

Antenna Modelling with NEC2

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NEC2



- NEC - Numerical Electromagnetic Code
 - Lawrence Livermore Laboratory
 - Program Description - 1981
 - Part 1 – Theory
 - Part 2 - Code
 - MiniNEC
 - BASIC
 - IBM PC

NEC2



- NEC2
 - September 1996
 - NEC-2 Manual, Part III: User's Guide
 - Antenna current
 - Antenna patterns
 - Ground
 - Wires near the ground (not in the ground)

NEC2



- NEC2
 - Perfect ground
 - Real ground
 - Conductivity
 - Dielectric Constant
 - Antenna currents calculated with Real ground
 - Impedance is accurate
 - This was a limitation of MiniNEC

NEC2



- NEC2
 - Various compilations available (.EXE)
 - Allow different size antennas (PC memory)
 - [Nec2d.zip](#) – real ground separate (Sommerfield)
 - [Nec2dXS_VM.zip](#) – real ground compiled in
 - Command line driven
 - Text file input (Fortran cards)
 - Large text file output

NEC2



- NEC2
 - Third party GUI programs
 - EZNEC
 - 4NEC2
 - MMANA-GAL
 - MiniNEC

NEC2



- NEC4
 - Wires in the ground
 - Licensed
 - Expensive
 - Restricted availability
 - EZNEC and 4NEC2
 - If you have bought the license from LLL

NEC2



- **EZNEC-ARRL**

- ARRL Antenna Book CD
- Buy the book
- EZNEC demo program except when a specially "signed" EZNEC description file (included on the Antenna Book CD) is opened.

NEC2



- **4NEC2**
 - Arrie Voors
 - www.qsl.net/4nec2
 - free
- **Full-house version of NEC2**
 - Version 5.7.5 (April 2009)
 - Some bugs
 - Announced end of support
 - Version 8.5.11 (6 Dec 2012)

Modelling



- Quotes from the EZNEC User Manual
 - Modelling is the technique of evaluating the performance of something by evaluating the performance of a substitute called a model.

Modelling



- The accuracy of the results are never better than the accuracy with which the model matches the real object
 - It is imperative to learn the limitations of your modelling tools
 - you are analysing a **model** of an antenna, not an actual antenna. So your accuracy is always limited by how accurately you model the real antenna and its environment.

Modelling with NEC2



- NEC2 antenna models are made from
 - wires
 - sources & loads
 - ground
- physical wires or metallic tubes, are easily modelled
- some, like a closely wound helical dipole antenna, can't be modelled accurately

Modelling with NEC2



- An antenna is modelled as a collection of straight wires.
 - **Straight** should be emphasized; a round loop, for example, must be modelled as a polygon of straight wires
 - You define where the wires are placed in space by giving their x, y, and z coordinates

Modelling with NEC2

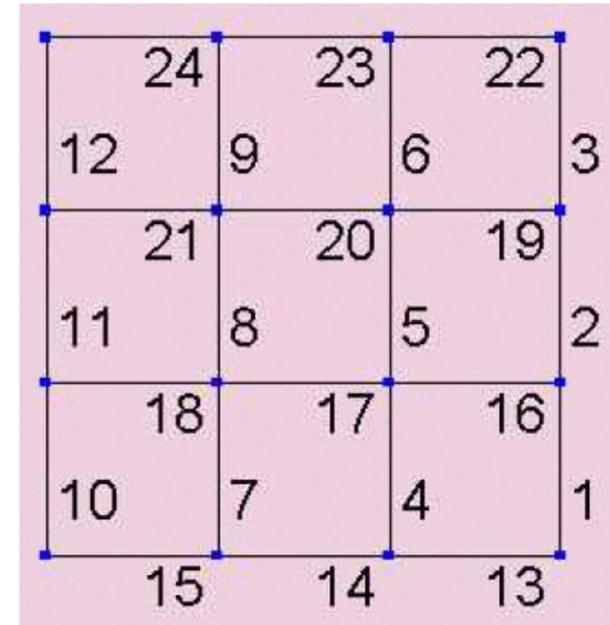


- Junctions between wires
 - only allowed at the end of a wire
- Crossing wires in the same space leads to big errors
 - Rather break them and form a junction
 - An X-shaped structure requires 4 wires

Modelling with NEC2



- Conducting Surfaces
 - Grid of wires with sides ~one tenth of a wavelength
 - Each side of each square is a separate wire



Modelling with NEC2



- Segments
 - wires are divided into segments
 - the current on each segment is calculated
 - the skill in modeling is in choosing the number of segments
 - 20 segments per wavelength for pattern
 - 40 for impedance
 - Generally greater accuracy for more segments
 - Slower for more segments (time $\propto N^2$)
 - Tip: Increase N & see how the results vary

Modelling with NEC2



- Wire Limitations

L = Segment Length

D = Wire Diameter

- $0.001\lambda < L < 0.05\lambda$
- $D \ll \lambda/\pi$
- $L > D$
- $L > 4D$ near junctions/bends

Modelling with NEC2



- Wire Limitations

- Close spaced parallel wires

- wires should be several diameters apart
 - Align segments on the wires

- Junctions

- Minimize changes in L and D
 - Use tapered segments near junctions
 - Tapered diameter

Modelling with NEC2



- Wire Limitations
 - Horizontal wires above ground
 - For real or perfect ground
 - Spaced a few diameters above ground
 - MiniNEC ground
 - Spaced a few tenths of a wavelength above ground

Modelling with NEC2

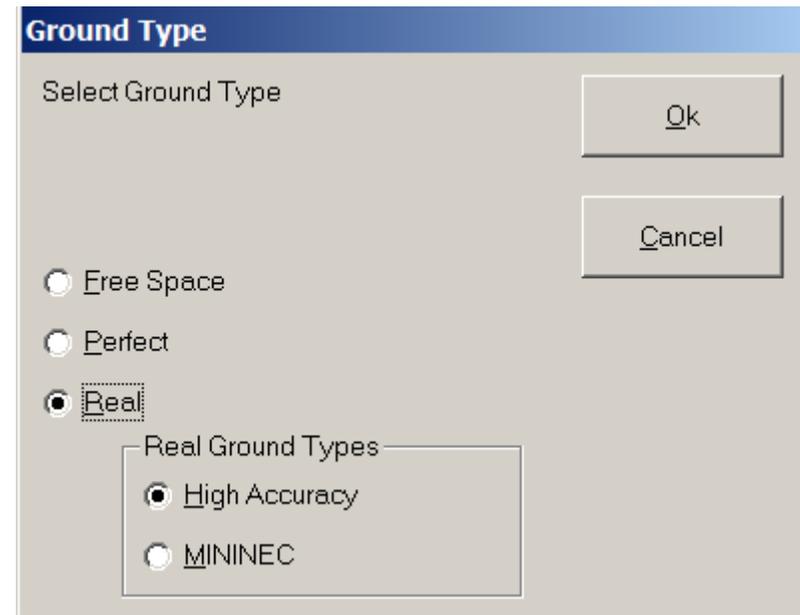


- Wire Limitations
 - Connections to Ground
 - Valid for perfect and MiniNEC ground
 - Expect impedance errors with connections to real ground

Modelling with NEC2



- Ground Type
 - Free Space
 - Pattern & ground loss
 - Perfect
 - Pattern near horizon
 - Ground losses
 - Real (MiniNEC)
 - Ground losses
 - Real (High Accuracy)
 - Ground connection



Modelling with NEC2



EZNEC+ v. 5.0 (No Key - Plus Operation)

File Edit Options Outputs Setups View Utilities Help

40m Hustler on Car - Taper

>	File	Hustler 40m on Car tapered.EZ
>	Frequency	7.075 MHz
	Wavelength	42.3735 m
>	Wires	297 Wires, 316 segments
>	Sources	1 Source
>	Loads	1 Load
>	Trans Lines	0 Transmission Lines
>	Transformers	0 Transformers
>	L Networks	0 L Networks
>	Ground Type	Real/High Accuracy
>	Ground Descrip	1 Medium (0.005, 13)
>	Wire Loss	Aluminum (6061-T6)
>	Units	Meters
>	Plot Type	3D
>	Step Size	2 Deg.
>	Ref Level	0 dBi
>	Alt SWR Z0	20 ohms
>	Desc Options	

Open
Save As
Ant Notes
Currents
Src Dat
Load Dat
FF Tab
NF Tab
SWR
View Ant
NEC-2
FF Plot

Modelling with NEC2



- Sources go in segments
 - Current (I)
 - Voltage (V)
 - Split Current (SI)
 - Split Voltage (SV)
 - Plane wave (EZNEC Pro and 4NEC2)

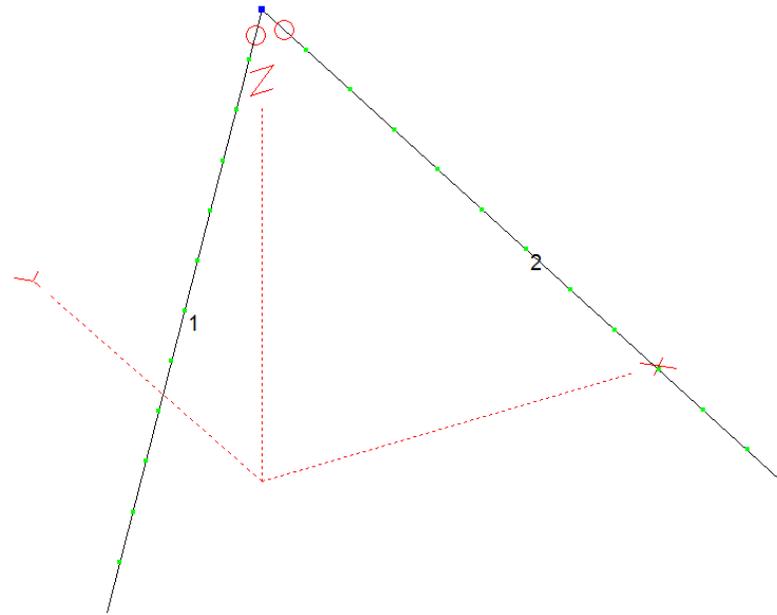
The screenshot shows a window titled 'Sources' with a menu bar containing 'Source' and 'Edit'. Below the menu bar is a table with the following columns: No., Specified Pos., Actual Pos., Amplitude, Phase, and Type. The 'Specified Pos.' column is further divided into 'Wire #' and '% From E1'. The 'Actual Pos.' column is further divided into '% From E1' and 'Seg'. The 'Amplitude' column is further divided into '(V, A)'. The 'Phase' column is further divided into '(deg.)'. The 'Type' column has a dropdown menu.

	No.	Specified Pos.		Actual Pos.		Amplitude (V, A)	Phase (deg.)	Type
		Wire #	% From E1	% From E1	Seg			
▶	1	2	0	0	1	1	0	SI
*								

Modelling with NEC2



- Split Sources
 - SI
 - SV
 - At junctions



Modelling with NEC2



- Loads
 - In segments

The screenshot shows the 'Loads (RLC)' dialog box in the NEC2 software. The dialog has a menu bar with 'Load', 'Edit', and 'Other'. Below the menu bar is a table titled 'Loads' with the following data:

No.	Specified Pos.		Actual Pos.		R (ohms)	L (uH)	C (pF)	R Freq (MHz)	Config	Ext Conn
	Wire #	% From E1	% From E1	Seg						
▶ 1	3	50	50	1	5.5621	41.984	0.36917	7.05	Trap ▼	Ser
*										

Overlaid on the bottom of the 'Loads' dialog is a 'Change Load Type' sub-dialog. It contains the following text: 'Choose load type. WARNING: loads will be converted to new type. Most changes are not reversible except with undo and will change differently with frequency.' Below the text are three radio button options: 'R + jX', 'RLC' (which is selected), and 'Laplace'. There are 'Ok' and 'Cancel' buttons on the right side of the sub-dialog.

Modelling with NEC2



- Loads
 - Series and Parallel RLC
 - Trap Series RL with parallel C

Hustler 40m resonator

The screenshot shows the 'Loads (RLC)' window in NEC2. The window title is 'Loads (RLC)' and it has a menu bar with 'Load', 'Edit', and 'Other'. The main area is a table titled 'Loads' with the following columns: No., Specified Pos., Actual Pos., R, L, C, R Freq, Config, and Ext Conn. The table contains one row of data for a trap load.

No.	Specified Pos.		Actual Pos.		R (ohms)	L (uH)	C (pF)	R Freq (MHz)	Config	Ext Conn
	Wire #	% From E1	% From E1	Seg						
▶ 1	3	50	50	1	5.5621	41.984	0.36917	7.05	Trap	Ser
*										

A dropdown menu is open over the 'Config' cell, showing the options: Ser, Par, and Trap. The 'Trap' option is currently selected.

Modelling with NEC2



- Transmission Lines
- Transformers
- L Networks

Modelling with NEC2



EZNEC+ v. 5.0 (No Key - Plus Operation)

File Edit Options Outputs Setups View Utilities Help

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>	Ground Descrip	1 Medium (0.005, 13)
>	Wire Loss	Aluminum (6061-T6)
>	Units	Meters
>	Plot Type	3D
>	Step Size	2 Deg.
>	Ref Level	0 dBi
>	Alt SWR Z0	20 ohms
>	Desc Options	

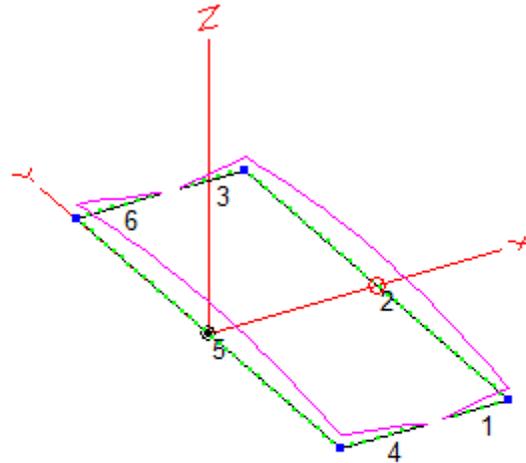
Open
Save As
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Currents
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FF Tab
NF Tab
SWR
View Ant
NEC-2
FF Plot

Modelling with NEC2



Wires
Moxon

EZNEC+



Modelling with NEC2

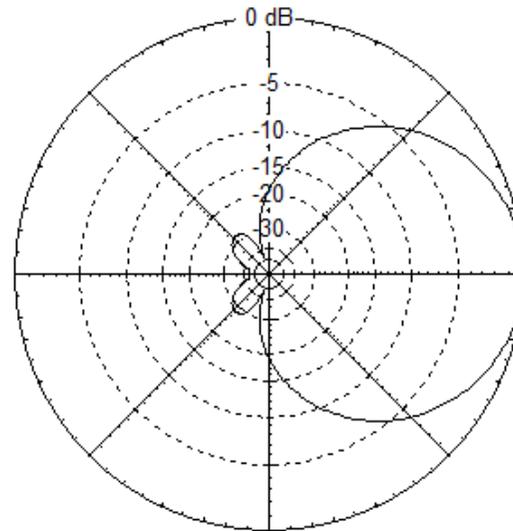


Pattern

Free space

Total Field

EZNEC+



14.1 MHz

Azimuth Plot
Elevation Angle 0.0 deg.
Outer Ring 6.04 dBi

Cursor Az 0.0 deg.
Gain 6.04 dBi
0.0 dBmax

Slice Max Gain 6.04 dBi @ Az Angle = 0.0 deg.
Front/Back 42.79 dB
Beamwidth 77.8 deg.; -3dB @ 321.1, 38.9 deg.
Sidelobe Gain -21.77 dBi @ Az Angle = 132.0 deg.
Front/Sidelobe 27.81 dB

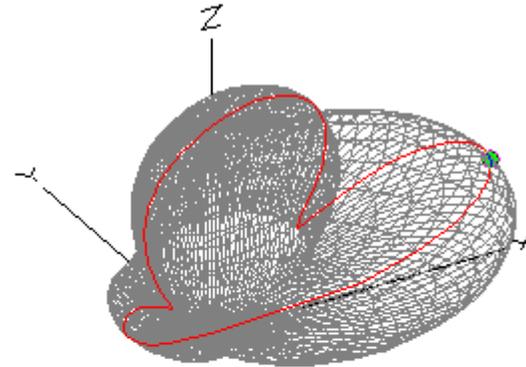
Modelling with NEC2



EZNEC+

Pattern

- 18 MHz
- 12m
- Average ground



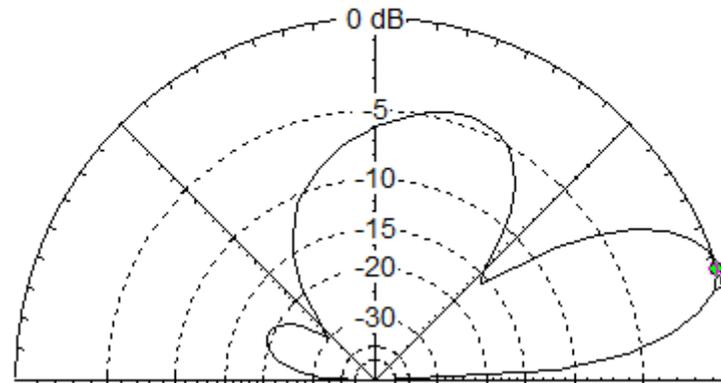
Modelling with NEC2



Elevation Pattern

Total Field

EZNEC+



18.1 MHz

Elevation Plot		Cursor Elev	18.0 deg.
Azimuth Angle	0.0 deg.	Gain	10.7 dBi
Outer Ring	10.7 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	10.7 dBi		
Slice Max Gain	10.7 dBi @ Elev Angle = 18.0 deg.		
Beamwidth	20.7 deg.; -3dB @ 9.1, 29.8 deg.		
Sidelobe Gain	6.35 dBi @ Elev Angle = 69.0 deg.		
Front/Sidelobe	4.35 dB		

Modelling with NEC2



- Examples
 - Dipole
 - Moxon
 - Inverted Vee
 - Mobile 40m Hustler

Modelling with NEC2



Thank You

EZNEC+

