2018 Antenna Contest Submission, Double Topped Flagpole Antenna

Renamed from: A Multiband Flagpole with Dual Top Hat Wires

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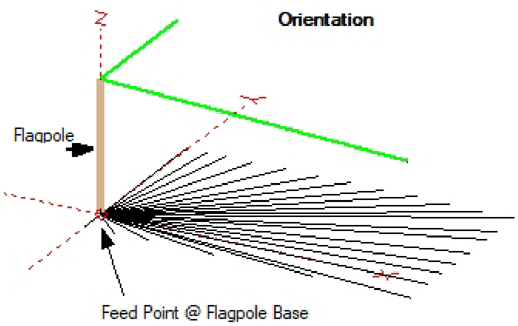
2018 Antenna Contest Submission, HF Multi Band Antenna

A Flagpole with Unsymmetrical Flattops, covers 80 through 10 Meters.
It’s Low Observable, Legal Limit and uses Simple Matching Network (if needed)



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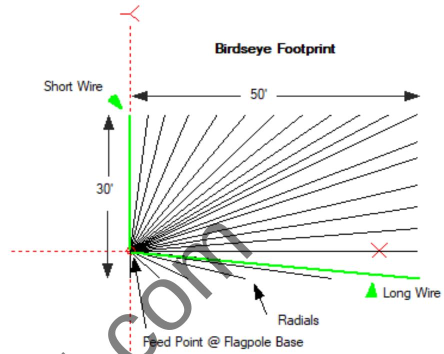


This **HF Multi Band Antenna** covers 80 - 10 Meters (30 Meters with an L/C Network or remote tuner) and fits within a 30’ x 50’ area with height less than 30’.

The antenna uses a vertical element and two flattops of unequal lengths. Radial wires are required and placed at the earth/grass interface. I used a Flagpole as the vertical element. I wanted to erect the Flagpole to show the colors, so this application suited two wishes, flag display and low observable antenna.

The diagram shows 2 wires (green) which form top-hats for the vertical member of the antenna; they add capacitive top-hat loading which forces higher current into the upper portion of the flagpole. The wires are stranded copper 0.028 inches (#21) and become invisible to the casual observer at ~30’ distance and handle SSB legal limit power. The ratio of the currents in the wires is frequency dependent and flows away from the vertical junction.

Analysis and installed data proved that the angle between the wires can be varied between 180° to as little as ~ 75°. The ~95° angle for this antenna was chosen to meet the 30x50 dimensional goal.
There are 24 radials at the feed point base and extend to the limits of the 30 x 50 area.
Note, the end heights of the flattop wires could be lowered to make the antenna work in a slightly smaller area or drop down wire could be added to the ends for the same purpose. (See installs 1 and 2).

The vertical element of the antenna is a 20’ aluminum pipe of 2" diameter and 0.065" wall thickness (repurposed from a commercial ham Flagpole antenna) it is the central support for the 2-wire flattop. The Flagpole is insulated at the base and the antenna may be fed with 50Ω coax, center conductor to the flagpole, sheath to the radials. Include a ground rod for safety. The vertical element could be #16 wire attached to a fiberglass push-up pole. A 4:1 Step-Up Un-Un (relay selected) is suggested to match the antenna to the feedline to reduce losses and ease tuning.

This antenna is installed at 3 locations in our community. The Vertical Height fixes one end of each wire. The remaining dimensions are the result of trimming the antenna to characteristics of the individual home site.

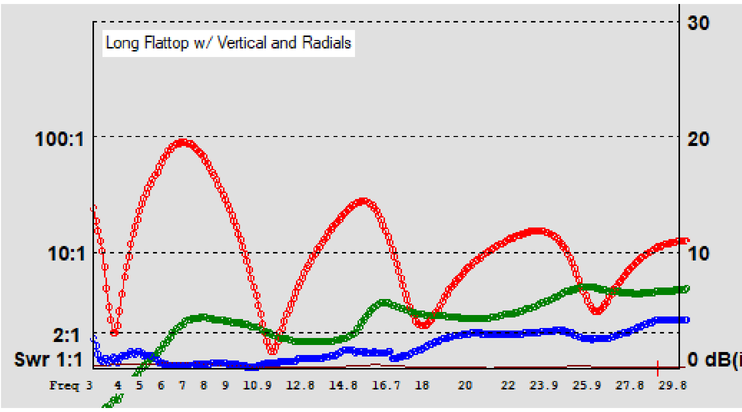
Installed Dimensions, Feet

	Vertical Pipe Height	Long Wire Length	Long Wire Hgt @ Far End	Short Wire Length	Short Wire Hgt @ Far End	**Wire Orientation**
Site 1	21.25	45.1	8.5	24.2	8.5	**Slanted Down**
Site 2	20	46	17	27	17	**Slightly Slanted Down**
Site 3	**25**	49.7	~19.7	22.5	~15	**Drooping**

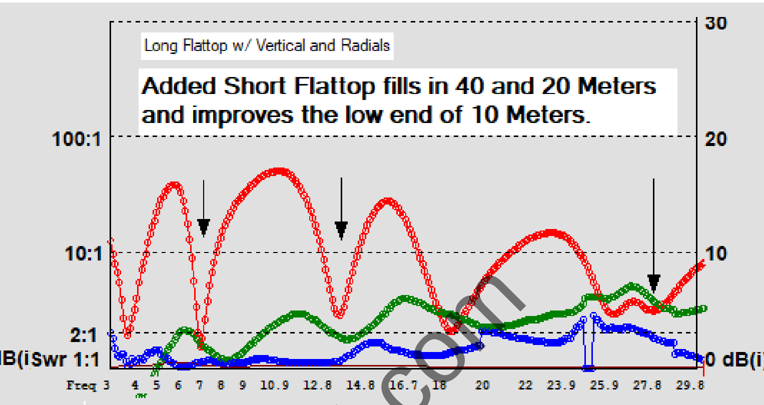
Details of the sites are discussed in detail in the Installed Site section.

Early On Proof of Concept Testing (@ W1EJM QTH)

Nec V2d Model of 1 Wire vs 2 Wires, adding the 2nd wire adds 3 bands: Z=50Ω Reference



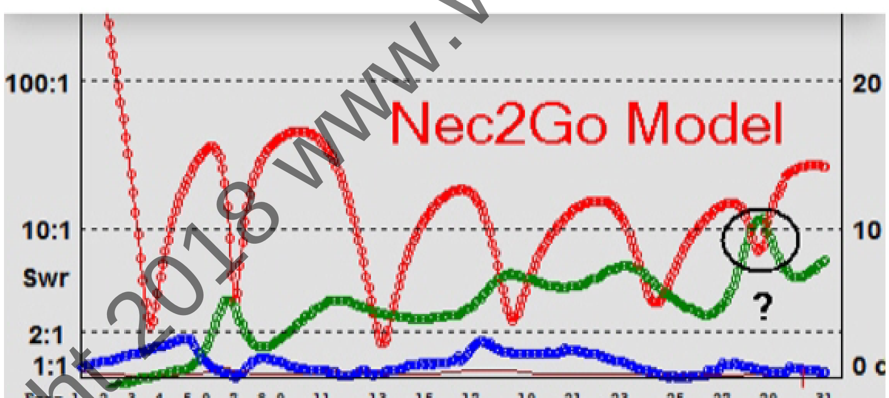
75/17 and 12 Meters



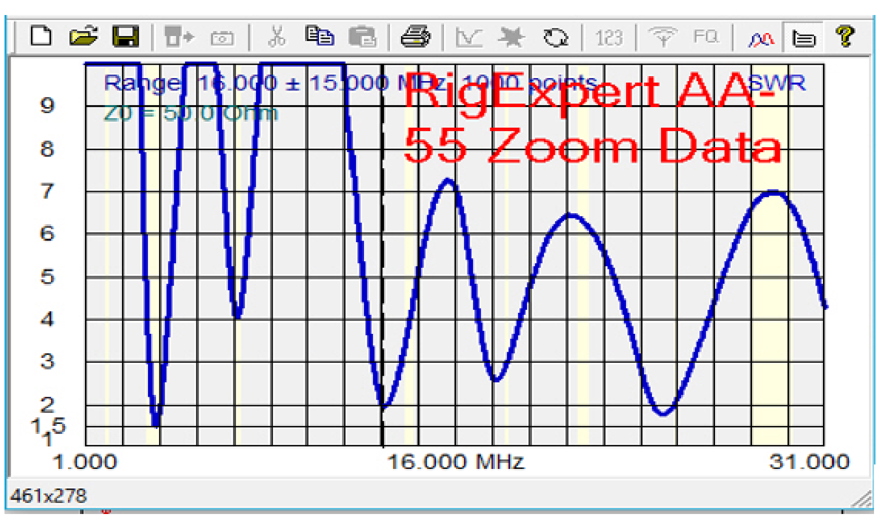
75/40/20/17/12 and 10 Meters

Nec 2d ***Model Compared to Prototype Antenna***
Measurement Using the Rig Expert AA-55 Zoom, Z=50Ω Reference

Log {



Linear



Nec-2d Based Modeling,

75/80 Meters Performance Prediction

On 75/80 Meters the antenna functions as an Inverted-L with high currents in the vertical and the long horizontal wire. A low current flows into the short wire. The antenna pattern is omnidirectional on 75/80 Meters. The longer wire length is used to set the center of the desired 200KHz bandwidth within the band.

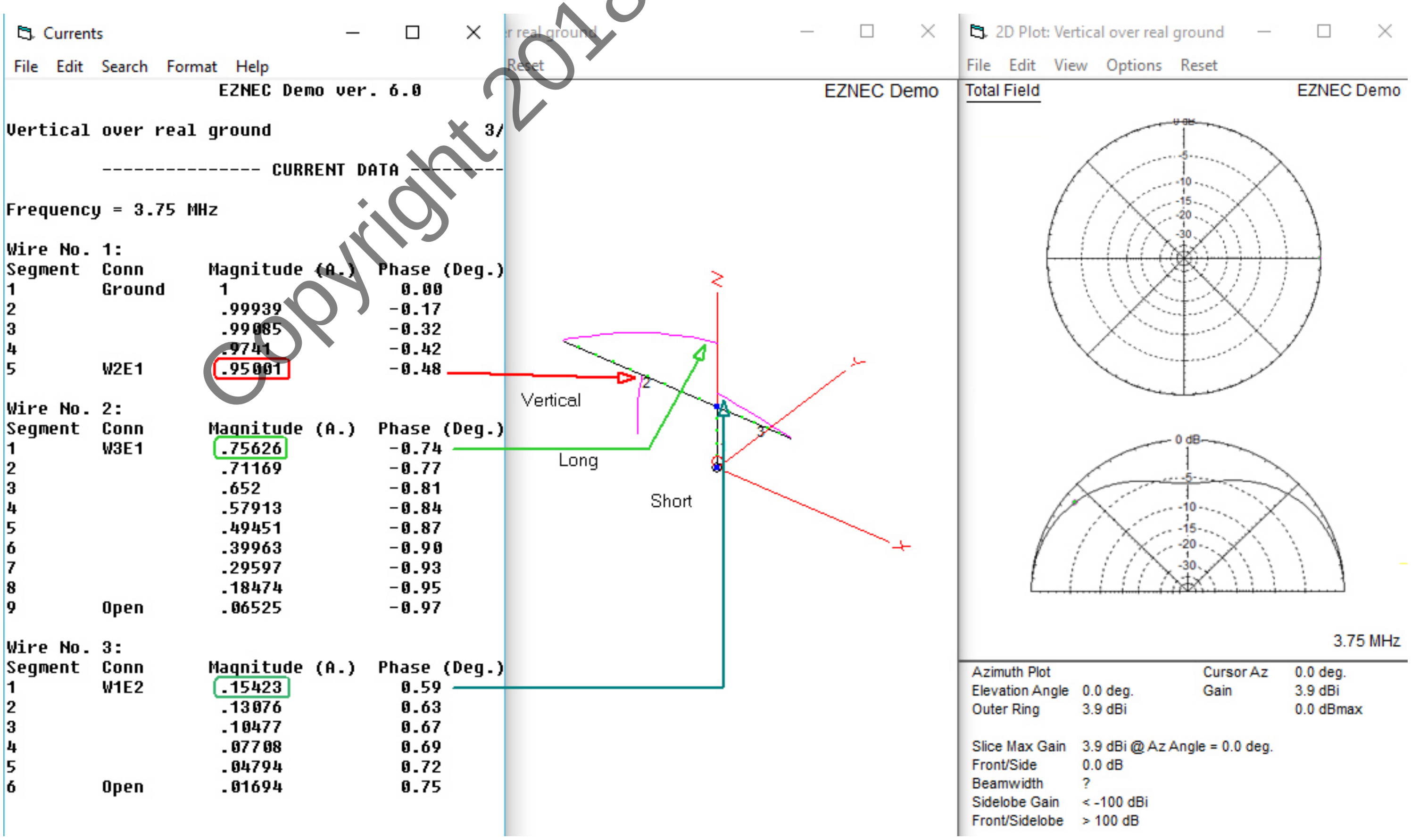
As with most 75-80 Meter antennas, the band is wide compared to antenna bandwidth of ~200KHz for low Vswr. My in-shack tuner (Palstar AT2K) allows tuning out the reactive and transforming the resistive values to reach 1:1 anywhere in the 500KHz band limits, but my typical operation is within the 200KHz that I normally use.

For simplicity of explanation of the vertical and wire currents, I removed the radials, forced Perfect Ground and used the EZNEC Demo (for diagram clarity) to show the currents, *ignoring current phase angle for the moment*, into the vertical (Wire 1) as 0.999 at the base and 0.95 at the junction of the top wires. Thus, high current flows throughout the length of the vertical element. So we can expect a strong vertical component in the field.

On 75/80 Meters, at the top of the vertical, the current flow is predominantly into the long wire (Wire 2), so for the sake of simplicity, look at magnitude only and you will see currents in the vertical (Wire 1) splits into two currents of 0.75 in the long wire and 0.15 in the short wire. The long top wire accepts most of the current while the short wire (Wire 3) accepts very little current thus the pattern is omni as we would expect from an Inverted-L. (P~I^2)

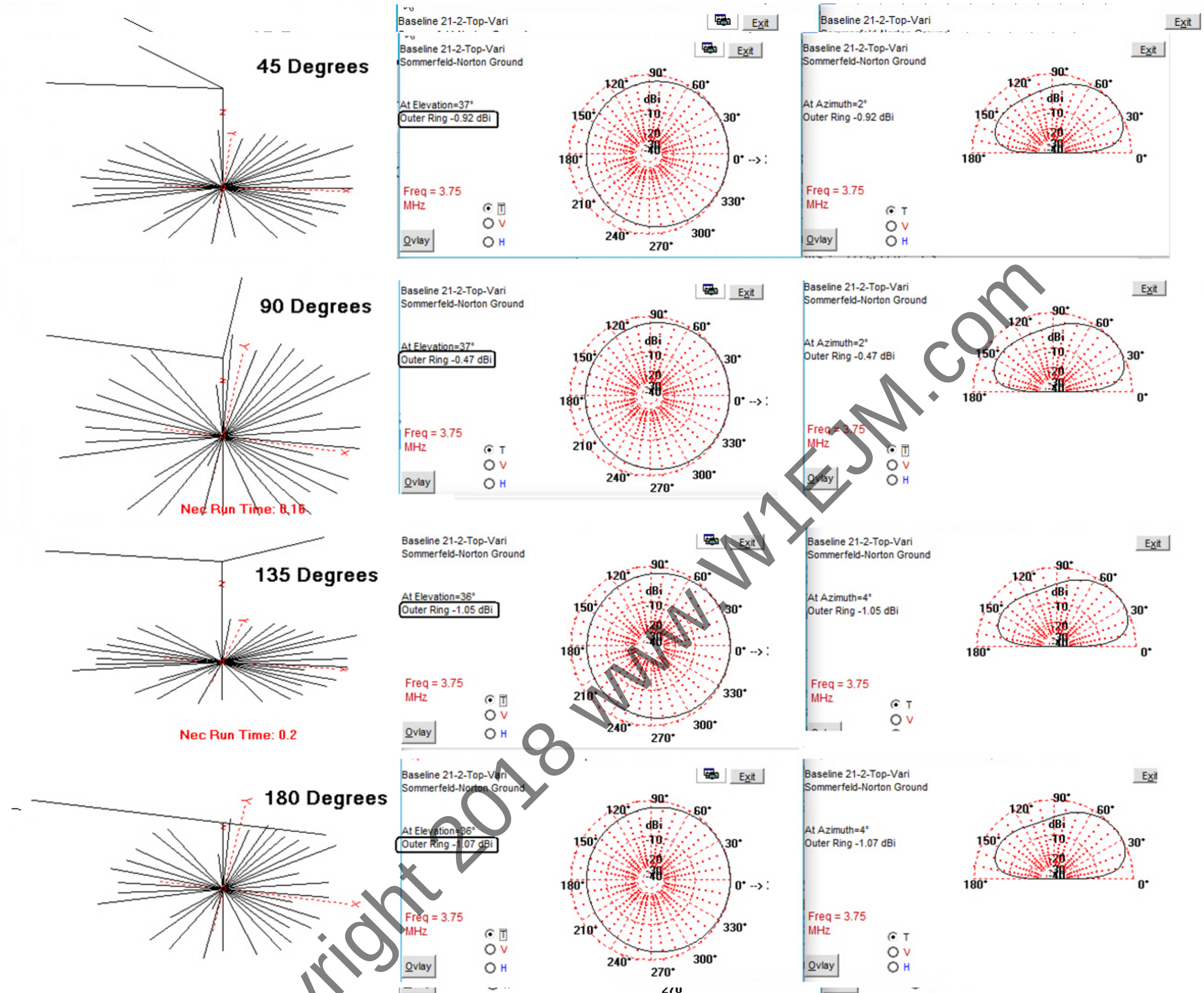
When the phase of the currents is taken into account we see both wire currents flow away from the junction, so the fields will partially cancel and the effect will be to increase the "top hat" capacitive loading a bit as it would in a "T" type antenna.

75/80 Meter Currents:



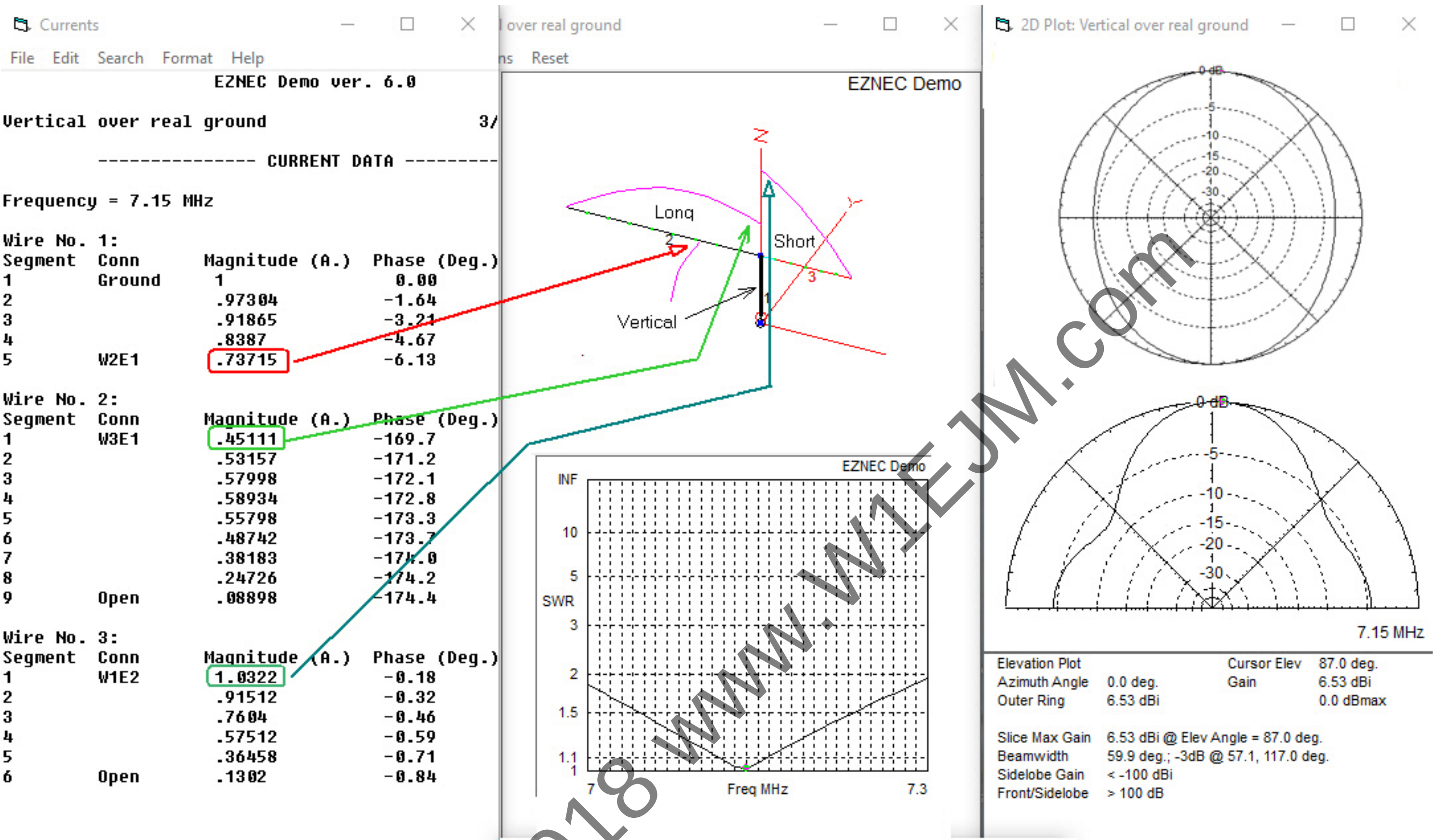
75/80 Meter Pattern / Az-El Plots vs. Angle Between Wires

The model shows Azimuth and Elevation plots are not affected strongly by the angle between wires.



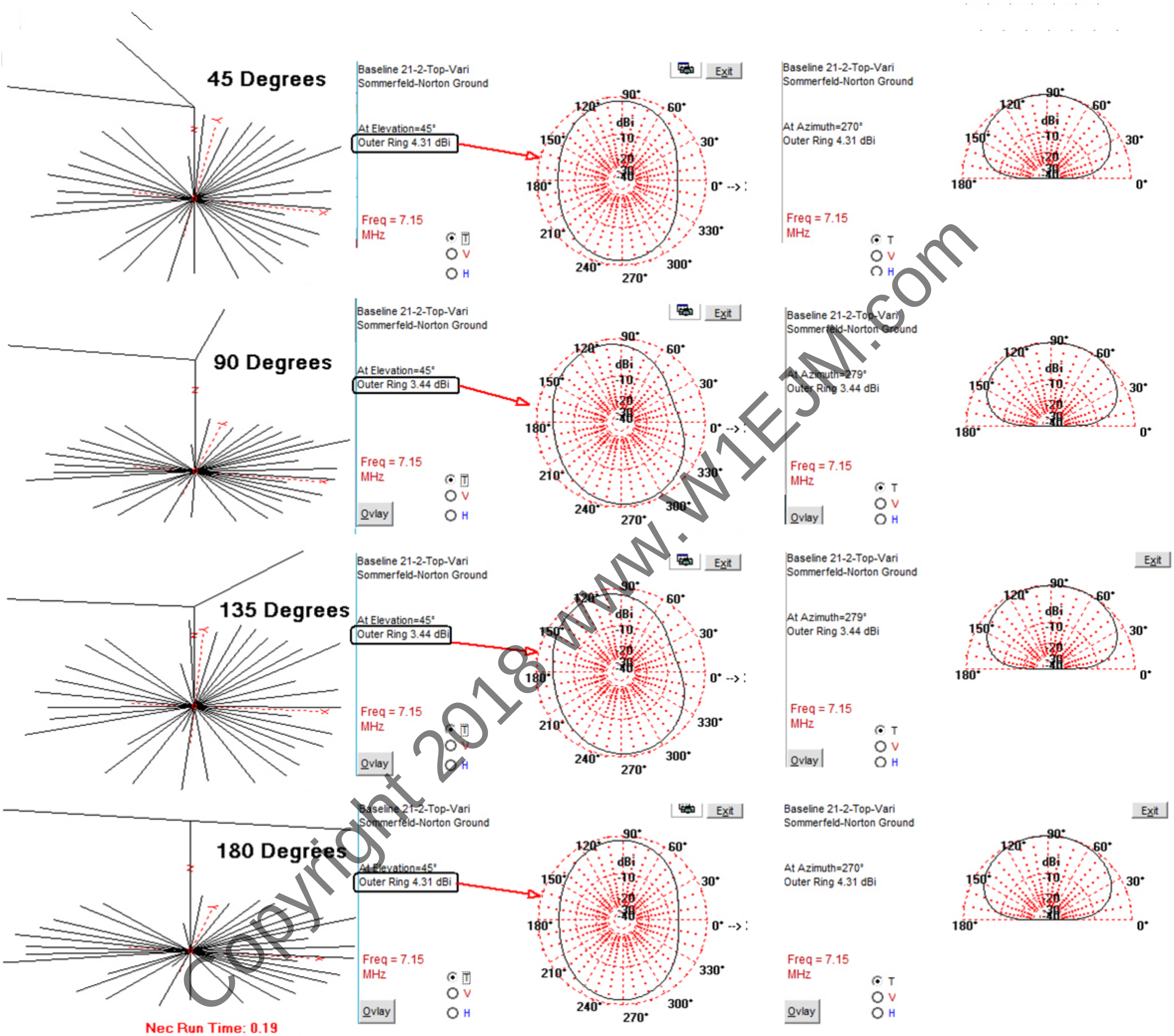
40 Meter Currents:

On 40 Meters, high current from the Vertical flows into the short wire. The short wire length is used to resonate the antenna on 40. The antenna is broadband on 40 Meters so the short wire is used to trim to the middle of the band.



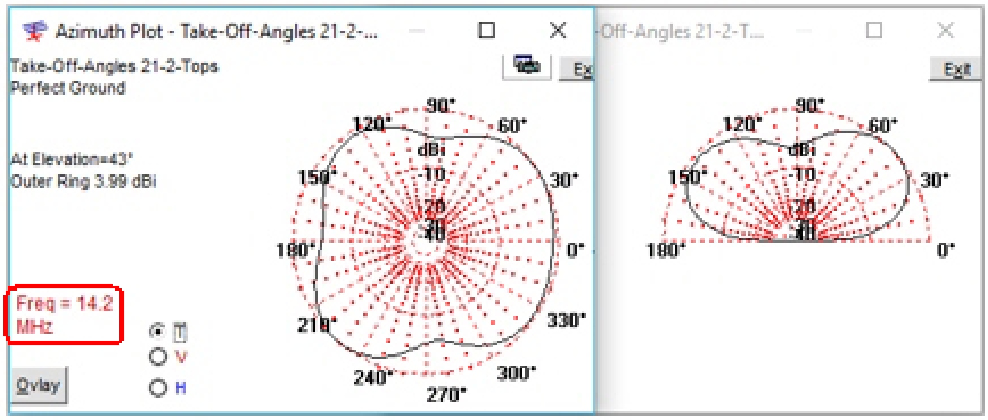
40 Meter Pattern / Az-El Plots vs. Angle Between Wires

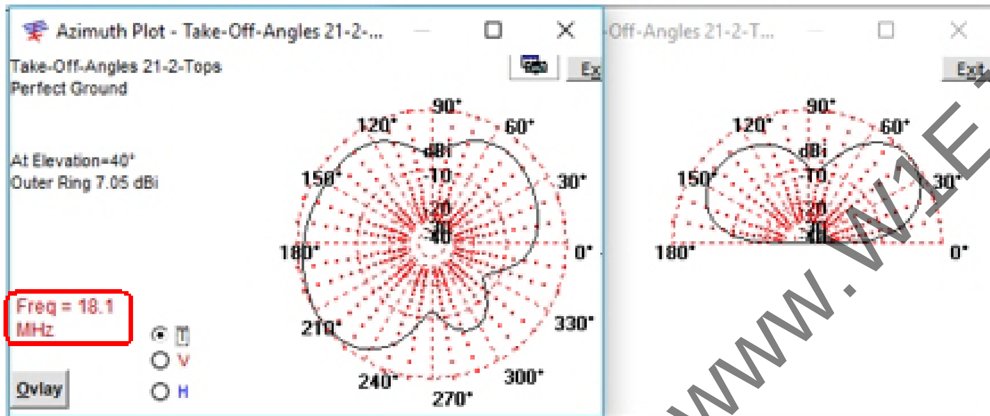
The model shows that the angle between the top-hat wires has little effect on the directionality of the antenna which is steered to be broadside of the long wire.

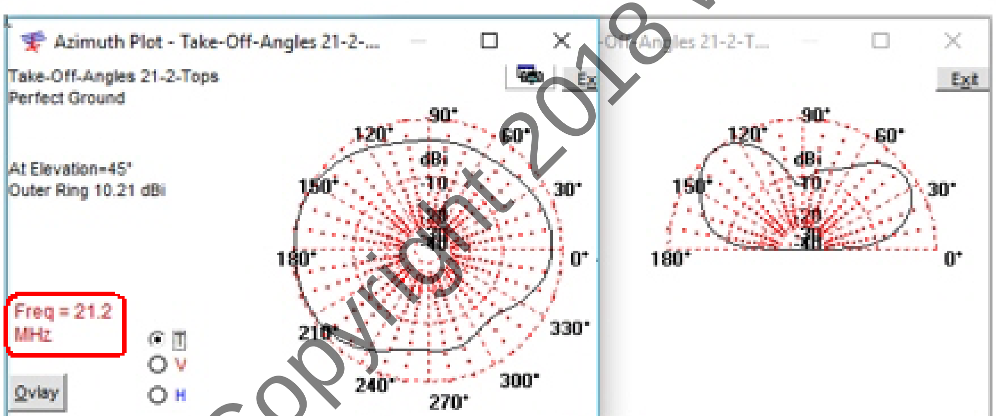


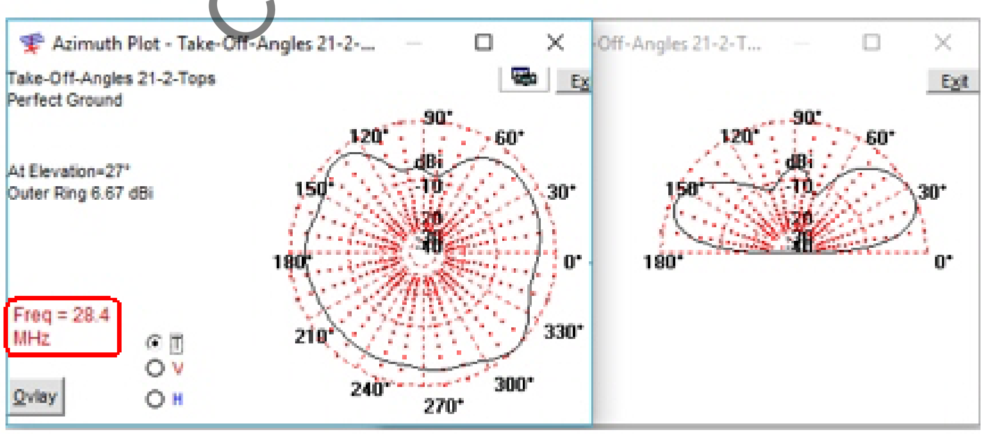
20 - 10 Meter Pattern / Az-El Plots @ 90° Angle Between Top Hat Wires

These patterns are consistent with 'flattop antennas" at higher than fundamental design frequency of 7.15MHz.



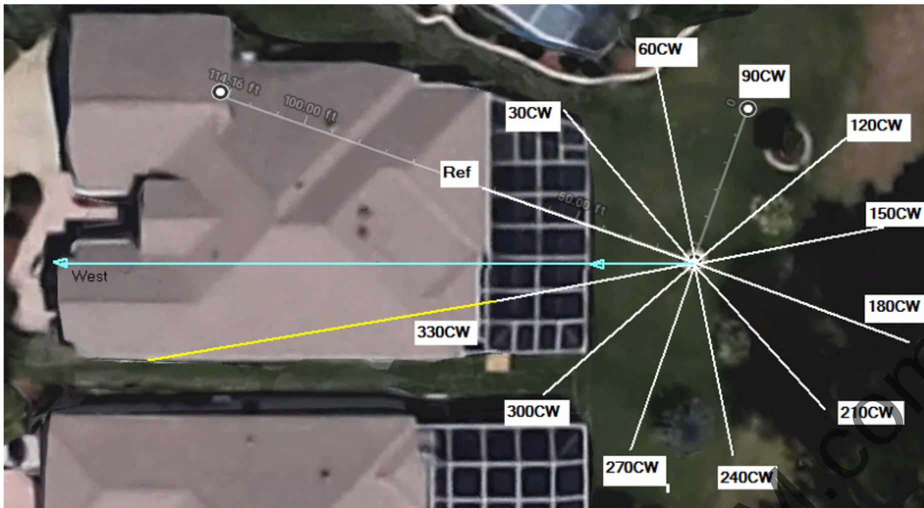






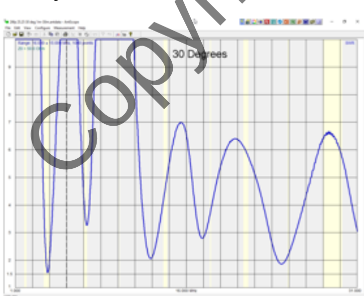
Angular Sensitivity Testing at W1EJM QTH

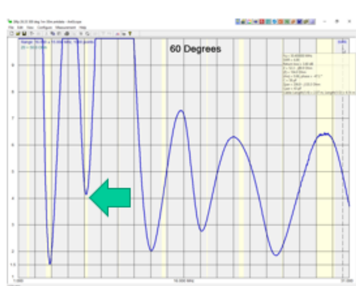
Aerial View of Antenna Location and Measurement Angles

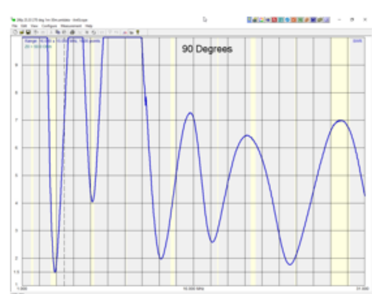


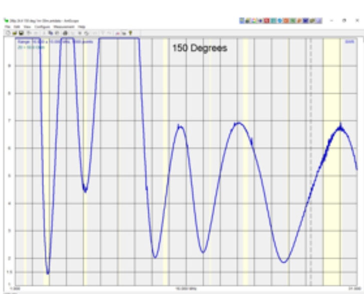
Measurement Flag Locations and Computer Setup

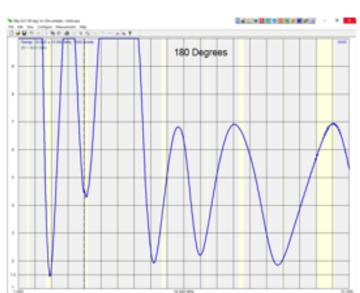
Angular Sensitivity at 30° Intervals from 30° to 180 °. Variation due to angle is minor.

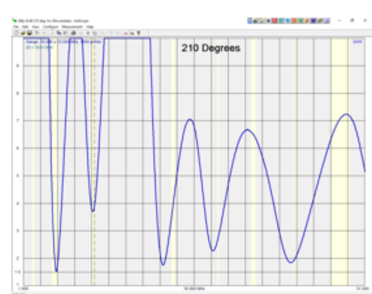












NEC Vswr and Gain Predictions:

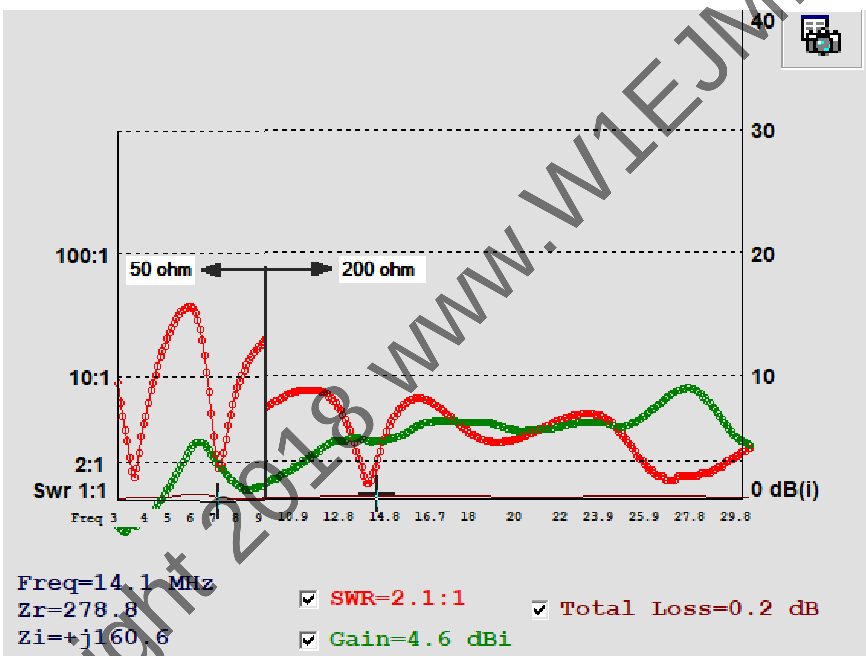
4Nec2 and Nec2Go modeling programs were used for this antenna.
The model files are attached to this contest submission package.

80-10 Meter performance was achieved for 49.7’ and 22.5’ long flattop wires atop a 25’ metallic pole. The antenna is tolerant of some variations such as lower end heights, droop in the wires, shorter metallic pole. There is interaction between these parameters as the “Installed Dimensions” table demonstrates, but a full discussion of these interactions is beyond the scope of this contest entry document.

Below, the graph overlays indicate 2 matching Z values. I used 9MHz as the transition Frequency.

The analysis Zo was 50Ω below 9Mhz and 200Ω above 9MHz.

On these higher bands the antenna matches better to 200Ω feed impedance. So, for these higher bands a 4:1 Step-up Un-Un is recommended to improve the match at the Flagpole base.



In this “split screen” graph the Feed Point Vswr and Gain are shown for 50Ω feed and for 200Ω Step-Up Un-Un.

The model indicates less than 2:1 Vswr at 3.7MHz and 2.1:1 at 7.2MHz with 50Ω feed in both cases.

With a 50Ω to 200Ω step-up Un-Un, the 14MHz is low and 25MHz through 29MHz are below 2:1 Vswr while 18.1 and 21 are less than 3:1 VSWR at the feed point.

Vswr values less than 3:1 are usually matched with “in shack” tuners or internal tuners.
Other Un-Un ratios may be somewhat better. (Z for 3.8MHz is ~15Ω while 7.15MHz is ~100Ω).

Installed Dimensions, Feet

	Vertical Pipe Height	Long Wire Length	Long Wire Hgt @ Far End	Short Wire Length	Short Wire Hgt @ Far End	**Wire Orientation**
Site 1	21.25	45.1	8.5	24.2	8.5	**Slanted Down**
Site 2	20	46	17	27	17	**Slightly Slanted Down**
Site 3	**25**	49.7	~19.7	22.5	~15	**Drooping**

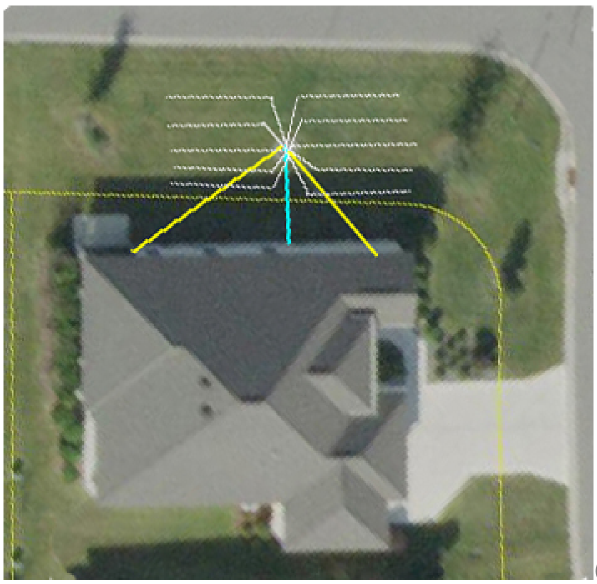
Installation Details for 3 Sites:

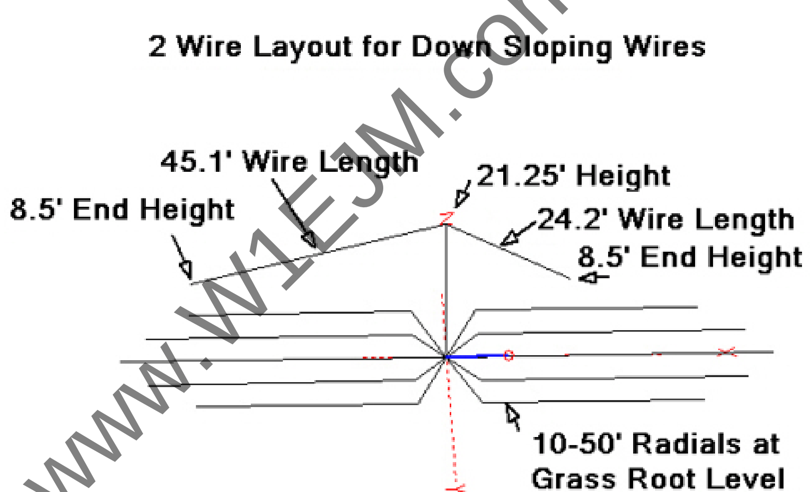
There are currently **3 Sites** installed of this type of antenna in my community and they have been in operation daily, at my QTH for 1 year, 1.5 years and 4 years at the other two local ham QTH's.

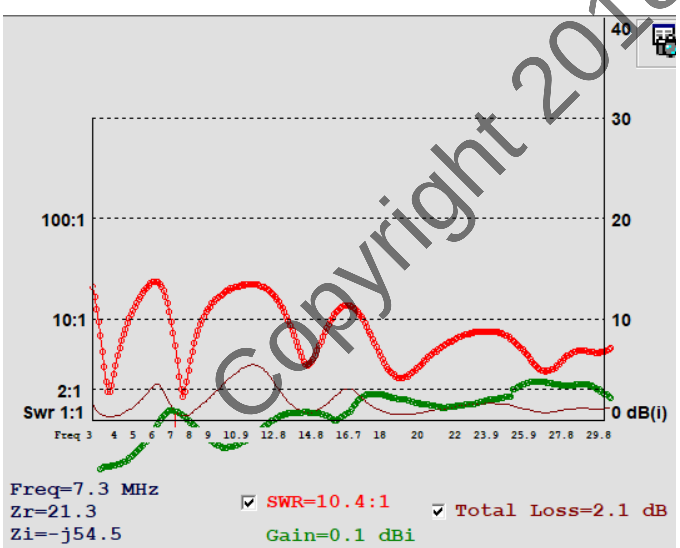
Site 1   in **2014**

–Daily use 75 SSB and regular use 40, 17, 10 and 6 Meters

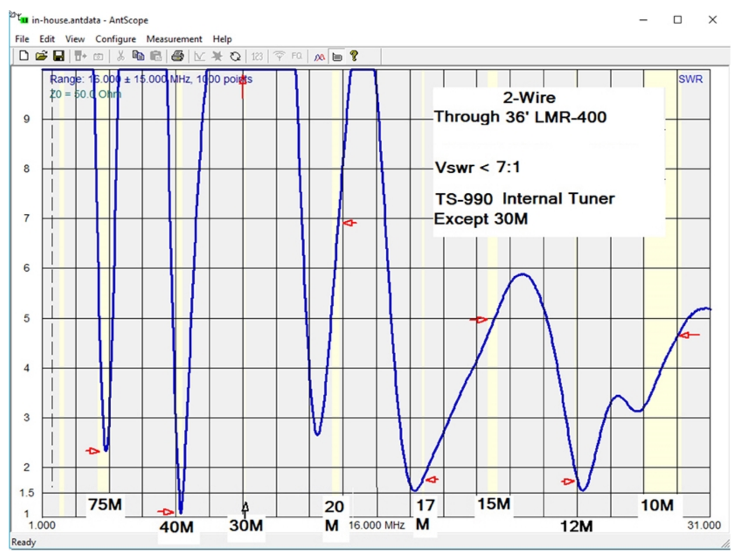
–TS-990 Internal Auto Tuner **ONLY**, direct 50Ω coax to antenna feed point







Model Vswr **LOG** Scale 50Ω



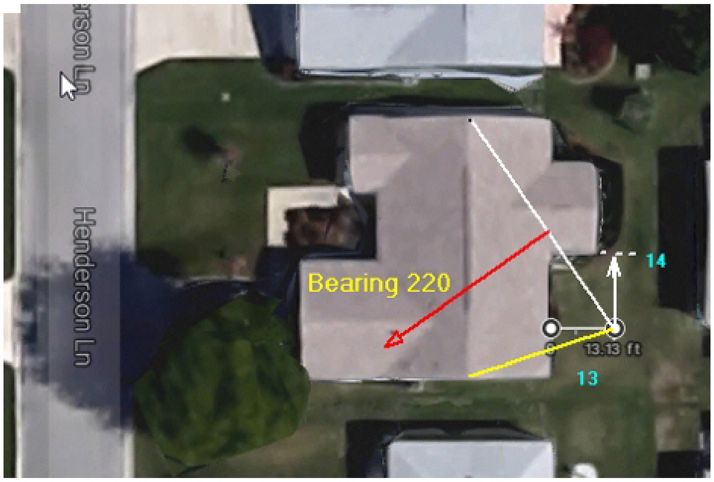
AA-55 Zoom –Vswr **LINEAR** Scale 50Ω

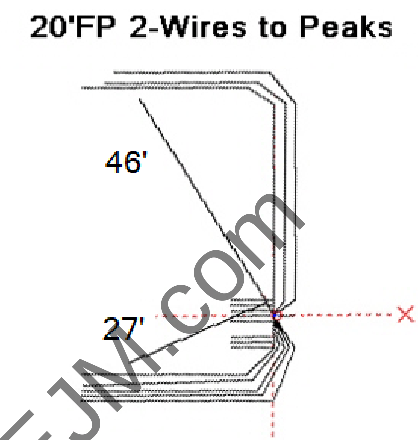
Site 2 in **2017**

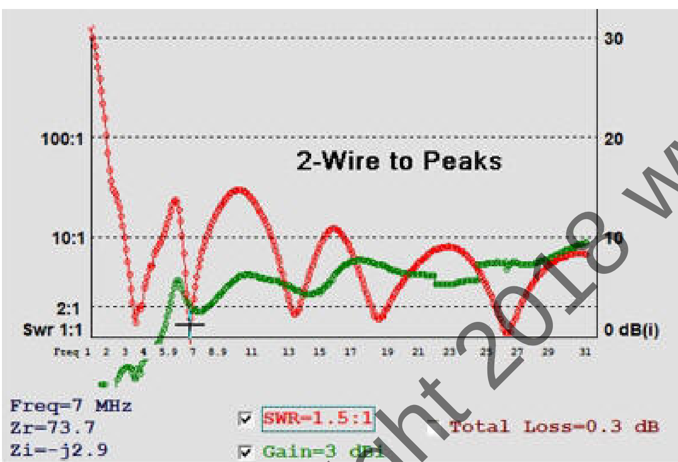
–In- Shack IC-7300 tunes 75 through 10

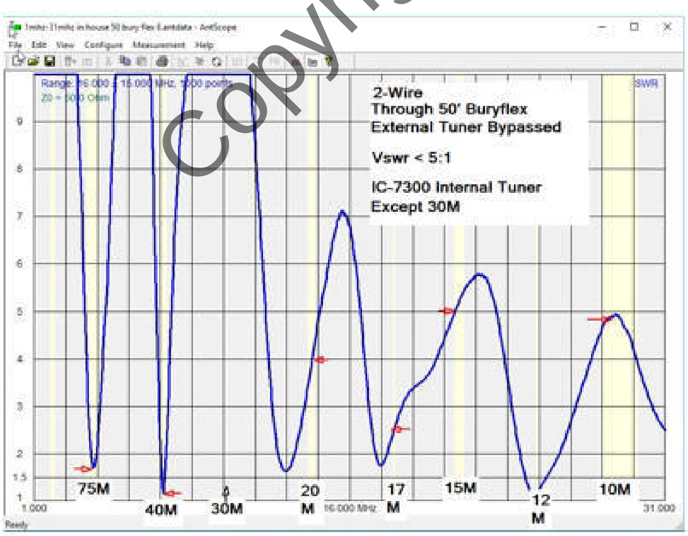
–Blue SWR Plot below is direct 50Ω coax to antenna feed point

–Operator generally uses the Auto-Tuner at the FP Base to avoid tuning concerns









Top Model Vswr **LOG** Scale 50Ω

Bottom AA-55 Zoom –Vswr **LINEAR** Scale 50Ω

Site 3 Install at **W1EJM** QTH 2017 Testing and 2018 Daily Use

–Daily SSB use on 75 and 40 regular use on 20 – 10 Meters 100w or LL.

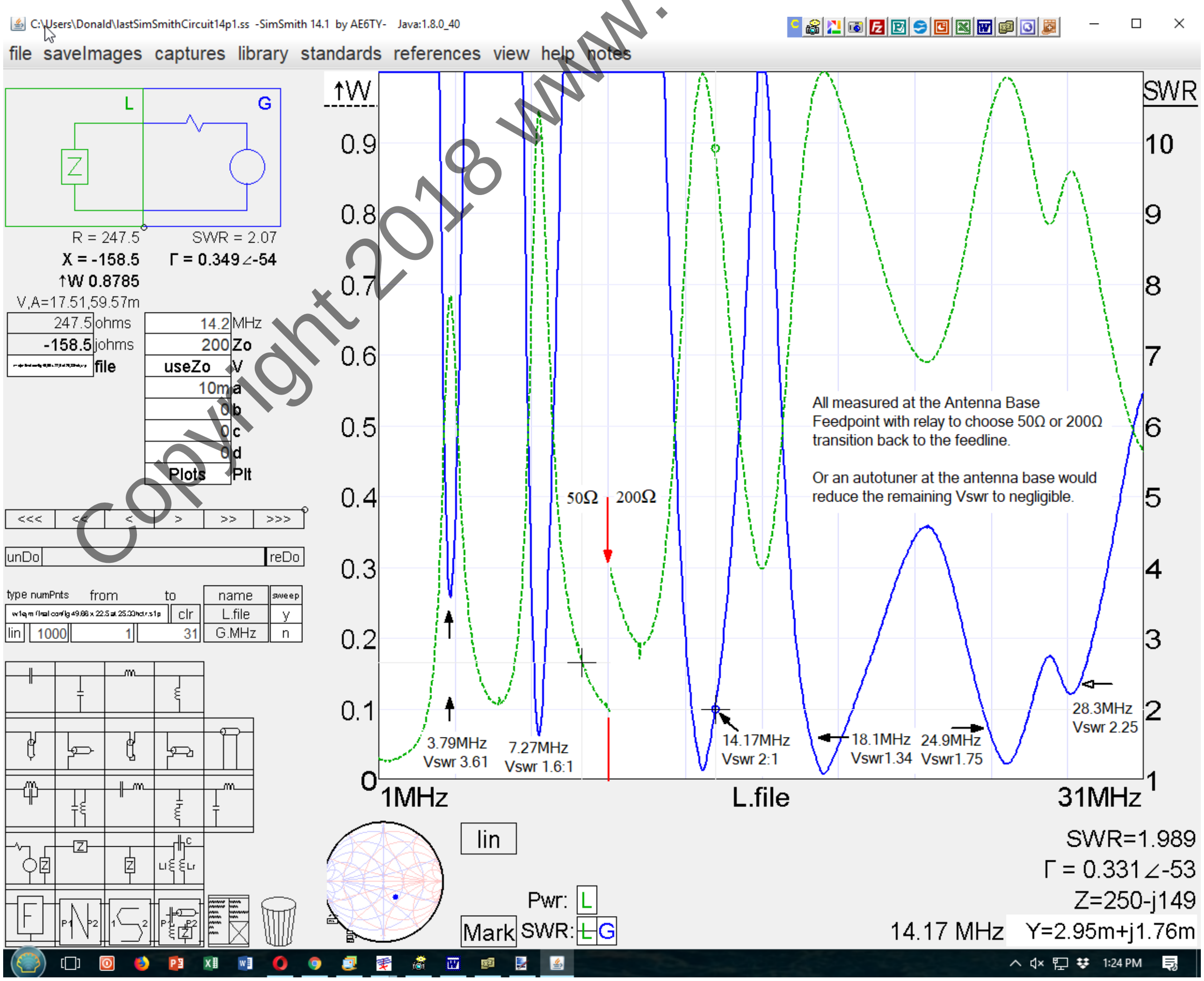
–Preliminary test/data collection and angular sensitivity testing

–In- Shack IC-7300 Internal Tuner

- 60' RG8u, Z=50Ω, tunes 75 - 10 (200KHz on 75), No match on 30 or 15 Meters
- 60' RG8u, 4:1 Step-Up UnUn at base, No Match on 75 or 30 Meters all other bands Vswr less than 1.7 to 1 was easily matched by IC-7300 Internal Tuner.

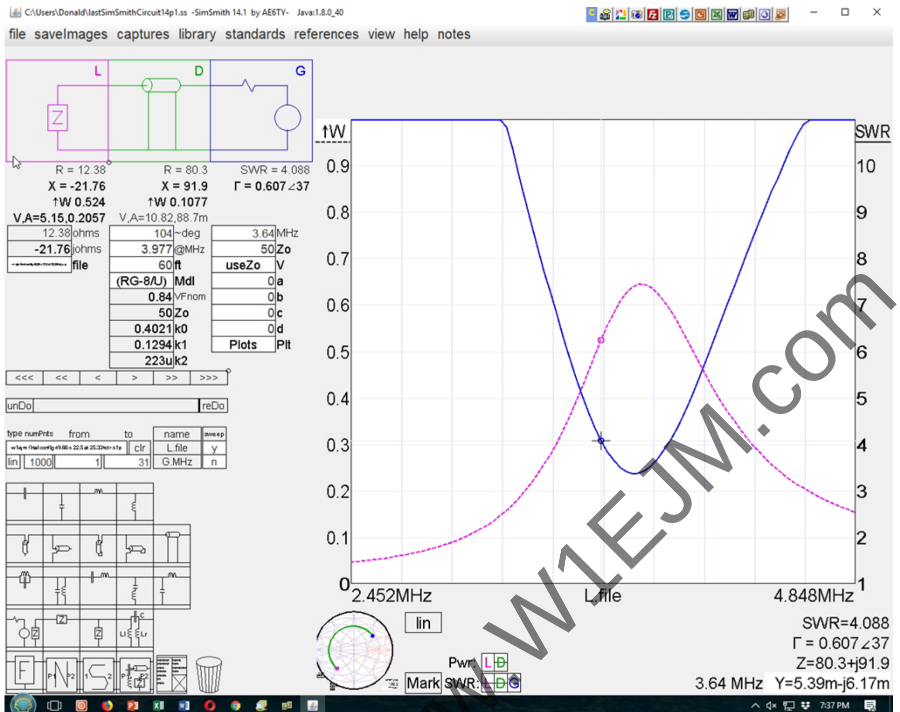
We used SimSmith and the Frequency, Vswr, R and X from the Rig Expert AA-55-Zoom.
File named: w1ejm final config 49.66 x 22.5 at 25.33hctr.s1p
We used that file to display the test result and then used the SimSmith program to select L/C values needed at the antenna base to match the RG8u feed line.
The intent was to determine the range of L/C values needed for matching to 50**Ω** for the full band 3.5 to 4.0 Mhz. Those value limits were L=2.37 to 3.6uH while C=198pF to 1100pF.

These values are in the range of inexpensive L network Auto Tuners (L=0.72uh to ~25uH and C=15pF through 4000pF) which would operate at the antenna base.

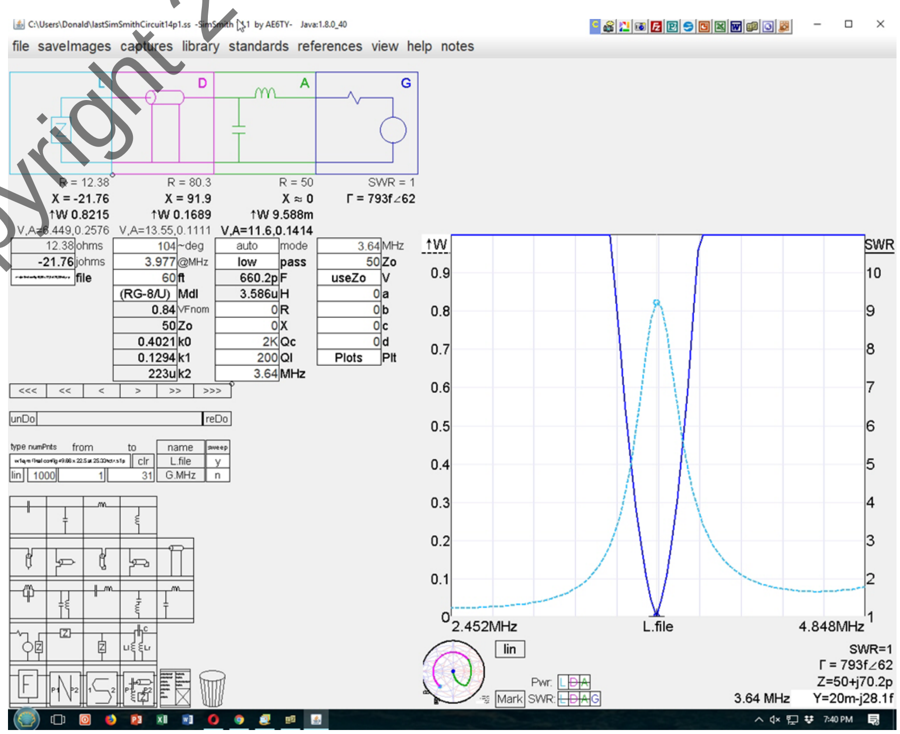


Sample at 3.64MHz

Without a Network
In shack Vswr 4.088 if unmatched then loss at Pant 0.524w ~ -3db



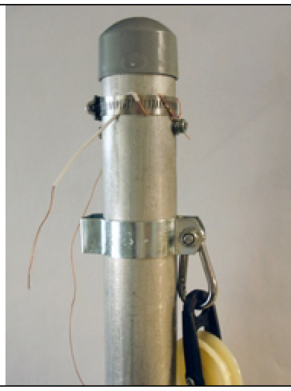
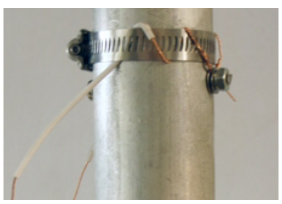
With an L/C Network
In shack Vswr 1.0 when matched then loss at Pant 0.8215w ~ -0.85db ~ 2db less loss



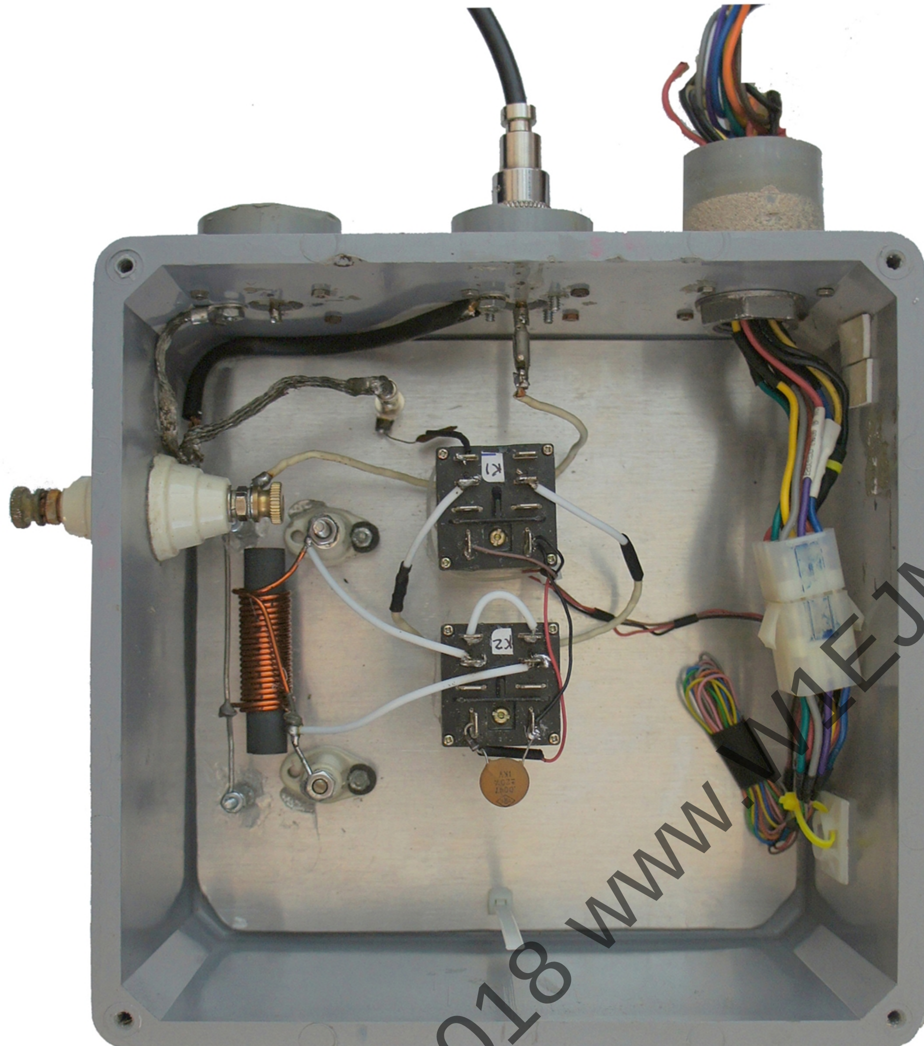
Antenna Mechanical Details and Parts Identification:

Antenna, Strain Relief Flattop connection

Mast: Can be a conductive pole that is insulated from ground at the Feed Point or a non conductive mast wit #16 wire as the vertical electrical member.

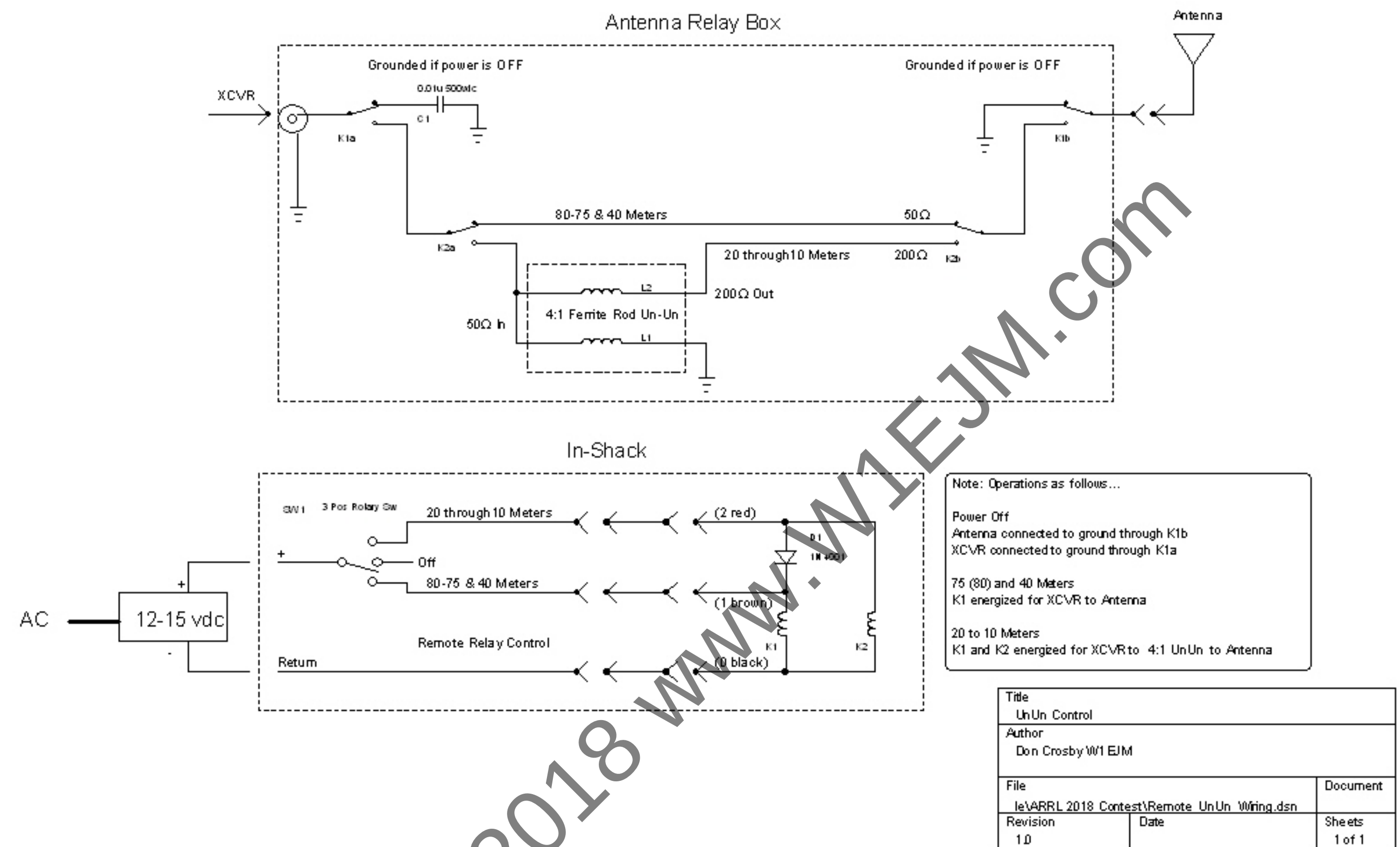
		Conduit Cap Stainless Hose Clamp FP Pulley (optional)
		Stainless Steel Hose Clamp w/ abrasion resist tubing. Teflon Tubing 2mm ID or plastic tube from Windex Squirt Bottle
		Blood Run , Uninsulated Stranded 1x7 Copper Trolling Wire, tin/nickel 32 lb test 0.030 in dia.
		Monofilament Fishing Line 30 LB Test or Spiderwire Fishing line EZ Braid Line, 20 LB Test #1140573 Moss Green

Remote Enclosure for Relays and 4:1 Step-Up Un-Un



Parts List:
4:1 Step-Up UnUn 50Ω to 200Ω rod or toroid shape (I used a salvaged W2AU unit)
Power Relay DPDT Amarat AP622198 12v DC Coil
Connectors, feed thrus standoffs, non critical, use as available
Weatherproof Box 8x8x4 www.Homedepot.com Cantex Model# E989N-CAR

Schematic Relay Box and Control Switch



Computer Files:

- Nec2Go file: ARRL 2Wire 22Vert-L 24 Rad.ant
- 4Nec2 file: ARRL 2Wire 22Vert-L 24 Rad.nec
- Rig Expert file: w1ejm final config 49.66 x 22.5 at 25.33hctr.s1p

Windom:

The Windom is a member of the horizontal Dipole family antenna. It is 1/2 λ long at the lowest operating frequency and exhibits good performance on it's even harmonics.

The Windom is fed somewhat off center at a high Z point commonly using ladder line or a Balun to connect from the feed point to another location. At that location, a variety of matching topologies are used to transform the balanced system to an unbalanced low Z for ease of use.

Of special interest is that the original feed system for the Windom in year ~1927 was a single conductor attached to the (offset) feed point on the horizontal wire. That single feed wire was attached to a high Z, single ended matching unit referenced to ground and then to the transmitter. The configuration was described in QST, September 1929.

Radials:

4Nec2 and Nec2Go programs use the NEC-2 calculation engine and neither of these programs can allows wires (radials) below ground in the model.

L.B. Cebik W4RNL (SK) compared modeling results for above and below ground radials (in the May 2001 antenneX Online Issue #49) and concluded that NEC-2 produced results that were "reasonable enough" to allow "usable" modeling of radials above ground with NEC-2 given the caveat that performance predictions would not be as accurate as those which used the NEC-4 modeling engine which allows radials below ground.

Above/Below Ground Radials: L.B. Cebik W4RNL (SK) authored many antenna articles and did a great deal of NEC based modeling. He occasionally addressed modeling radials above and below ground and believed that above ground modeling was acceptable for ham use (wires below ground are a not supported in NEC-2).

Safety:

RF voltage is present at ground level on the antenna mast so precautions are taken. When I activate the main switch in my shack to power my equipment, the receiver unit of an "infrared driveway sensor" is also powered up. The receiver gives an audible sound to indicate it's operating. The sonic output from the receiver triggers a 'flip flop' and disables the transmitter key and PTT line, thus preventing RF to the antenna. The 'flip-flop' is reset each day by manual pushbutton to return to normal operation. Batteries in the sensor are recharged by a small solar panel.