SWR & Simple Antennas

Bob, W1IS

Bob, KC1DSQ

SWR – Hams Magic Number

What is it?

How does your Rig Respond?

How do you Measure it?

Bob W1IS & Bob KC1DSQ

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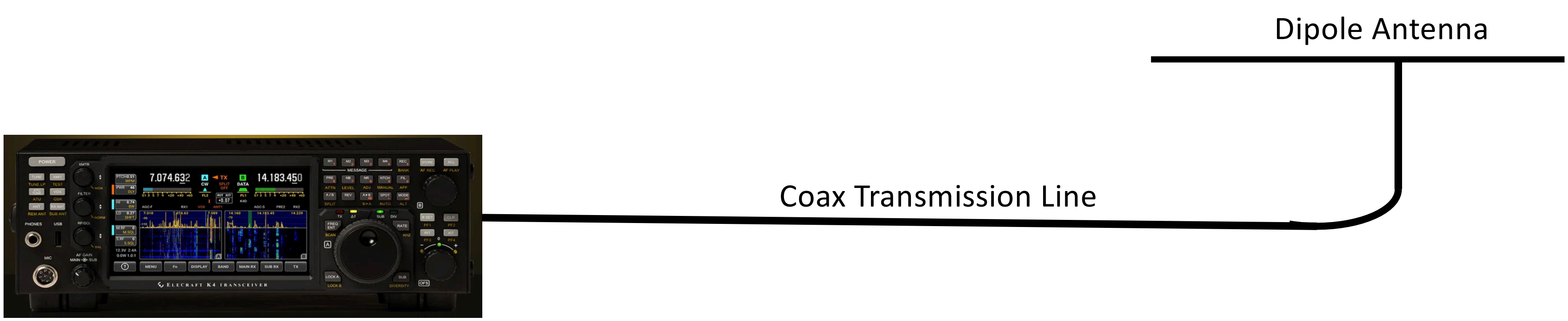
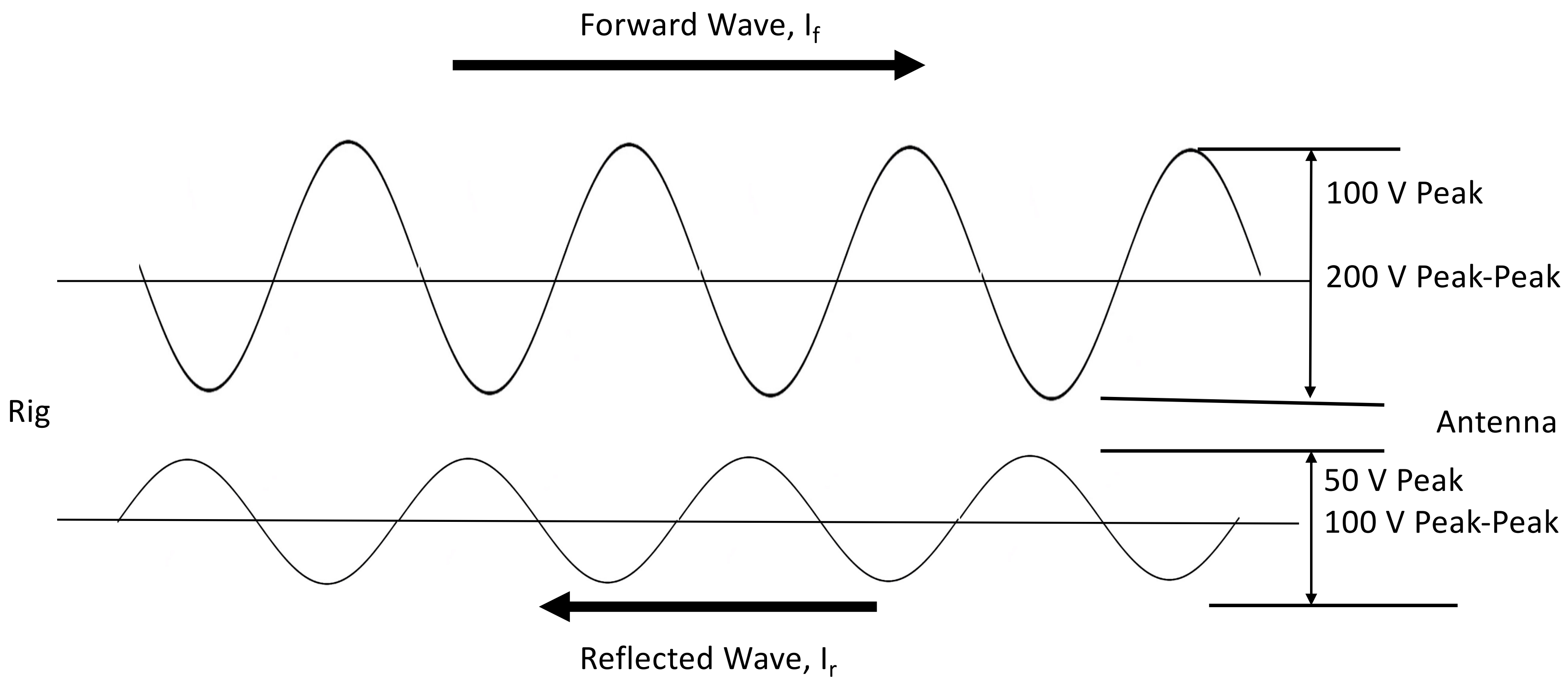
What is SWR?

Standing **W**ave **R**atio

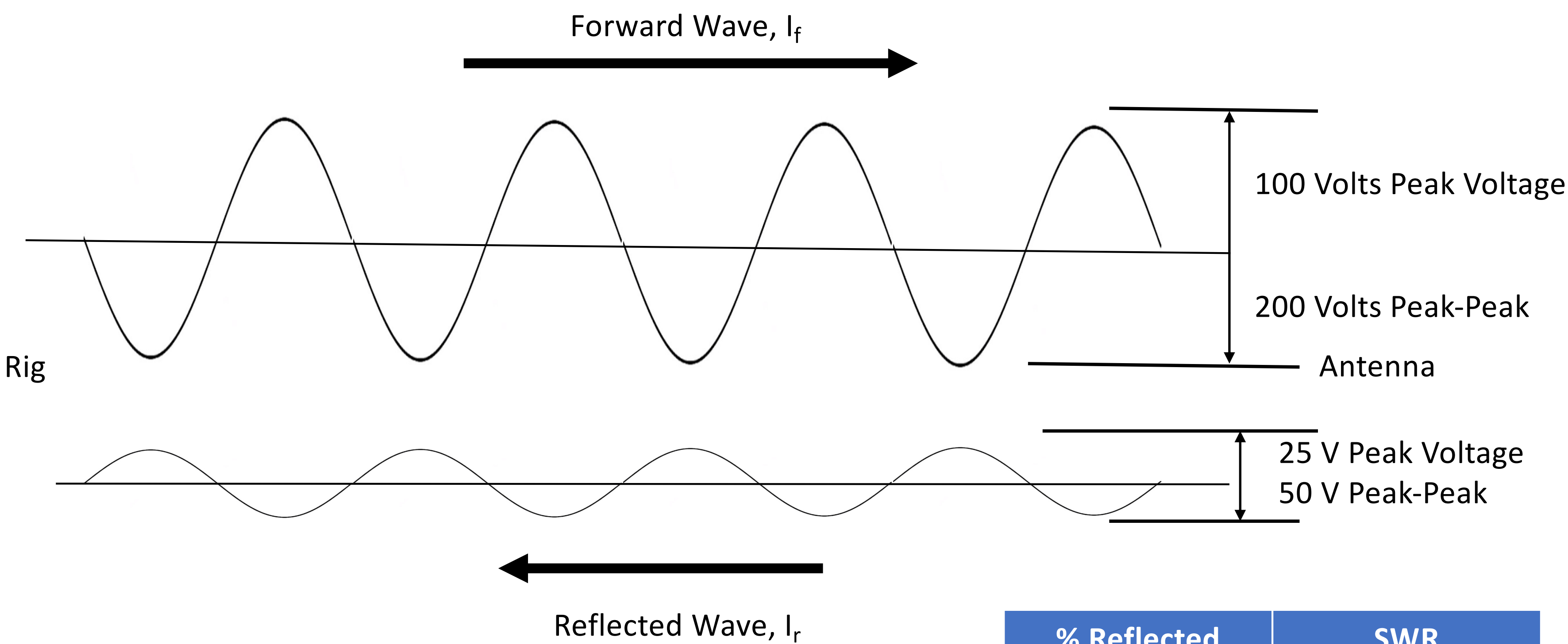
What happens at the Antenna?
What happens on the Transmission Line?





- Standing Wave is Sum of Forward and Reflected Waves
- SWR= Vmax/Vmin = (100+50) / (100-50) = 3:1
- Rigs Automatically Cut Power - SWR > 2:1

https://www.youtube.com/watch?v=kf6qk-Gnjag



SWR= Vmax/Vmin = (100+25)/(100-25) = 1.67:1

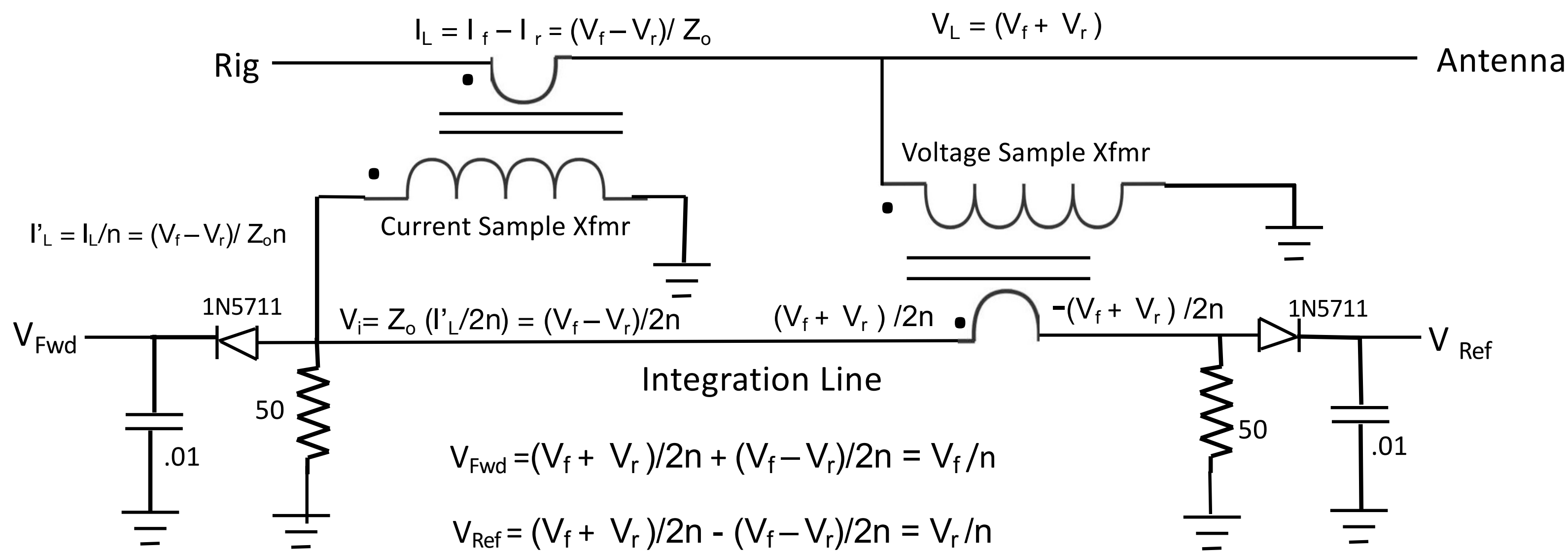
% Reflected	SWR
100	Way Too High
50	3:1
25	1.67:1
0	1:1

Math to Isolate Forward and Reflected Power

- Voltage on the line is: $V_L = V_f + V_r$
- Current on the line is: $I_L = I_f - I_r$
- Convert I_L to a Voltage (for 50 Ω Line)
- $V_{IL} = (I_f - I_r)\ 50 = V_f - V_r$
- Adding $V_L + V_{IL} = (V_f + V_r) + (V_f - V_r) = 2V_f$ ~Forward Power
- Subtracting $V_L - V_{IL} = (V_f + V_r) - (V_f - V_r) = 2V_r$ ~ Reflected Power

- Now we need a circuit that does the Math

Schematic - SWR Forward & Reflected Power Meter



Note: Each Xfmr n:1, $Z_o = 50$ Ohms

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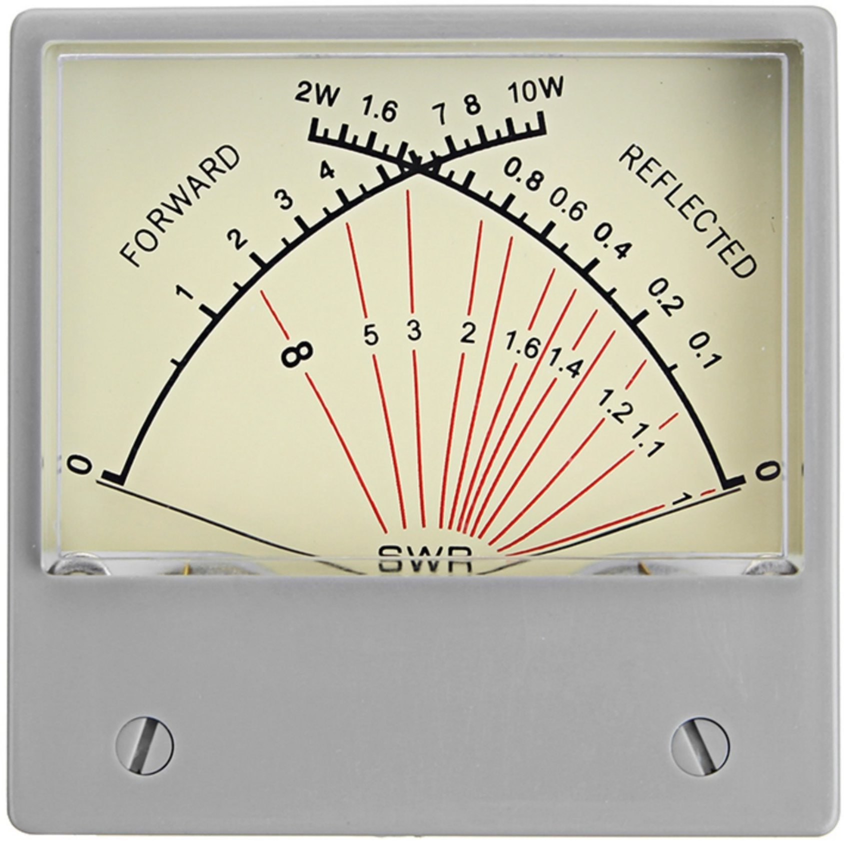
SWR / Power Meter



Simple Wire Antennas

Bob Glorioso W1IS
Bob Rose KC1DSQ

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Agenda

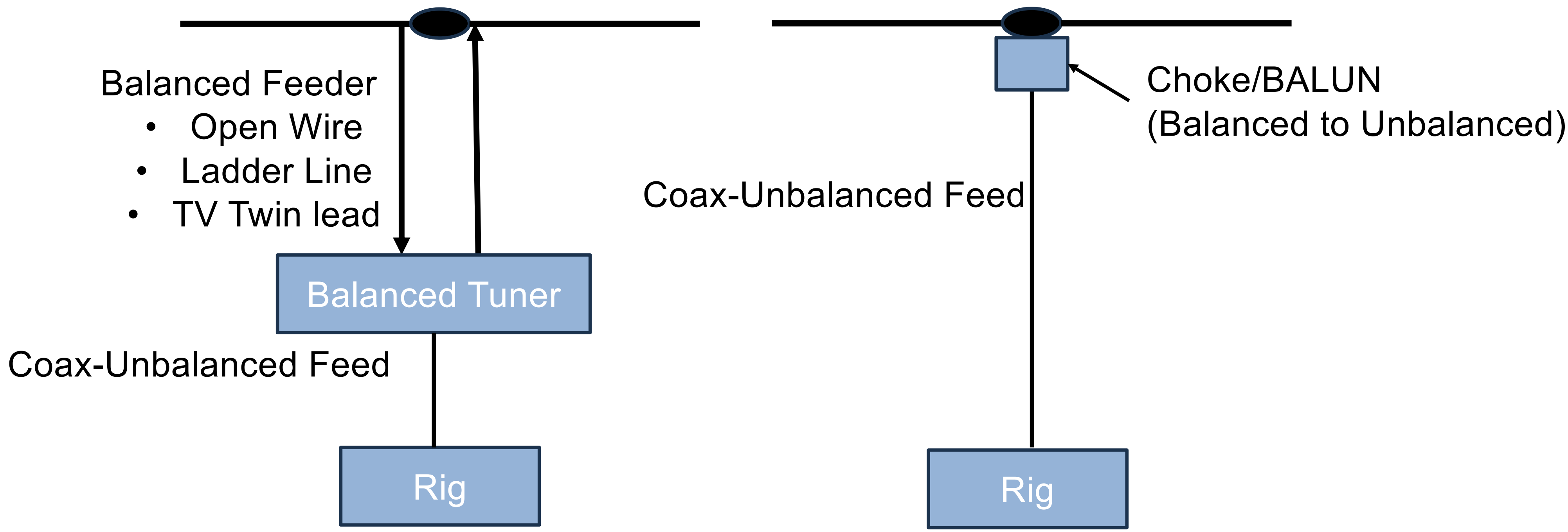
- Antenna Builders Tool Box
- The Dipole
  - 6 Meter Dipole for New and Old Techs
- Verticals (Incl. 2M & 70cm J-Pole)
- Inverted L
- 40 m Vertical
- 40 m C-Pole
- Portable 40 m Wire Beam

Antenna Builders Tool Kit

Antenna Analyzer
Wire –
    #14 THHN
    Davis RF #FW14BK
Wire Cutter & Stripper
Insulators
Coax & Connectors
Crimping Tool

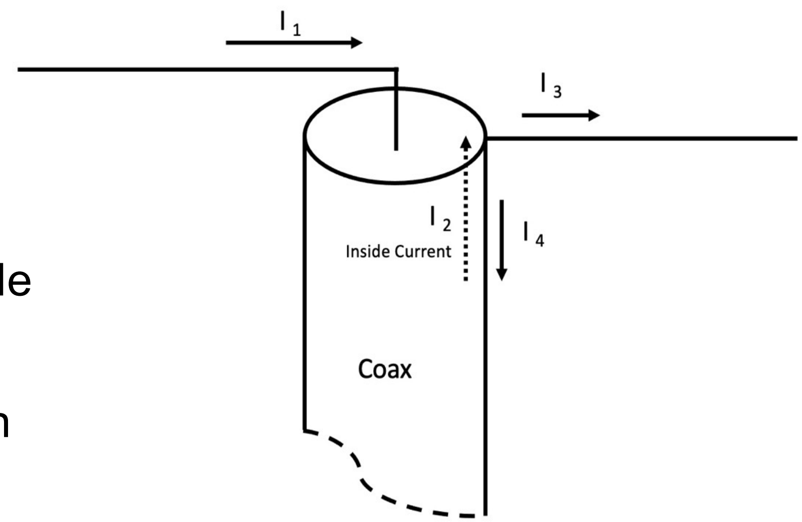
Antenna Launcher:
    Bow & Arrow
    Sling Shot
550 Parachute Cord
100’ Measuring Tape
Quality Black Electrical Tape
Assorted Hand Tools
Screwdrivers, Pliers, Soldering Iron, etc

The Humble Dipole



Why a Choke Balun?-Coax's 3rd Conductor

- Skin Effect - RF current flows on outside of all conductors
- "Thus, Outside of Shield Is the Third Conductor
- Unbalanced Antenna Current Travels to Rig on Outside of Coax, I_4
- Outside Current Radiates & Changes Antenna Pattern
- RF Feedback in Shack Causes Problems **with everything**
- Choke Balun at Feed Point Suppresses Current, I_4 ,
- **Making the Antenna System Balanced**



Choke Balun

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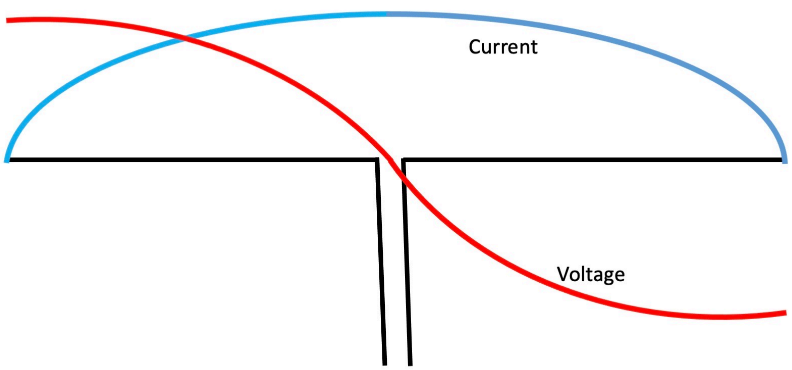
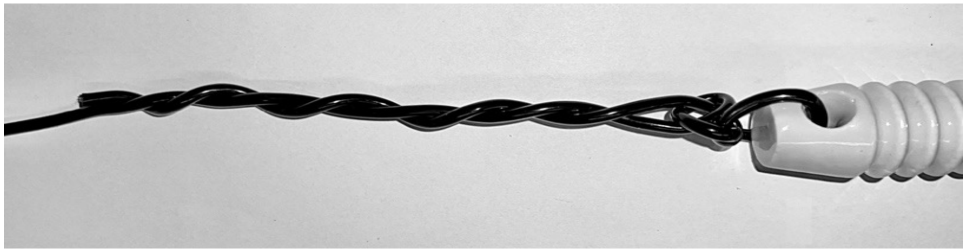
Dipole's Voltage & Current Distribution

- Peak Current, Minimum Voltage at Middle
- High Voltage & Zero Current at ends
- High Voltage Causes Current Flows Ends to Middle & Surrounding Objects
- Danger – HIGH VOLTAGE



Dipole L = 468/F : 1/4Vertical L= 234/F

- Approximation that Gets the Length in the Ball Park
- Add a Little for Wrap, Tying Measuring Error Flexibility!
- At Deployment Height, Measure Min SWR Frequency
- New_Length = Current_Length x (Current_Freq / Target_Freq)
- Adjust by Wrapping the Excess and Trying Again
- At Correct Length, Trim the Excess or Tape in Place



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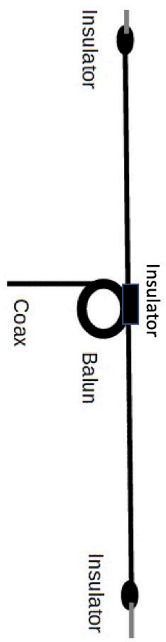
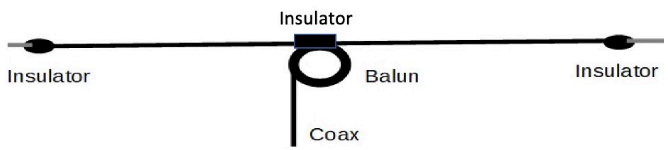
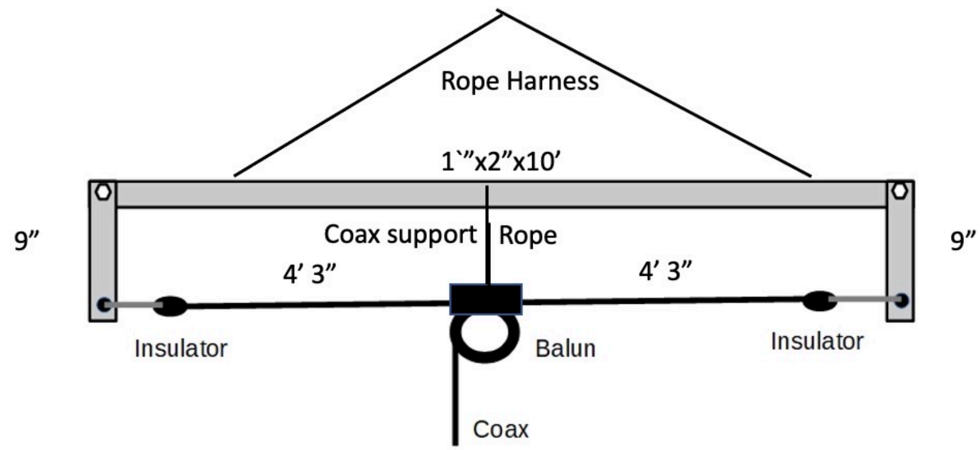
Simple 6M Dipole







Balun – 3 Turns RG-8x, 3” Diameter – Wrapped in Tape

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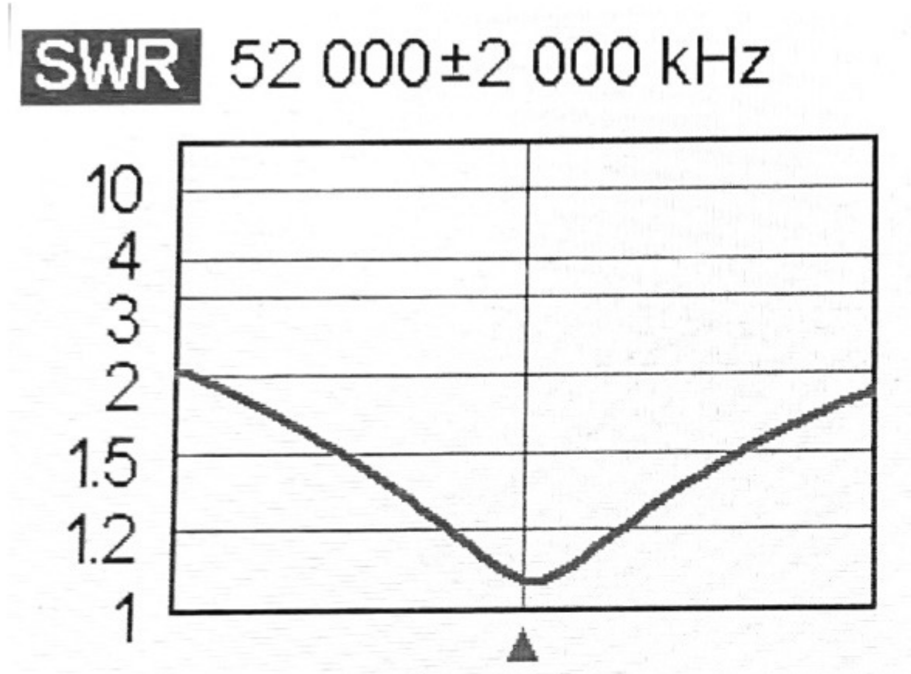
Covers the Full Width of the Band

- Lengthen for Lower SWR on CW, SSB, or Digital
- Shorten for Lower SWR on FM



Coupling to Nearby Objects and Ground Causes Imbalance & End Effect

- Dipole in Free Space is Balanced
- Dipole Near Objects is Not Balanced
- Most Current Comes from Ends, High V
- Current From Ends is called END EFFECT
- Makes Antenna Look Electrically Longer & Lowers Resonant Frequency ~ 2%
- Current Same Direction Both Wires to Shack & Rig, etc. Common Mode Current, CMC
- Can you now explain why you should tune at final height?

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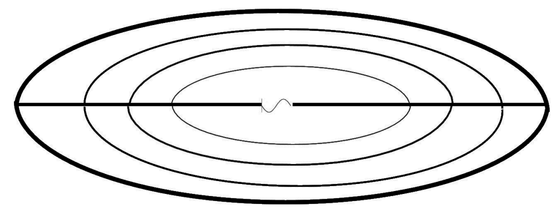
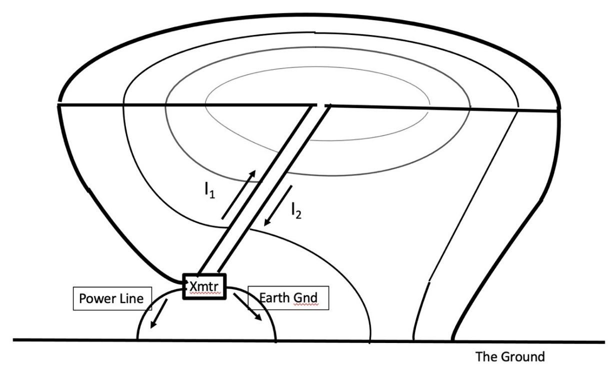




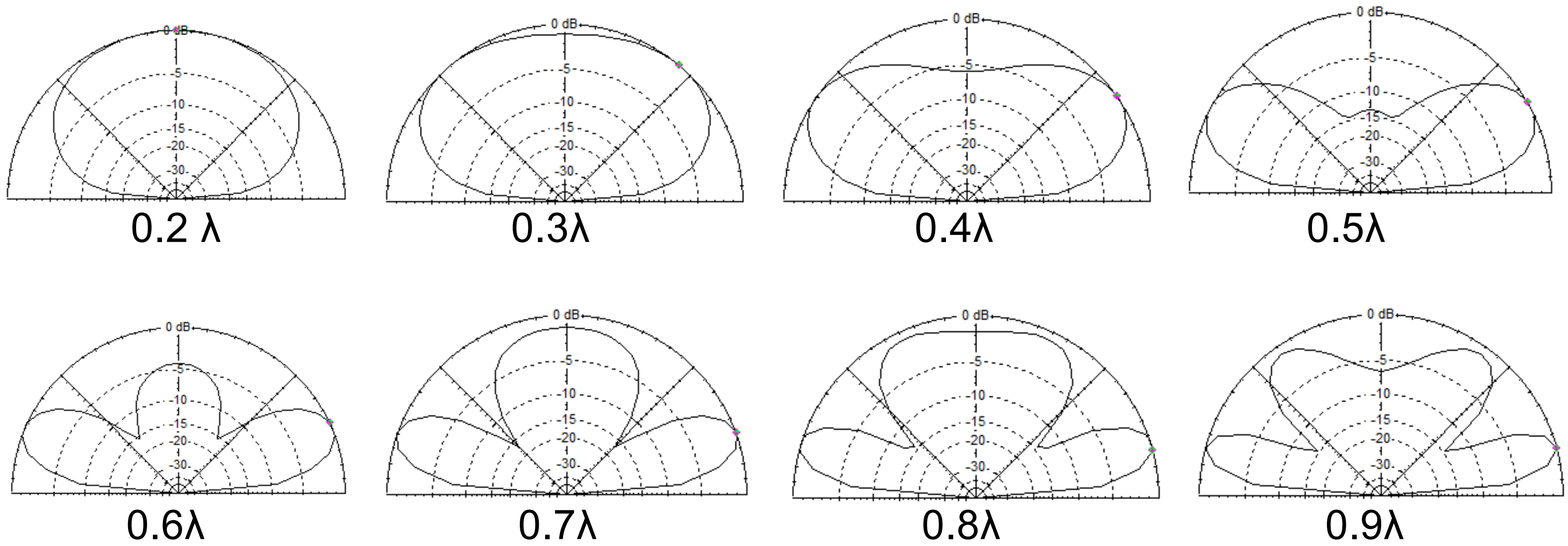
Resonant Frequency Changes with Height

- Coupling and Current Flow Increases Closer to Ground
- Antenna Becomes Electrically Longer than its Physical Length.
- Increased Coupling Lowers Resonant Frequency
- Deployment Height of Half Wavelength Works Well for a Number of Reasons
- Tune your antenna at height

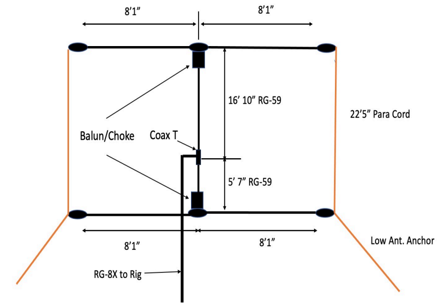
Height Ft	λ	Minimum SWR Frequency MHz
20	0.15	7.06
30	0.23	7.07
40	0.29	7.12
50	0.36	7.18
60	0.46	7.20

Elevation Pattern Changes with Height

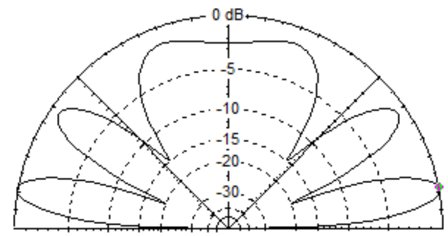
- 0.3 λ or Lower is a Good NVIS Radiator ~ 78 ft on 80M
- Going Above 0.5 λ Lowers Takeoff Angle, Radiates More Vertical Power

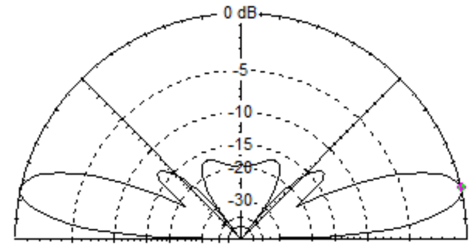


10 m Stacked Dipoles

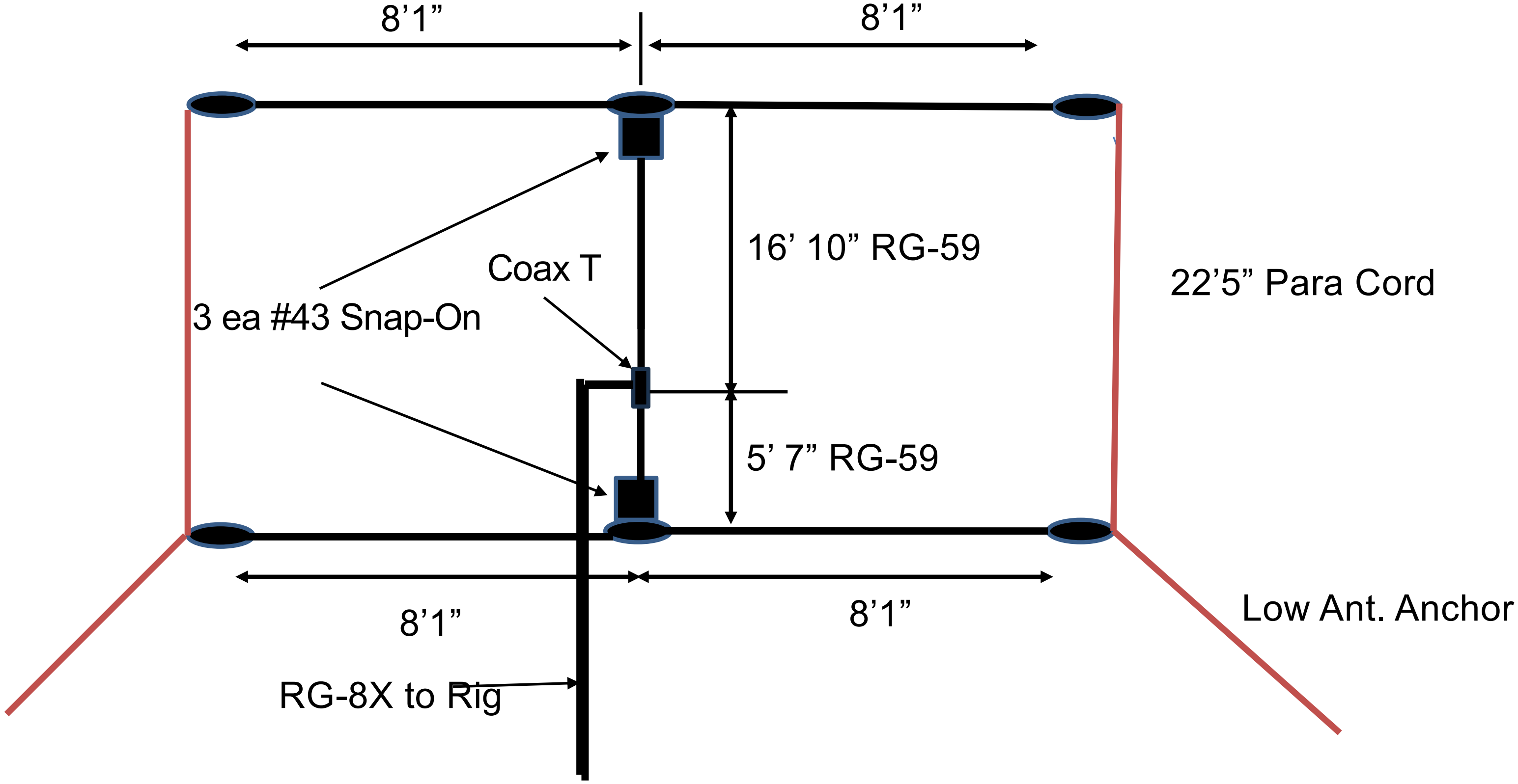


- Increasing Dipole Height is Usually Desirable.
- Don't be so sure!
- Eventually, a Vertical Lobe Develops
- Takes Energy Away From Useful Directions
- A Stack of 2 Dipoles Suppresses Lobe at all Heights.





10M Stacked Dipoles



Stacked Dipole Details

- Optimal Spacing is 0.6 -.75 Wavelengths
- Impedance of Dipoles Transformed to 100 Ohms by ¼ Wavelength 75 Ohm Cable – Dipoles Wired in Parallel with Tee is 50 Ohms
- Problem: 2 runs of ¼ wavelength Do not Span 0.6 Wavelengths
  - Make the Top Coax ¾ Wavelength introduces 180 Degree Phase Shift
  - Reversing the Coax Connection at One Dipole fixes 180 Degree Shift
  - If Center Conductor Goes to the Right Leg of Top Dipole, Center Conductor of Bottom Dipole must Go to Left Leg

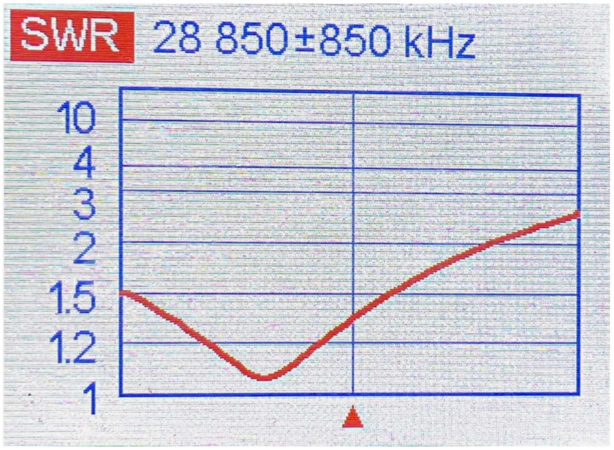
Gain and Takeoff Angle at Different Heights 1 Dipole vs. Stack of 2

- Very Low Takeoff Angles 1- 2λ Heights
- Up to 3.46 dB Gain Increase @55 ft
- Inexpensive & fun virtual amplifier!

Height ft	Type	Gain DB@X degrees T/O
40	1 dipole	8.15@12
	2 dipoles	9.94@15
45	1 dipole	7.45@11
	2 dipoles	11.4@11
50	1 dipole	7.5@10
	2 dipoles	11.6@9
55	1 dipole	8.14@9
	2 dipoles	11.6@9

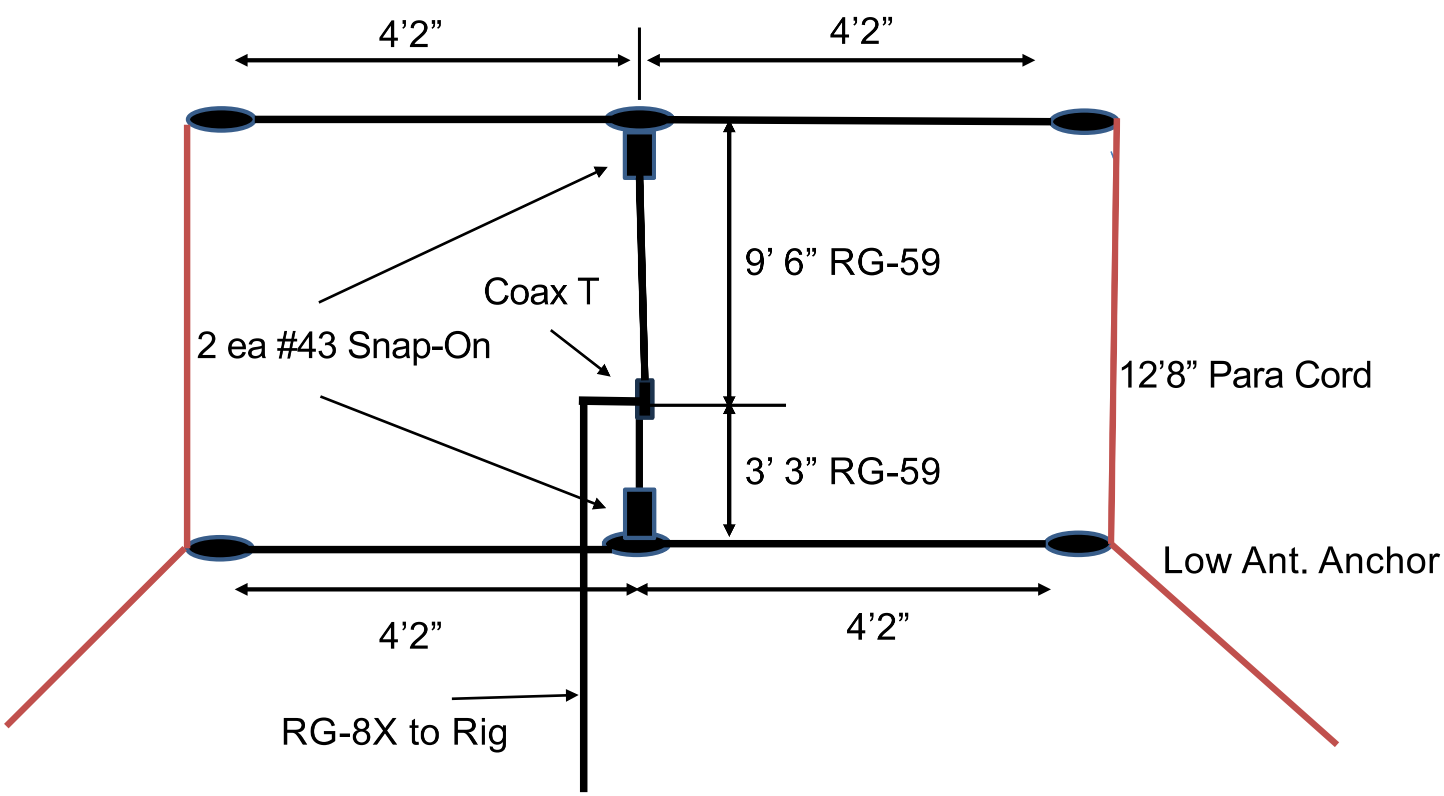
Tuning

- Launch the Top Dipole Alone Using a 100 Ohm Resistor in Tee - Proxy for Lower Dipole
- Adjust Length for min SWR Where You Want It
- Adjust the Lower Dipole to the Same Length
- Add RG-8X fee, Launch Both Dipoles, Anchor the Bottom Dipole, and Measure SWR
- Have Fun at Higher Radiated Power



6M

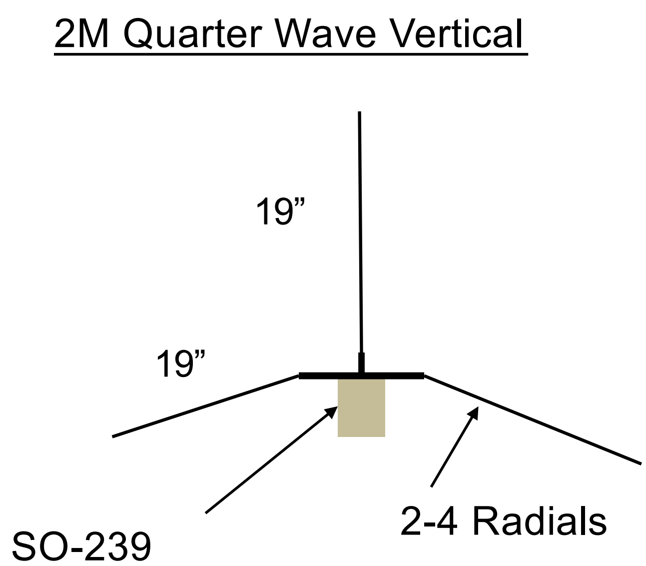
6 Meter Stacked Dipoles



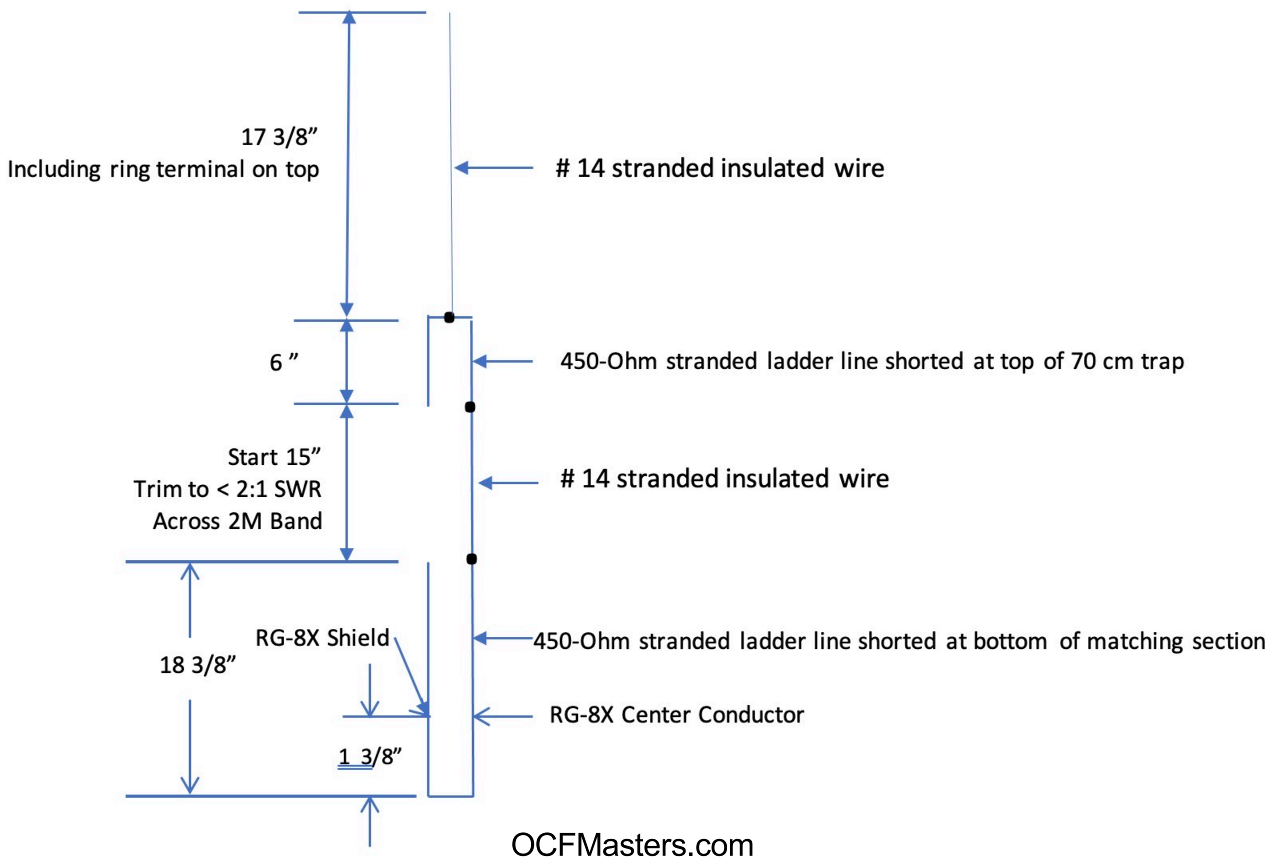
Height ft.	# Dipoles	λ	Gsin dBi@ X degrees
20	1	1.0	8.06@13
	2	1.0	10.07@15
30	1	1.5	8.13@9
	2	1.5	11.5@10
40	1	2.0	8.12@7
	2	2.0	11.23@10
50	1	2.6	8.0@5
	2	2.6	11.87@5
60	1	3.0	8.01@4
	2	3.0	12.34@5

Simple 2 M Vertical

- Buss Bar or #12-14 Solid House Wire
- Loop Top – Hang with Tie Wrap
- Loop Radial Ends for Safety



2M & 70 cm J-Pole (Vertical End Fed)



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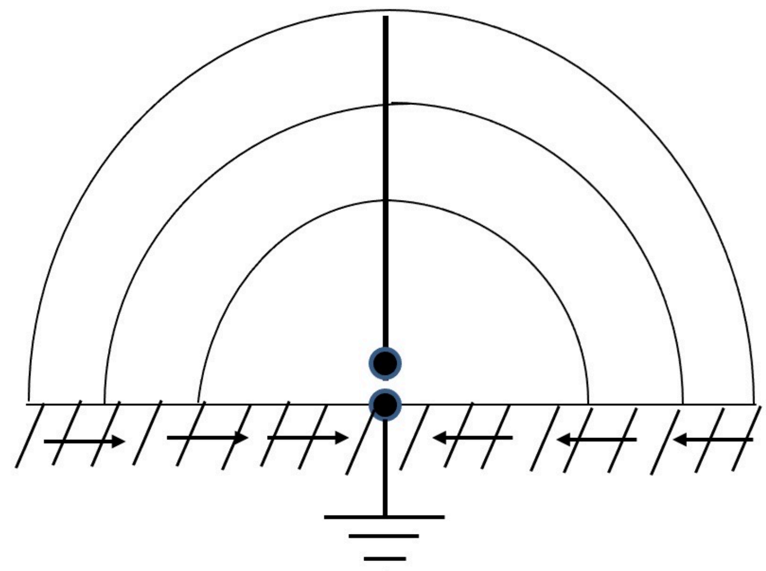
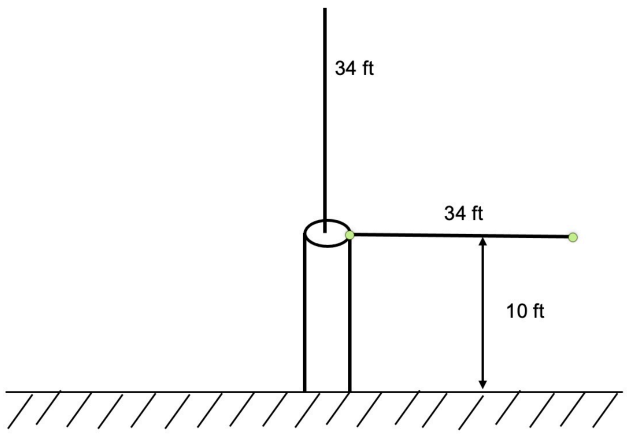
HF - Ground Mounted Vertical

- A Quarter Wavelength Radiator Ground is Mirror to Create the Second Half of Dipole
- Ground has Poor Conductivity
- Radials Reduce Ground Resistance & Loss
- Radials Untuned, Any Length.
- More radials always better – lowers loss
- Impedance with perfect ground = 35 ohms

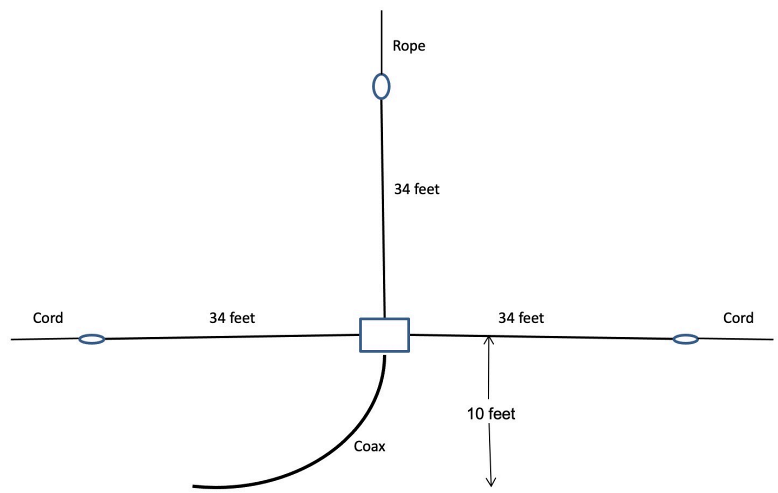


Raise Radials Vertical

One or Two Radials
Radials >10ft off ground minimize ground losses
Radials are “tuned”



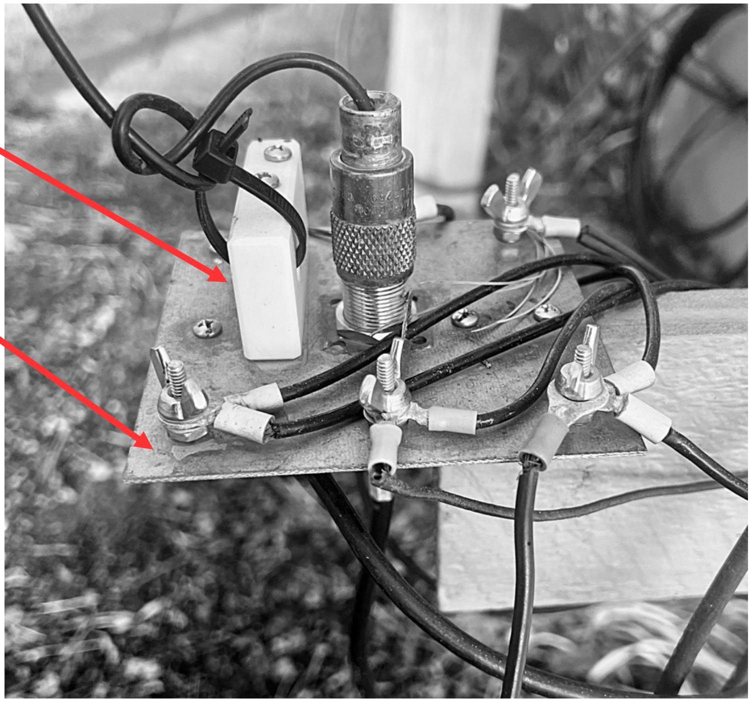
- Dipole wires at 90 degrees
- Radiation pattern slightly directional



- Radials 180 degrees – omni – pattern

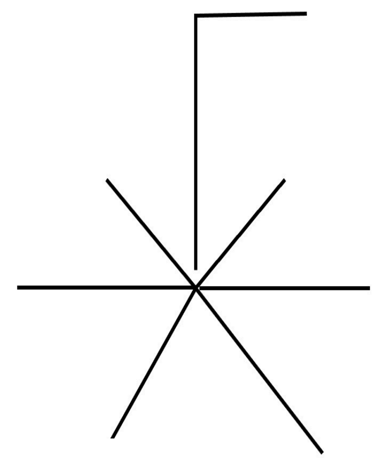
Base For a Vertical

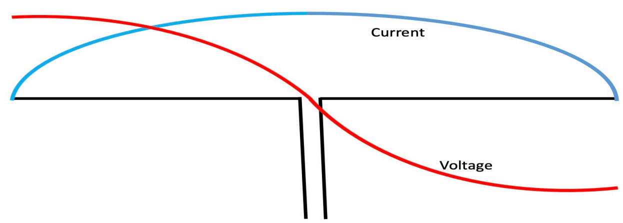
- Provide Strain Relief for Vertical Wire
- Copper Clad Board Attach Point for Antenna & Radials
- Use Stainless Steel Hardware
- Base
  - Stake in Ground
  - Cantilever off House or Tree



HF Inverted L

- L - Element is Half Wavelength Bent to fit Space
- Compact Footprint
- Vertical Run is as high as trees/supports allow.
- Horizontal Run Provides Remainder for 1/4λ.
- Low Takeoff Angle
- Good for DX on Low Bands
- Needs to be Tuned
- Vertically Polarized – Why?
- More Radials Always Better
- Radial Length Not Critical





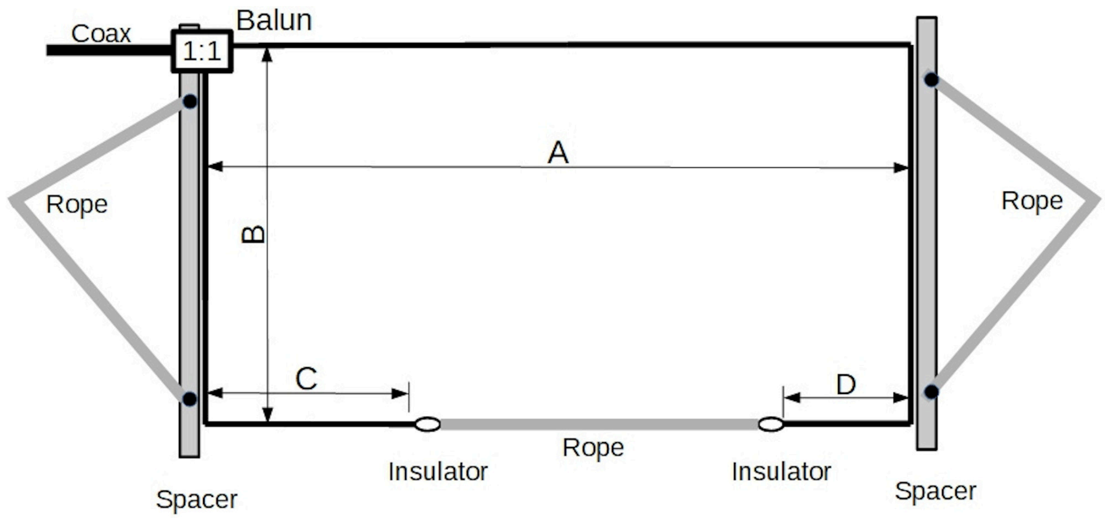
Vertical Antenna Performance

- Gain 4-6 dB Lower Than a Horizontal Dipole
- More Radials Lowers Ground Losses
- Azimuth Pattern is Omnidirectional
- Takeoff Angle Much Lower Than Dipole
- Low Takeoff Angle is Good for DX
- Impedance is Typically 35 Ohms

C-Pole Horizontal

- A C-Pole is half wavelength dipole bent into a “C” Shape
- Compromise Antenna fits Small Space
- 40 m version is12 x 24 ft, vs. 66 ft Full Dipole
- Center Impedance low, feed off-center to 50 Ohm point
- Don’t Forget the UNUN/Choke/Balun.
- Horizontal - Gain about 4.4 dBi at 30 Ft with a high takeoff angle
- At 25 Degrees Takeoff, Gain is about -1.0 dBi

C-Pole Layout Uses Wood Spreaders



- A = 24 Ft, B = 12 Ft, C = 7.5 Ft, D = 10.17 Ft
- Off Center Rope Harness Compensates for Weight Imbalance, 1:1 Balun

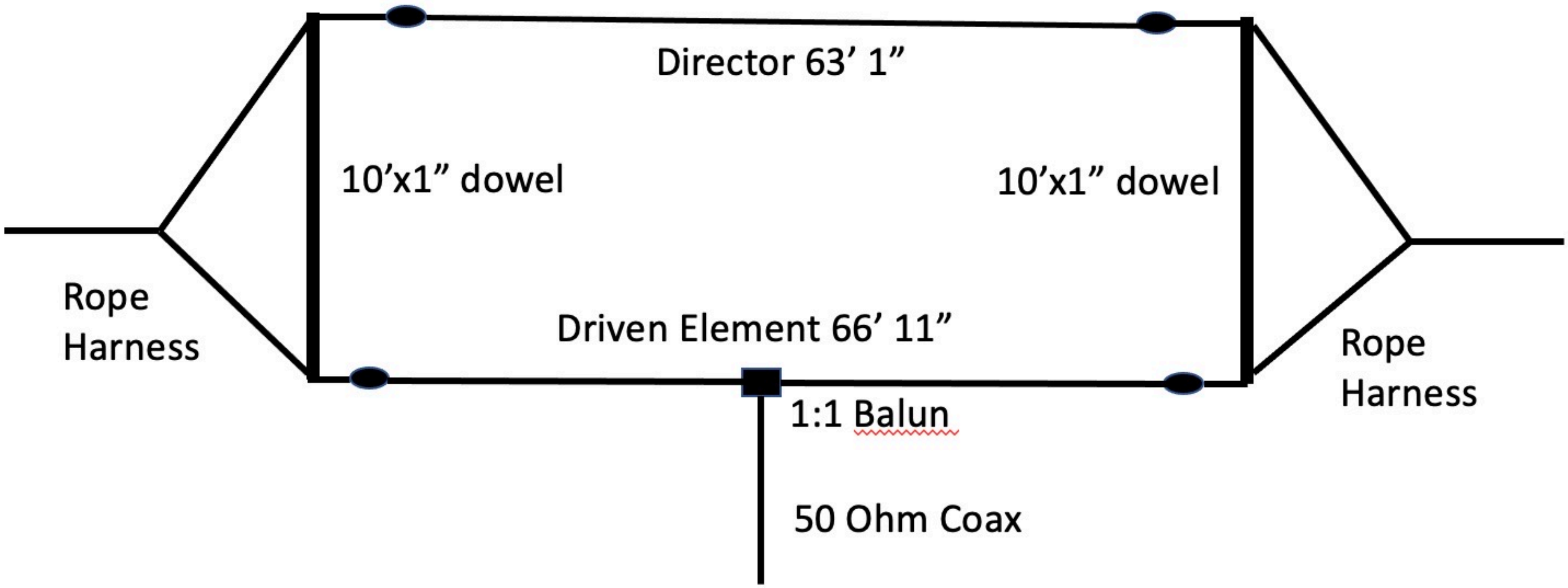
Dimensions are Flexible

- Total Length of Radiator is About 66 Ft
- Widths Between 10 Ft and 14 Ft Will Produce a Usable Antennas
- The Gap Should be > 6 Ft.
- A Small Gap Reduces Bandwidth
- Position of Feedpoint Determines the Impedance
- Balun is Required (Off Center Feed is Unbalanced)

40 M Portable Wire Beam

- Primarily Motivated by Field Day
- Obviously Not Rotatable
  - Here in the Northeast, Point WSW - Cover Most of the Country
  - Point the Other Way & Cover Europe
- Flip Direction with Armstrong Rotator - Pull the Feedline!

40 m Beam Configuration



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40 m Beam Design

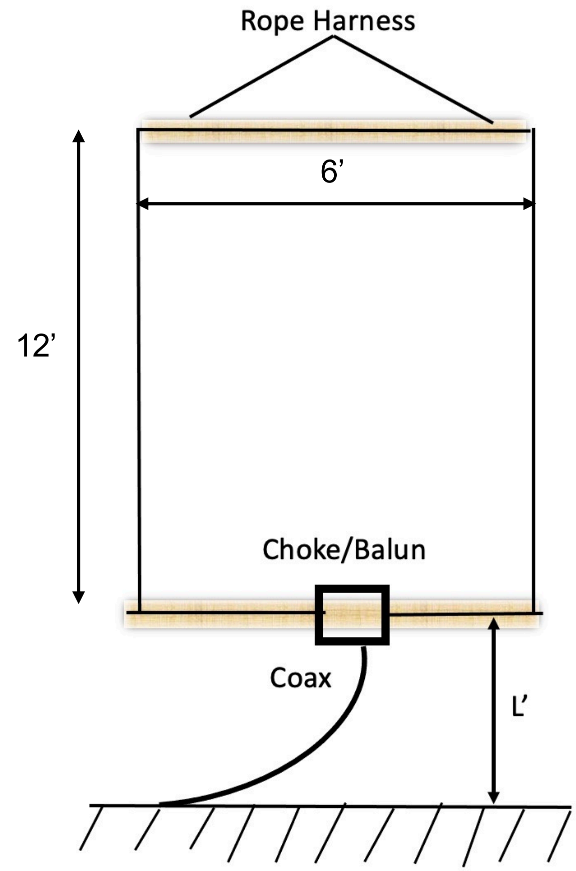
- Driver/Director Spaced 10 ft Apart
  - 10 ft Spreaders fit in an SUV
- Rope Harness Supported Off Center to Level the Antenna
- Dimensions Shown are for SSB Portion of the Band
- Gain is 8.4 dBi and Front/Back is 8.5 dB at 7.2 MHz
- For CW, Driver is 68’ 9” Director is 64’ 4”
- Used Successfully in Field Day for Several Years

40m Beam Particulars

- Balun is Implemented with Choke – 5 Turns RG-8X Wrapped & Taped in 5” Coil at Feedpoint
  - Provides 10 dB of Isolation
- Spreaders are 10’ Dowels 1.25” in Diameter
- Wire is #14 THHN or #14 Flexweave from Davis RF

Simple 10M Vertical Loop

- Wood Spreaders
- Balun - 3 T RG-8x 4” D taped
- Hang From Tree Limb ~20’ up
- Max Gain Perpendicular to Plane
- ~ 1dB Gain over Dipole
- Scalable to other Bands



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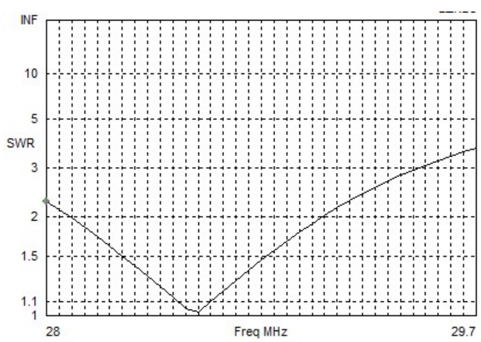
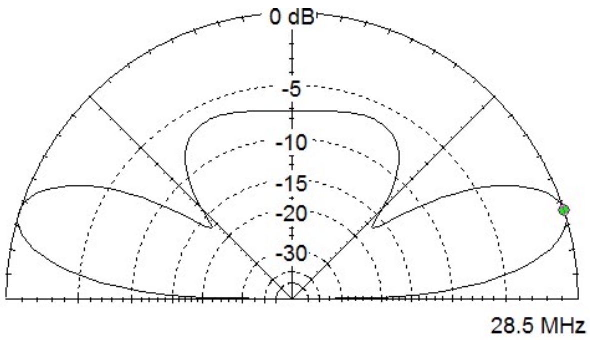
Dimensions and Performance

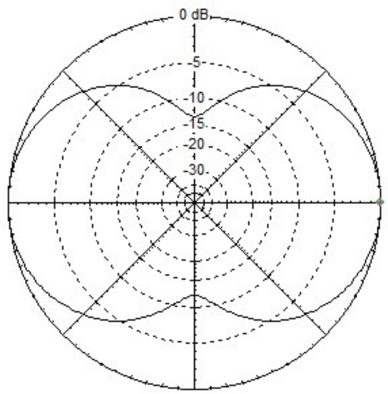
Band	Takeoff Angle, Degrees @ 20 ft To Bottom	Gain, dBi @ 20 ft	Dimensions, Feet
20 m	27	7.37	13.6’ x 22.25’
17m	23	7.03	9.3’’ x 18.83’
15 m	21	7.88	7.88’ x 16.05’
10 m	18	7.99	6’ x 11.8’
6 m	11	8.18	3.4’ x 6.6’

10 m SWR and Pattern

- Other Bands are Similar







THANK YOU

73 DE

Bob, W1IS
&
Bob, KC1DSQ

(Bob)^2 Latest Publications

- “A 70-cm ”Kitchen Array” CQ Magazine, August 2023, pp77-81
- “Wire Antennas 160 meters to 70 cm, Concepts, Construction and On the Air,” available at OCFMasters.com, Ham Radio Outlet Salem, Amazon

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