The 43 Foot Vertical

Bill Leonard
N0CU
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This presentation is based upon charts from:

"The 43-Foot Vertical"
by Phil Salas -AD5X
ad5x@arrl.net

(Comments in BLUE are mine, not Phil's)

Multiband Antenna Options

1) Multiband Fixed Height Vertical using Traps

2) Multiband Variable Height Vertical using the SteppIR BigIR III

3) Multiband Fixed Height Vertical using an antenna matcher in the shack – such as 43 footer

4) Multiband Fixed Height Vertical using an antenna matcher at the antenna base – 43 footer again

5) Forget the vertical and get a multiband dipole

Multiband Antenna Options

1) Multiband Fixed Height Vertical using Traps

2) Multiband Variable Height Vertical using the SteppIR BigIR III

No one antenna is best for all applications!

4) Multiband Fixed Height Vertical using an antenna matcher at the antenna base – 43 footer again

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Concept Behind the 43 Foot Vertical

- Take a resonant vertical monopole antenna that works good one band, but is unuseable on most other bands, and change it so it is useable on a number of bands.

- The 43 foot length is non-resonant on any band (impedance matching is required on all bands)

AD5X Outline

- **Why a vertical?**
- **Important characteristics of a vertical antenna**
- **Ground Losses and Antenna Efficiency**
- **Why a 43-foot vertical?**
- **SWR-related coax and unun losses**
- **RF Voltages**
- Matching Networks for 160-and 80-meters
- Building your own 43-foot vertical

(Last two topics not covered in this presentation)

Why Use a Vertical?

Advantages:

- Generally are inexpensive
- Relatively unobtrusive
- Self-Supporting
- Easy to ground mount
- Low angle of radiation (maybe, maybe not)
- Good DX performance (maybe, maybe not)
- Omni-directional (no rotator needed!)

Disadvantages:

- Omni-directional (no gain or F/B)
- Needs a ***good radial system*** ***for best performance***
- Needs ***good ground characteristics for best performance***

Important Characteristics of a Vertical Antenna

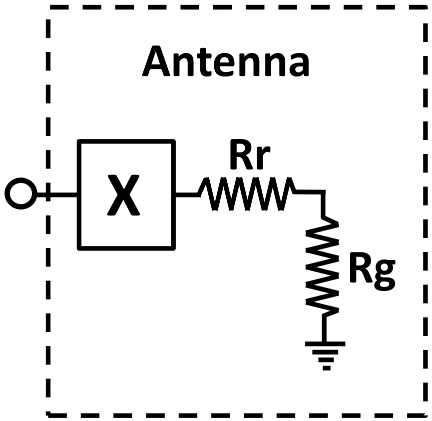
- **Efficiency:**
  - How much of the transmitter power is being radiated
  - Can be a significant problem with vertically polarized monopole antennas
  - Determined by:
    - Antenna design (radiation resistance)
    - Ground characteristics in the NEAR FIELD (~1/2 wavelength)
      - Conductivity & permittivity
- **Pattern**
  - Is the transmitted power going where you want it to?
    - Peak gain
    - Take-off angle
  - Determined by:
    - Antenna design
    - Ground characteristics in the FAR FIELD (~10 wavelengths)

Important Takeaway

- A vertical monopole antenna installed over a poor ground with no radials will have:
  - Very poor efficiency and
  - Poor pattern (low gain and high takeoff angle)
- A vertical monopole antenna installed over a poor ground with an ideal radial system will have:
  - Near 100% efficiency and
  - Poor pattern (low gain and high takeoff angle)
- A vertical monopole antenna installed over an excellent ground (without any radial system) will have:
  - Near 100% efficiency and
  - Good pattern (good gain and low takeoff angle)

Vertical Antenna Efficiency

- Radiation Resistance (Rr) is the "effective" resistance of the antenna
  - Hypothetical resistance (not a real resistor)
  - Value varies from milliohms to thousands of ohms
- Ground loss (Rg) is power lost due to heating of the ground
- Antenna Efficiency (%) = 100 x Rr/(Rg + Rr)
  - Assumes X is tuned out by impedance matching network



Simple Calculations

- 43 foot antenna on 160 meters:

Rr = 43/128 X 36 = **4 ohms**

- EZNEC = 3 ohms

C = 3.5 x 43 = 150.5pf = **-j580 ohms**

- EZNEC = -j640 (VNA actually measured –j580)
- Nearby objects add some stray capacitance

Efficiency Calculation

- **A ¼-wave vertical has a radiation resistance of 36 ohms**
- **Assume 10 ohms of ground loss**
  - **Probably a *<u>much better ground than most hams have</u>***
- **SWR = 1.09:1**
  - **Rr + Rg = 36 + 10 = 46 ohms**
  - **SWR = 50/46 = 1.09**
- **Antenna efficiency is 78%**
  - **If you have a 100 watt transmitter, you will radiate 78 watts**

Note:

- **Higher ground loss can result in a *<u>BETTER</u>* SWR!**

Electrically Short Antennas

- The shorter the antenna, the lower the Rr
- A Hustler 6BTV 80/40/30/20/15/10 meter vertical is 24 feet tall
  - On 80 meters, it is only 0.092 wavelength long
  - Rr decreases approximately as $1/(\text{length})^2$
  - So Rr is approximately 5 ohms
- With 10 ohms ground loss, the <u>efficiency is 33%</u>
  - Assumes <u>*no trap/inductor losses*</u> (trap loss could add 2dB)
- Now your 100 watt transmit signal results in only <u>33 watts being radiated</u>

Electrically Short Antennas (cont'd)

- **A Butternut HF-9VX with TBR-160 160M loading coil is 26 feet tall**
- **On 160 meters, it is only 0.051 wavelength long.**
- **Rr decreases as 1/(length)^2**
- **So Rr is approximately 1.5 ohms**
- **With 10 ohms ground loss, the <u>efficiency is 13%</u>**
  - **Assumes no inductor/loading coil/matching losses**
- **Now your 100 watt transmit signal results in only <u>13 watts being radiated</u>**

Matching losses could easily drop this number below 10 W

The 43-foot Vertical Antenna

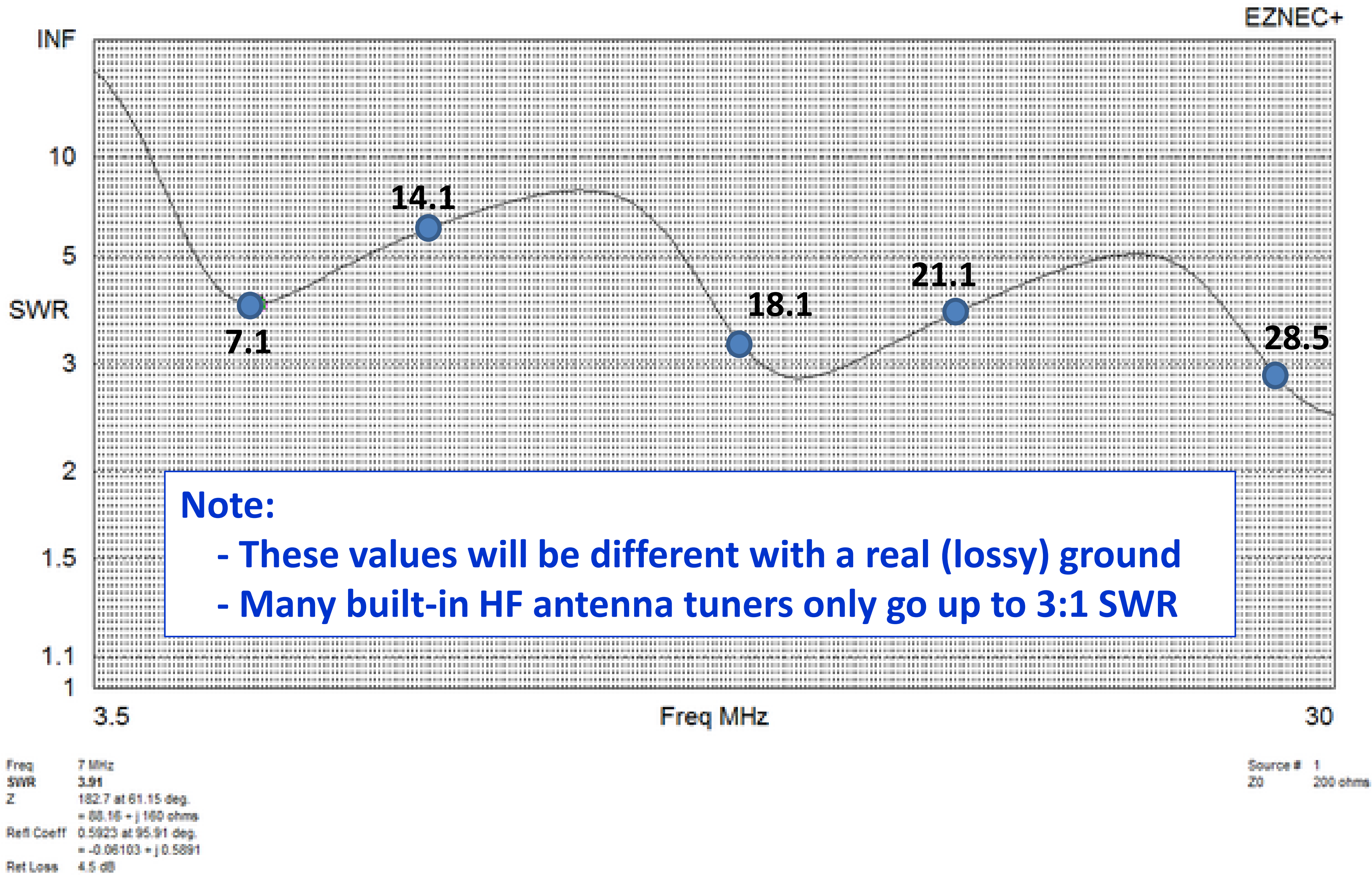
Advantages

- Still can be self-supporting & moderately unobtrusive
- Approximately 3x higher radiation resistance than the typical trap or loaded vertical.
- No trap or loading coil losses to worry about
- Modest compromise SWR from 60-10 meters when fed with a 1:4 unun.(UNUNs are designed to work with resistive loads!)

Disadvantages

- Take-off angle is not optimum on 12/10 meters
  - More on this later
- You need an in-shack tuner (remote tuner is much better)

43-foot SWR over Perfect Ground with 1:4 Unun at the Antenna (EZNEC)



Efficiency Comparison

- **The Hustler 6BTV on 40 meters**
  - **The 24-foot Hustler is 0.188 wavelengths long**
  - **Rr = 20 ohms**
  - **Efficiency = 67% (assumes Rg = 10Ω & *no coil losses*)**
    - ***Note:There are multiple inductors (traps) in-line on 40 meters***
- **The 43-foot vertical on 40 meters**
  - **Antenna is 0.34 wavelengths long**
  - **Rr = 65 ohms**
  - **Efficiency = 87% (with Rg = 10Ω with *no coils/traps*)**
  - **The required tuner may have more loss than coils/traps**

43-foot Antenna Disadvantages

- Can be moderately (very) expensive
- High take-off angle above 15 meters
  - DX performance >1/4-wave vertical 60-15 meters, but 5dB down from 10 meter ¼-wave vertical at 10 degree take off angle (but higher Rr compensates some)
- Really needs base matching on 160/80-meters
  - Regardless of what the 43-foot antenna vendors say
- Example: With Rg = 10Ω
  - 160 Meter SWR = 324:1, 80 Meter SWR = 41:1

Matching & Coax Losses

- **Some 43-foot antenna vendors claim the antenna can be matched from 160-10 meters with your in-shack tuner.**
- **One vendor says to use 150 feet of RG-213 for best all-band operation of the 43-foot antenna (so you can tune from the tuner in your shack). Another vendor says to *ADD 150 feet of RG-213 to your cable run.***
- **The typical 160 meter base impedance of a 43-foot antenna with the 1:4 UNUN is 2-j183. 150 feet of coax transforms this to a matchable 38 + j180 (?) at the shack.**
- **But the antenna SWR is ~ 150:1 resulting in 12dB (two S-units) of *coax losses due to the SWR at the antenna. Plus about ≥6dB ground loss.* Total loss ~18dB.**
  - **TX = 100W results in *2-watts radiated (No! 2 W reaches ant) Some antenna mfgs don't understand the basics!***

To Maximize Efficiency

- **Minimize coax loss:**
  - **Use shortest length possible**
  - **Heliax semi-rigid cable**
  - **LMR-400 coax**
  - **RG-213 coax**
  - **Do matching _AT_ the antenna**
- **Install the best radial system you can afford**
- **Do the matching <u>at the base</u> of the antenna**
  - **For high power & high SWR, may need to use relay switching**
  - **Matching on 160/80 meters is difficult**
    - **The mismatch may be too great for most manual/auto antenna tuners**
      - **<u>VERY</u> high RF voltages & currents**

RF Voltage & Current

- An electrically short antenna has high capacitive reactance. This *WILL cause high RF voltages across a matching network.*
- Example: Assume 1500 watts and a perfect ground system (Rg = 0) on 160 meters. In this case all power is delivered to Rr.

<u>At the base of the antenna:</u>

$I = \sqrt{(1500/3)} = 22.4$ amps rms

$|Z| = \sqrt{(3^2 + 600^2)} = 600$ (?)

So, Vrms = 22.4 x 600 = 13,440 and Vpk = 19,007 volts (?)

Don't overlook UNUN current & voltage limitations

Matching Network Issues

- Any antenna with low Rr will have large RF current
  - Inductor & capacitor heating & contact degradation on switches & relays

- Any antenna with high X will have large RF voltage at the feed point
  - Safety concern!
  - Capacitor/switch/relay breakdown in matching network

Vertical Antenna Pattern Over Real Ground

Ground characteristics affect both efficiency ***and*** radiation pattern

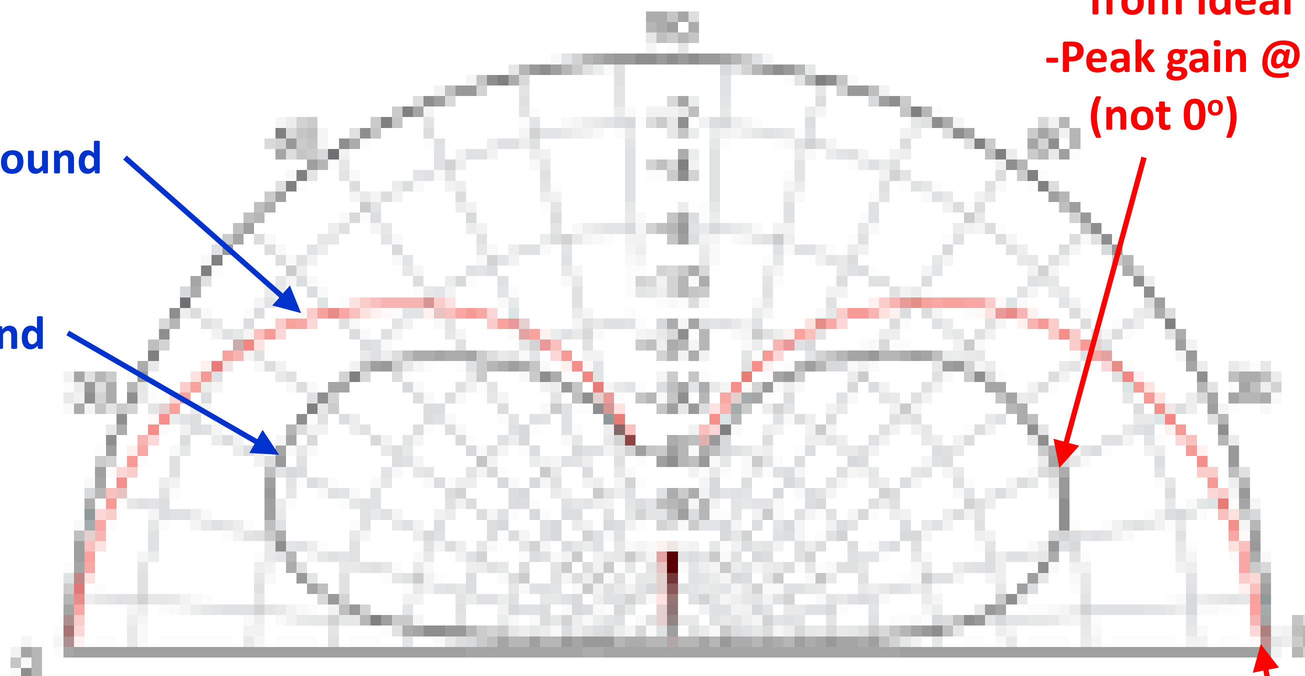
¼ Wave Monopole

-Peak gain down 8 dB from ideal vertical

-Peak gain @ 30º (not 0º)

Perfect Ground

Lossy Ground



Peak gain down 6 dB compared to dipole

- **Lossy ground results in:**
  - Lower gain
  - Higher takeoff angle (pattern may be no better for DX than a dipole)

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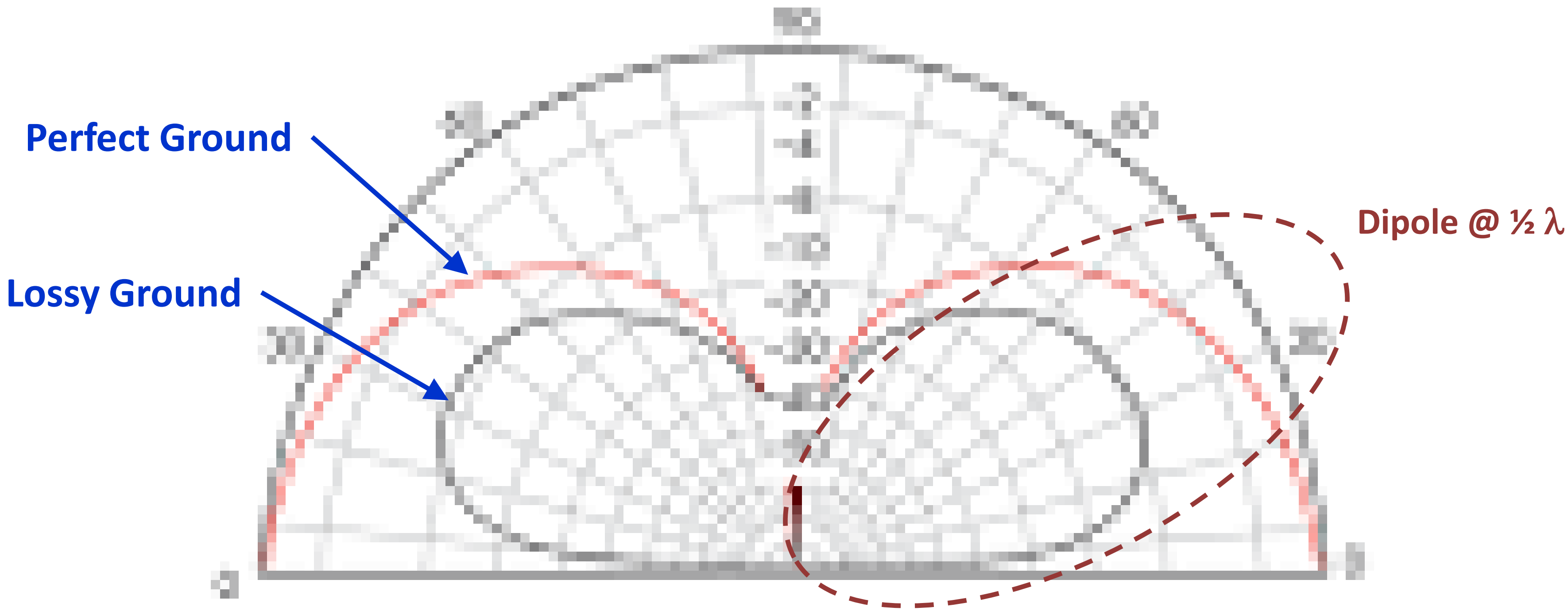
¼ Wave Monopole



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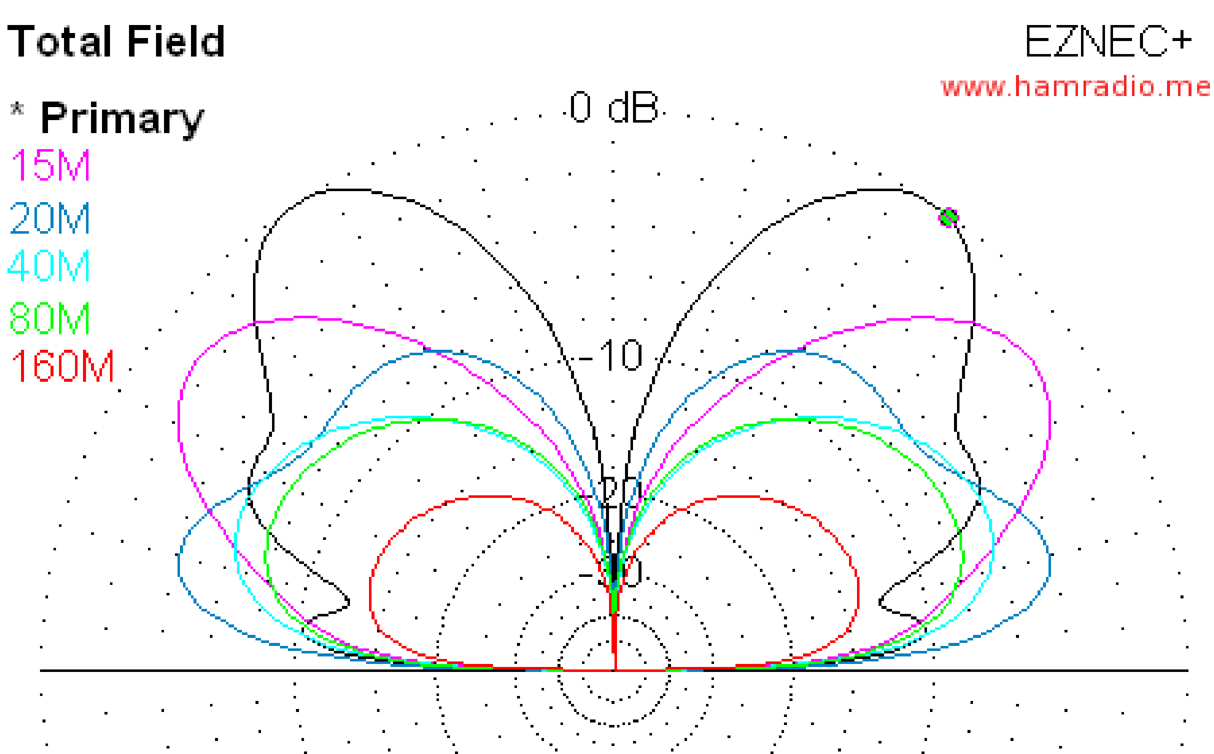
Pattern Over Real Ground (cont'd)

- Peak Gain for 43 Foot Vertical:
  - ~ 5 dBi @ 57° for 10 meters – impressive, but high angle
  - ~ 4 dbi @ 37° for 15 meters
  - ~ 1 dBi @ 16° for 20 meters – nice low angle
  - ~ 0 dBi @ 25° for 40 meters
  - ~ -2 dBi @ 29° for 80 meters – this is quite functional
  - ~ -8 dBi @ 23° for 160 meters – lossy, but it does work
- Peak Gain for a Dipole is 5-9 dBi (depends upon height above ground)



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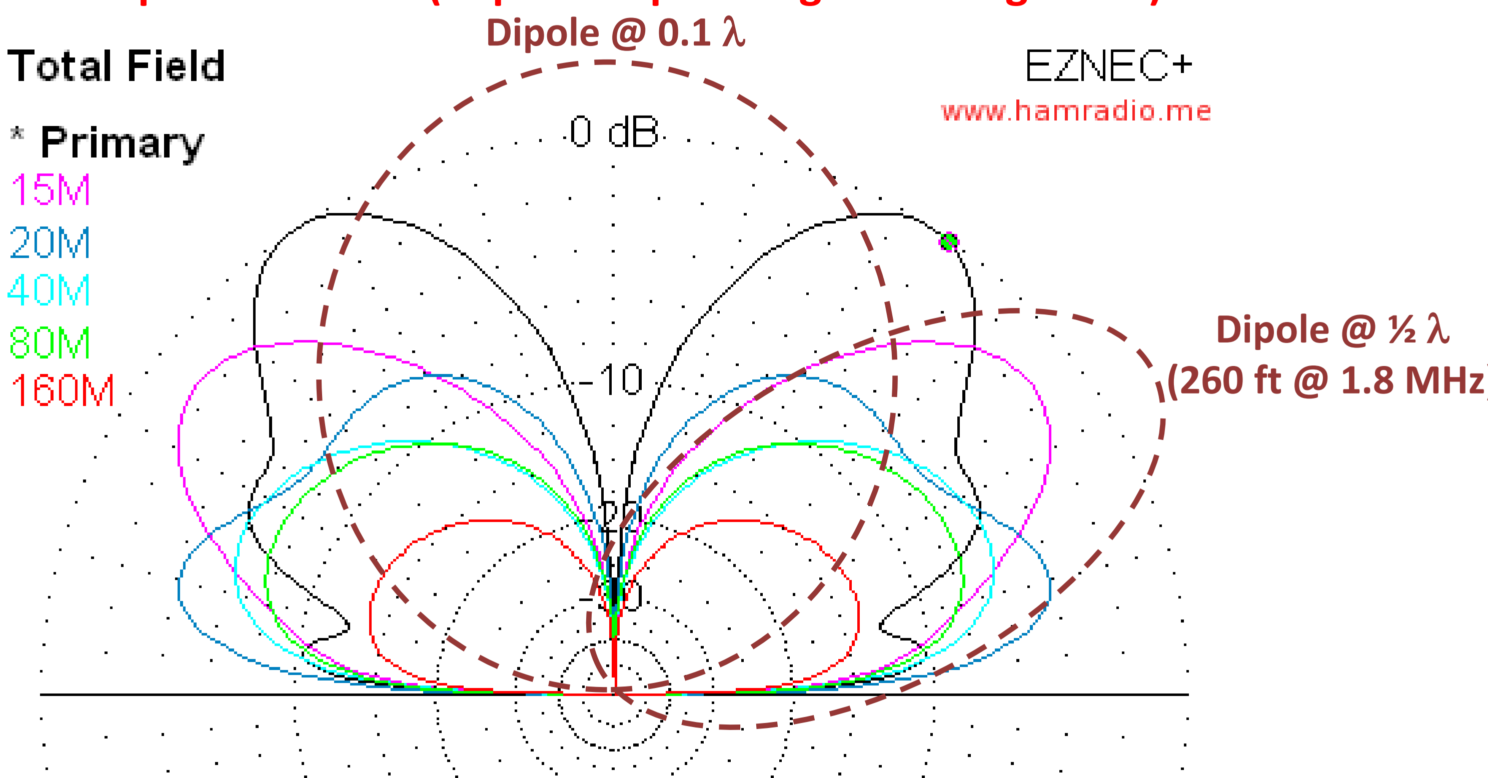

Summary

- The more metal in the air, the better the antenna
  - Radiation resistance increases as the square of the length change.
  - Increased radiation resistance improves antenna efficiency over real ground.
- A 43-foot antenna is very (?) good for 60-10 meters
  - Modest to low gain
  - High takeoff angles on higher bands
  - Not a very good DX antenna for 160/80 meters, but probably better than a dipole up only 40 ft (if the losses are low)
- A 43-foot antenna needs base matching to provide good (?) results on 160-and 80-meters.
  - Detailed matching network details at www.ad5x.com

Summary cont'd

- This is not a cheap antenna (>$1300)
    - Antenna $400
    - High power remote antenna tuner $800
    - High power UNUN $150
    - Radial system $100
- Vertically polarized antennas installed over poor ground are not good DX antennas
- Not an easy antenna to install