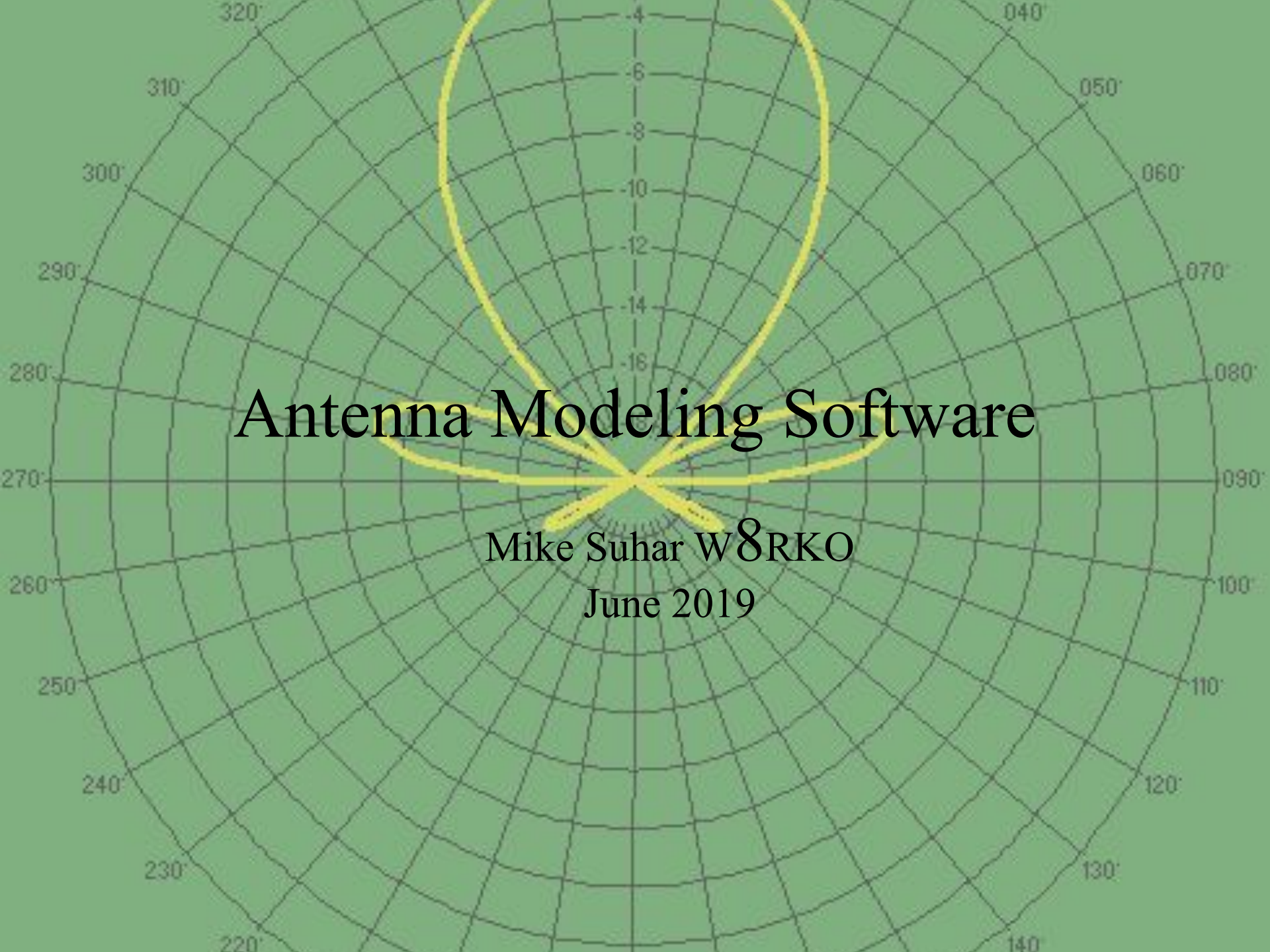


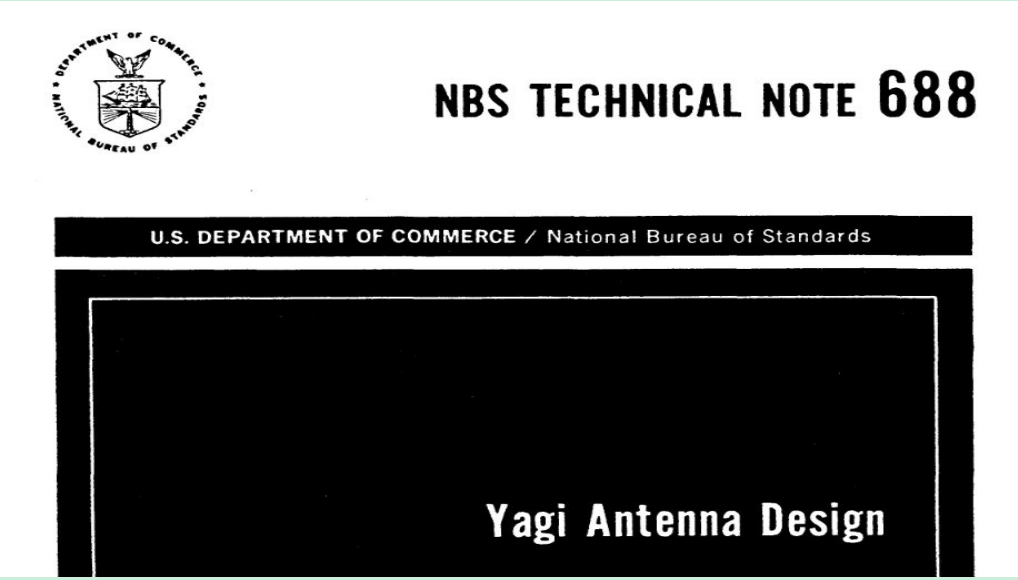
Antenna Modeling Software

Mike Suhar W8RKO

June 2019

The Old Days

The best design was a paper by U.S. Department of Commerce/National Bureau of Standards. Document NBS-TN-688, December 1966



For This Presentation

- YagiCAD (VK3DIP)
- EZ-NEC (version 6)
- Quick discussion of:
  - YAGIMAX
  - YAGI Calculator (VK5DJ)
  - Antenna Optimizer (ao.exe)
  - DOSBox (DOS emulator for Linux or Windows)

Word of Caution

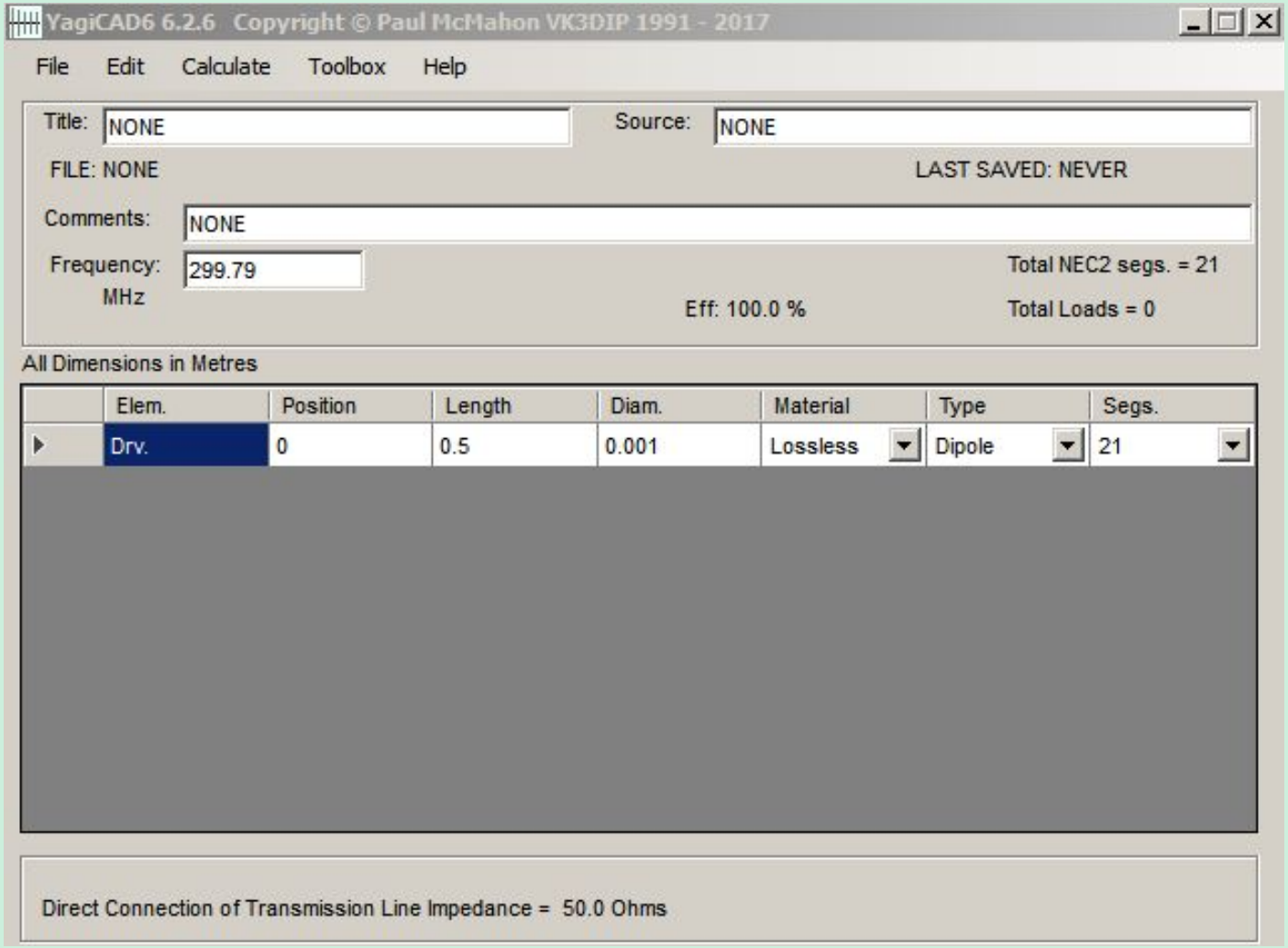
READ the documentation for and understand the capabilities and LIMITATIONS.

- YAGIMAX and AO analyze monoband yagis only
  - Will not work for Long Periodic antennas
- NEC2 can not analyze radials in the ground or small loop antennas (<0.05 wavelength)
- Frequency limitations
- Number of elements for the YAGI programs
- For some structures/antennas may need to be creative how they are entered.

YagiCAD

- Engine appears to be NEC2 as of version 6
- Help file could be better (including what is on the website)
- Will export files for NEC2, NEC4, EZ-NEC
- Use examples provided or enter your own data
- Will scale design to other frequencies
- Designs the match (folded dipole, gamma, etc)
- Optimizes design


Demo Time
ICANHASCHEEZBURGER.COM

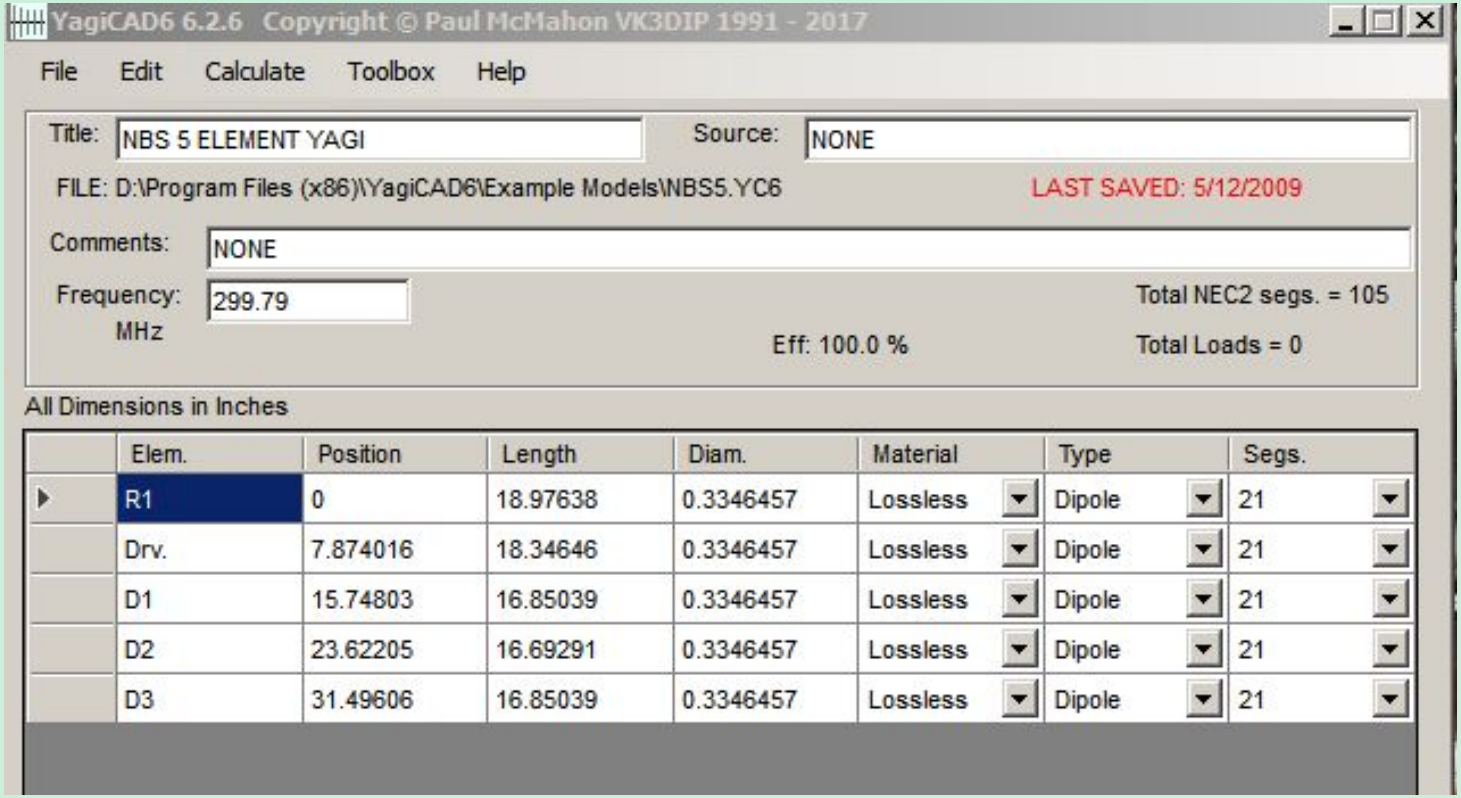


YagiCAD Main Window

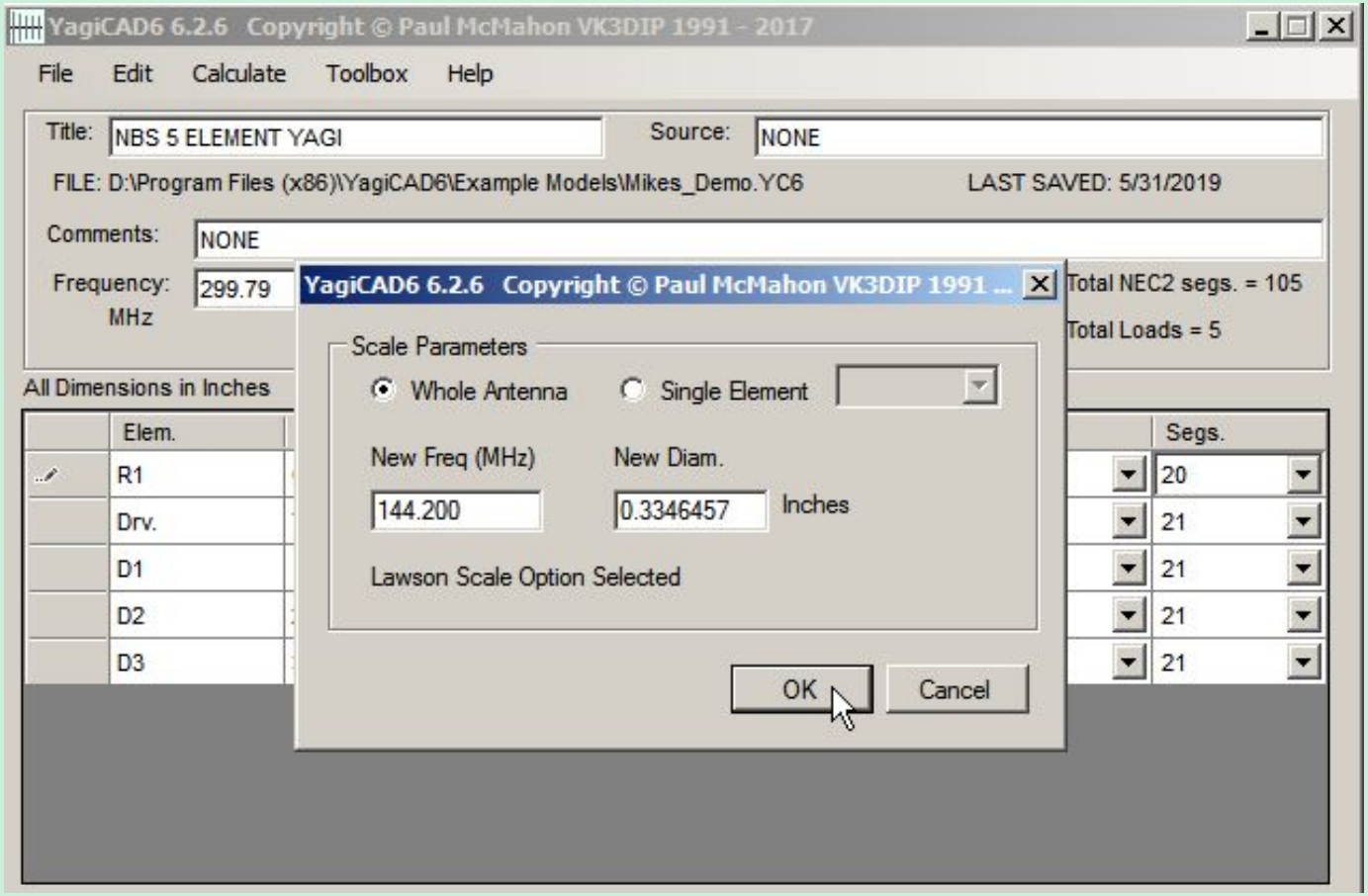
Software Provides Example Models

- 2mCornerReflector.YC6
- 4e315mFFY.YC6
- 4el6mOWA.YC6
- 4el6mWBOWA.YC6
- 5el2mOWA.YC6
- 5el6mOWA.YC6
- 8el2mQuagi.YC6
- 8el70cmOWA.YC6
- 9el70cmOWA.YC6
- 10el70cmOWA.YC6
- 11e2mLFA.YC6
- 12e2mLFA.YC6
- 12el23cm.YC6
- 12el23cmOWALowQ.YC6
- 12el70cmOWA.YC6
- 13e23cmLFA.YC6
- 23cm12EowaTRIG.YC6
- 70cmK6YNBQuagi.YC6
- ais_159mhz-4e.YC6
- ARRL40m3quad.YC6
- cebik3.YC6
- Cebik6el2mOWA.YC6
- Cebik7el2mOWA.YC6
- Cebik8el70cmOWA.YC6
- Cebik12el2mOWA.YC6
- Cebik12elOWA2m.YC6
- Cebik12elOWA70cm.YC6
- CHCH6.YC6
- CHCH10.YC6
- DL6WU20.YC6
- EF0213.YC6
- EF7012.YC6
- K6YNBQuagi.YC6
- LAW3.YC6
- LAW4.YC6
- LAW4P.YC6
- LAW5.YC6
- LAW6.YC6
- lyngby.YC6
- NBS3.YC6
- NBS5.YC6
- NBS6.YC6
- NBS12.YC6
- NBS15.YC6
- NBS17.YC6
- OptVE3SQB3el2mQuad.YC6
- VE3SQB3el2mQuad.YC6
- VE3SQB8el2mQuagi.YC6

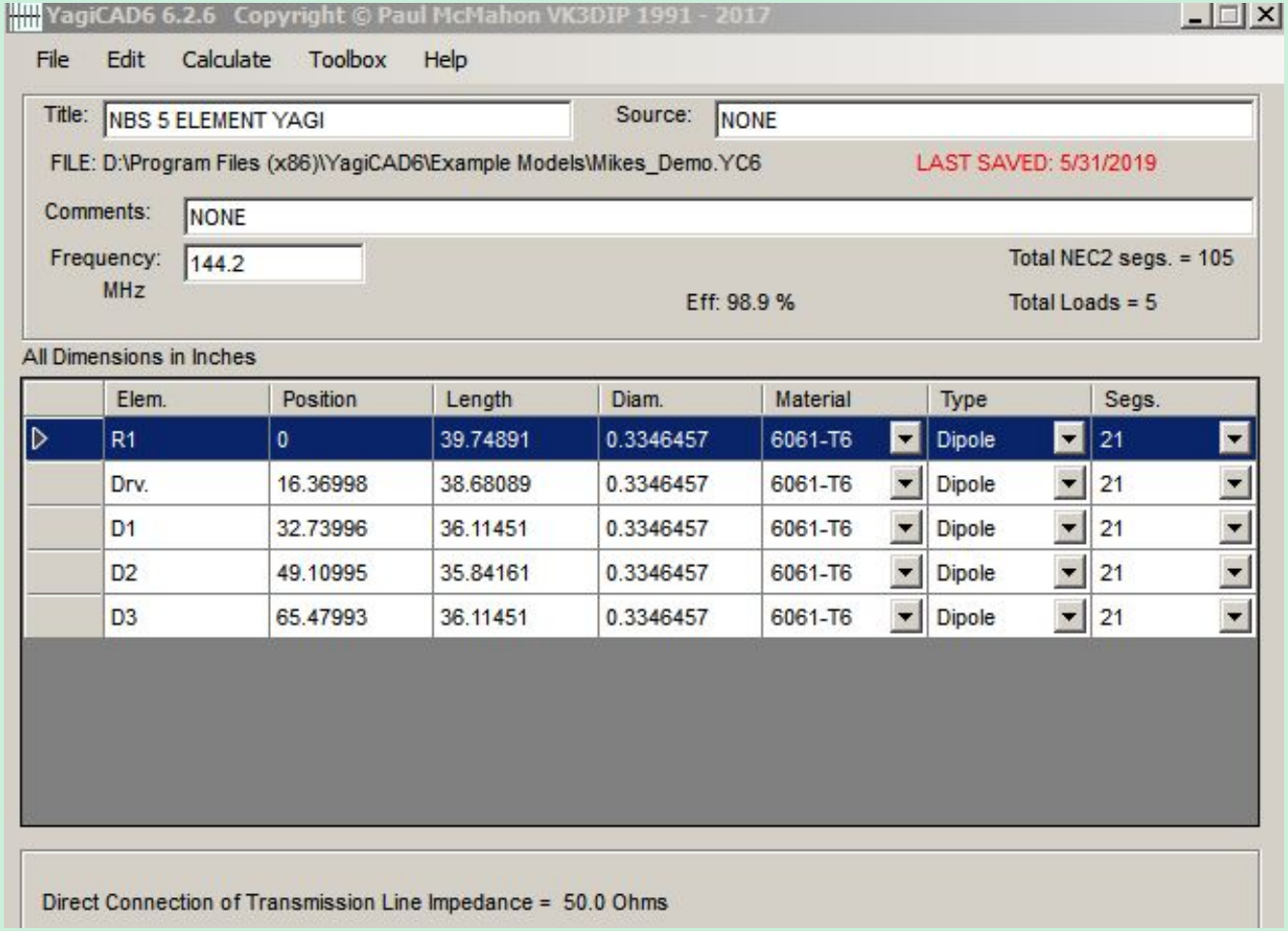
Will select the 5 element NBS example Note the model's frequency (299.79 MHz)



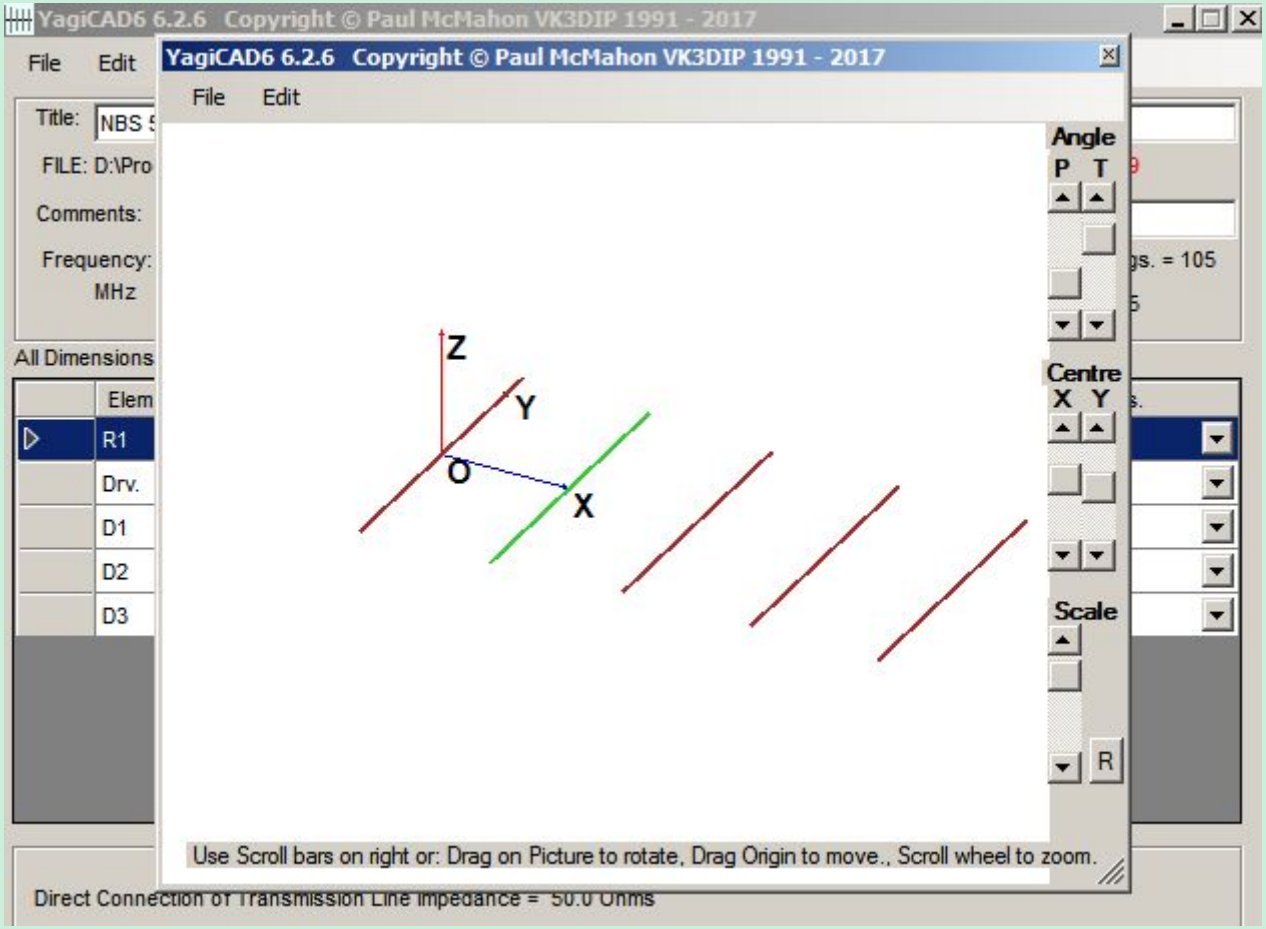
Scale to your frequency. On Menu select Toolbox/Scale



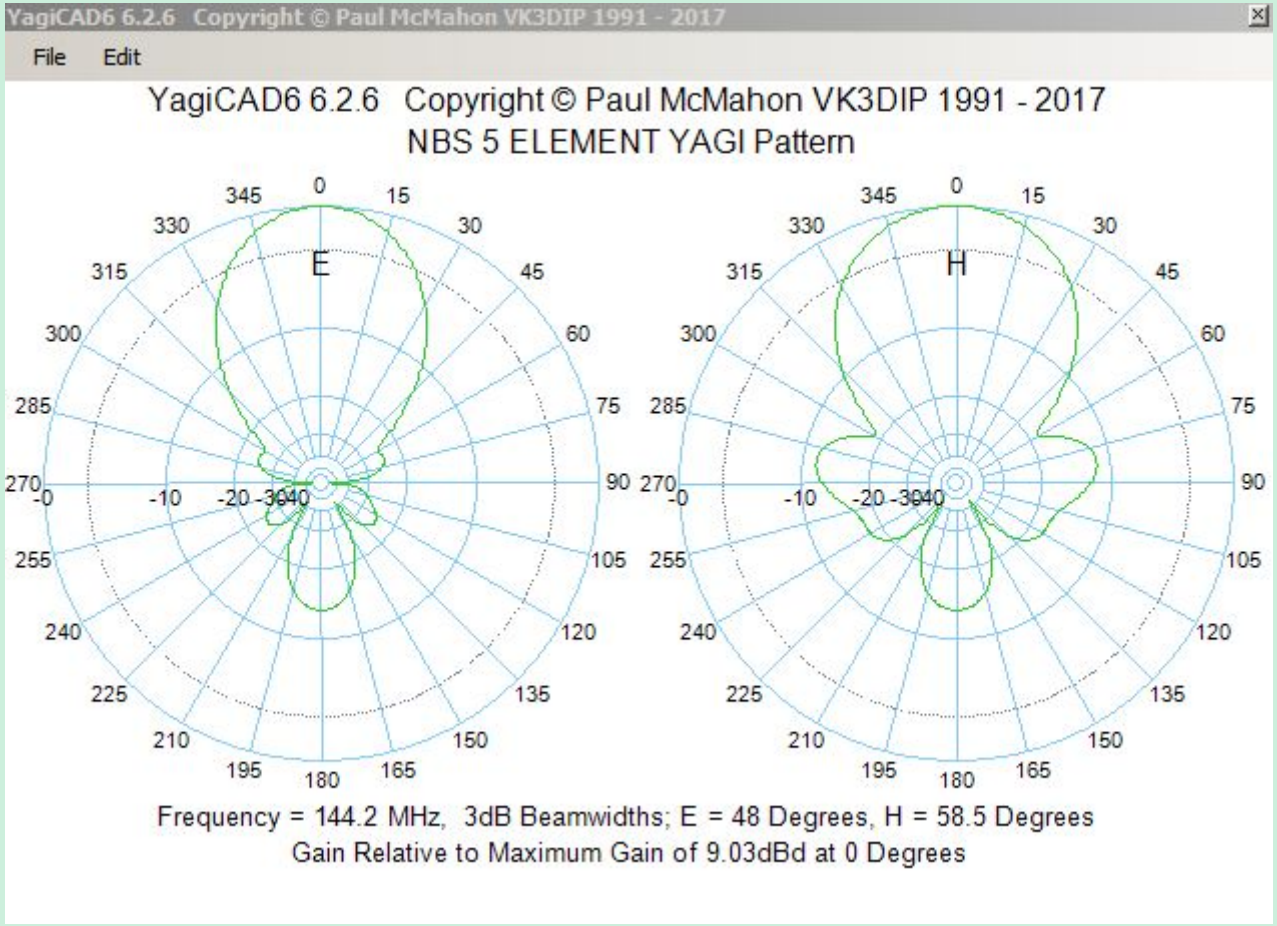
We now have the antenna on 144.2 MHz



The antenna looks like (Toolbox/View Yagi):

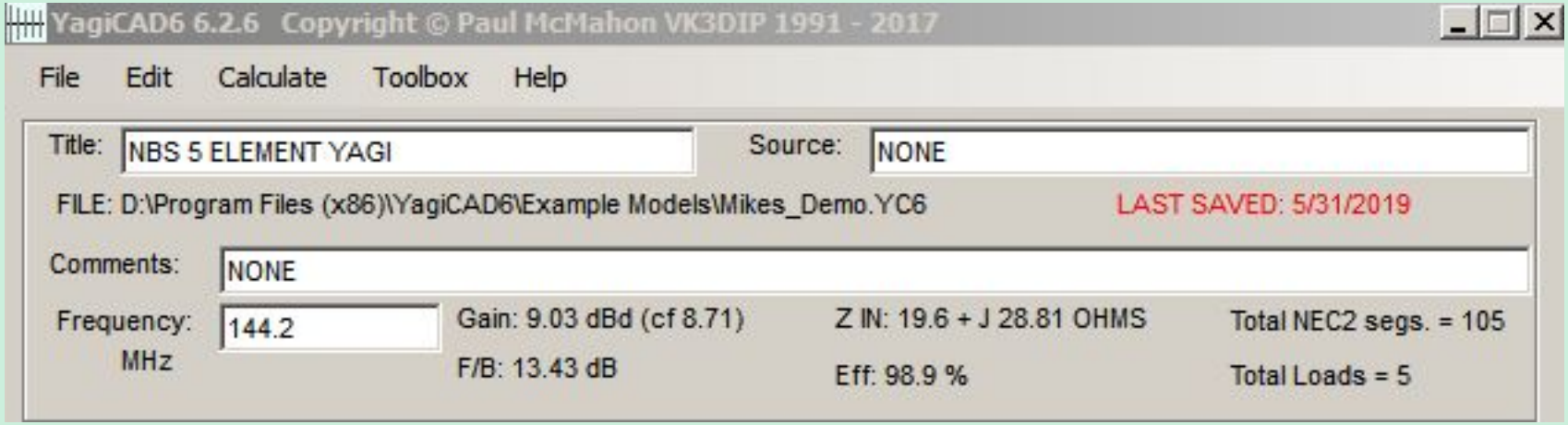


Calculate the pattern as it stands now
(Calculate/Pattern at 144.2 MHz)



Pattern plots are most often shown in either the plane of the axis of the antenna or the plane perpendicular to the axis and are referred to as the azimuth or "E-plane" and the elevation or "H-plane" respectively.

Calculate/Basic provides Impedance, Front-to-back and efficiency



The driven element impedance of 19.6 +j 28.82 is poor referenced to 50 ohms (VSWR = 3.5:1). We can run the program for a gamma match (or something else), but first lets optimize the antenna.

First optimization will be front-to-back by changing the spacing and then lengths of the elements. Driven element length optimized for resonance. On the menu Calculate/Auto Optimize – Front-to-back. Save your current yagi with a new name incase you screw it up and have to start over.

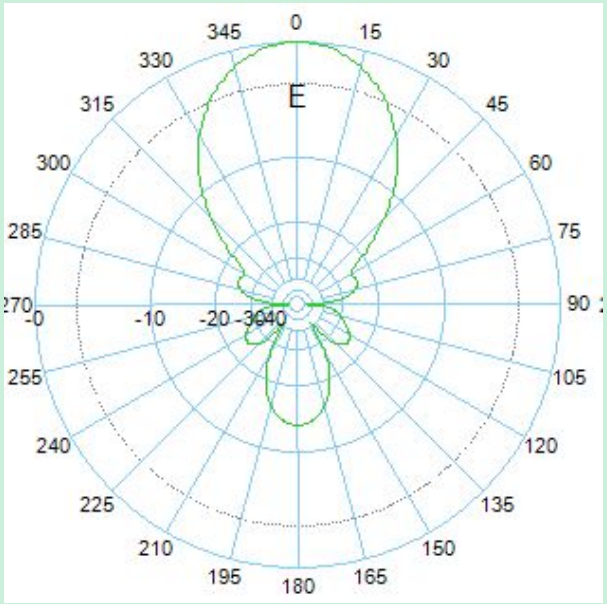
Before: Drv: 16.37, D1: 32.74, D2: 49.11, D3: 65.48 (spacing)

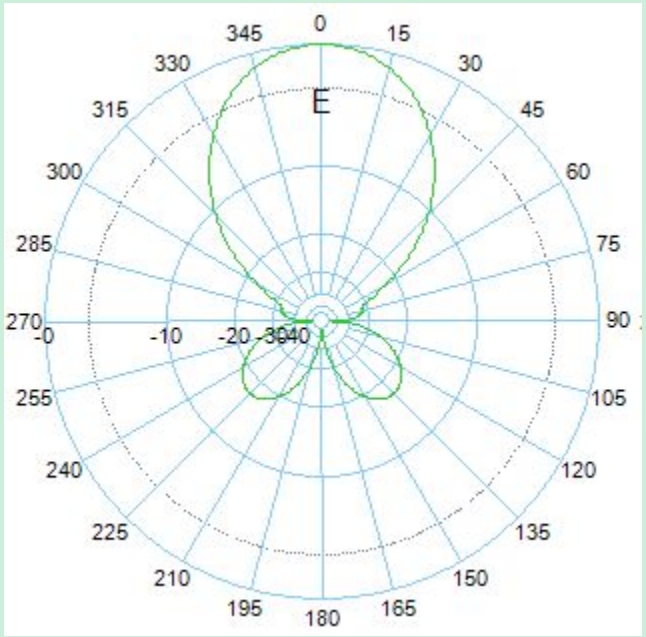
F/B 13.4 DB, Z: 19.6+j28.81, Fwd Gain: 9.03 DBd

After: Drv: 23.94”, D1: 32.9, D2: 49.04, D3: 65.49

F/B 73 DB, Z: 27.34 –j0.06 (VSWR 1.9:1), Fwd Gain: 8.14 DBd

But look at the pattern (before – after)



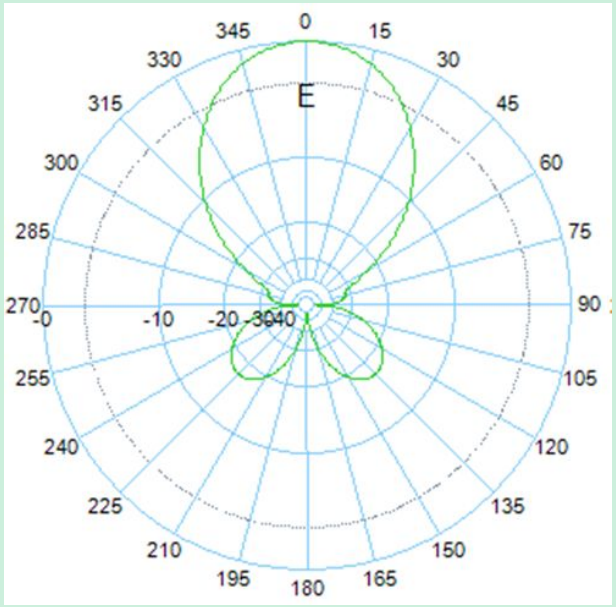


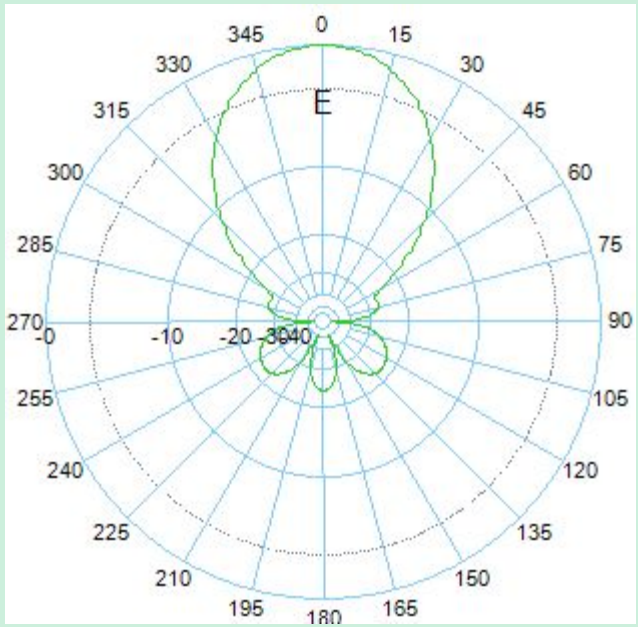
The previous optimization produced F/B of 73DB which is probably not realistic. Also, two side lobes appeared. Lets to this again but optimize for the general pattern.

1st Opt: Drv: 23.94", D1: 32.9, D2: 49.04, D3: 65.49, F/B: 73 DB,
Z: 27.34 –j0.06 (VSWR 1.9:1), Fwd Gain: 8.14 DBd

2nd Opt: Drv: 22.14, D1: 32.73, D2: 49.11, D3: 65.48
F/B: 24 DB, Z: 34.3 +j6.27 (VSWR 1.5:1), Fwd Gain: 8.5 DBd

First vs Second Optimization Pattern:





Final Design

YagiCAD6 6.2.6 Copyright © Paul McMahon VK3DIP 1991 - 2017

File Edit Calculate Toolbox Help

Title: NBS 5 ELEMENT YAGI Source: NONE

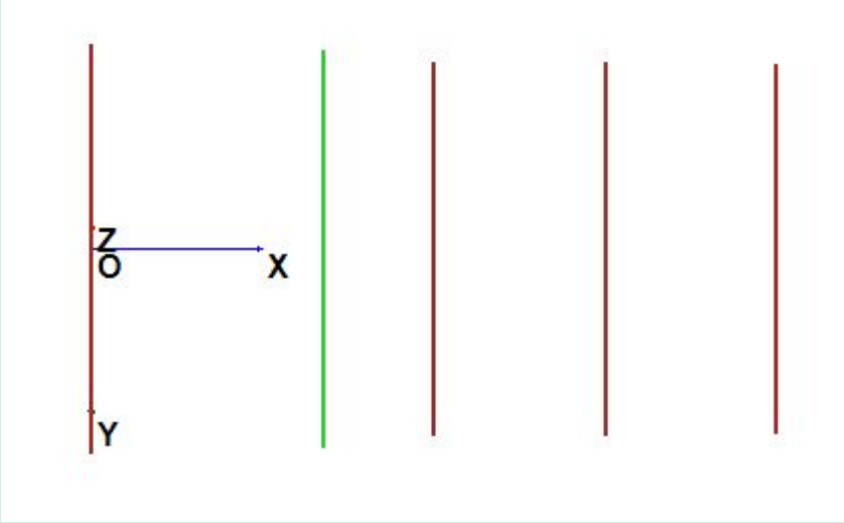
FILE: D:\Program Files (x86)\YagiCAD6\Example Models\Mikes_Demo_V2.YC6 LAST SAVED: 5/31/2019

Comments: NONE

Frequency: 144.2 MHz Gain: 8.5 dBd (cf 8.71) F/B: 23.98 dB Z IN: 34.3 + J 6.27 OHMS Eff: 99.2 % Total NEC2 segs. = 105 Total Loads = 5

All Dimensions in Inches

	Elem.	Position	Length	Diam.	Material	Type	Segs.
▷	R1	0	39.7489	0.3346457	6061-T6	Dipole	21
	Drv.	22.14046	38.68089	0.3346457	6061-T6	Dipole	21
	D1	32.73485	36.11451	0.3346457	6061-T6	Dipole	21
	D2	49.11237	36.43502	0.3346457	6061-T6	Dipole	21
	D3	65.47992	36.02448	0.3346457	6061-T6	Dipole	21

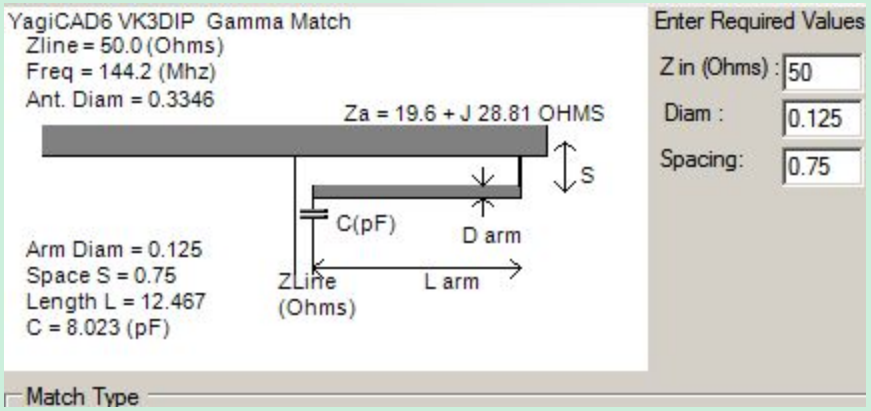


Design a Match

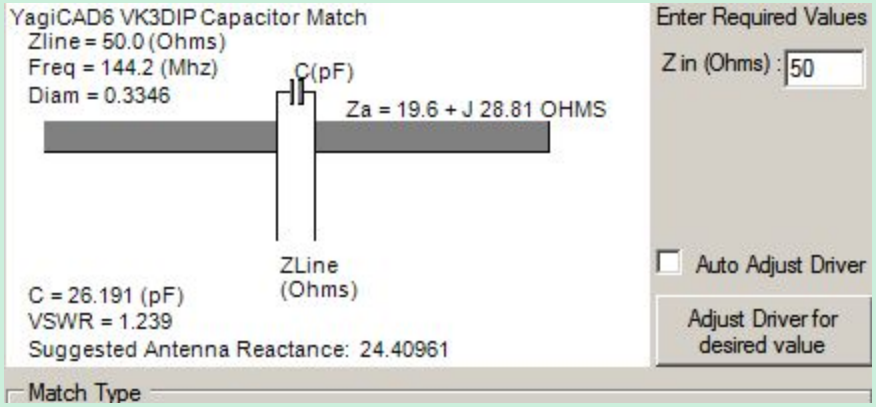
- Based on the original Z of 19.6 +j28.81 (3.5:1 VSWR)
- Some matches won't work with positive reactance: Hairpin, Inductor
- Program optimization for resonance allow you to specify a reactance.
- Some won't work as the Z values are out of range for that match: Gamma (no C), Tee (no C), Gamma with some values of the rod and spacing (rod 1/8", spacing ¾")
- Folded dipole required a very large diameter top element!

Working with what we have

- Gamma Match



- Capacitor, but note it wants “j” of +24.4

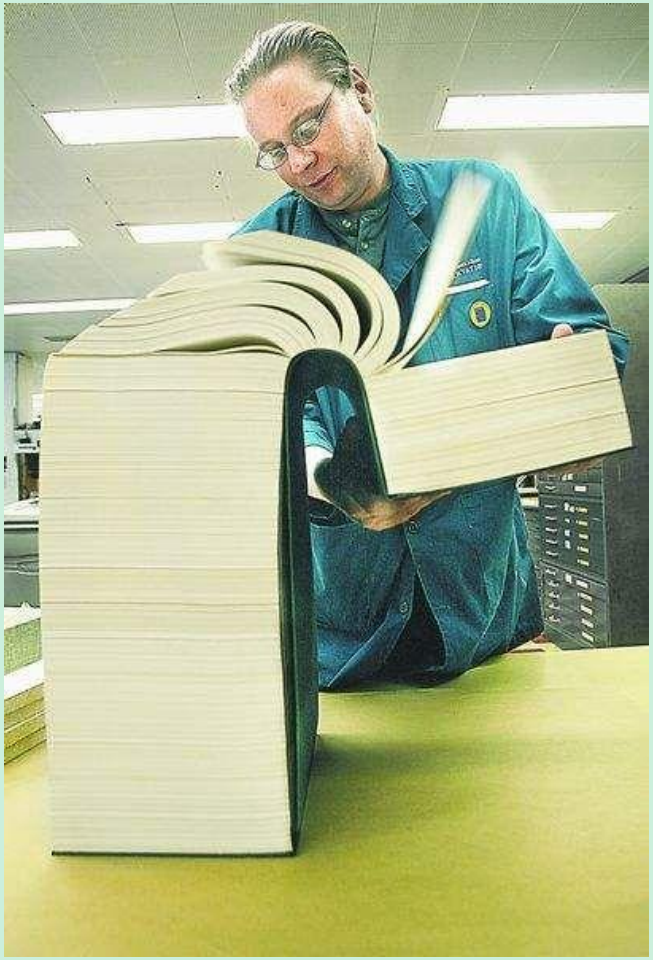


EZ-NEC (www.eznec.com)

Roy Lewallen, W7EL

- Four versions available (windows only):
  - Free version
    - Limited in number of “wires” (500)
  - EZNEC +
    - 2000 “wires
    - 10000 frequency steps vs 1000
    - More SWR displays: smith chart, return loss, etc
    - Circular polarization vs only linear on free version
    - Others
  - EZNEC PRO (/2 and /4)
    - /4 version uses NEC-4 engine. All others use NEC-2
    - /4 Requires NEC-4 license so cost is much higher
    - Other enhancements too numerous to show here. See website

Read the Manual



Model Tower

Effective Diameter of a tower for conversion to a "wire" in NEC:

$$= \left(\frac{D*F^2}{2}\right)^{\frac{1}{3}}$$

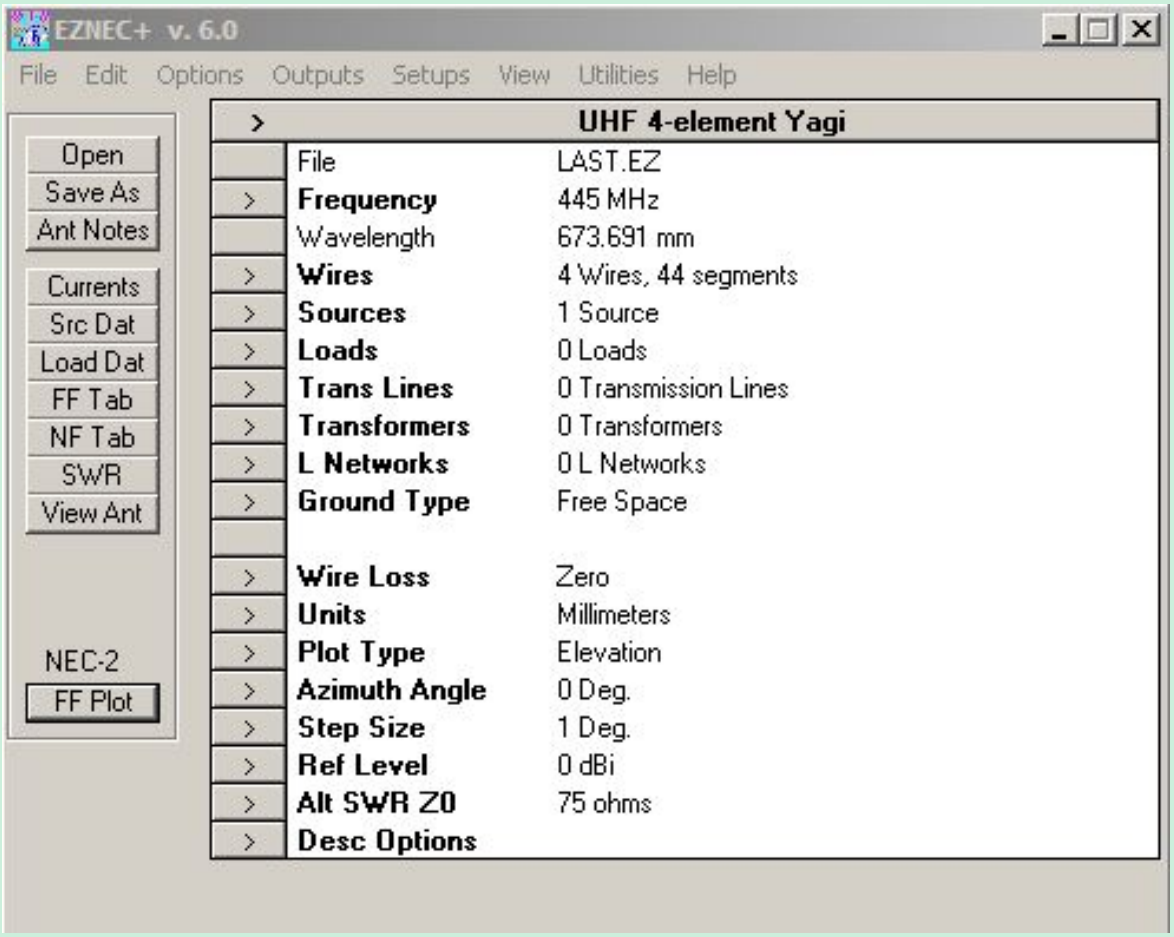
That is the CUBE root.
D = Diameter of a leg
F = Face width
Use the same units of measure

For a Rohn 25:
D = 1.25"
F = 12"

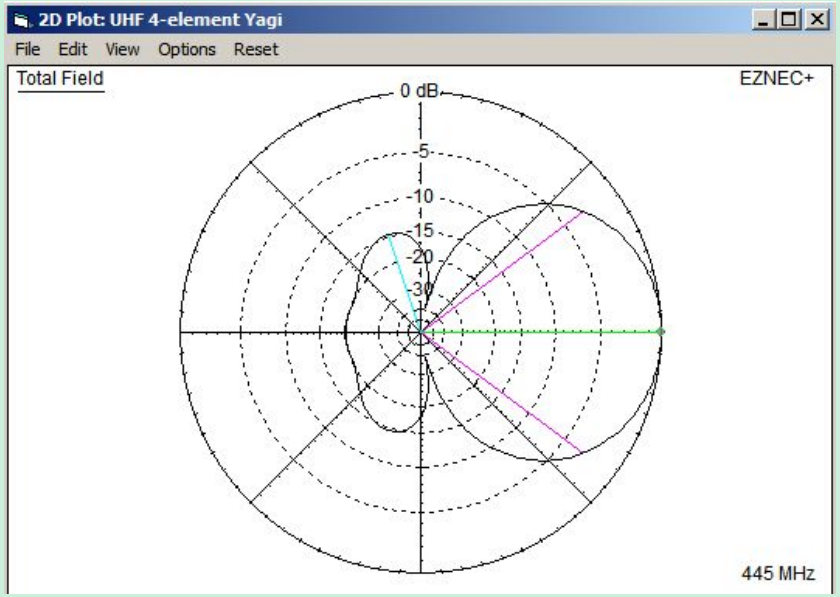
Effective wire diameter=
((1.25*12^2)/2)^(1/3)=4.4814"

Oh good grief. Your not going to let this clown give another demo!

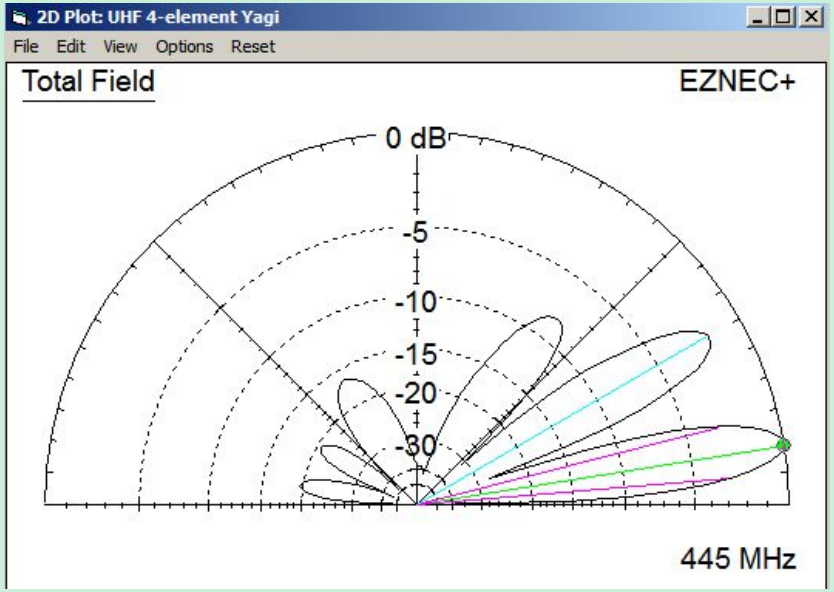
EZ-Nec Main Window



Free Space vs a Ground
Elevation Plot

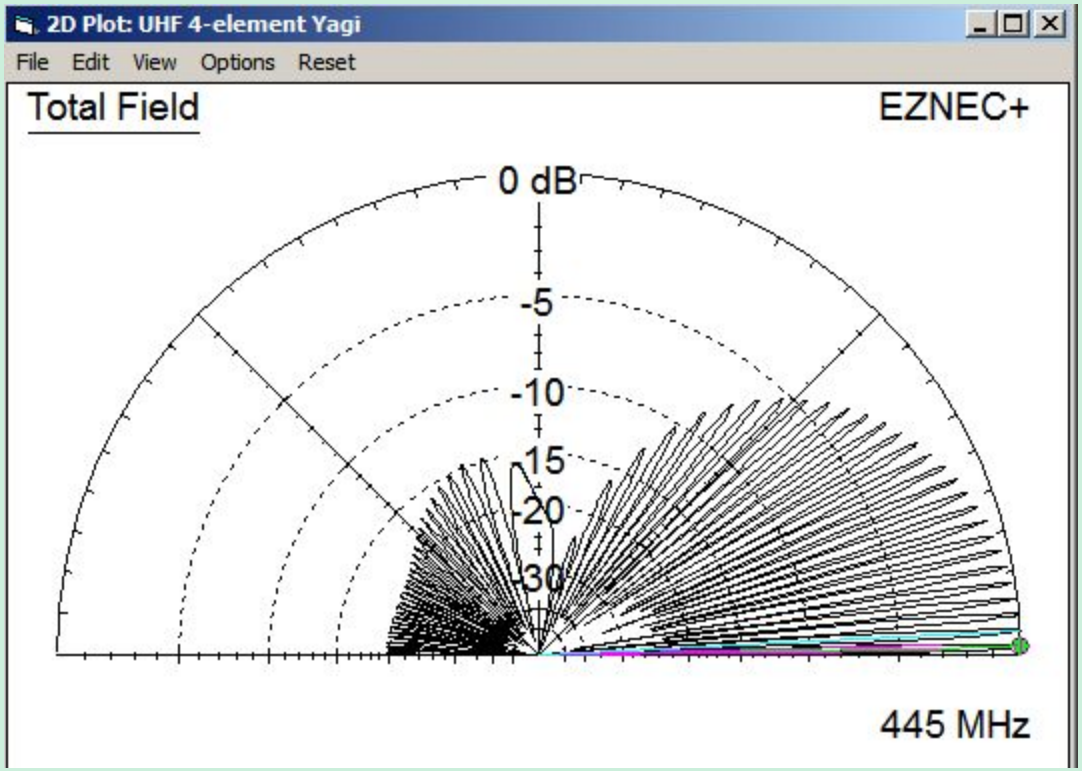


Free Space



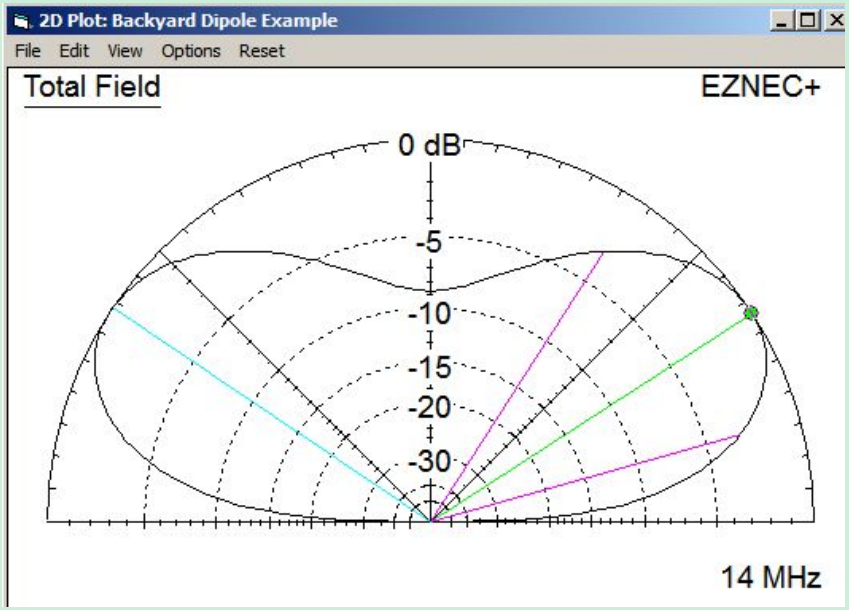
1 meter above perfect Ground

Antenna height (Z) changed to 10,000 mm (32 feet), perfect ground, angle step size set to 0.1 degree. Pattern looks odd so program having issue with height vs wavelength over ground. Looking more like free space.

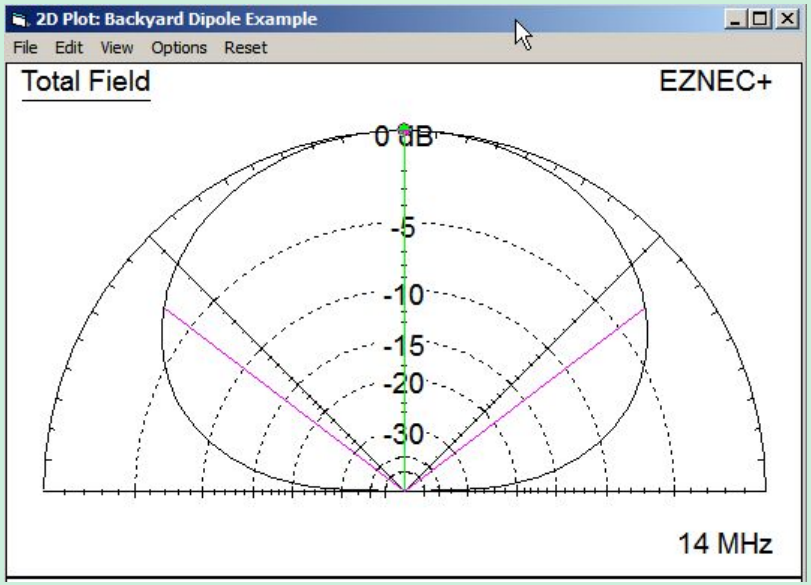


NVIS designs

Near Vertical Incidence Skywave



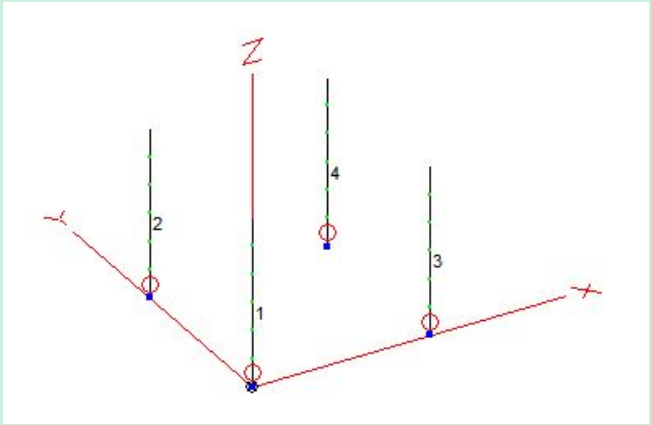
20 meter dipole at 30 feet. Not NVIS



20 meter dipole at 10 feet. NVIS

4SQUARE

Note multiple phased sources

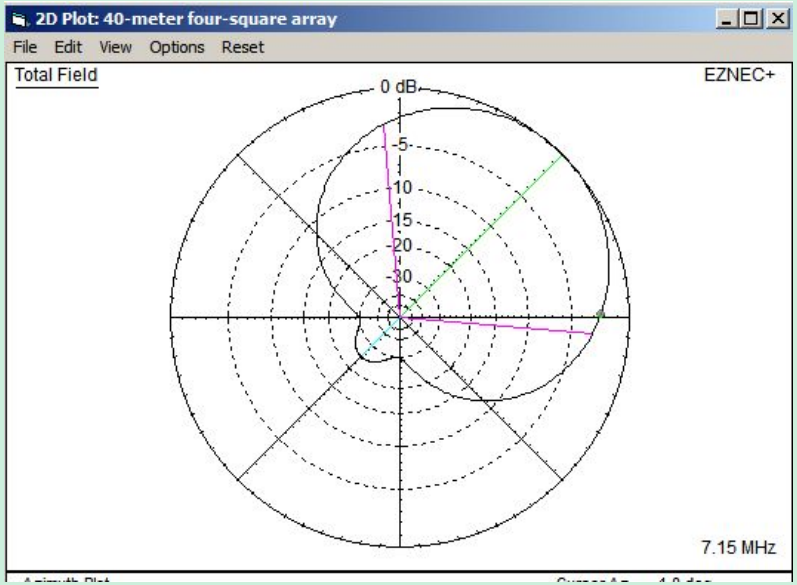


Sources

Source Edit

Sources

	No.	Specified Pos.		Actual Pos.		Amplitude	Phase	Type
		Wire #	% From E1	% From E1	Seg	(V, A)	(deg.)	
▶	1	1	0	8.33333	1	1	0	I
	2	2	0	8.33333	1	1	-90	I
	3	3	0	8.33333	1	1	-90	I
	4	4	0	8.33333	1	1	180	I
*								



My 160m Inverted-L

Wires

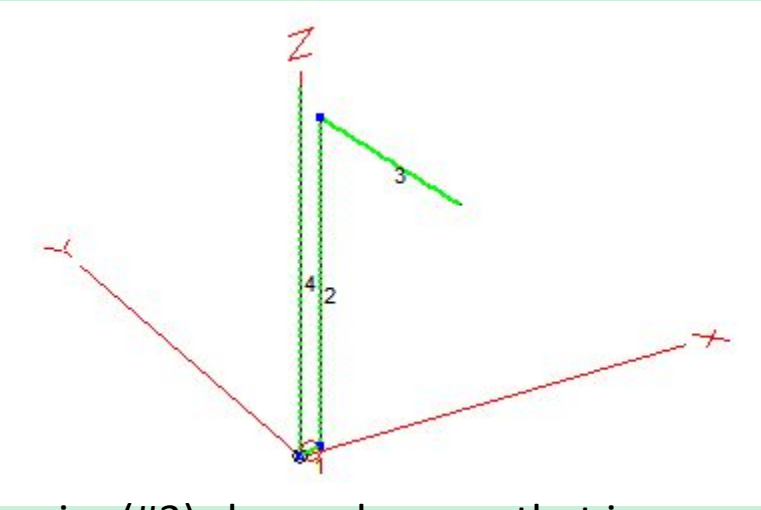
Wire Create Edit Other

☐ Coord Entry Mode ☐ Preserve Connections ☑ Show Wire Insulation

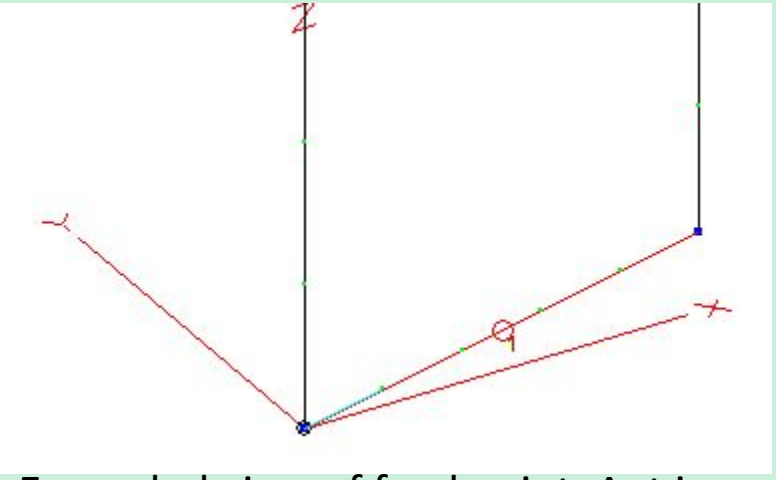
Wires

	No.	End 1				End 2				Diameter	Segs	Insulation	
		X (ft)	Y (ft)	Z (ft)	Conn	X (ft)	Y (ft)	Z (ft)	Conn	(in)		Diel C	Thk (in)
▶	1	0	0	0	Ground	5	0	1	W2E1	#12	5	3.5	0.045
	2	5	0	1	W1E2	5	0	80	W3E1	#12	50	3.5	0.045
	3	5	0	80	W2E2	39	0	49		#12	50	3.5	0.045
	4	0	0	0	Ground	0	0	90		4.48	50	1	0.045
*													

I have included my tower (wire #4) to see if there is any pattern distortion

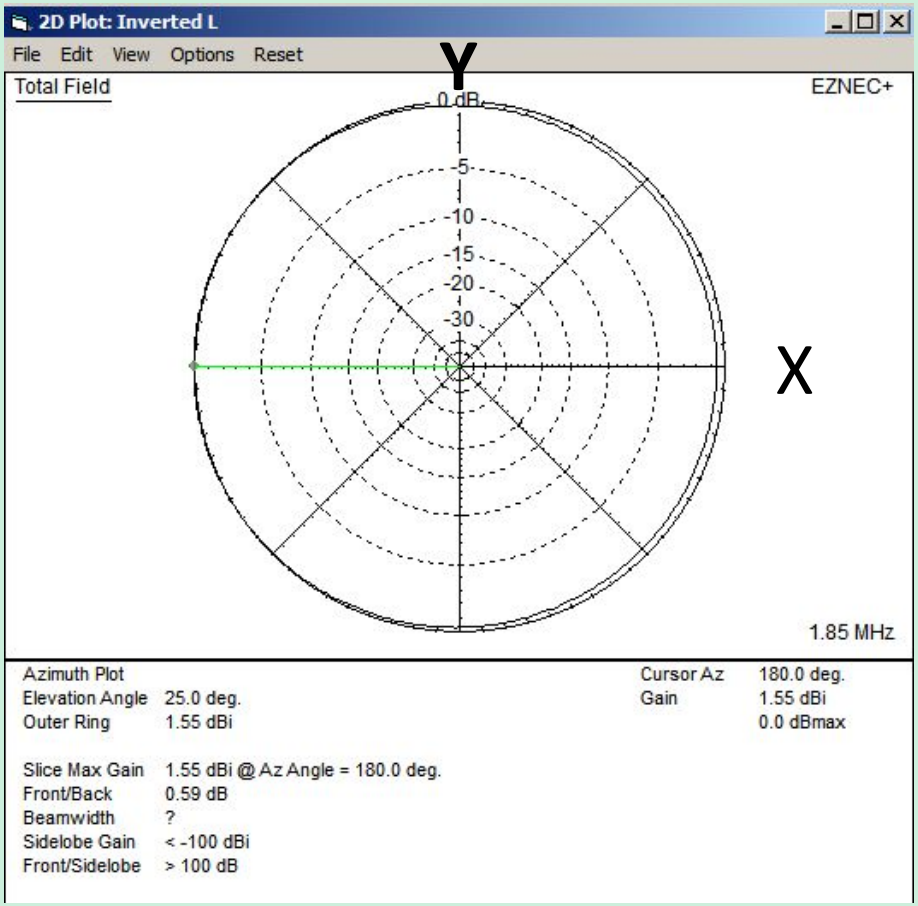


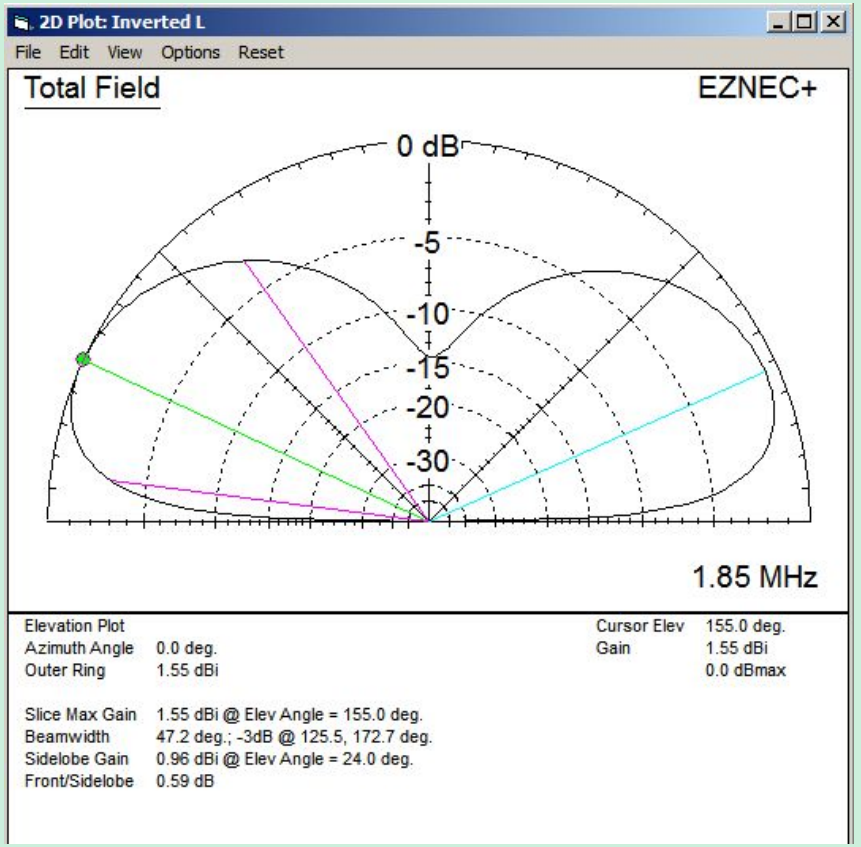
Note top wire (#3) slopes down as that is as high as I could get it in the tree



Expanded view of feed point. Ant is 5’ off of the tower.

Pattern


2D Plot: Inverted L
File Edit View Options Reset
Total Field
EZNEC+
Y
X
0 dB
-5
-10
-15
-20
-30
1.85 MHz
Azimuth Plot
Elevation Angle 25.0 deg.
Outer Ring 1.55 dBi
Cursor Az 180.0 deg.
Gain 1.55 dBi
0.0 dBmax
Slice Max Gain 1.55 dBi @ Az Angle = 180.0 deg.
Front/Back 0.59 dB
Beamwidth ?
Sidelobe Gain < -100 dBi
Front/Sidelobe > 100 dB


2D Plot: Inverted L
File Edit View Options Reset
Total Field
EZNEC+
0 dB
-5
-10
-15
-20
-30
1.85 MHz
Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 1.55 dBi
Cursor Elev 155.0 deg.
Gain 1.55 dBi
0.0 dBmax
Slice Max Gain 1.55 dBi @ Elev Angle = 155.0 deg.
Beamwidth 47.2 deg.; -3dB @ 125.5, 172.7 deg.
Sidelobe Gain 0.96 dBi @ Elev Angle = 24.0 deg.
Front/Sidelobe 0.59 dB

Inverted-L Impedance
(No radials on the model)

```
---------- SOURCE DATA ----------

Frequency = 1.85 MHz

Source 1      Voltage = 36.75 V at -64.69 deg.
              Current = 1 A at 0.0 deg.
              Impedance = 15.71 - J 33.22 ohms
              Power = 15.71 watts
              SWR (50 ohm system) =  4.688  (75 ohm system) =  5.746
```

-J33 reactance (capacitive) so my wire is short. Need to matching network. L-network will work but will need to be variable for the entire 160m band. Modeling ground with NEC2 is difficult if you are trying to see the effect on impedance. The REAL/MININEC model uses real ground for gain/pattern calculations but uses PERFECT ground for impedance calculations.

Inverted-L Actual Measurements

Actual Measurement

1800 KHz 25.0 –j44
1840 KHz 24.8 –j37
1850 KHz 21.6 –j35
1900 KHz 16.0 –j20
Resonance 1956 KHz 12 +j0

EZ-NEC (note that wire length is not the same as actual)
1850 kHz: 15.7 –j33

References

- YagiCAD by VK3DIP www.yagicad.com
- YagiMax www.iw5edi.com/ham-radio/?yagimax,127
- Yagi Calculator by VK5DJ www.vk5dj.com/yagi.html
- MMANA-GAL hamsoft.ca/pages/mmana-gal.php
- DOSBOX www.dosbox.com
- EZ-Nec www.eznec.com
- ARRL Antenna Book floppy/CDs for software