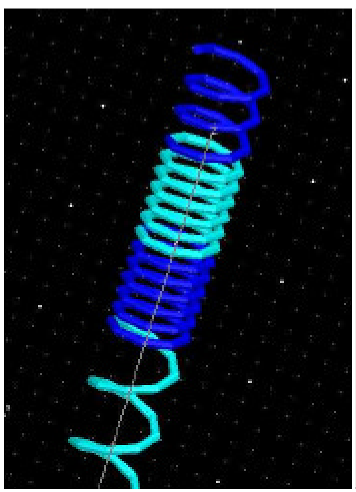
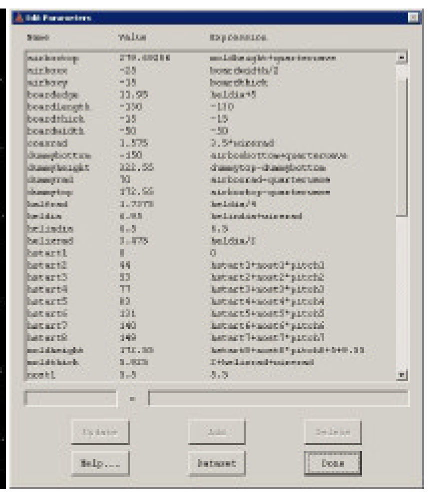
Multi-pitch, Multi-Band Helical antenna





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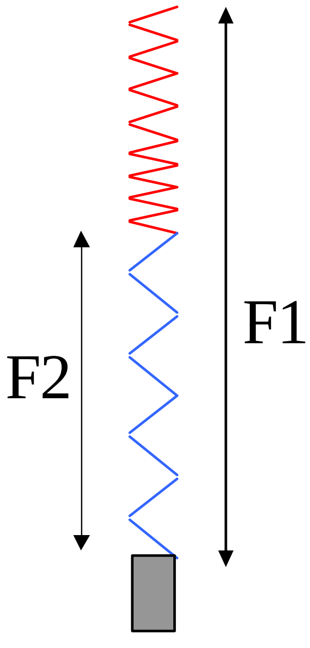
Multi-pitch Helical Antenna



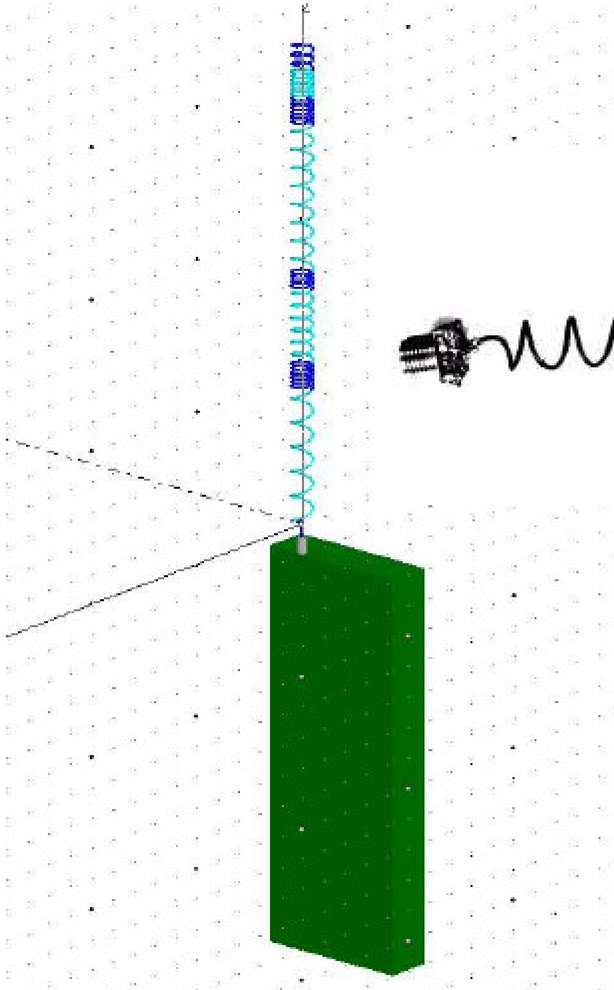
- Manipulating the pitch and length combinations to create multiple resonant frequencies.

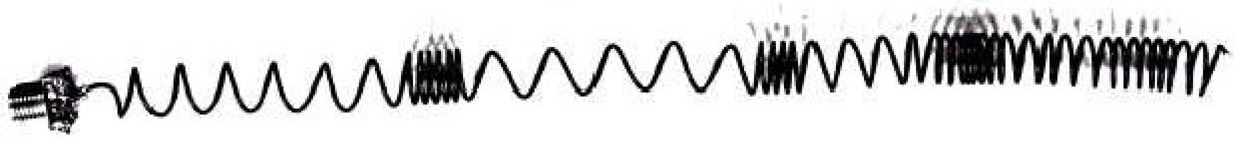
- The fundamental resonance, F1 is determined by the total wire length.

- The higher resonance, F2 is determined by the length of the lower loose section indicated in blue.

Zhou, G. "A non-uniform pitch dual band helix antenna." IEEE Antennas and Propagation Symposium, Salt Lake City, Utah 2000 Volume 1, pp. 274 –277.

Multi Band- Multi pitch Single helix





Project Summary

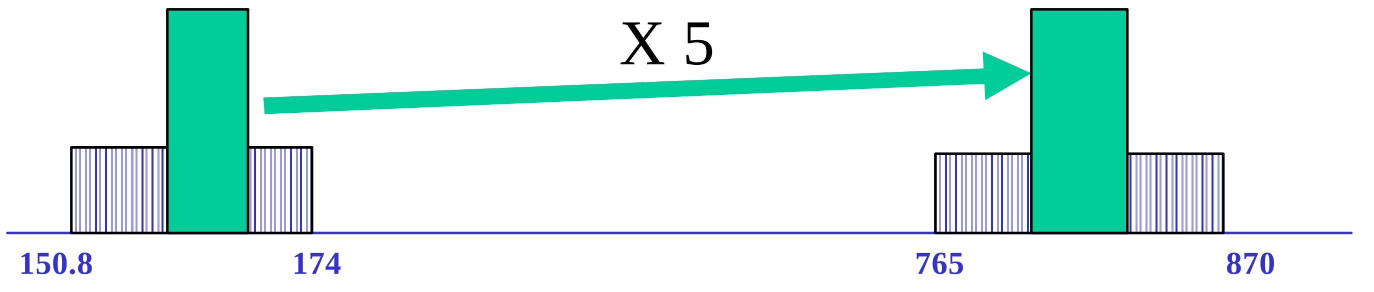
- Creating multiple, overlapping resonance at 700-800 MHz band and leaving the VHF part of the response as in ordinary, narrow band helical antenna.
- The resonance at higher frequencies couple with the harmonics from the lower frequencies and resulting in broad bandwidth. The antenna operates on the lower frequency resonances as on uniform pitch helixes, and the bandwidths can be further broadened by means of matching components.

Design Strategy

The two bands are related, the 5th harmonics of the first band fall on that of the second.

Design Strategy

Designing a narrow band helix for VHF, will result in another resonance in the 700/800 MHz band.

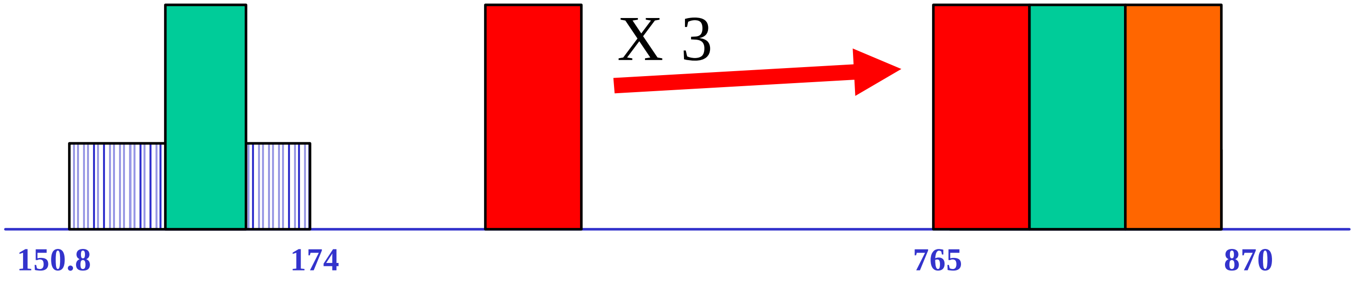


Design Strategy

Add a section with different pitch to create discontinuity, inserting a resonance in the 700/800 MHz band.

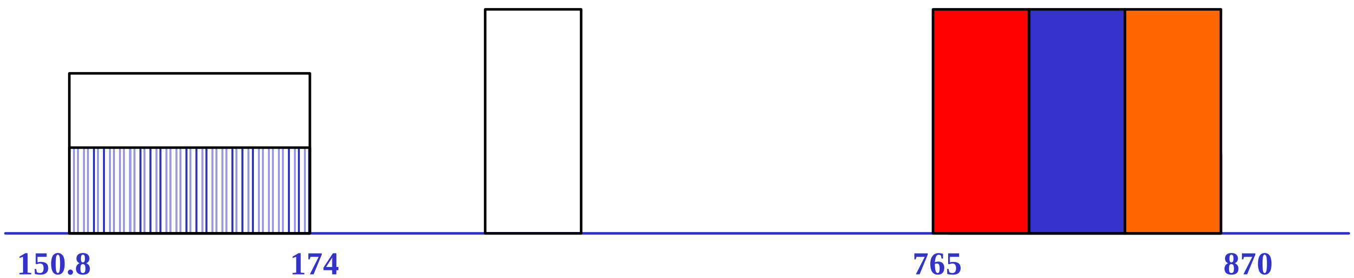
Design Strategy

Adding another section to insert another frequency whose 3rd harmonics falls in the 700/800 MHz band.



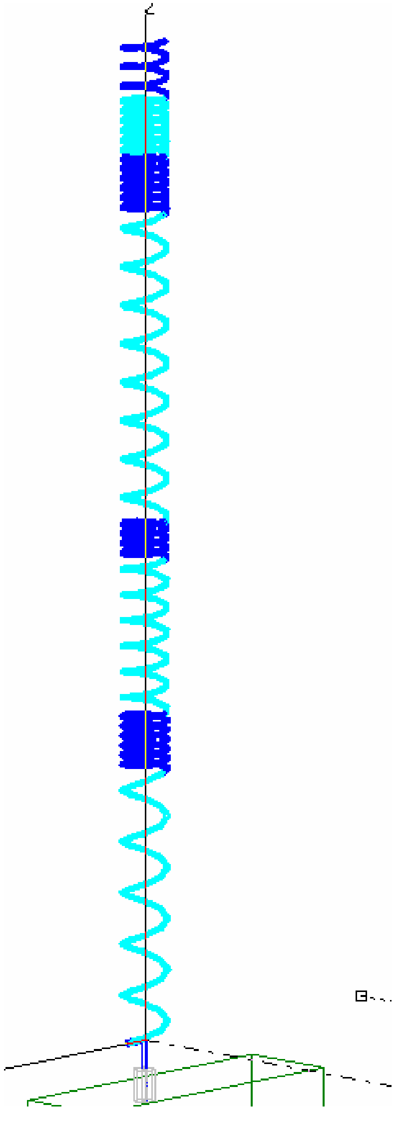
Design Strategy

Broaden the VHF part with a simple matching circuit.



Modeling multiple pitch helix

- The HFSS modeling can only generate uniform pitch helixes.
- Divide the helix into sections with different pitches.
- Draw sections on top of one another.



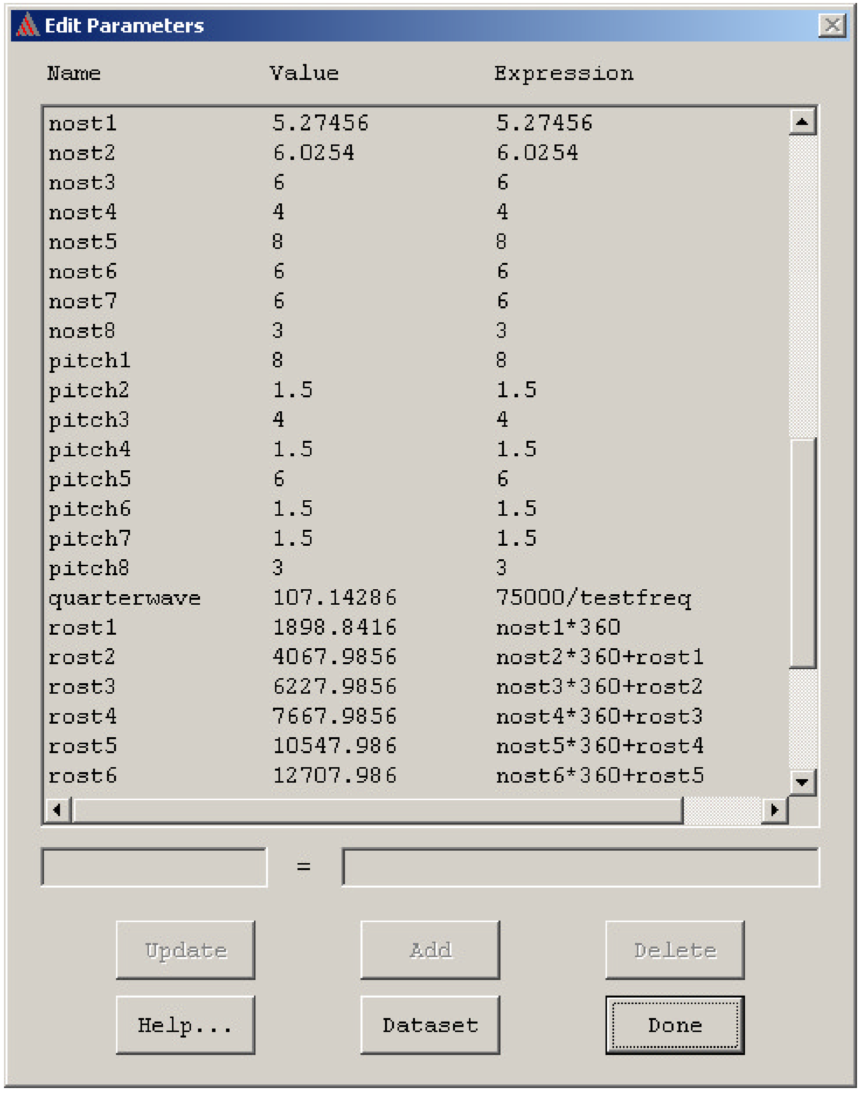
Making tunable helix model

- Using Macro
- Setting dimensions to variables
- Define relationships/equations
- No manual re-drawing
- Optimetrics ready

Assigning Parameters to the Helix Sections

- Helix diameter, *helixrad*
- Number of turns, *nostx*
- Pitch of helix, *pitchx*
- Z-position of starting point, *hstartx*
- Angle of rotation of the starting point, *rostx*

Defining design parameters



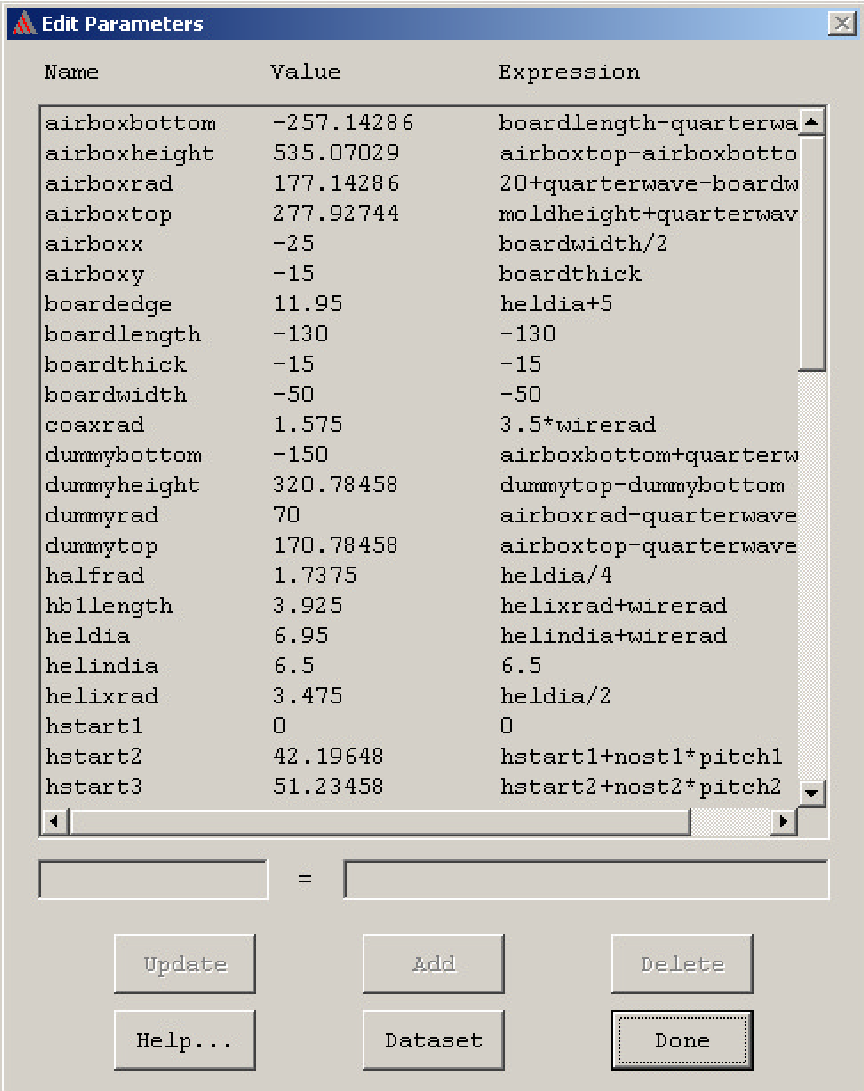
Edit Parameters

Name	Value	Expression
nost1	5.27456	5.27456
nost2	6.0254	6.0254
nost3	6	6
nost4	4	4
nost5	8	8
nost6	6	6
nost7	6	6
nost8	3	3
pitch1	8	8
pitch2	1.5	1.5
pitch3	4	4
pitch4	1.5	1.5
pitch5	6	6
pitch6	1.5	1.5
pitch7	1.5	1.5
pitch8	3	3
quarterwave	107.14286	75000/testfreq
rost1	1898.8416	nost1*360
rost2	4067.9856	nost2*360+rost1
rost3	6227.9856	nost3*360+rost2
rost4	7667.9856	nost4*360+rost3
rost5	10547.986	nost5*360+rost4
rost6	12707.986	nost6*360+rost5

=

Update Add Delete

Help... Dataset Done



Edit Parameters

Name	Value	Expression
airboxbottom	-257.14286	boardlength-quarterwa
airboxheight	535.07029	airboxtop-airboxbotto
airboxrad	177.14286	20+quarterwave-boardw
airboxtop	277.92744	moldheight+quarterwav
airboxx	-25	boardwidth/2
airboxy	-15	boardthick
boardedge	11.95	heldia+5
boardlength	-130	-130
boardthick	-15	-15
boardwidth	-50	-50
coaxrad	1.575	3.5*wirerad
dummybottom	-150	airboxbottom+quarterw
dummyheight	320.78458	dummytop-dummybottom
dummyrad	70	airboxrad-quarterwave
dummytop	170.78458	airboxtop-quarterwave
halfrad	1.7375	heldia/4
hbllength	3.925	helixrad+wirerad
heldia	6.95	helindia+wirerad
helindia	6.5	6.5
helixrad	3.475	heldia/2
hstart1	0	0
hstart2	42.19648	hstart1+nost1*pitch1
hstart3	51.23458	hstart2+nost2*pitch2

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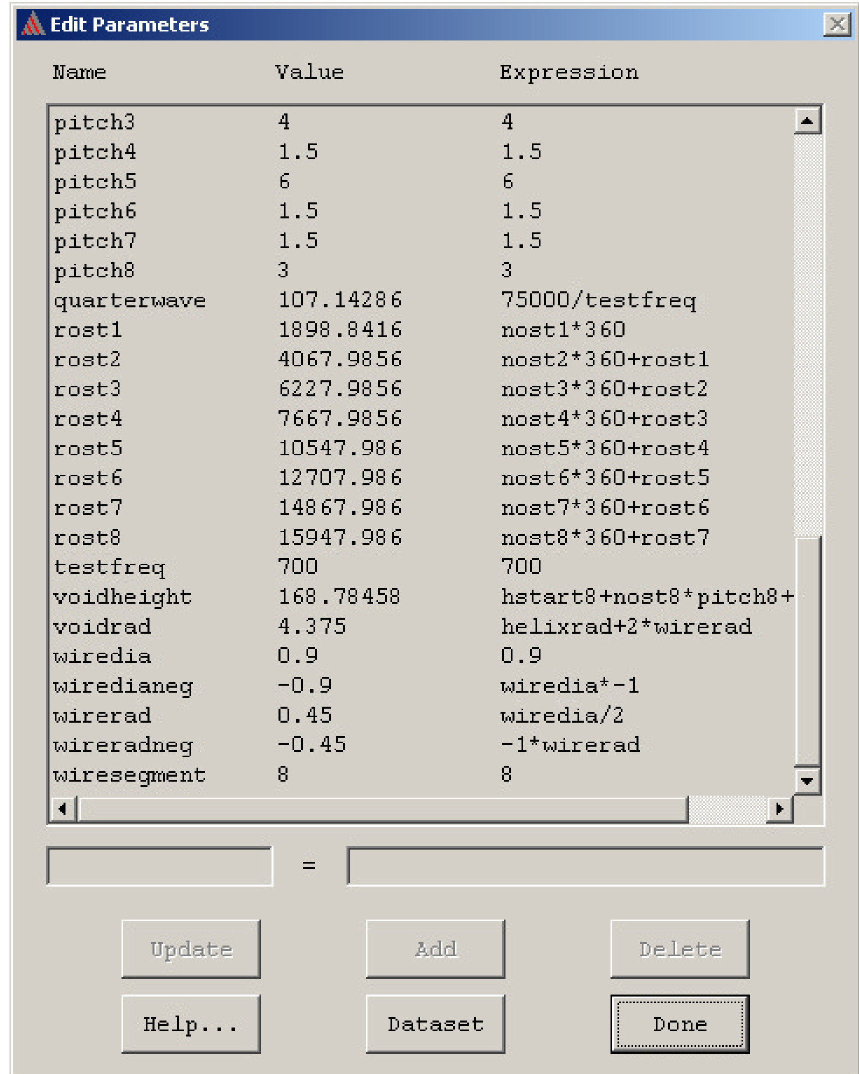
Update Add Delete

Help... Dataset Done



Edit Parameters

Name	Value	Expression
pitch3	4	4
pitch4	1.5	1.5
pitch5	6	6
pitch6	1.5	1.5
pitch7	1.5	1.5
pitch8	3	3
quarterwave	107.14286	75000/testfreq
rost1	1898.8416	nost1*360
rost2	4067.9856	nost2*360+rost1
rost3	6227.9856	nost3*360+rost2
rost4	7667.9856	nost4*360+rost3
rost5	10547.986	nost5*360+rost4
rost6	12707.986	nost6*360+rost5
rost7	14867.986	nost7*360+rost6
rost8	15947.986	nost8*360+rost7
testfreq	700	700
voidheight	168.78458	hstart8+nost8*pitch8+
voidrad	4.375	helixrad+2*wirerad
wiredia	0.9	0.9
wirediameg	-0.9	wiredia*-1
wirerad	0.45	wiredia/2
wireradneg	-0.45	-1*wirerad
wiresegment	8	8

=

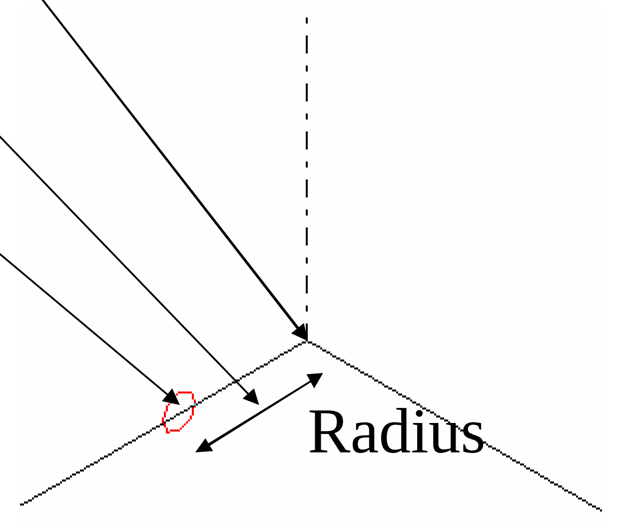
Update Add Delete

Help... Dataset Done

Setting helix diameter and cross-section (helix base, *hb1*)

NewObjColor 255 0 0

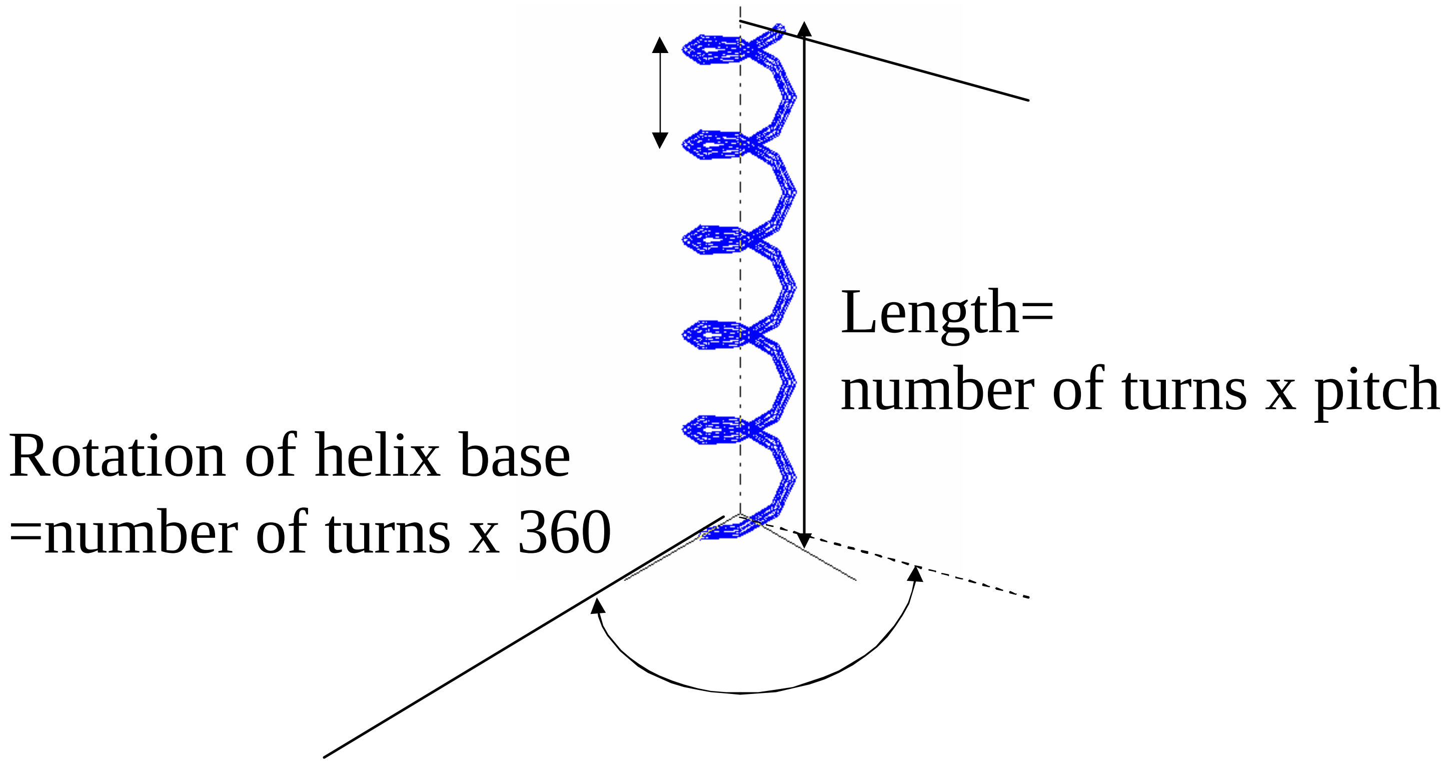
Circle [helixrad, 0, hstart1] 1 wirerad "hb1" 1 wiresegment [0, helindia, hstart1]



Draw the first helix

NewObjColor 0 0 254

Helix "hb1" 2 pitch1 nost1 8 0 "helix1"



Drawing the subsequent helix

"**hstart2**=hstart1+nost1*pitch1"

Circle [helixrad, 0, hstart2] 1 wirerad
"hb2" 1 wiresegment [0, helindia, **hstart2**]

Select ("hb2")

Rotate 2 rost1

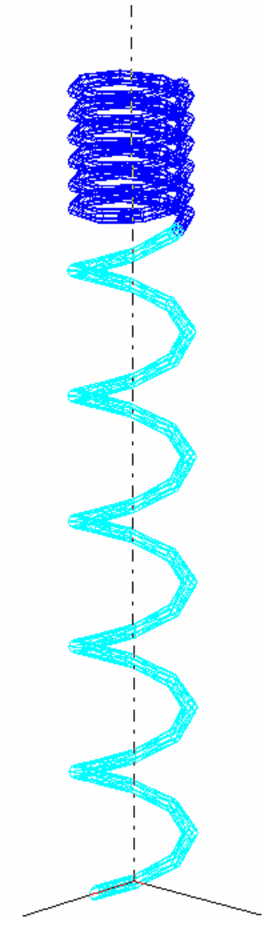
Deselect ("*")

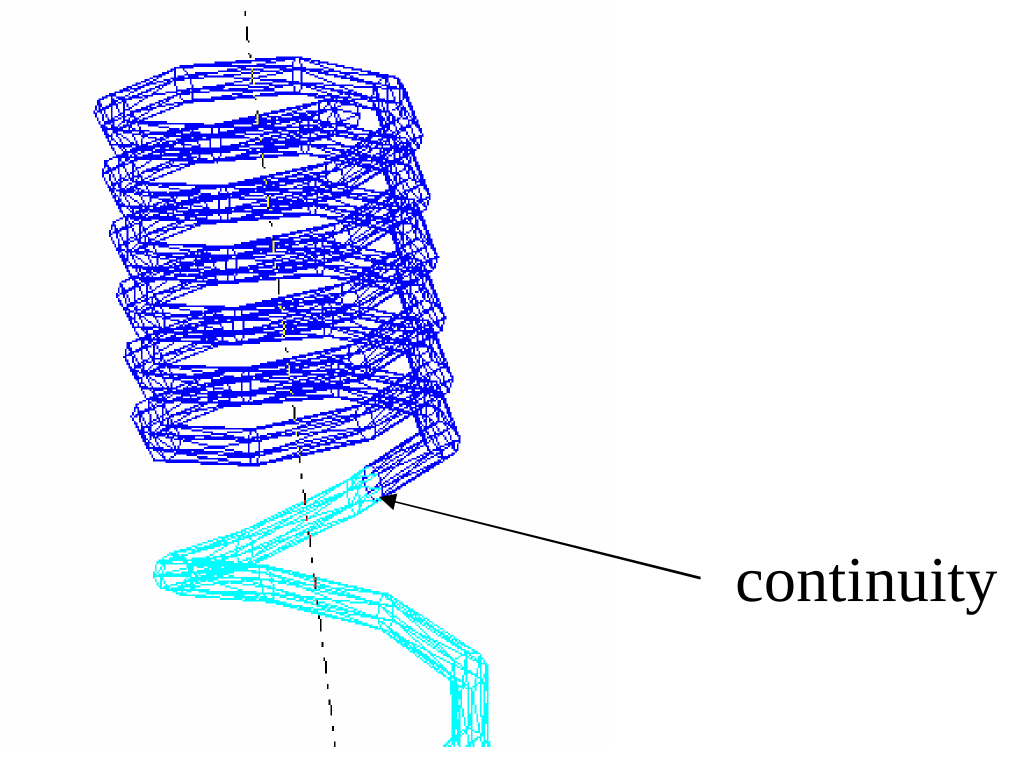
NewObjColor 0 0 254

Helix "hb2" 2 pitch2 nost2 8 0 "helix2"

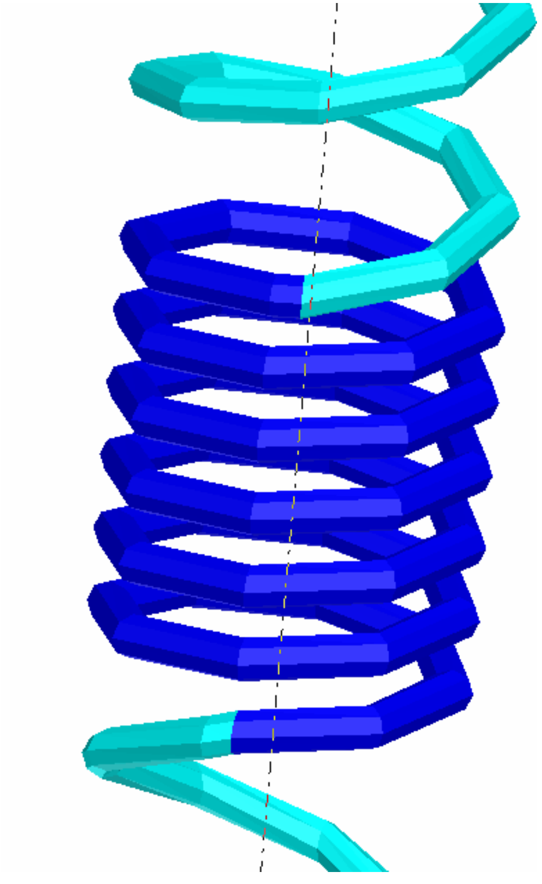
"rost1=nost1*360"

Second Helix





Third helix



NewObjColor 0 255 255

Circle [helixrad, 0, hstart3] 1 wirerad "hb3" 1 wiresegment [0, helindia, hstart3]

Select ("hb3")

Rotate 2 rost2

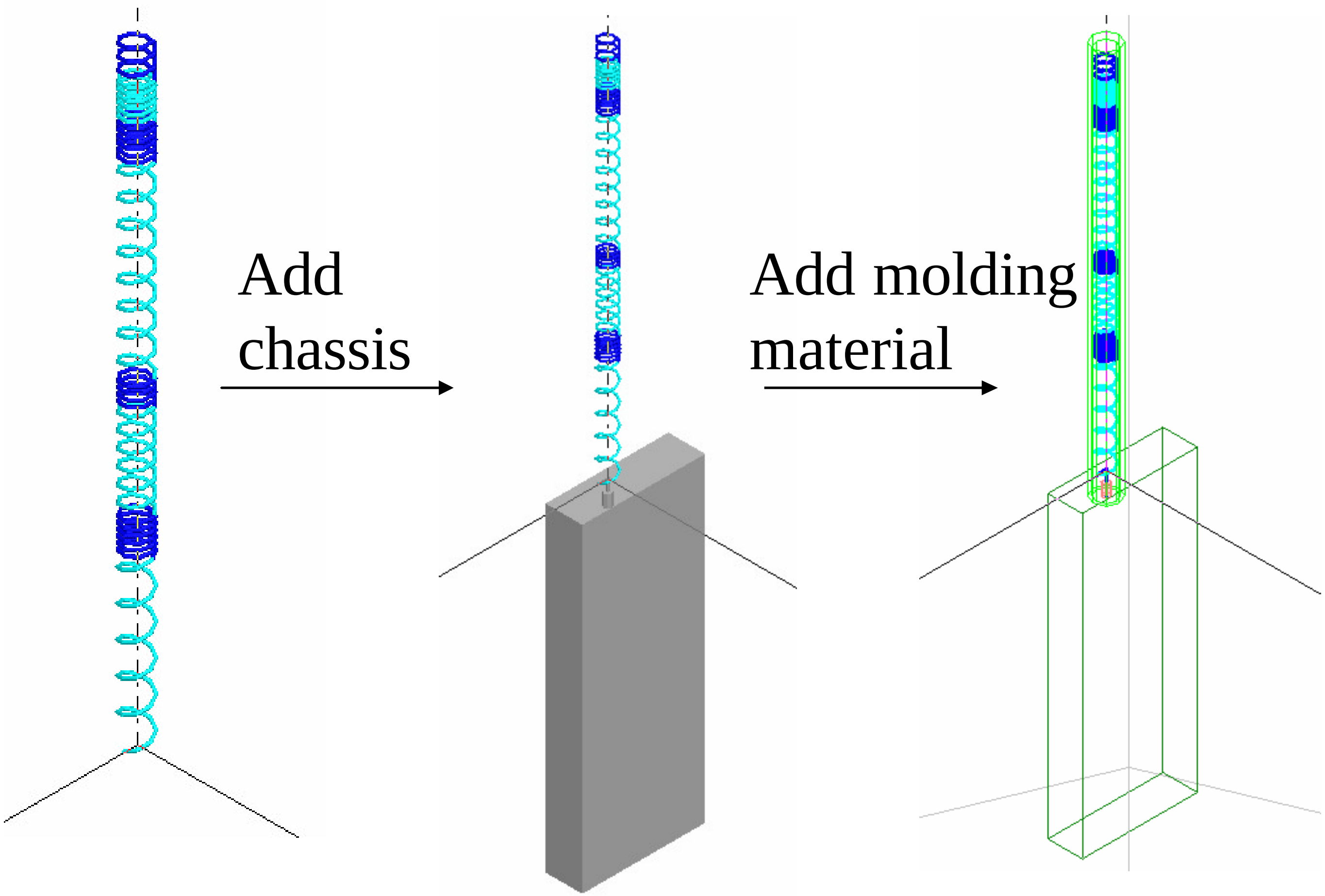
Deselect ("*")

#helix3

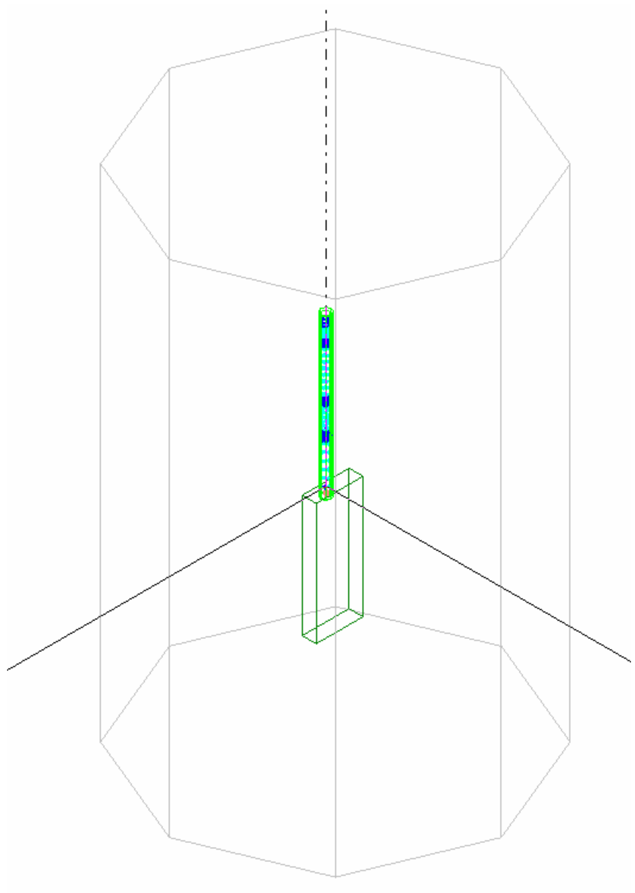
NewObjColor 0 255 255

Helix "hb3" 2 pitch3 nost3 8 0 "helix3"

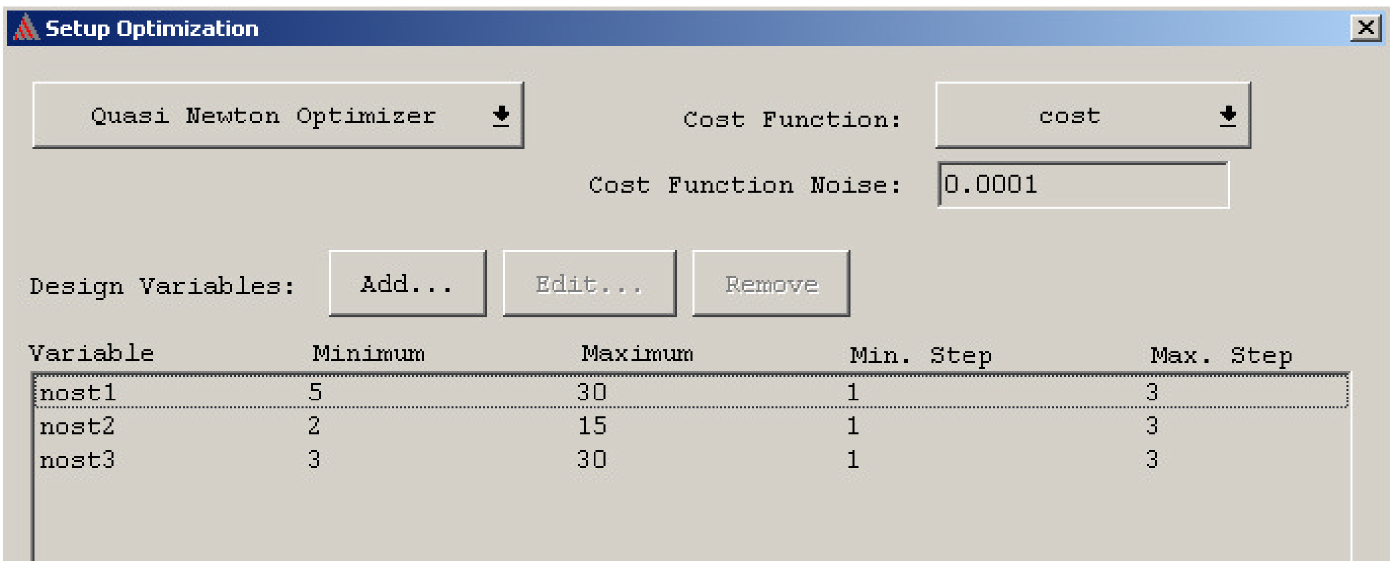
Completing the model

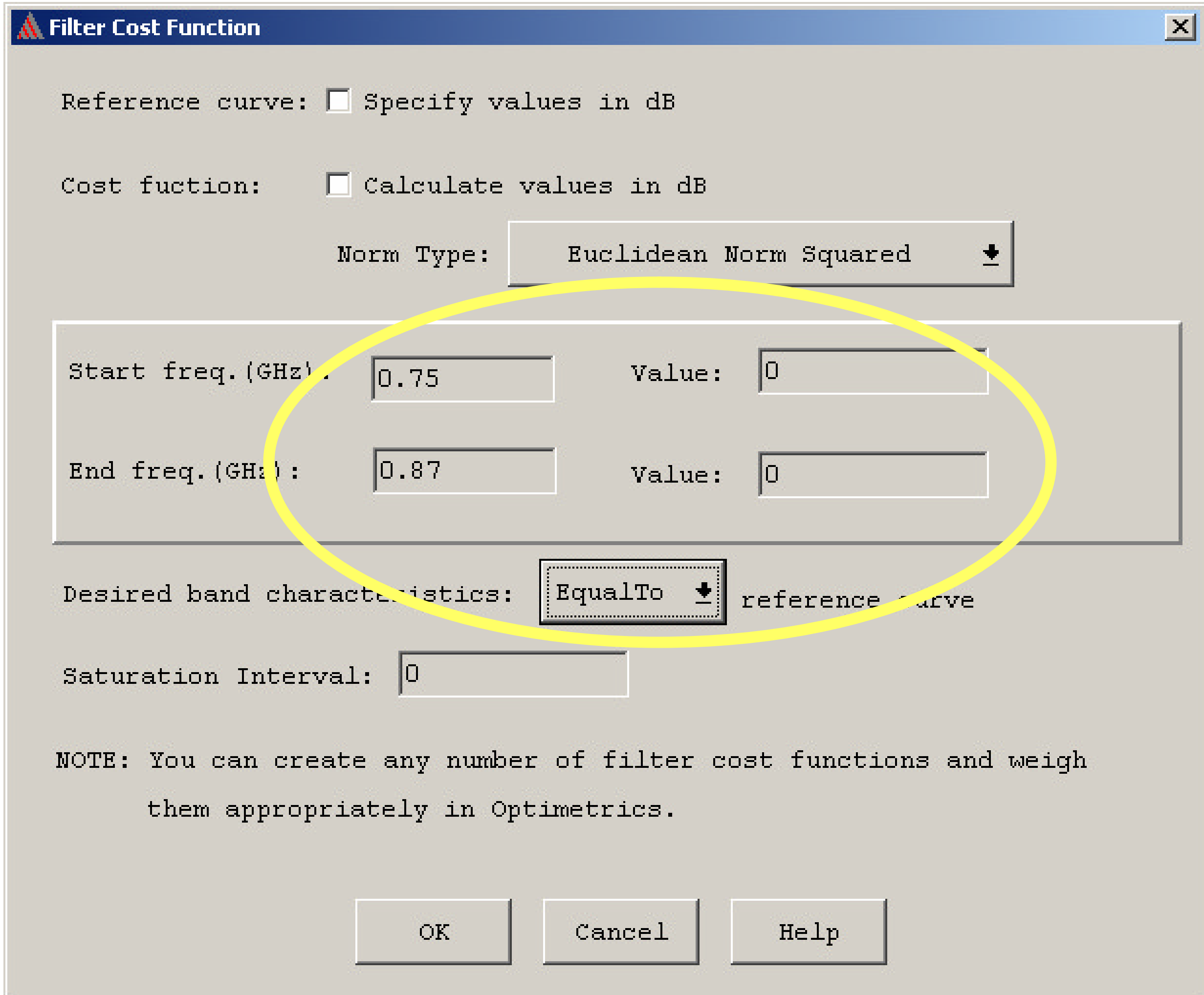


Completed model

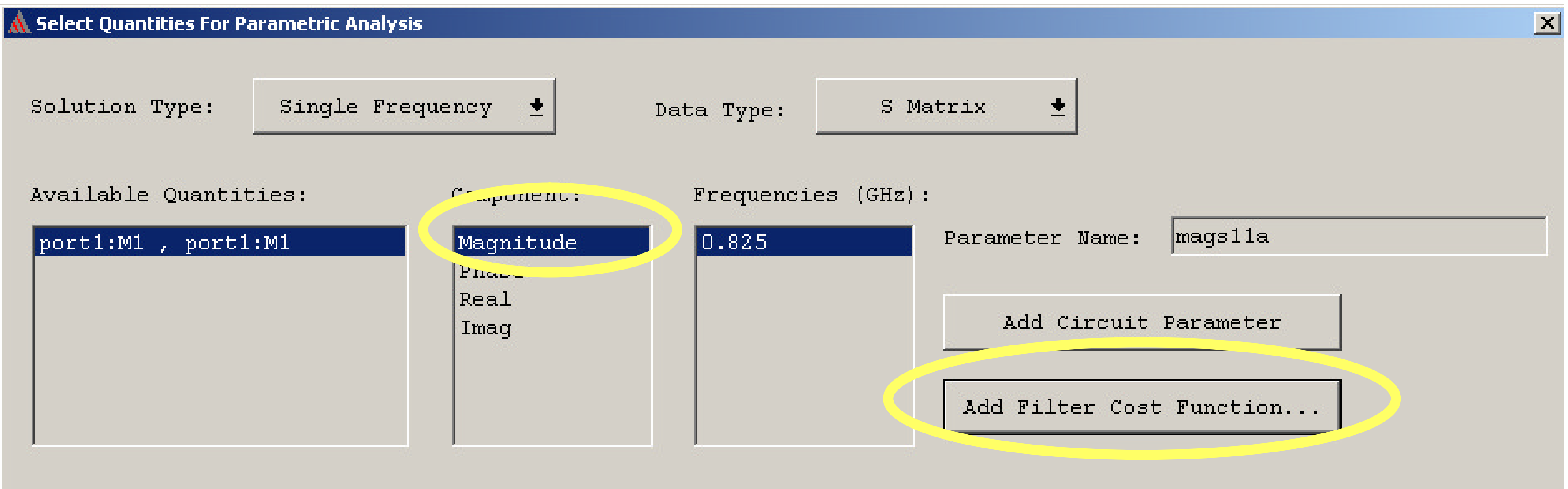


Optimetrix setup

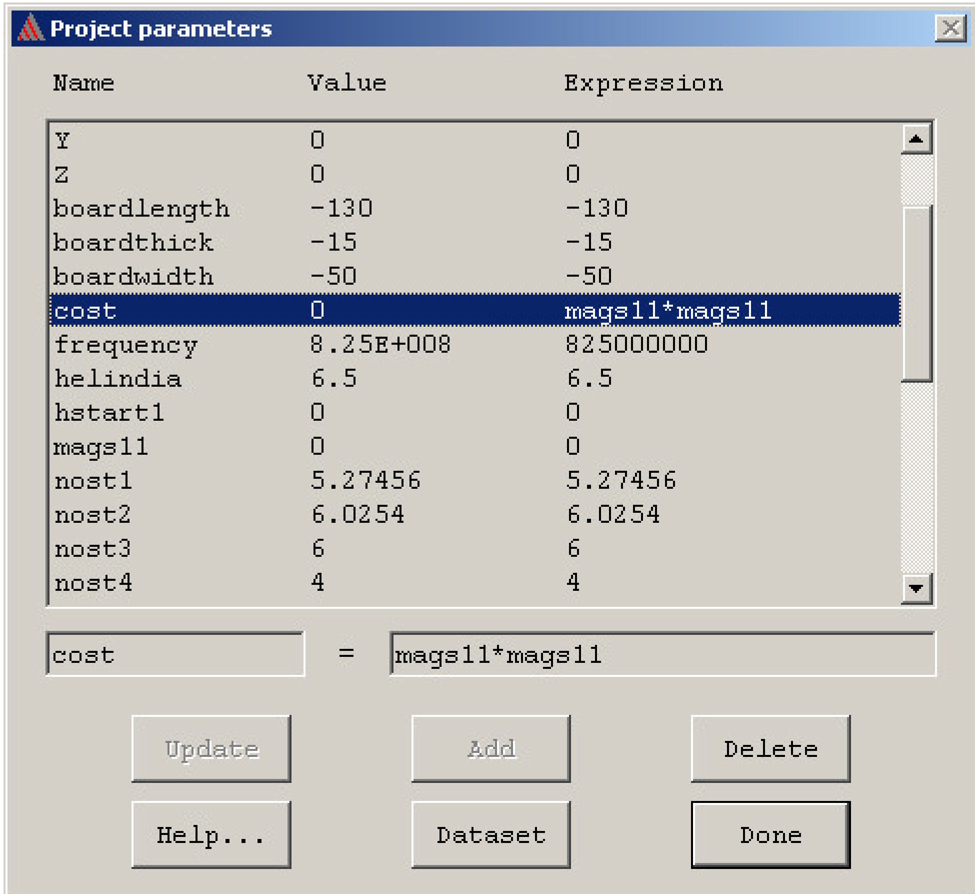




Filter Cost Function
Reference curve: Specify values in dB
Cost fuction: Calculate values in dB
Norm Type: Euclidean Norm Squared
Start freq.(GHz): 0.75
Value: 0
End freq.(GHz): 0.87
Value: 0
Desired band characteristics: EqualTo reference curve
Saturation Interval: 0
NOTE: You can create any number of filter cost functions and weigh them appropriately in Optimetrics.
OK
Cancel
Help


Select Quantities For Parametric Analysis
Solution Type:
Single Frequency
Data Type:
S Matrix
Available Quantities:
port1:M1 , port1:M1
Magnitude
Real
Imag
Frequencies (GHz):
0.825
Parameter Name:
magsl1a
Add Circuit Parameter
Add Filter Cost Function...

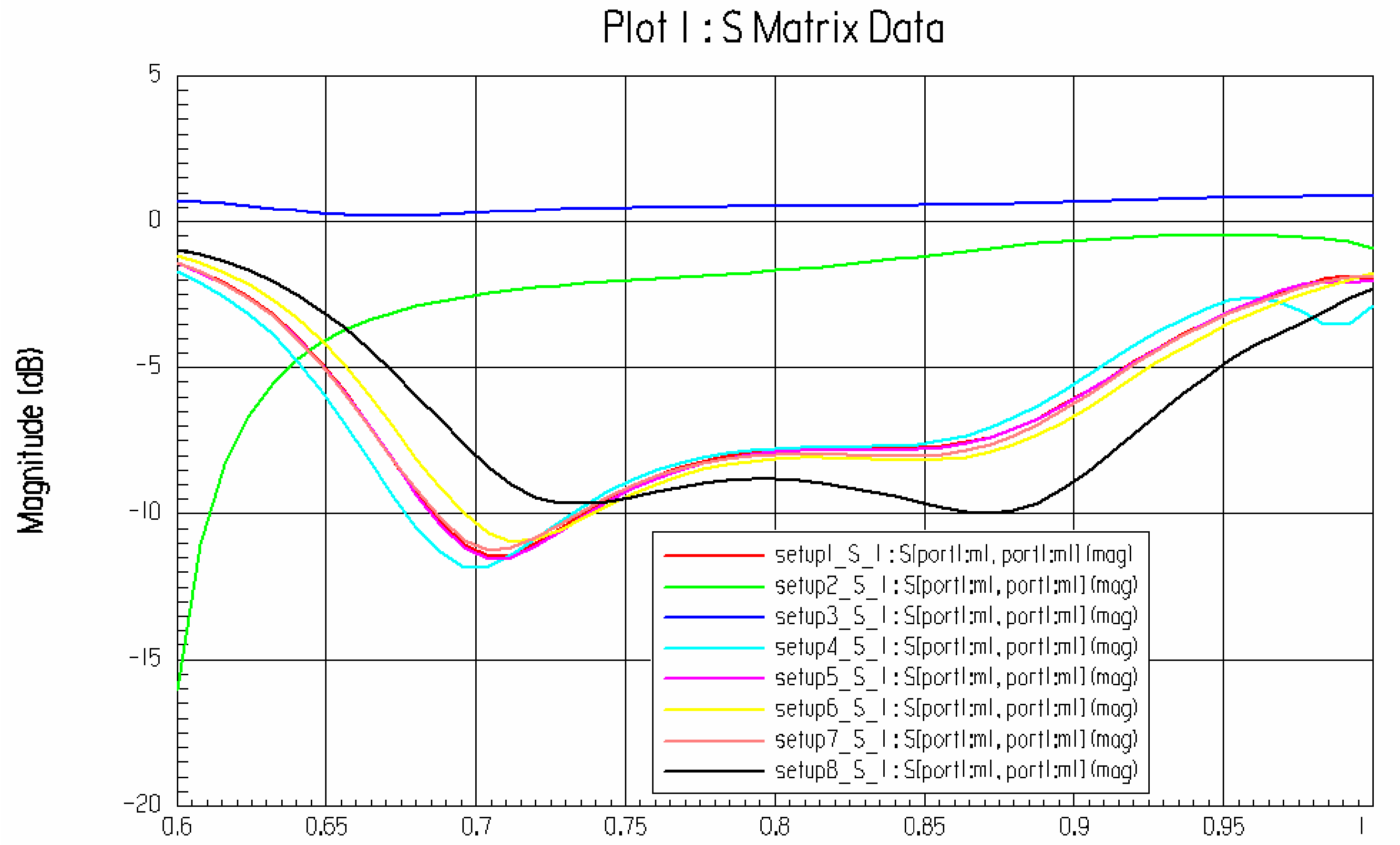
Setting cost function



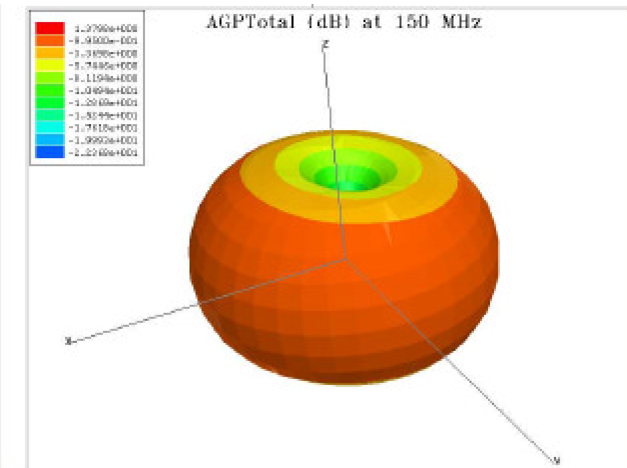
Optimetrix Table

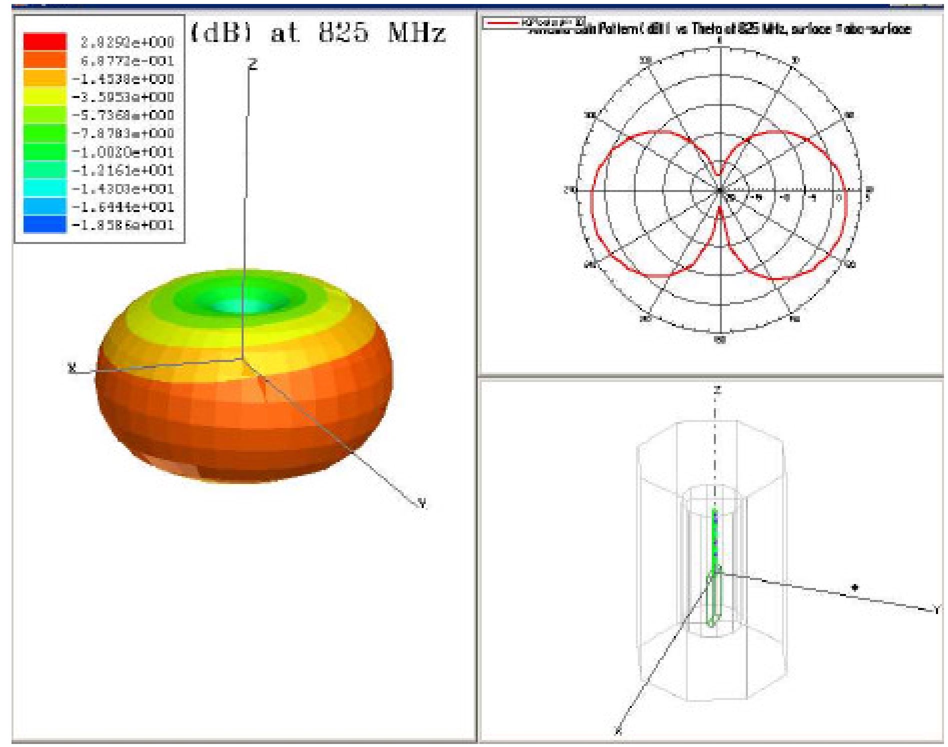
Setup	nost1	nost2	nost3	Solved	Sensitivity Done	Save Fields	Solve	cost
setup1	5.27456	6.0254	6	Y	N	N	N	0.0252633
setup2	8.27456	6.0254	6	Y	N	N	N	0.487711
setup3	5.99929	6.0254	6	Y	N	N	N	0.082592
setup4	5.27456	6.40226	6	Y	N	N	N	0.0268227
setup5	5.27456	6.0254	6.78271	Y	N	N	N	0.0246349
setup6	5.27456	5.64854	6	Y	N	N	N	0.0216641
setup7	5.27456	6.0254	5.21729	Y	N	N	N	0.0233851
setup8	5	5.51443	5.9404	Y	N	N	N	0.0145325

Optimetrix results



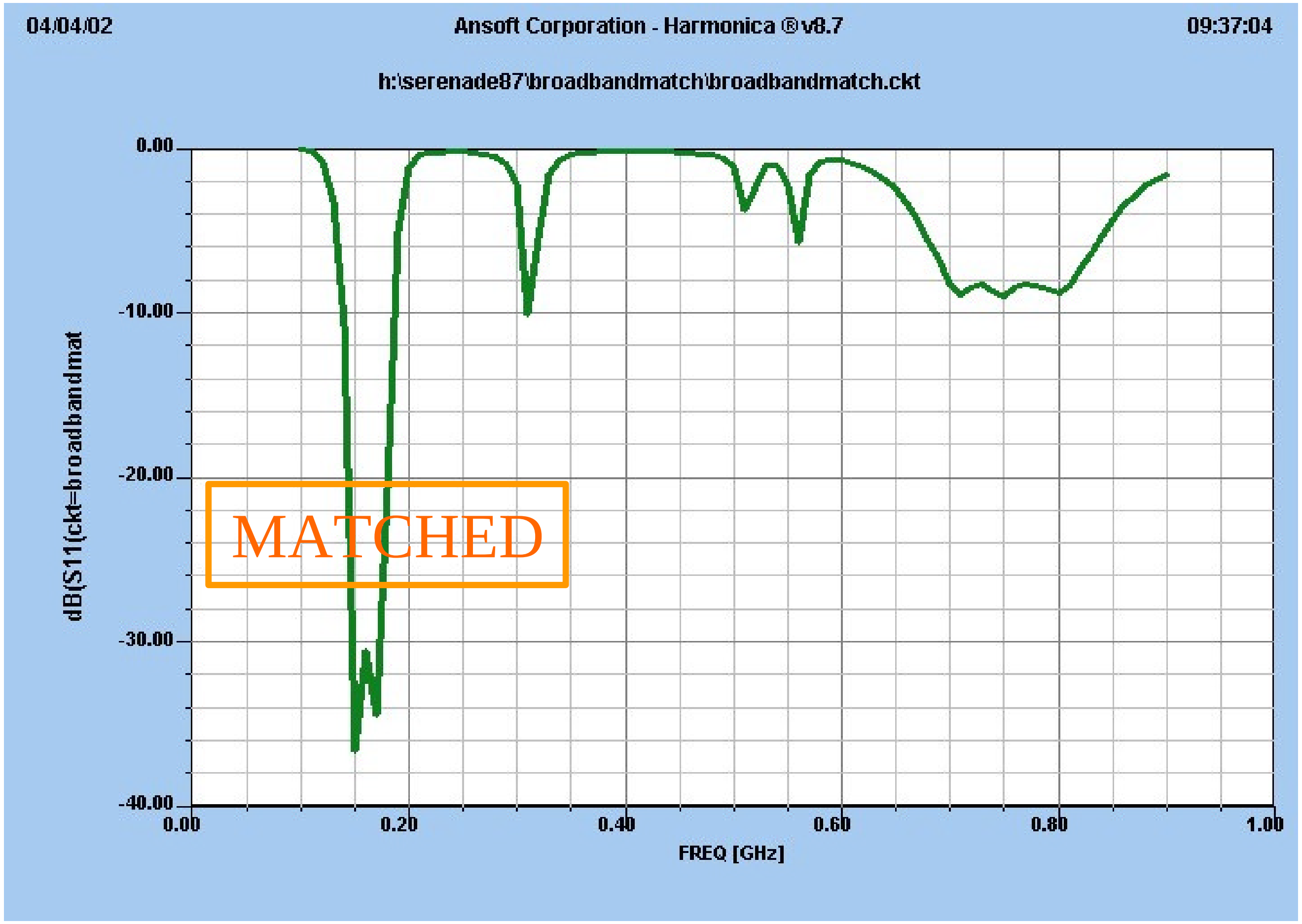
Radiation performance





The radiation pattern of both VHF) and 700/800 MHz band indicate that the antenna exhibits radiation patterns equivalent to that of dipole antenna.

Measure Overall Return Loss



Benefit of using macro

- Save time – no redrawing
- Portable – cut and paste
- Optimetrix ready
- Tweaking dimension using pulled down menu – edit parameters

Optimetrics

- Saves data of all iterations
- Easy adaptation of designs onto new chassis- re-optimizing