

# GLOUCESTER COUNTY ARC SOUTHERN NEW JERSEY

LEARNING BY DOING @ TECH SATURDAY

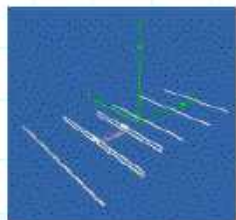
RADIO SOFTWARE SERIES - 4NEC2 – ANTENNA MODELING

JIM WRIGHT, N2GXJ

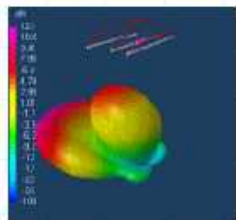
# INTRODUCTION

- 4NEC2
  - What can it do for me?
  - Where do I get it?
  - How do I use it?
- Oh, and did I mention, it's free?





# 4nec2



## NEC based antenna modeler and optimizer

by Arie Voors

4nec2 is a completely free Nec2, Nec4 and windows based tool for creating, viewing, optimizing and checking 2D and 3D style antenna geometry structures and generate, display and/or compare near/far-field radiation patterns for both the starting and experienced antenna modeler.

When running frequency sweeps, linear or logarithmic style SWR, Gain, F/B-ratio and impedance line-charts are produced. With the included Optimizer and Sweeper one is able to optimize antenna- and/or other environment-variables for Gain, resonance, SWR, efficiency and/or F/B, F/R-ratio. With the sweeper one is able to graphically display the effect of changing one or more of these variables for a specified range of values/frequencies.

For the starting modeler a graphically based 3D geometry-editor is included which requires no additional NEC knowledge while still enabling you to create and visualize and compare current distribution, far/near-field patterns and Gain/SWR charts. More experienced modelers can use the gradient style and/or the genetic algorithm based optimizers to improve their designs.

To list some of its features or see some screenshots, click the appropriate links below on the left. To download and try the software click upmost two links below on the right (setup.exe) or the third link for a single zip containing all separate files.

NOTE: When experiencing problems running 4nec2, please consult the 'List known bugs' page on this website for latest news.

### Information

- [List features](#)
- [View screenshots](#)
- [Show release notes](#)
- [List known bugs](#)
- [FAQ](#)

[4NEC2 Tutorials](#)

[Links and other stuff](#)

### Downloads

- \* [Latest 4nec2 version \(5.9.3\)](#)
- \* [4nec2 files as a ZIP \(no install\) \(5.9.3\)](#)

[\(4\)Nec2 support files](#)

[Gnuplot 2D/3D plotting](#)

[Its-IF propagation prediction](#)

[HAM-magazine article in Dutch](#)

# www.qsl.net/4nec2

## PLEASE START BY DOWNLOADING THIS SOFTWARE



TIP:

Please record path to where you install it!

Will need to access models in that folder later!

# INTRODUCTION

- Ever buy an antenna?
  - Ever build one?
- Problem

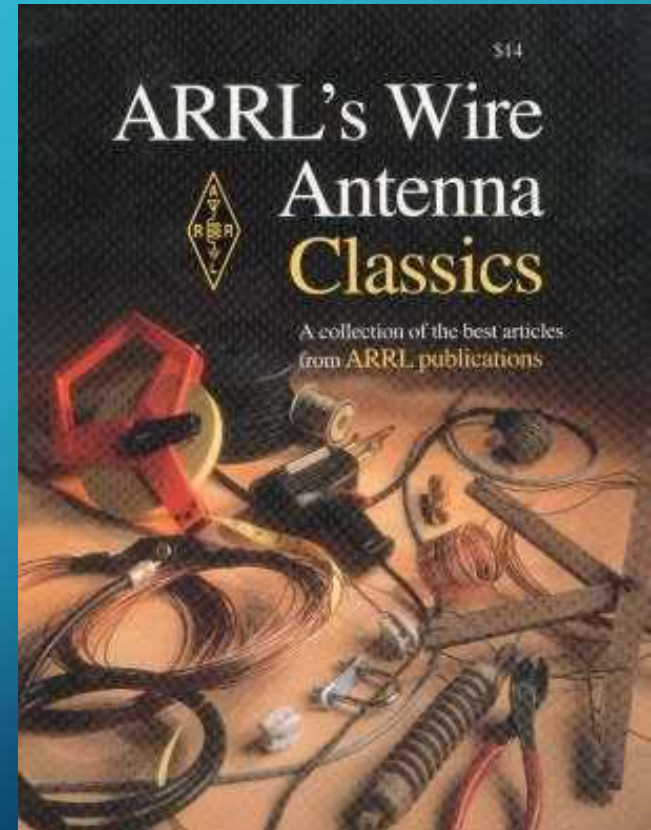
If you can't touch, smell, hear, or see radio waves,  
how are you expected to understand how an antenna works?



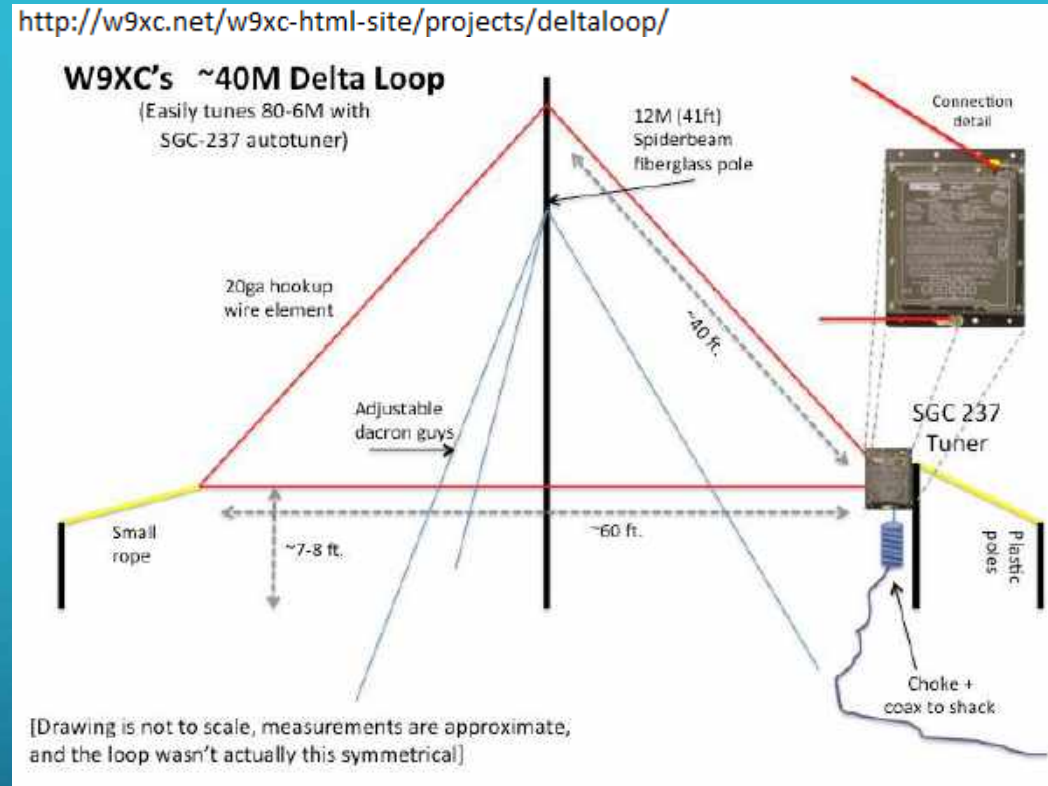
# A COMMON APPROACH TO ANTENNAS

- Buy one 😊
  - Lots of choices!
- Build one 😊
  - Part of the fun of being a licensed Amateur!
    - Proven design?
    - Original design?

Measure/adjust, measure/adjust,  
measure/adjust, measure/adjust, , , is ok?



# WHAT'S THAT I HEAR ABOUT A WIRE LOOP?



- What if was shorter or longer? Higher, lower? What if mount horizontal?  
Square vs Triangle? What if feed on side instead of corner? What if? What if? What if?



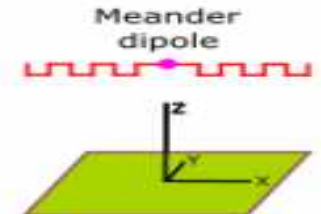
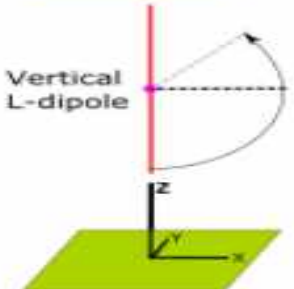
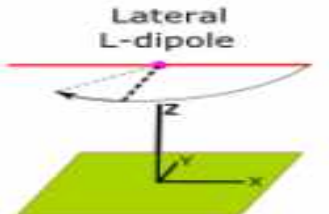
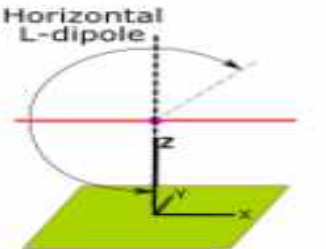
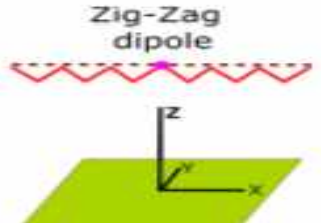
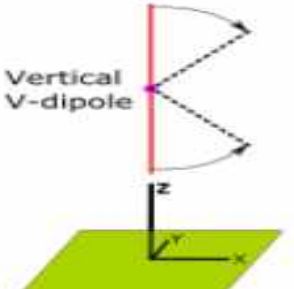
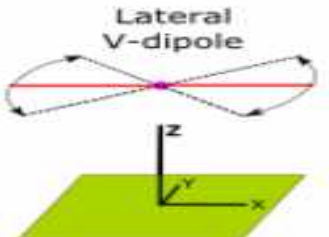
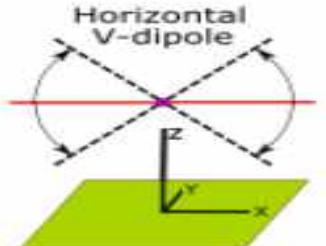
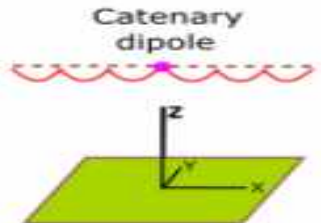
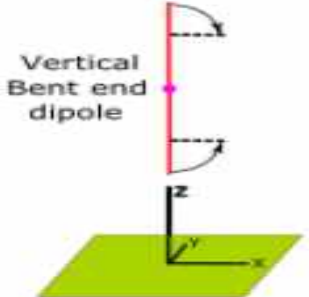
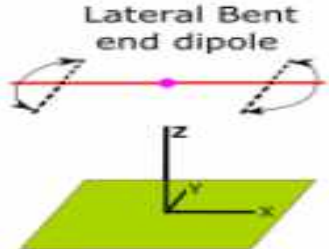
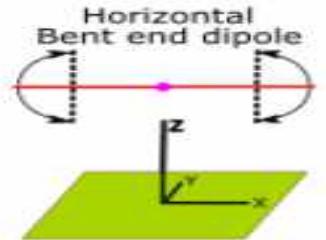
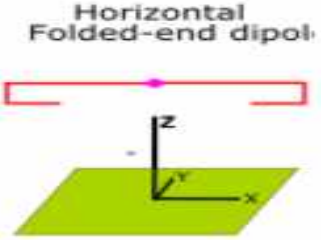
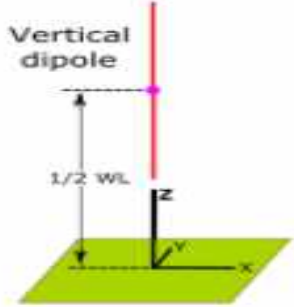
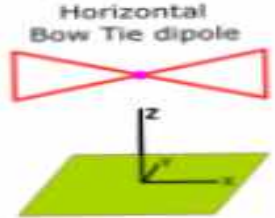
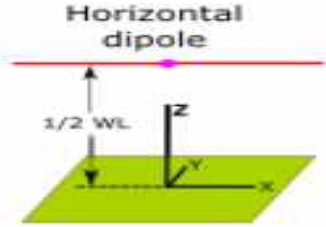
AH, THE “SIMPLE” DIPOLE.....

<https://www.qsl.net/kk4obi/>



What if?.....





### Center-fed Bent-Dipoles

- [Pictures](#)

### Horizontal

- [Standard dipole](#)
- [Bent end dipole](#)
- [Folded end dipole](#)
- [Bow Tie dipole](#)
- [V-dipole](#)
- [L-dipole](#)

### Lateral

- [Bent end dipole](#)
- [V-dipole](#)
- [L-dipole](#)

### Vertical

- [Standard vertical dipole](#)
- [Bent end vertical dipole](#)
- [V-dipole vertical](#)
- [L-dipole vertical](#)

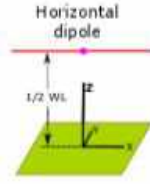
### OCF

- [OCF Impedance](#)
- [OCF Tall L-dipole](#)
- [OCF Wide L-dipole](#)
- [OCF Harmonics](#)

### EFHW

- [Straight](#)
- [Sloping](#)
- [Inverted V](#)
- [Inverted L](#)

Click on  
"Standard Dipole"



## The Standard Horizontal Dipole Characteristics

**Impedance:** 68.9 -j0.26 ohms (versus 72.0 -j0.23 ohms in free space)  
**SWR 50:** 1.38 (versus 1.44 SWR in free space)  
**Radiation Efficiency:** 74.5%

**Gain:** 7.32 dBi at 30 degrees elevation above horizontal (versus 2.15 dBi omni-directional in free space)

**Beam Width:** 30 degrees (half-power points, -3 dBi)

**Nulls off ends:** -2.7 dBi (This is a total difference of 10 dBi between signals from the sides and the ends).

**4NEC2 Antenna Model:** [Here](#)

**Looking at the Figure 1 below:**

The Red trace (Hor Plane) is as if you were looking down at the radiation where the top and bottom lobes are 7.32 dBi.

The Blue trace (Ver Plane) is as if you were looking at the radiation pattern from the side where the left and right lobes are 7.32 dBi.

Note the red and green lines from the origin. The red lines indicate at the red dot where the angle of radiation is maximum, 7.32 dBi. The green lines define the 30 degree beam width up from 15 degrees to 45 degrees or down from vertical from 45 degrees to 75 degrees.

The short red bar represents the dipole structure to help understand the shape of the Red trace (Hor plane) radiating from the sides of the dipole

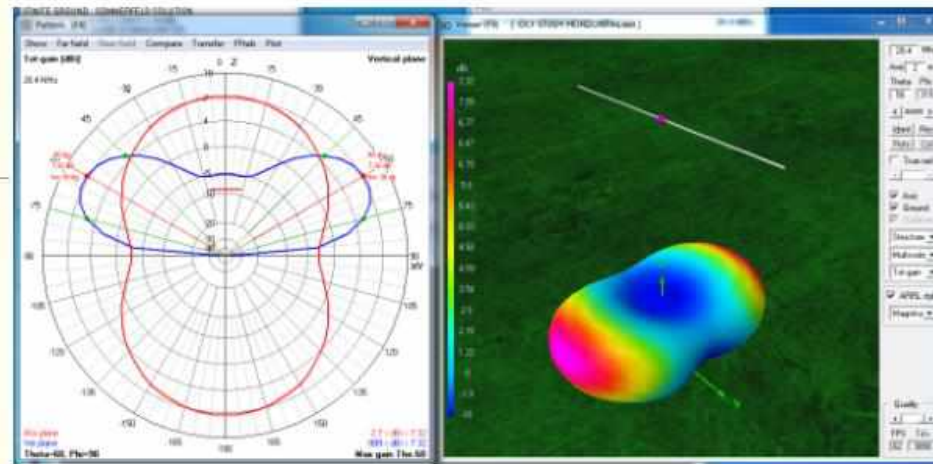


Figure 1  
Dipole Polar Graph and 3D view

The 3D view from above is to make clear the far field radiation pattern represented by the graph.

What if higher,  
or lower? ...

# What if higher, or lower? ...

Elevation effects on antenna radiation pattern								KK4OBI
<b>0.1 Wavelength Dipole Elevation</b>								<i>Radiation Pattern</i>
Band	160m	75/80m	40m	20m	15m	10m	6m	
mHz	1.8	3.8	7.1	14.2	21.3	28.4	52.0	
Feet	53.5	25.9	14.0	6.9	4.6	3.5	1.9	
<b>0.25 Wavelength Dipole Elevation</b>								<i>Radiation Pattern</i>
Band	160m	75/80m	40m	20m	15m	10m	6m	
mHz	1.8	3.8	7.1	14.2	21.3	28.4	52.0	
Feet	133.7	64.7	34.9	17.4	11.6	8.7	4.7	
<b>0.5 Wavelength Dipole Elevation</b>								<i>Radiation Pattern</i>
Band	160m	75/80m	40m	20m	15m	10m	6m	
mHz	1.8	3.8	7.1	14.2	21.3	28.4	52.0	
Feet	267.4	129.5	69.8	34.7	23.1	17.3	9.5	
<b>0.75 Wavelength Dipole Elevation</b>								<i>Radiation Pattern</i>
Band	160m	75/80m	40m	20m	15m	10m	6m	
mHz	1.8	3.8	7.1	14.2	21.3	28.4	52.0	
Feet	401.1	194.2	104.7	52.1	34.7	26.0	14.2	
<b>1.0 Wavelength Dipole Elevation</b>								<i>Radiation Pattern</i>
Band	160m	75/80m	40m	20m	15m	10m	6m	
mHz	1.8	3.8	7.1	14.2	21.3	28.4	52.0	
Feet	534.8	259.0	139.6	69.4	46.3	34.7	18.9	
<b>1.25 Wavelength Dipole Elevation</b>								<i>Radiation Pattern</i>
Band	160m	75/80m	40m	20m	15m	10m	6m	
mHz	1.8	3.8	7.1	14.2	21.3	28.4	52.0	
Feet	668.6	323.7	174.5	86.8	57.8	43.3	23.7	

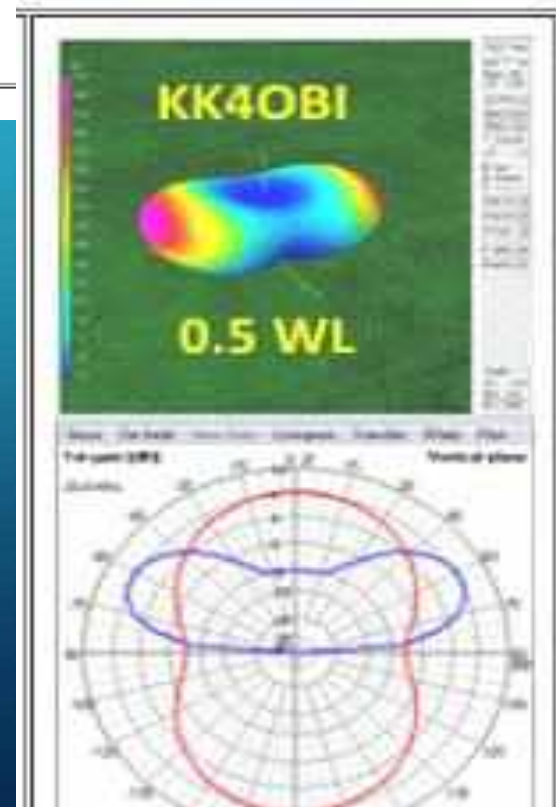
**Animation**

*The image to the right is an animated .gif.*

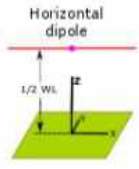
The 3D pictures and polar graphs illustrate the changes in far field radiation pattern due to antenna elevation over real ground.

- The range shown is from 0.1 to 2.0 wavelengths high.
- 0.1, 0.2, 0.3, 0.4, 0.5 WL are by slow steps then;
- by fast steps between each 0.5 WL thereafter.

This animation is larger and has more detailed information than the images in the table above.



## The Standard Horizontal Dipole Characteristics

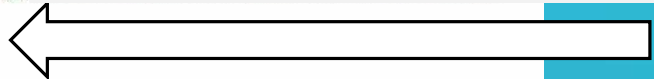


Impedance: 68.9 -j0.26  
SWR 50: 1.38  
Radiation Efficiency: 7

Gain: 7.32 dBi at 30 degrees elevation above space)  
Beam Width: 30 degrees (half-power p  
Nulls off ends: -2.7 dbi (This is a total diff ends).

4NEC2 Antenna Model: [Here](#)

Click on  
"4NEC2 Antenna Model"



Looking at the Figure 1 below:

The Red trace (Hor Plane) is as if you were looking down at the radiation where the top and bottom lobes are 7.32 dBi.  
The Blue trace (Ver Plane) is as if you were looking at the radiation pattern from the side where the left and right lobes are 7.32 dBi.

Note the red and green lines from the origin. The red lines indicate at the red dot where the angle of radiation is maximum, 7.32 dBi. The green lines define the 30 degree beam width up from 15 degrees to 45 degrees or down from vertical from 45 degrees to 75 degrees.

The short red bar represents the dipole structure to help understand the shape of the Red trace (Hor plane) radiating from the sides of the dipole

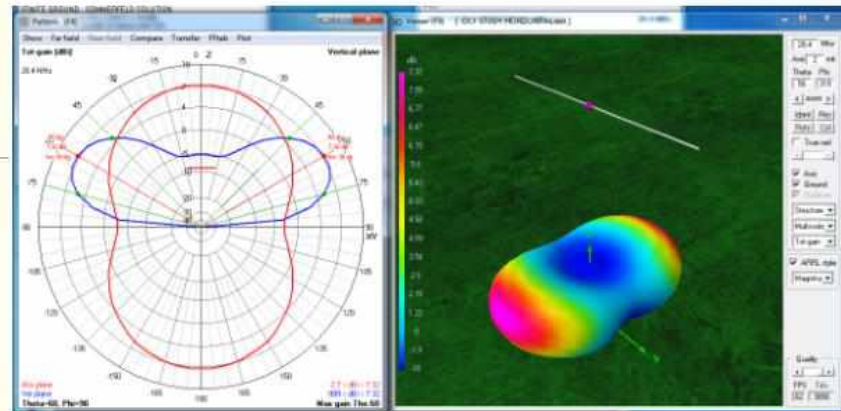


Figure 1  
Dipole Polar Graph and 3D view

The 3D view from above is to make clear the far field radiation pattern represented by the graph.

## KK4OBI Bent Dipoles

This is the 4NEC2 antenna bend model for: **Standard Horizontal Dipoles**

To use this model:

- Below. Highlight and copy (Ctrl C) the program control codes (CM, CE, SY,etc).
- Open Windows Wordpad and copy (Ctrl V) the control codes into Wordpad.
- Go to "File, Save as..." and name your new antenna model.
- In Windows Explorer, right-click on your new model and "Rename" the file to end as ".nec".
- Open the new model to optimize for various angles of bend (Symbols, "Ang=").

4NEC2 is an NEC2, NEC4, Windows based antenna modeler and optimizer by Arie Voors. It is available free of charge at: [www.qsl.net/4nec2/](http://www.qsl.net/4nec2/)

CM CM Standardized bent dipole model for comparison studies

CM CM #14 AWG, 1/2 wave over ground at 28.4 mHz

CM CM Center fed. Fixed Horizontal Arm, Variable angle arm.

CM CM Dick Reid, KK4OBI, 2016

CE

SY hor=2.573466 'Fixed horizontal arm. Optimized 28.4 mHz length meters.

SY ang=90 'Angle degrees of variable arm. 90=horizontal. 0=down. 180=up.

SY var=2.573466 'Variable arm length meters. Optimized for each angle.

SY x=var\*Sin(ang) 'X-value of variable arm

SY z=var\*Cos(ang) 'Z-value of variable arm.

SY hgh=5.282 '150/28.4=5.282m =1/2 wl feedpoint

GW 2 25 -hor 0 hgh 0 0 hgh #14 'Fixed horizontal arm

GW 3 25 0 0 hgh x 0 hgh-z #14 'Variable angle arm

GE -1

GN 2 0 0 0 14 6.e-3

EK

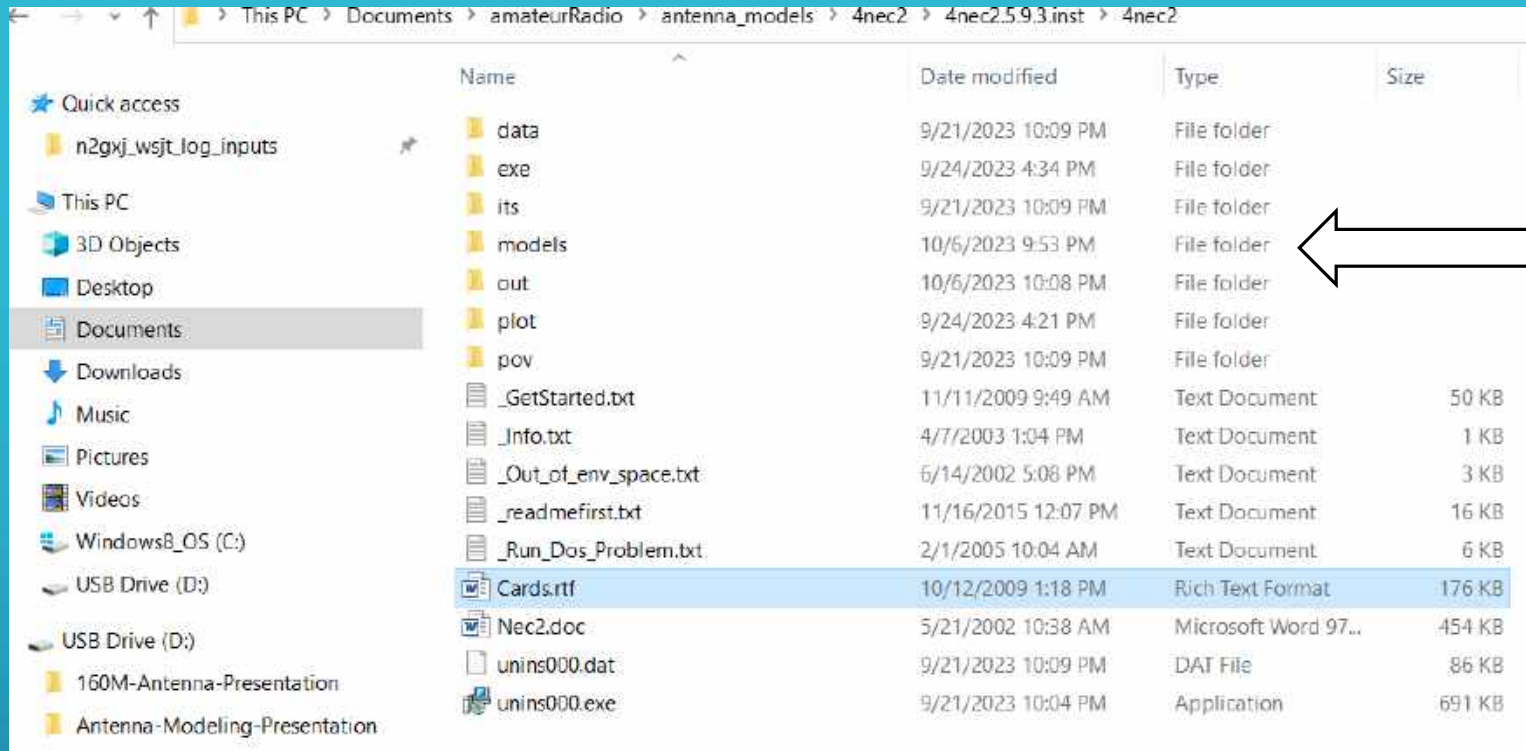
EX 0 2 25 0 1 0 0

EX 0 3 1 0 1 0 0

FR 0 0 0 0 28.4 0

EN

Do this. Save file to desktop. We will use it shortly .



Find “Models”  
folder where  
you installed  
4NEC2

Find the folder where you installed 4nec2

- In here will see “Cards.rtf”, that you can read about, if you like.
- Key concept in all NEC is NEC uses “cards” for programming, and cards need to be entered in a certain order.
  - Don’t worry about it – I’ll show you how 4NEC2 user interface makes this easy for you.
- There is also “models” folder in here. ➔ Open this “models” folder . . .

Name

- A-Example-originals
- A-JW-Collection
- Aperiodic
- Equations
- Fractals
- HFActiveFeed
- HFbeams
- HFcollinear
- HFmultiband
- HFshort
- HFsimple
- HFvertical
- LFvertical
- Nec4
- Objects
- opt
- SPatch
- VHFbeams
- VHFmultiband
- VHFsimple
- zz\_EZnec
- zz\_MiniNec
- 🔦 Example1.nec
- 🔦 Example2.nec
- 🔦 Example3.nec
- 📄 Optimizer.log
- 📄 ReadMe.txt

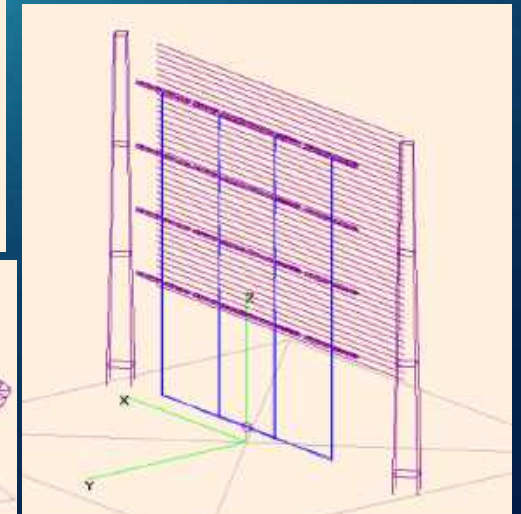
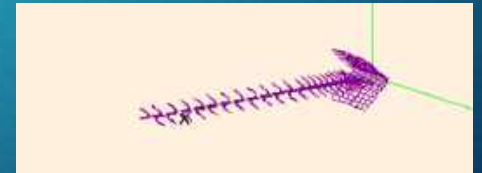


## Recommend:

1. create your own folders here, starting with Letter "A" so you can find easy while running the program.
2. Put copy of the notepad version of the bent dipole .nec card file we just saved into your own collection folder
3. For safe keeping, put a copy the original "Example#.nec" files in other folder, in case want to edit the originals

Look at all these pre-made examples can copy from!!!

- From LF to HF to VHF
- From simple to complex
- Have fun exploring!



# WHAT CAN IT DO?

**Main [V5.8.15] (F2)**

File Edit Settings Calculate Window Show Run Help

Filename: **deltb40.out**    Frequency: **7.15** Mhz  
 Wavelength: **41.93** mtr

Voltage: **142 + j0 V**    Current: **705 - j25.7 mA**

Impedance: **201 + j7.33**    Series comp.: **3036** pF  
 Parallel form: **201 // j5529**    Parallel comp.: **4.026** pF

S.W.R.50: **4.03**    Input power: **100** W  
 Efficiency: **98.54** %    Structure loss: **1.459** W  
 Radiat-eff.: **69.44** %    Network loss: **0** uW  
 RDF [dB]: **6.95**    Radiat-power: **98.54** W

Environment     Loads     Polar

GROUND PLANE SPECIFIED.  
 WHERE WIRE ENDS TOUCH GROUND, CURRENT WILL BE INTERPOLATED TO  
 FINITE GROUND. REFLECTION COEFFICIENT APPROXIMATION  
 RELATIVE DIELECTRIC CONST.= 13.000  
 CONDUCTIVITY= 5.000E-03 MHOS/METER  
 COMPLEX DIELECTRIC CONSTANT= 1.30000E+01-1.25706E+01

Comment  
 Right-angle Delta, bottom-fed, 40 meters, #14 copper  
 L. B. Cebik, W4RNL

**3D Viewer (F9) [deltb40.out]**

7.15 Mhz  
 Axis: **5** mtr  
 Theta: **80**    Phi: **280**

zoom

Ident Res  
 Rotc Col

True rad.

Axis  
 Ground  
 Surfaces

Structure  
 Multi-color  
 Tot-gain

ARRL style  
 Quality

FPS: **58**

**Geometry (F3)**

Show View Validate Currents Far-field Near-field Wire Plot

**deltb40.out**    **7.15 MHz**

Seg's/patches: **113**    start: **-90** stop: **90** count: **37** step: **5**  
 Pattern lines: **2701**    Theta: **-90** stop: **90** count: **37** step: **5**  
 Freq/Eval steps: **1**    Phi: **0** stop: **360** count: **73** step: **5**  
 Calculation time: **0.172** s

**Geometry (Scaling=Meters)**     Use wire tapering

Nr	Type	Tag	Segs	X1	Y1	Z1	X2	Y2	Z2	Radius
1	Wire	1	33	-29.2	0	20.8	0	0	50	2.6706e-03
2	Wire	2	33	0	0	50	29.2	0	20.8	2.6706e-03

**Pattern (F4)**    280

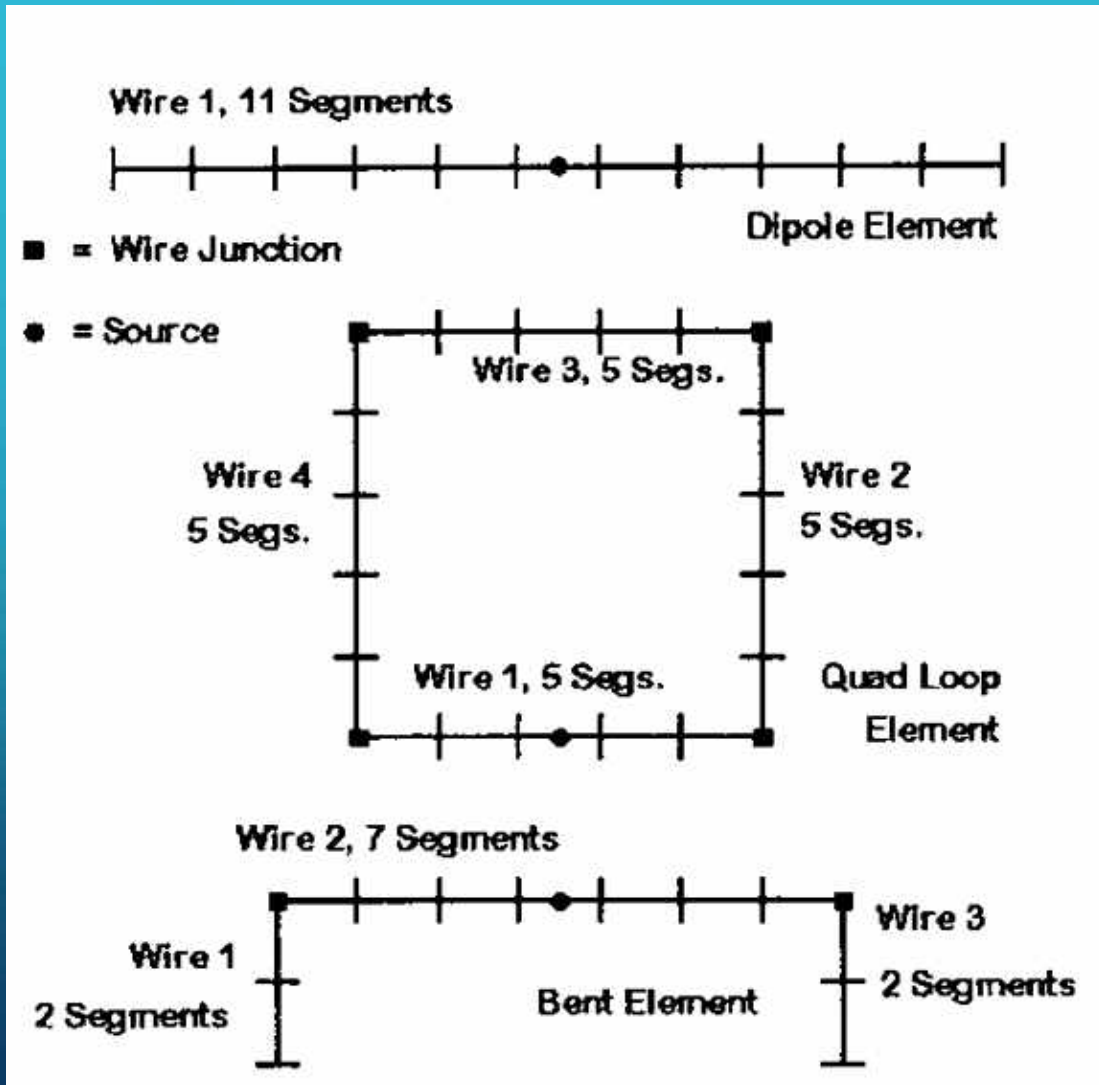
Show Far field Near field Compare Transfer FFtab Plot

**Tot-gain [dBi]**

7.15 MHz

Vertical plane

# KEY CONCEPTS IN ALL NEC MODELS



WIRES : antenna is collection of “wires”, could be wires, rods, tubing, solid surfaces, towers – anything that radiates

- Wire have properties, such as diameters, and material properties (e.g copper, aluminum, coated or not)

SEGMENTS : each wire is logically partitioned into segments upon which the calculations are performed.

- The more segments, the higher the resolution of results, but the more memory and longer time it takes to run.
- Good trade off is at least 10 segments per half wavelength.
- Recommend Odd number of segments (for placing sources)
- Note also, segment length must be at least 4 times larger than the wire diameter (not usually a concern unless using fat wires and many segments)



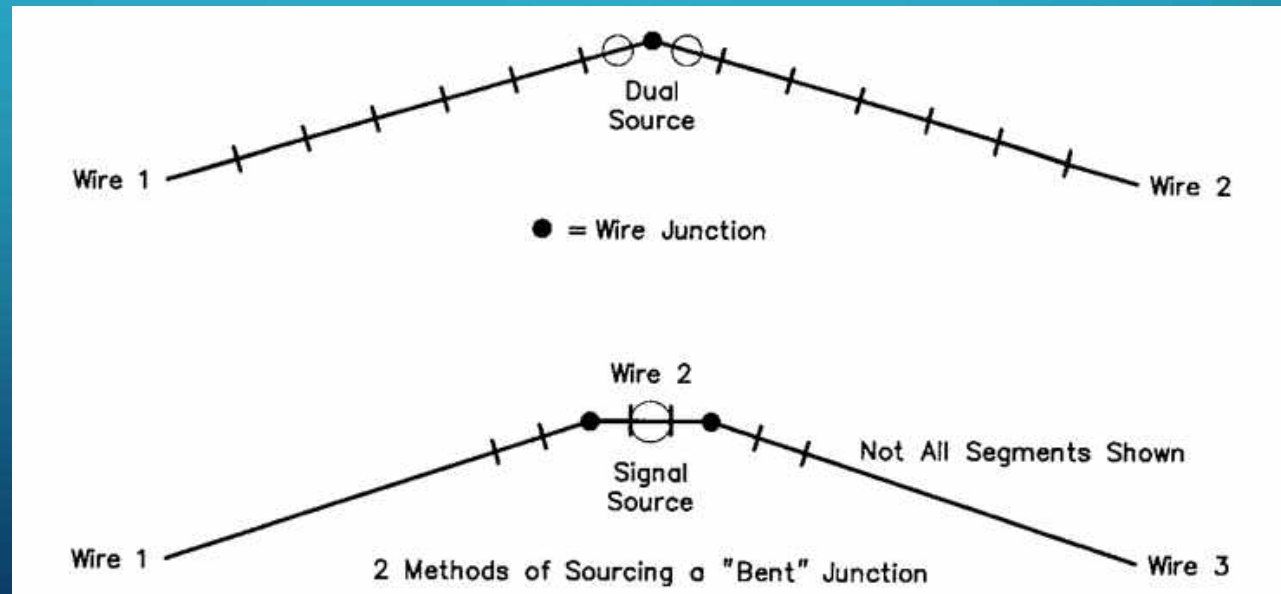
# KEY CONCEPTS IN ALL NEC MODELS

SOURCES : the feedpoints, bring voltage or current to wires

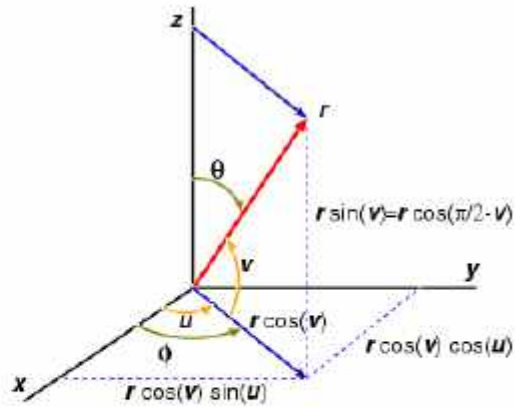
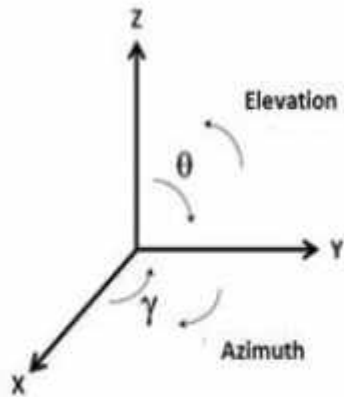
- Model places in center of a wire segment you specify

WIRE JUNCTION : point in space where wires touch

- Ends of two or more wires have same  $[X, Y, Z]$  coordinates in space



# KEY CONCEPTS IN ALL NEC MODELS



- looking straight Up/Down is:
  - 90° if using Elevation
  - 0° if using Theta

## [X, Y, Z] 3D COORDINATES :

NEC defines points in space and antenna structures using 3D structures

- A wire goes from point [X1, Y1, Z1] to point [X2, Y2, Z2]
- Z generally means straight up
- X in one direction horizontal, Y in the other direction horizontal

Example1.nec - 4nec2 Edit (file changed)

File Cell Rows Selection Options

Default straight line wire-element  Upd  Ins.  Del.  Copy

Symbols	Geometry	Source/Load	Freq./Ground	Others	Comment								
<b>Geometry</b> (Scaling=Meters) <input type="checkbox"/> Use wire tapering													
Nr	Type	Tag	Segs	X1	Y1	Z1	X2	Y2	Z2	Radius			comment
1	Wire	1	9	0	-.2418	0	0	.2418	0	.0001			Wire 1, 9 segments.

# READY TO TRY? FREE ANTENNA MODELING

Using your laptop, From comfort of the couch

Tinker, tinker!

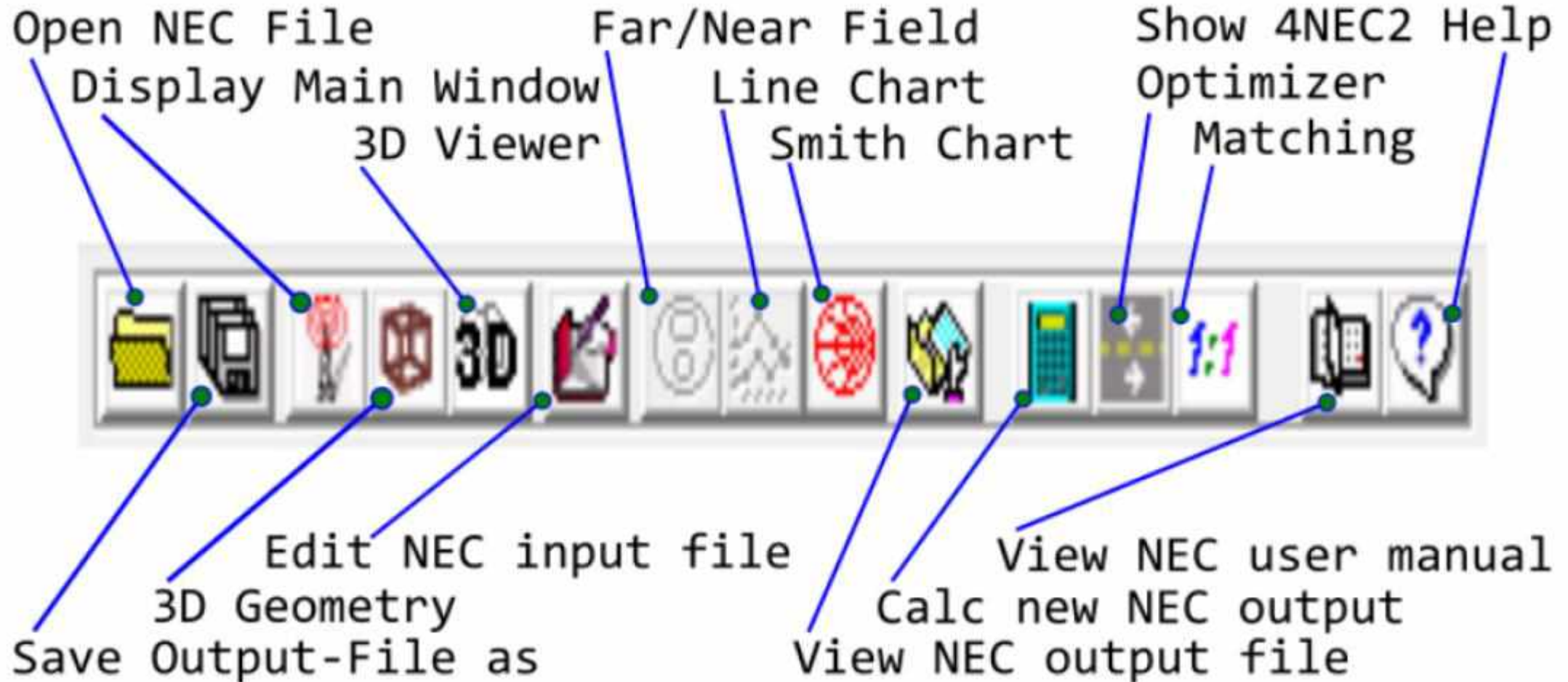
- Professional grade nec2
- Windows-based tool
- Creating
- Viewing
- Optimizing
- Checking
- 2D and 3D style geometry
- Generate, Display, Compare
- Near-field, Far-field
- Frequency sweeps
- SWR, Gain, Resonance, SWR, Efficiency, Front/back
- Lots of starting samples

# READY TO TRY?

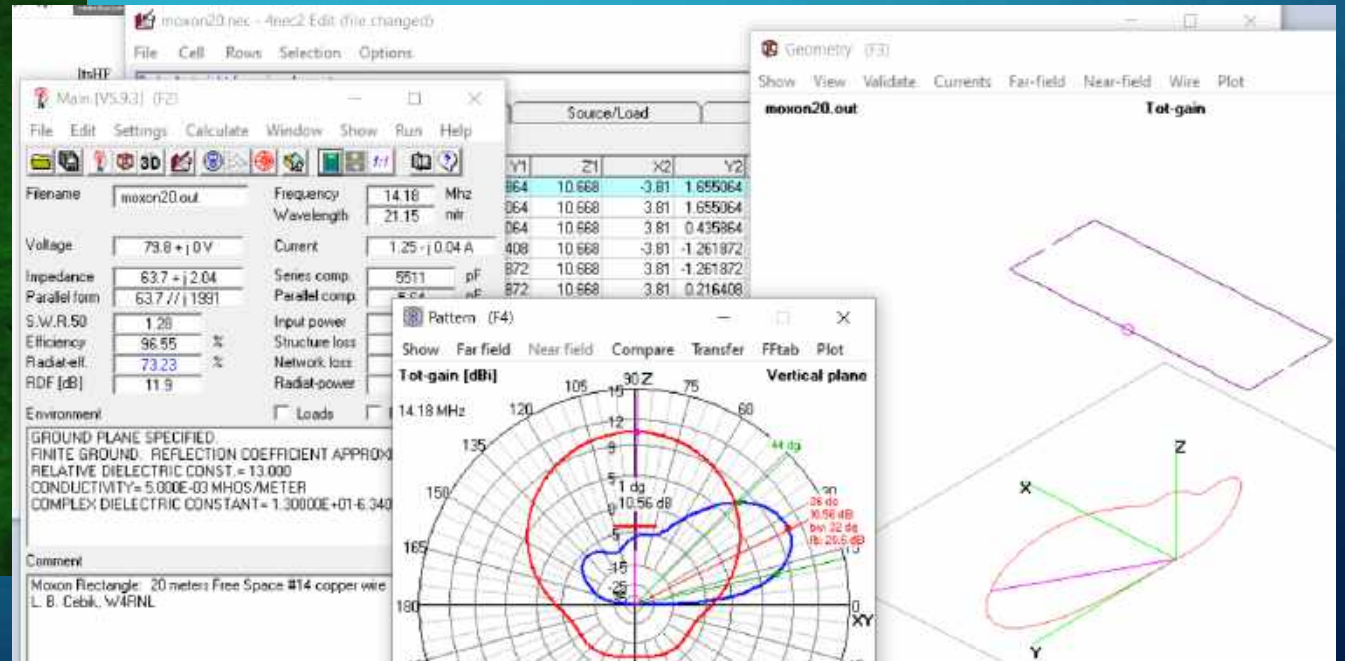
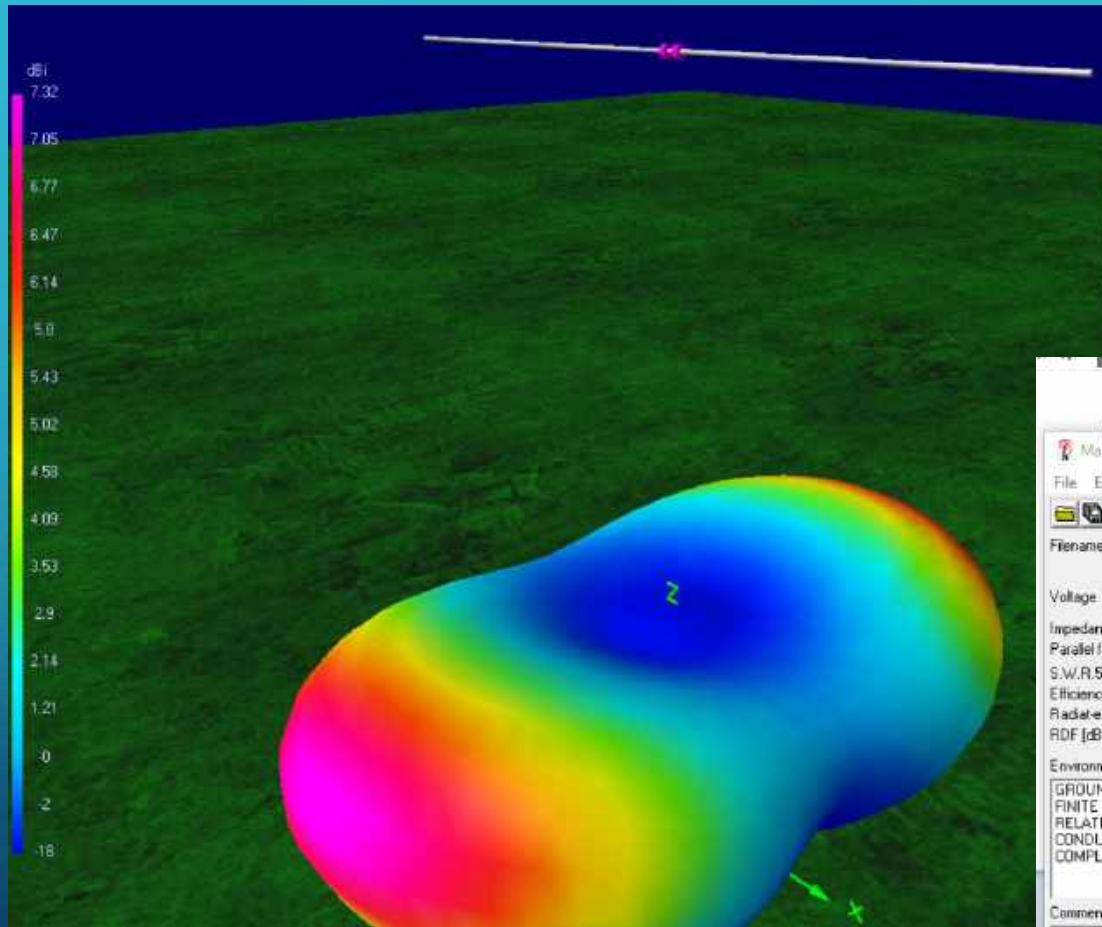
## STEPS TO MODEL IN ANY NEC

1. Model the antenna and structures
2. Add the sources, loads, and ground data
3. Check geometry and segmentation
4. Run the simulation and review results
5. Tweak and re-run

# ALRIGHT! LET'S GO! START UP YOUR 4NEC2



# EXAMPLES TO DEMO



# THANK YOU!

- Questions?