Antennas and Propagation

Computer Exercise 1:
Modeling of Linear Antennas in 4NEC2 Software

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Tasks

1. Compute the input impedance and the length of a dipole antenna *2l* (Fig. 1a) operating at half wave resonance for receiving DVB-T 2, TV-channel 26, from the TV transmitter Brno-Hady. Consider the wire diameter of *d*=2 mm. Familiarize with the 4NEC2 software and model the dipole in the 4NEC2 software and determine the input impedance and the reflection coefficient for characteristic impedance of the feeder Z_0 = 75 Ω. Depict radiation patterns of the antenna and determine its directivity and gain. Compare the results from 4NEC2 software with the computed ones.
2. Model in the 4NEC2 software a folded dipole (Fig. 1b) of the same length and the diameter as the dipole antenna. The distance of the wires of the folded dipole is λ/30. Determine the input impedance and the reflection coefficient for the characteristic impedance of the feeder Z_0 = 300 Ω. Depict the radiation patterns of the folded dipole and determine its directivity and gain. Compare results for the folded dipole and the dipole antenna.

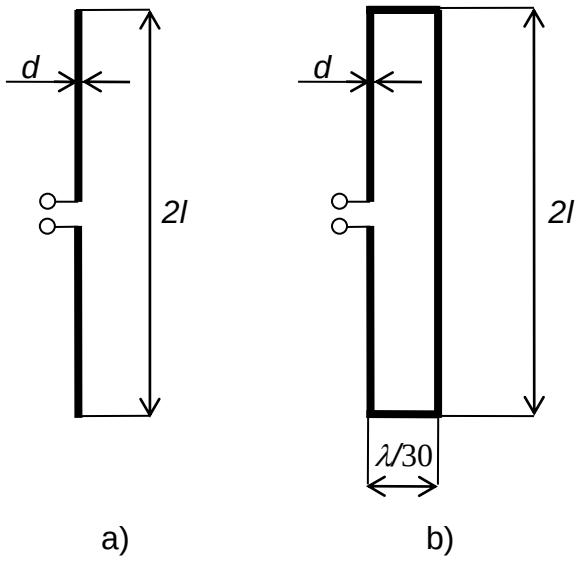


Fig. 1: Dipole antenna a) and folded dipole b).

Evaluation of Input Impedance and Length of Dipole Antenna

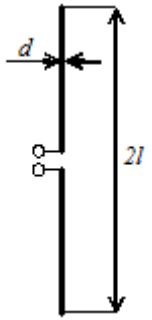
DVB-T 2, TV-channel 26

d = 2a = 2 mm

$Z_0 = 75\ \Omega$

l=?

R_{in}=?



26.TV-channel -> f=514 MHz

Exploiting knowledge from Lecture 2:

$$\lambda = \frac{c}{f} = \frac{3 \cdot 10^8}{514 \cdot 10^6} = 584\, mm$$

$$\frac{\lambda}{2a} = \frac{\lambda}{d} = \frac{584}{2} = 292$$

From the graph (Lecture 2) we can read $R_{in} = 59\,\Omega,\ \xi = 0.935$

So length of dipole arm is

$$l = \xi \frac{\lambda}{4} = 0.935\, \frac{584}{4} = 136{,}5\, mm$$

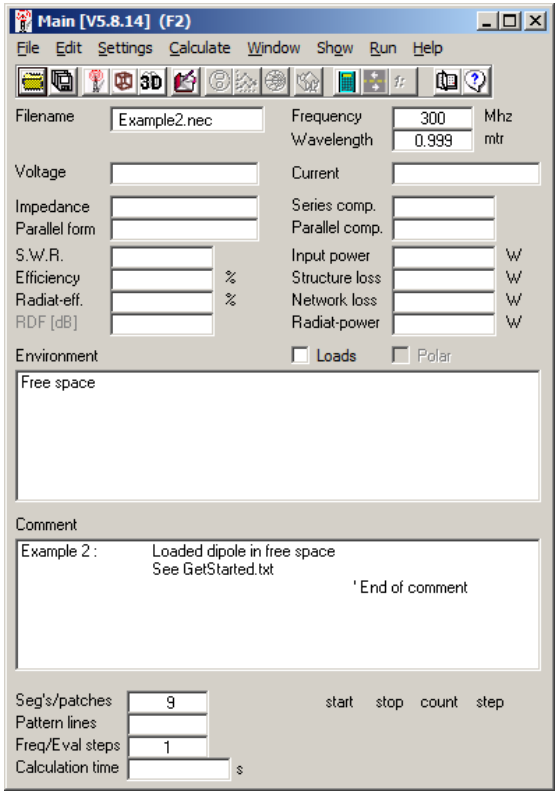
4NEC2

- NEC (numerical electromagnetic code):
  - Software Numerical Electromagnetics Code(NEC-2) has been developed in 1970s in the Lawrence Livermore Laboratory (Livermore, California) [1]
  - Based on a numerical solution of electromagnetic field integral equations by Method of Moments (MoM) – modelling of perfectly conductive wire segments located in 3D space (thin wire approximation considered)
  - There are available different versions of this software and one of them is 4NEC2
- 4NEC2:
  - Is completely free Nec2, Nec4 and windows based tool for creating and optimizing antenna structures [2]
  - More information (tutorials, download,…) can be found https://www.qsl.net/4nec2/

- This document is prepared for computer exercise, to get more knowledge about 4NEC2, please look to Tutorials at https://www.qsl.net/4nec2/

Modeling of Dipole Antenna in 4NEC2

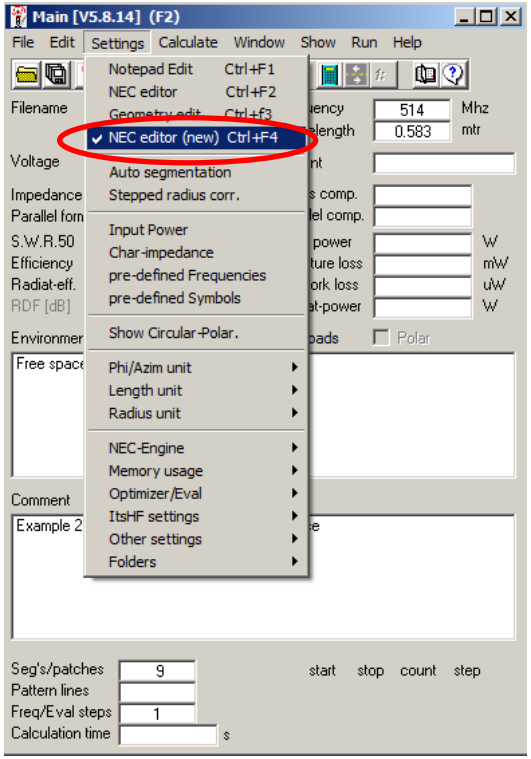
- If necessary, download and install 4NEC2 from https://www.qsl.net/4nec2/, it is also possible to download zip file
- Run program



Main window of 4NEC2

Modeling of Dipole Antenna in 4NEC2

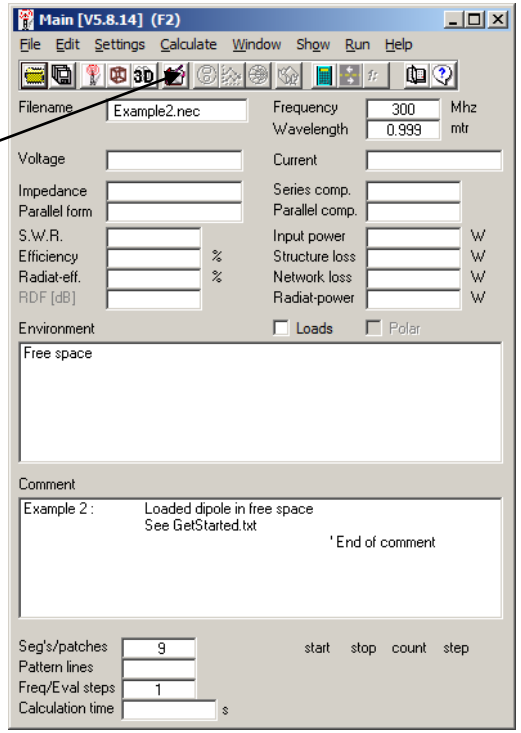
- To start design of your antenna, copy existing design from directory 4NEC2\models\, e.g: Example2.nec, to your work directory and if necessary, rename it
- Then open the file Example2.nec (menu *File->open 4nec2 in/out file*)
- There are different options of antenna model creation, let's exploit NEC editor
- To exploit that editor, check/tick in menu *Setting->NEC editor*

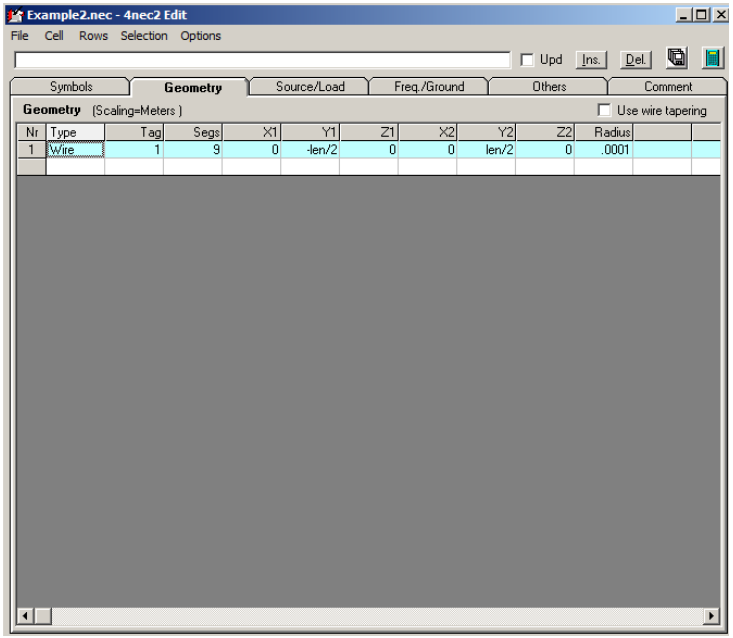


Modeling of Dipole Antenna in 4NEC2

- Further, click on *Edit NEC input-file* button in main window, and edit window will appear
- Gradually define properties of your antenna model

Edit NEC input-file

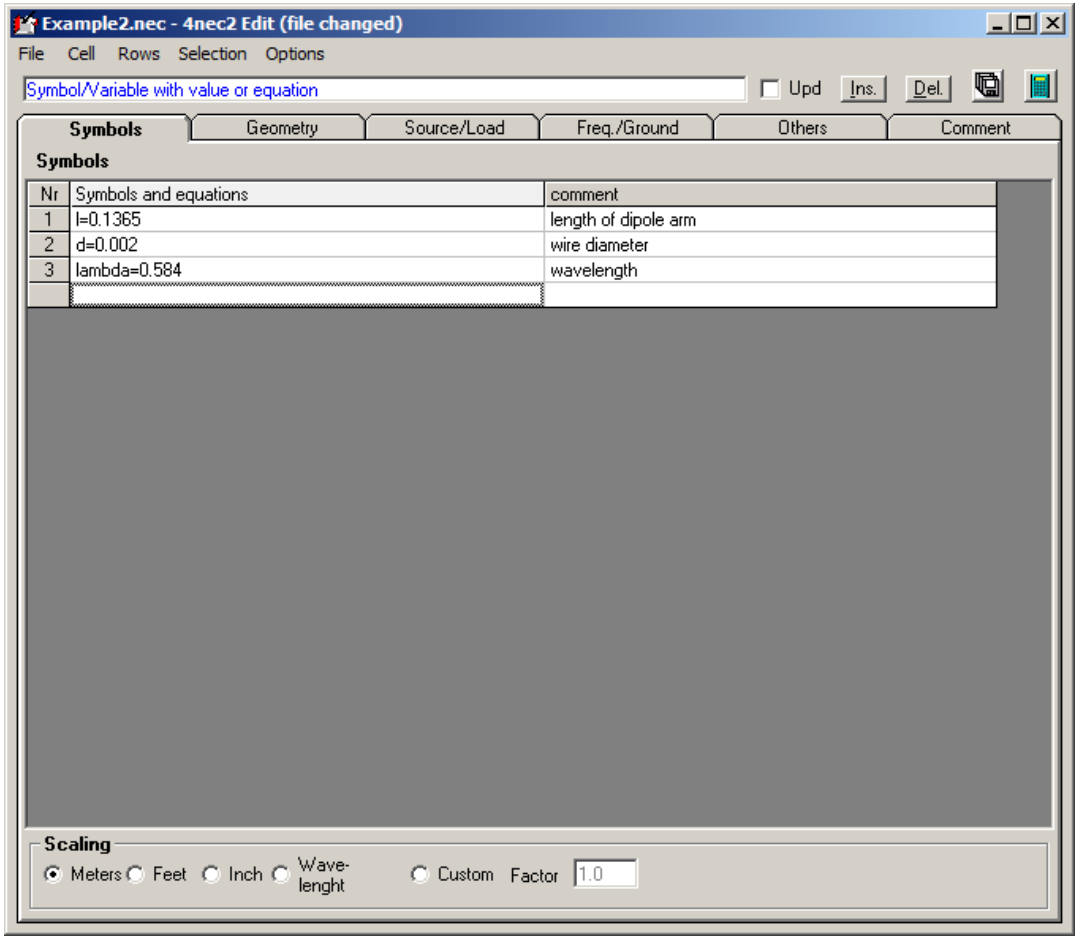




Edit window of 4NEC2

Modeling of Dipole Antenna in 4NEC2

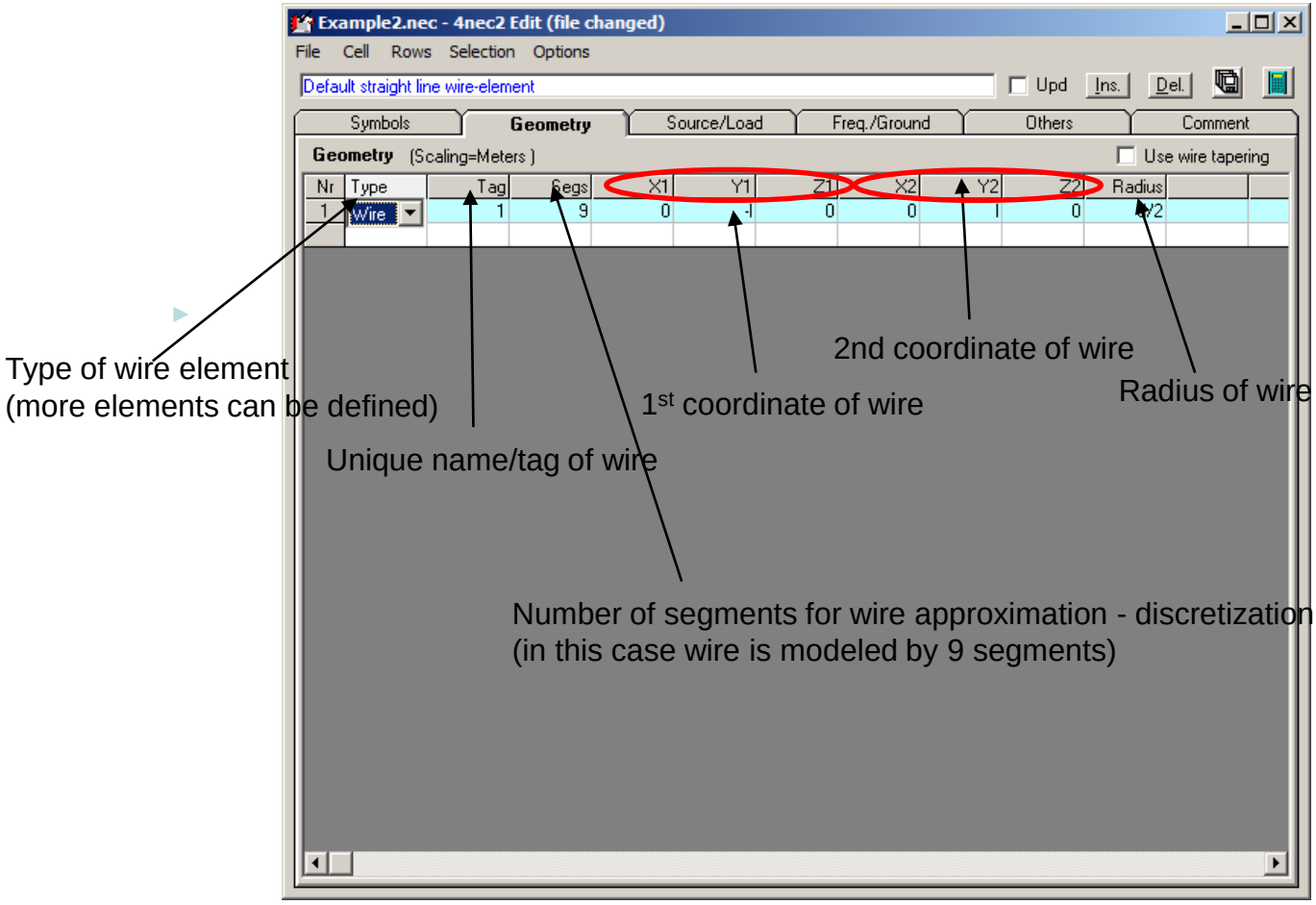
- On dialog box *Symbols*, define symbols/variables of your project
- Do not forget to select appropriate units/scaling for your quantities



Dialog box Symbols

Modeling of Dipole Antenna in 4NEC2

- On dialog box *Geometry*, define geometry of your dipole antenna (lets consider that dipole is located at origin of coordinate system along axis y)



Dialog box Geometry

Modeling of Dipole Antenna in 4NEC2

- To obtain accurate results, following rules for dimensions and alignment of wires must be followed [1]:

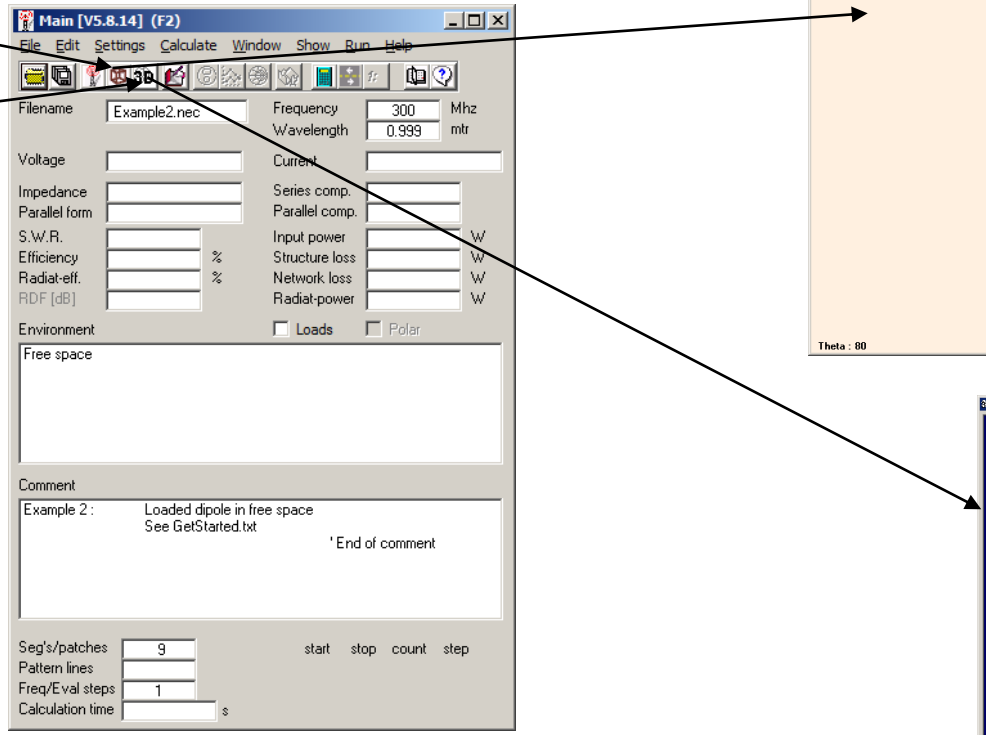
Segment length	$l < \lambda/10$
Segment radius	$r < \lambda/100$, $r < l/8$
Segment connections $l_1 > l_2$ $r_1 > r_2$	 $l_1 < 5l_2$ $r_1 < 5r_2$

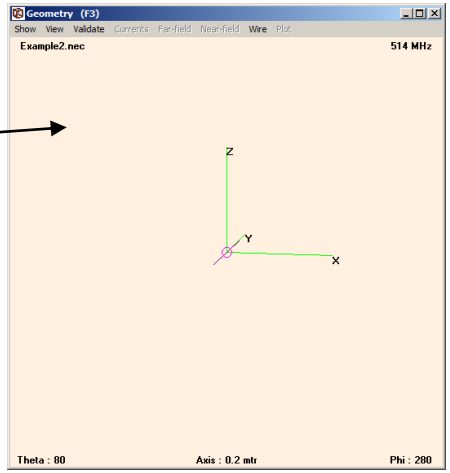
Modeling of Dipole Antenna in 4NEC2

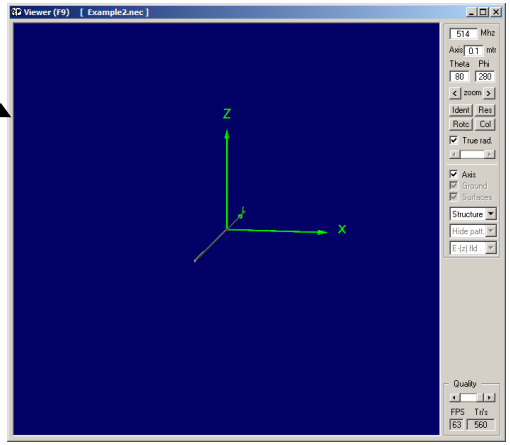
- After definition of antenna geometry, structure can be seen by clicking in *Main* window (F2), *3D Geometry* (F3) or *3D View*

3D Geometry

3D Viewer

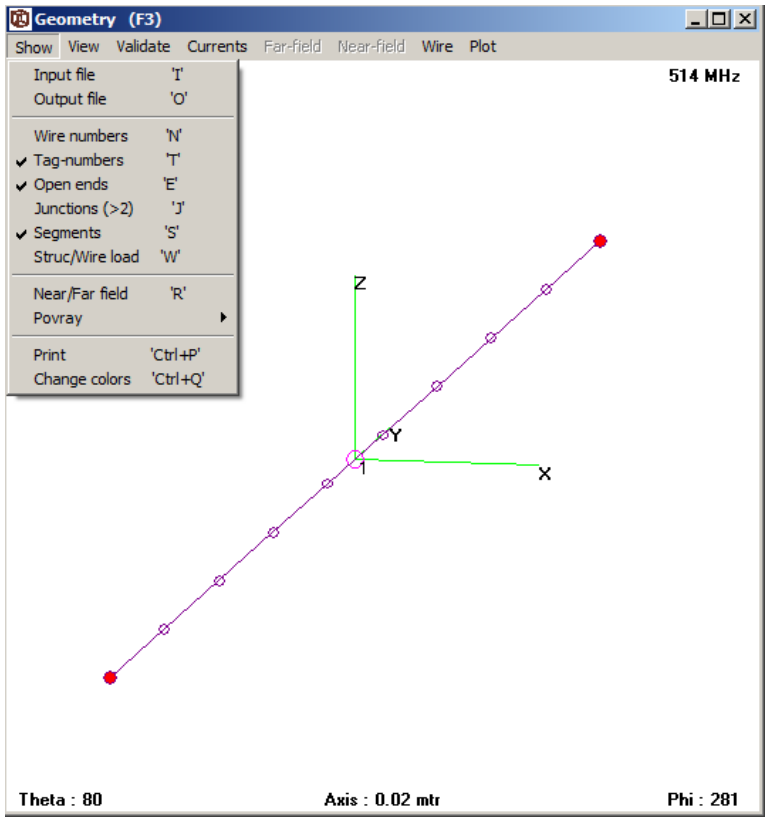






Modeling of Dipole Antenna in 4NEC2

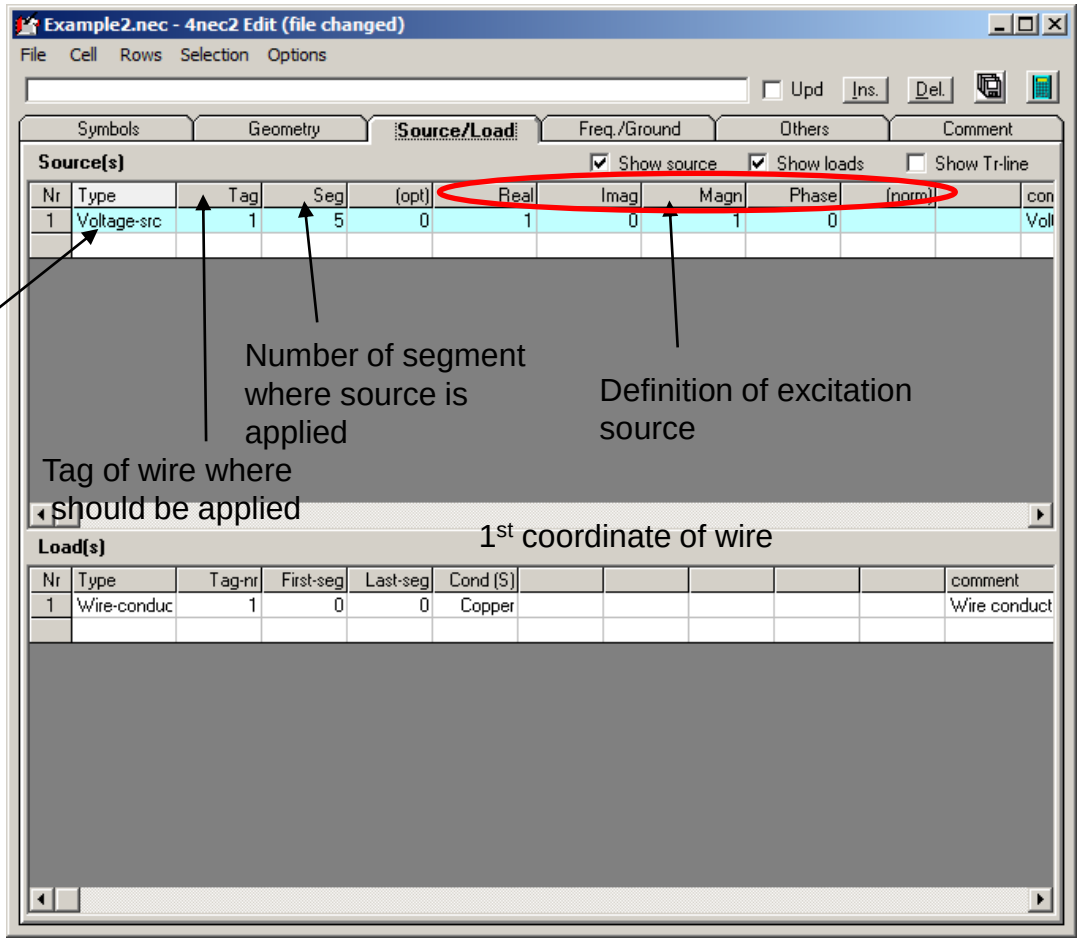
- In *3D Geometry* (F3) window, you can depicted current antenna model, please explore now menu *Show*, *View* and *Validate*
- Menu *Show*: showing important information related to your structure
- Menu *View*: selection of view to your model
- Menu *Validate*: validation of antenna geometry



Showing Tag-numbers, Open end discretization
Segments of your antenna model
Note that pink circle shows position of excitation

Modeling of Dipole Antenna in 4NEC2

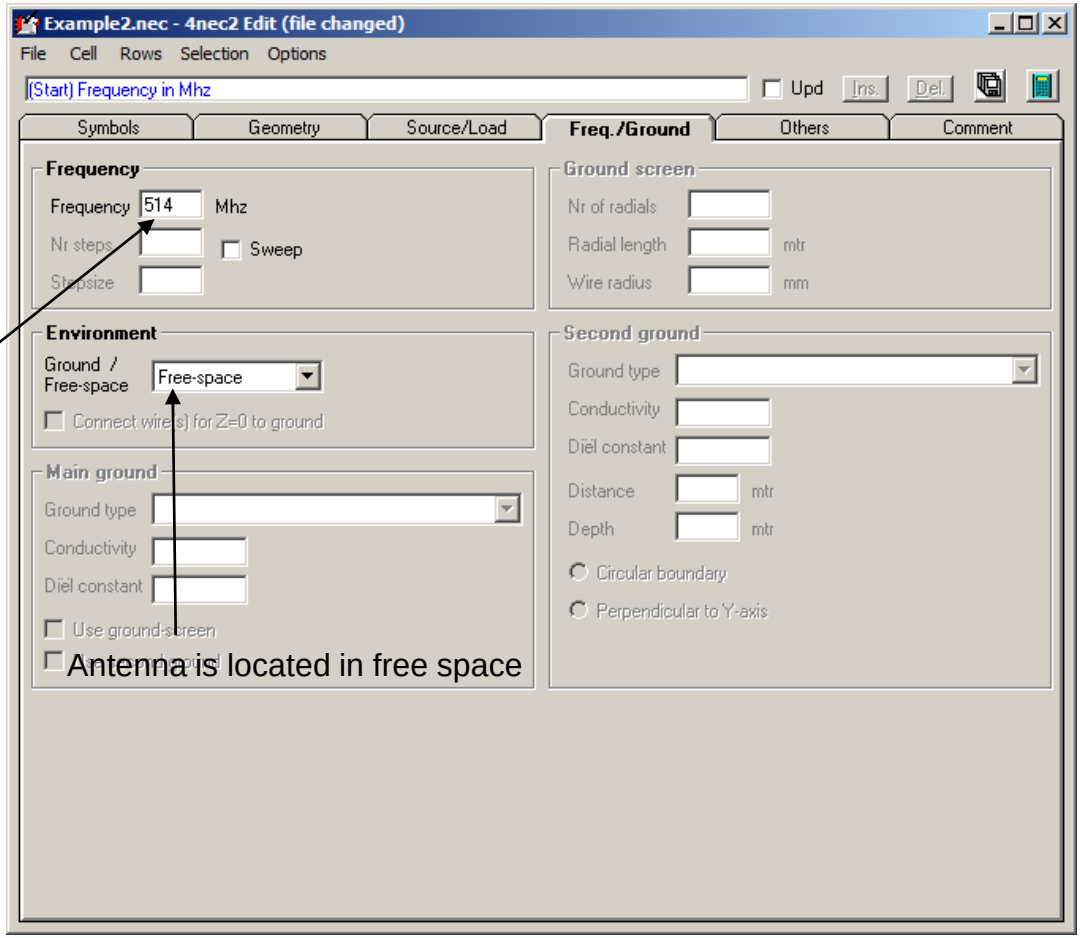
- On dialog box *Source/Load*, *Source/Load* for antenna can be defined



Dialog box Source/Load

Modeling of Dipole Antenna in 4NEC2

- On dialog box *Freq/Ground*, you can define frequency of solution and surrounding environment

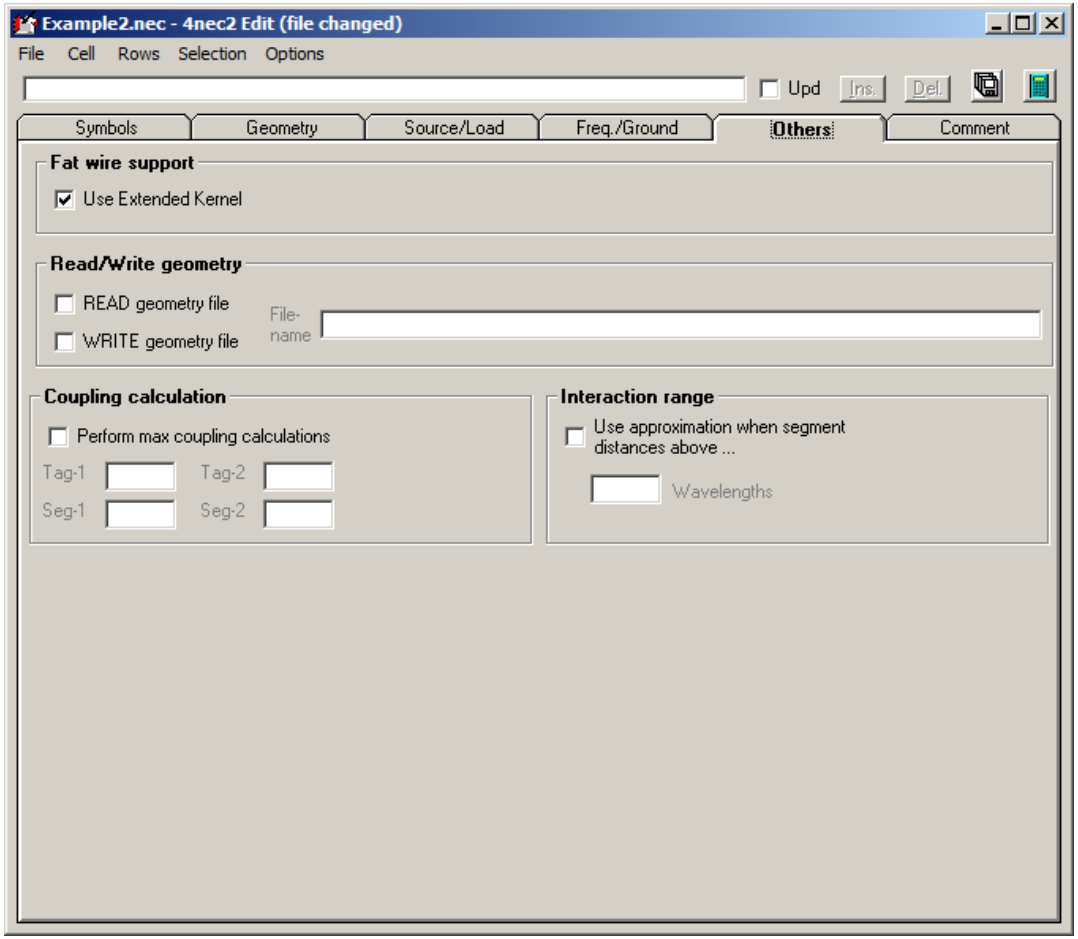


Frequency of solution

Dialog box Freq/Ground

Modeling of Dipole Antenna in 4NEC2

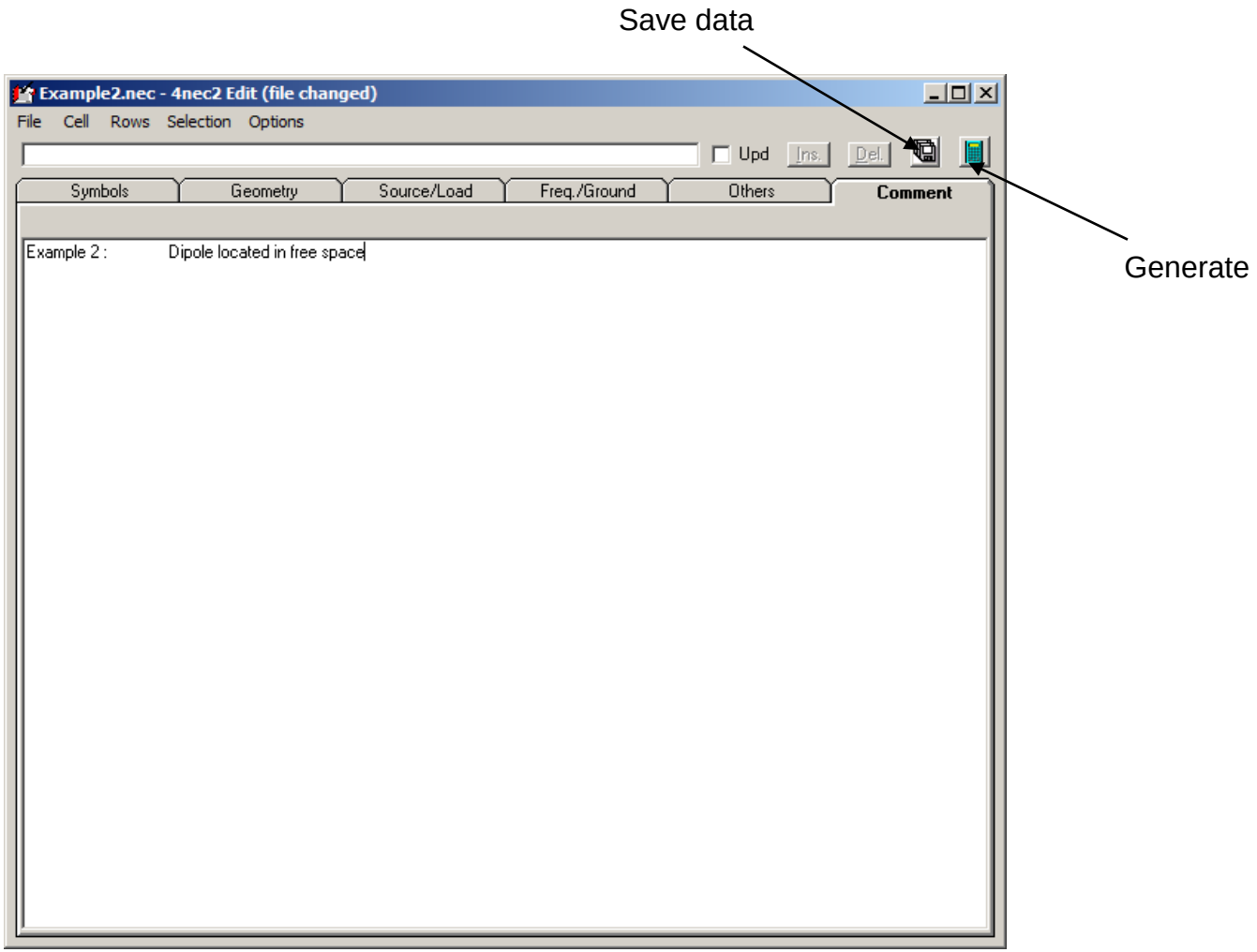
- Dialog box *Other* leave as it is



Dialog box Other

Modeling of Dipole Antenna in 4NEC2

- On Dialog box *Comment*, write important information related your antenna and its description

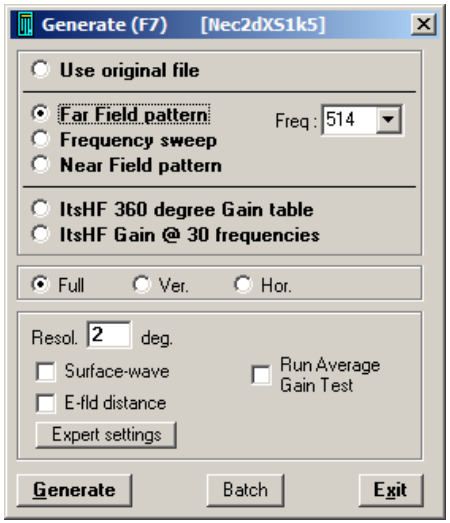


Dialog box Comment

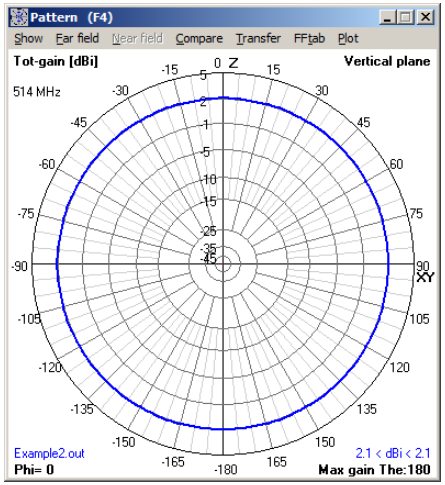
- Finally save data and Generate

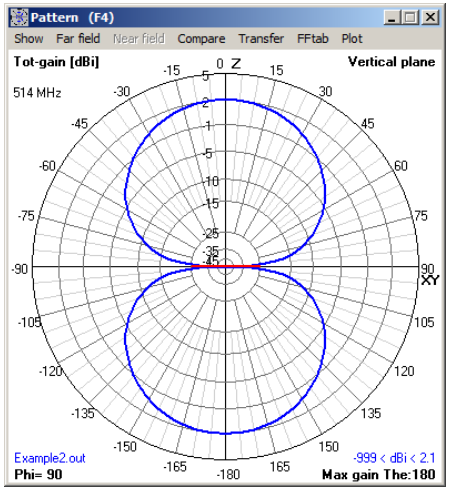
Modeling of Dipole Antenna in 4NEC2

- Let's evaluate radiation pattern by setting the following window and clicking on *Generate*



- 2D radiation pattern is obtained (different cuts can be obtained by arrows)

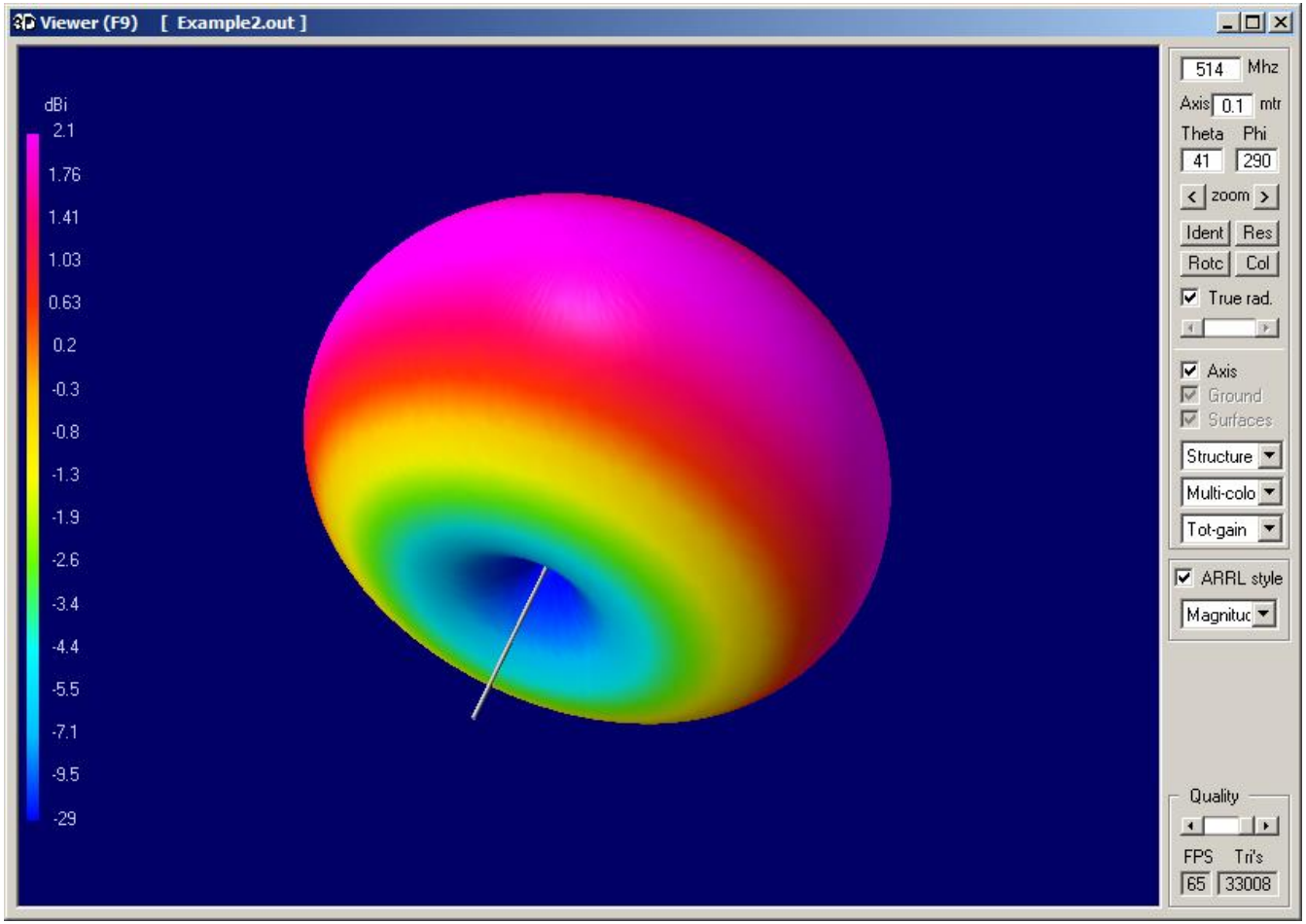




- Please, explore menu of *Pattern* (F4) window

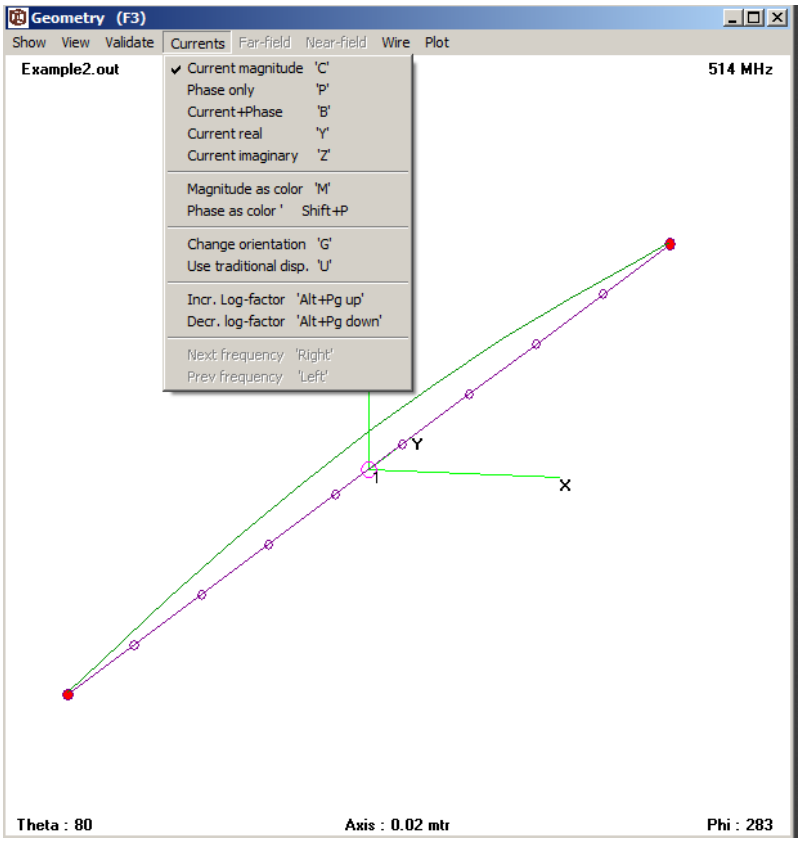
Modeling of Dipole Antenna in 4NEC2

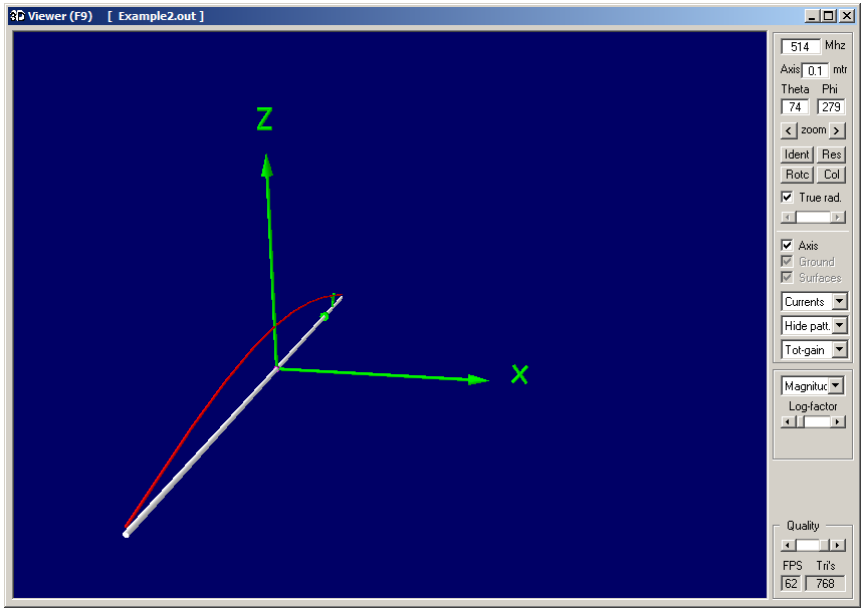
- 3D radiation pattern can be obtained through *3D Viewer* (F9)
- Please, set the viewer according to following figure and explore it



Modeling of Dipole Antenna in 4NEC2

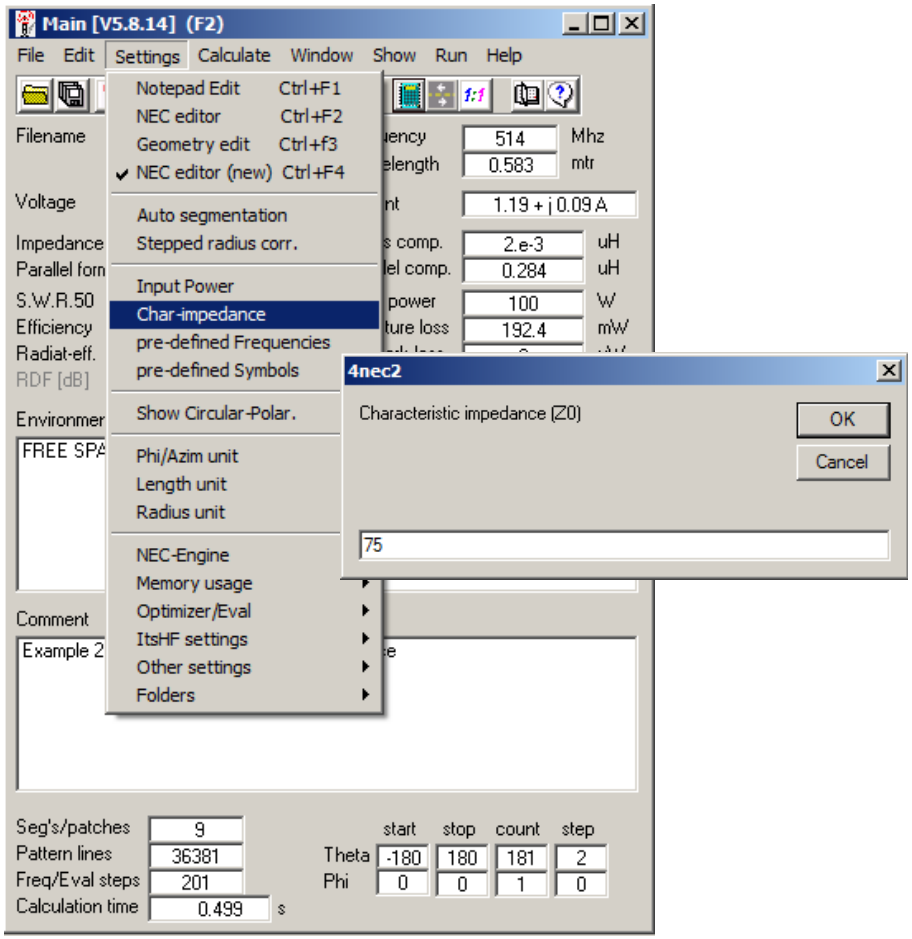
- Current distribution at frequency of solution can be depicted in *Geometry* (F3) window or in *3D Viewer* (F9)





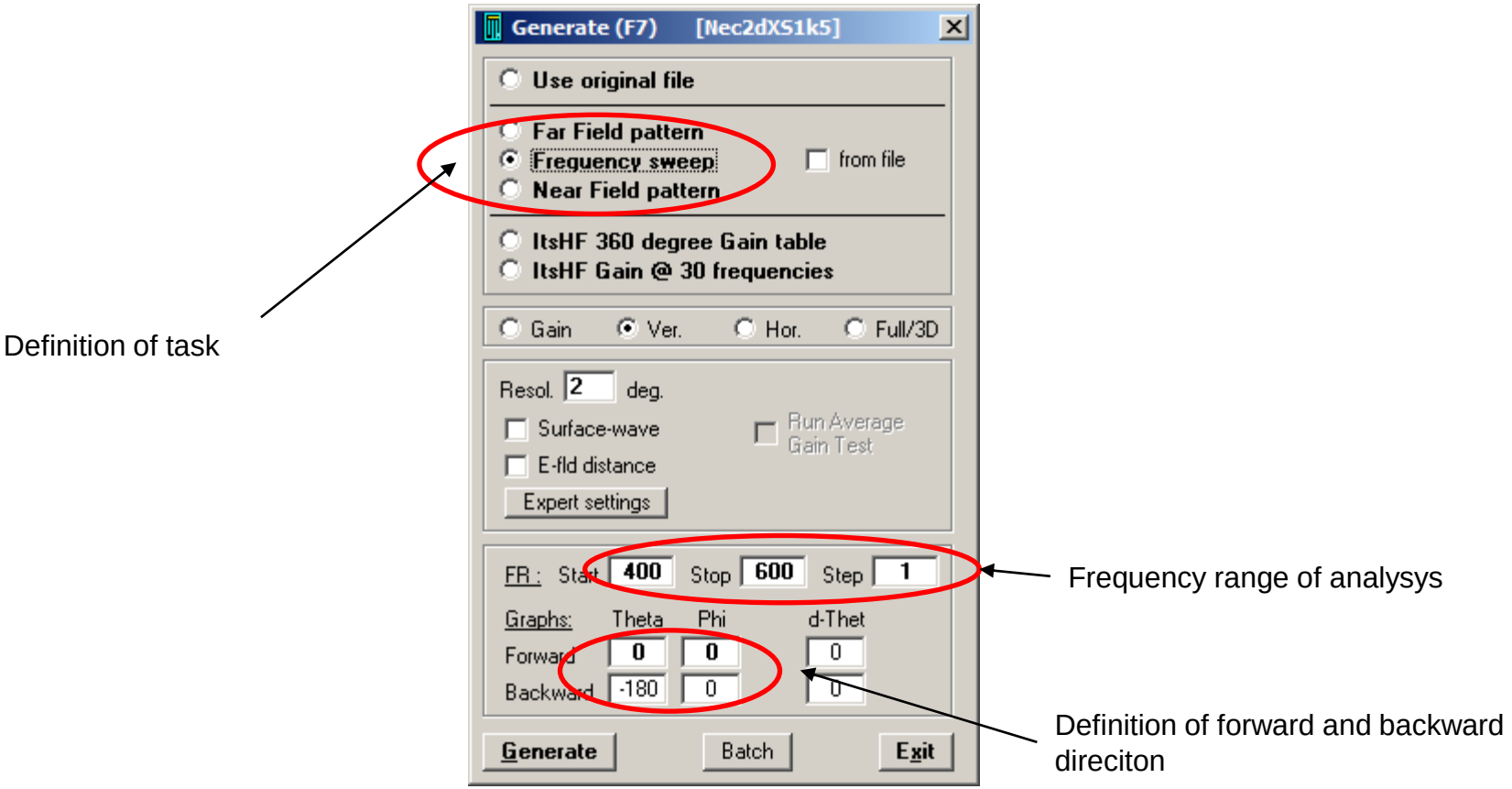
Modeling of Dipole Antenna in 4NEC2

- To evaluate frequency response of your antenna, e.g. Reflection Coefficient, VSWR, Input impedance…., at first set the characteristic impedance of feeding line in menu *Settings->Char-impedance* to desired value 75 Ω



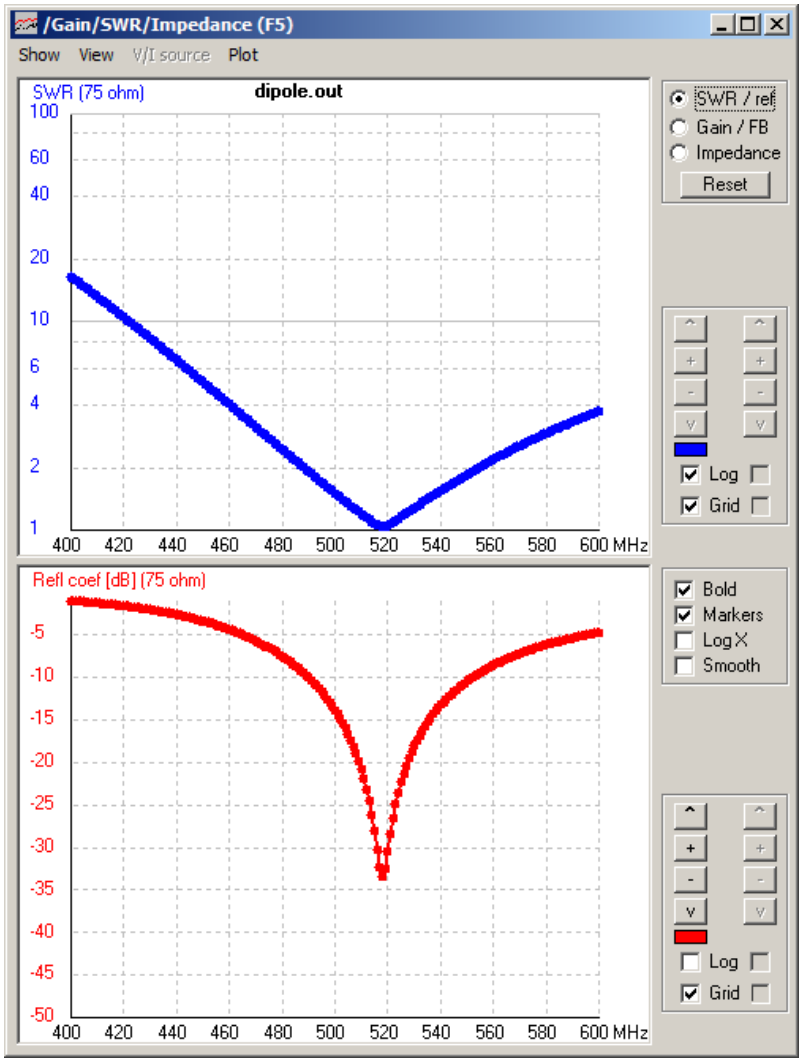
Modeling of Dipole Antenna in 4NEC2

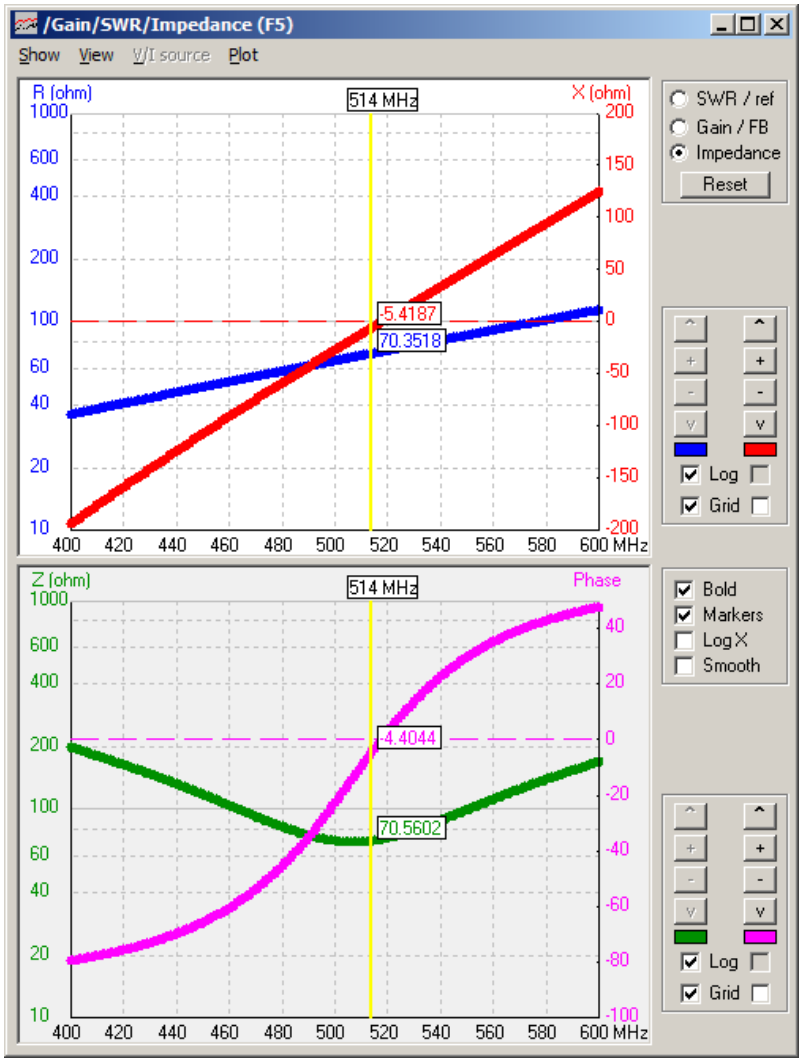
- And frequency response (press F7, or click on button *Calculate new output data*, or use menu *Calculate ->NEC output data*) and set dialog box as below, and click on button *Generate*



Modeling of Dipole Antenna in 4NEC2

- After calculation, *Gain/VSWR/Impedance* (F5) window appear, by clicking on graf, values at cursors apper



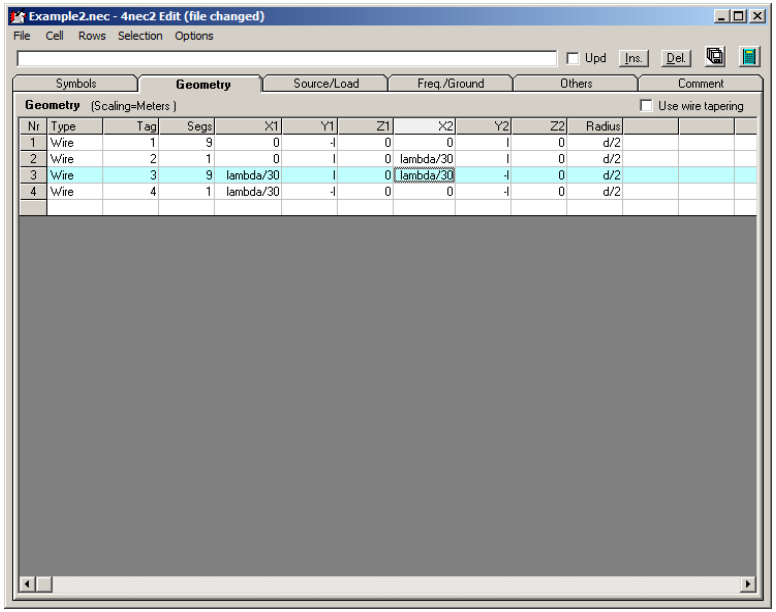


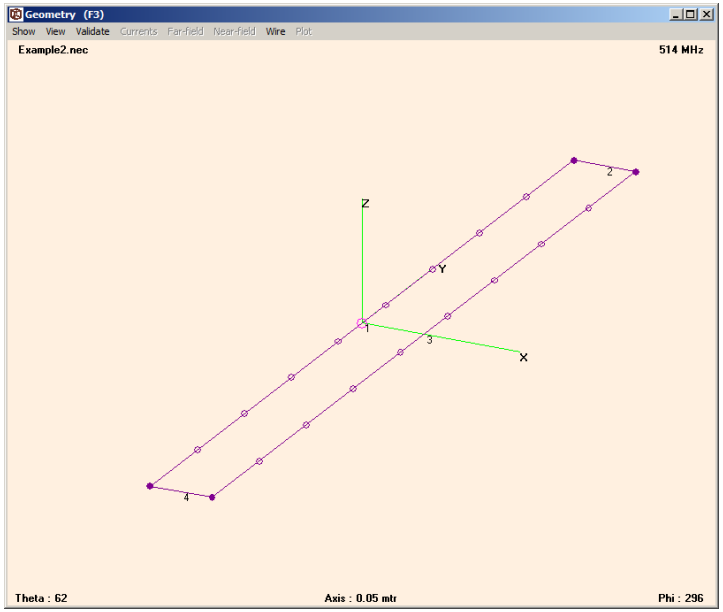
Modeling of Dipole Antenna in 4NEC2

- To finish modeling of dipole antenna:
  - Explore influence of number of discretization segments on input impedance of antenna
  - Tune dipole antenna to resonate at the center frequency of 26th TV-Channel (514 MHz)
  - Compare results from 4NEC2 (resonance length, input resistance) with analytical solution.

Modeling of Folded Dipole in 4NEC2

- To model folded dipole in 4NEC2:
  - Exploit current knowledge of 4NEC2 and model folded dipole in 4NEC in same way as dipole antenna
  - Determine input impedance and reflection coefficient of folded dipole for characteristic impedance of feeder Z_0 = 300 Ω
  - Depict radiation patterns of folded dipole and determine its directivity and gain
  - Compare results for folded dipole and dipole antenna…
- Geometry of folded dipole can be defined as presented below…





References

[1] P. Knott, Tutorial: Wire Antennas, Antenna Enginnering, p.1-10, 2009.

[2] https://www.qsl.net/4nec2/