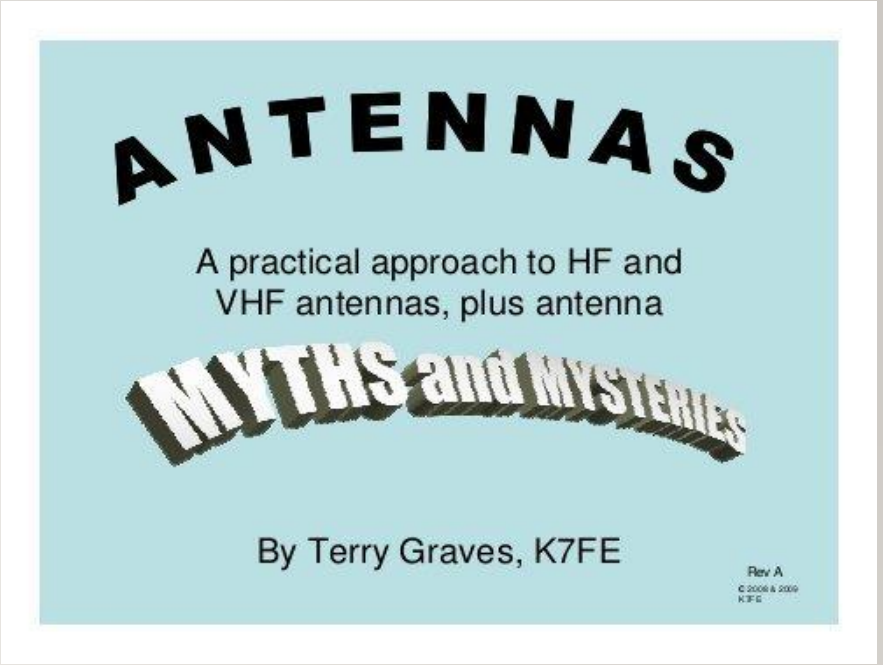
Think "ANTENNA SYSTEM" not just:

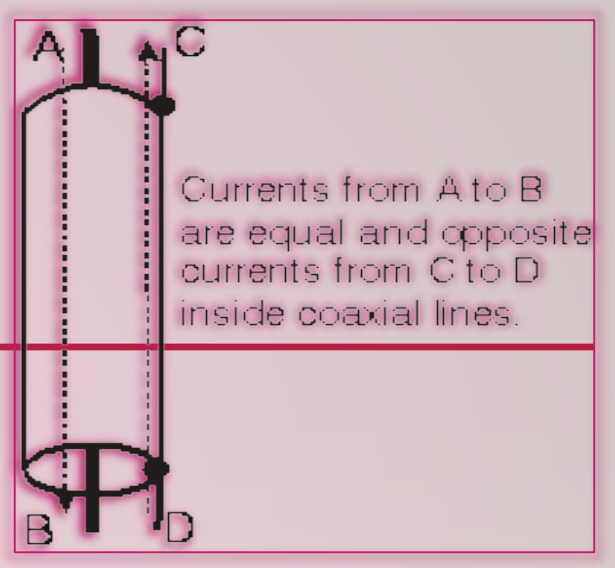
- The antenna
- The coax or feedline
- The radials
- The balun
- The ground
- The matching network




# HAM ANTENNAS

"Everything works in tandem. If one part is not performing, then the other parts are brought down. Big Gun stations make sure that all parts of their antenna system are working properly." K7FE

# 2 >> COMMON MODE CURRENT <<




1. Kirchhoff's Current Law: "the sum of currents flowing into a node equal the sum of currents flowing out"
2. If the "antenna system" does not have an established path for the displacement current to leave the antenna (node) then one will be found, i.e., likely the feed line.
3. The current on the feedline flowing back from the antenna is common mode current.
4. Common Mode Current is lost power and may be an unwelcome destructive element.
5. This CMC occurs with any un-balanced antenna: End fed wire, vertical, mobile
6. No antenna is perfectly balanced or unbalanced, thus always some CMC.

# 3 UNDERSTANDING OF SIGNAL TRANSMISSION

- **Displacement Current** – The flow of alternating current energy through a capacitor (via dielectric plate buildup) or the air (displacement) to complete the circuit.
- **Common Mode Current** – The flow of current back down a transmission line because as a secondary path vs. out the antenna which would have been displacement current.
- **Counterpoise** – The conductors > in length > than ¼ wavelength of the frequency at the end of a single wire (or rod) antenna. Possibly the feedline if no other conductor.
- **Radial Field** – A sufficient number of conductors at the point where a transmission line connects to an antenna wire or rod that provide a counterpoise to the antenna.

# 4 ANTENNA BASICS: +BALANCED+ +UNBALANCED+

- **THE DESIRE: Maximize Signal Radiation and Reception > Minimize Displacement Current**
- **Get the Signal to the Antenna for TX and Back to the Receiver for RX**
  - Displacement Currents – Occur in all un-balanced antennas
  - True Dipoles with Balanced Feed Lines **=** Minimal Displacement Current
  - Coax – Signal is sent via the outer surface of the center conductor and not the shield
  - Common Mode Current – The signal being sent back down the coax shield (not radiated)
- **Basic Antennas:**
  - **Balanced** – Hertz, Dipoles and Loops
  - **Unbalanced** - Marconi (end-fed) and verticals

> Hertz antenna is self-resonant and operates independent of a counterpoise.
> Marconi antenna always requires a counterpoise of some form.

# 5 PROBLEM > RF IN THE SHACK

- **Properly balanced coaxial or open wire feed lines with balanced antennas should contribute minimal RF at the operating position, even absent a shack ground!** Many people assume that RF in the shack or (worse yet) RF burns are tied to problems from poor station grounds. RF in the shack should be treated like an alarm bell, it is saying "There is a balance issue in the feed line and/or antenna." Don't just ground it and "mask" the problem.
- **End fed antennas are notorious for imbalance and stray RF or RFI.** When you run a long-wire or some other single wire feeder (a radiator) directly into the shack it will often contribute high levels of RF into the shack, so it is best to connect to a remote tuner outside of your shack. Then bring coax from the tuner to your operating position.

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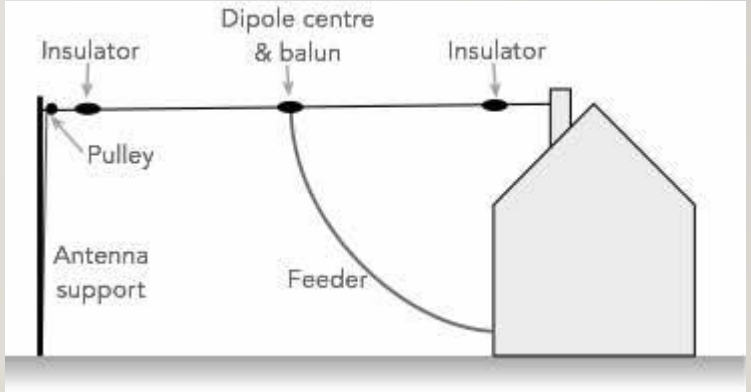
# 6 BALANCED ANTENNA DIPOLE: TWO IDENTICAL CONDUCTIVE ELEMENTS

- A balanced antenna has symmetry about the feed point such as a dipole where two conductors carry equal but opposite voltages such as twin lead or ladder line.
- This "push-pull" center fed concept has currents largely equal in both halves thus establishing an electric field where most of the signal is released to the area around it.
- A counterpoise is not required.
- Antenna Impedance must match the feedline as closely as possible or there is the potential of common mode currents.
- Depending on the type of yagi, it can be a balanced antenna.

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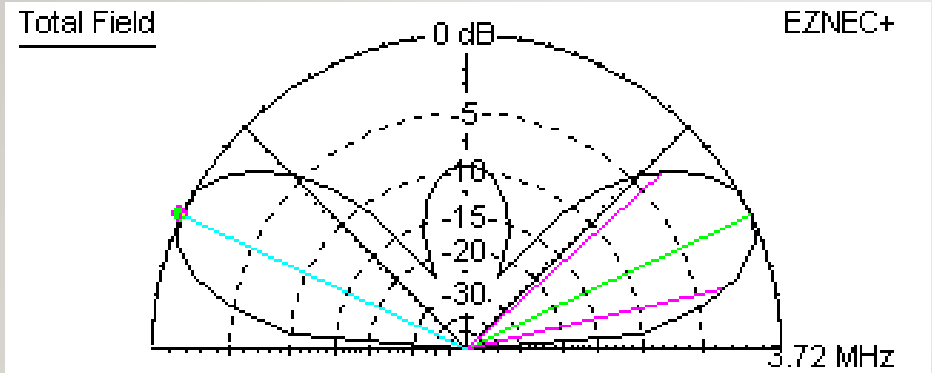
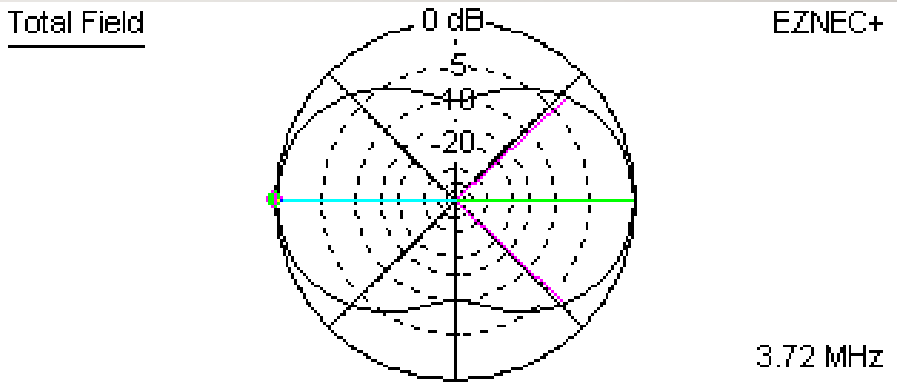
# 7 BASIC DIPOLE ANTENNA RADIATION NOTE THE GAIN




| | | | |
|---|---|---|---|
| Elevation Plot | | Cursor Elev | 155.0 deg. |
| Azimuth Angle | 0.0 deg. | Gain | 8.55 dBi |
| Outer Ring | 8.55 dBi | | 0.0 dBmax |
| | | | 0.0 dBmax3D |

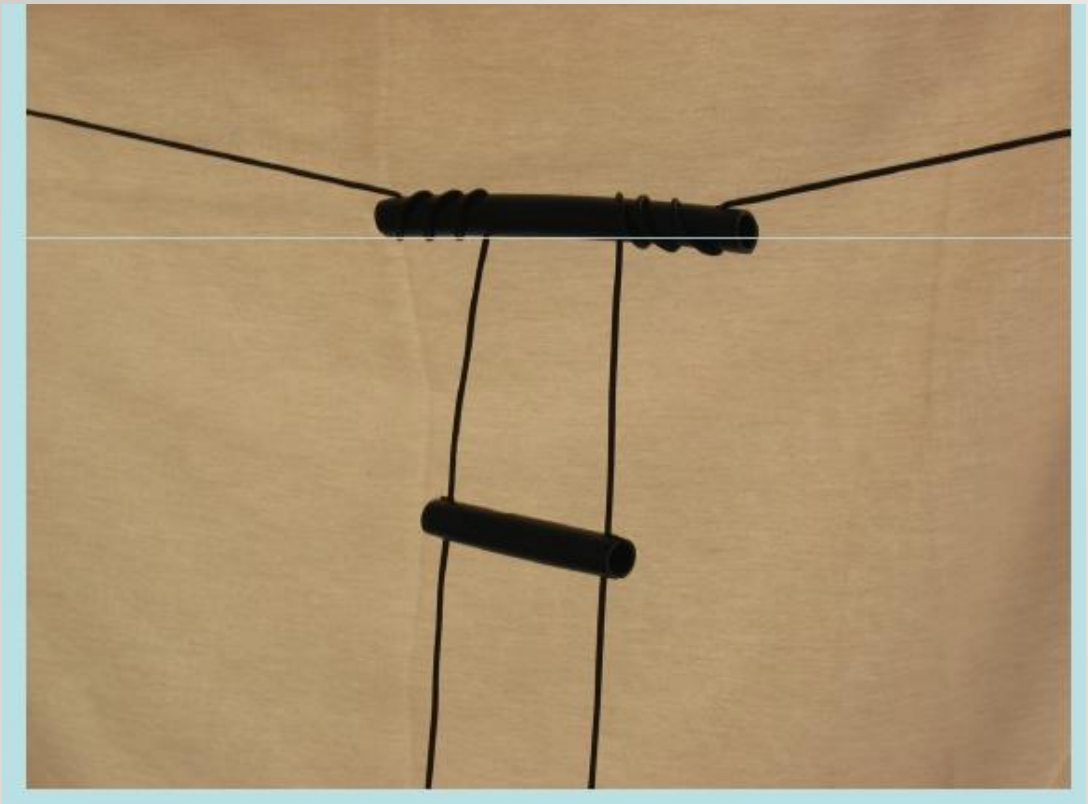
| | |
|---|---|
| 3D Max Gain | 8.55 dBi |
| Slice Max Gain | 8.55 dBi @ Elev Angle = 25.0 deg. |
| Beamwidth | 28.8 deg.; -3dB @ 13.1, 41.9 deg. |
| Sidelobe Gain | 8.55 dBi @ Elev Angle = 155.0 deg. |
| Front/Sidelobe | 0.0 dB |




| | | | |
|---|---|---|---|
| Azimuth Plot | | Cursor Az | 180.0 deg. |
| Elevation Angle | 25.0 deg. | Gain | 8.55 dBi |
| Outer Ring | 8.55 dBi | | 0.0 dBmax |
| | | | 0.0 dBmax3D |

| | |
|---|---|
| 3D Max Gain | 8.55 dBi |
| Slice Max Gain | 8.55 dBi @ Az Angle = 0.0 deg. |
| Front/Side | 10.08 dB |
| Beamwidth | 86.1 deg.; -3dB @ 316.9, 43.0 deg. |
| Sidelobe Gain | 8.55 dBi @ Az Angle = 180.0 deg. |
| Front/Sidelobe | 0.0 dB |

# 8 FALSE MYTH:
# OPEN LINE FEEDLINES RADIATE MORE THAN COAX



- A balanced open line or ladder line with a balanced antenna will radiate no more than coax if properly installed.
- Field intensity measurements prove this fact.
- If feedline radiates, it and/or your antenna is out of balance and needs corrective action.

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# 9 FEEDLINE BALANCE - THE CORRECT AND SIMPLE RULES

- **Each conductor must have equal currents 180 degrees out-of-phase with the other conductor at the same point**
- **Each conductor must have equal voltage and opposite voltages with reference to ground or the spatial area around the conductors.**
- **Unless all of these conditions are met, the feedline could be a source of unwanted energy bringing RF in to the shack or noise ingress into the antenna.**

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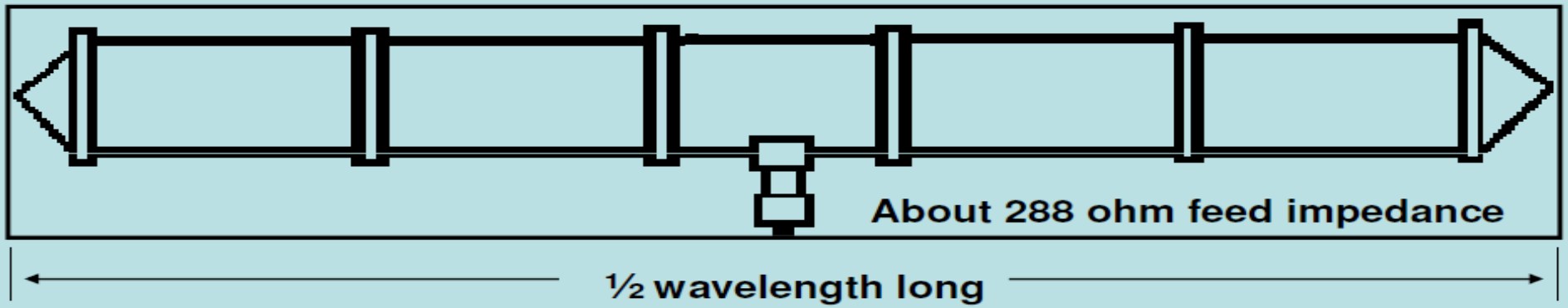
# 10 FOLDED DIPOLE

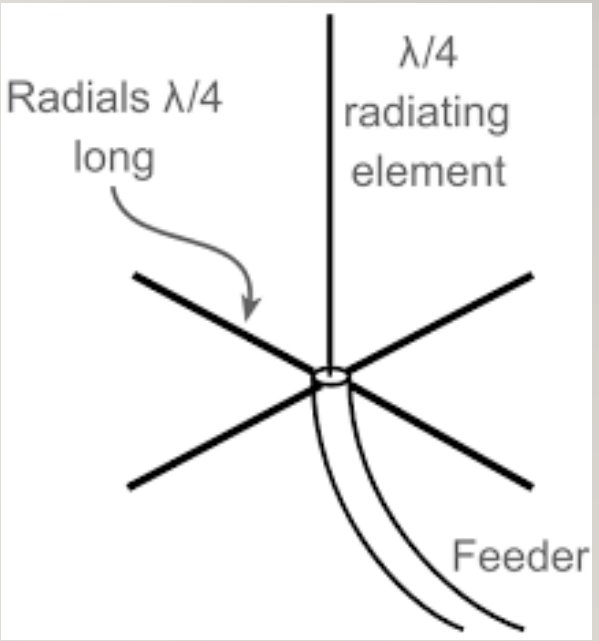



**Feed with ladder line and use a tuner or use a 4:1 balun at the feed point and use coax for one band operation.**

**A "folded dipole has a wider VSWR bandwidth than a single wire dipole.**

# 11 VERTICAL UNBALANCED ANTENNA SINGLE ROD OR WIRE - OTHER HALF IS THE EARTH

- **Four tuned radials is not enough, there would be common mode current on the coax in nearly every condition.** Just not enough surface area to dissipate the displacement currents. Need >25 radials.
- **Raising the antenna above the earth helps but still does not present a zero-resistance ground though fewer radials are required.**
- **A choke to reduce common mode current may be needed to reduce current being sent back to the radio.**
- **A Jepp or J-Pole is a ¾ wave length with the counterpoise folded back along side the radiator.** The feed line will always radiate thus always use a choke to reduce effects.

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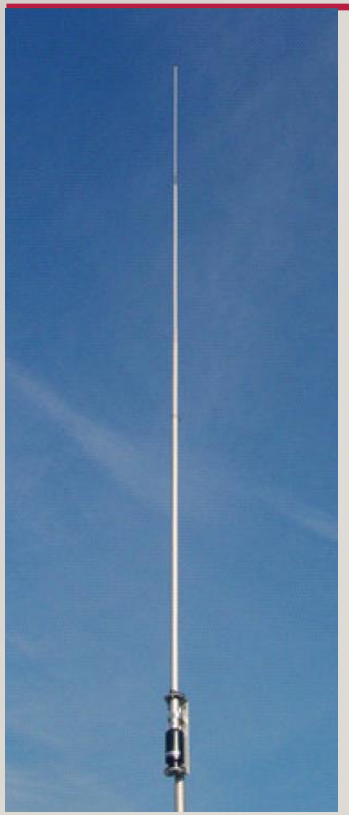
# 12 COMET CHA-250B VERTICAL WITH NO GROUND RADIALS

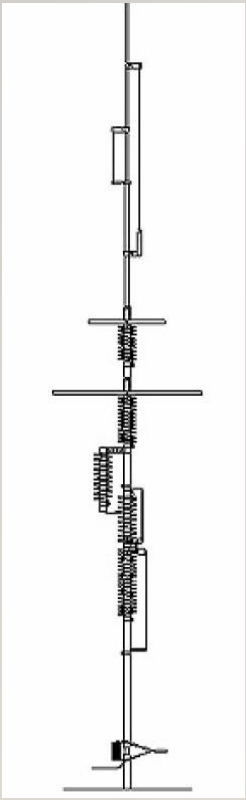


- **VSWR is under 1.6:1 from 3.5 MHz to 57 MHz**
- **Not sure where the other half of the antenna is?**
  - **Possibly the mast and feed line**
  - **Possibly radials, if there are any**
- **Almost like a vertical end fed with a 9:1 balun**
- **This is what is used at the hospital to reach Knoxville on the HF bands**
- **It has been used for EOCs where a horizontal antenna is not feasible**

K7FE's comment to this antenna:

- **Conceptually a poor design but for some it works and is the only solution.**

# 13 BUTTERNUT HF9V 80-6 9-BAND VERTICAL



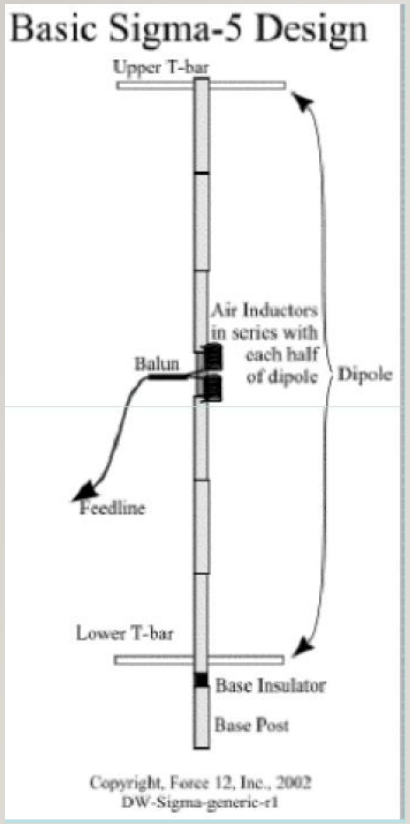
- **Nine popular bands, 80 – 6 meters**
  - **Add-on 160 meter kit**
- **Only 26' high**
- **No lossy traps**
- **No radials required w/CPK Counterpoise Kit**
- **Radials do help performance**

K7FE's comment to this antenna:

- **Adding radials to provide some amount of counterpoise does improve this antenna.**

# FORCE 12 BASIC SIGMA-5 DESIGN

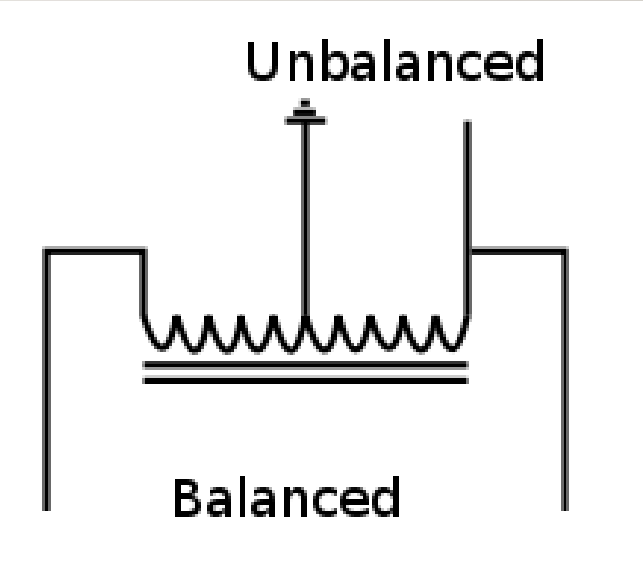
See K2KW.com for more information.




- **A center fed vertical dipole, base mounted and top hats**
- **No counter poise required as it is balanced**
- **Must be mounted above the ground as high as possible**
- **Note use of:**
  - **Air inductor loading coils**
  - **Balun to match impedance**
  - **Balun reduces common mode currents**

# 15 BALUN
# BALANCED <> UNBALANCED TRANSFORMER

- **Current Balun**
  - Current is most important to balance.
  - Adds common mode isolation and can be used at each end of a transmission line
  - Best choice overall and only choice to provide isolation
- **Voltage Balun**
  - Many times used for end fed antennas due to high impedance matching needs (i.e. 9:1)
  - Does NOT provide common mode isolation
  - Core can be magnetized if too much power is used



# 16 WILL A BALUN ACTUALLY HELP?

- **Yes** – If the desire is for the antenna to do exactly what is suppose to do with is directivity pattern thus being more predictable.
- **Yes** – Even with a ground plane antenna a balun will reduce the distortion produced by an insufficient counterpoise by reducing common mode current in the feed line.
- **Yes** – Even with a dipole, the antenna will produce a more uniform "figure eight" pattern with a balun at the feed point to the antenna.

So the question remains. **Does a Balun really matter?** **……Not necessarily.**

- For verticals or dipoles, on the coverage patterns distortions may actually be desirable for your communications.

K7FE

# 17 FIXED STATION ANTENNAS

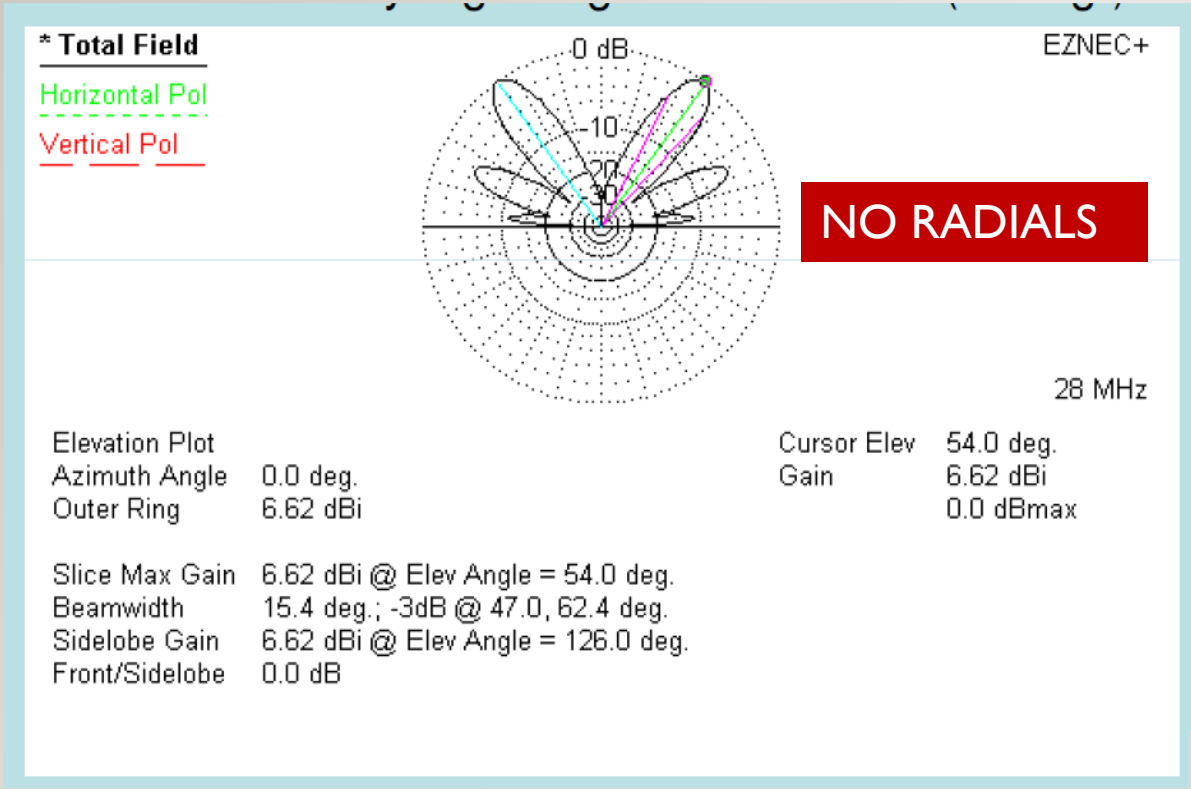
SEARCH: TOM, W8JI

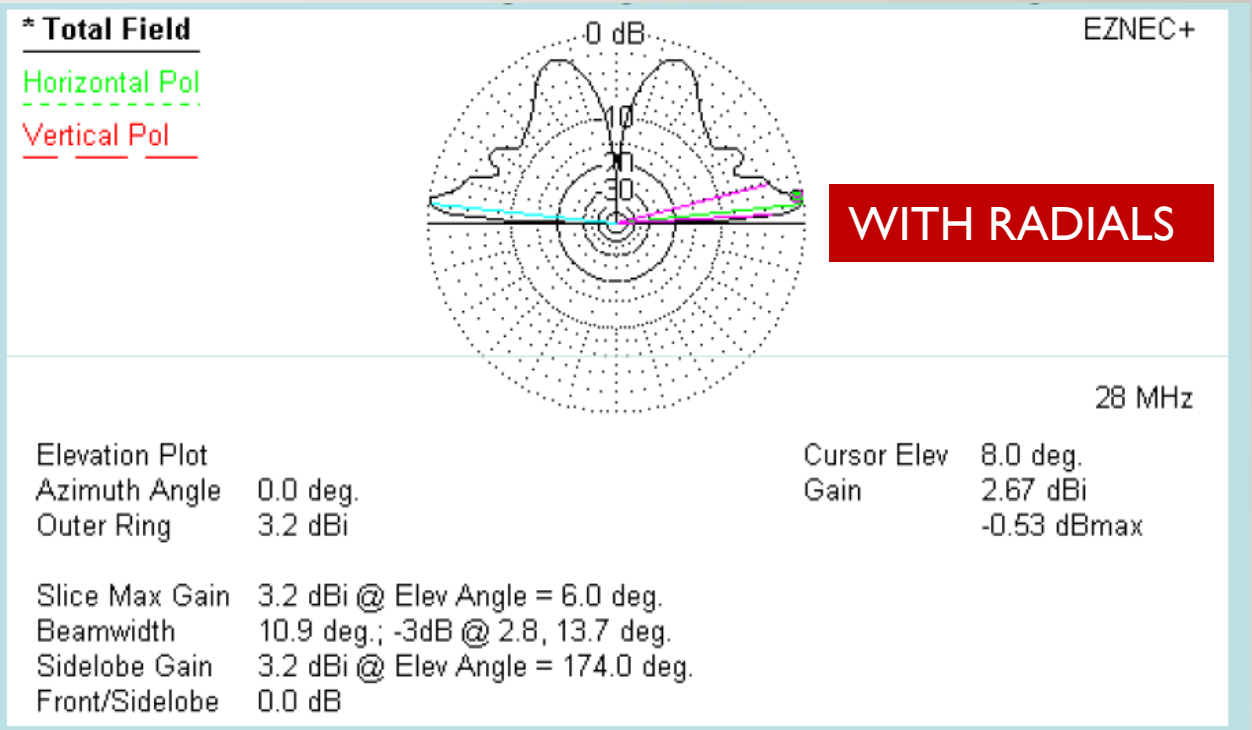
- **Dipole (balanced) Antenna** – There may be some reflected signal due to improper impedance matching to the antenna thus reducing effectiveness.
- **End Fed Antenna** – Always have common mode currents (either the mount, a wire to ground or the coax using a feedline current choke Balun) plus a counterpoise.
- **Off Center Fed Antenna (Windom)** – Considerable common mode current is created and must be dealt by the feed line with a properly placed current choke Balun.
  - W8JI recommends using 10-20 turns RG58 on a 4" diameter core for the lower bands installed at the antenna feed point (even to a yagi), then ground the coax to the feed line as it departs the coil and ground again at the entry point to the ham shack.

# VERTICAL RADIATING ELEMENT RADIALS ARE NEEDED

- **The commercial broadcast standard for radials on an HF vertical is 120 1/4 wave wires "buried" two to three inches** to achieve the best low angle performance. Those experiments were performed by G.H. Brown, "Ground Systems as a Factor in Antenna Efficiency" Proceedings IRE (now IEEE), June 1937, p 753.
- **Fewer "elevated" radials will perform about as well as 120 ground mounted ones.** A base mounting height above ground of about 1/10 to 1/16 of a wavelength seems optimum for 4 radials.....but will vary with soil conductivity. HF tests by Al Christman – KB8I; "Elevated Vertical Antenna Systems," QST, August 1988.
- **Poor soil requires more elevated radial height for the same effectiveness.**
- **Your roof or patio cover is an excellent location to mount an HF vertical/radials** and take advantage of the "less radials required at an elevated height" phenomena.
- **Bend radials if necessary**. Insufficient room for full length radials, then cut them full size and then bend as required to fit location. They will be slightly less efficient, but perhaps not noticeably. K7FE

# 19 VERTICAL HALF WAVE ANTENNA

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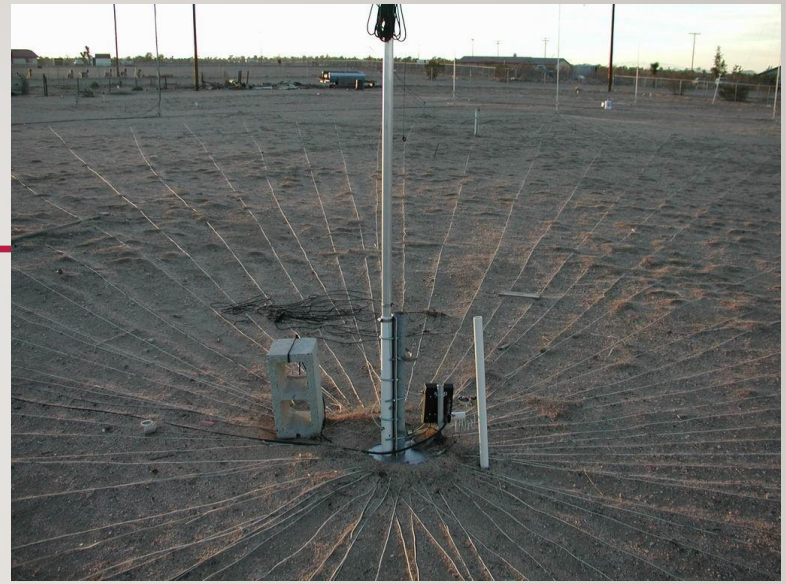
# 20 RADIAL RULES



- **Elevate your radials if possible and feasible.**
- **A half wave vertical radials to be longer than a ¼ wavelength.**
- **Nix ground rods (except for lightning protection).**
- **Insulated copper wire will work as well as bare copper wire for radials and stranded or solid makes no difference.**

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# J-POLE
# THERE ARE NO COMMERCIAL J-POLE ANTENNAS

- **Their performance at a specific site is unpredictable because the j-pole antenna interacts with nearby objects like the coax, mast, tower, building, etc.**
- **Gain of a J-pole may be less than a properly made 1/4 wave ground plane.**
- **A J-pole, like ANY end fed antenna, needs radials, a counterpoise or ground plane to work properly.**
- **The J-pole is one antenna that probably should have a coax balun should you decide to try this poorly conceived antenna.**
- **A "copper cactus" is fun to build, but a ground plane will usually out perform it.**
- **J-poles are high on the list of MYTHS that fail to live up to the claims.**

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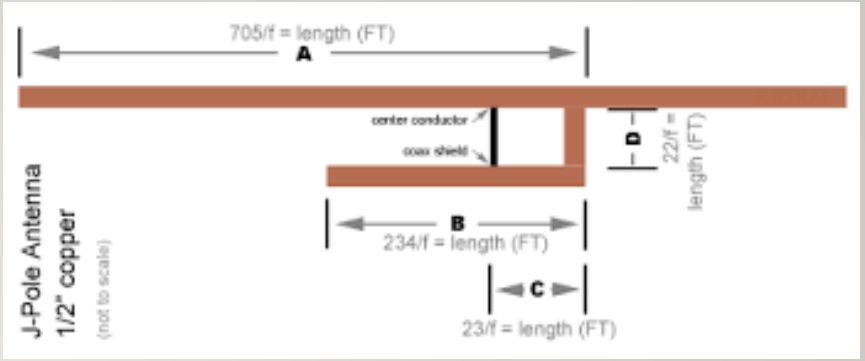
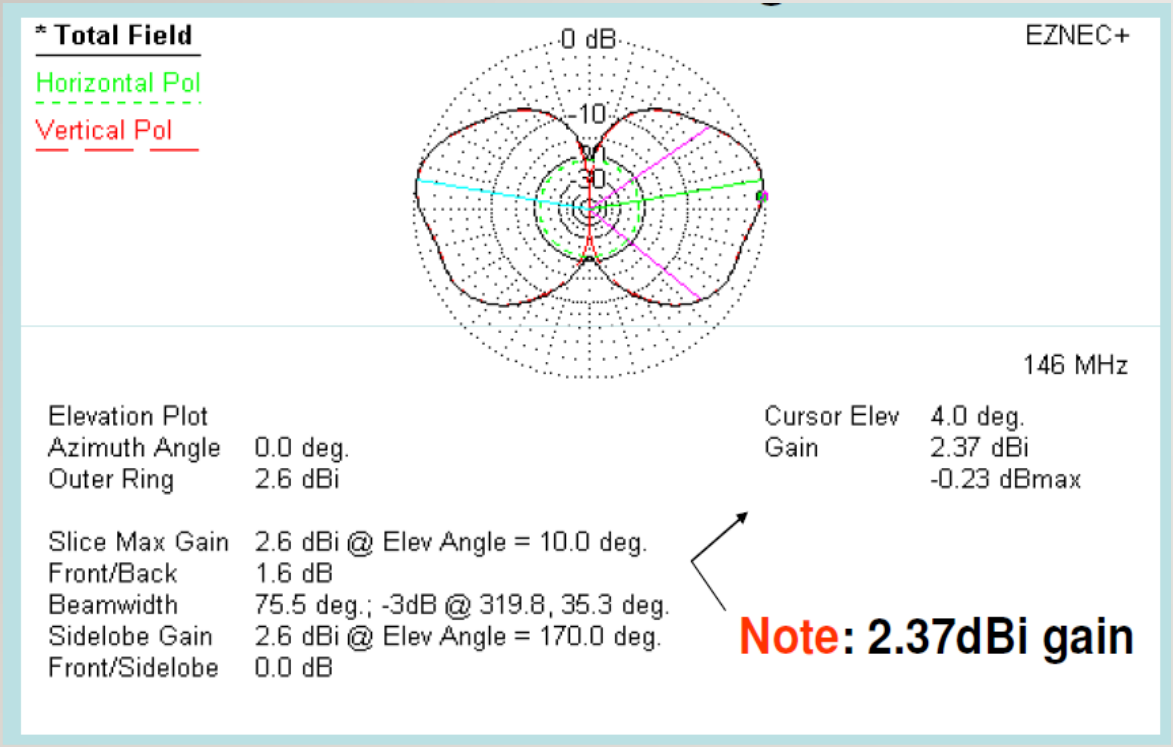
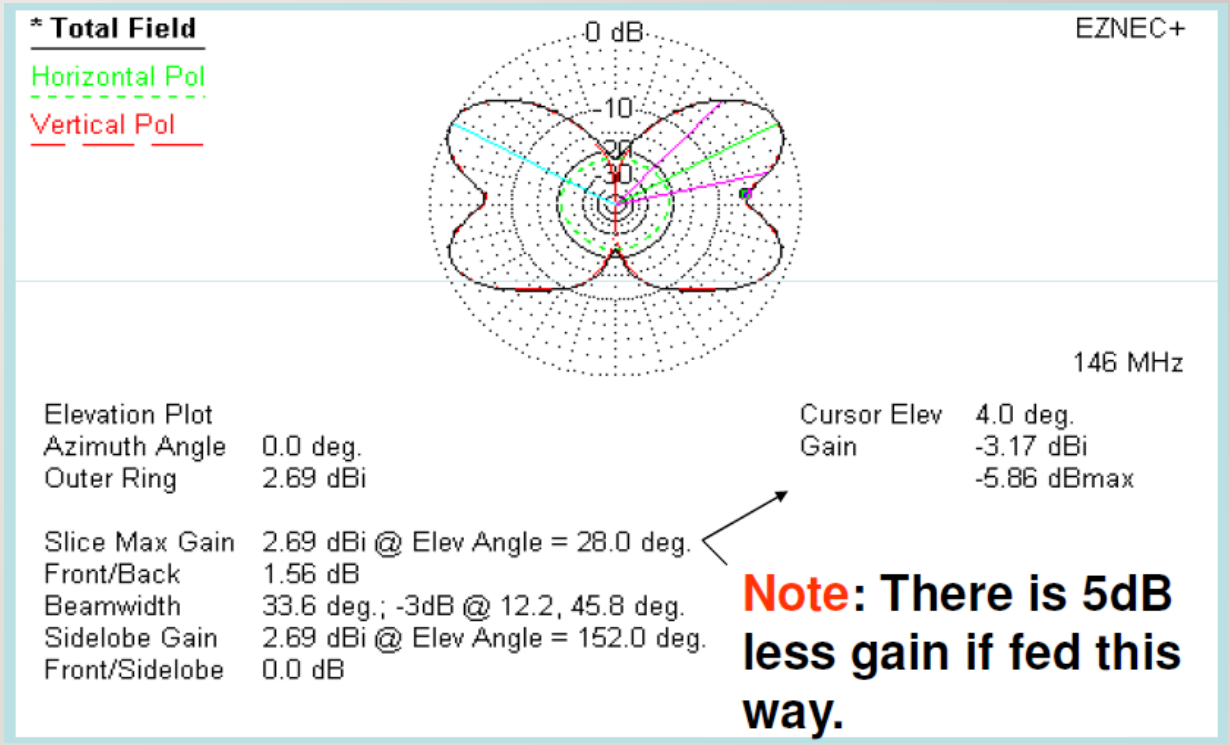
# 22 J-POLE FEEDLINE CONNECTIONS




Preferred: **COAX Center to short element.**




Not Recommended: **COAX Center to long element.**

# 23 MYTH: ALL ANTENNAS NEED A GROUND >>FALSE<<

- **Some antennas use a ground to complete their circuit.**
  - **HF and VHF/UHF Mobile Antennas try to make use of vehicle body.**
  - **End fed antennas need radials (J-Pole, wire, Zepp and Windom)**
- **Antennas that are self completing and do not need an RF ground.**
  - **Dipole**
  - **Cubical Quad**
  - **Loop**
  - **Rhombic**

**Do not let a pathetic antenna prevent you from operating. Just make improvements when possible.**

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# 24 MYTH: A 5/8 WAVE ANTENNA HAS MORE GAIN THAN A GROUND PLANE FALSE

- **The losses in the matching coil at the base reduce gain to a rough amount of 2 dB which means very little.**
- **Where and how you mount the antenna on your vehicle is important.**
- **The 2.85dB theoretical gain is only for a perfect loss less matching coil and with the antenna over a "perfect" infinite flat ground plane.**
- **Magnetic mounts provide a "much less than perfect" ground plane. They also can be a road hazard for other drivers if they bounce off of your vehicle. Drill a hole and place it where it works best**

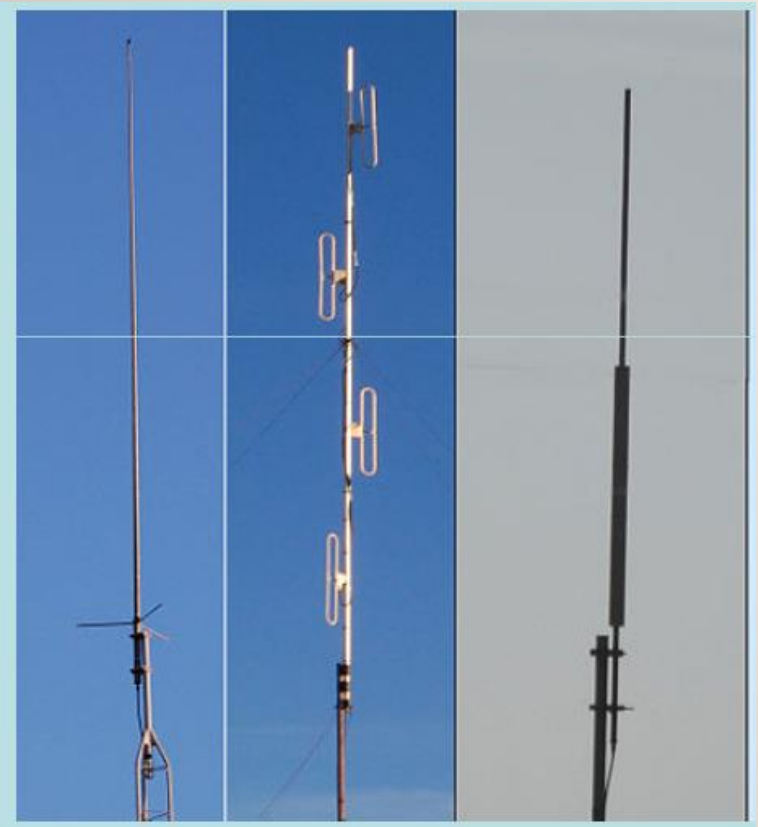
K7FE

# 25 ANOTHER COMPARISON

- ***"In the end, it is dubious whether a 5/8-wavelength monopole has any significant operating benefit over a 1/4-wavelength monopole, each with 4 radials. Perhaps the higher top height of the longer antenna will yield some benefit when its base is very close to the ground.***
- ***However, the 5/8-wavelength monopole always requires some form of matching system for use with a 50-ohm coaxial cable, and matching systems at VHF are not without loss. At rooftop and higher levels, the sloping radial monopole with a 1/4-wavelength radiator or a half-wavelength dipole will do as well--or better".***

**– L. B. Cebik, W4RNL**

# 26 COLLINEAR ANTENNAS >>> ALL ARE BALANCED ANTENNAS <<<



- Collinear antennas do have a higher gain than a ¼ wave ground plane.
- VHF/UHF repeaters usually make use of antennas as shown.
- However, a poor antenna mounted high will outperform a good antenna mounted low.
- Height is everything.

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# 27 HF ANTENNA HEIGHT

- **Horizontal antennas** should be at least ½ wave length high for DX (low angle of radiation).
- **NVIS Antennas** need high angle of radiation, thus a 0.15 to 0.2 wavelength horizontal antenna height works well to send signal straight up, bounce off of the ionosphere and down to stations within a couple of hundred miles.
- **Vertical antennas** may be ground mounted for DX if you plan on installing a lot of radials, however they benefit from roof mounting using fewer radials to achieve the same efficiency as a ground mounted vertical.

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# 28 LET'S TAKE A BREAK

## >>> NEXT UP <<<


- Antenna Aperture/Gain
- Transmit and Receive Antennas
- Antenna Location – Mobiles
- Mobile Counterpoise!
- Portable and Stealth Antennas

# 29 DOES ANTENNA SIZE REALLY MATTER?

- Antenna gain is a function of **"effective" aperture or "effective"** area.
- Simply increasing the size of antenna does not guarantee an increase in effective area; however, other factors being equal, **antennas with higher maximum effective area are generally physically larger**.
- Yagis with longer booms have more gain than those with shorter ones, …….. assuming they each have the same number of elements.

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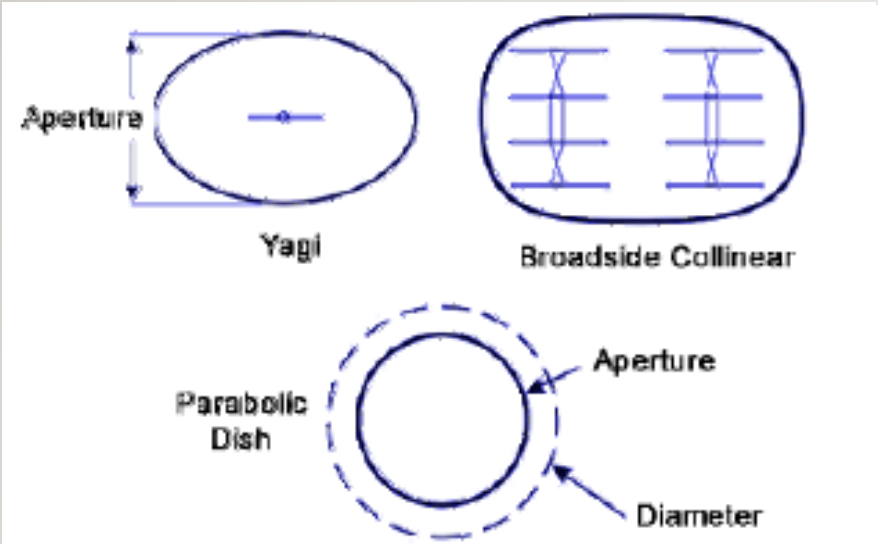
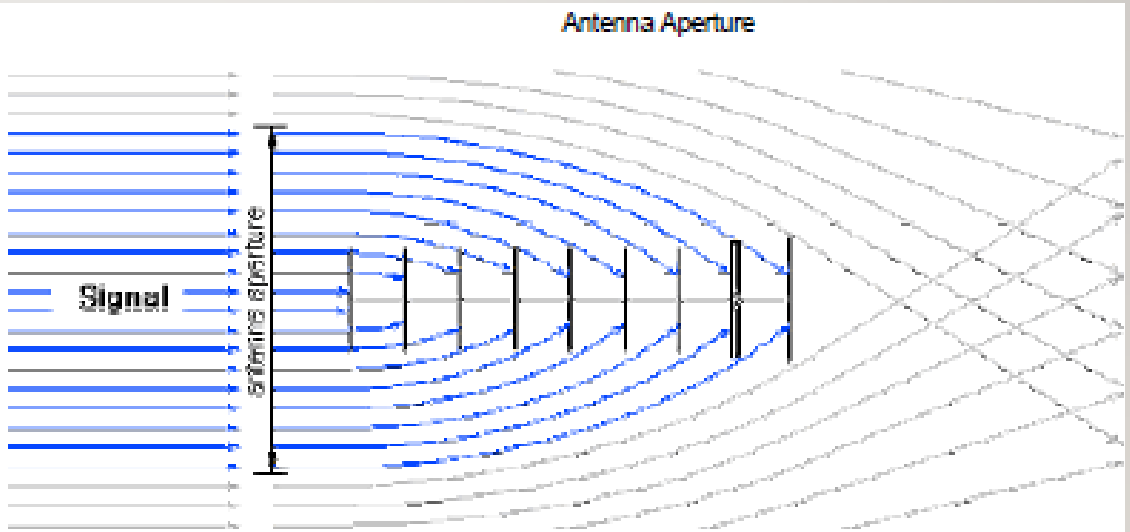
# ANTENNA APERTURE GAIN




Antenna gain is directly proportional to aperture and in most cases gain is increased by focusing the radiation in a single direction. Power cannot be created by the antenna though a narrower beam-width is possible which is measured as gain.

ARE GOOD TRANSMITTING ANTENNAS EQUALLY GOOD FOR RECEIVING?

**NO**

- **Verticals have an low angle of radiation for DX but are noisy when receiving**
- **Antennas such a Beverage and some other "wave" antenna have low noise on receive but very poor efficiency for transmitting primarily due to their height above the ground. The ground acts like a ferrite bead and just soaks up the RF energy as heat.**
- **Using a TR relay with two antennas is a means of getting around the issue as described where a vertical is used for transmit and a horizontal wire for receive.**

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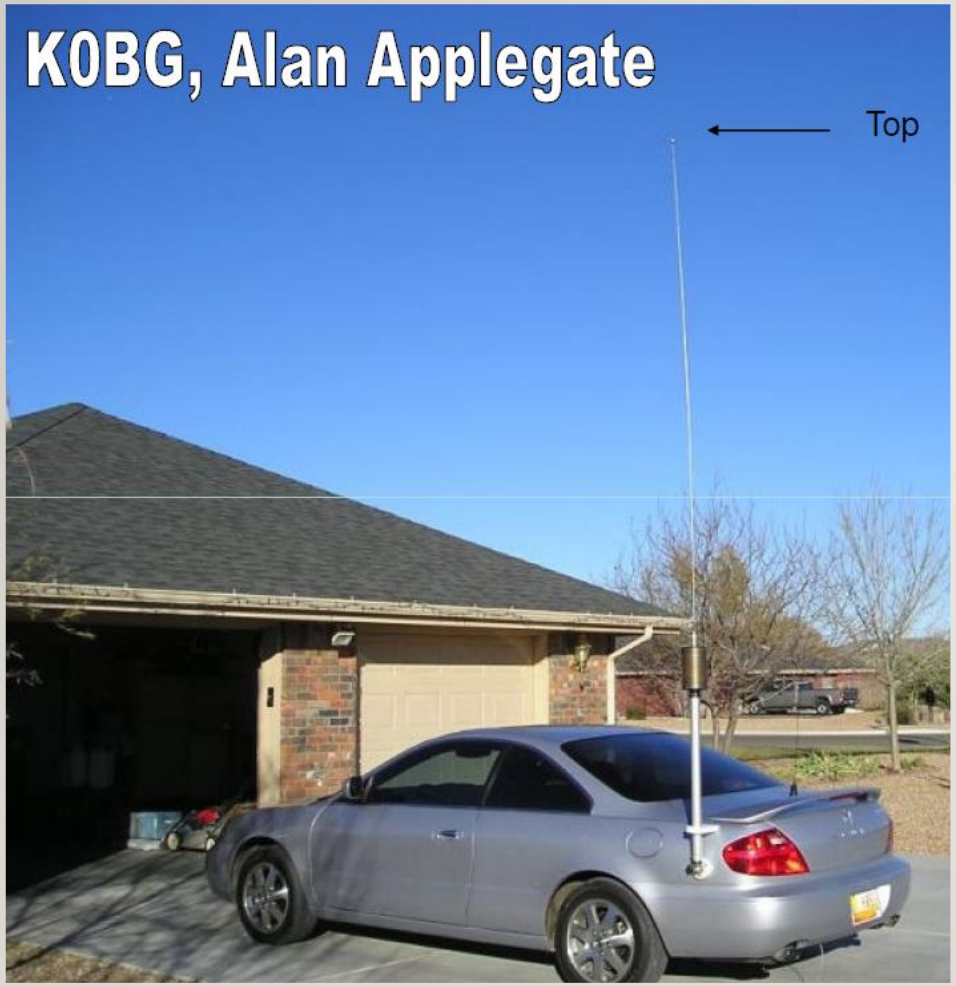
# DOES STATION LOCATION MATTER? VALLEY VS. HILLTOP

- HF stations in the valley floor hear and are heard as well as on a hilltop, all other conditions equal.
- Elevation benefit > The low angle skywave window of 2-way reception may be "longer" not louder.
- Line of sight contacts like VHF and will be expanded.




# BIGGER IS BETTER

# 34 HF MOBILE ANTENNAS A HAMSTICK <> A SCREWDRIVER

Which has the lowest VSWR?



# 35 LOWEST VSWR

- **A dummy load has the best VSWR and huge bandwidth, but…..**
- **Antennas with small diameter coils and/or use a small gage wire have higher losses which add in series with the antenna feed impedance to makes these antennas have what looks to be a better match to 50 ohms.**
- **The large coil Screwdriver antenna wins out over the Hamstick primarily because it has lower loss and does a better job of radiating the signal.**
- **Consider Hamsticks for 10, 12, 15 or 17 meter bands only.**

K7FE

# 36 RULES OF THUMB FOR MOBILE HF ANTENNAS

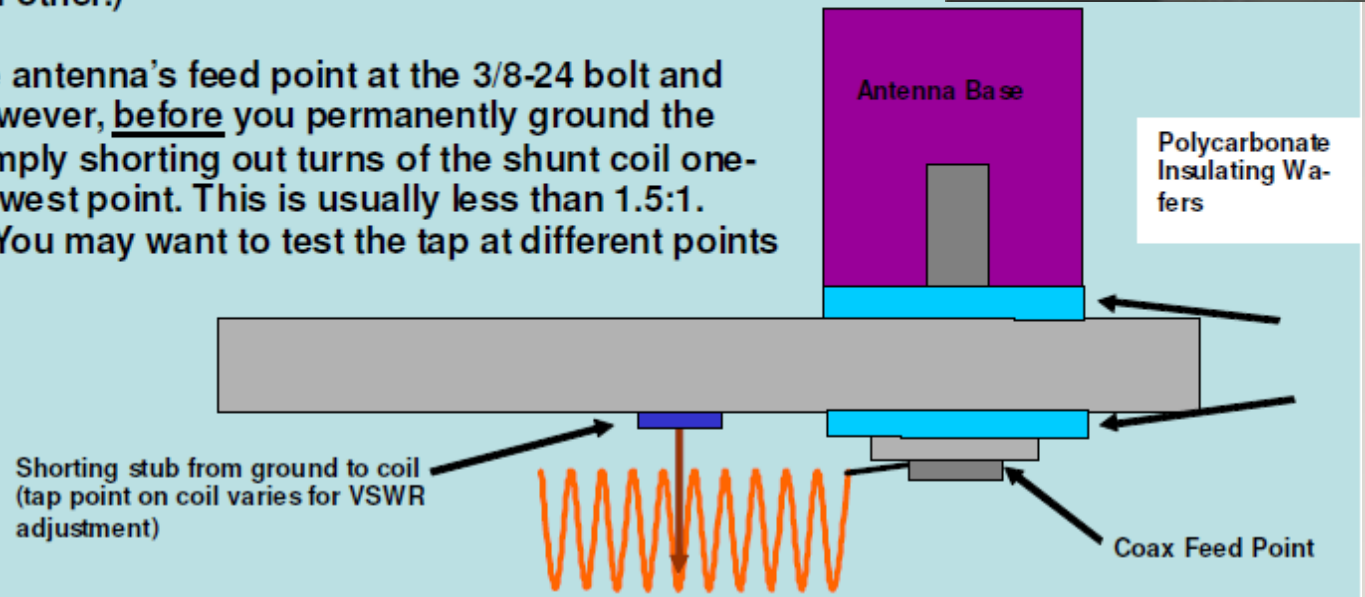
- **Low loss antennas have a feed impedance more closely reflecting their theoretical impedance. 160, 80 and 40 meter antennas on a vehicle are much shorter than ¼ wavelength long, thus have a very low feed impedance.**
- **Bug Catcher and large screwdriver antenna's feed impedance may be as low as 2 to 15 ohms thus need to be matched at the base to step them up to 50 ohm coax impedance. The actual feed impedance changes with each band, ie, the lower the band (like160M), the lower the feed impedance.**
- **Small diameter coil and small gage wires of some less efficient antennas add in series with the antennas impedance to raise the feed impedance thus reducing effectiveness.**

K7FE

# 37 HI-Q ANTENNAS BASE IMPEDANCE MATCHING

For the 40 and 80 Meter bands, you MUST use a matching device to bring the feed point impedance close a nominal 52 ohms. This can be easily achieved with the supplied shunt coil. (A shunt coil may be made using #14 or heavier bare copper wire, close-wound on a 1.25" to 1.5" mandrel, and then stretched slightly to create an air gap of approximately one half of the wire's diameter between the turns--just make sure coils aren't touching each other.)

One end of the coil is attached to the antenna's feed point at the 3/8-24 bolt and the other end to goes to ground. However, before you permanently ground the coil, determine the best VSWR by simply shorting out turns of the shunt coil one-by-one until the VSWR reaches its lowest point. This is usually less than 1.5:1. Solder the ground tap at this point. You may want to test the tap at different points

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# 38 MORE RULES OF THUMB FOR MOBILE ANTENNAS

- **Remember, you are building an antenna system, it is not just the antenna alone. Bonding, coax, matching, capacity hat or not, mounting location and method of mounting are all parts of the system.**
- **Bumper or hitch mounts (close to the ground) have greater ground losses than mounting higher on the vehicle.**
- **Keep antenna loading coils as far away from the metal vehicle body as possible.**
- **NEVER use mag mounts for an HF mobile antenna as true grounding is not possible.**

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# 39 VEHICLE HF ANTENNA LOCATIONS


- **Preferred Locations**
  - Pickup – Bed Center or ¾ towards the rear, upper sides half way towards the rear.
  - Minivan – Rear side panel, high near the roof line, center of the roof is best.
  - Autos – Trunk lid bonded well, rear fender up high, center of the roof
- **Poor Locations**
  - Pickup - Near the metal cab due to loading coil issues lowering the Q.
  - Minivan – Lower side, rear bumper or hitch mounts due to proximity of coil to metal.
  - Auto – Below bumper or trailer hitch mounts. Due to ground losses and connection to metal.

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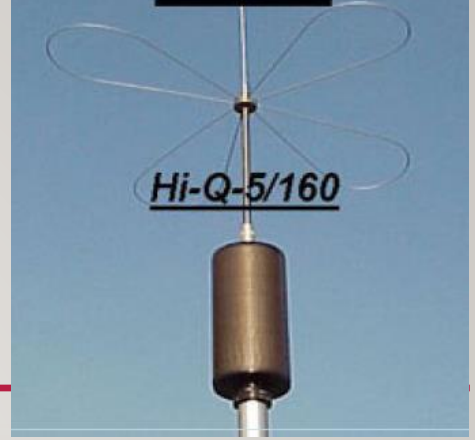
# TOP HAT ALSO CALLED CAPACITIVE HAT




- **A large "hat" or capacitance at the top of the antenna allows considerable shortening of length with no loss in efficiency.**
- **For a given height antenna, efficiency is increased with a hat mounted one or two coil lengths above the loading coil.**
- **Fewer turns are required on the loading coil when using a capacitance hat and the antenna current distribution is improved.**
- **Less turns = less loss**

# 41 MOBILE ANTENNA COMPARISON AT 75 METERS SHOOTOUT CONDUCTED IN CA IN THE 80'S


Reference Antenna

- 0 dB – Bugcatcher/Screwdriver with large top hat
- -2 dB - Bugcatcher/Screwdriver with NO top hat
- -5 dB - 8.5' Whip with Bugcatcher base loading coil
- -6 dB - Bugcatcher with stainless middle loading coil
- -8 dB – Hustler High power system
- -12 dB – Hamstick
- -12 dB – 11.5' Whip with SGC-230 autotuner
- -14 dB – CB Whip with SGC-230 autotuner

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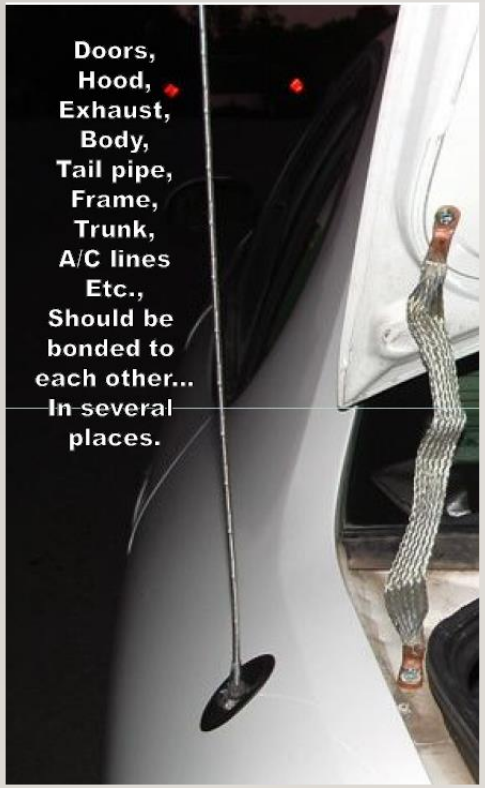
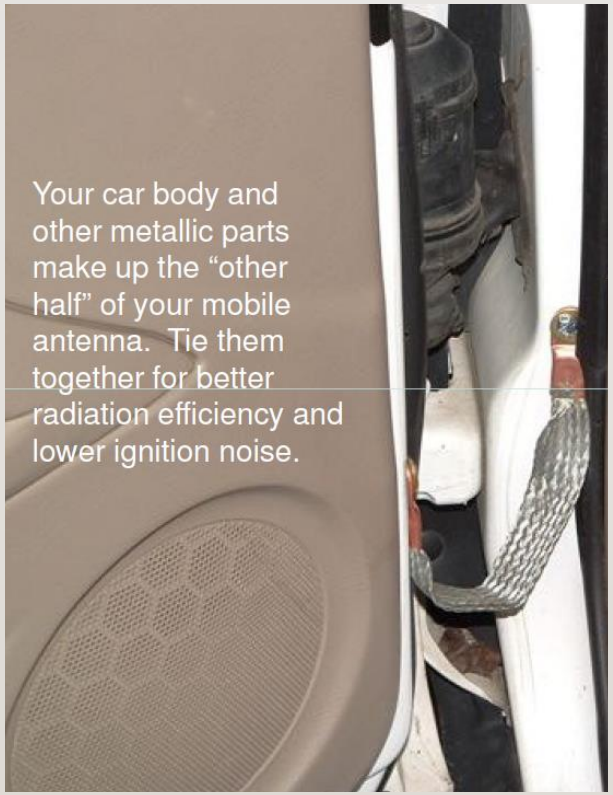
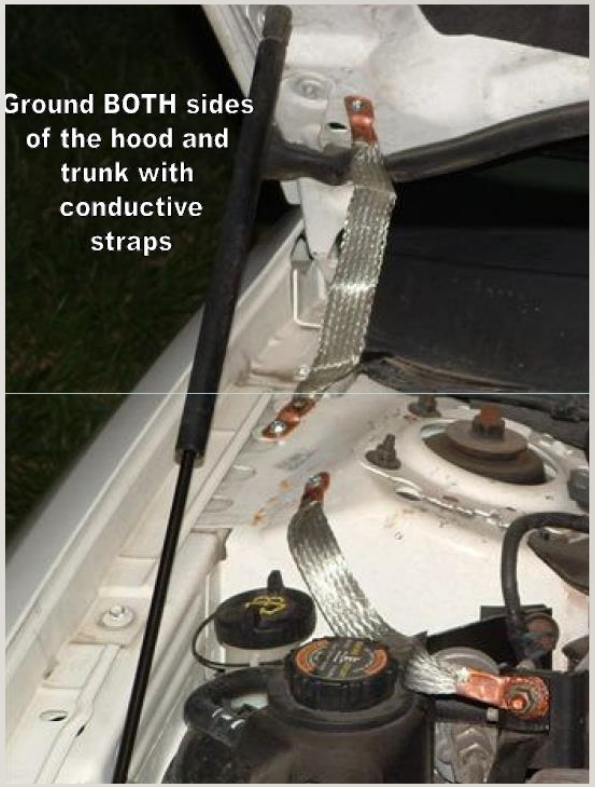
# 42 BONDING IS EXTREMELY IMPORTANT IMPROVES RADIATION EFFICIENCY



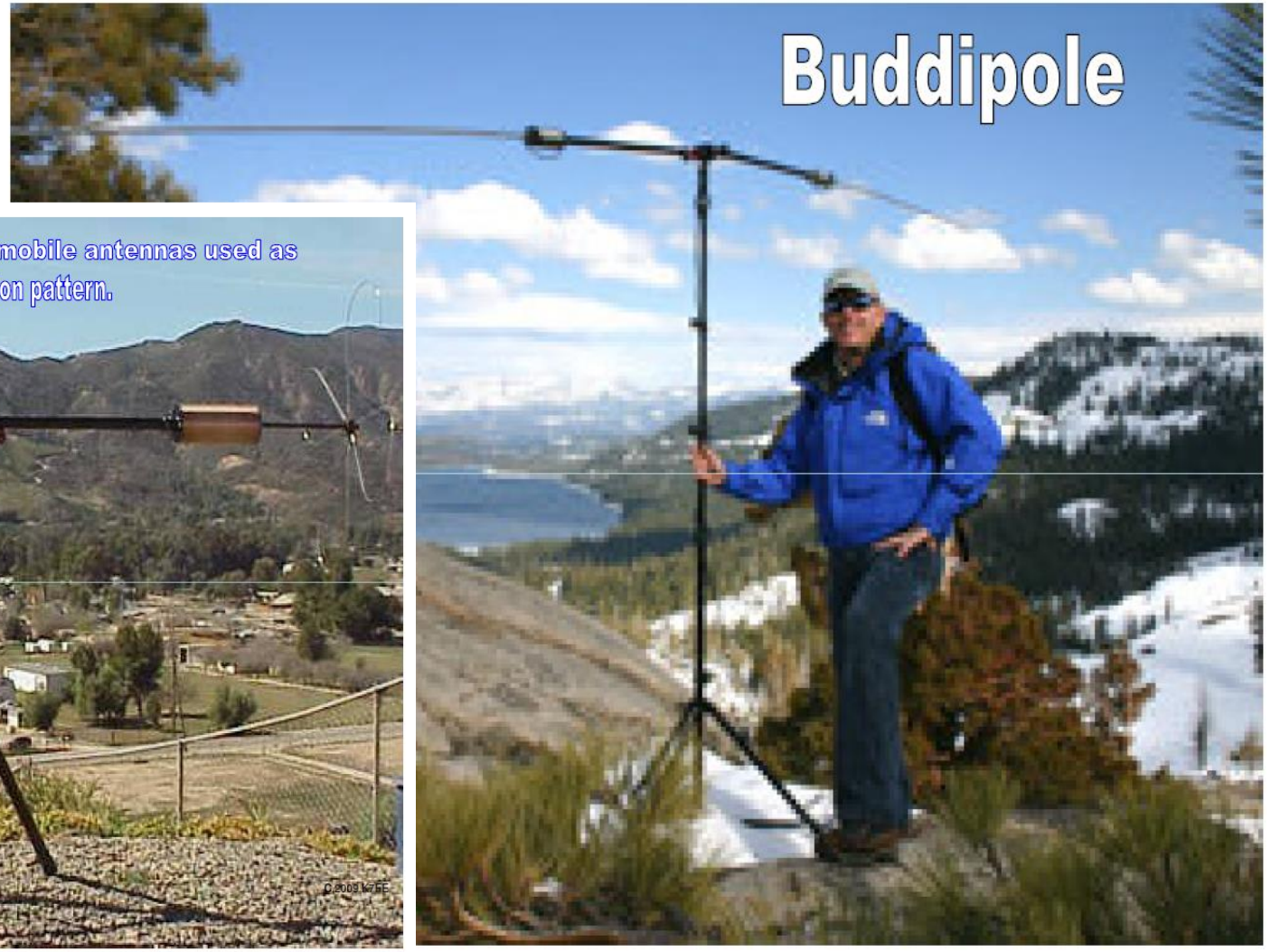



# MOBILE SUMMARY
# TYPICALLY A SHORTENED UNBALANCED ROD

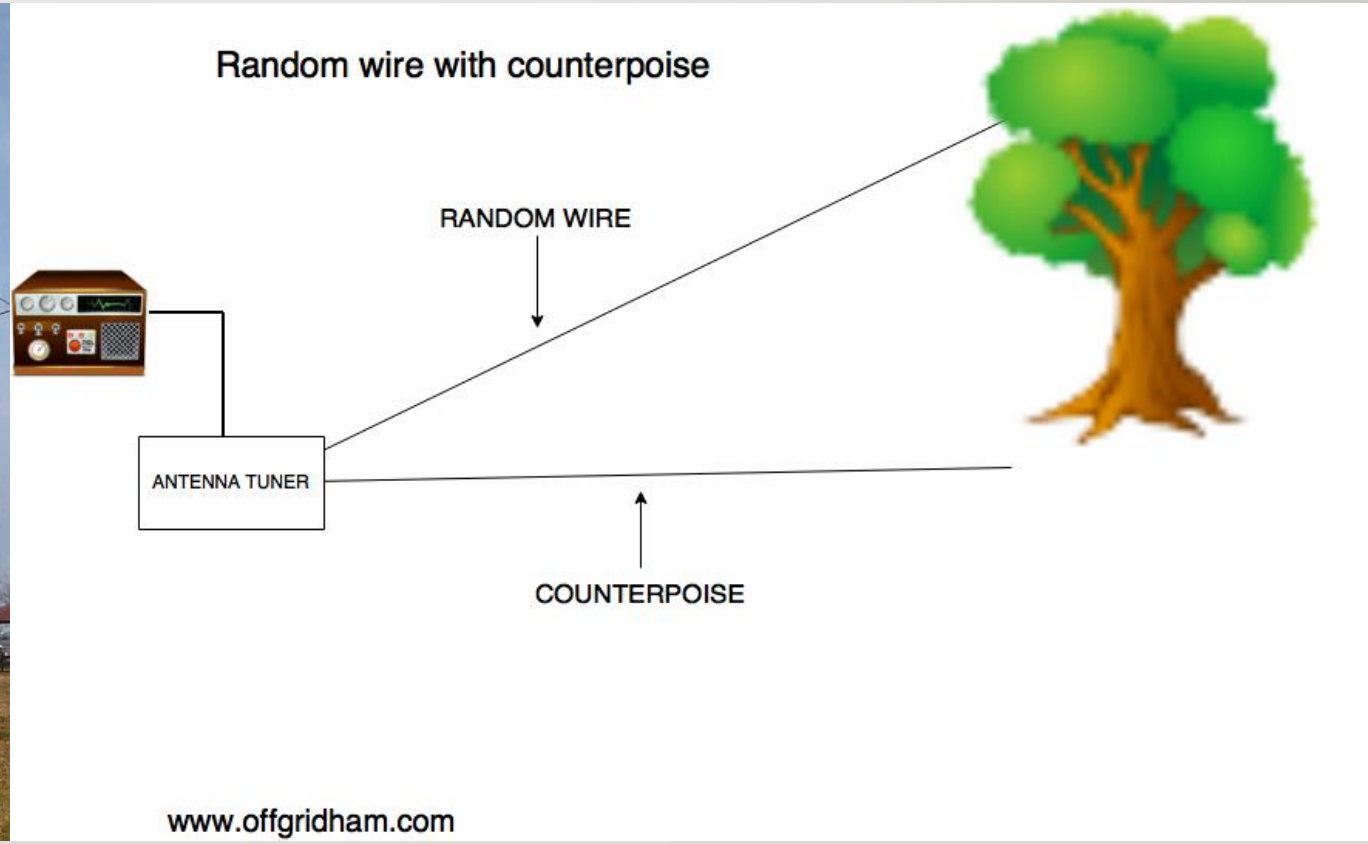
- **Antenna Type – ¼ wave, shortened with loading coil (<1/4 wave)**
- **Antenna Placement – Center of Roof or elsewhere**
- **SWR – Not the only measure, check the common mode current (MFG-854)**
  - **Choke (one or two ferrite split bead, Mix 31) with 6-7 turns of RG-58 through it)**
- **Ground Bond – Insure the ground of the coax at the antenna is bonded to vehicle metal as this is where the antenna mounting is.**
- **Counterpoise – Remember, this is the other half of the antenna.**
  - **By Definition, <1/4 wave, not a counterpoise)**

# 44 PORTABLE


View from W6HIQ's back yard. Two of his mobile antennas used as
a low dipole - - - semi NVIS radiation pattern.


Buddipole

# 45 MORE PORTABLE ANTENNAS

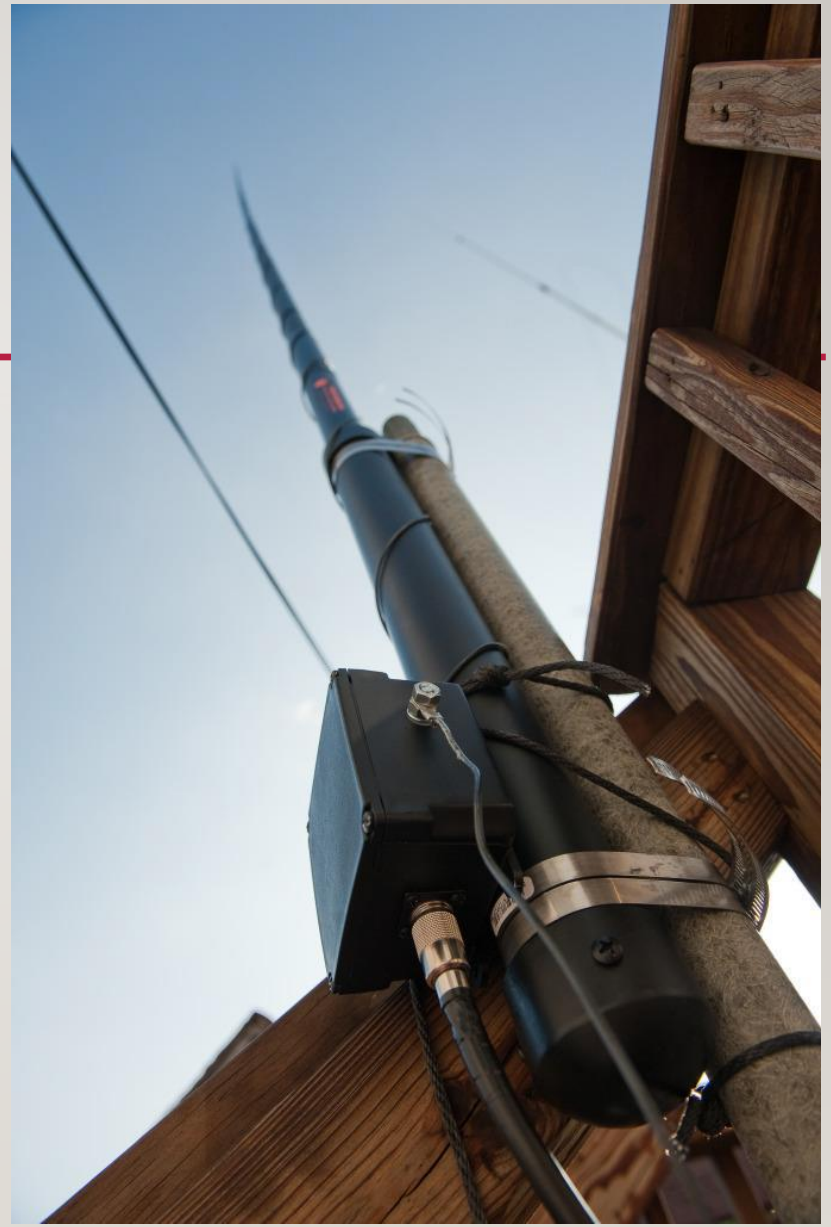


# LOADING COILS, CONDUCTOR SIZE

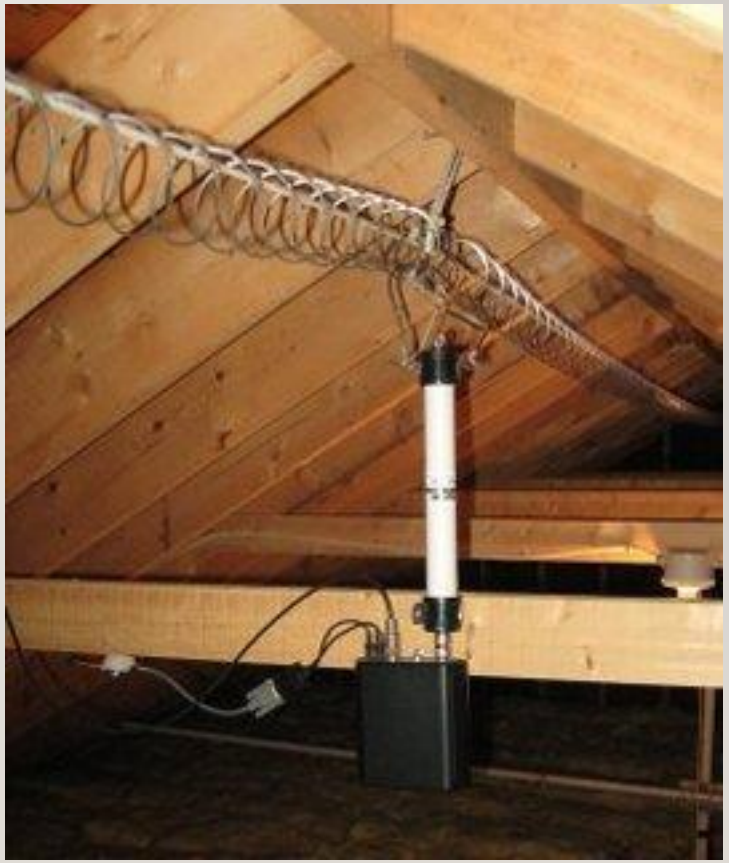
1. All loading coils result in loss.
2. Where the loading coil is placed does not really matter (except for mobiles)
3. The diameter of the wire or rod does matter. Larger diameter = greater bandwidth
4. The idea is to get the antenna design into a manageable size for the planned use

# 47 HIDDEN/STEALTH

# 48 MORE STEALTH ANTENNAS



# 49 EVEN MORE STEALTH ANTENNAS



# 50 GUIDE TO STEALTH ANTENNAS

- **Modulation Matters – 5W CW = 250W SSB, 5W PSK = 2,500W SSB**
- **Height Matters – LOS for VHF/UHF and increased radiation for HF**
- **Antenna Length Matters – Shorter the antenna the poorer the signal**
- **Radials Matter – Try to get a minimum of 32 radials or elevate with minimum of four**
- **Inverted-L Does Work**
- **Be Creative and Get On the Air**

# 51 RF EQUIPMENT PROBLEMS

1. **The antenna system: Design, engineering and/or installation**
2. **Antenna is to close to the radio system**
3. **Ground loops in the AC or DC power system or between equipment**
4. **Poor equipment design for intended purpose**
5. **Defective cable and/or connectors**


# FINALLY, THAT'S IT!

QUESTIONS