Simulation of Wire Antennas using 4NEC2



A Tutorial for Beginners Version 1.0

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1. Introduction

NEC (= **Numerical Electric Code**) is a simulation method for wire antennas, developed by the Lawrence Livermore Laboratory in 1981 or the Navy. To realize this an antenna is divided into "short segments" with linear variation of current and voltage (like SPICE when simulating circuits). The results are very convenient and the standard for this simulation technique is **NEC2**.

Time is running and so the weaknesses of NEC2 (e. g. simulation errors when wires are crossing in a very short distance or when using buried wires) were overcome with 4NEC2. But 4NEC2 was top secret for a long time, no export allowed and still today very expensive (= starting at 2000\$). So a normal private user will take NEC2 and has the choice between lots of offers in the Internet. The two leaders are **EZNEC** (= not free of charge) and **4NEC2** (= completely free).

Especially 4NEC2 offers a huge amount of possibilities and options (including graphical 3D display of the results) and was programmed by Arie Voors. Its main advantages are the optimizing tools and the parameter sweeps. It can be found and downloaded free of charge from the Internet.

Two program packages must be installed: first "4NEC2.zip" and afterwards "4NEC2X.zip" in the same directory. "4NEC2" is the NEc calculator but "4NEC2X" (= 4NEC2 Extended) offers after pressing F9 the mentioned coloured 3D presentation of the simulation results with a lot of features.

Please note:

4NEC2 is an unbelievable huge tool with infinite possibilities. So this tutorial wants to "open a door" and so the user gets the necessary fundamental information about the usage of the software. He has then to continue itself....

2. Installation

No problem: after the download (<u>http://home.ict.nl/~arivoors/</u>) unzip the package and start the 4NEC2 exe file. After the successful installation right click on the 4NEC2X – exe file and install this software in the same directory. The software is completely free and no licensing necessary. Bugs or proposals for improvements can be mailed to the author Arie Voors who has done a huge work. So tell him "Thank you" in the mail for his work.

3. Getting Started

Click on the **4NEC2X icon** and you get two windows on your screen:

Main	(F2) and
Geometry	(F3)

After the simulation two additional windows can be opened:

Pattern	(F4) and
Impedance / SWR / Gain	(F5).

Remarks:

- a) Input and property inputs, modifications and start of simulation are all done in the Main window.
- b) The antenna geometry is shown in the Geometry window due to the Input NEC File.
- c) Far field and near field simulation results are presented in the Pattern window.
- d) And finally when sweeping you can see the impedance or the SWR or the F/B ratio versus frequency by pressing F5.

4. Geometry Builder, Geometry Editor or Text Editor to create a NEC File?

This must be decided by the user who has the choice.

a) Creating the NEC file with the **Geometry Builder** is fine. For Patch-, Plane-, Box-, Helix-, Spherical-, Cylinder- or Parabolic structures there exist own menus with own screens and the usage is really simple. **But you have only the listed 7 antenna types...**

b) To create any desired structure is an affair for the **Geometry Editor**. This editor this mainly foreseen for beginners and is easy of use.

The next 3 editors concentrate directly on the NEC file, because this is the goal of all preparation for the simulation. That needs more effort for the user but gives more options for simulation and optimizing.

But remember:

All length values in a NEC File are always read as "Meters". Otherwise you must write an additional "GS" card with a scaling factor for correction (example: entries in Inches...) which is applied to the complete structure.

But now let's have a look at the 3 editors:

With a simple text editor like **Notepad** you have to write the pure NEC file and / or modify entries in it. So the complete antenna structure must exist in your brain before writing -- but this is the fastest and most effective way.

That is not difficult and after a short time you are familiar with this method. Then you are able to modify structures or parts of them in a hurry....

The **"old 4NEC2** – Editor" was a progress because of using buttons to separate the different parts of the NEC file (but today no longer used and maintained).

e) the "new 4NEC2-Editor" uses menus with lines and columns for the different entries. Very fine -- but the user with lot of experience misses now the direct view on the complete NEC file. So after some time of working with 4NEC2 nearly everybody returns to Notepad.....

In the following examples and projects all these different editor methods are demonstrated. So please examine and decide yourself.

5. Starting with the included "example2.nec" (300MHz Dipole)

5.1. Far Field Simulation

Please change to the folder "models" and open the "example2.nec" file.

👔 Main [V5.8.1] (F2)	🕲 Geometry (F3)	
File Edit Settings Calculate Window State Run Help	Show View Validate Currents Far-field Near-field Wire Plot	
	EXAMPLE2.NEC 300	MHz
Filename EXAMPLE2.NEC Frequency 300 Mhz Wavenength 0.999 mtr		
Voltage Current	Dipole _z	
Impedance peries comp.	z	
Parallel form Parallel comp.		
S.W.R. Input power W		
Efficiency % Structure loss W		
Radiat-eff. 🛛 🎽 Network loss 🔤 W		
Radiat-power W		
Environment	X	
Free space Button F7 = Calculator		
Comment		
Example 2: Loaded dipole in free space See GetStarted.txt 'End of comment		
Seg's/patches	Number of common	-
Pattern lines	– Number of segmer	its
Freq/Eval steps		and the second
Calculation time s		
	Theta : 80 Axis : 0.2 mtr Phi	: 280

In the left (= Main) window you find the simulation frequency and wavelength (= big red circle). The small red circle in the under left corner of the window indicates that the dipole is divided into 9 segments. The right window shows the dipole geometry in the related coordinate system.

🖪 Generate (F7) [Nec2dXS1k5] 🔀
C Use original file
Frequency sweep Near Field pattern
© ItsHF 360 degree Gain table CutsHF Gain @ 30 frequencies
Resol. 5 deg. expert settings E-fid Surfaveve Run Average
E-fid Surf-wave Gain Test
<u>G</u> enerate Batch E <u>x</u> it

Now press the F7 button (= start of calculation) and choose "Far Field pattern", "Full" and "Generate".

An arc resolution of 5 degrees will do the job for the first time, giving short calculating times.

Then press "Generate".

This is the success and the main window is now fulfilled with entries and data. Now Press F4 and the vertical radiation pattern is shown in an additional window.



The "Show" menu in the Pattern (F4) window offers several options. With "Next pattern" and Previous pattern" you can walk through the diagrams.



Pressing "**Indicator**" gives an additional radial cursor for the diagram. If you left click on any point of the pattern curve with the mouse the cursor snaps to this point and the values of this point are indicated.

🛞 Pa	tern ∖⊊4)		U
Show	Far field Near field Compare (OpenPF	
Тоt-g а 300 МН	 Horizontal plane 'Spacebar' ARRL-style scale 'L' Show Multi pattern 'M' Show Bold lines 'B' Font scaling 	75	
15 165	Next Phi/Az slice 'Right' Prev Phi/Az slice 'Left" Next The/El slice 'Up' Prev The/El slice 'Down'		
180	 No normalization 'Home' Normalize overall Normalize each 		Т
195	High/low ranges	• Fr	

Jnder "Far Field" can be found:

- a) The switch for changing to the Horizontal Plane.
- b) The option to change to the "**ARRL-style scale**", using a logarithmic scaling for the amplitude including an "automatic scaling spread". So all lobes of a pattern are visible without efforts.
- c) "Multi Pattern" shows all diagrams for chosen polarity.
- d) "Bold lines" gives thick lines of the curves and
- e) "Font scaling" is self explaining.
- f) At last you can switch the azimuth angle (Phi) and / or the elevation angle (Theta) forward or reverse.

The rest of the menu should be tested by yourself.

5.2. Coloured 3D Presentation

This option needs "4NEC2X". So please start your work in the future always by opening this program.



Close 4NEC2 and start

4NEC2X

Use again the "example2.nec" file and repeat the far field simulation. Then select **F9** to start the 3D Viewer and you will get this screen.

Now press the left mouse button when rolling your mouse -- this varies the azimuth and elevation angle of the diagram (...for you the result is like a flight in a helicopter around the antenna...). Now play a little bit with the following buttons:

- a) "Ident" is used to identify and to mark a desired segment after entering the segment number.
- b) "Res" = "Reset" to the start position after the invoke of the 3D presentation.
- c) "Rotc" is used to define a segment as rotation centre.
- d) "Col" invokes the colour menu .

Structure 💌	Let us continue with the proposed 3D presentation of the antenna's radiation.
Multi-colo 💌	Chose these settings
Tot-gain 💌	
ARRL style	
Magnitur	and you get this screen. The pattern can be rotated like before by using the mouse.



Here follow some presentations which are of interest for a lot users:



Or all the segments of the wire can be made visible:



Play now yourself with this huge amount of possibilities...but this takes time....

5.3. Opening the NEC-File with Notepad

Change to the Main menu (F2), open "settings" and chose **notepad editor**. Then press F6 to open the NEC file of the antenna.

Please do not jump over this chapter, because a deep analysis of the NEC file details helps to modify or to optimize or to analyse error messages.

🖡 Example2.nec - Editor	
Datei Bearbeiten Format Ansicht ?	
¦⊐M Example 2 : Loaded dipole in free s ⊂M See GetStarted.txt	pace 🔄
CM See GetStarted.txt CE	' End of comment
ςγ len=.4836	' Symbol: Length for WL/2
GW 1 9 0 -len/2 0 0 len/2 0 .0001 GE 0	' wire 1, 9 segments, halve wavelength long. ' End of geometry
ĻD 5 1 0 0 5.8001E7	' Wire conductivity
EX 0 1 5 0 1 0 FR 0 1 0 0 300 0 EN	' Voltage source (1+j0) at wire 1 segment 5. ' Set design frequency (300 Mc). ' End of NEC input

Every line starts with a short abbreviation (= **card** name) and describes in a short form the task of the line.

Attention: In the main window you find a "NEC short reference" in the help menu.

Now let us examine every line.

Line 1 and line 2:	"CM" starts a comment line with a maximum of 30 signs.
Line 3:	"CE" is "End of comment"
Line 4:	"SY" stands for a "Symbol" and this is always a Variable (here: length = len=0.4836). Caution: all length values in a NEC file are given and calculated in Meters. Corrections can be made by using an additional "GS" card (= geometry scaling) e. g. when using feet instead of meters. This scaling factor is applied to the complete structure.
Line 5:	"GW" =,,Geometry of wire". Let us have a detailed look at the entries of this line.
	The line starts with "1" (= "Wire number 1").
	"9" indicates that the wire is divided into 9 Segments.
	"0 / -len/2 / 0" are the xyz coordinates of the wire's starting point. Length unit is always "Meter".
	"0 / len/2 / 0" are the xyz coordinates of the wire's end point.
	".0001" is the wire's radius in Meters.
Line 6:	"GE" = end of "geometry information", followed by a number which describes the ground
	"0" means: no ground = free space. "-1" or "1" represent a ground, but the details must be entered in a separate "Ground card" (= GN card).

 "5" = in this example only "LD 5" is used to enter the conductivity of the antenna wire. "1" = Wire 1. "0 0" = two empty fields. "5.8001E7" is the conductivity for copper (in mhos). Line 8: "EX" = "Exitation". "0" = a voltage source is used for excitation. "1" = wire 1 (= tag 1) is excited "5" = excited segment of Wire 1. "0" = an empty field. "1 0" = real and imaginary part of the applied complex voltage (1 + j0). So in this case a real voltage of 1V is used Line 9: "FR" = frequency information. Normally a sweep is used and must be programmed. So some information is necessary if only a fixed frequency is used: "0" = linear frequency step is foreseen. "0 0" = two empty fields. "300" = start value of frequency = 300MHz. "0" = gives a frequency step width of Null MHz 	Line 7:	"LD" = " Loading of a segment ". Please use the NEC short reference and the NEC manual in the online help to find out all options.
"0 0" = two empty fields. "5.8001E7" is the conductivity for copper (in mhos). Line 8: "EX" = "Exitation". "0" = a voltage source is used for excitation. "1" = wire 1 (= tag 1) is excited "5" = excited segment of Wire 1. "0" = an empty field. "1 0" = real and imaginary part of the applied complex voltage (1 + j0). So in this case a real voltage of 1V is used Line 9: "FR" = frequency information. Normally a sweep is used and must be programmed. So some information is necessary if only a fixed frequency is used: "0" = linear frequency step is foreseen. "0 0" = two empty fields. "300" = start value of frequency = 300MHz.		"5" = in this example only "LD 5" is used to enter the conductivity of the antenna wire.
		"1" = Wire 1.
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 "0" = an empty field. "1 0" = real and imaginary part of the applied complex voltage (1 + j0). So in this case a real voltage of 1V is used Line 9: "FR" = frequency information. Normally a sweep is used and must be programmed. So some information is necessary if only a fixed frequency is used: "0" = linear frequency sweep ("1" gives a logarithmic sweep) "1" = only one frequency step is foreseen. "0 0" = two empty fields. "300" = start value of frequency = 300MHz. 		"1" = wire 1 (= tag 1) is excited
 "1 0" = real and imaginary part of the applied complex voltage (1 + j0). So in this case a real voltage of 1V is used Line 9: "FR" = frequency information. Normally a sweep is used and must be programmed. So some information is necessary if only a fixed frequency is used: "0" = linear frequency sweep ("1" gives a logarithmic sweep) "1" = only one frequency step is foreseen. "0 0" = two empty fields. "300" = start value of frequency = 300MHz. 		"5" = excited segment of Wire 1.
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 Normally a sweep is used and must be programmed. So some information is necessary if only a fixed frequency is used: "0" = linear frequency sweep ("1" gives a logarithmic sweep) "1" = only one frequency step is foreseen. "0 0" = two empty fields. "300" = start value of frequency = 300MHz. 		
 "1" = only one frequency step is foreseen. "0 0" = two empty fields. "300" = start value of frequency = 300MHz. 	Line 9:	Normally a sweep is used and must be programmed. So some information is necessary
"0 0" = two empty fields."300" = start value of frequency = 300MHz.		"0" = linear frequency sweep ("1" gives a logarithmic sweep)
" 300 " = start value of frequency = 300MHz.		"1" = only one frequency step is foreseen.
		" 0 0" = two empty fields.
"0" = gives a frequency step width of Null MHz		" 300 " = start value of frequency = 300MHz.
		"0" = gives a frequency step width of Null MHz
Line 10: "EN" = end of NEC file		

5.4. Using the 4NEC2 Editor

Caution:

As already mentioned you have the choice between an old and a new version (...you find them in the "Settings" of the Main menu).

5.4.1. Working with the old 4NEC2 Editor

No problem, it's like working with Notepad in a modern environment. But this editor version is obsolete.

🖆 Edit NEC input-file		
File Edit Options		
Comment line	c .	
Card CM Example 2 : Loaded dipole in free space	Comment	-
Tent Tenanipie z Teodada alpoie in nee opao		
	Comnt Ins Del 🛄	
CM Example 2 : Loaded dipole in free space)	
CM See GetStarted.txt CE	'End of comment	
SY len=.4836	' Symbol: Length for WL/2	
GW 1 9 0 -len/2 0 0 len/2 0 .0001 'Wire 1 GE 0	, 9 segments, halve wavelength long. 'End of geometry	
LD 5 1 0 0 5.8001E7	'Wire conductivity	
EX 0 1 5 0 1 0 FR 0 1 0 0 300 0 'Set de EN	'Voltage source (1+j0) at wire 1 segment 5. sign frequency (300 Mc). 'End of NEC input	
1		

5.4.2. The new 4NEC2 Editor



All the used wires and their properties are listed on the next card "Geometry" (Tag Number / number of segments / xyz coordinates of wire start and end / radius of wire in Meters).

🖆 EXAMPLE2.NEC - 4nec2 Edit							
File Cell Rows Selection Options							
Default straight line wire-element				🔲 Upd	Ins.	<u>)</u> el.	
Symbols Geometry	Source/Load	Freq./Groun	d Y	Others		Comment	
Geometry (Scaling=Meters)					🗆 Us	se wire taperi	ing
Nr Type Tag Segs	X1 Y1	Z1 X2	Y2	Z2	Radius		
1 Wire 1 9	0 -len/2	0 0	len/2	0	.0001		

On the Source / Load card must be noted that a real voltage source (magnitude = 1V) is connected to Tag 1 / Segment 5.

(Remember: In the load card "LD" in the true NEC file there was only one entry the value of the conductivity of the copper for the wire).



😭 EXAMPLE2.NEC - 4nec2 Edit		
File Cell Rows Selection Options		
Symbols Geometry Source/Load	Freg./Ground	At last info
Frequency	- Ground screen	sweeping
Frequency 300 Miz	Nr of redicis	for a fixed 300MHz a
Vr steps Sweep	Radial length	
Stepize	Wire radius	
Environment	-Second ground —	
Ground / Free-space	Ground type	
	Conductivity	
	Diël constant	

last information about frequency and veeping must be entered. No problem r a fixed frequency simulation at 00MHz and a dipole in free space.

5.5. Near Field Simulation

🖪 Generate (F7) [Nec2dXS1k5] 🛛 🔀	Open main ["] (F2) and press "F7 ". Then choose "Near Field Pattern " and "E-Field " and check the entries. This is the task:
 C Use original file C Far Field pattern C Frequency sween Near Field pattern C ItsHF 360 degree Gain table C ItsHF Gain to 30 frequencies ItsHF Gain to 10 C H-fid 	Show the E Field distribution for Y = 0 (= centre of dipole as seen in the direction of the antenna wire and step "X" from -20m to +20m in steps of 1,6m and
Start Stop Step X -20 20 1.6 (mtr) test Y 0 0 1 Tot-points Z 0 50 2	"Z" from 0 to 50m in steps of 2m."

🛞 Pa	ttern (l	-4)				
Show	Far field	Near field	Compare	OpenPF	Plot	
300 Mł	in (V/m) 					Y=0 mtr
82.4	50 <u>2</u>					
77.3	45					
72.2	43					
67.2	40					
62.1	35					
57						
52	30					
46.9	25					
41.8						
36.8	20					
31.7	15					
26.6	10					
21.6	10					
16.5	5					
11.4						
6.35	0 ا_1	-20 -15	-10 -5	υ 5	10 1	5 20 25 1
■1.28 Y=0 ml					1.0	0 2 13 (201 2 00 4
	r IPLE2.ou	t				8 < [V/m] < 82.4 x: X=0.8; Z=0

This is the simulation result.

Important:

The scaling of the field distribution belongs to an Input Power of 100W (See the "Settings" menu and then "Input Power" for changing)

(Remember:

This power value is also used when simulating the current distribution on the antenna wire).

5.6. Sweeping the SWR and the Input Reflection



Press F2, then "F7. Select "Frequency sweep".

Enter the sweep range from 295 to 305 MHz in the lower half of the menu. Use a step width of 0.1MHz.

Select "Ver" (= Vertical Pattern) and start the Simulation with the button "Generate".





6. First own Project: 300MHz Dipole over realistic Ground

6.1. Modification of the NEC-File

The easiest way is to use the NEC file of the last example and to modify it:

- a) now the dipole hangs 1m above the ground and
- b) a realistic ground shall be used.

At first create a new folder for own projects (e. g. "**own_examples**") and in it an additional folder this task ("**dipole_over_ground**"). Then copy the NEC file of the last example into this new folder and rename it to

dipole_over_ground.nec

Then start 4NEC2X and select the new 4NEC2 editor in the settings menu. Open the new file "dipole_over_ground.nec" (by pressing F6).

At first enter in the geometry	card the height of the	dipole's start and end	point to $\mathbf{z} = 1\mathbf{m}$
At mot enter in the geometry	y calu lite height of lite i	apple s start and end	

🗳 dipole_over_ground.nec - 4nec2 Edit									
File Cell Rows Selection Options									
Default straight line wire-element									
Symbols Geometry	Source/Load Freq./Ground	Others Comment							
Geometry (Scaling=Meters)									
Nr Type Tag Segs	X1 Y1 Z1 X2	Y2 Z2 Radius							
1 Wire 1 9	0 -len/2 1 0	len/2 1 .0001							

Then switch to "Freq./Ground". Select "**Real ground**" and "**Average**". Let the field "**Connect wire for Z = 0 to ground**" free.

🗳 dipole_over_ground.nec - 4nec2 Edit	
File Cell Rows Selection Options	
	🗖 Upd _insel. 🛄
Symbols Geometry Source/Load	Freg./Ground Others Comment
Frequency	Ground screen
Frequency 300 Mhz	Nr of radials
Nr steps Sweep	Radial length mtr
Stepsize	Wire radius mm
Environment	Second ground
Ground / Free-space Real ground 💽	Ground type
Connect wire(s) for Z=0 to ground	Conductivity
	Diël constant
Main ground	Distance mtr
Ground type Average	Depth mtr
Conductive 0.005	C Circular boundary
Diël constant 13	C Perpendicular to Y-axis
🔲 Use ground wreen	
Use second ground	

Now open the NEC file with notepad to see the modifications:

⊂M ⊂M	Example 2	: Loade	ed dipole	e 1m abov	e ground				
CM CM CM		New height: z = 1m							
CM									
CE SY	len=.4836	'Syml	ool: Leng	th for w	<i>I</i> L/2				
GW	1	9	0	-len/	/2 1	0	len/2 1 .0001 'wire		
GE	-1				e-ends i	not conr	nected to ground,		
			ard requ						
LD	5	1	0	0	580000	000	'wire conductivity		
ΞN	2	0	0	0	13	0.005	Ground card		
EK EX FR EN	0 0	1 0	5 0	0 0	1 300	0 0	- 'Voltage source (1+j0) at wir∉		

The entries in the Ground card GN are easy to understand:

"2"	=	Sommerfeld Norton Ground.
"13"	=	Dielectric constant
".005"	=	Conductivity in mhos/m

6.2. Far Field Simulation



This is now a well known procedure: Press **F7**, select "**Far Field Pattern**" and "**Full**", followed by "**Generate**".

That gives this pattern for the "Vertical Plane".

Press F9 (or the 3D button in the menu bar) and you can see the 3D pattern when using the indicated settings:



6.3. Near Field Simulation

🛚 Generate (F7) 🛛 [Nec2dXS1k5] 🛛 🔀
🔿 Use original file
C Far Field pattern
Rear Field pattern
C ItsHF 360 degree Gain table
C ItsHF G = @ 30 frequencies
© E-fic O H-fid
Start Stop Step X -20 20 1.6 (mtr) test
Y 0 0 1 Tot-points
Z 0 50 2
Generate Batch Exit
<u>G</u> enerate Batch E <u>x</u> it

No problem: use these settings and at once you get the Electrical Field Strength around the dipole.

Input power is 100W.



6.4. Sweeping the SWR and the Input Reflection

🖩 Generate (F7) [Nec2dXS1k5] 🔀								
C Use original file								
Far Field pattern Frequency sweep from file Near Field pattern								
⊂ ItsHF 360 degree Gain table ⊂ ItsHF Gain @ 30 frequencies								
⊂ Gain (♥ Ver C Hor. ⊂ Full/3D								
Resol. 5 deg. expert settings E-fid Surf-wave Gain Test								
FR : Start 295. Stop 305. Step .1								
Laraphs: Theta Phi d-Thet Forward 5 0 0 Backward -175 0 0								
<u>G</u> enerate Batch E <u>x</u> it								

Open this well known F7 menu, select "**Frequency sweep**" and choose a sweep range from **295 to 305MHz** with a frequency step of 0.1MHz. Select "**Ver**" = **Vertical** and click on "**Generate**" to start the simulation.

After the (longer) calculation time we get the result. The only difference to the last chapter is an increase of 1.5MHz of the frequency for minimum reflection



7. Second project: 300MHz Dipole using thick wires

7.1. The Thick Wire Problem

📕 Symbols - Editor	
Datei Bearbeiten Format Ansicht ? ! Default SY(mbols)/constants Pi=3.14159265358979 ! AWG wire radi in mm's #0=8.2525mm/2 #1=7.3482mm/2 #2=6.5430mm/2 #3=5.8268mm/2 #4=5.1892mm/2 #4=5.1892mm/2 #5=4.6203mm/2 #6=4.1148mm/2 #7=3.6652mm/2 #8=3.2639mm/2 #9=2.9058mm/2	In the last examples an ideal and infinite thin wire was used for the simulation. But in practice the wire radius must be increased to get some mechanical stability. When opening "Settings" in the main menu you find in " pre-defined symbols" an AWG (= American Wire Gauge) list. .
<pre>#10=2.5883mm/2 #11=2.3038mm/2 #11=2.3038mm/2 #13=1.8288mm/2 #14=1.6281mm/2 #15=1.4503mm/2 #16=1.2903mm/2 #17=1.1506mm/2 #17=1.1506mm/2 #19=0.9119mm/2 #20=0.8128mm/2</pre>	Choose "#3" with a diameter of 5.8mm because this gives enough mechanical stability. Open the NEC file with the editor, enter this value and save all. So the Geometry card must now look like in the new 4NEC2 editor:

۶	🖆 DIPOLE_OVER_GROUND.NEC - 4nec2 Edit												
F	File Cell Rows Selection Options												
ł	Wire radius [diameter/2](for fine segment)												
		Symbols		Geometry		ource/Loa	d Y F	Freq./Groun	d Y	Others		Comment	t
	Geometry (Scaling=Meters)												
	Nr	Туре	Tag	Segs	×1	Y1	Z1	X2	Y2	Z2	Radius		
	1	Wire	1	9	0	-len/2	1	0	len/2	1	#3		

Caution:

M DIPOLE_OVER_GROUND.NEC - 4nec2 Edit	
File Cell Rows Selection Options	Now you must open
	"Others" to activate the
Symbols Geometry Source/Load Freq./Ground Others	 extended kernel for the fat wire support!
Fat wire support	

When checking the NEC file with Notepad you will now find an additional new card:

The card is named "EK" (= extended kernel) and in the future this new line can also be added by hand with the Notepad editor...

(Information: the new 4NEC2 editor adds this line automatically).

7.2. Far Field and Near Field Simulation



There are no changes compared to chapter 6.2 (far field) and to chapter 6.3 (near field for an input power of 100W)



7.3. Sweeping the SWR and the Input Reflection



This is the influence of the thick wire: the frequency for minimum reflection has decreased to a value with is 10MHz lower.

7.4. Sweeping the Antenna Gain

At first repeat the simulation of the vertical radiation pattern (see chapter 7.2.), but with an angle resolution of 1 degree.



In this diagram the elevation angle for maximum gain is indicated as **Theta = 76 degrees**.

In the left lower corner of the diagram an azimuth angle of 360 degrees is indicated (this means that we see a "cut" through the 3D pattern at this angle).

🖪 Generate (F7) [Nec2dXS1k5] 🛛 🔀
O Use original file
C Far Field pattern Freguency sweep from file T Near Field pattern
C ItsHF 360 degree Gain table C ItsHF Gain @ 30 frequencies
ເ⊂ Gain C Ver. C Hor. C Full/3D
Resol. Image expert settings □ E-fld □ Surf-wave □ □ E-fld □ Surf-wave □ □ Gain Test
FR: Start 280. Stop 310. Step .2
Graphs: Theta Phi Forward 76 0
<u>G</u> enerate Batch E <u>x</u> it

- Press **F7** to enter the following options:
 - a) Frequency sweep
 - b) "Gain"
 - c) Angle resolution of 1 degree
 - d) Sweep from 280 to 310MHz with a step width of 0.2MHz
 - e) Set Theta to 76 degrees and Phi to 0 degrees

Now press "Generate".

(Click off the information that in this case no "F/B" data = front to back data are available. Ignore ist and continue with "Generate")

After the simulation process we see window F5 with the SWR and the input reflection S11.

t-01	neta= 76	: Phi= 3	60		d	ipole_	thick	wire.	out					
									·					
							to	ta		ai	n			
						/	U	La	' Y	Jai				
					1									
		<u>eeeeje</u>	<u> </u>						Ţ		i i i			
4				į́					.		į́			
									· +					
											+			
		+-												
	282 284	286	288	290	292	294	296	298	300	302	304	306	308	310 MHz
280 : 'back; '	282 284 Theta= 76			290	292	294	296	298	300	302	304	306	308	310 MHz
280				290	292	294	296	298	300	302	304	306	308	310 MHz
280 : 'back; '				290	292	294	296	298	300	302	304	306	308	310 MHz
280 : 'back; '				290	292	294	296	298	300	302	304	306	308	310 MHz
280 : 'back; '				290	292	294	296	298	300	302	304	306	308	310 MHz
280 : 'back; '				290	292	294	296	298	300	302	304	306	308	310 MHz
280 : 'back; '				290	292	294	296	298	300	302	304	306	308	310 MHz
280 : back; '				290	292	294	296	298	300	302	304	306	308	310 MHz

Select "**Show**" and "Forward Gain" to get the diagram with gain versus the irequency.

(And in the lower diagram we see that the remark "no F/B data available" is true).

7.5. Sweeping the Input Impedance

Open "Show" and select "Imp / Phase".

Now the exact value of the resonant frequency can be determined to 291MHz (there X = 0).

And as theory says, the input impedance has a value of 70Ω (= radiation resistance).



8. A wonderful toy: the Smith Chart Machine

When a simulation is successfully done a Smith chart symbol is highlighted in the menu bar. So we repeat the frequency sweep of the SWR and the Input reflection over a **frequency range from 270 to 310MHz with a step width of 0.2MHz** and press the Smith chart button. This gives the following screen:



The simulated S11 is shown as black coloured curve.

In the right lower corner of the screen you find the actual **frequency** (here. 270MHz). Use the "right" resp. "left arrow key" on the keyboard to walk through the simulated frequency range and you will here see the S11 value for this frequency.

Caution:

The information "Mouse" in the next line shows always the impedance value at the actual mouse cursor position (....and NOT the converted S11 value of the curve for the simulation frequency). This impedance is indicated in serial and in parallel form.

Additionally we find a pink curve and a green vector running through the actual point of the S11 curve. The circle radius gives the S11 magnitude (here: 0.409) and this circle is the way on which we march when a transmission line is connected to the input of the antenna.

The phase of S11 is indicated by the green vector (..use the scaling on the circumference of the Smith chart).



On the left of the Smith chart some additional information is indicated (using pink pointers).

Caution: At first think a horizontal separating line between the upper and the lower nomograms (= marked in red colour).

In the upper half you get the relation between the actual SWR and the SWR voltage ratio.

In the lower half the relations between reflection loss, return loss (in dB), power reflection coefficient and voltage reflection coefficient are indicated.

In the menu for this presentation you find "Export" and "Import".

This can be used to produce a Touchstone file (= S parameter file) for export purpose or data saving. You have the choice between "magnitude / phase" or "dB" form. Also Z parameter files can be produced and exported.

And, if you want, use this Smith chart machine to read and to present foreign (= imported) Touchstone files.

9. Optimizing (Key F12)

What is an antenna design worth without optimizing? This can be done after pressing F12, but some preparation is always necessary:

Every antenna data (which shall be varied for optimizing) must before in the NEC file be replaced by a variable with a definite default value.

9.1. Optimizing the Antenna Length (thick wire dipole of chapter 7)

Task:

The resonant frequency of the "thick" dipole (see chapter 7) should be 300MHz. So let us automatically vary the wire length until only the radiation resistance can be measured at the dipole's input at 300MHz (and X = 0)

Step 1:

Open the NEC file with Notepad and set the default value of the variable "len" to 0.465m. So this line must now look like:

SY len=0.465

Step 2:

This is now the NEC file:

CM CM CE				Loaded dipole above Som Thick wire used (#3) End of comment	merfeld ground
SY	len=0.465				' Symbol: Length = 0.465m for WL/2
GW	/ 1 9 0 -len/2 1 0 len/2 1 #3		-len/2 1 0 len/2 1 #3	' Wire 1, 9 segments, halve wavelength long, 1m above ground, ' wire gauge: #3	
GE	-1				Geometry data entering finished. Ground used, ends of wiresnot connected to ground. GN ground card necessary
LD 5 GN2 EK	1 0	0 0	0 0		' Wire conductivity ' Sommerfeld ground, er = 13, conductivity = 0.005 mhos / m ' Extended wire kernel used.
EX FR 0 EN	-	1 0	-	0 1 0 300 0	' Voltage source (1+j0) at wire 1 segment 5. ' No sweep, frequency = 300MHz ' End of NEC file

Step 3:



At first use a frequency sweep of the input impedance from 280 to 320MHz to show the goal of optimization.

Step 4:



Press F12 and check whether "Optimize" and "Default" are set in the upper left corner of the menu. Then select the variable (by clicking in the list) which shall be varied for optimization. In this example we have only "len" as variable and this variable can be activated by a mouse click on its name. But check whether "len" now can be found under "Selected".

At last we set the goal of optimization. It is possible to optimize more but one antenna property but in this case every property must be combined with a **figures of merit in %** (blue circle in the figure).



Important:

Right click on the "X-in" window with its entered value of 100% to get this additional menu. There select "minimize" as optimization goal.

At last press "Start" and wait.

🕄 Optimizer: Ready			
Settings Function Option Optimize Defau Variables Selected Ienell 455 Ien	Weighting factors (FOM) in %: SWR Gain F/B F/R R-in X-in Eff. 0 0 0 0 0 0 0 0 0 0 0 0 Surf-wave at distance = 1 Km Theta 75 75 Tot-gain * Phi 0 180 Freq-sweep d-Thet 0 0 0 300 300	Variable Sensivity: Rum len 1.1 2.1 3.1 4.1 5.1 6.1 .1	
Calculated results:	Stop Update NEC-file Exit Show Log Plot result	Variable Values:	This is th seconds press " O
Run: SWR Gain F/B 3.4 1.4596 0 4-1 1.4636 0 4-2 1.4535 0 4-3 1.4472 0 4-4 1.4421 0 4-5 1.4375 0 5-1 1.4421 0 5-2 1.4397 0 5-3 1.4397 0 5-4 1.4421 0 5-4 1.4421 0	F/R R-in X-in Eff. Res. % Step % ▲ 0 0 72.845 2.2714 99.91 -0.02 0.4 0 0 73.083 2.3357 99.91 -7e-3 0.1 0 0 72.609 1.6094 99.91 7.e-3 0.1 0 0 72.102 0.2782 99.91 7.e-3 0.1 0 0 72.102 0.2782 99.91 7.e-3 0.1 0 0 72.102 0.2775 99.91 1.e-3 0.1 0 0 71.87 -0.381 99.91 1.e-3 0.1 0 0 71.928 -0.217 99.91 2.e-3 0.025 0 0 72.043 0.1121 99.91 2.e-3 0.025 0 0 72.043 0.1278 99.91 -6e-4 0.025 0 0 72.102 0.2782 99.91 -6e-3	Run: len 3:4 0.4706 4:1 0.4711 4:2 0.4701 4:3 0.4697 4:4 0.4682 4:5 0.4687 5:1 0.4688 5:3 0.4693 5:4 0.4693 6:1 0.4693 6:2 0.4693	

This is the result after 23 seconds and you can press "**OK**"



In the center of the screen changes something and you have now the choice between "Resume" and "Update NEC-File".

Press "**Update NEC-File**" to save the necessary modifications. If you now check the file by opening it with Notepad you will find a **new value for the wire length with "len=0.4697".** So start a new simulation (F7) with the same frequency sweep as before.

F/B Bin Xin LEff Bes %



9.2. Parameter Sweep

Often it is of interest how some characteristic antenna data (e. g. input impedance) vary not only with frequency but also with special antenna properties (e.g. height over ground). To get a good overview in this case you can use the parameter sweep for this purpose. Here comes an example.

9.2.1. Input Impedance for different Antenna Heights Task:

Simulate the input impedance of the thick dipole at f = 300MHz when varying the height over ground between 0.5m and 1,5m in 20 steps.

Step 1:

Use Notepad to open the NEC file for the following modifications:

- a) In the "SY" card add an entry for height as a variable with a default value of 1m (hght=1).
- b) Replace the value of 1m in the GW card by the variable "hght".

CM CM CE		Example 2 : Loaded dipole above Sommerfeld ground Thick wire used (#3) End of comment
SY	len=0.4697, hght=1	' Symbols: Length = 0.4697m for WL/2, height = 1m
GW	1 9 0 -len/2 hght 0 len/2 hght	#3 'Wire 1, 9 segments, halve wavelength long, 1m' above ground, wire gauge: #3
GE	-1	 Geometry data entering finished. Ground used, ends of wires not connected to ground. GN ground card necessary
-	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	 'Wire conductivity on "Load" card 'Sommerfeld ground, er = 13, conductivity = 0.005 Siemens / m 'Extended wire kernel used. 'Voltage source (1+j0) at wire 1 segment 5. 'No sweep, frequency = 300MHz 'End of NEC file

Step 2:

Optimizer and Evaluator (F12)	
Settings Function Option Sweep Ver-p Min. Max. Variables Selected 0.5 1.5 Ien=0.4697 hght 0.5 1.5 Hght=1 Select "hght" and set	SWR Enter 20 simulation steps at 300MHz Surf-wave at distance = 1 Km Theta 80 80 Tot-gain Phi 0 0 Resolution 5 deg. Use fixed stepsize
the limits to 0.5m and 1.5m	Nr. of step 20 Fremency 300 T
Calculated results: Show Log	Plot result Variable Values:

Press F12 to open the optimizer menu. Sweep the height over ground from 0.5m to 20m using 20 steps at 300MHz.

Step 3:

Start the sweep and wait for the message "End of Sweep". Then click on "OK". F5 opens the access to the impedance, the SWR ratio and the gain. Use the "Show" menu to get the simulation result for the impedance versus the antenna height over ground.



It is nice to see that the input resistance (= radiation resistance) only varies a little bit at different heights. But the reactance....

9.2.2. Far Field Pattern for different Antenna Heights

This is not very difficult. First open the windows F3 and F4.

F3 is a resume of all simulated patterns. But in F4 only one pattern can be indicated for the choosen height over ground.

Click on F4 to activate it and use the horizontal Cursor tabs to regard the pattern collection.

(Caution: these are the tabs on the right hand side of your keyboard).

The actual height is indicated in the left upper corner of F4, the actual pattern is up lighted in red colour in F3.



10. Third Project: Geometry Builder or Text Editor to design a Helix Antenna?

10.1. Fundamentals of Helix-Antenna Design



(Literature: "ARRL Antenna Book", chapter 19-5. An excellent book which must be recommended...)

A helix antenna consists of more but three turns of alumina or copper wire and constant pitch. This gives a circular polarized radiation in direction of the antenna axis (in the left illustration: upwards) and an antenna gain of more but 8dBi.

The radiation resistance has a value of approx. 140Ω , if a circumference value of one wavelength is used. Increasing or decreasing the ratio of circumference and wavelength alters the radiation resistance in the same manner. So the perfect matching of the antenna to 50Ω is sometimes heavy work. But one important advantage is the large usable frequency range with nearly constant gain and radiation resistance and the circular polarization.

. This antenna shall work over "perfect ground" and so in practice you often find a metal plate or disc (...or sometimes a little alumina pot!) at the feeding side.

In the Web lot of information and design software for a helix antenna can be found. Especially the Online Calculator are a real help and easy to use. So let us design a 1600MHz which can not only be used for GPS but also for Meteosat Weather Satellite Reception with such an Online Calculator (homepage: http:// www.vk2zay / calculators / helical.php)

Waxial-Mode Helical Antenna - Mozilla Firefox Datei Bearbeiten Ansicht Chronik Lesszeichen Extras Hilfe	@_×
😮 🗣 🖒 🖌 🖌 http://www.vk/2zay.net/calculators/helical.php	P
🖸 🔹 🕡 🕥 🔹 helix antenna de 🔽 🔍 Search 🔹 🌜 🔛 🔛 Video History 🔹 Record Audio 😂 Convert 🕐 Play 🥜 Settings 🧊 Record Music 🎽 TV Channels * 💽 💽 Redorf 🚱 😳 Old *	+
♥! · ●	+ 🛛 😁
🚹 Antenna design calculators, RF calculat 💿 🖌 Axial-Mode Helical Antenna 🛛 🔯	1

Axial-Mode Helical Antenna Calculator

This is my simple implementation of the ARRL Antenna Book design equations for the axial-mode helical antenna. The dimension limits are enforced to ensure axial-mode radiation. Larger C/A tightens the radiation pattern at the expense of circularity.

The 50 ohm matching techniques are discussed at length in the ARRL book. I have had good luck with the 1/4-1/2 turn close spaced matching technique, which sacrifices less bandwidth than a coax matching network, but more than building four short helicals in an array with the tapered parallel feed system.

Frequen	cy 1600	Hertz * 10 ⁶
Turns	5	turns (at least 3)
CIA	1	Circumference/Wavelength (0.75 - 1.33)
D/A	1	Reflector Diameter/Wavelength (0.8 - 1.1)
SIA	0.25	Turn Pitch/Wavelength (0.2126 - 0.2867)
calculate	e	

Wavelength (A): 187.375 mm

Winding Diameter: 59.643 mm Winding Circumference: 187.375 mm Winding Spacing: 46.844 mm Winding Length: 965.709 mm

Reflector Diameter: 187.375 mm Boom Length: 234.219 mm

Gain: 14.031 dBic Half-Power Beamwidth: 46.510 deg Fertig

🐮 Start 😻 Axial-Mode Helical An... 🏠 Helix

From this screen we get the following antenna property collection:

Number of windings (= turns)	=	5
Operating frequency	=	1600MHz
Beam length	=	234.219mm
Pitch (= winding spacing)	=	46.844mm
Diameter	=	59.643mm
(Wire diameter is 2mm)		

💽 < 🎃 🔊 🔀 09:57

10.2. Design using the Geometry Builder

Start "main", then "run". Select "Geomtry Builder". Go to the "Helix" card for the necessary entries:

Ti Geometry Builder (V2.4)	
Patch Plane Box Cylinder Parabola	Helix Sphere Help
HelixLength L in mtr.0.2342Radius R1 in cm.2.982Radius R2 in cm.2.982Number of turns5Segments per turn24Left/Right handedNumber of helices1Add center connections	lenght L number of turns
Use auto-segmentation Frequency in Mhz 1600	R1 X
Segmentation mediu 👻	
Start with tagnumber 1	✓ Use equal-area rule to set wire-radius Manual wire radius 1 (!)
Rotate X, Y, Z 0 0	0 != symbols also allowe
Move X, Y, Z	0 (!) Exit Create

Caution:

Let us use 24 segments per turn.

For a wire diameter of 2mm the radius is 1mm.

Be aware that 3 different units (Meters, Centimetres and Millimetres) are used when entering data!

Because "Left / Right handed" is not marked you will automatically get a left hand circular polarization of the radiation.

If everything is OK, press "Create" to create the NEC file, which will open automatically. But with (5 turns) x (24 segments per turn) = 120 segments it is a little huge... Save it at once using an adequate namen (e. g. "helix_01.nec") and close the file and the Geometry Builder.

Go to "Main", open this NEC file and select "NEC Editor (new)" in the "Settings" menu. Then press F6.

On the "Geometry Card" you find the entry for 120 segments with the all the coordinates and the wire radius of 0.001m

On the "**Source / Load**" card a voltage source must be applied to "Tag 1" and "Segment 1" with a real amplitude of 1V:

File	e Cell	Rows	Selection	Options								
S	tandard V	oltage s	ource						🗌 🗌 Upd	Ins. D	el.	
	Symt	bols	ΥG	ieometry	Sou	rce/Load	Freq./G	round	Others		Comment	
	Source(s)					🔽 Sł	now source	🔲 Show lo	bads 🗌	Show Tr-line	e
	Nr Type		Tag	Seg	(opt)	Real						e com
	· ·		Tag	Soa	(opt)	Pool						

File Cell Rows Selection Options	\sim
Symbols Geometry Source/Load	Freg./Ground
Frequency	Cound screen
Frequency 1600 Mhz Nr steps	Nr of radials Radial length
Stepsize	Wire radius
Environment	Second ground
Ground / Free-space Perfect gnd 🗨	Ground type
✓ Connect wire(s) for Z=0 to around	Conductivity

The frequency is set to 1600MH. No sweep is used. We use perfect ground and connect wires for Z=0 to ground.

File	Cell	Rows	Selection	Options				
	Sym	bols	Υ G	ieometry				
Fat wire support								

On the "Others" card the Fat wire support must be activated.

The last card of the menu is used for comments.

Now it is time to save the finished NEC file.

10.3. Far Field Simulation



Press F7 and start the Far Field simulation. The result is a maximum gain of 9.34dBi



For better understanding:

Press F9 and you can admire the feeding of the Helix antenna.

The left end of the first segment is connected to ground and the voltage source is applied to the centre of this segment.

10.4. Frequency Sweep of Gain and Impedance



A sweep of the gain from1500 to 1800MHz shows very clear the promised wide band properties of a Helix antenna.

The gain starts at 9.2dBi for 1500MHz and rises up to 10dBi at 1800MHz.



And also the input resistance (= radiation resistance) has a constant value of 1000 in this frequency range.

10.5. Once more the same procedure, but now using the Notepad Editor

This is faster but needs some effort. Every line of the NEC file will be analyzed with its task and function:

📕 h	elix_calc_01	- Editor						
Date	i Bearbeiten	Format Ansi	cht ?		_			
CM I CM I CM I	Helix over Helix star Excitation	perfect ts at gro at first	ground ound t segment	of helix	Cor E	nmen ind of	ments	"CM" is always a comment card,
GH	1	120	0.04684	0.2342			0.02982 .001	but the end of the comments must be marked by "CE".
GE	1							
GN	1							
ЕK								
EΧ	0	1	1	0	1.	0		
FR	0	0	0	0	1600.	0		
EN								



After the listing of the wire structure a "GE" card (= end of geometry) must follow. But his card is combined with the "Ground Plane Flag" and a look into the NEC manual gives the following information:

gpflag - Geometry ground plain flag. 0 - no ground plane is present. 1 - Indicates a ground plane is present. Structure symmetry is modified as required, and the current expansion is modified so that the currents in segments touching the ground (x, Y plane) are interpolated to their images below the ground (charge at base is zero) -1 - indicates a ground is present. Structure symmetry is modified as required. Current expansion, however, is not modified, Thus, currents on segments touching the ground will go to zero at the ground.

Now it is getting clear:

gpflag = 0 means no ground.

If a ground is existing, gpflag must be set to +1 or -1 and an additional "GN card" (= ground card) is necessary in the NEC file.

So in our example we use **gpflag = 1 to connect the helix start to ground.**

The mentioned "GN" card (= ground card) follows at once. Here the information from the NEC manual:

IPERF (I1) - Ground-type flag. The options are:					
-1	nullifies ground parameters previously used and sets free-space condition. The remainder of the card is left blank in this case.				
ο	finite ground, reflection-coefficient approximation.				
1	perfectly conducting ground.				
2	finite ground, Sommerfeld/Norton method.				

In unserem Fall verwenden wir den "**perfectly conducting ground**" (= ideal leitenden Boden) und **setzen deshalb dieses Flag auf "1"**.

Hinweis: bei "finite ground" sind dann auf dieser Karte noch weitere Angaben über die Dielektrizitätskonstante und die Bodenleitfähigkeit erforderlich!

"EK" means "Extended thin wire kernel" to increase the simulation accuracy when using thick wires for the antenna structure. This is the text in the NEC manual:

ITMP1 (I1) - Blank or zero to initiate use of the extended thinwire kernel.

-1 to return to the standard thin-wire kernel.

We use this improvement offer and so we find in the NEC file a line only with "EK" as content.

"EX" means "Excitation of the antenna by an energy source":

"0" = a voltage source is applied

"1" = Tag 1 is used for excitation

"1" = number of the segment of this tag, where the voltage source is applied to (..at the centre of this segment)

"0" = empty field on this card

"1 0" = real and imaginary part of the applied complex voltage (here: 1 + j0). That means that a real voltage of 1V is applied

"FR" = frequency sweep information.

"**0**" = linear sweep (1 = logarithmic sweep)

"0" = no frequency steps used. So only the frequenca start value is used for a simulation.

"0 0" = two empty fields on this card

"1600" = start value of frequency sweep = 1600MHz

"0" = frequency step width = 0 MHz for our example

"EN" = end of NEC file

10.6. Once more: Far Field Simulation



This the form of the diagram is nearly identical to the patter in chapter 9.3.

One difference is the reduced maximum gain calculation (8,9dBi compared to 9,3dBi in chapter 9.3.)



Pressing F9 shows that the helix start is connected to ground and the voltage source applied to the centre of the first segment.

10.7. Once more: Frequency Sweep of Gain and Impedance

	ain: Th	oton (- Dhi	. 0			h	alix c	alc_02	t out						
i i	jaint ini	eta# u	, enir					anx_c	aic_02	out						
				daa			andra	سأعف			-	-	-	_	-	-
15	00 15	20 15	i40 '	1560	1580	1600	1620	1640	1660	1680	1700	1720	1740	1760	1780	1800MH;
15	00 15	20 15	i40 ·	1560	1580	1600	1620	1640	1660	1680	1700	1720	1740	1760	1780	1800MHz
	<mark>, / SW</mark> View															
	n)						he	lix_ca	lc_02	out)	(ohm)
ohr			-	-	-										-	-55
ohr																-60
ohi	_															-65

1560 1580 1600 1620 1640 1660 1680 1700 1720 1740 1760 1780

The gain curve is identical to chapter 9.4. but the absolute values are reduced by 0.4dB.

The impedance curves are absolutely identical to chapter 9.4. and the radiation resistance has its correct value of 100Ω .

10.8. Feeding the Antenna by a short Piece of Wire

This is the reality because normally an SMA or N connector is used to feed the helix. This connector is screwed on the other side of the ground plane alumina plate and feeds the antenna through a drilled hole in the plate. So the helix structure is "lifted" to avoid a contact between the first antenna winding and the alumina plate.

In the NEC file

600 500

- a) The antenna structure must be lifted by 5 mm
- b) A new wire must be added from the helix start to the perfect ground. The voltage source for excitation is then connected to the centre of this wire.

This can be done in the NEC file using Notepad:



This is the new file with modified comments, a "lifted" helix ("GM" = geometry move), an added piece of wire and a modified excitation point at the centre of the piece of wire.

Explanations:

a) Shift of complete helix structure

The "GM" card can be used to shift, rotate and copy structures. That is a little complicated and the NEC manual is necessary for detailed information. But the upwards helix shift by 5mm is simple when regarding the "GM" card:





b) The connector wire ("feedline")

After shifting the complete helix structure for 5mm a wire with a length of 5mm must be inserted between the start of the helix and the ground. The name of the wire with only 1 segment is "Tag 130".





F7 starts the far field simulation.

No changes...



When pressing F9 you can see the added new feedline and the shifted helix structure (voltage source applied to the centre of this wire = marked in pink).

And now the sweep results from 1500 to1800MHz.



The gain: no changes...



But the impedance has changed:

Lifting the helix structure increases the "height of the antenna over ground" and this gives a new radiation resistance of 150Ω .

Also the reactance differs now...

Appendix: Short overview of the most important "Cards"

" CM "	= comment with a maximum of 30 characters in one line						
" CE "	= end of comments						
"SY "	= " Symbol " = definition of a Variable (or more, separated by a comma, for optimizing or parametric sweep).						
" GW "	= "Geometry of wire". Entries are necessary in the following range:						
:	Tag number / number of segments / XYZ coordinates of start point / XYZ coordinates of end point / wire radius in Meters.						
"GM"	 "Geometry Move". Structures can be rotated, shifted and copied (For details see the NEC2 manual). But shifting a structure is simple. The necessary line for a 5 mm (upwards) shift is 						
	GM 0 0 0 0 0 0 0.005 0						
"GE"	= "End of geometry". The following number says: "0" = no ground (= free space)						
	"-1" or "1" says: ground is present. But now an additional ground card is obligatory. The NEC2 manual says:						
	0 - no ground plane is present.						
	1 - Indicates a ground plane is present. Structure symmetry is modified as required, and the current expansion is modified so that the currents on segments touching the ground (x, Y plane) are interpolated to their images below the ground (charge at base is zero)						
	-1 - indicates a ground is present. Structure symmetry is modified as required. Current expansion, however, is not modified, Thus, currents on segments touching the ground will go to zero at the ground.						
"LD"	= "Loading of a segment". See the NEC manual or the online help to use this option with success.						
	Very often only " LD 5 " is used and this gives the conductance of the antenna wire. The line starts with the tag number and after two empty fields follows the conductance (e. g. " 5.8001E7 " for copper in mhos / m).						
"GN"	= Ground card. This card is always obligatory if GE is followed by a number. Please have a look at the NEC2 manual for correct usage of "freespace" or "finite ground" or "perfect ground" or "Sommerfeld – Norton ground".						
" EK "	= "Extended thin wire kernel". This increases the accuracy when using non infinite thin wires. The manual says:						
	ITMP1 (I1) - Blank or zero to initiate use of the extended thin- wire kernel.						
	-1 to return to the standard thin-wire kernel.						

" EN "	= "End of Run"
	" 0 " = frequency step width is 0 MHz. This programs a simulation at only one frequency (here. 300MHz)
	" 300 " = sweep starts at a frequency of 300MHz
	" 0 0 " = two empty fields.
	"1" = only 1 frequency step.
	" 0 " = " linear sweep " ("1" = logarithmic sweep)
	(Explained by an example line: "FR 0 1 0 0 300 0")
"FR"	= "Frequency sweep".
	"1 0 " is a real voltage source (no imaginary part) with an amplitude of 1V
	" 0 " = stands for an empty field
	The source is applied to tag 1 / segment 5
	"0" = a voltage source is used
	Example: EX 0 1 5 0 1 0
" EX "	= "Exitation" of the structure by an energy source.

"EN" = "End of Run"