The Care and Feeding of Simple, Broadband HF Antennas

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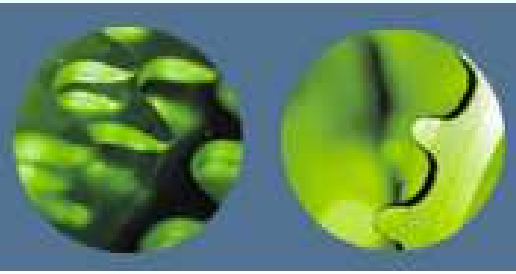
Problem Statement

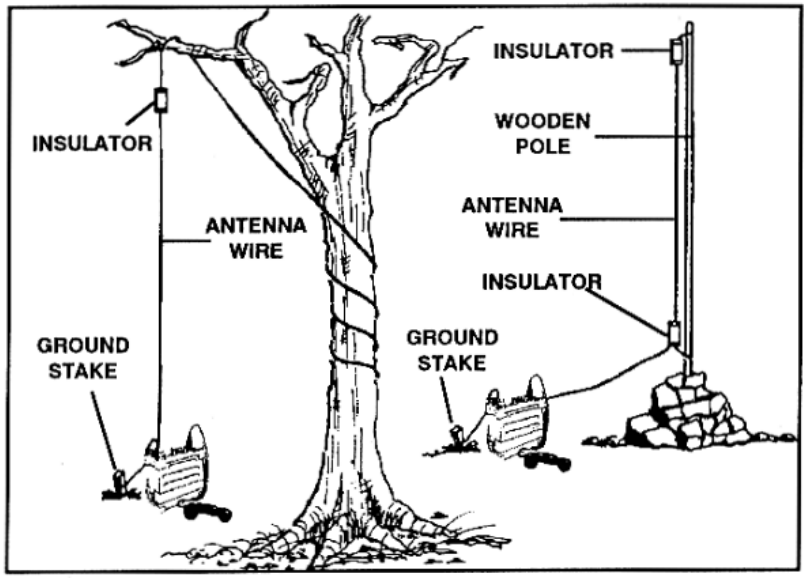
1. Cover multiple HF Amateur Bands with one antenna.
   - 80m through 10m if possible.
2. Use single feedline.
3. Minimize cost
4. Minimize visibility of the antenna.
5. Reasonable performance.



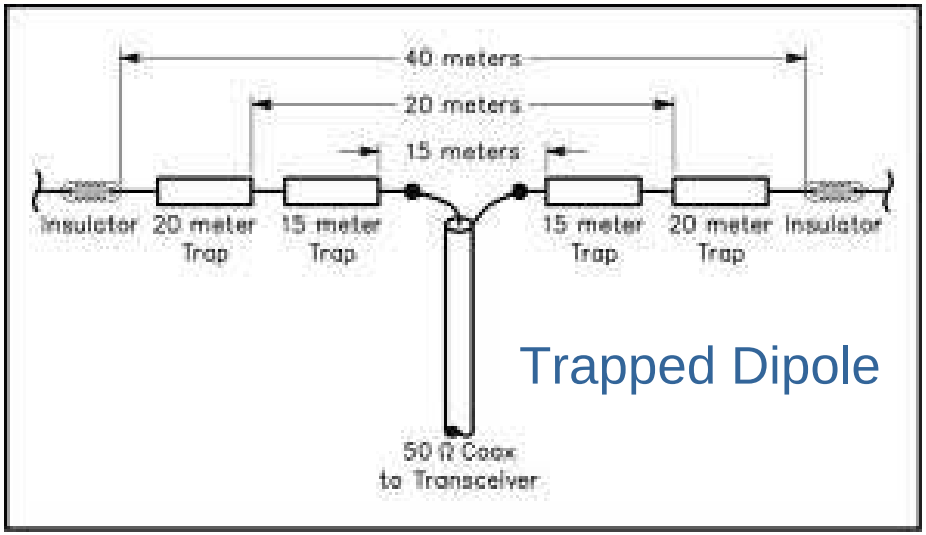
Some Approaches

- Trapped Dipole or Fan Dipole
  - Reasonable compromise.
  - Difficult to achieve more than about 3-4 bands.
  - Visibility increased (compared to single wire).
  - May be difficult to thread through trees.
- Doublet antenna or wire loop
  - Simple, low cost
  - Low visibility
  - Usually easy to install and thread through trees.
  - But poor impedance match across HF.
- Wire vertical
  - Requires radials
  - Easier to place tuner at the antenna feed point.

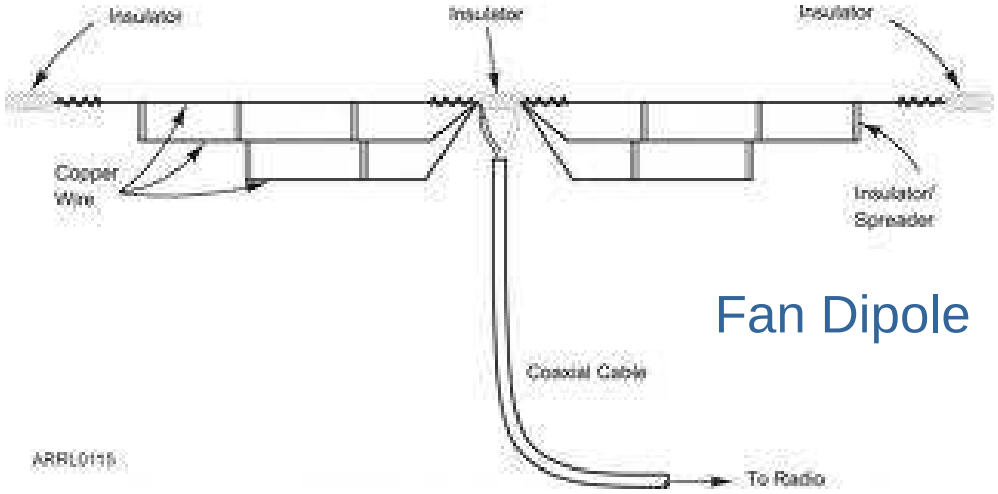
Antenna Drawings



Vertical wire

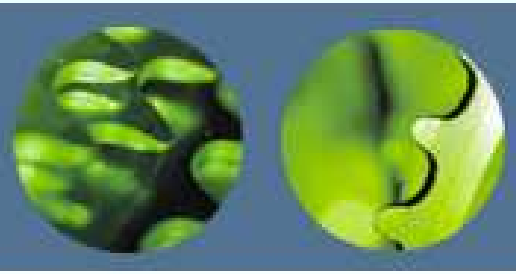


Trapped Dipole



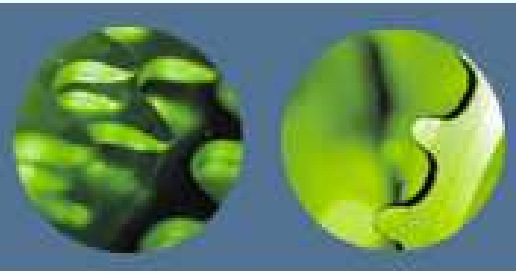
Fan Dipole

Doublet (non-resonant dipole)



Common Misconception

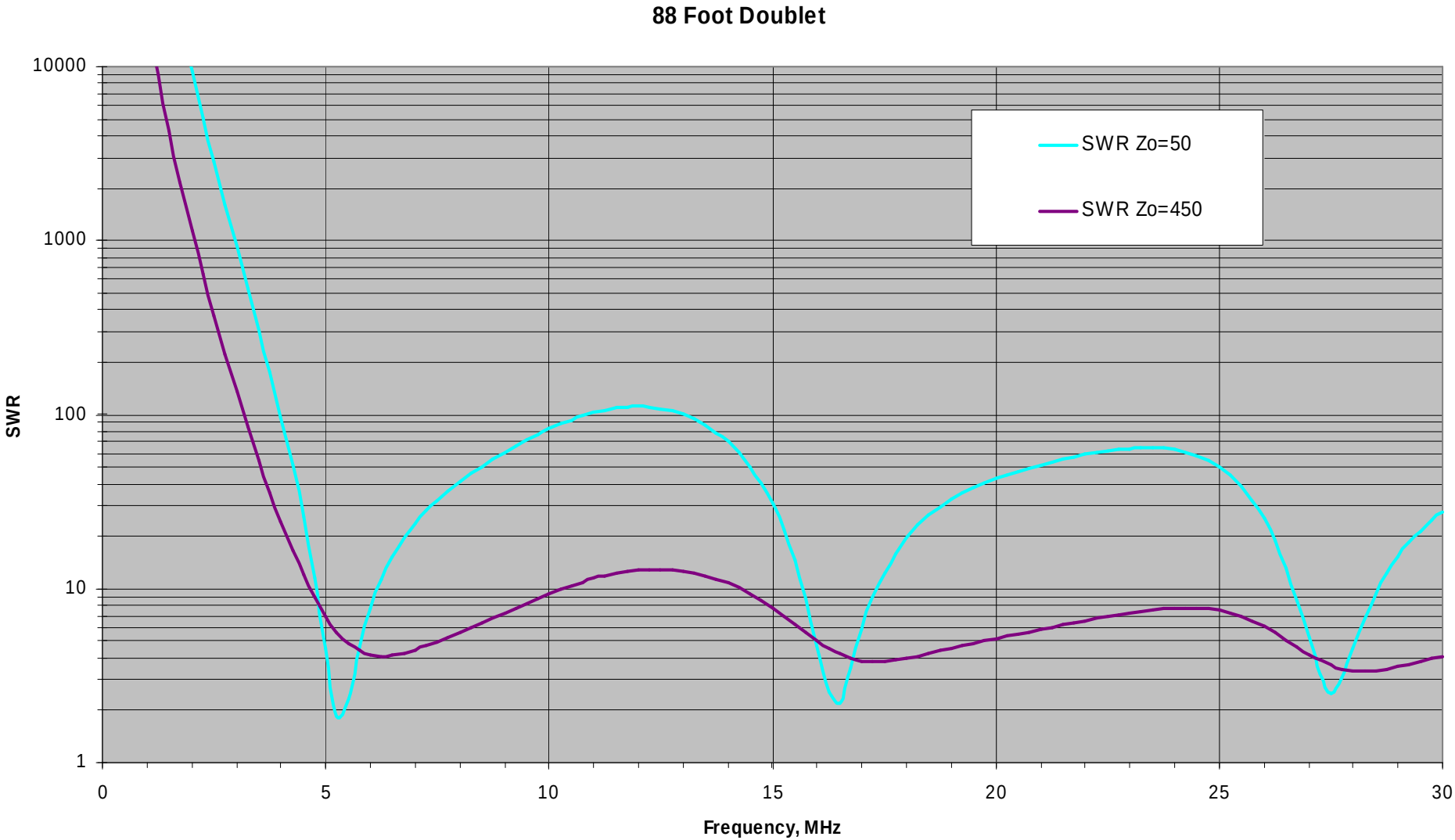
- Misconception: An antenna (dipole or loop) must be resonant to work well.
  - Antenna does not need be resonant to work well (for example: extended double zepp)
  - However, we do need to compensate for antenna impedance mismatch so that it will accept power.
  - If antenna is too short, losses may be high.



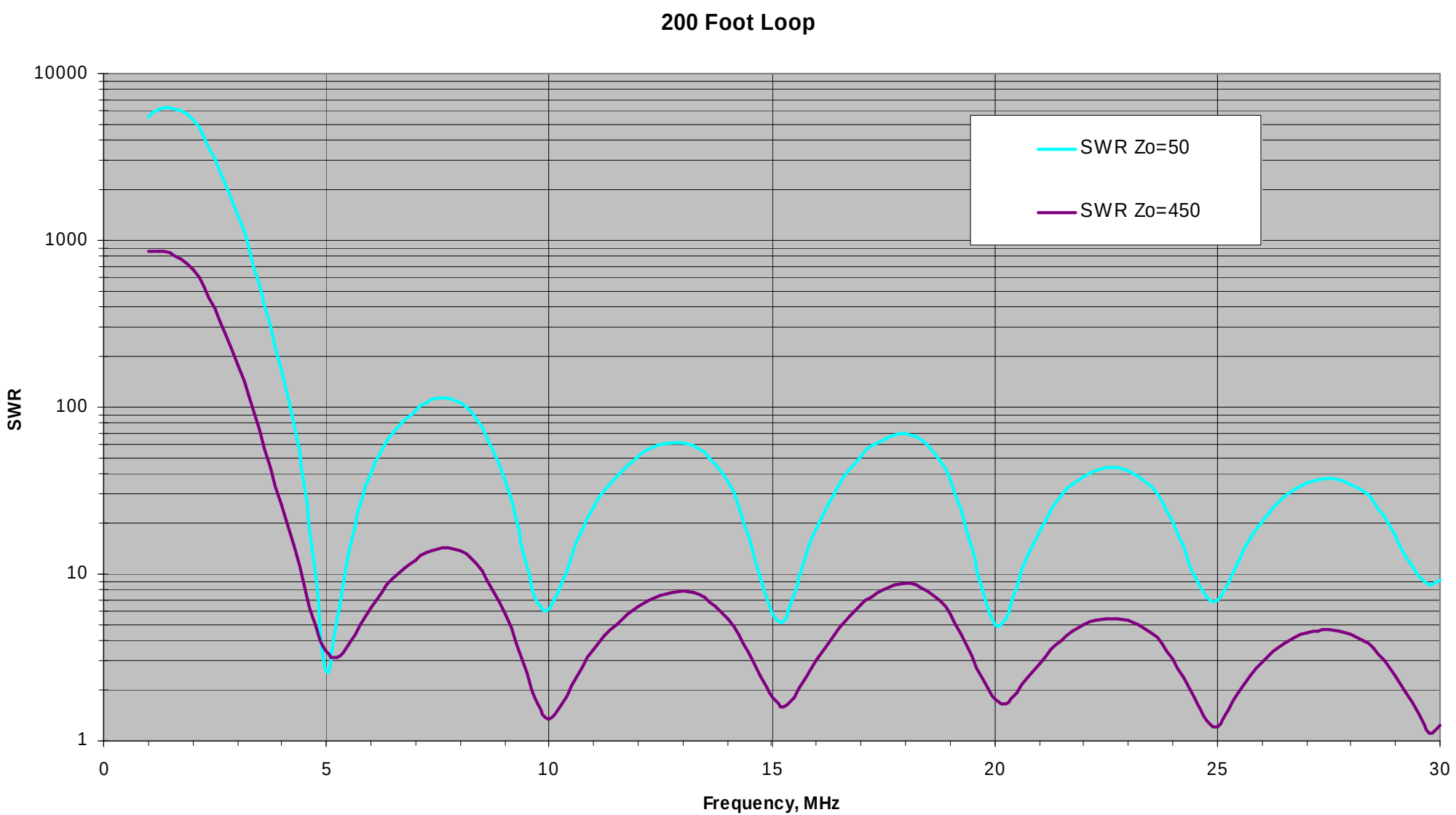
Impedance of Doublet or Loop

- Dipole: Low impedance at f/2, 3f/2, 5f/2, etc. (odd multiples of half wavelength).
- Loop: low impedance at f, 2f, 3f, 4f, etc. (odd and even multiples of wavelength).

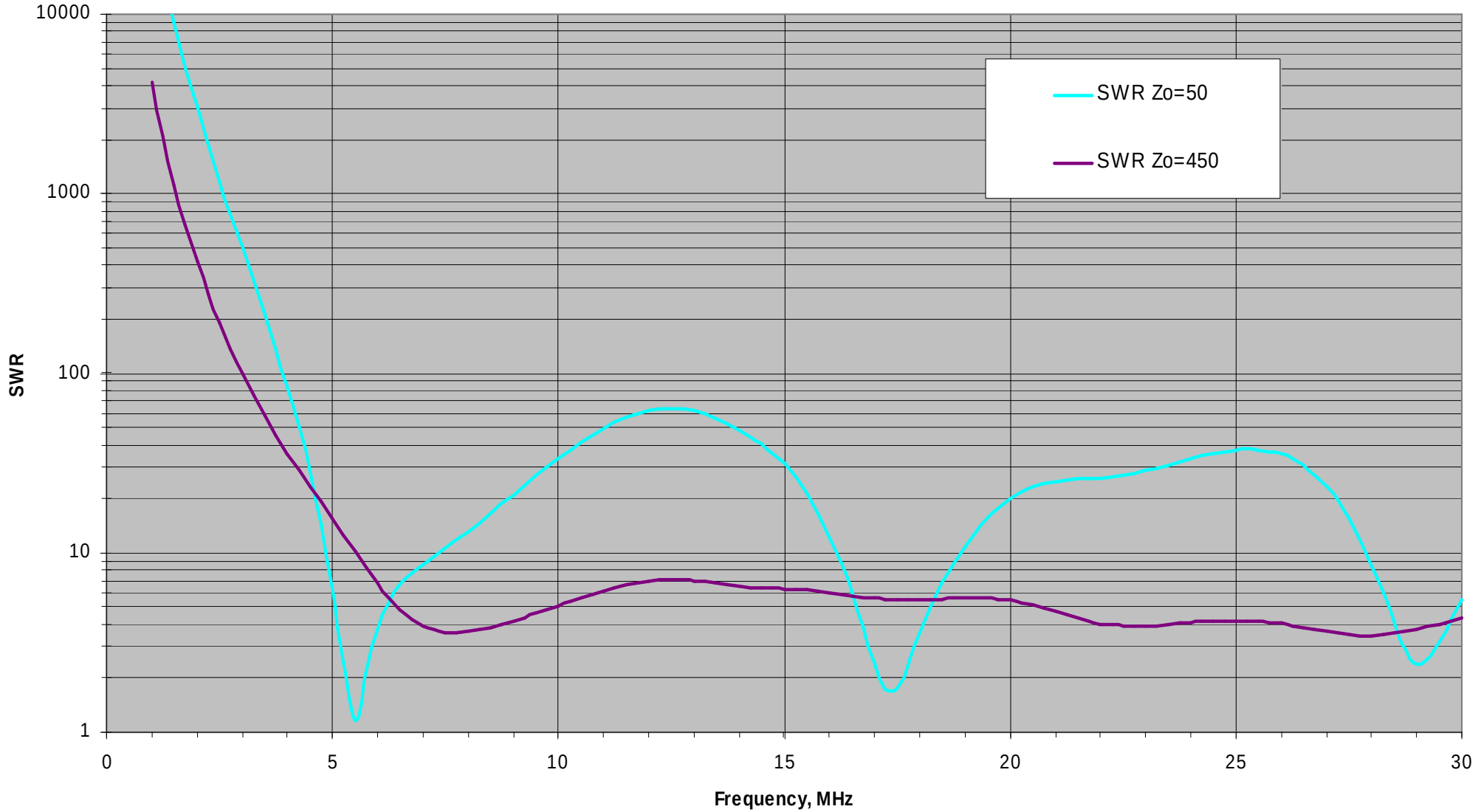
SWR - 88 foot doublet

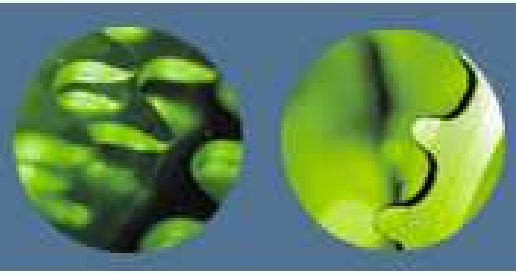


SWR - 200 foot loop



SWR – 43 foot wire vertical + 16 radials

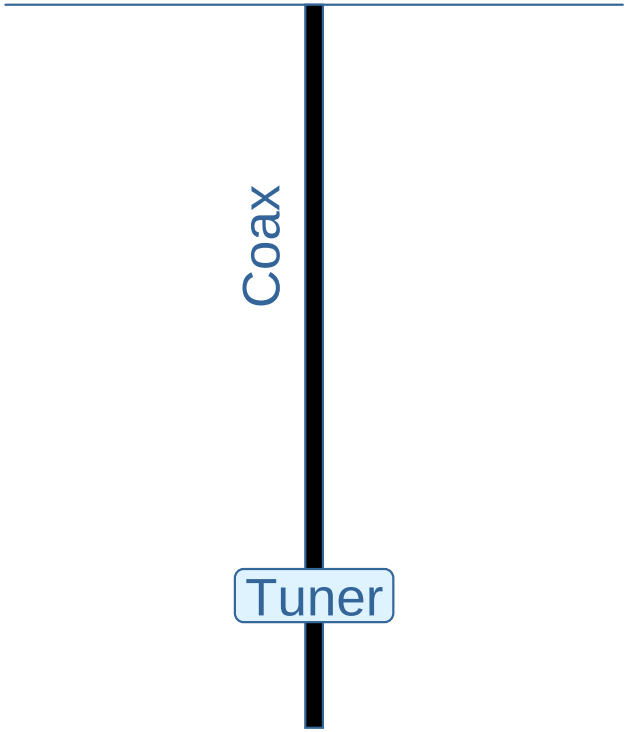




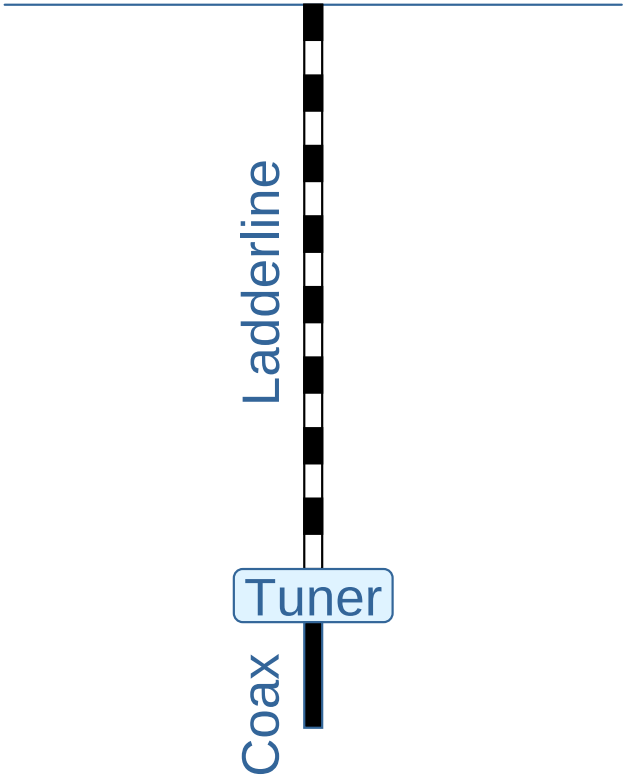
Approaches to Matching

1. Make the antenna resonant
   - Unfortunately this is a narrow-band process.
   - Requires lot of antenna elements or traps to cover many HF bands.
2. Place a variable antenna tuner right at the antenna:
   - Requires adjustment as we change frequency.
   - Automatic remote tuner (and power) is needed.
   - Feedline operates ‘matched’ (a good thing).
3. Use a manual tuner in the shack.
   - Feedline operates ‘mis-matched’ causing excess loss (a bad thing).

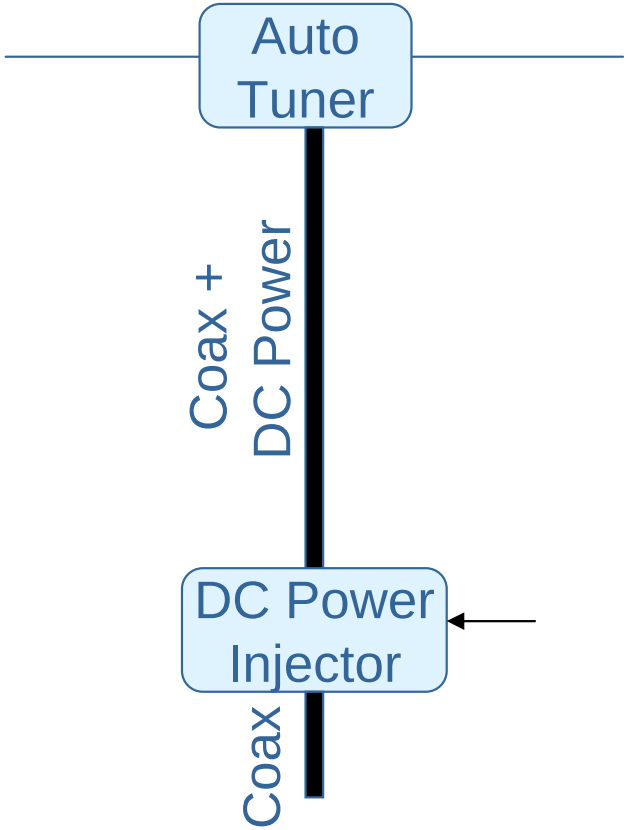
Feed options



High line loss at high-SWR frequencies



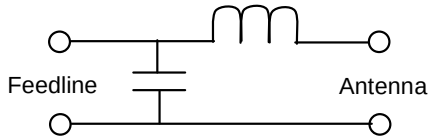
Indoor manual or auto-tuner.



Remote outdoor auto-tuner near antenna feedpoint.

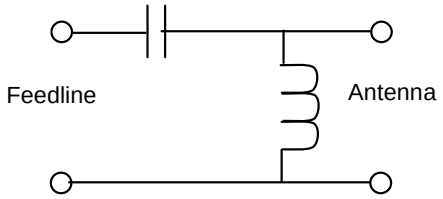
Matching Network: 40m doublet on 80m

- Z_{in} = 20.7 – j947 Ω SWR_{50} = 868:1 'Q' at the antenna is 45.5
  - Antenna voltage @ 1500 watts = 8056 volts !
  - A traditional high-pass T-network just can't match this load.
- L-network is much easier for this case.
  - Lser = 44.1 μH, Cshunt = 1100 pF
- 35 feet away, through the feedline
  - Z_{in} = 4.1 – j222
  - Lser = 10.7 μH, Cshunt = 3100 pF (note **huge** value of C)
- 50 feet away, through the feedline, a T-network can match (but high losses).
  - Z_{in} = 3.1 – j12.5
- At half-wavelength of feedline, again HPF T-network cannot achieve match.

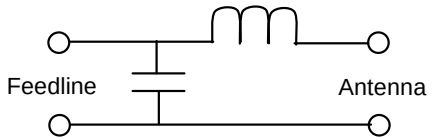


Matching Network: 40m doublet on 20m

- Z_{in} = 1717 – j2505 Ω SWR_{50} = 107:1
  - 'L-network' can match – but the components must be swapped around from 80m configuration



- 16 feet away through the feedline:
  - Z_{in} = 29.5 – j2.9 Ω
  - L-network needs original configuration

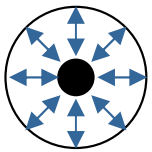


→L-network configuration depends on the line length

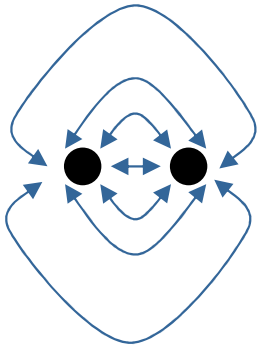
  - T-network matches through many different combinations of line length.

Feedline

- Feedline has loss.
  - Ladderline usually has lower loss than coaxial cable.
  - Ladderline requires more care in routing than coax.



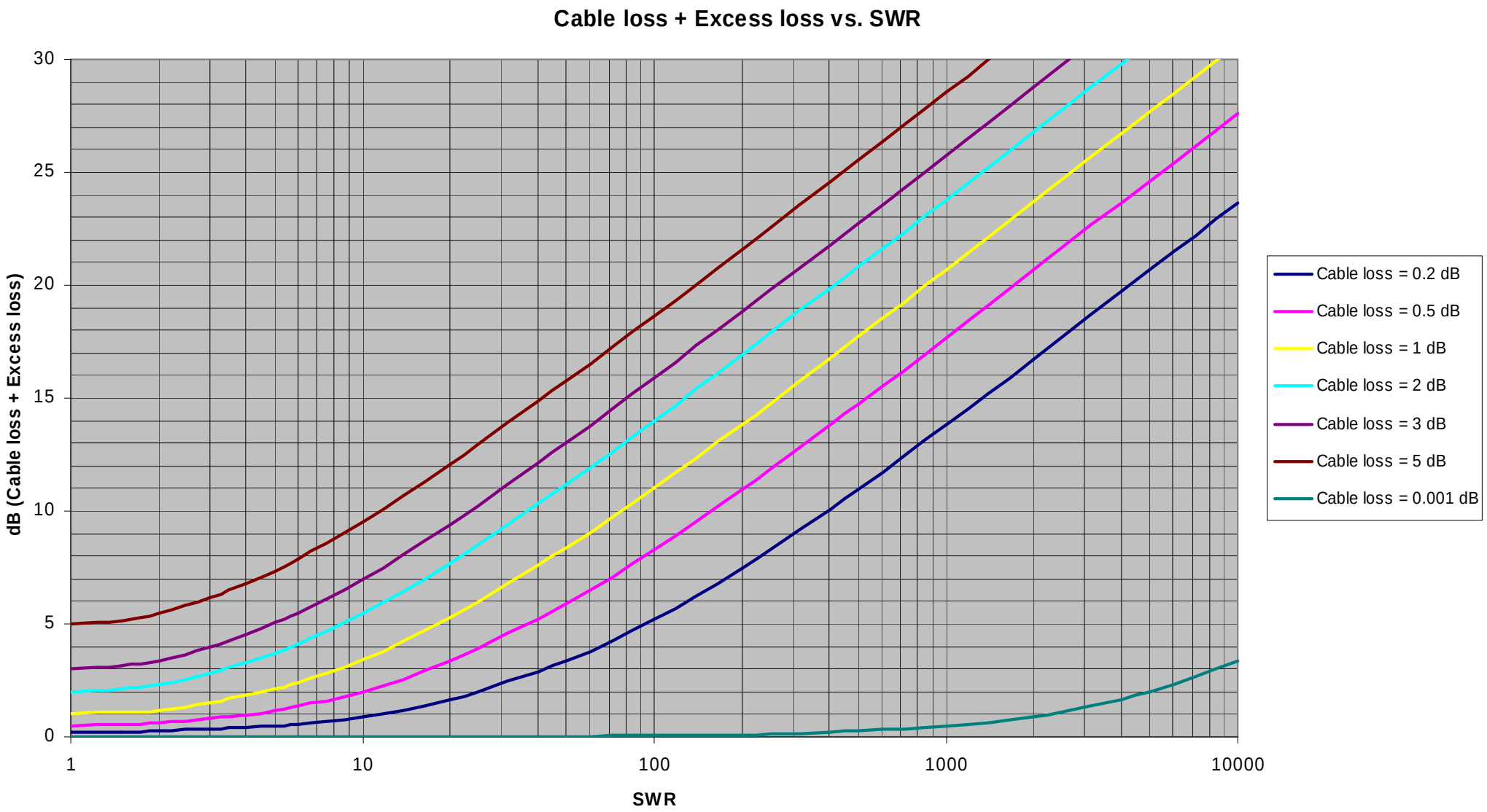
Coax: electric field is completely inside the dielectric (assuming no common mode current).



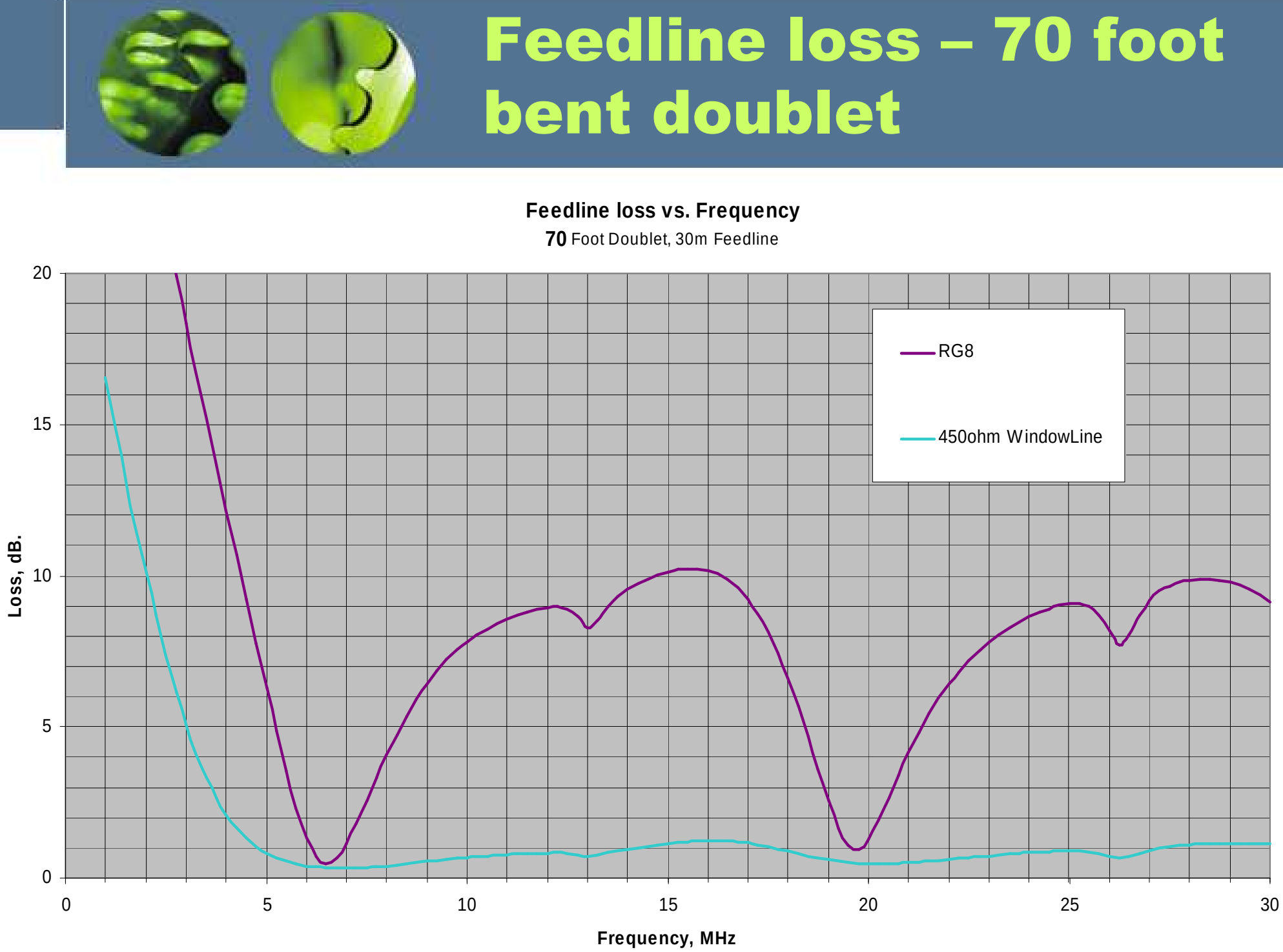
Ladderline: electric field is mostly within 4x conductor spacing. Separation from other conductive objects needed.

- If the SWR on the line is low, the loss is lowest.
  - As the SWR increases, the line loss increases.
  - Both coax ***and*** ladderline can have catastrophic losses under high SWR conditions.

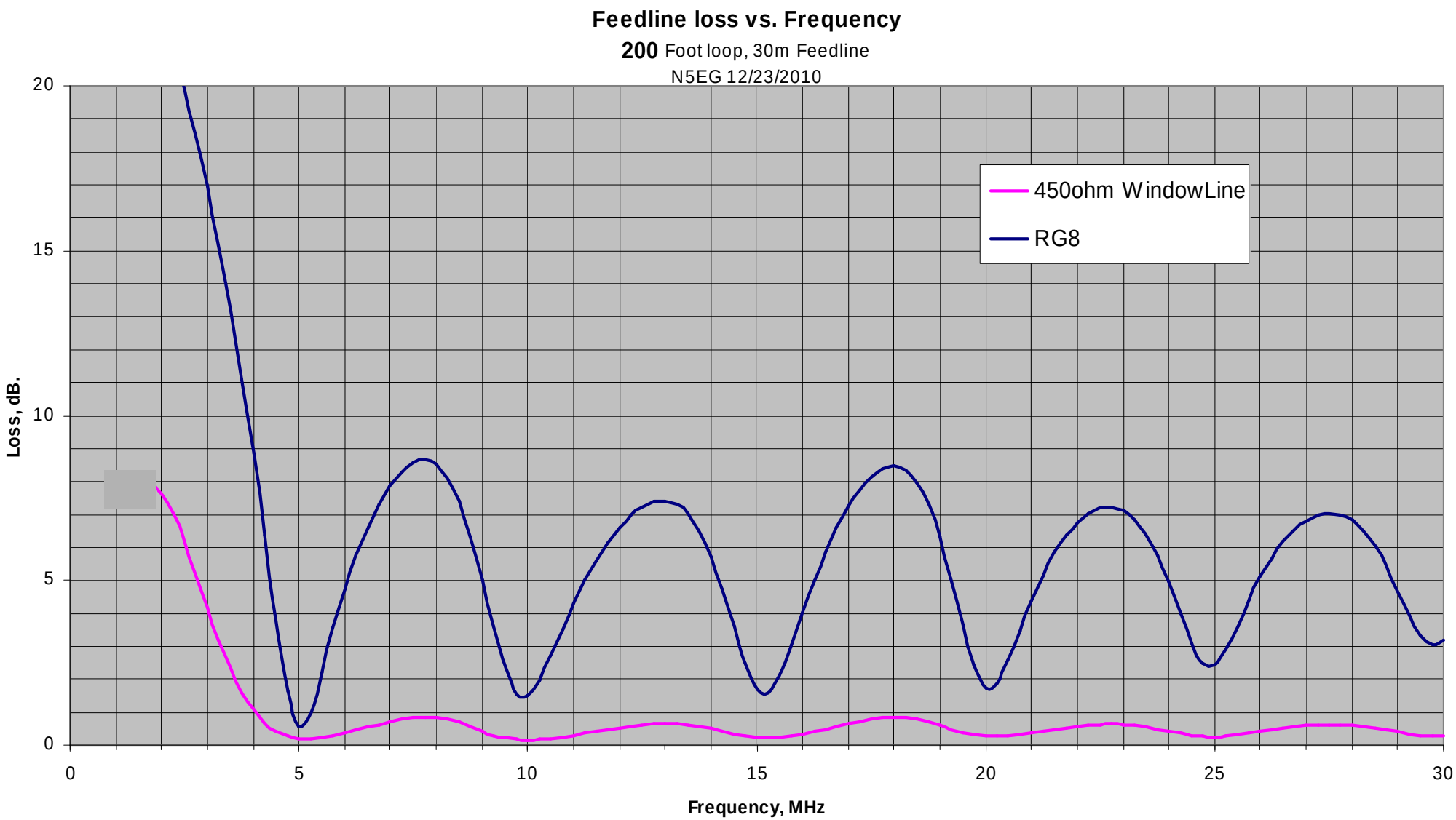
Line Loss vs. SWR



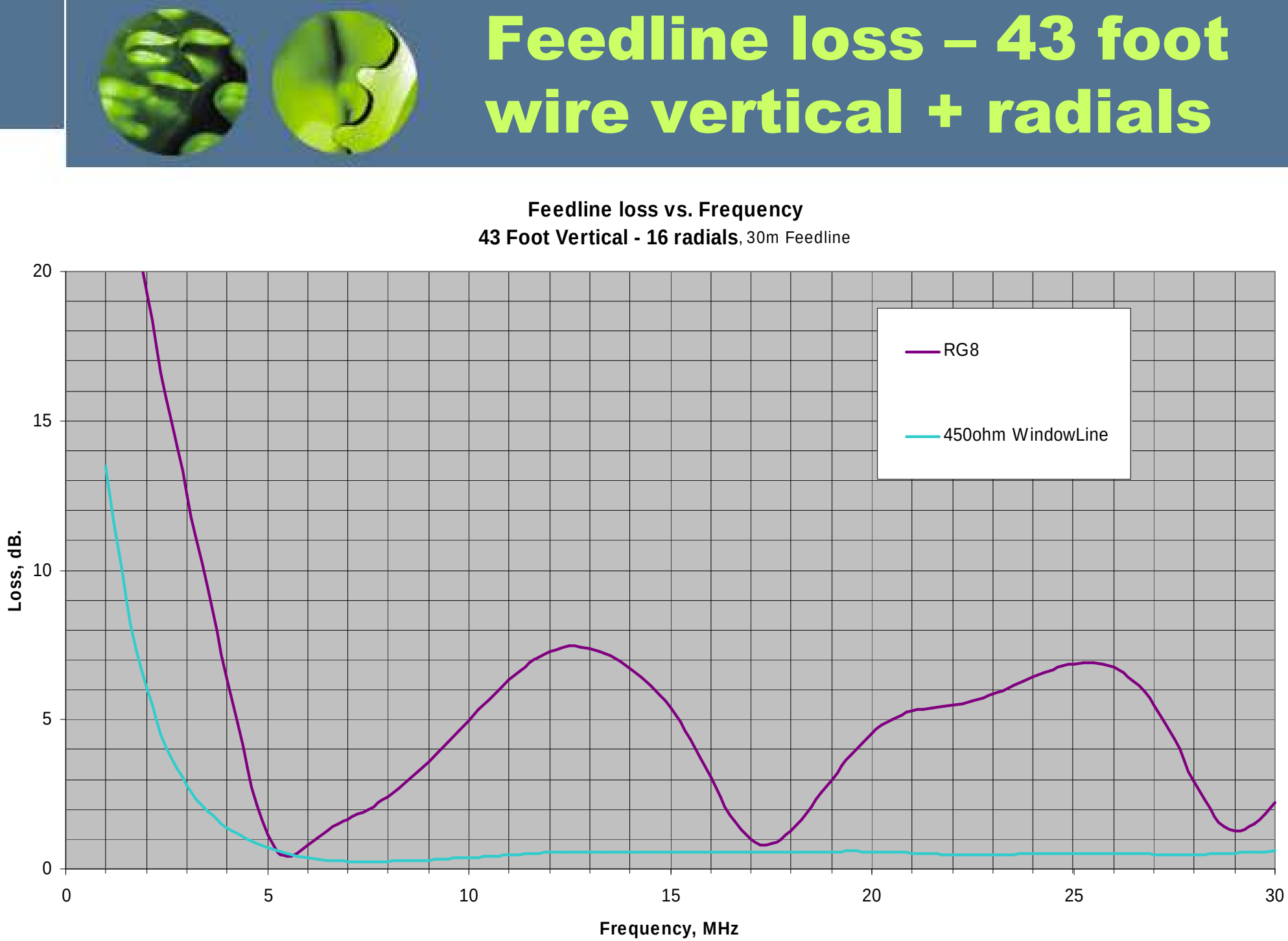
Feedline loss – 70 foot bent doublet



Feedline loss – 200 foot loop

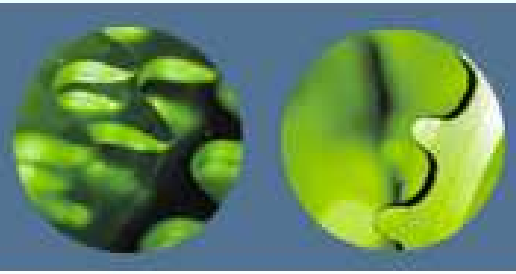


Feedline loss – 43 foot wire vertical + radials



Feedline conclusion

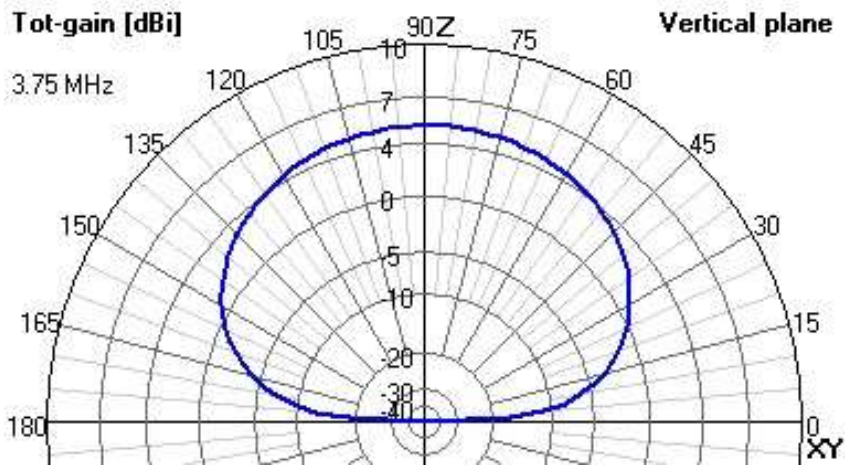
- High SWR causes problems.
- Feedline needs to have very low loss for wideband operation.
- Coaxial cable loss usually always too high.
- Heavy-gauge ladderline recommended for reasonable feed distances -or-
- Put your tuner right at the antenna.
  - That may be easier for a vertical than doublet or loop.



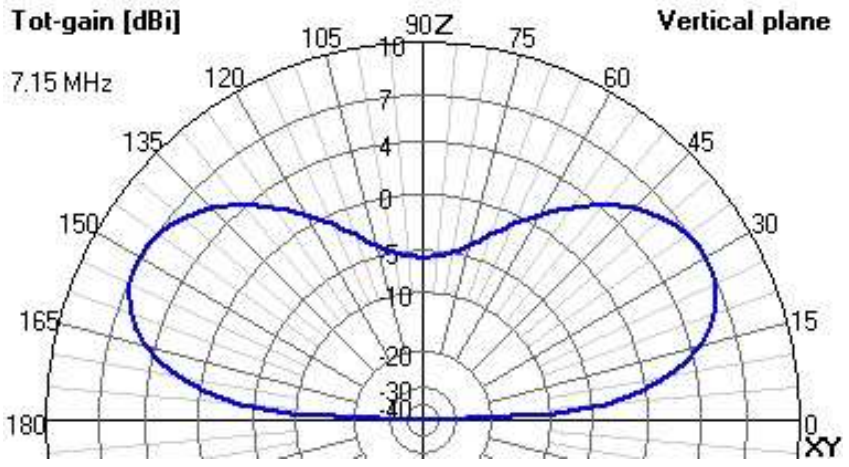
Antenna Pattern

- Since we're operating the antenna far away from normal resonant points, what happens to the pattern?
  - Almost omni-directional at low frequencies.
  - Like a dipole where it's ~ half wave.
  - Has gain at full wavelength.
  - Pattern develops many lobes at higher frequencies.

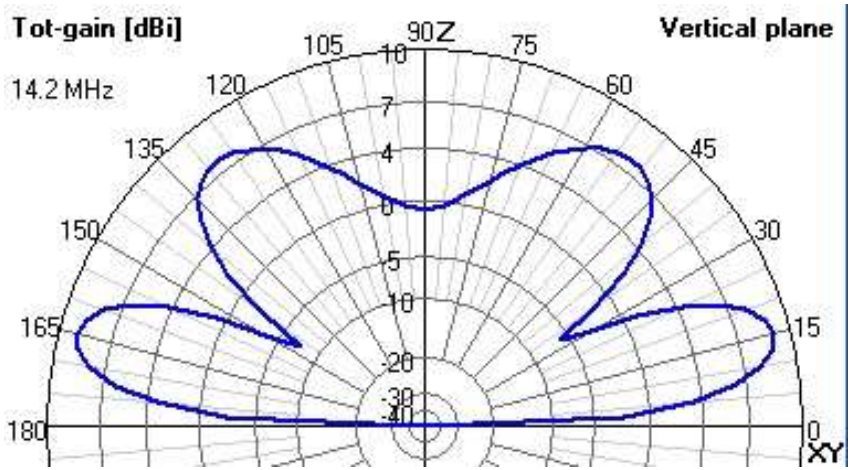
70 foot doublet elevation pattern



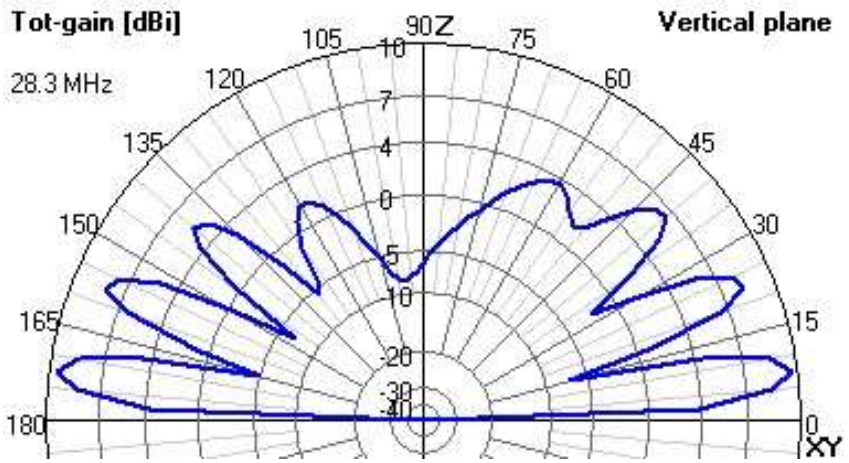
80 meters



40 meters

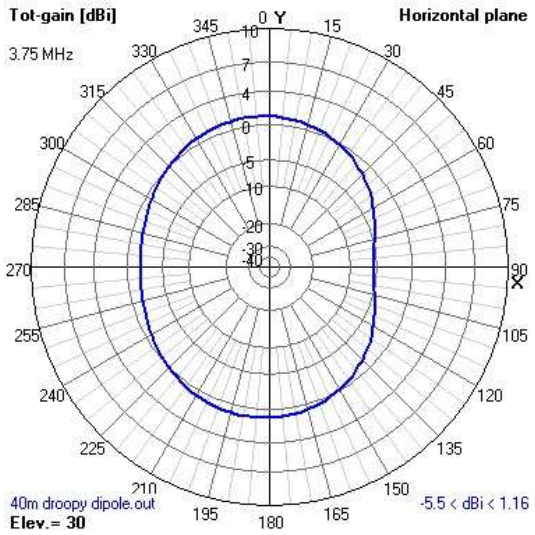


20 meters

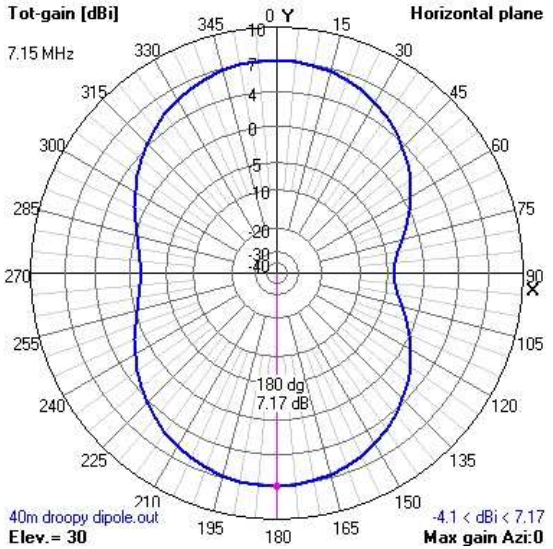


10 meters

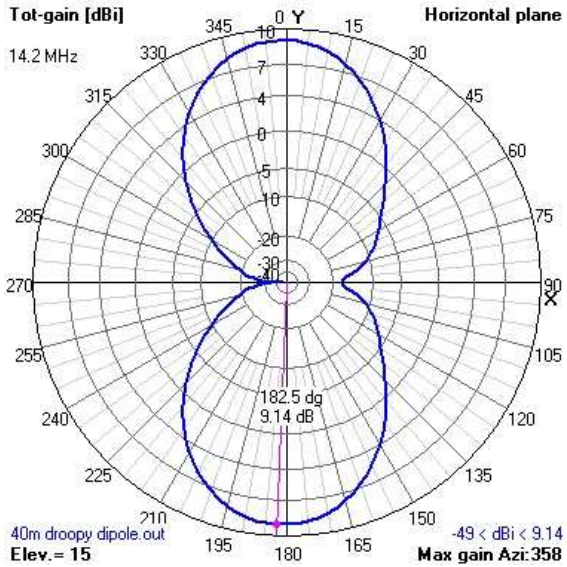
Azimuth pattern of 70 foot slightly non-symmetrical doublet



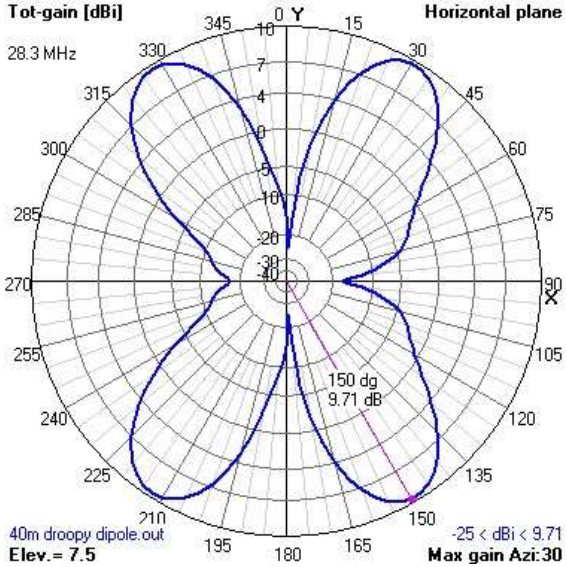
80 meters



40 meters

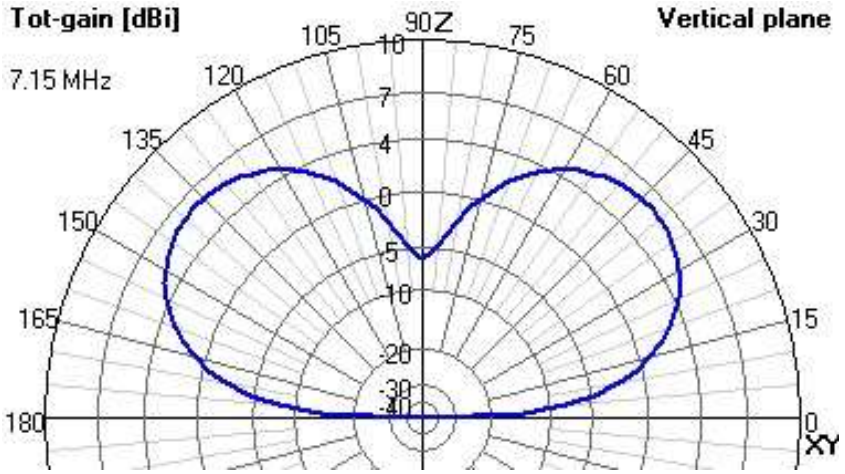


20 meters



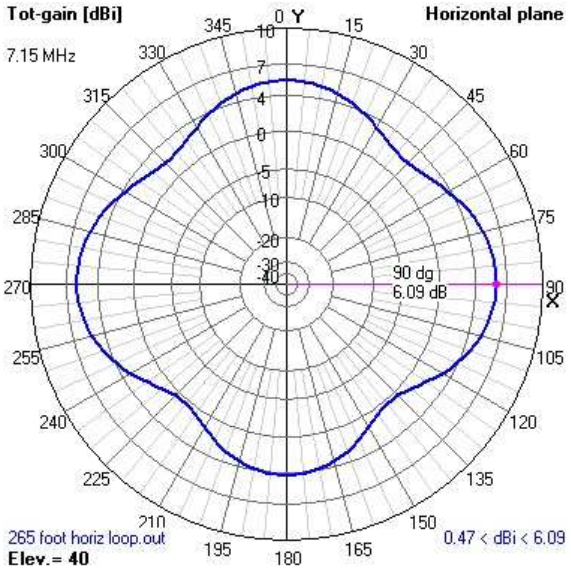
10 meters

Elevation pattern of 2-wavelength loop

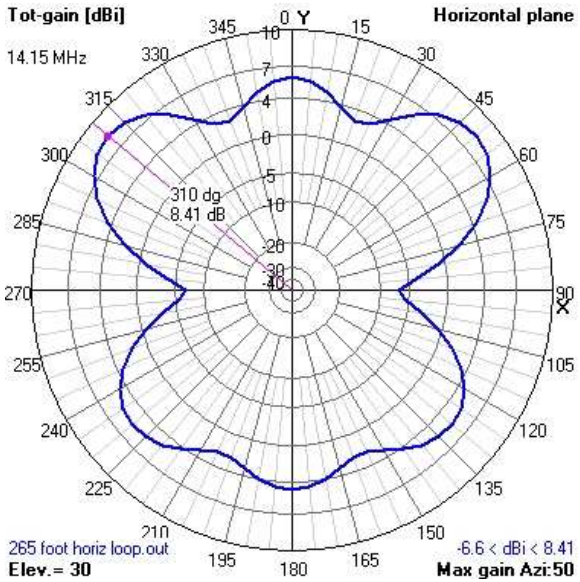


40 meters

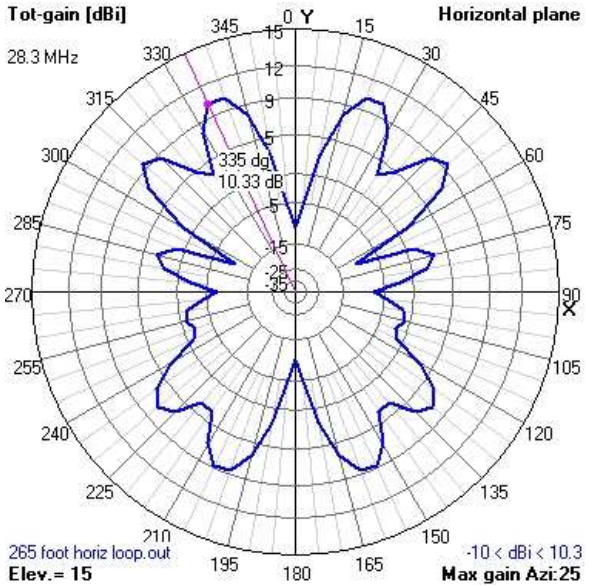
Azimuth pattern of 265 foot loop



40 meters

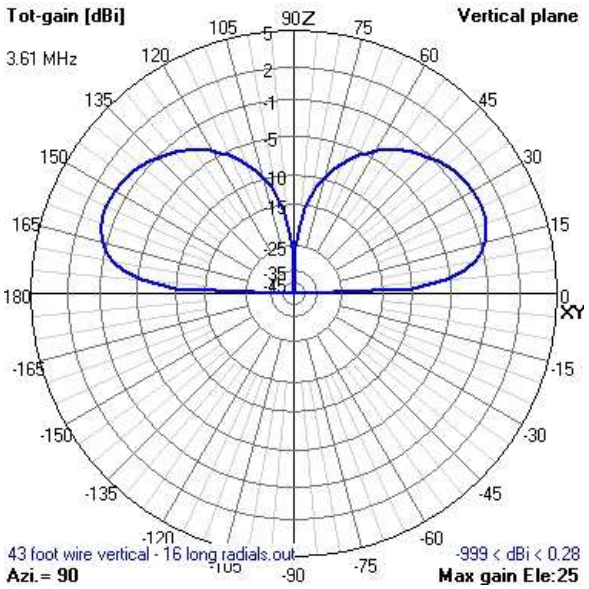


20 meters

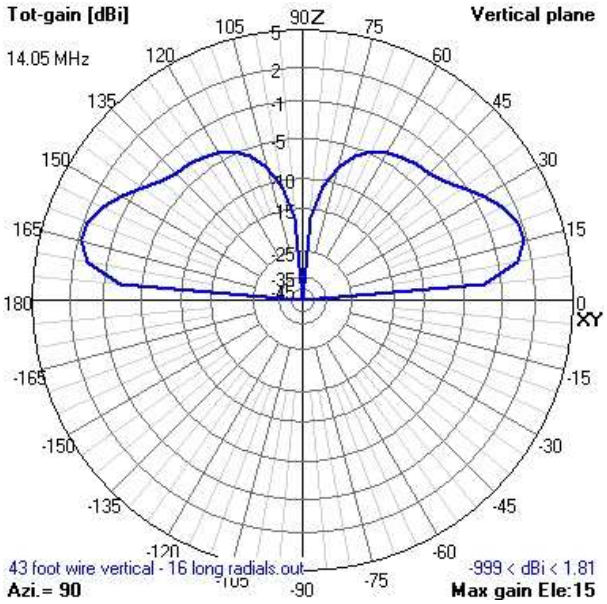


10 meters

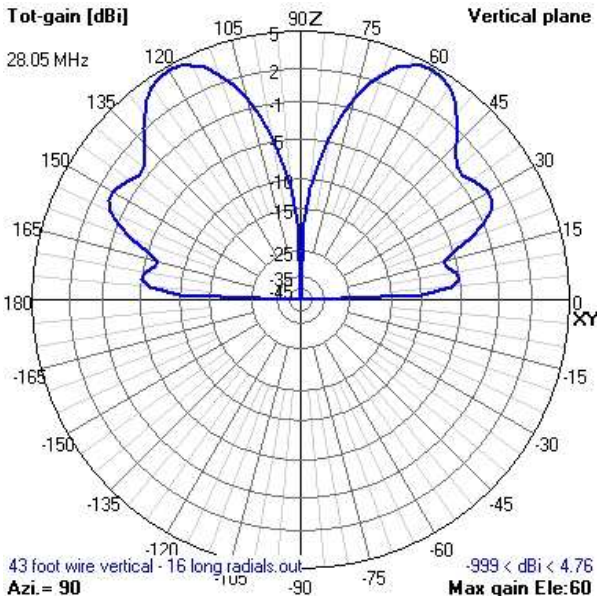
Elevation pattern of 43 foot vertical



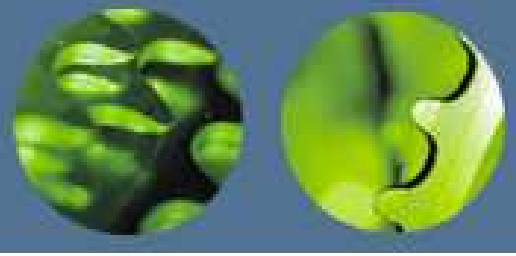
80 meters
(looks almost exactly the same on 40 meters)



20 meters



10 meters



Summary

- A simple non-resonant antenna can work well over a wide range of HF frequencies.
- It's especially critical to control feedline losses:
  - Need antenna tuner at the antenna, or
  - Feed with low loss line (ladderline) and use antenna tuner in the shack.
- Doublet & Loop need to be > 65% of full size:
  - Or even ladderline losses may become too high.
- On higher bands, the antenna pattern becomes 'messy'.