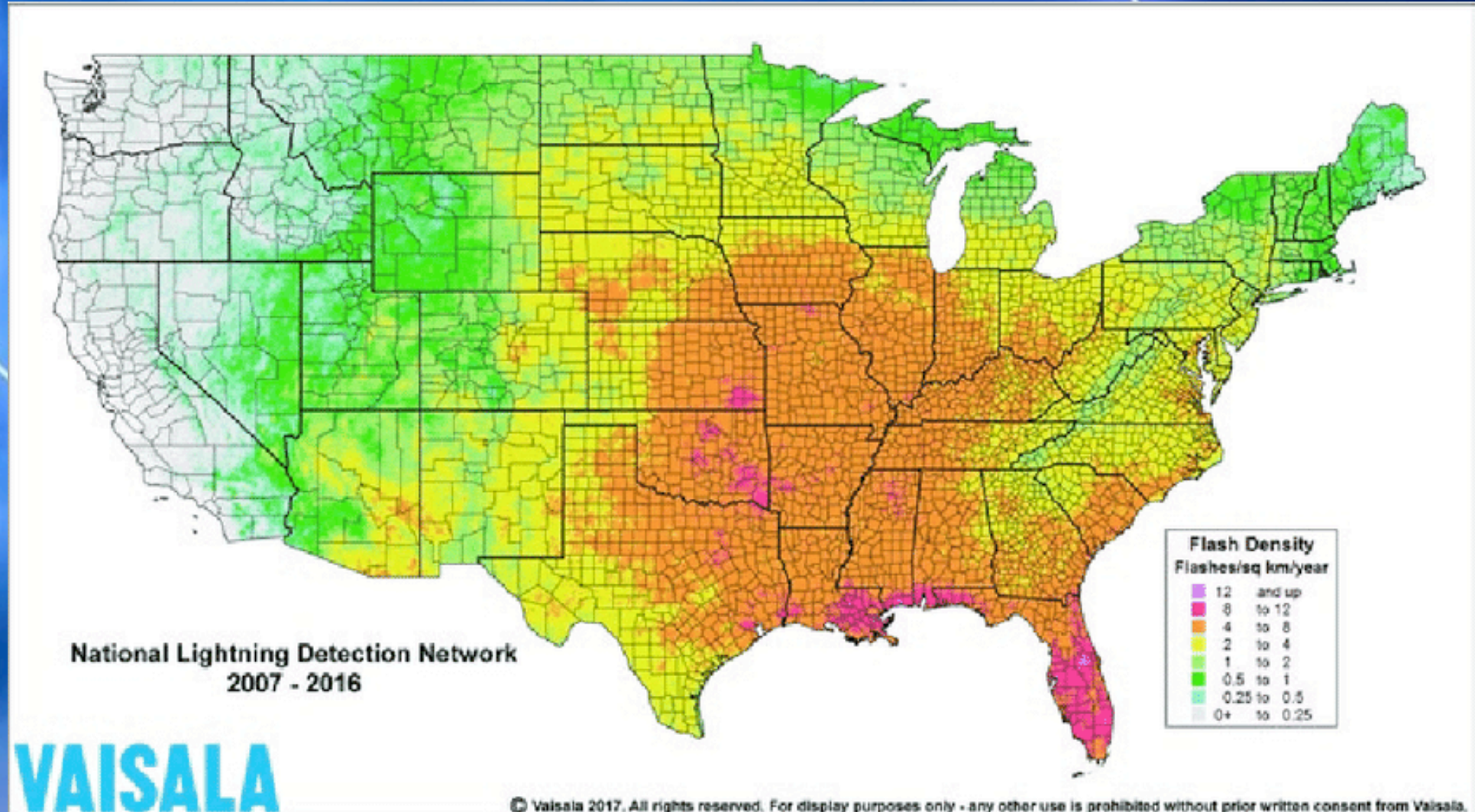
At the root of a tree,
the lightning blew a
big hole in the dirt.

Lightning Protection (2)



- This is the antenna feedpoint, about 200-300 feet from the melted area.
- The explosion actually expanded the metal box!!
- A melted area around the antenna washer is visible. This washer forms an intentional closely-spaced spark gap.

Lightning Protection (3)

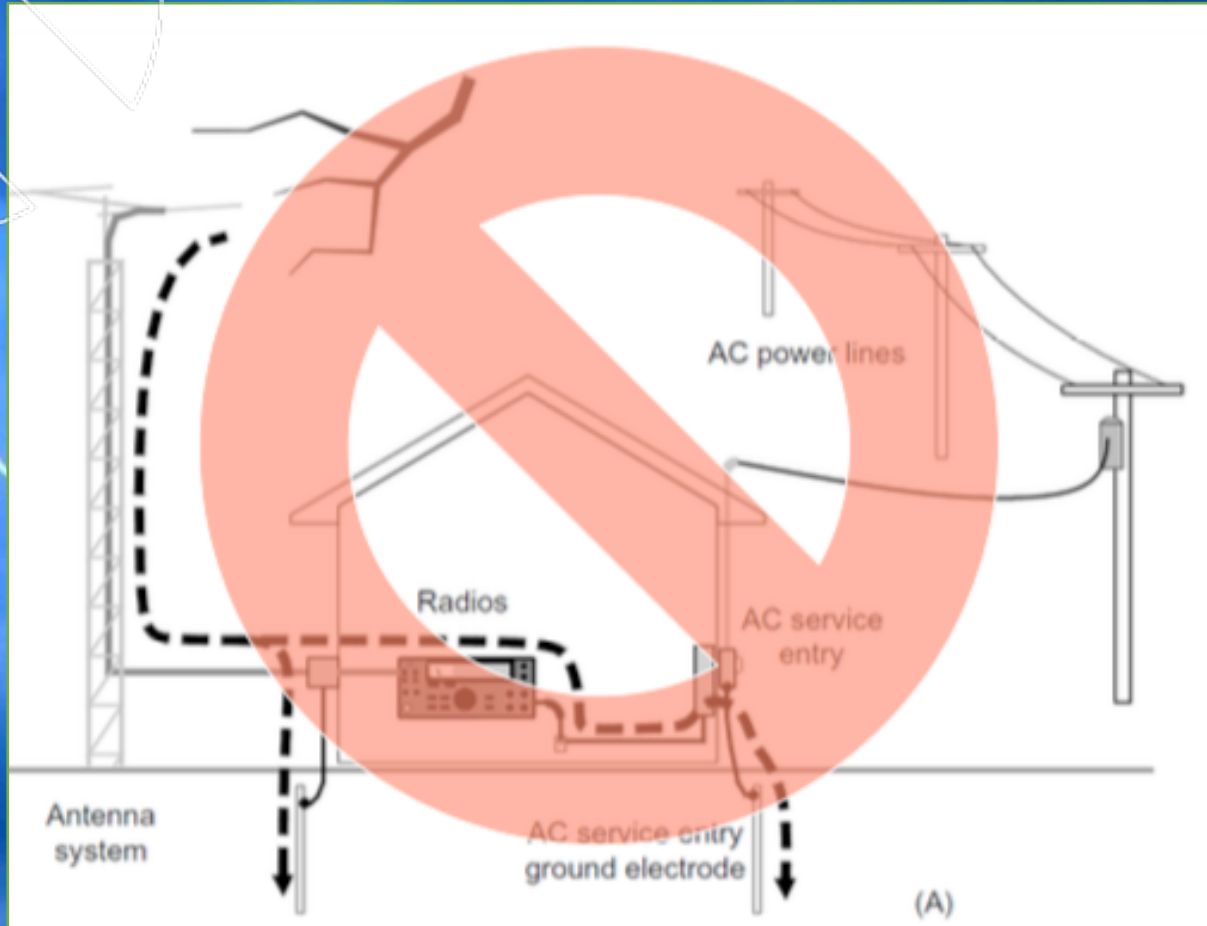


Chicago = 4 to 8 flashes/ sq. km./year (~ .39 mile)

Lightning Protection (4)

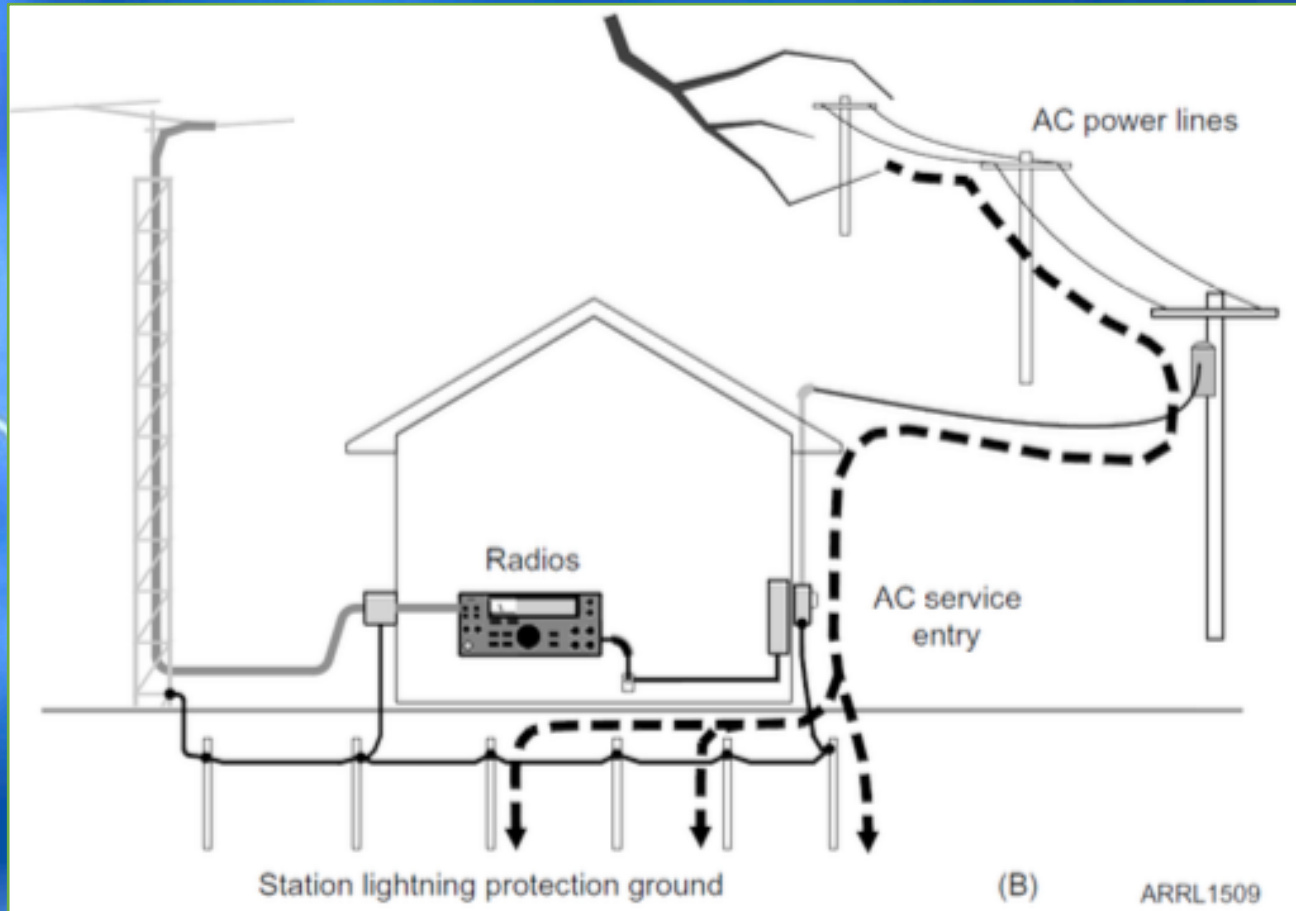
- You can't steer **LIGHTNING**, but...
you *can* help lightning make “good decisions”
- Heavy, low-impedance paths to the Earth
- Inductance is more important than resistance
- Paths should be *outside* your residence
- Don't make it easy for lightning to go through your station on its way to the Earth

Lightning Protection (5)



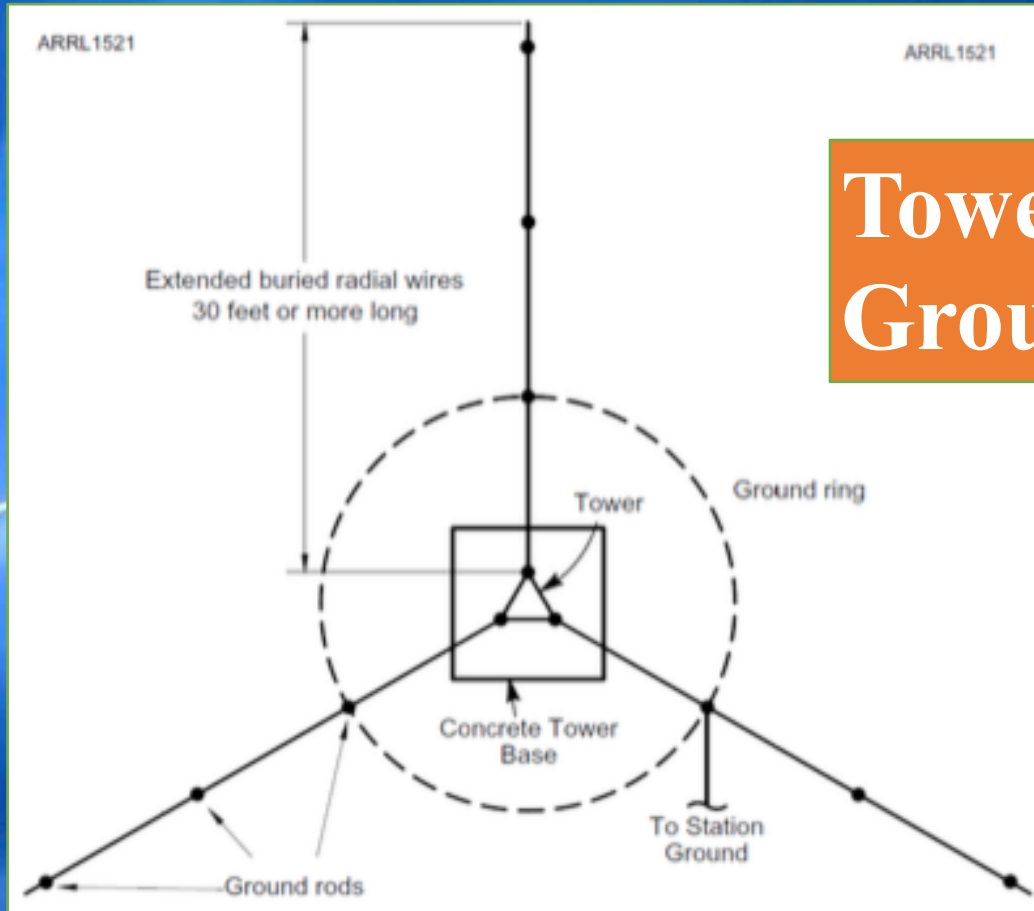
Ground paths
should go
around your
station

Lightning Protection (6)



**Ground paths
should go
around your
station**

Lightning Protection (7)



Tower Grounding

Consider combining your lightning ground with your RF ground system

Lightning Protection (8)



**Bond feed lines
to the tower**

Lightning Protection (9)



Tower grounding and radial system - copper straps run to inside SPGP

SPGP - single point ground panel

Lightning Protection (10)



All cables & ground straps head inside for the SPGP

Lightning Protection (11)



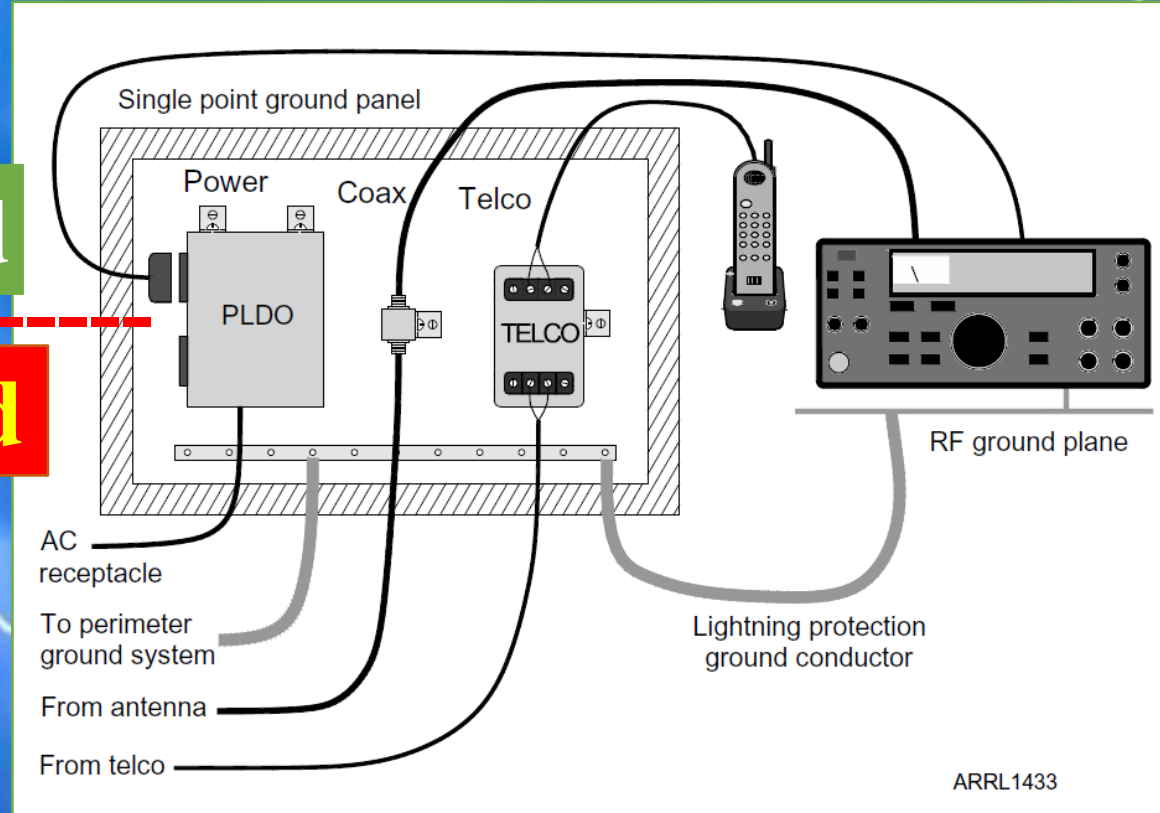
Vertical antenna protection

Coaxial lightning/surge protector

Lightning Protection (12)

Protected

Unprotected



Lightning Protection (13)

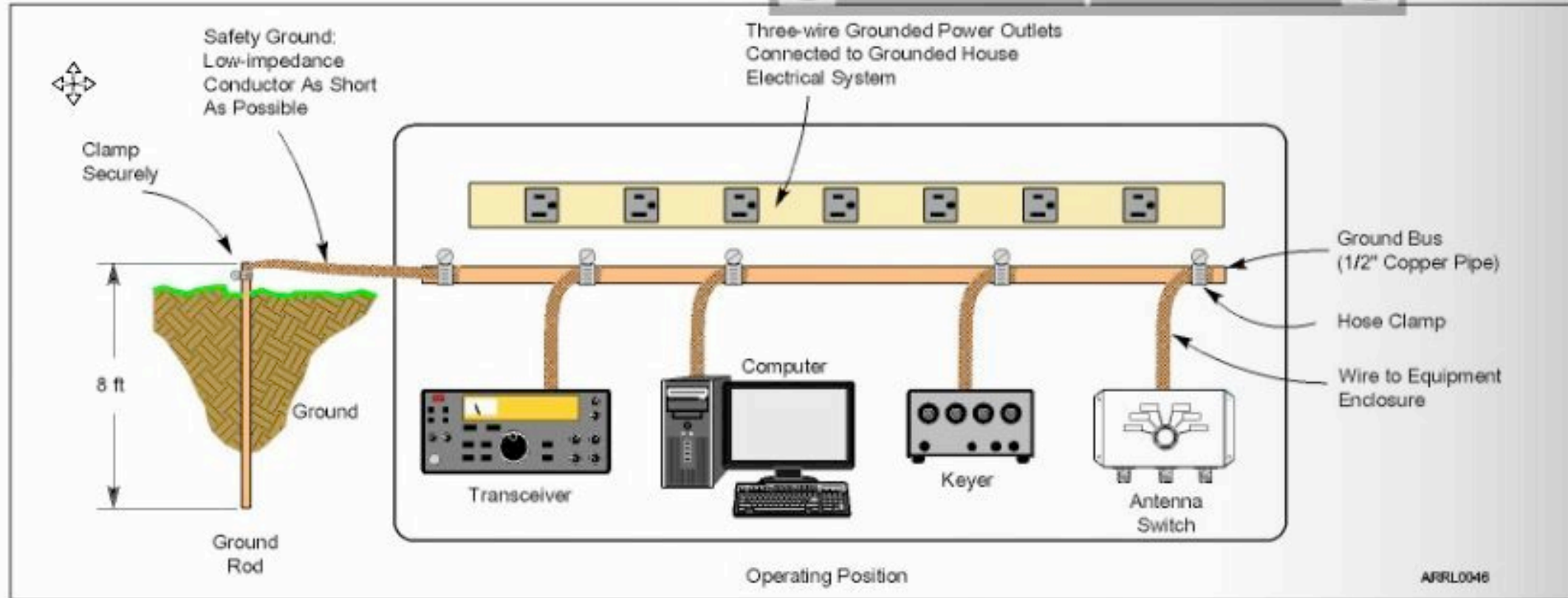
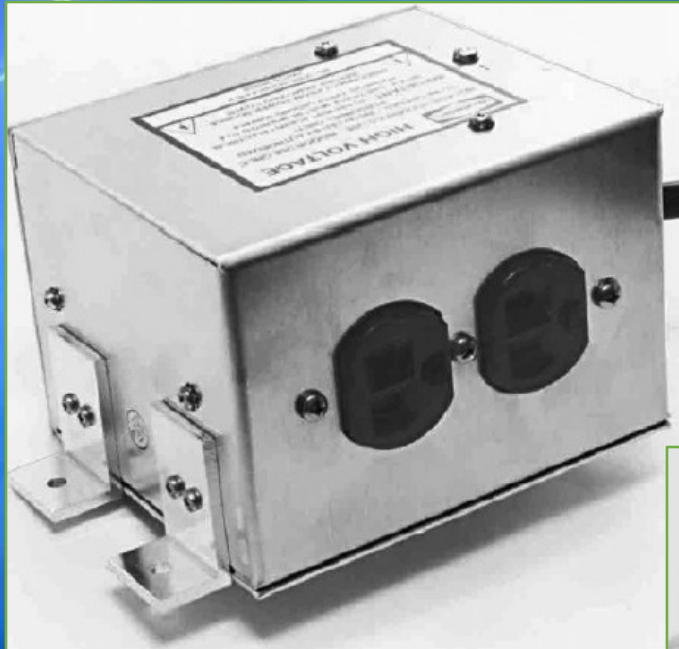
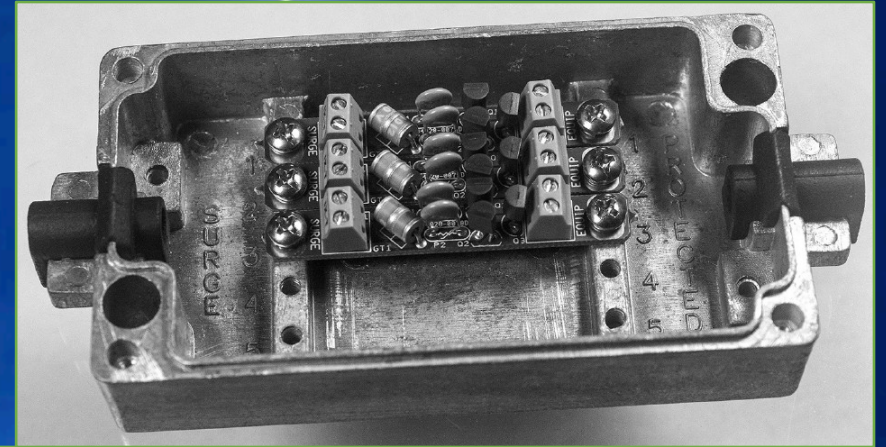


Figure 2 — The ground bus shown in this figure provides effective bonding between the various pieces of equipment at RF. The ac safety ground is also connected to the ground bus, but is of limited effectiveness at RF.

Lightning Protection (14)



Single-point
Ground Panel

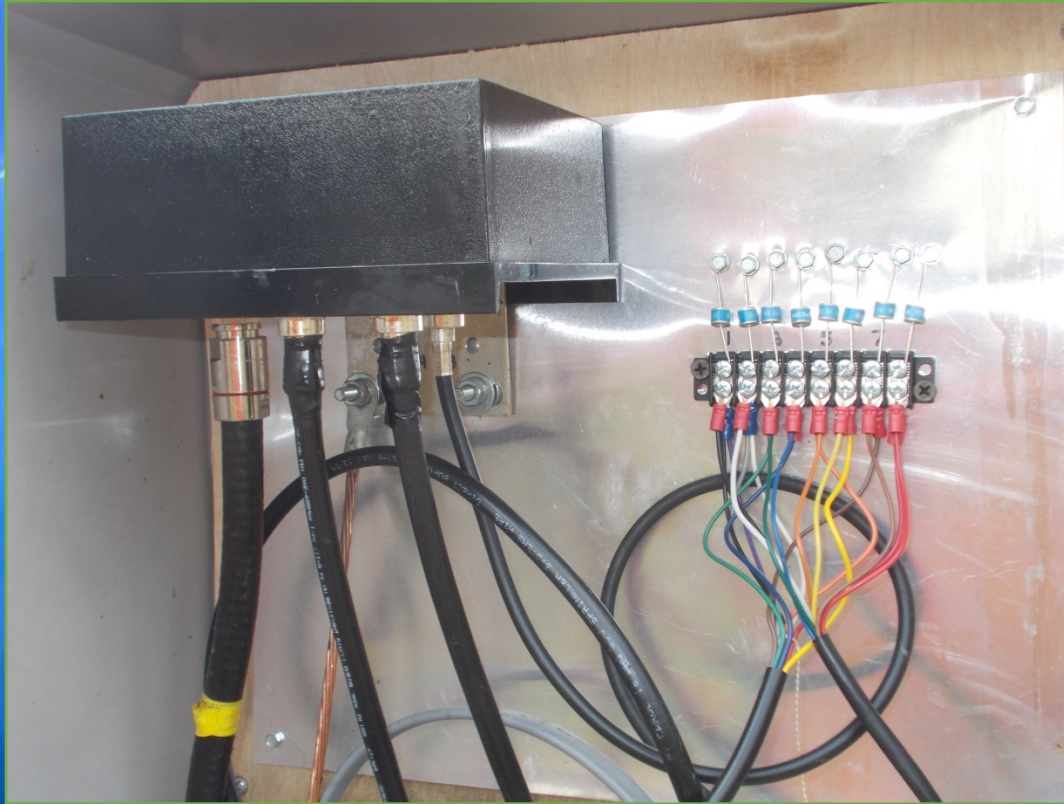


Lightning Protection (15)



**Single-point
Ground Panel**

Lightning Protection (16)



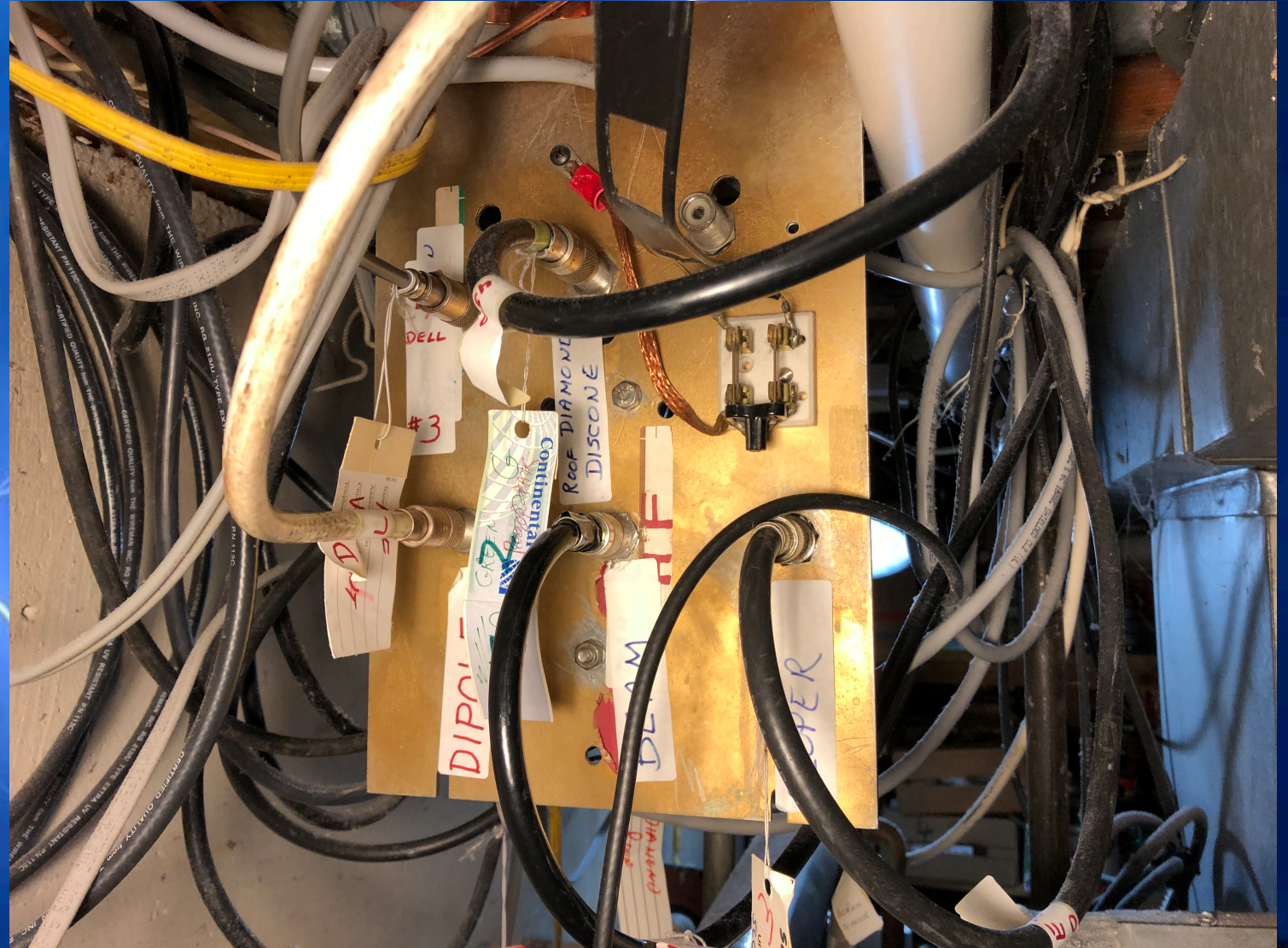
**Single-point
Ground Panel**



Lightning Protection (18)

Single-point
Ground Panel

W9HLQ



Lightning Protection (18a)

Single-point
Ground Panel

W9HLQ



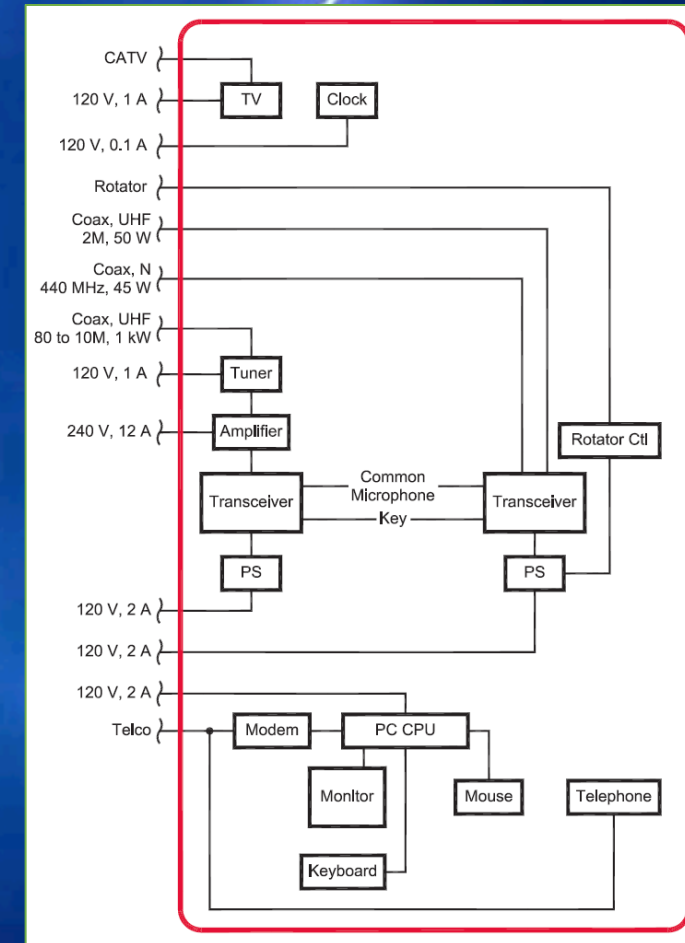
Lightning Protection (20)

Single-point
Ground Panel

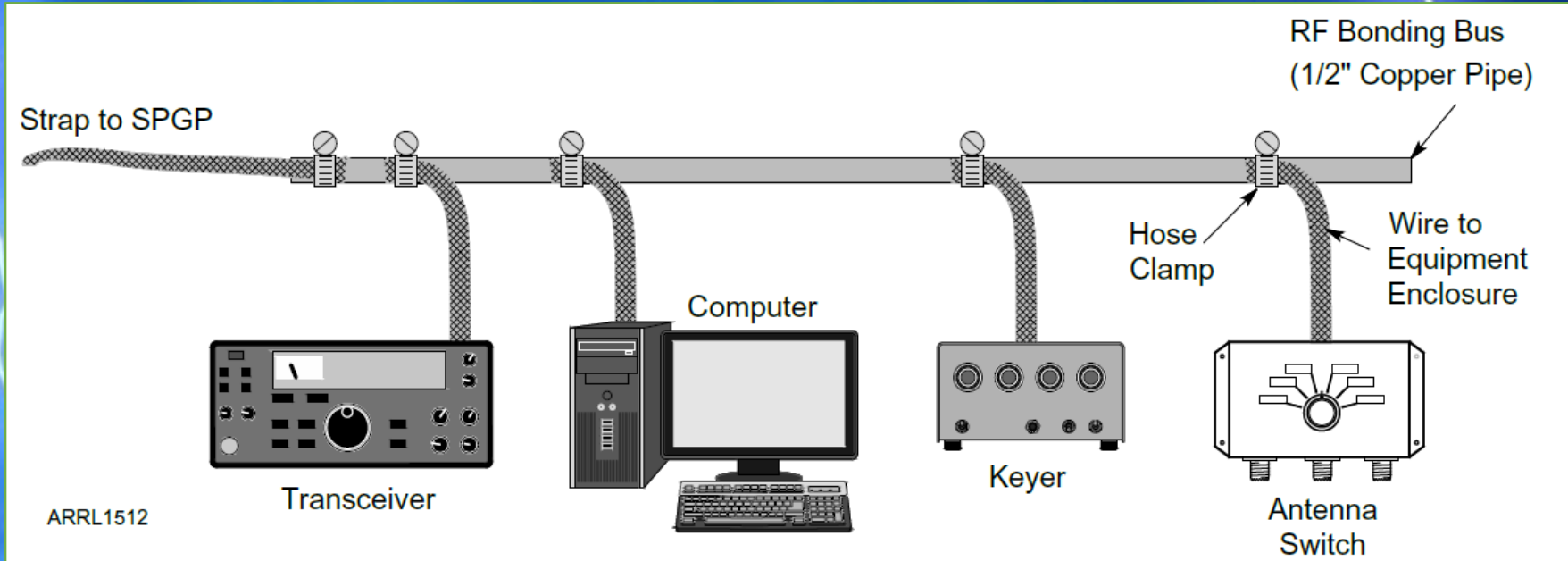


Lightning Protection (21)

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



Lightning Protection (22)

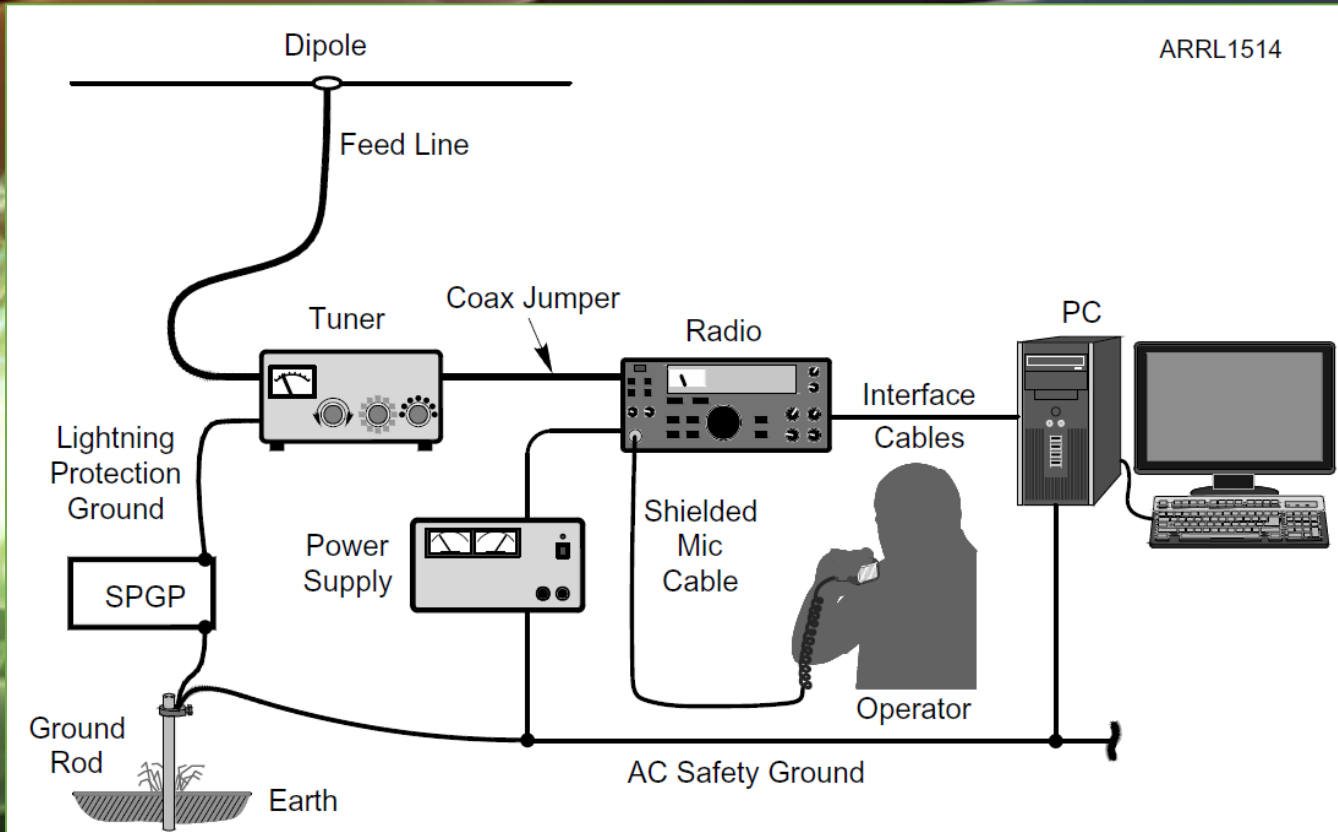


Bonding inside the shack

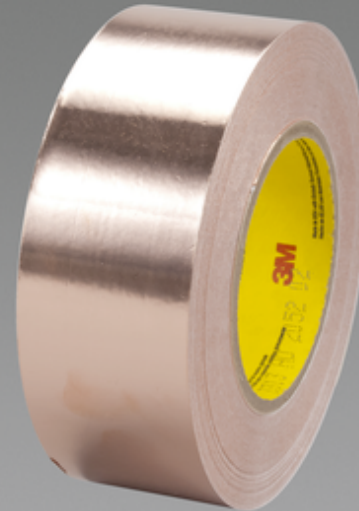
Radio Frequency (RF) Management



RF Management (1)



Everything in the station is an antenna



RF Management (2)

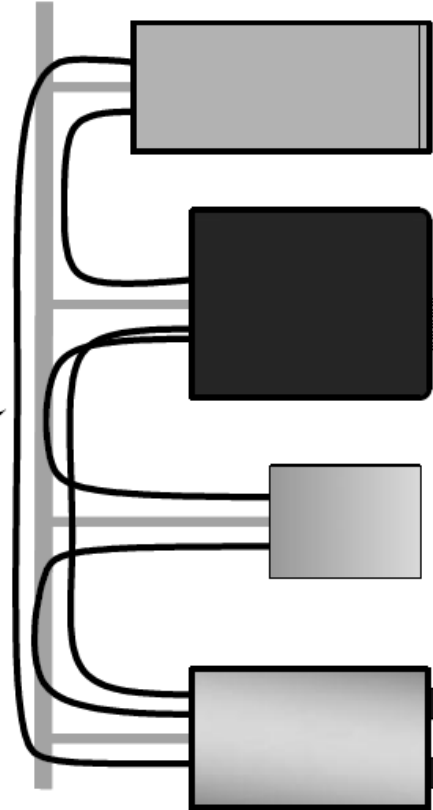
- Everything in the station is an **antenna**
- Forget about an “**RF ground**”
Concentrate instead on **bonding**
 - **Equalize voltage to minimize current**
 - Eliminates “**hot spots**”
 - Reduces **RFI** from **common-mode current**
 - Reduces sensitivity to physical configuration
 - Minimizes **audio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

RF Management (3)

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



Keep Cables
Together



RF Management (4)

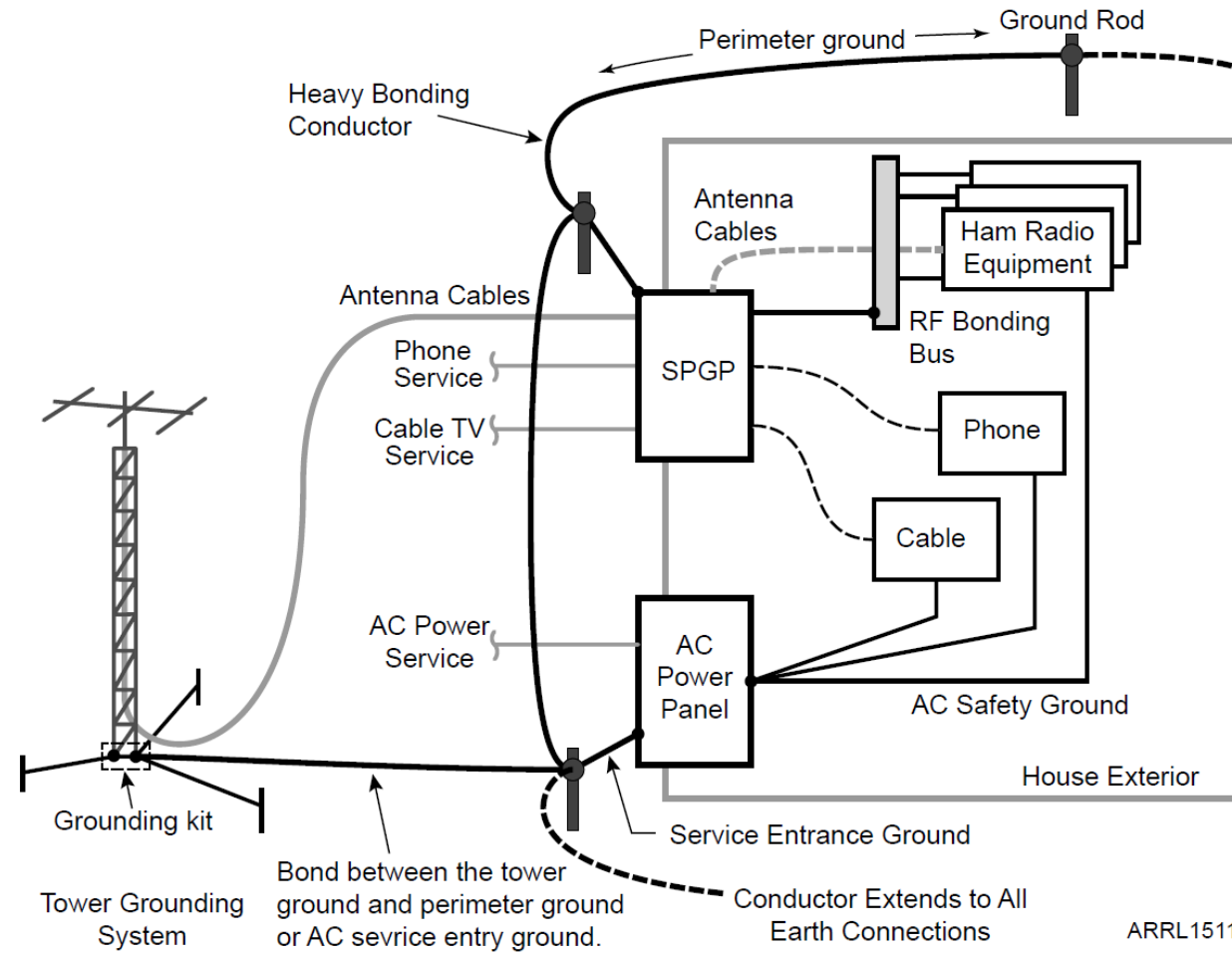
- **RF ground plane**
- Sheet of metal
- Helps equalize voltage
- Run cables along the ground plane
- Bond to station ground system
- MFJ Artificial Ground



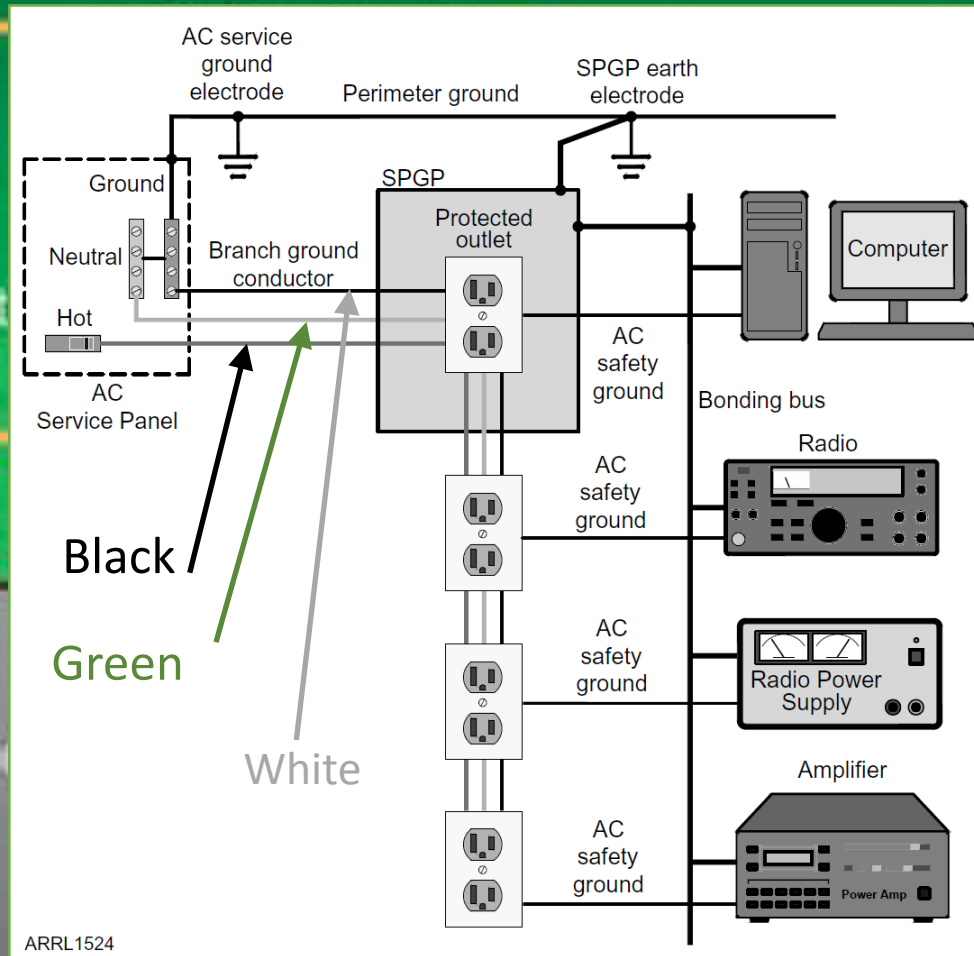
Ground Systems (1)

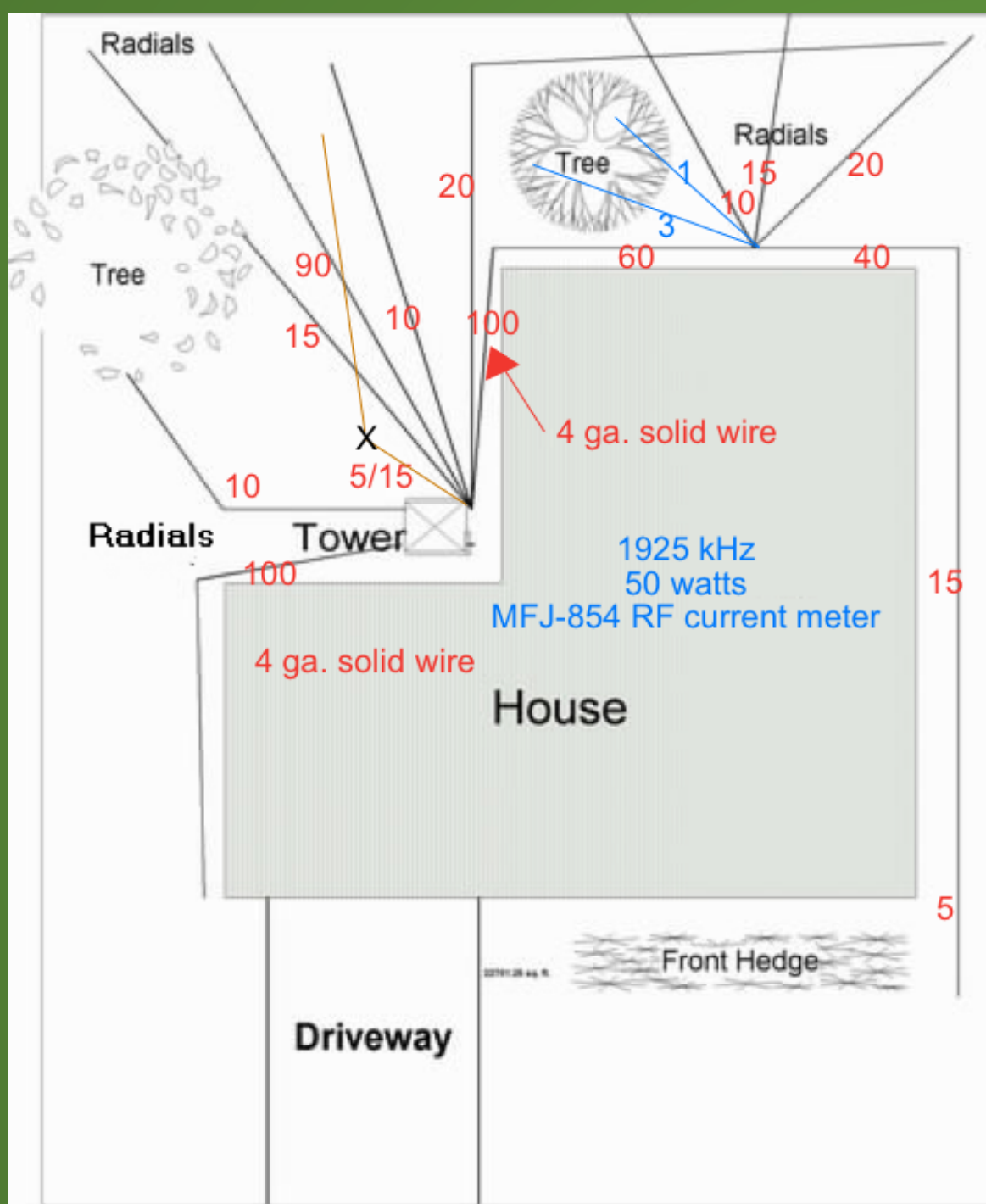
- **And now the good news...**
- “One **GROUND** system to rule them all”
- **All currents flow on all wires**
- A single, solid **GROUND** system made of short, heavy, direct connections satisfies all of the requirements for...
 - ✓ **AC Safety**
 - ✓ **Lightning** Protection
 - ✓ **RF** Management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

Ground Systems (2)



Ground Systems (3)





RF Radial System actual example

Measurements made at W9HLQ
5/2011

1925 kHz
50 watts
MFJ-854 RF current meter

Professional Associations

- **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
- **Lightning Protection Institute** (www.lightning.org/learn-more/library-of-resources) — papers and tutorials on lightning protection techniques

Companies and Products

- **Polyphaser**

www.polyphaser.com/resources/white-papers

various papers and tutorials on lightning protection for communications facilities, including ham stations

More PolyPhaser info: Hamfesters Follow-Up Data

www.hamfesters.org/main/meeting/meeting-follow-up-data-files/

- **Wireman** (www.wireman.com) *tools & supplies for electricians*

- **Mobileers** 160 meter web site:

mobileers.com/main/getting-on-160/grounding-information/

Standards Bodies

- **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
- **AT&T Practice TP-76416** “Grounding and Bonding Requirements for Network Facilities” – <https://ebiznet.sbc.com/sbcnebs/Documents/ATT-TP-76416.pdf>

Books

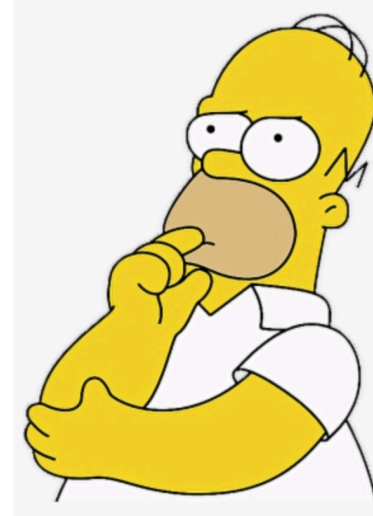
- Block, R. R., **The “Grounds” for Lightning and EMP Protection**, Second Edition, PolyPhaser Corporation, 1993.
- Rand, K. A., **Lightning Protection and Grounding Solutions for Communications Sites**, PolyPhaser Corporation, 2000.
- **ARRL Technical Information Service sections**
 - **Electrical Safety** — 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)
- **Grounding and Bonding for the Radio Amateur** by NØAX– ARRL Bookstore

Links and slides can be found at

- www.nf8m.com - *grounding info*
- Thanks to **H. Ward Silver, NØAX** and **Contest University** <http://contestuniversity.com> (Sponsored by **Icom**.)



I know we have covered a lot of material and may have left you confused.....



I know we have covered a lot of material and may have left you confused....but now you can be confused at a much higher level.

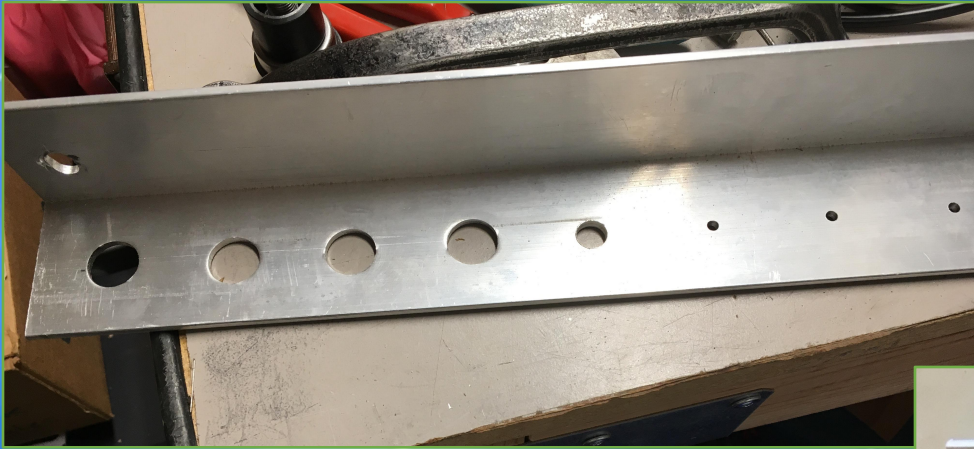


??? Questions ???



Thank you and stay grounded!

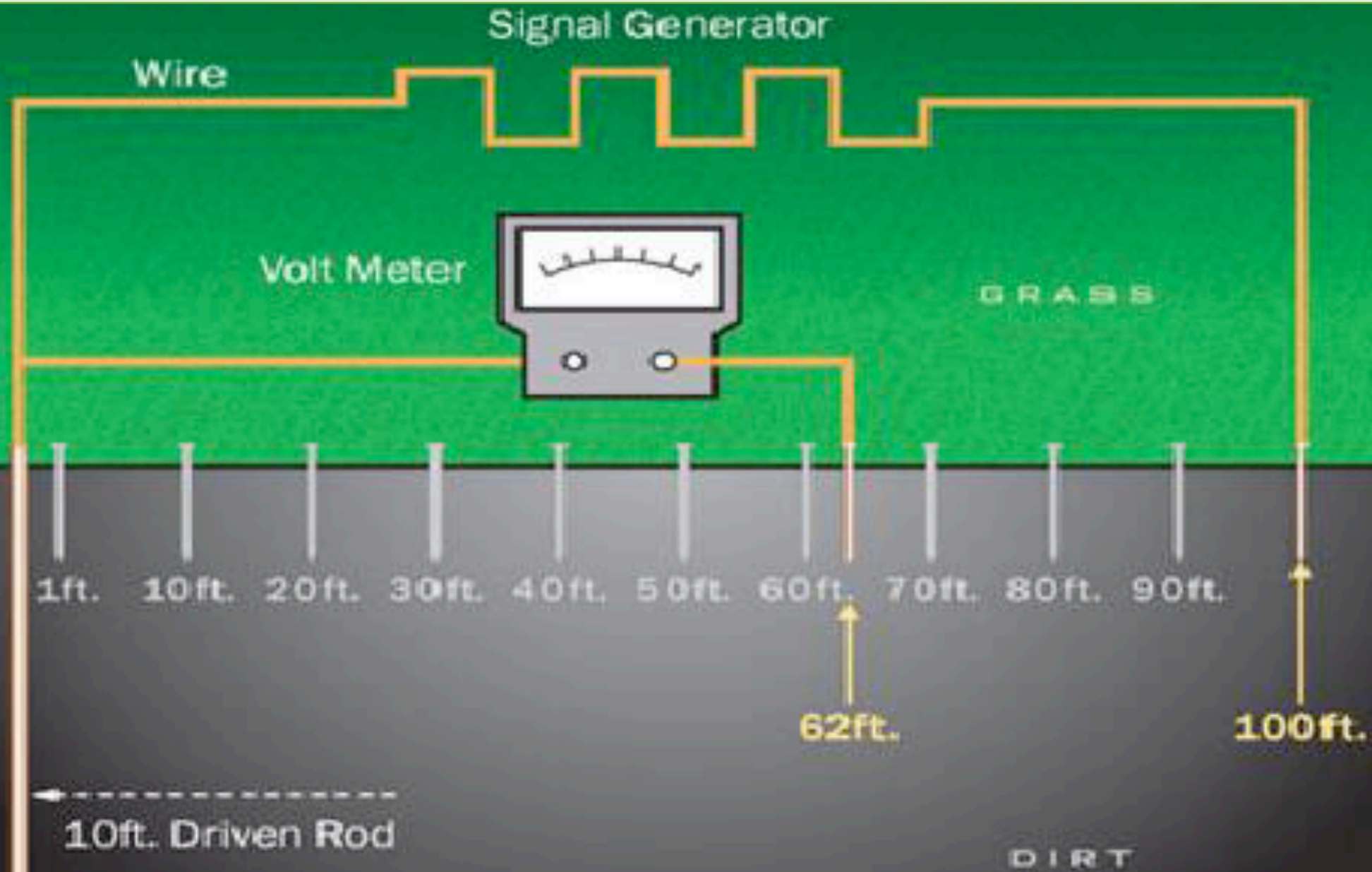
Lightning Protection (17)



**Single-point
Ground Panel**



Ground Systems



Lightning Protection (20)



Single-point
Ground Panel

Lightning Protection (19)



Single-point
Ground Panel

