

# Wire Antenna Design – Vol 1

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# Terminology

- Resistance(R): an element that dissipates energy.
- Reactance (X): acts like resistance but does not dissipate energy.
- Impedance (Z):  $Z = R + jX$  -> combination of resistance and reactance
- Isentropic Antenna: an ideal antenna with uniform radiation pattern.
- Directivity: degree to which the antenna pattern is not uniform.
- Wavelength( $\lambda$ ): distanced traveled in one cycle
- Decibel (dB): relative unit of measure – always compares quantities.
- Resonance: when the reactance of an antenna is zero.
- Match: When the source and load impedances are equal.

secant lines

$$f'(x) = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$$
$$f(x) = \lim_{h \rightarrow 0} \frac{(x+h)^2 - x^2}{h}$$
$$= \lim_{h \rightarrow 0} \frac{x^2 + 2xh + h^2 - x^2}{h}$$
$$= \lim_{h \rightarrow 0} \frac{2xh + h^2}{h}$$
$$= \lim_{h \rightarrow 0} \frac{2xh + h^2}{h} = 2x$$

$f(x) = \lim_{\Delta x \rightarrow 0} \frac{\Delta y}{\Delta x}$

$f'(a) = \lim_{h \rightarrow 0} \frac{f(a+h) - f(a)}{h}$

# Objectives

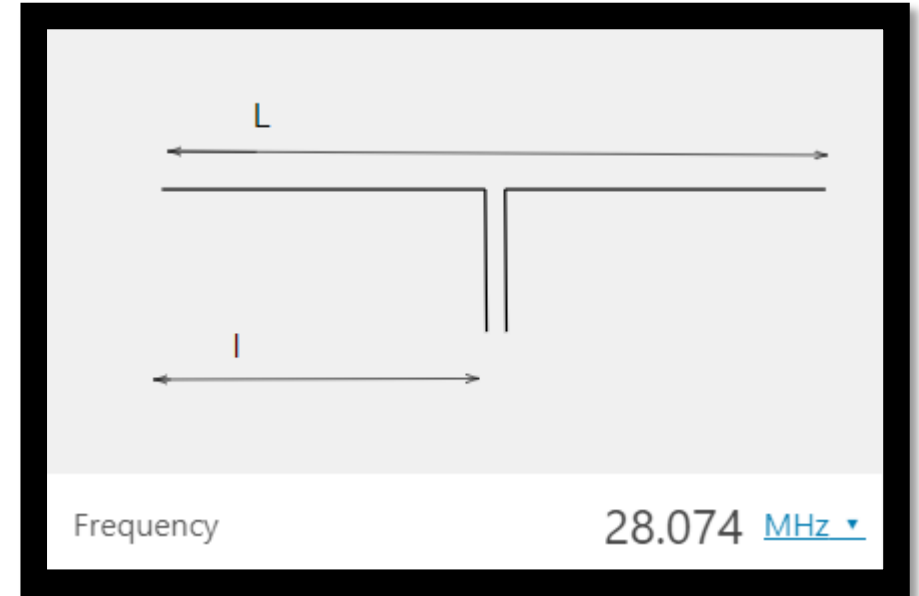
- Review Designs for common Wire Antennas
  - Dipoles
  - Off-center Fed Dipole
- Verify operation in simulation
- Demonstrate Tuning In Simulation
- Demonstrate effects of antenna height and configuration

# Dipole Antenna Design

- Generally mono-band ( 15m may work on 40m)
- Simple design - Two equal lengths of wire connected to a choke balun in the center.
- Ideally  $\lambda/2$  above the ground
- Design equation[ARRL Antenna book, page 9-2]
- $L$  = total length in feet,  $f$  = desired frequency in MHz

$$L = \begin{matrix} 468/f \text{ ft} \\ 485/f \text{ ft} \\ 490/f \text{ ft} \end{matrix}$$

How fast do radio waves travel in the antenna material?  
Depends on the material!

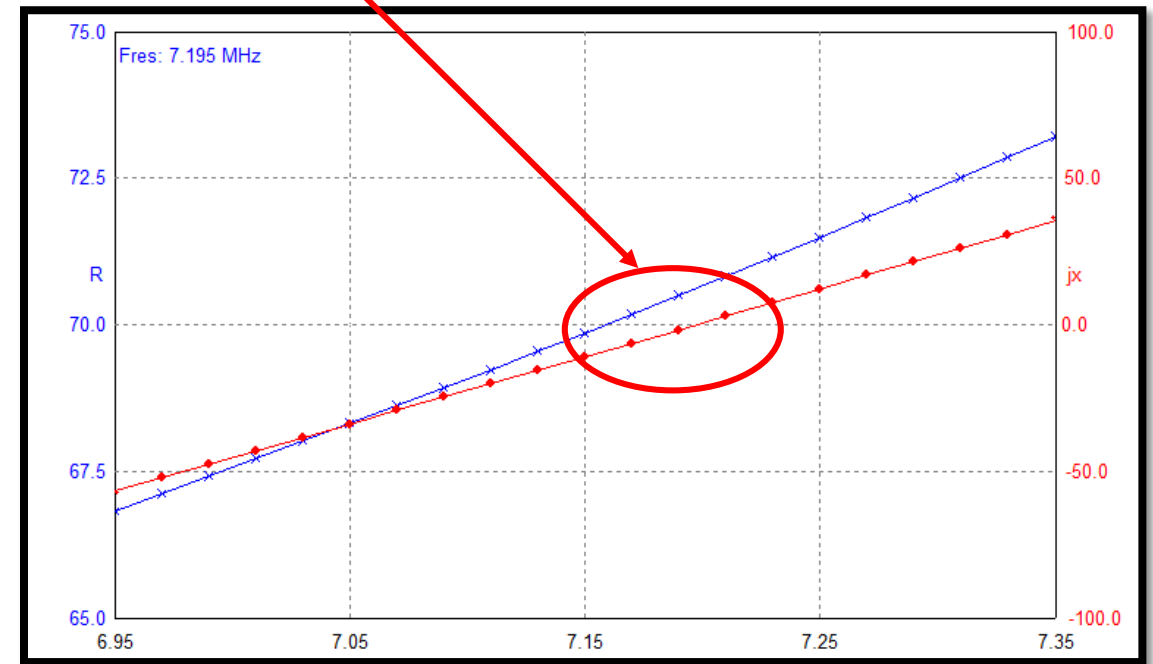
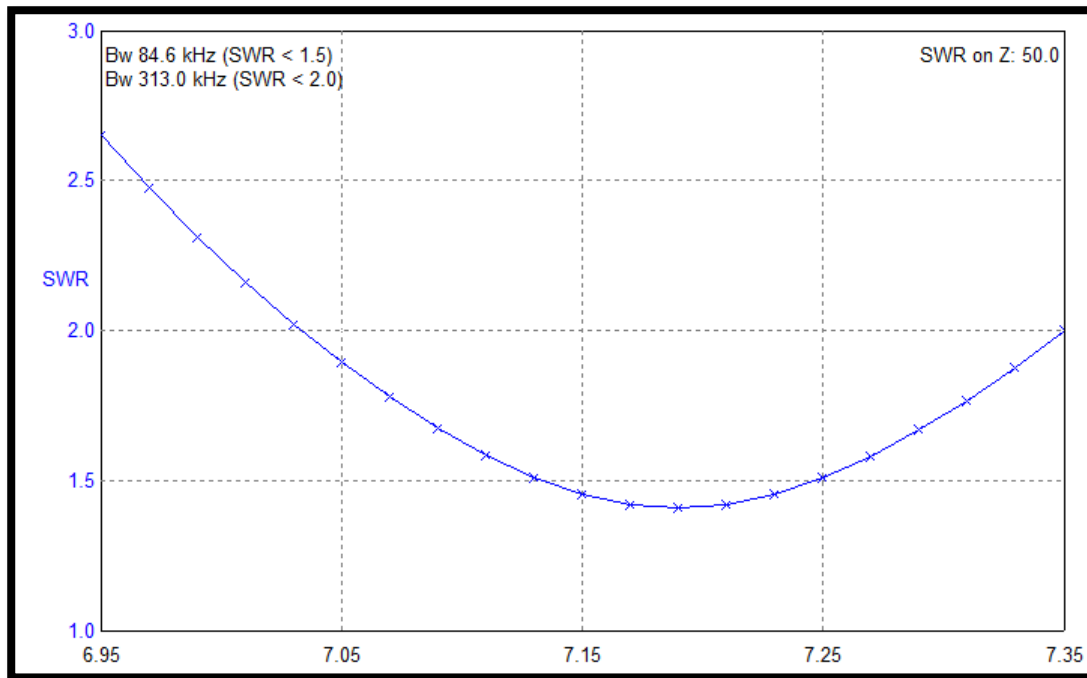


# Design Scenario

- Target 7.150 MHz (40m band)
  - 40m is generally available 24 hours – DX at night, Local during the day
  - Can usually cover most of the band with SWR < 3.0:1
- Start Long – lower antennas need to be longer
  - $L = \frac{490}{f} = 68.5 \text{ ft} \rightarrow 68\text{ft } 6\text{in}$  (20.9m)
  - Call it 68 feet
- Use 14ga copper Wire

# Results for Half Wave Above Ground (68 ft)

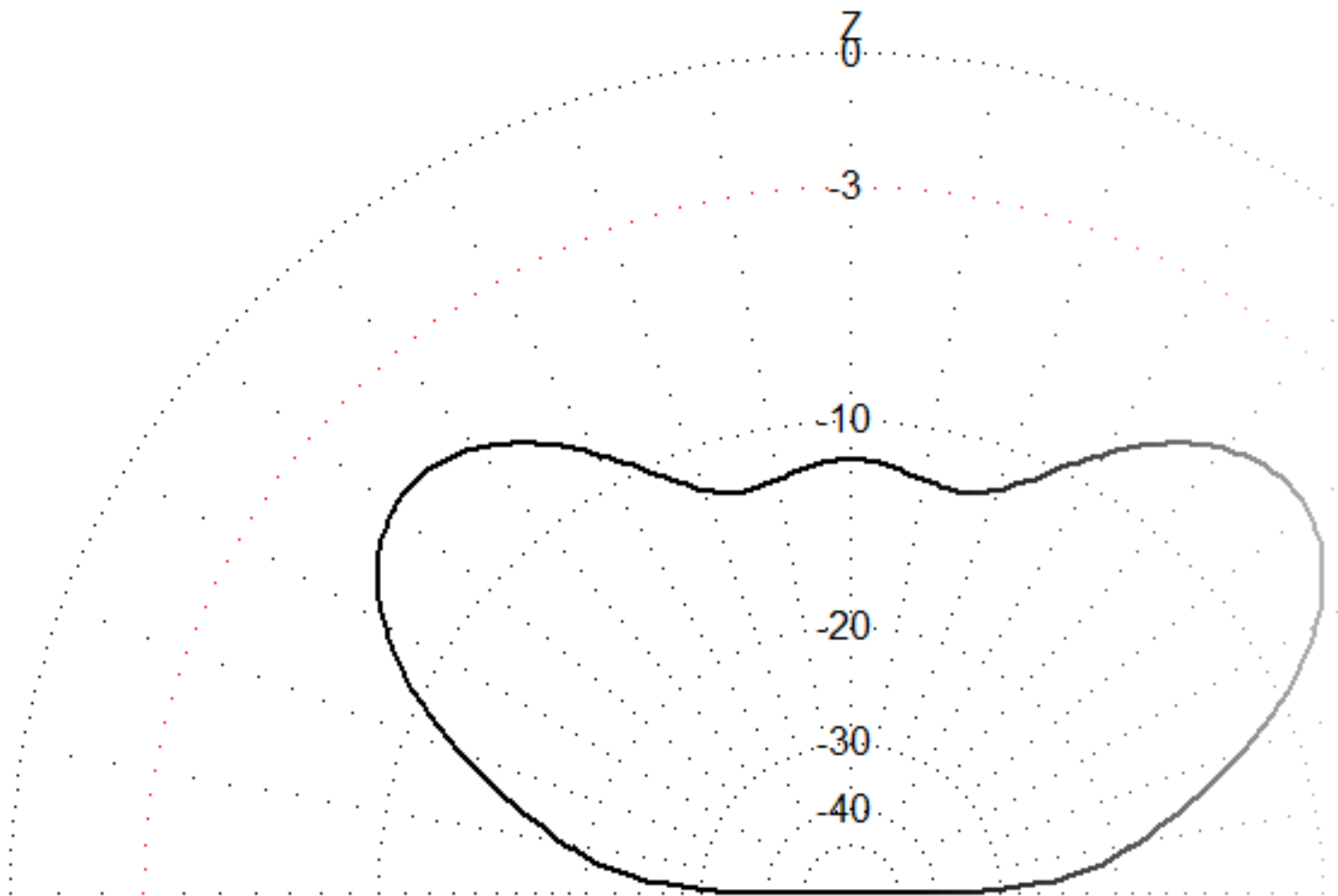
Predicted Resonance @ 7.19 MHz



This is a good antenna -> Work most of 40m without tuner

Simulate using MMANA-GAL (<http://gal-ana.de/basicmm/download/download.php?mm=2>)

# Antenna Pattern at 68ft



- Peak Gain @ 40°
- Improves DX
- Still works for close stations

Ga : 5.29 dBi = 0 dB (Horizontal polarization)  
F/B: -4.77 dB; Rear: Azim. 120 deg, Elev. 60 deg  
Freq: 7.150 MHz  
Z: 69.884 - j10.421 Ohm  
SWR: 1.5 (50.0 Ohm),  
Elev: 43.0 deg (Real GND :20.90 m height)

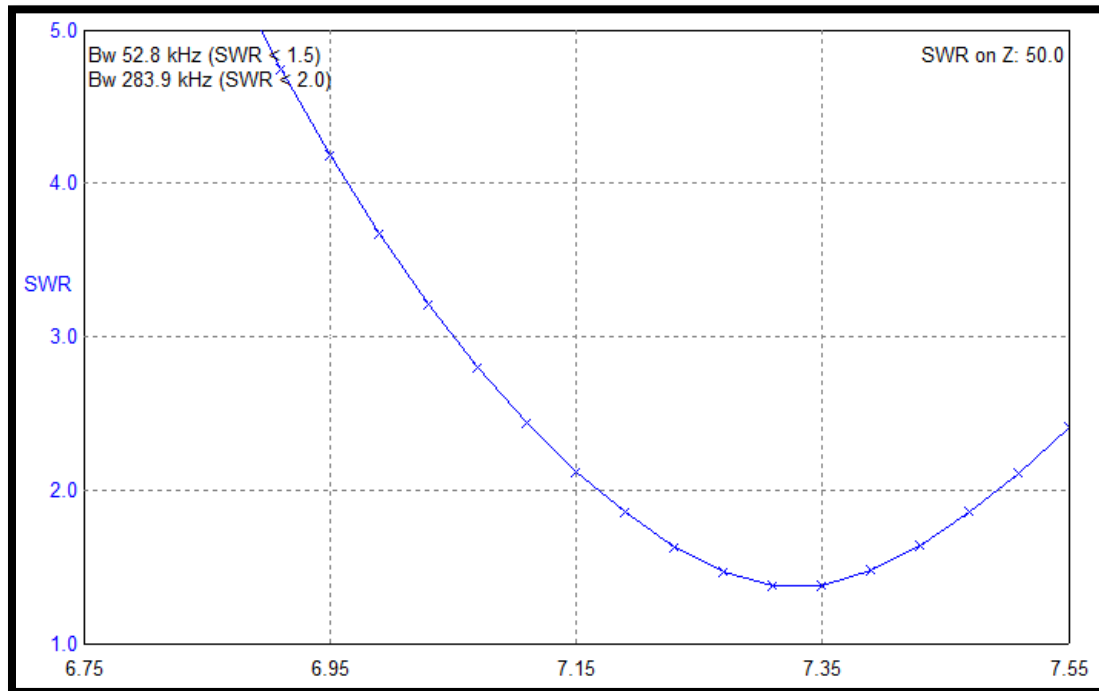
What if?

- Cut it shorter?
- Move it lower?
- Inverted V?

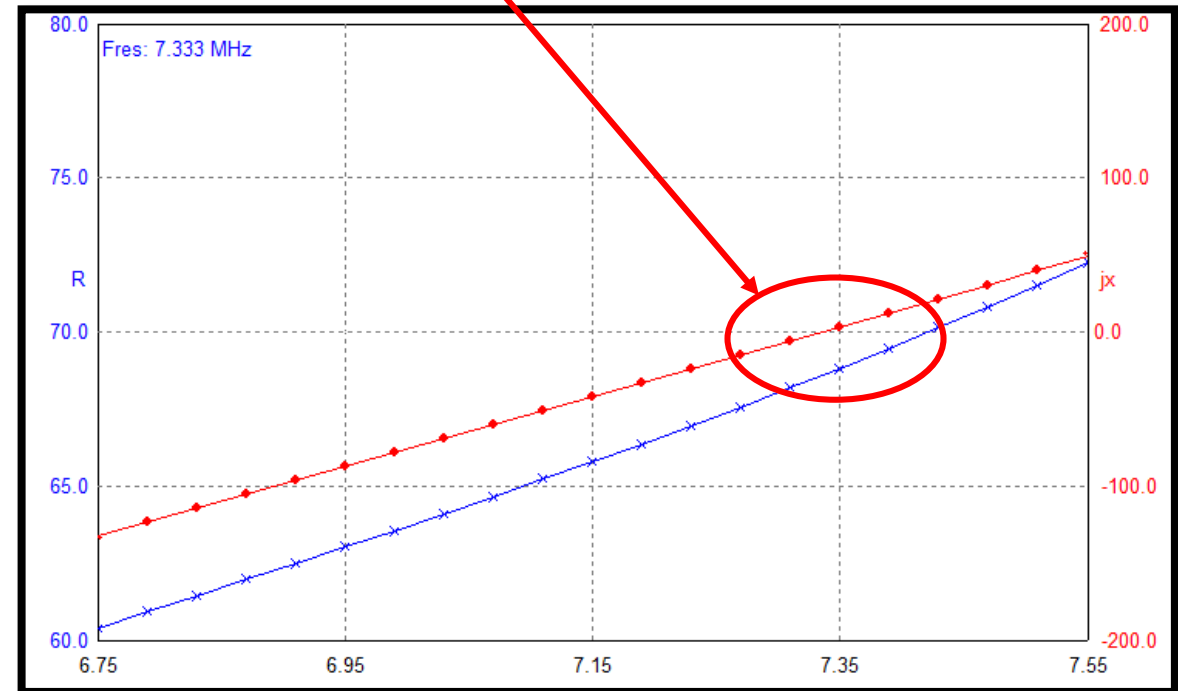
# Cut it Shorter?

# $L=67.5'$

Predicted Resonance @ 7.33 MHz



SWR



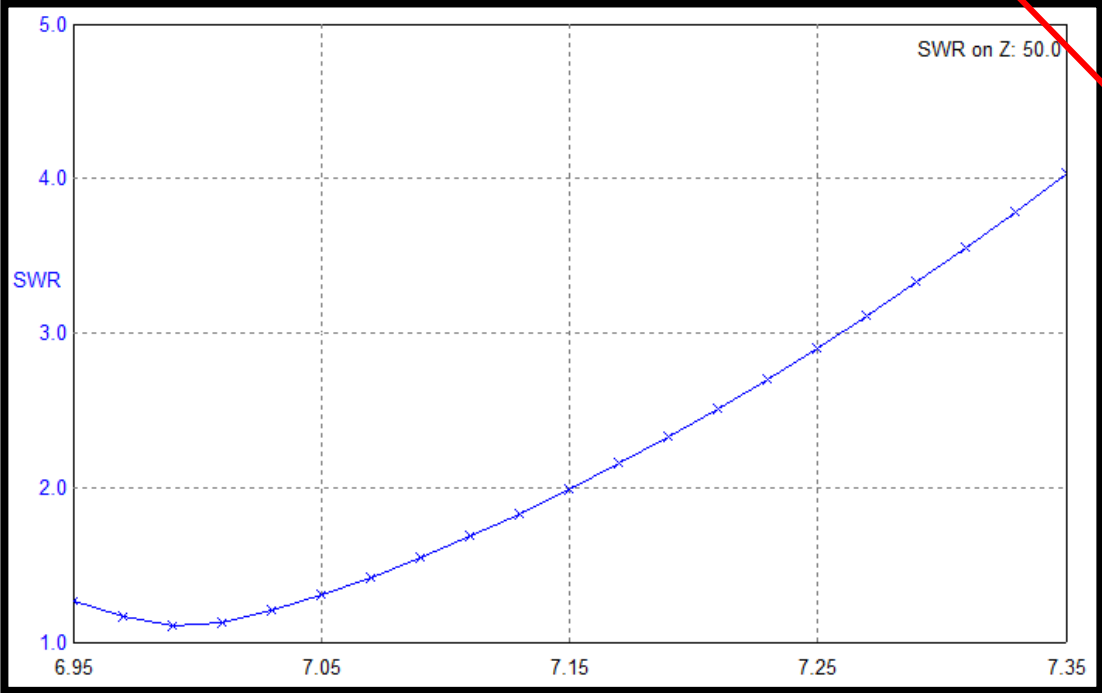
Impedance

Cutting shorter moves resonant point higher in frequency

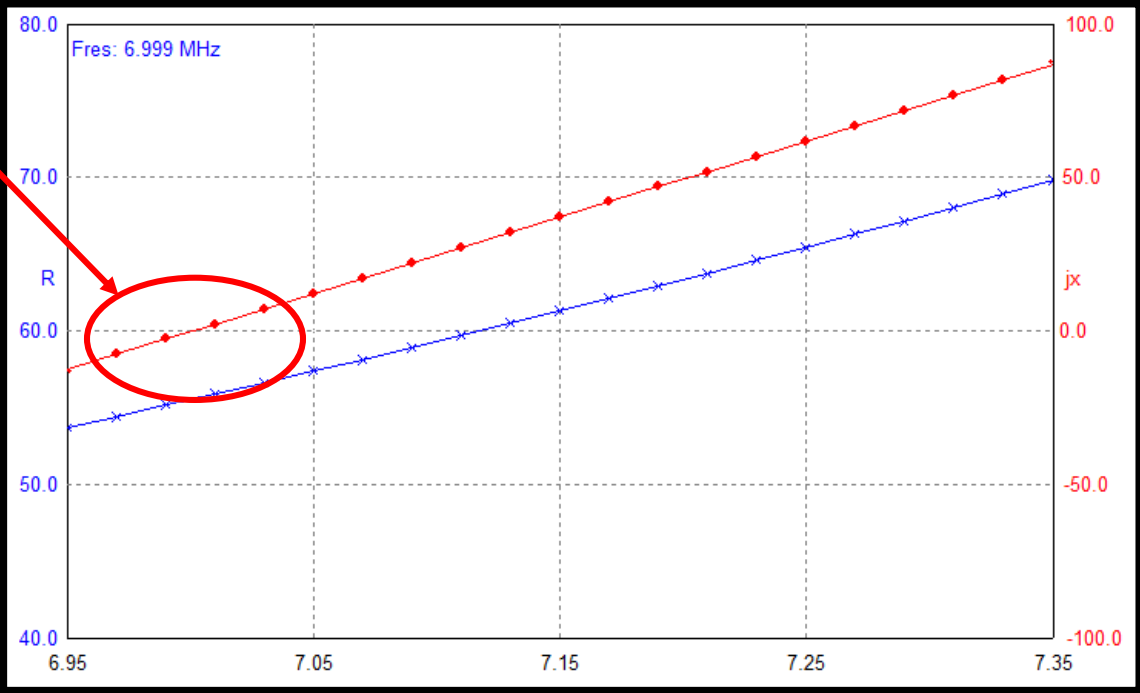
# Move it Lower?

# H = 25ft

Predicted Resonance @ 7 MHz

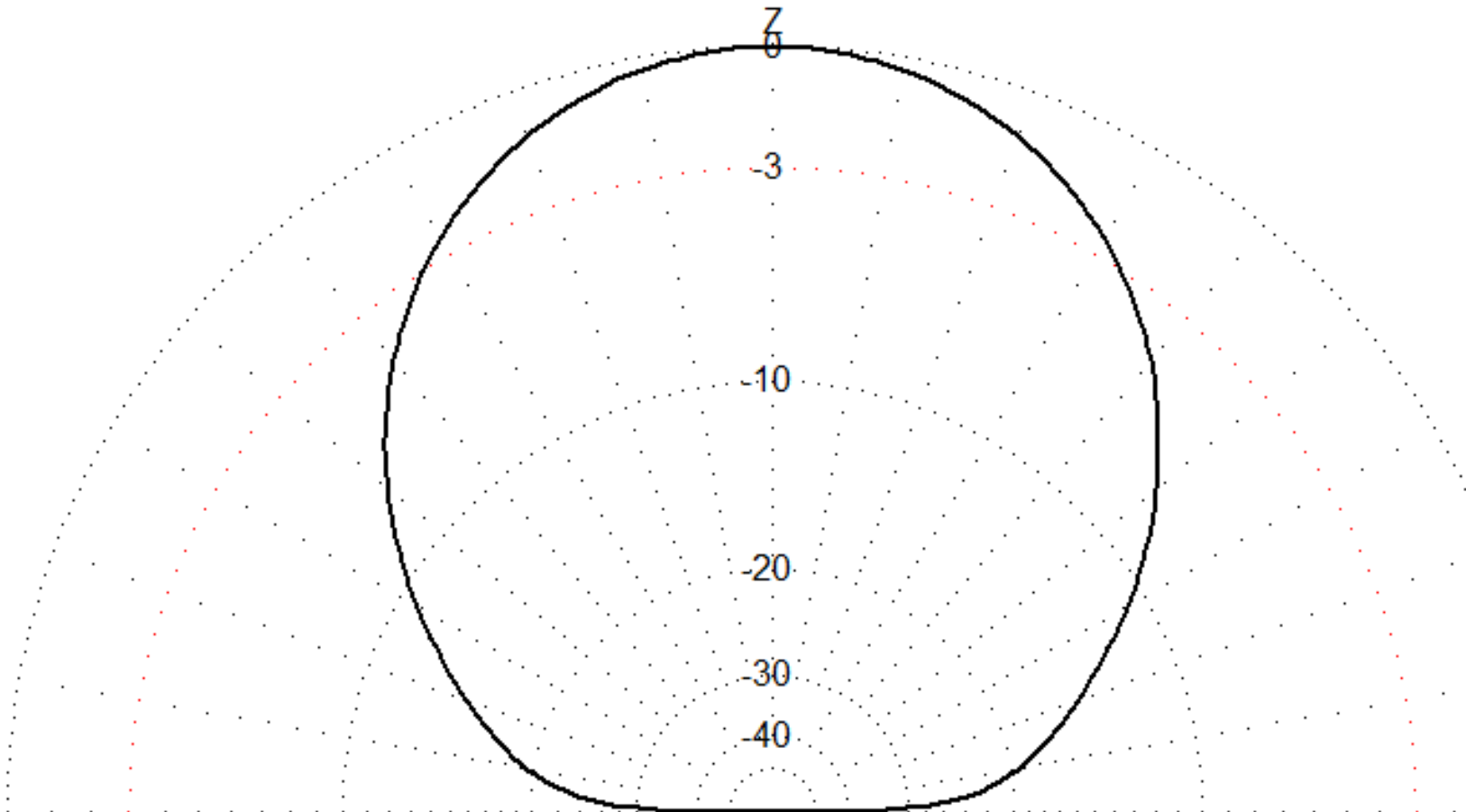


SWR



Impedance

Moving lower makes our antenna perform like it is too long



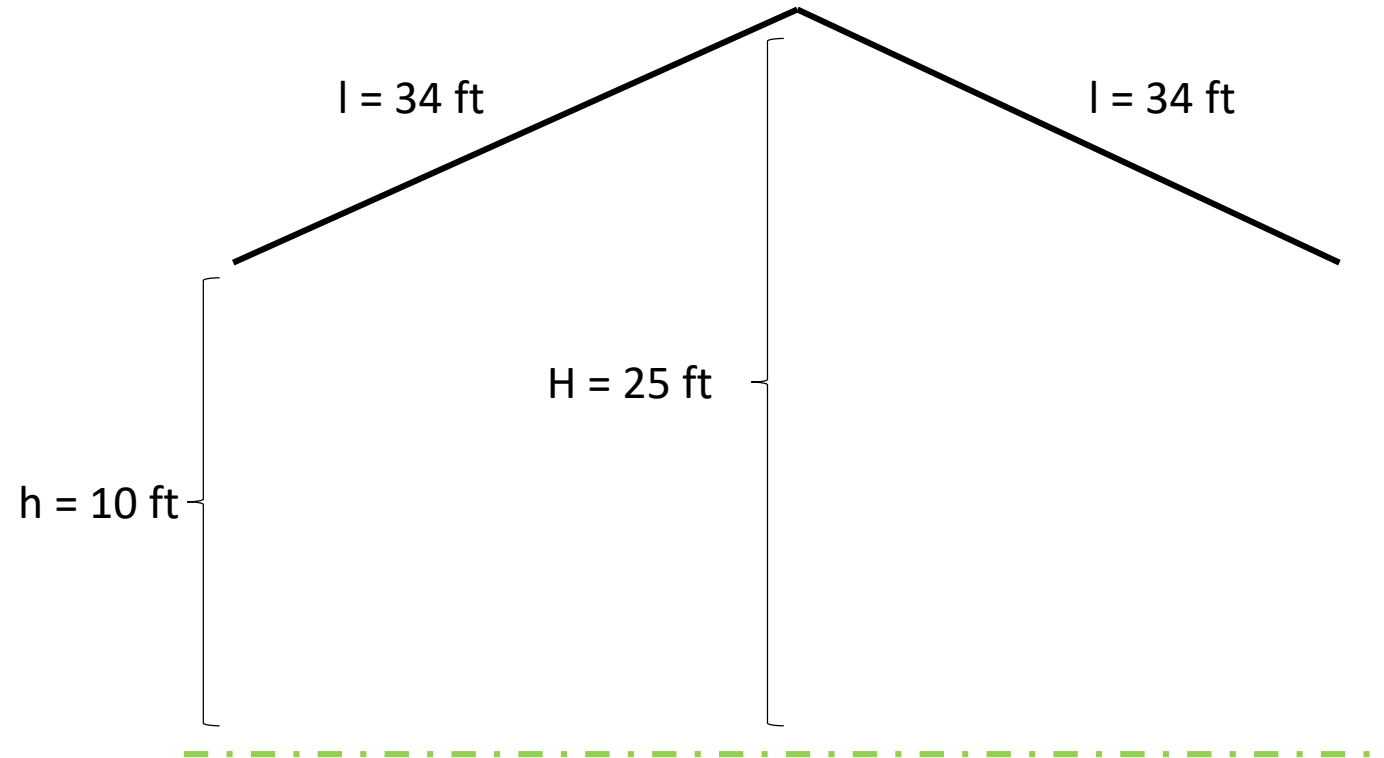
Ga : 6.82 dBi = 0 dB (Horizontal polarization)  
F/B: -3.59 dB; Rear: Azim. 120 deg, Elev. 60 deg  
Freq: 7.150 MHz  
Z: 61.377 + j37.444 Ohm  
SWR: 2.0 (50.0 Ohm),  
Elev: 90.0 deg (Real GND :7.62 m height)  
(For elev. angle 45.0 dg Peak:5.5 dBi)

# What about the pattern?

- Max gain at 90°
- Still Receives DX
- Not a terrible antenna

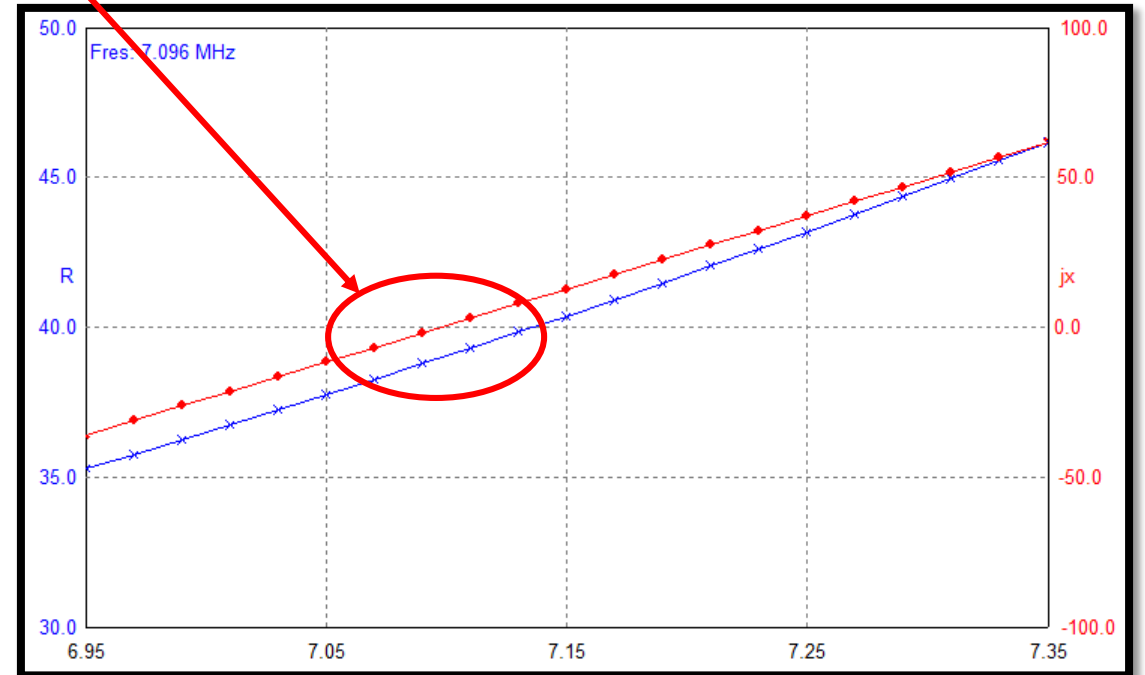
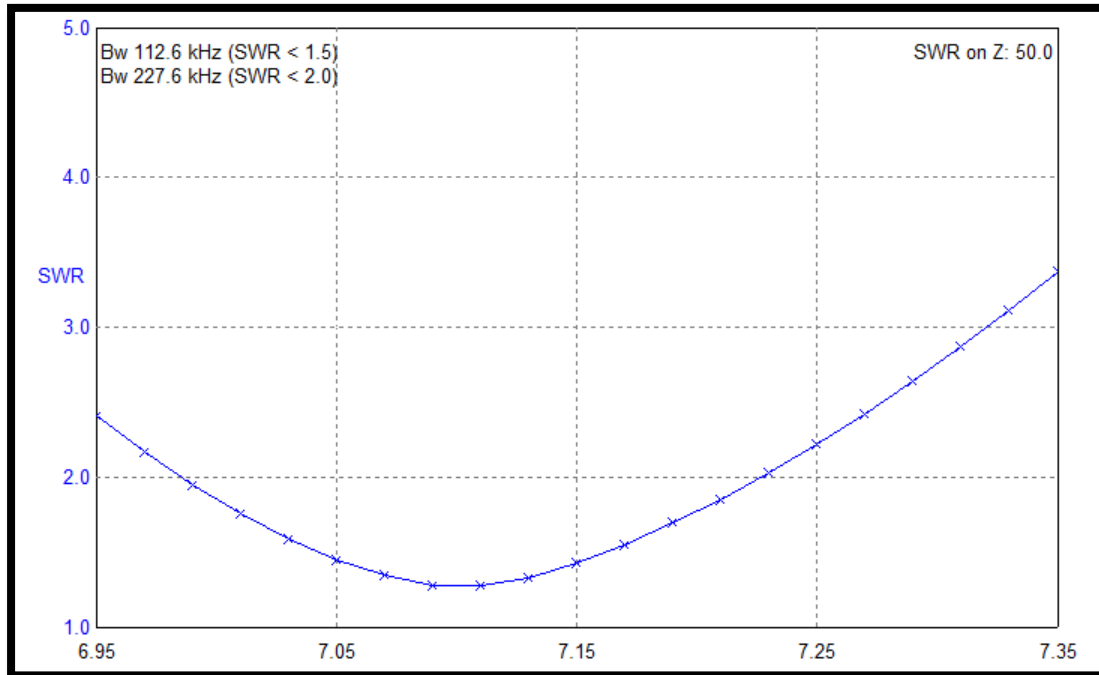
# Inverted V

- Center Height 25 ft
- End Height 15 ft

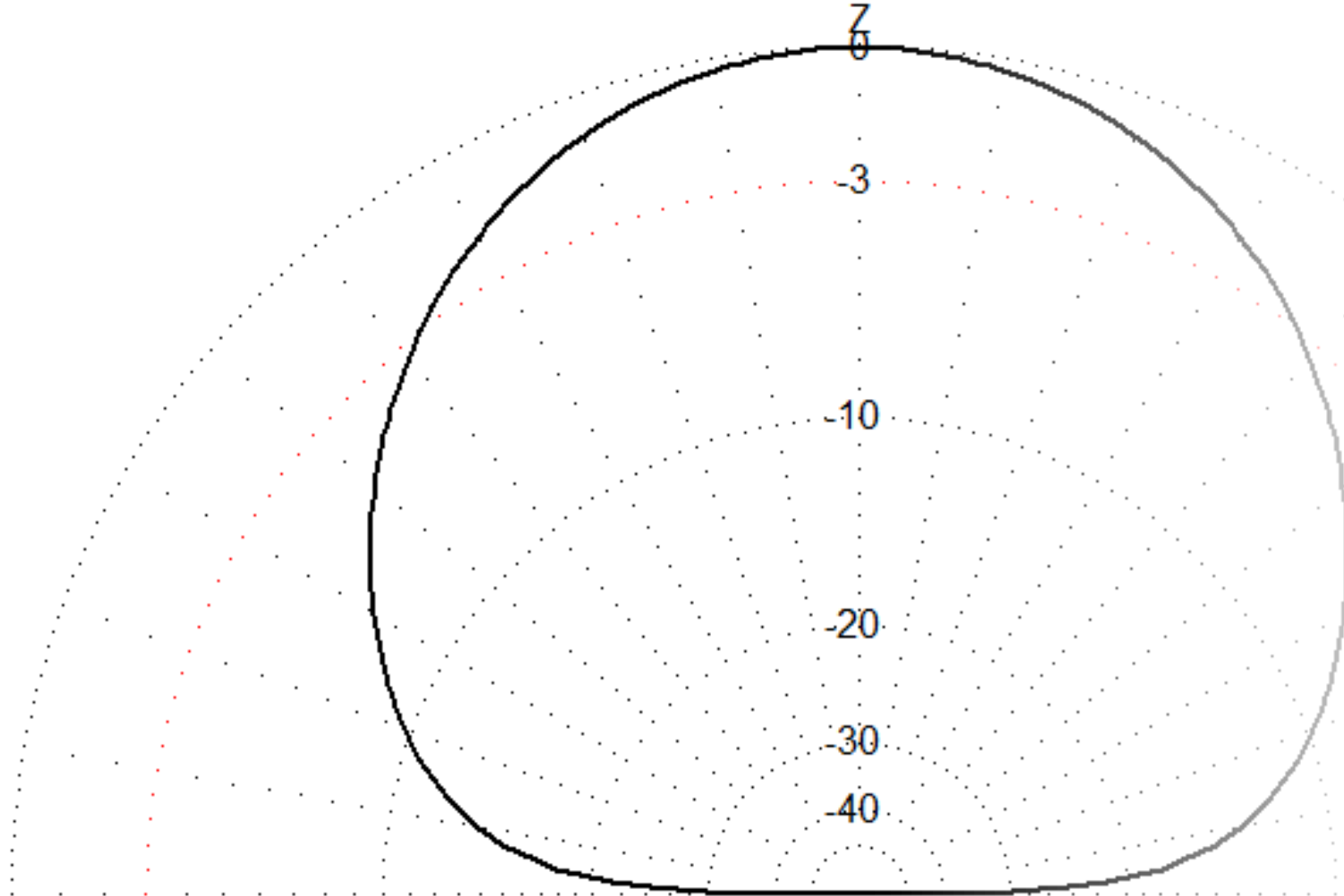


# Inverted V Performance

Predicted Resonance @ 7.1 MHz



Resonant Frequency Moves Higher

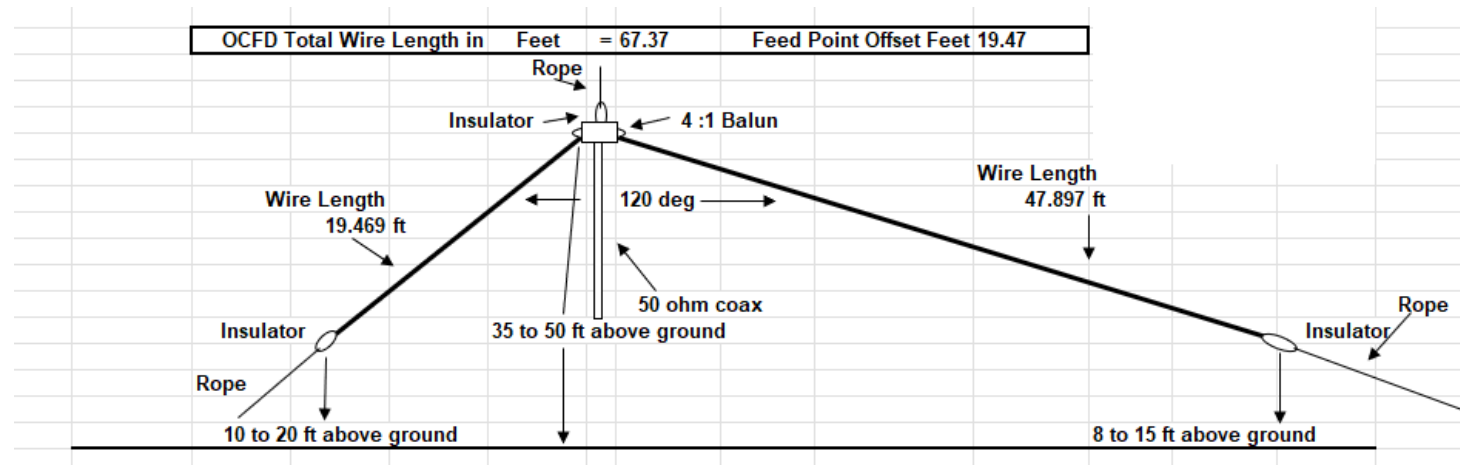


## Inverted V Pattern

- Gain increases at lower angle
- Good Compromise Antenna

Ga : 6.39 dBi = 0 dB (Horizontal polarization)  
F/B: -2.26 dB; Rear: Azim. 120 deg, Elev. 60 deg  
Freq: 7.150 MHz  
Z: 40.426 + j13.169 Ohm  
SWR: 1.4 (50.0 Ohm),  
Elev: 90.0 deg (Real GND :7.62 m height)  
(For elev. angle 45.0 dg Peak:4.7 dBi)

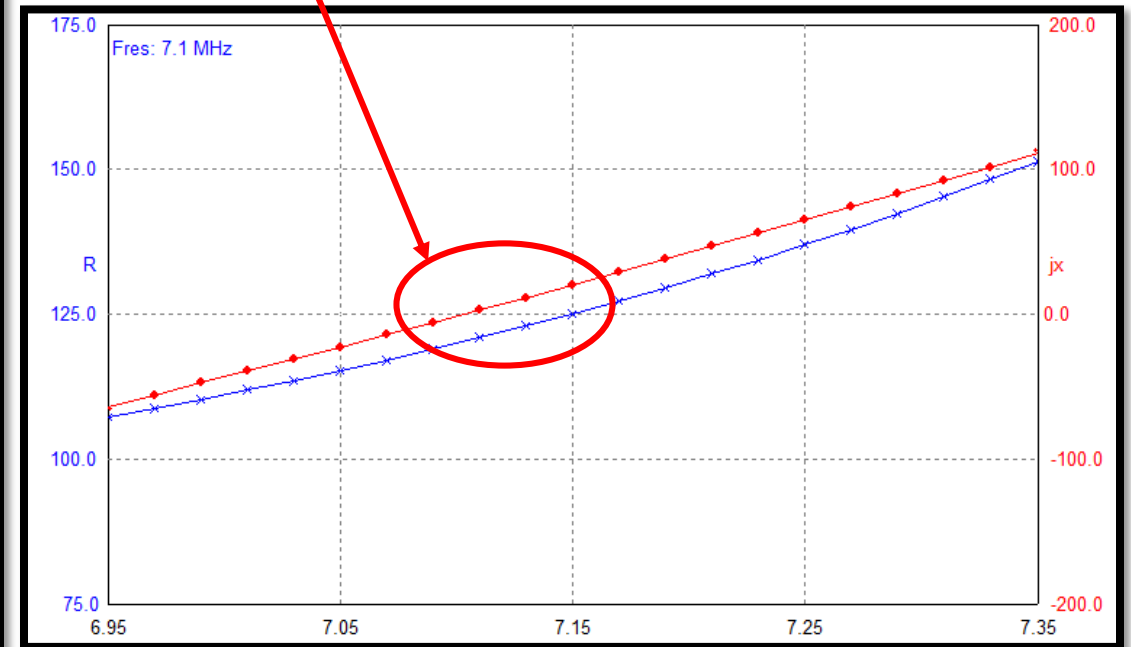
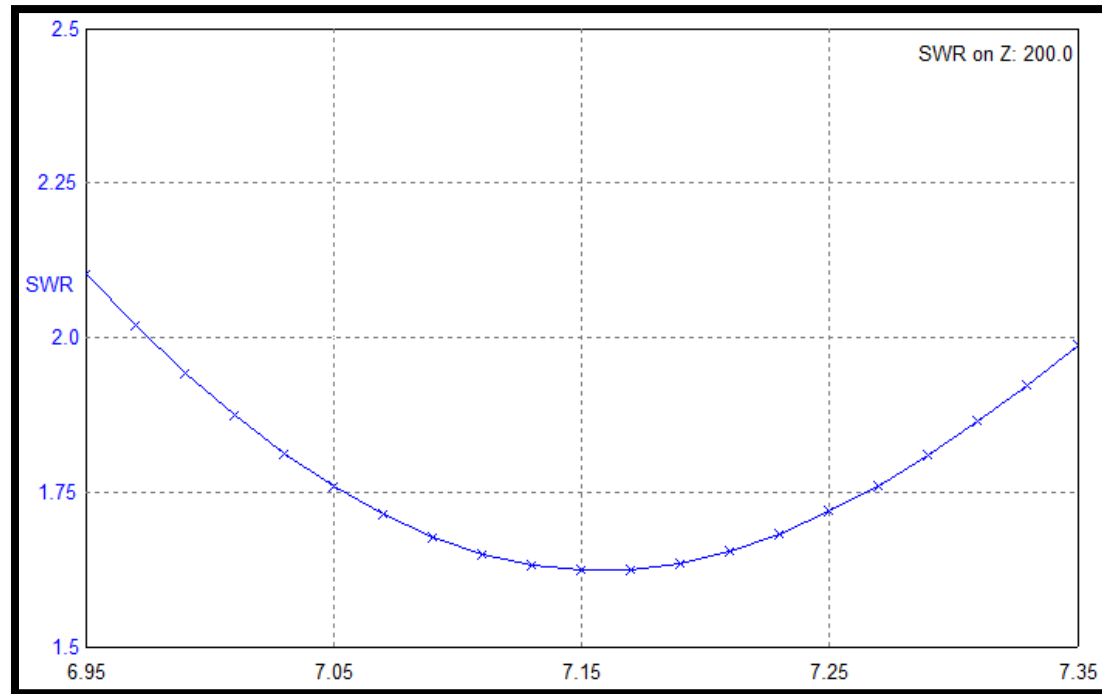
# Off-center Fed Dipole Design



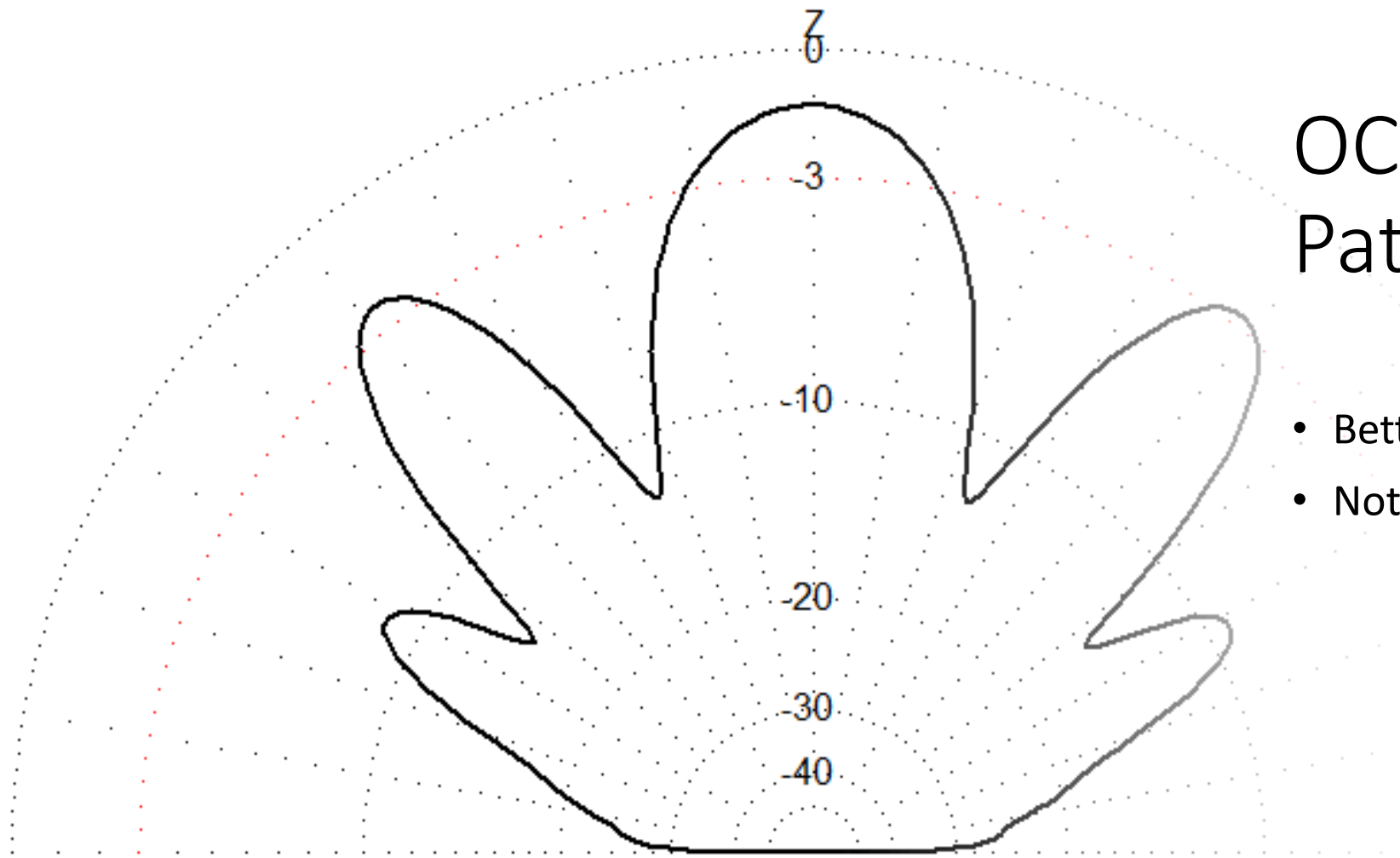
- Center Frequency 7.150 MHz
- Requires 4:1 Balun -> Transforms 200 ohm impedance to 50 ohm
  - Transforms 200 ohm impedance to 50 ohm
  - Divides Impedance error by 4 (50 ohms high, radio only sees 12 ohm error)
- Requires Calculator Program To Design

# Off-center Fed Dipole 7.15 MHz

Predicted Resonance @ 7.101 MHz



Impedance at Resonant Frequency Z=120 Ohm



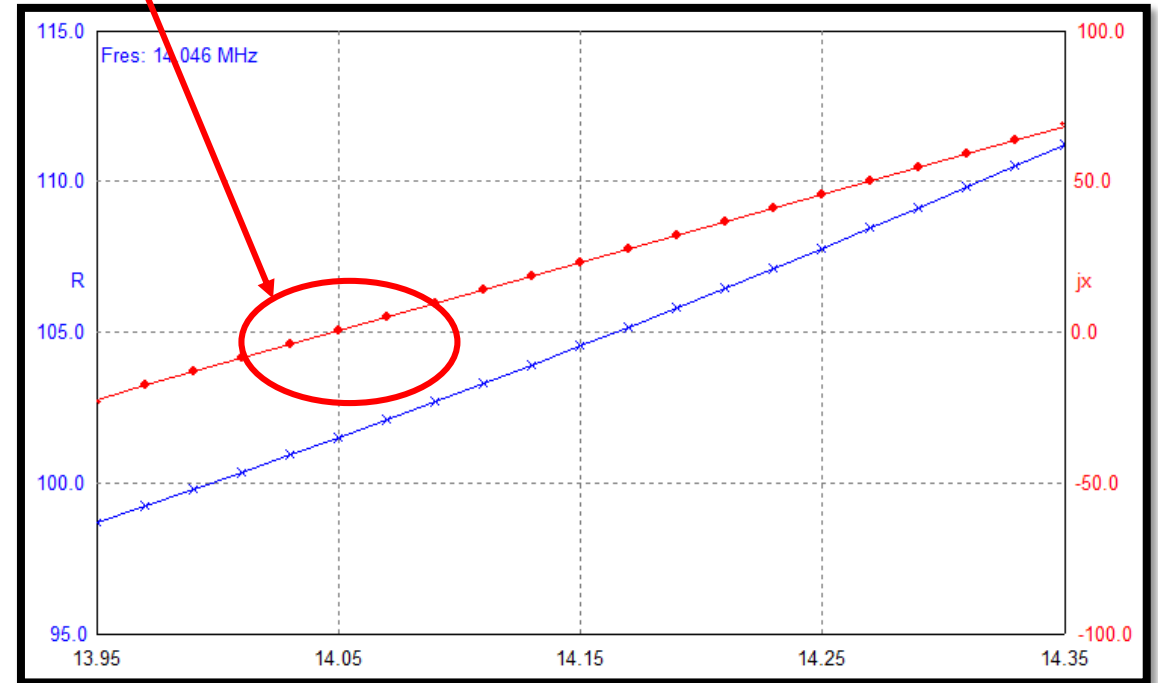
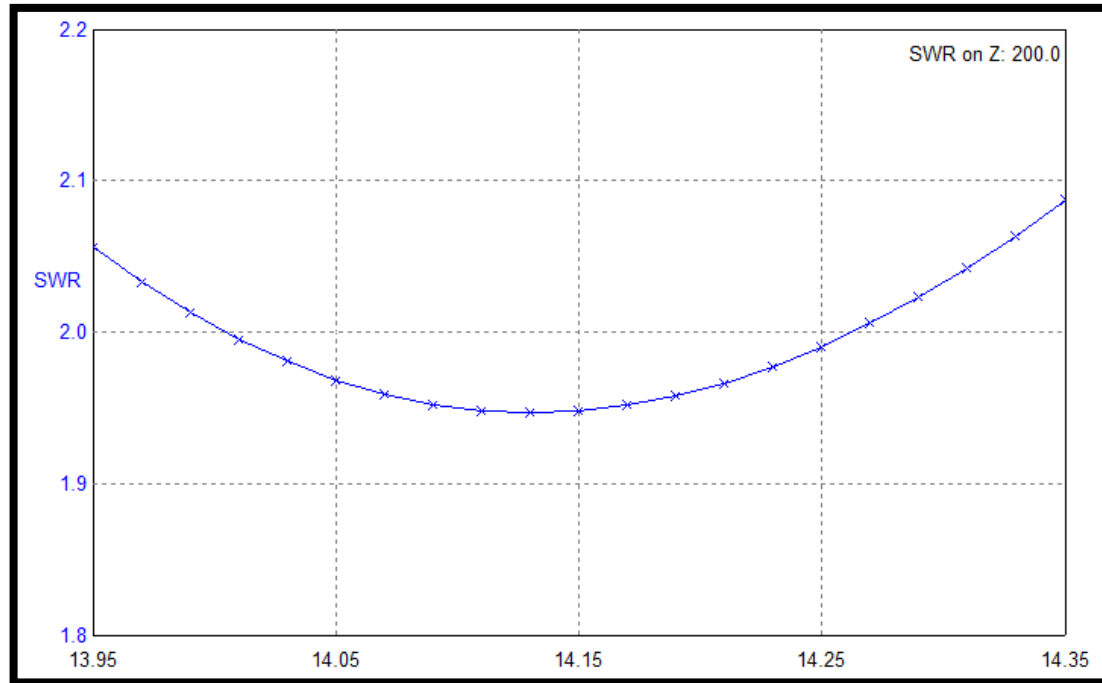
## OCF Dipole Pattern

- Better than a flat dipole at 25ft
- Not as good as Inverted V

Ga : 5.63 dBi = 0 dB (Horizontal polarization)  
 F/B: -4.00 dB; Rear: Azim. 120 deg, Elev. 60 deg  
 Freq: 7.150 MHz  
 Z: 125.285 + j21.161 Ohm  
 SWR: 1.6 (200.0 Ohm),  
 Elev: 89.8 deg (Real GND :68.00 m height)  
 (For elev. angle 45.0 dg Peak:5.6 dBi)

# What about 20m?

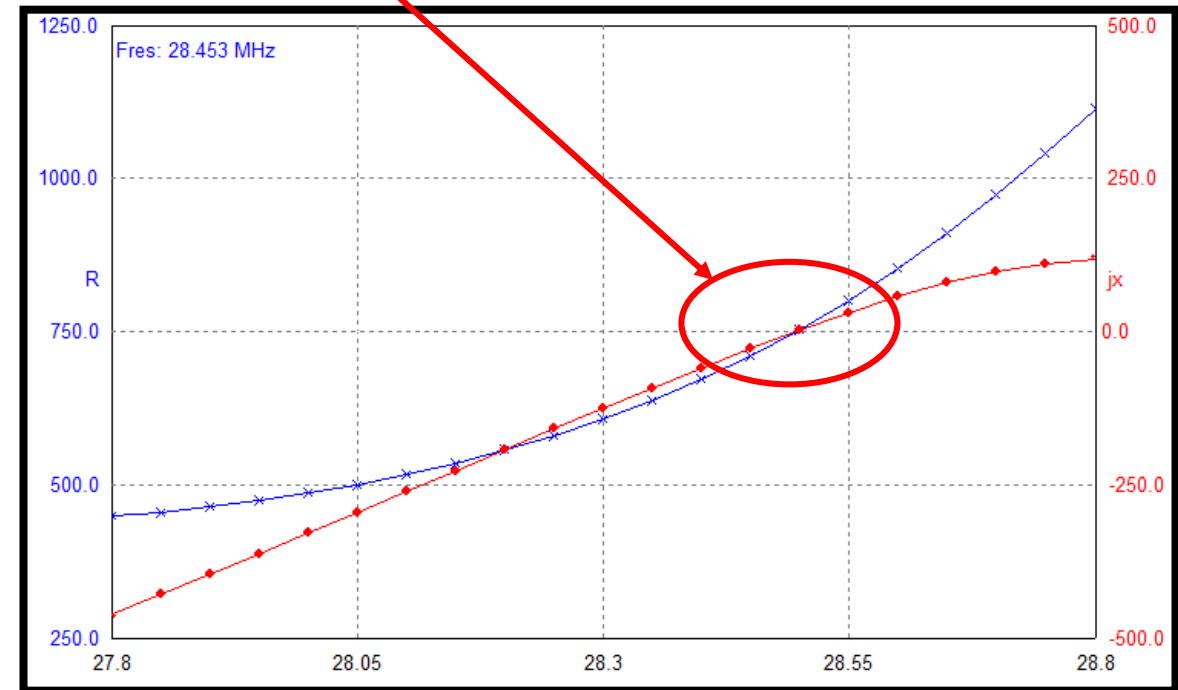
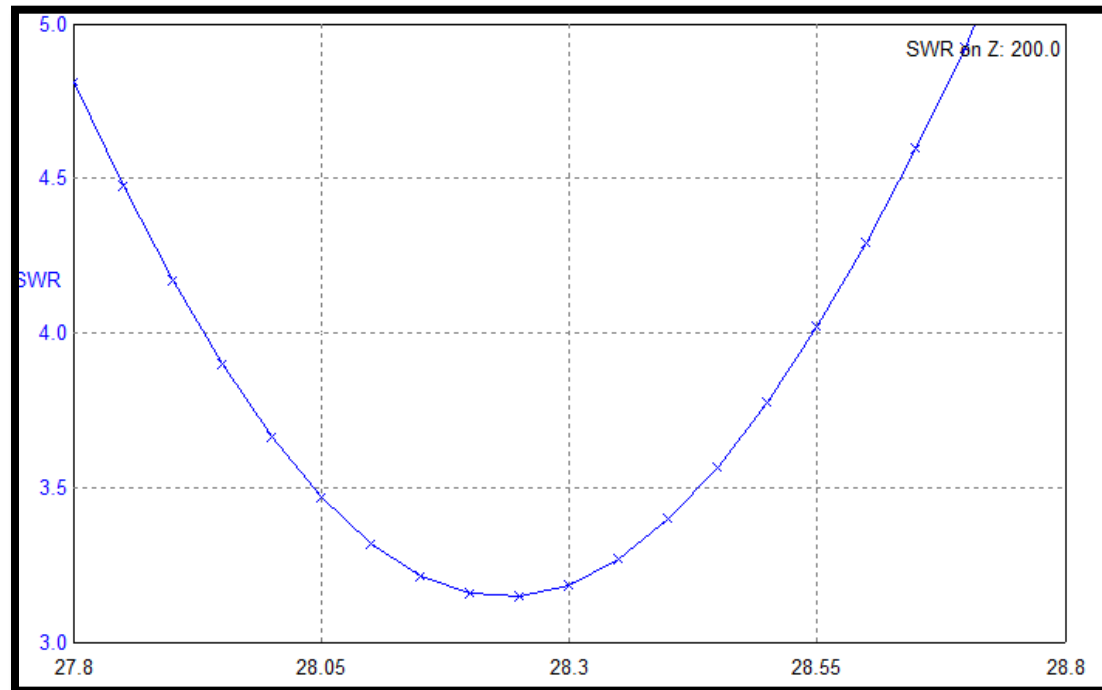
Predicted Resonance @ 14.05 MHz



Same antenna we designed for 40m

# What About 10m?

Predicted Resonance @ 28.39 MHz



Same antenna we designed for 40m

# Summary

- The ground has a large effect on your antenna
- Tune your antenna where you plan to use it
- Bandwidth efficiency trade