RACES Field Operations Course - Unit 8

MF / HF Fundamentals

Our Objective:

"To bring our newly upgraded General Class licensees up to speed on MF and HF, before the next disaster!"

Why "MF / HF?"

After viewing this unit you should know:

- **WHAT** are the unique characteristics of MF / HF?
- **WHY** does RACES use them?
- **WHICH** MF / HF bands are used for EmComm?
- **WHEN** are MF / HF preferable to VHF / UHF?
- **WHY** is choosing the right frequency so important?
- **HOW** is EmComm different from working Dx?
- **BASICS** of equipment setup and antennas
- **OPERATING** hints and practices...

What is "MF" / "HF" *Versus UHF and VHF*

Band	Frequency Range	Amateur Band
MF	0.3 - 3 MHz	160 meters
HF	3.0 - 30 MHz	80, 75, 40, 30, 20, 17, 15, 12, 10 meters
VHF	30 - 300 MHz	6, 2, 1.25 meters
UHF	300 - 3000 MHz	70 cm, 23 cm and up

The entire MF / HF bandwidth is only 29.7 MHz., but it does amazing things Beyond Line Of Sight which are impossible at higher frequencies!

WHY use MF / HF for EmComm?

Reliable "24 / 7" Communication!

- Reliability
  - Not dependent on repeater infrastructure!
  - 24 hrs / day, 7 days / week, year-round
- Wide-area coverage
  - Statewide / Regional / Nationwide
- Flexibility
  - Ability to change bands, modes
    - Work around problems or conditions

How do MF/ HF work? Requirements for success:

- **Basic knowledge** of equipment, procedures and techniques that "work"!
  - **Knowledge of propagation!**
  - **Proper frequency selection!**
  - **Suitable antenna design!**
- **Reliable equipment!**
- **Use of good operating practices!**

Propagation Modes:

- **Line of sight (LOS)**
- **Ground wave**
- **Classical sky wave**
- **High angle (NVIS)***

*__N__ear __V__ertical __I__ncidence __S__ky wave

Line of Sight (LOS)

- **Direct wave mode**
  - **Most common at VHF, UHF and above**
  - **Limited by terrain absorption**
    - Path blockage
  - **At MF / HF frequencies generally limited to stations "within sight" of each other.**

Line of Sight (LOS)
(continued)

- **Ground-reflected wave mode**
  - Reaches Rx station after ground reflection
  - Arrives later than direct wave
  - Can cancel or enhance direct wave depending upon frequency, reflection
  - Generally weakens direct wave reception.

Line of Sight (LOS)

(continued)

- **Space wave mode**
  - Vector sum of direct + ground reflected wave
  - Use of "high ground" reduces terrain effects
  - Good LOS propagation for short range paths.

Ground Wave Mode

- **Vector sum of space wave + surface wave**
  - **Useful to 50 miles** in "ideal" conditions
  - **Affected by terrain**, vegetation, atmospherics.

Ground Wave Mode

(continued)

- **Surface wave mode** = Component of ground wave traveling along the earth's surface
  - Affected by ground conductivity
  - Direct and ground reflected waves tend to cancel when antennas close to ground
  - Signal diminishes with antenna height
  - Not useful more than 1λ above ground
  - Less attenuated with vertical polarization.

Classical Sky Wave

- **Uses *ionospheric reflection***
  - **Unique to MF and HF!**
  - **Enables long range communication!**
  - **Proper frequency selection** important
    - Shorter the distance, lower the MUF.

Classical Sky Wave

(Continued)

<u>"Skip zone"</u>

- Beyond ground wave
- "Too short" for "normal" sky wave
  - Whip antennas are poor on short paths

Near Vertical Incidence Sky Wave (NVIS)

- **<u>Vertical</u>** radio energy radiated at a *low enough frequency* is <u>reflected back to earth at all angles</u>.
  - **Effect similar to taking a fire hose with a “fog”nozzle and pointing it straight up!**
- **<u>Omni-directional</u>** pattern without “dead” spots.
- **<u>Continuous circular radiation pattern</u>.**

NVIS
(Continued)

- Proper frequency selection is critical!
- MUF lower at higher angles of incidence.
- Signal strength doesn't vary with small changes in operating location or height
- Less affected by terrain, vegetation
- Efficient for short paths *if a proper antenna is used.*
  - **Generally requires takeoff angle >70 degrees**

NVIS
(Continued)

- **Proper antenna choice is necessary** to suppress ground wave amplitude to prevent fading.
- 1/2 wave dipole at **1/4 to 1/10 λ above ground** to cause radiated energy to be directed vertically!
- Antenna is then **Omni-directional** and broadside orientation to receiving direction is unnecessary!

“There is no ‘skip zone,’ unless you create it!”

Summary of FM24-18, Appendix “N”

- Understand the relationship between the angle of radiation and the effective operating distance.
- Use a dipole at **1/4 to 1/10λ** above ground
  - **Physical height is not critical, +/- 0.1λ OK.,**
  - **Elevate 25 ft on 75-80 and 40m if you can do so safely**
  - **If you can’t erect a wire antenna safely, lay insulated wire on the ground! - Use transmatch it will work!!**
- Permits 400 mile, “24 / 7” operation w/o “skip”

NVIS is best for EmComm when:

- Operating area is not conducive to ground wave
  - **Mountainous terrain**
- Stations on the net are located in “skip zones”
  - For mobile whips or “usual” operating techniques.
- Areas of high signal attenuation
  - **Wet weather conditions in heavily forested areas**
- Operating positions below surrounding terrain
- Wide-area SAR and disaster relief operations
  - **Helicopters or light aircraft close to the ground.**

How EmComm is Different from DX?

- EmComm usually requires SHORT paths!
- Shorter path, needs higher radiation angle
- Higher angle means a lower MUF
- Means using 75-80 meters at night
- And 40 meters during the day
- Coverage within the active NVIS radius is usually quite "even."

Solar Activity and Propagation

- Critical frequency for F-layer propagation (fo) depends on Solar Flux Index (SFI)
- Usually below 4 MHz at night, rarely above 6 MHz in daylight.
- Fluctuates on 11 year cycle
- For current SFI listen to WWV every three hours starting 0000 UTC, 18 min. past hour.

Maximum Useable Frequency - MUF

Versus Frequency of Optimum Traffic (FOT)

- **MUF related to critical frequency (fo) by takeoff angle:** ***MUF = fo /Sin(takeoff angle)***
- **Because of high variability in ionosphere operating near the MUF is unreliable.**
- **FOT is the highest frequency where ionosphere propagation is 90% reliable.**
  - For reliability operate 20-25% below MUF

MUF Affected by Solar Index

- As SFI increases, MUF increases
- For NVIS winter is more critical than summer
- In low SFI 75-80 meters is useful in daylight
  - But not at night...
  - Winter 75-80 meters may go “long” late at night
- Momentary outages occur on daylight paths during solar flares...
- Evening QSB (fading) during geostorms.

EmComm During Low SFI

- Greatest challenge in low SFI is short path!
- Under 300 miles predicted MUF always above 2 MHz, but FREQUENTLY not above 3 MHz
- Limitations of amateur bands...
  - 40 meters unusable for EmComm in low SFI
    - Locations within 300 miles in “skip” zone.

Medium Frequency (MF)Use:

Why 160 meters?:

- Useful for all paths at night
- Only "MF" band that amateurs have
- May be the only way to make NVIS useable in some instances.

Negative:

- NOISY !#$%@^*&!!
- Ionospheric absorption is much greater
- Harder to radiate a strong signal
- Antennas are larger
- Resistive losses must be minimized.

Characteristics of MF

are not always in our favor because:

- **Low antenna gain**
- **Lower antenna efficiency**
- **Higher path losses**
- **Higher noise floor**
- **Requires greater RF output power to establish and maintain reliable contacts.**

Characteristics of 160 Meter Band

- During daylight 160 meter sky wave is almost completely absorbed in the D-layer
- Atmospheric noise of much higher intensity
  - Expect 5-8 dB increase from 40 to 80 meters
  - Expect 8-9 dB increase from 80 to 160 meters!

Antenna Fundamentals

- <u>Wire antennas</u>
  - Home brew versus "bought"
  - Fixed versus portable
- Temporary
- Versus permanent supports
  - Or NO supports
    (more about this later)

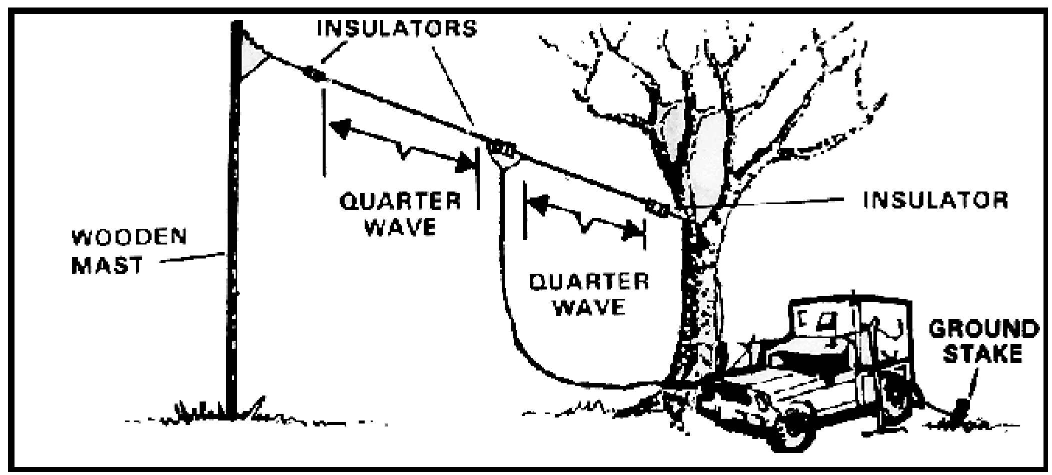


Figure 3-32. Half-wave doublet antenna.

Antenna Elmering

- Multi-band antennas (G5RV) require transmatch.
  - Keep G5RV ladder line“stub” kept away from any noninsulating material or ground.
  - “Legs” at minimum 120 degrees included angle
  - “Stub” always perpendicular to radiator
- Dipole, cut to frequency is a better performer

Use current mode balun with coax-fed dipoles

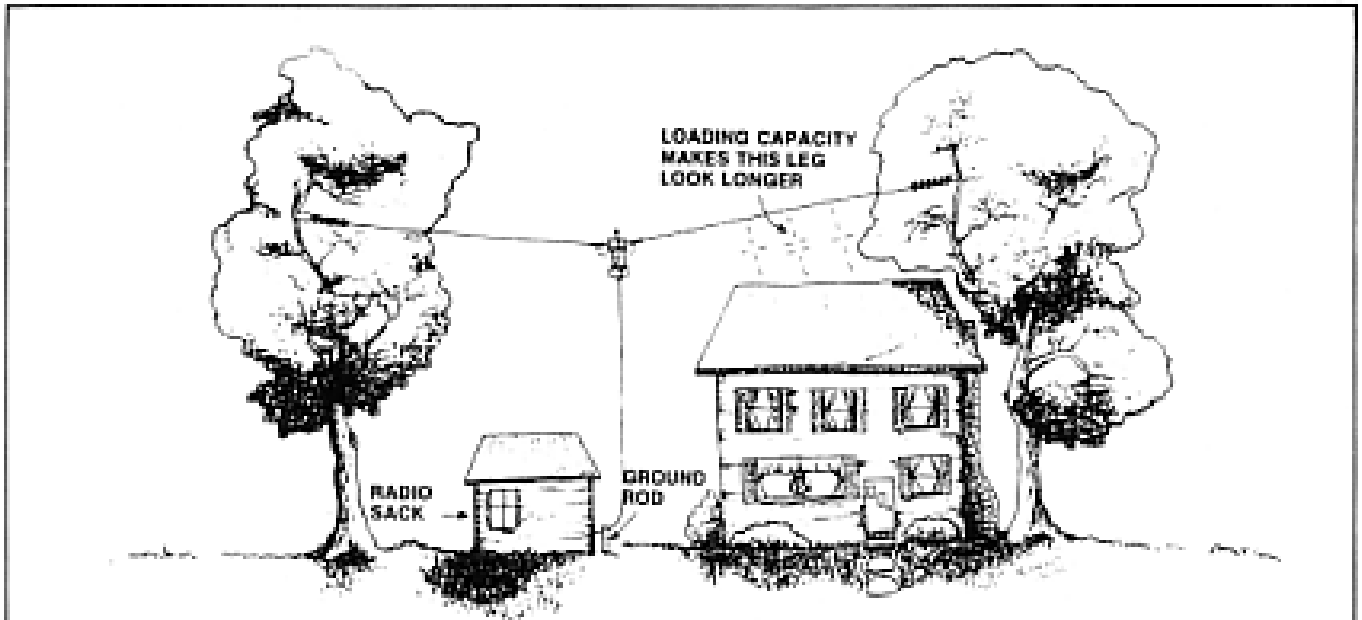
- Ferrite beads on coax at feed point
  - Minimizes RFI to other services,
  - Power supplies, etc.

Home Brew Wire Antennas

- **Insulated wire desirable for safety and durability.**
  - **Commonly available, at low cost**
  - **Less affected by elements, less risk of RF burns**
  - **Physical dimensions shorter due to decreased velocity of propagation**
  - **Works laid on the ground when used with transmatch often necessary in expedient situations.**

Home Brew Wire Antennas
(continued)

- **Proximity to ground or structures causes discrepancy in calculated vs. resonant length**
  - **Transmatch or cutting to frequency is recommended.**



Structures close to leg can make it electrically longer than the other leg.

Temporary Supports for Wire Antennas

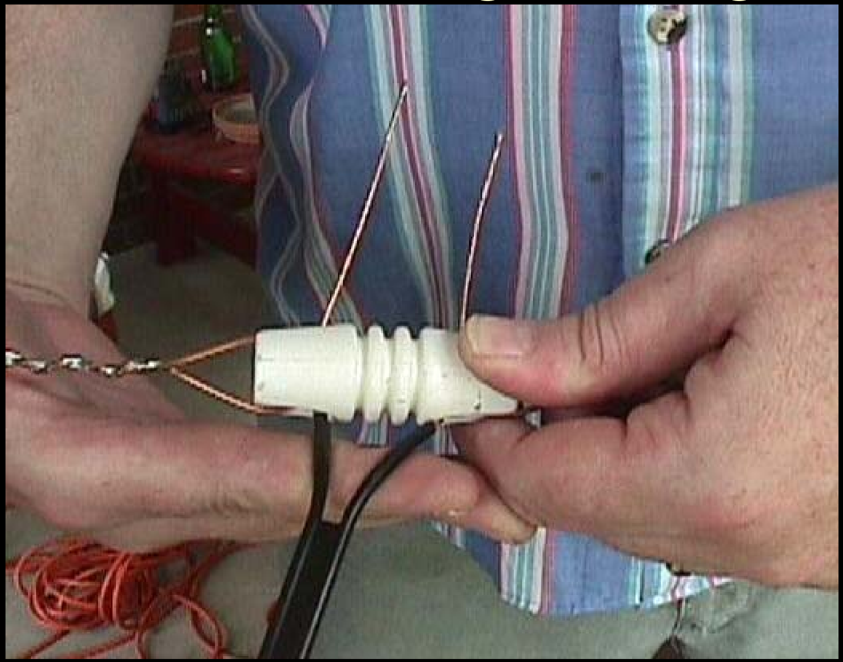
Hints on homebrew wire antennas:

- Getting your support lines up in the air
  - Slingshot, etc. small line first
  - Nowhere in proximity to power lines!!
- Remember that trees move!
  - Support ropes, pulleys and counterweights
- Insulated wire dipoles
  - Require NO elevated supports
  - Will “work” w/transmatch when laid on ground!

Hints on homebrew wire antennas

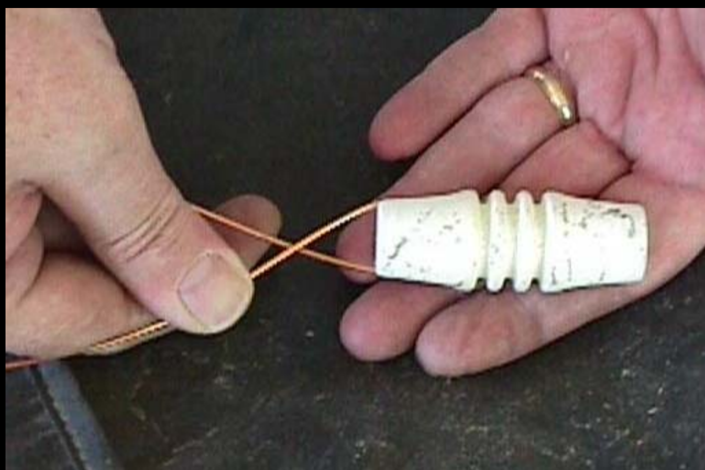
Photos courtesy N1FN www.morsex.com/dipole

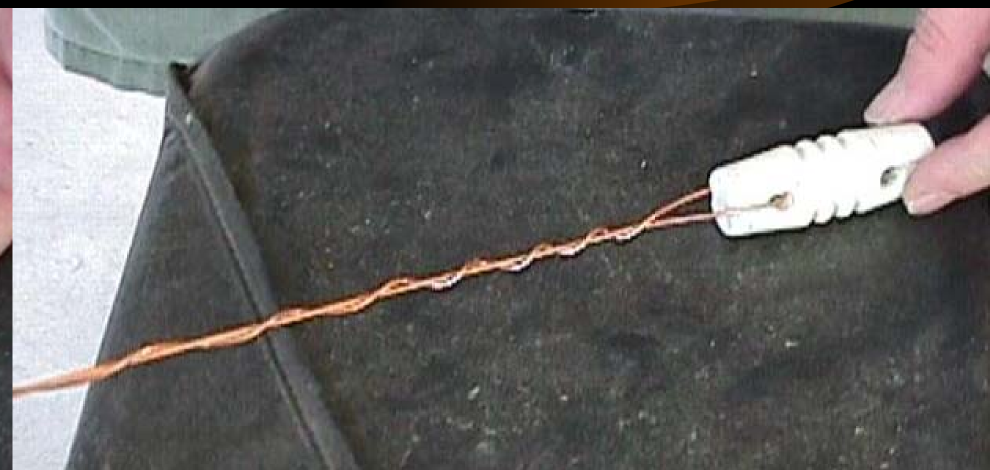
- Geometry for
- center insulators
  - Avoid breakage, arcing



Hints on homebrew wire antennas

- **Geometry for end insulators**
  - **Avoid breakage, arcing**





Antenna construction materials

- Wire
  - Stranded 12-14 AWG, SAE type oil resistant, insulated
  - Hard-drawn, Copperweld, or insulated
  - Insulators, ceramic, plastic, glass, improvised

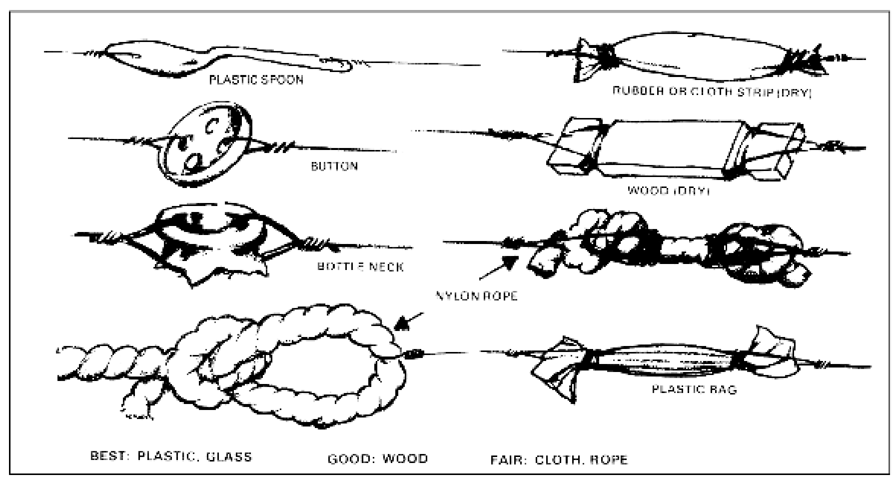


Figure 3-26. Improvised insulators.

Hints on homebrew wire antennas

(still need some good illustrations)

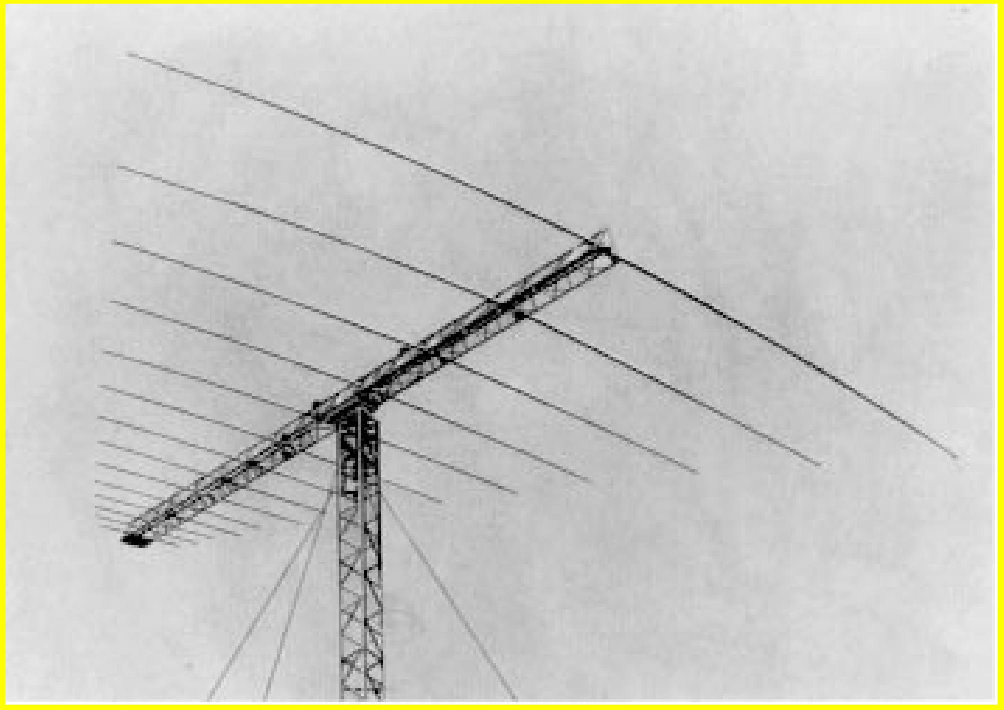
- **Knots, the bowline**
- **Coax strain relief**
- **Waterproofing**

Basic Construction Skills

- How to Solder…
- Install PL-259s the right way
  - Avoid too much heat, damages dielectric
    - “Solder It” Kit - low temp paste really works!
  - Pre-tin cheap nickel plated connectors
    - Recommend silver-plated Amphenol instead!
- Better yet, avoid PL-259s altogether, use “N”
  - Because PL-259s not constant impedance
  - PL-259s are not waterproof.

Fixed station antennas

- **Mil-surplus log periodics for 20 meters and down - BIG, heavy, EXPENSIVE!**



Fixed station antennas

- Mono / Multi-band beams
  - Most ham HF yagis antennas 7 MHz and higher
  - Less useful for EmCom, though great for Dx
- Verticals - better for DX than for EmCom"short path"
- Effects of icing

Fixed station antennas

- **Multi-band wire antennas**
  - **G5RV - requires transmatch**
  - B&W folded dipoles, etc.
- **Fan dipoles**
  - **Great “homebrew” project**
  - Several resonant dipoles, on shared feed point
- **Wire beams** - great if space available
- **Beverage antenna** - great if space available

Mobile Considerations

- **Noise reduction** - find source, use ferrite choke
- **RF and DC grounding**, bonding of body panels
- **Power connections**, vibration and water proof
- **Low voltage disconnect**

Mobile - Portable Considerations

- **Mobile antennas**
  - **Vertically polarized whips poor on short path**
  - **Lean / bend long whips horizontal**
  - **Use a transmatch**
  - **Dual -Hamstick-dipole adapter - if stationary**
- **Other mobile / portable antennas** that “work”
  - **For NVIS and EmComm applications**

Basic Operating Skills Use of controls:

- "Clarifier" / RIT, notch/ shift, RF gain, attenuation
- Power supplies, batteries and charging
- Equipment installations, wire gages and connections, fuses, diodes
- Fail to battery and reverse polarity protection
- Minimum field test equipment, tools
- Lightning protection...

Basic Operating Hints:
flesh out later

- **Where to put the equipment…**
  - Close to the battery and within 100 ft. of antenna
  - Ergonomic operatic position, writing area
  - Good air flow around equipment
  - Ventilation of battery banks
- **Equipment "nuts & bolts"**
  - Importance of RF ground,
  - Discussion of "hot chassis" problems
  - Antenna tuners
  - Which rigs?

Operating Practices

Minimum power to maintain reliable communications

- Reduce power when conditions are favorable!
  - 5-25w enough on SSB with a full-sized dipole!
  - 25-50w is usually needed for vertical mobile whips.
  - Reducing power permits batteries to last longer
  - But in noisy conditions even 100w may be marginal
- "Commanding the frequency"
  - Dealing with "LIDS" and malicious interference

Need More Information?

HF EmComm Resources on the Web:

http://www.varaces.org

http://www.k2bj.com

http://www.morsex.com/dipole

http://www.reliefweb.int

http://www.tactical-link.com

http://www.dxlc.com/solar/

Acknowledgements:

Virginia RACES is extremely grateful to the following individuals who have provided materials used in the production of this training

John R.G. Corbett
Steve Cuccio, NB3O
Marshall G. Emm, N1FN
Maj. Edward J. Farmer, P.E., CA SMR, AA6ZM
Art Feller, W4ART
David M. Fiedler, WB2CDG, LTC, NJ ARNG (Ret.),
Patricia Gibbons, WA6UBE
Jim Thompson, W4THU
Mark Wood, G4HLZ

Any Questions?

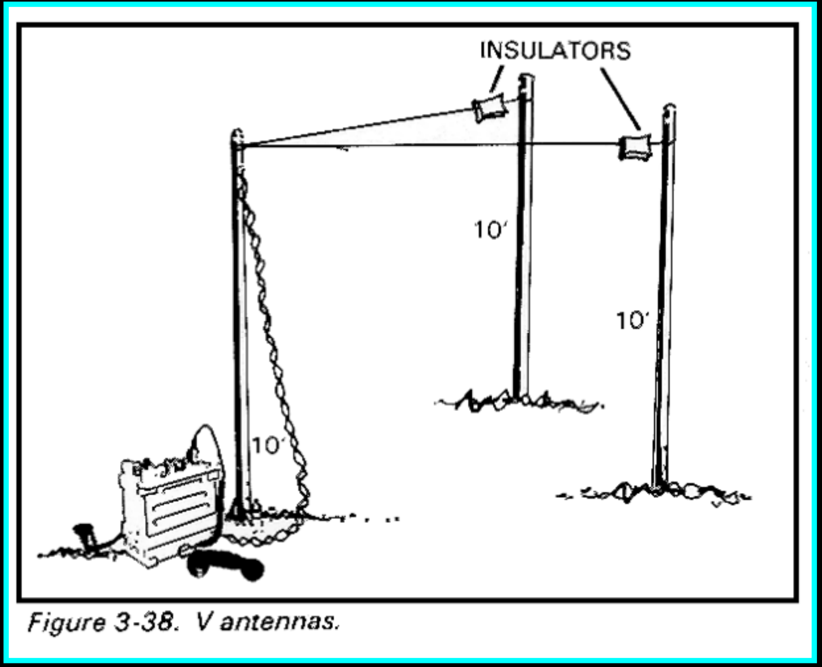


Figure 3-38. V antennas.

Legal

- Use of any of the herein contained materials is licensed for Non-Commercial, Educational Use Only, and may be withdrawn at any time.
- Questions or comments regarding licensing, or any other related matter, should be addressed to the State Emergency Radio Officer at www.varaces.org
- For specific licensing questions, please contact the State Emergency Radio Officer of Virginia RACES, Inc., the owner of this work.