

Antenna simulations

Part 2

Pekka Ketonen

OH1TV



Outline

Part 1

- Some principles in antenna design
 - typical steps in design process
- Opposite Voltage Feed
 - 2 phased verticals on 80m
 - 2 over 2 on 40m
 - Quad improved

Part 2

- Influence of location on antenna performance
 - Lakeside
 - Seaside
 - Steep coast, cliff
 - Hilltop
- Stacking

Content

1. Influence of surrounding water on vertical antenna
2. Influence of surrounding water on horizontal antenna
3. Influence of steep coast (cliff) on horizontal antenna
4. Hill top antennas
5. Stacking considerations
6. Mutual coupling of different bands

Soil conductivity and dielectric constant

Earth Type	Conductivity Sigma (Mhos/m)	Permittivity Epsilon
Poor	0.001	4.0 - 5.0
Moderate	0.003	4.0
Average	0.005 - 0.01	10.0 - 15.0
Good	0.01 - 0.02	4.0 - 30.0
Dry, sandy, flat (typical of coastal land)	0.002	10.0
Pastoral Hills, rich soil	0.003 - 0.01	14.0 - 20.0
Pastoral medium hills and forestation	0.004 - 0.006	13.0
Fertile land	0.002	10.0
Rich agricultural land (low hills)	0.01	15.0
Rocky land, steep hills	0.002	10.0 - 15.0
Marshy land, densely wooded	0.0075	12.0
Marshy, forested, flat	0.008	12.0
Mountainous/hilly (to about 1000 m)	0.001	5.0
Highly moist ground	0.005 - 0.02	30.0
City Industrial area of average attenuation	0.001	5.0
City industrial area of maximal attenuation	0.0004	3.0
City industrial area	0.0001	3.0
Fresh water	0.002 - 0.01	80.0 - 81.0
Fresh water at 10.0 deg C (At 100 MHz)	0.001 - 0.01	84.0
Fresh water at 20.0 deg C (At 100 MHz)	0.001 - 0.01	80.0
Sea water	4.0 - 5.0	80.0 - 81.0
Sea water at 10.0 deg C (to 1.0 GHz)	4.0 - 5.0	80.0
Sea water at 20.0 deg C (to 1.0 GHz)	4.0 - 5.0	73.0
Sea ice	0.001	4.0
Polar ice	0.00025	3.0
Polar Ice Cap	0.0001	1.0
Arctic land	0.0005	3.0

1. Influence of nearby WATER on vertical antenna



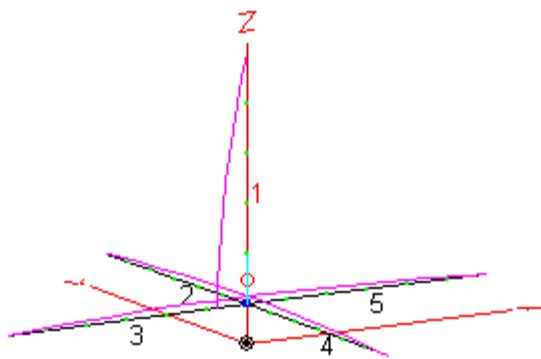
23.1.2011

OH1TV

5

80m vertical, average flat ground

4 elevated radials up 3m



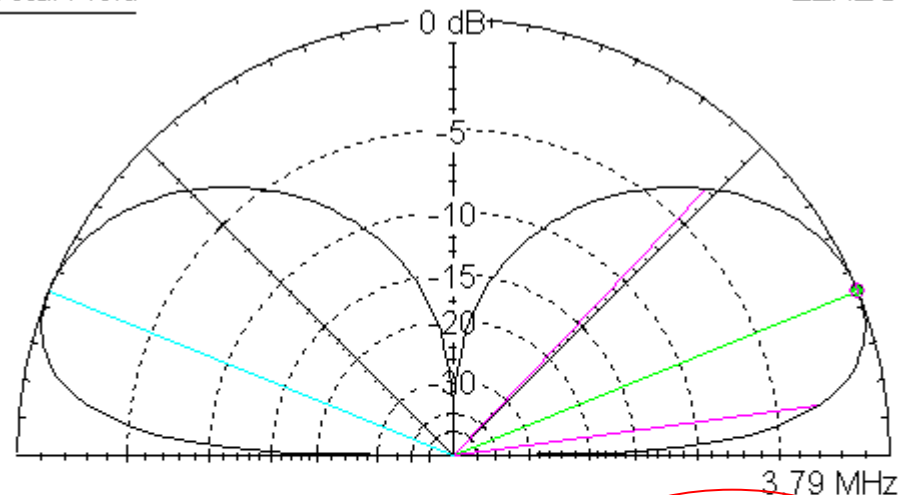
Average ground

5mS, $\epsilon=13$

Total Field

EZNEC

EZNEC



Elevation Plot	
Azimuth Angle	0.0 deg.
Outer Ring	0.29 dBi
Slice Max Gain	0.29 dBi @ Elev Angle = 22.0 deg.
Beamwidth	38.9 deg.; -3dB @ 7.7, 46.6 deg.
Sidelobe Gain	0.29 dBi @ Elev Angle = 158.0 deg.
Front/Sidelobe	0.0 dB

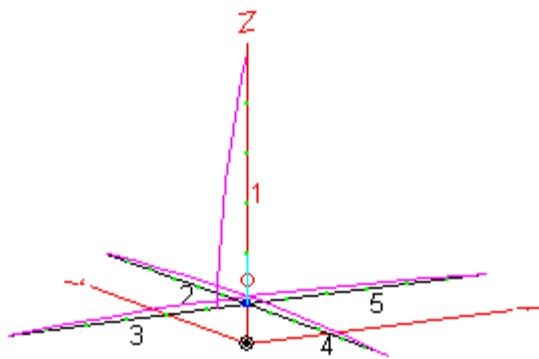
Cursor Elev	22.0 deg.
Gain	0.29 dBi
	0.0 dBmax

3.79 MHz

Theoretical maximum gain 5.15dBi

Vertical, fresh water 50m away, 3m down

4 elevated radials up 3m



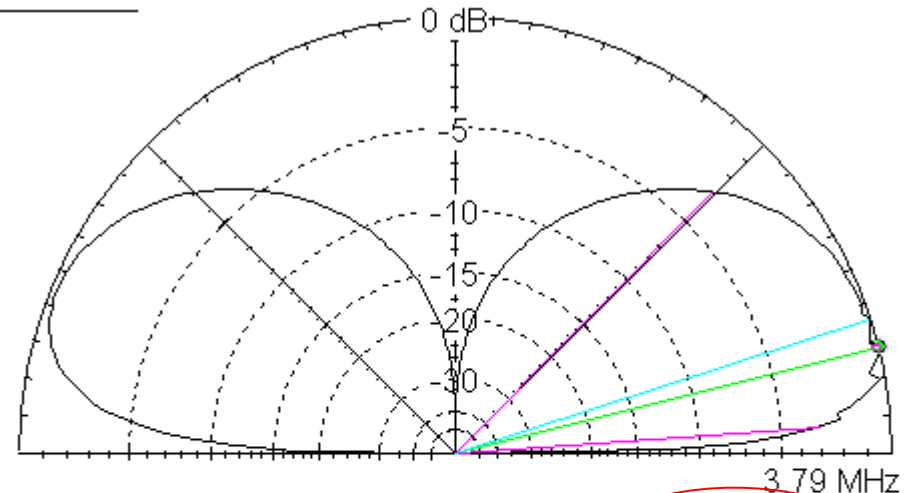
X<50m, Z=0, Average ground
5mS, $\epsilon=13$

X>50m, Z=-3m, Fresh water
5mS, $\epsilon=80$

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 0.54 dBi

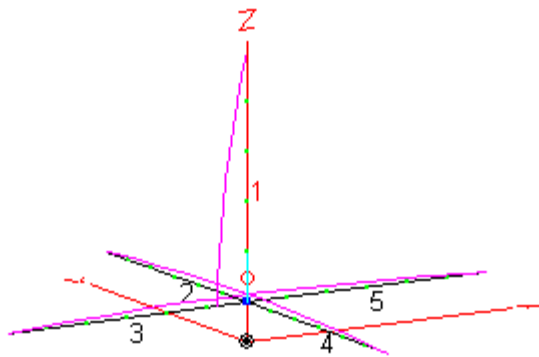
Slice Max Gain 0.54 dBi @ Elev Angle = 14.0 deg.
Beamwidth 41.2 deg.; -3dB @ 4.2, 45.4 deg.
Sidelobe Gain 0.5 dBi @ Elev Angle = 18.0 deg.
Front/Sidelobe 0.04 dB

Cursor Elev 14.0 deg.
Gain 0.54 dBi
0.0 dBmax

0.25dB fresh water gain
8deg lowered TOA

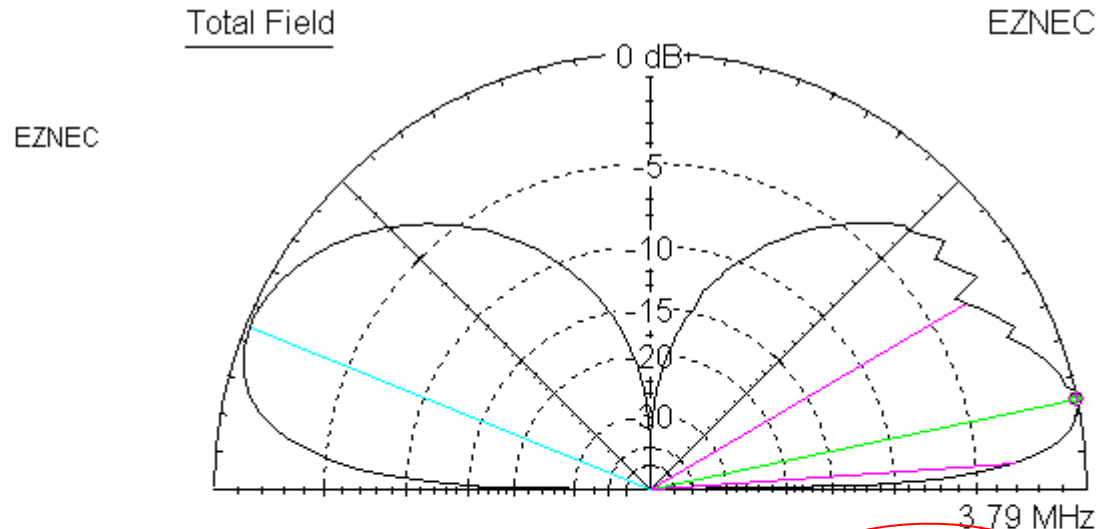
Vertical, fresh water 20m away, 3m down

4 elevated radials up 3m



X < 20m, Z = 0, Average ground
5mS, $\epsilon = 13$

X > 20m, Z = -3m, Fresh water
5mS, $\epsilon = 80$



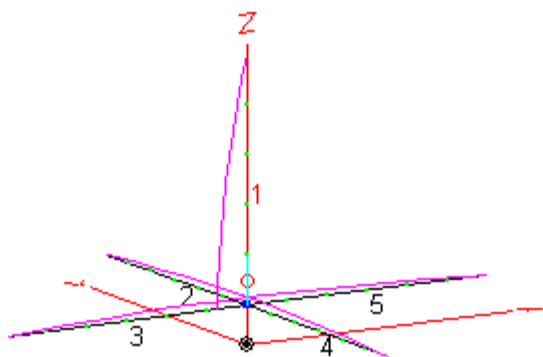
Elevation Plot	
Azimuth Angle	0.0 deg.
Outer Ring	0.47 dBi
Slice Max Gain	0.47 dBi @ Elev Angle = 12.0 deg.
Beamwidth	26.2 deg.; -3dB @ 4.1, 30.3 deg.
Sidelobe Gain	0.29 dBi @ Elev Angle = 158.0 deg.
Front/Sidelobe	0.19 dB

Cursor Elev	12.0 deg.
Gain	0.47 dBi
	0.0 dBmax

0.18dB fresh water gain
10deg lowered TOA

Vertical, fresh water 0m away, 3m down

4 elevated radials up 3m



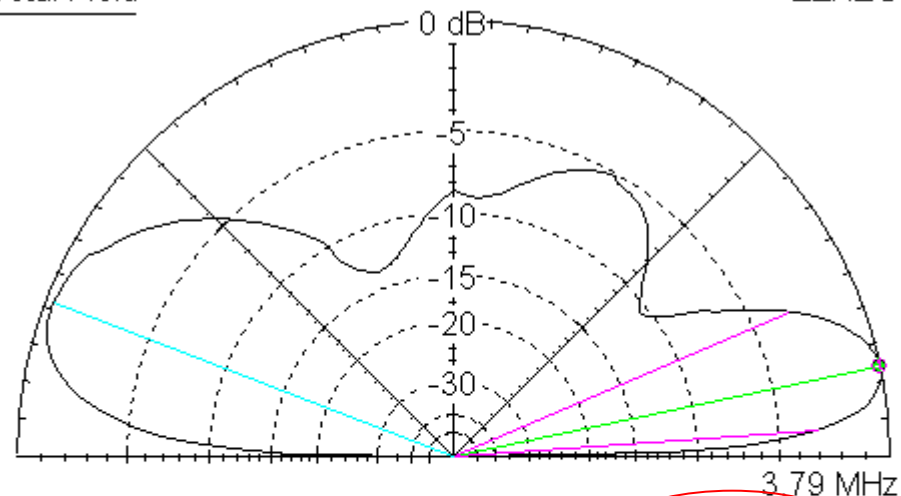
X<0m, Z=0, Average ground
5mS, $\epsilon=13$

X>0m, Z=-3m, Fresh water
5mS, $\epsilon=80$

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 0.5 dBi

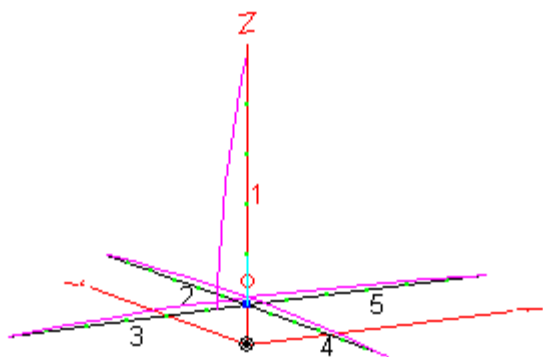
Slice Max Gain 0.5 dBi @ Elev Angle = 12.0 deg.
Beamwidth 19.1 deg.; -3dB @ 4.1, 23.2 deg.
Sidelobe Gain 0.15 dBi @ Elev Angle = 159.0 deg.
Front/Sidelobe 0.35 dB

Cursor Elev 12.0 deg.
Gain 0.5 dBi
0.0 dBmax

0.21dB fresh water gain
10deg lowered TOA

Vertical, sea water 50m away, 3m down

4 elevated radials up 3m



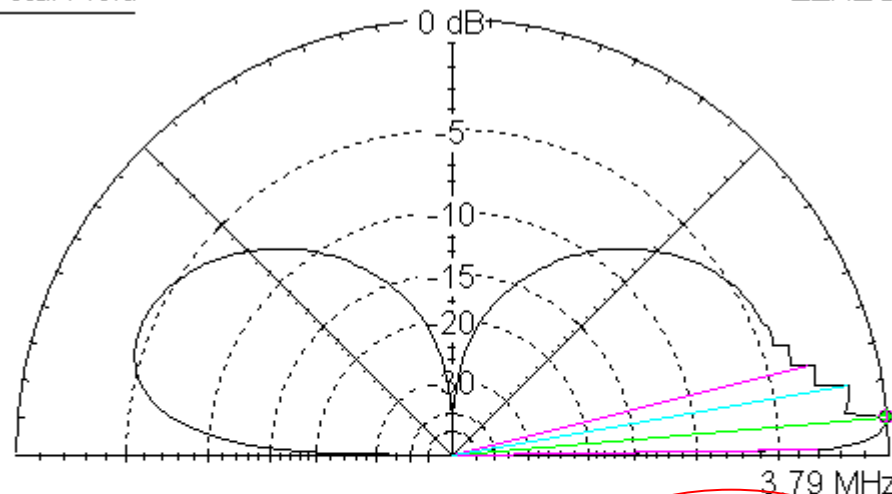
X<50m, Z=0, Average ground
5mS, $\epsilon=13$

X>50m, Z=-3m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 4.74 dBi

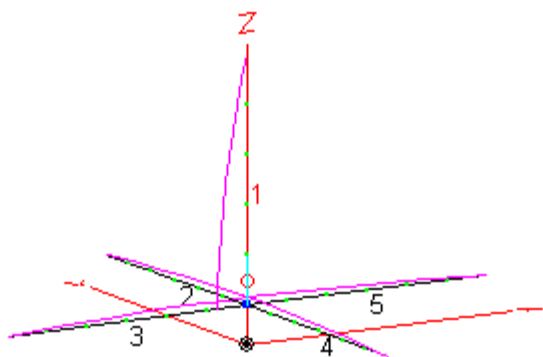
Slice Max Gain 4.74 dBi @ Elev Angle = 5.0 deg.
Beamwidth 13.3 deg.; -3dB @ 1.0, 14.3 deg.
Sidelobe Gain 3.35 dBi @ Elev Angle = 10.0 deg.
Front/Sidelobe 1.39 dB

Cursor Elev 5.0 deg.
Gain 4.74 dBi
0.0 dBmax

4.45dB sea water gain
17 deg lowered TOA

Vertical, sea water 20m away, 3m down

4 elevated radials up 3m



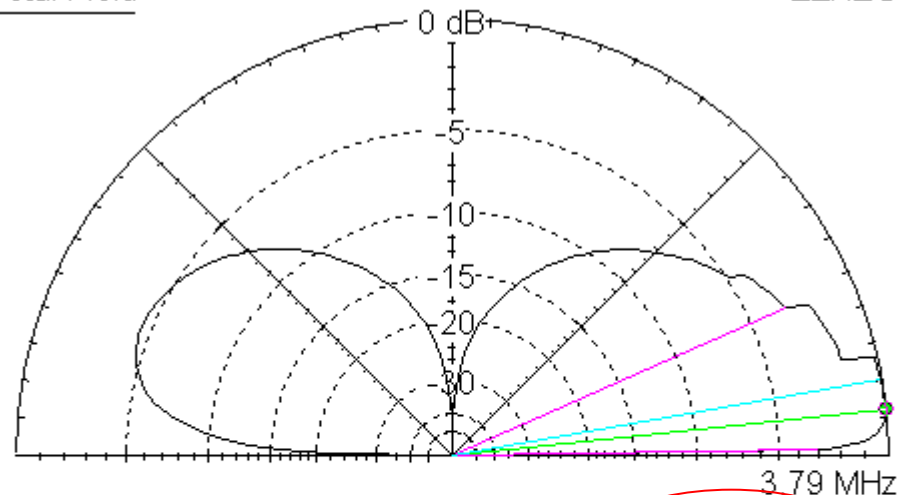
X<20m, Z=0, Average ground
5mS, $\epsilon=13$

X>20m, Z=-3m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot	
Azimuth Angle	0.0 deg.
Outer Ring	4.79 dBi
Slice Max Gain	4.79 dBi @ Elev Angle = 6.0 deg.
Beamwidth	22.9 deg.; -3dB @ 1.0, 23.9 deg.
Sidelobe Gain	4.74 dBi @ Elev Angle = 10.0 deg.
Front/Sidelobe	0.05 dB

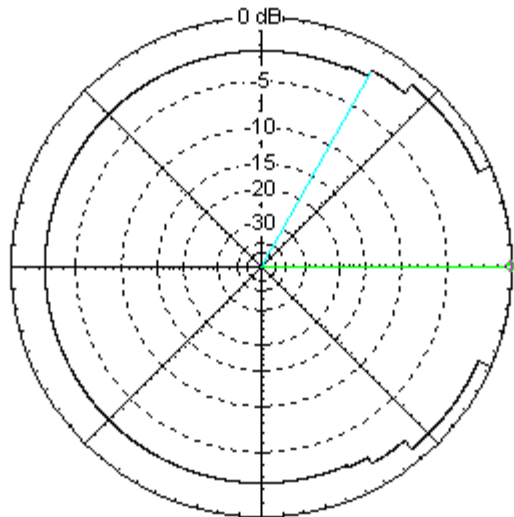
Cursor Elev	6.0 deg.
Gain	4.79 dBi
	0.0 dBmax

4.50dB sea water gain
16deg lowered TOA

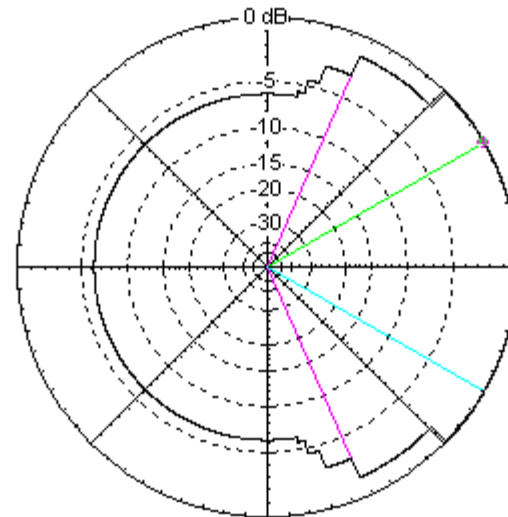
Vertical, sea water 20m away, 3m down

4 elevated radials up 3m
Elevation angles 22 and 10 deg

Total Field



EZNEC Total Field



EZNEC

3.79 MHz

3.79 MHz

Azimuth Plot
Elevation Angle 22.0 deg.
Outer Ring 2.79 dBi

Cursor Az 0.0 deg.
Gain 2.79 dBi
0.0 dBmax

Azimuth Plot
Elevation Angle 10.0 deg.
Outer Ring 4.77 dBi

Cursor Az 29.9 deg.
Gain 4.77 dBi
0.0 dBmax

Slice Max Gain 2.79 dBi @ Az Angle = 0.0 deg.
Front/Back 2.5 dB
Beamwidth ?
Sidelobe Gain 1.01 dBi @ Az Angle = 60.8 deg.
Front/Sidelobe 1.78 dB

Slice Max Gain 4.77 dBi @ Az Angle = 29.9 deg.
Front/Back 6.32 dB
Beamwidth 133.0 deg.; -3dB @ 293.5, 66.5 deg.
Sidelobe Gain 4.77 dBi @ Az Angle = 330.0 deg.
Front/Sidelobe 0.0 dB

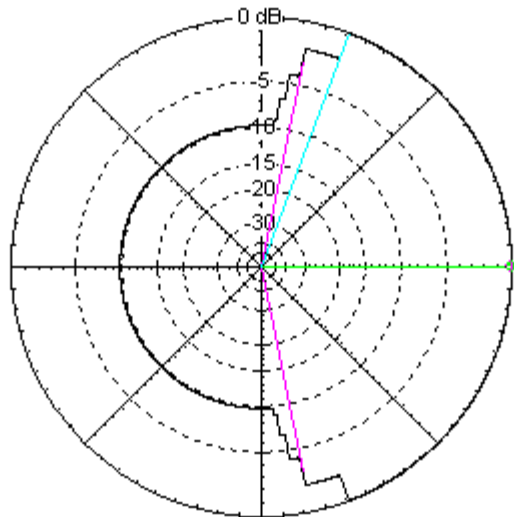
2.5dB sea water gain on 22deg

6dB sea water gain on 10deg

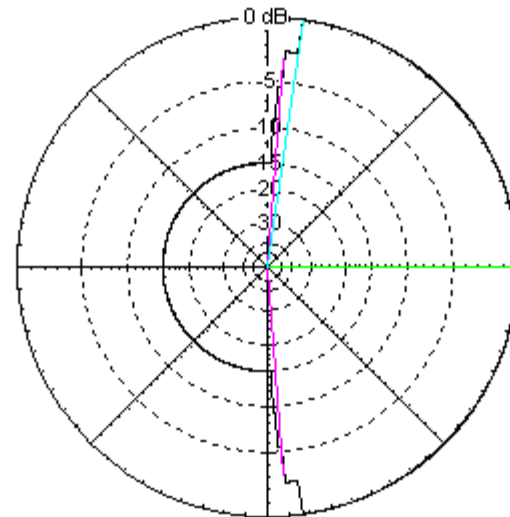
Vertical, sea water 20m away, 3m down

4 elevated radials up 3m
Elevation angles 5 and 2 deg

Total Field



EZNEC Total Field



EZNEC

3.79 MHz

3.79 MHz

Azimuth Plot
Elevation Angle 5.0 deg.
Outer Ring 4.75 dBi

Cursor Az 0.0 deg.
Gain 4.75 dBi
0.0 dBmax

Azimuth Plot
Elevation Angle 2.0 deg.
Outer Ring 3.78 dBi

Cursor Az 0.0 deg.
Gain 3.78 dBi
0.0 dBmax

Slice Max Gain 4.75 dBi @ Az Angle = 0.0 deg.
Front/Back 9.76 dB
Beamwidth 157.0 deg.; -3dB @ 281.5, 78.5 deg.
Sidelobe Gain 4.72 dBi @ Az Angle = 69.2 deg.
Front/Sidelobe 0.04 dB

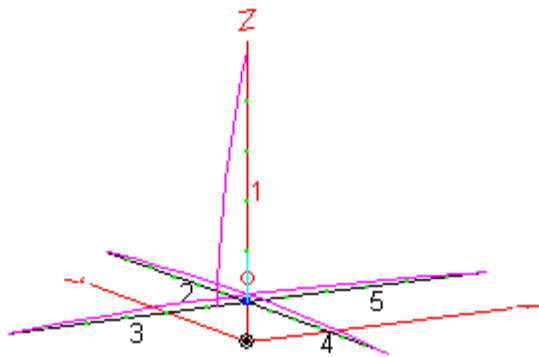
Slice Max Gain 3.78 dBi @ Az Angle = 0.0 deg.
Front/Back 14.98 dB
Beamwidth 170.8 deg.; -3dB @ 274.6, 85.4 deg.
Sidelobe Gain 3.77 dBi @ Az Angle = 81.8 deg.
Front/Sidelobe 0.01 dB

10dB sea water gain on 5deg

15dB sea water gain on 2 deg

Vertical, sea water 0m away, 3m down

4 elevated radials up 3m



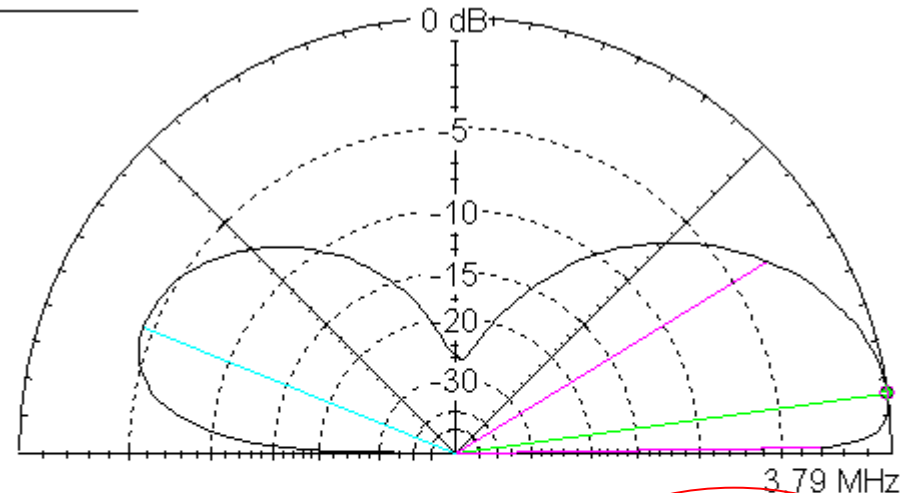
X<0m, Z=0, Average ground
5mS, $\epsilon=13$

X>0m, Z=-3m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

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Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 4.9 dBi

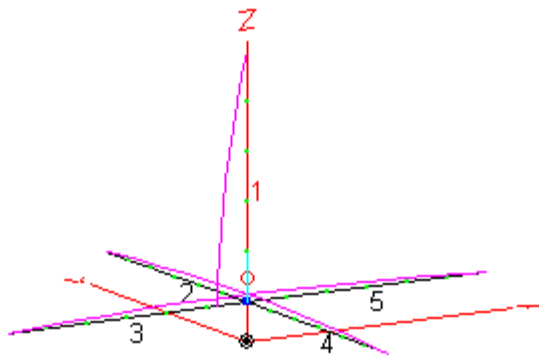
Slice Max Gain 4.9 dBi @ Elev Angle = 8.0 deg.
Beamwidth 30.4 deg.; -3dB @ 1.0, 31.4 deg.
Sidelobe Gain 0.43 dBi @ Elev Angle = 158.0 deg.
Front/Sidelobe 4.47 dB

Cursor Elev 8.0 deg.
Gain 4.9 dBi
0.0 dBmax

4.6dB sea water gain

Vertical, sea water 0m away, 20m down

4 elevated radials up 3m



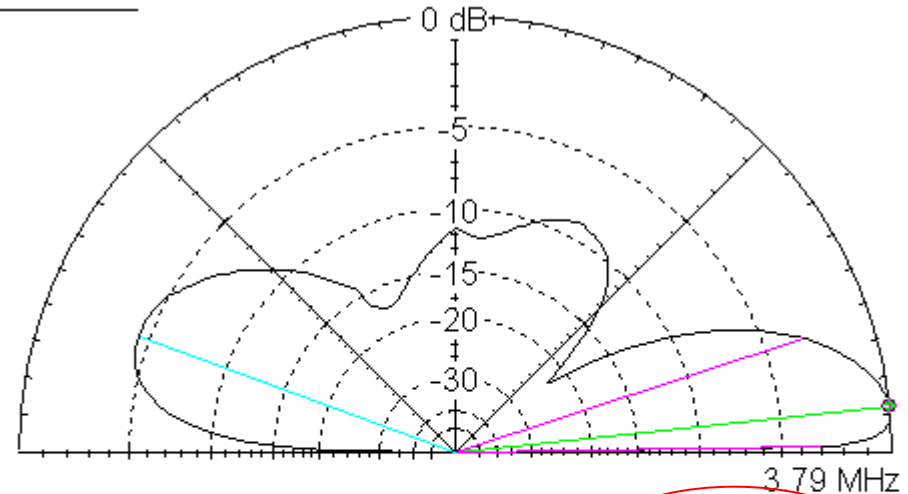
X<50m, Z=0, Average ground
5mS, $\epsilon=13$

X>50m, Z=-20m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 4.49 dBi

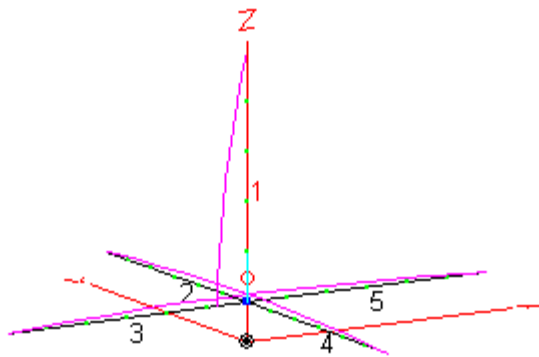
Slice Max Gain 4.49 dBi @ Elev Angle = 6.0 deg.
Beamwidth 17.1 deg.; -3dB @ 1.0, 18.1 deg.
Sidelobe Gain 0.07 dBi @ Elev Angle = 160.0 deg.
Front/Sidelobe 4.42 dB

Cursor Elev 6.0 deg.
Gain 4.49 dBi
0.0 dBmax

4.2dB sea water gain

Vertical, sea water 40m away, 20m down

4 elevated radials 3m high



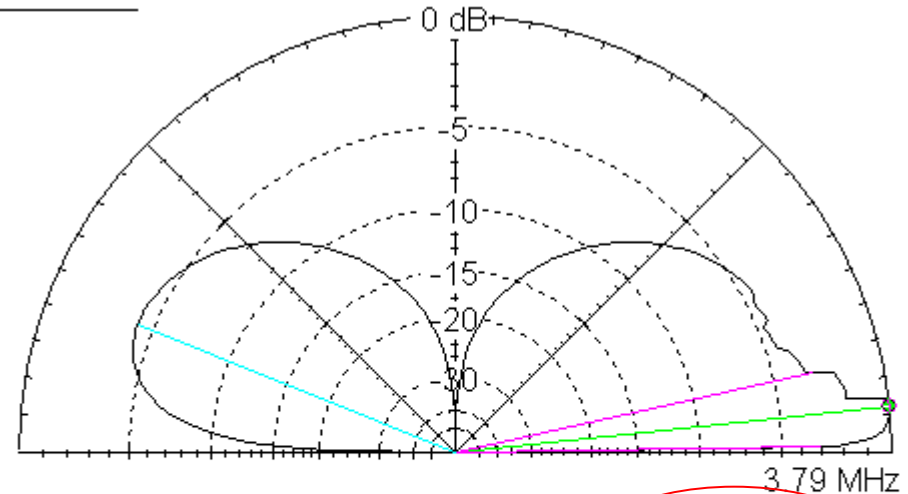
X<40m, Z=0, Average ground
5mS, $\epsilon=13$

X>40m, Z=-20m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 4.46 dBi

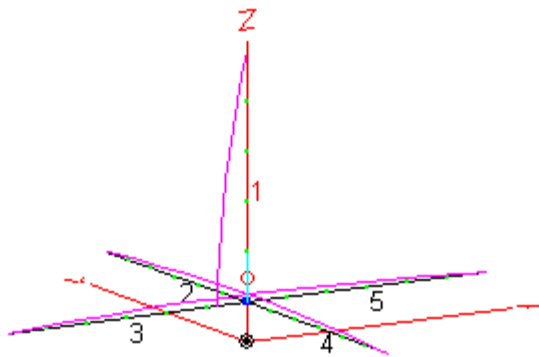
Slice Max Gain 4.46 dBi @ Elev Angle = 6.0 deg.
Beamwidth 11.7 deg.; -3dB @ 1.0, 12.7 deg.
Sidelobe Gain 0.29 dBi @ Elev Angle = 158.0 deg.
Front/Sidelobe 4.18 dB

Cursor Elev 6.0 deg.
Gain 4.46 dBi
0.0 dBmax

4.26dB sea water gain

Vertical, sea water 80m away, 20m down

4 elevated radials up 3m



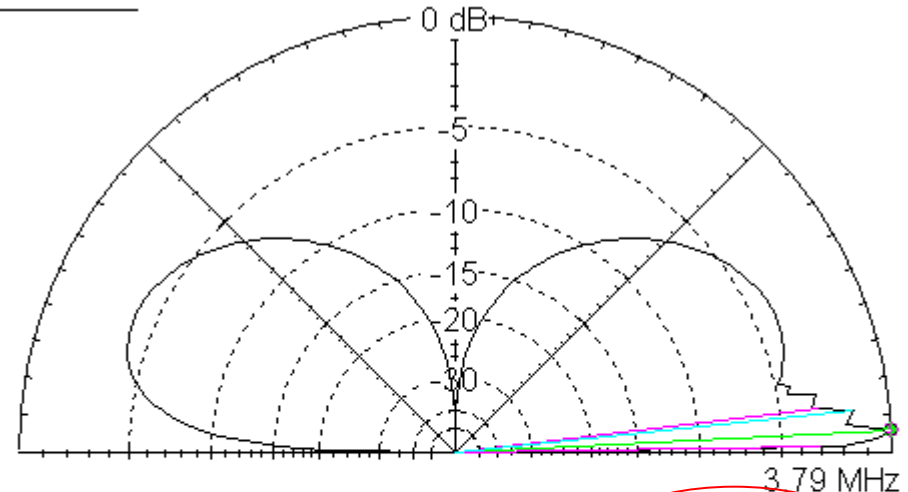
X<80m, Z=0, Average ground
5mS, $\epsilon=13$

X>80m, Z=-20m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 4.18 dBi

Cursor Elev 3.0 deg.
Gain 4.18 dBi
0.0 dBmax

Slice Max Gain 4.18 dBi @ Elev Angle = 3.0 deg.
Beamwidth 5.8 deg.; -3dB @ 1.0, 6.8 deg.
Sidelobe Gain 2.66 dBi @ Elev Angle = 6.0 deg.
Front/Sidelobe 1.52 dB

3.9dB sea water gain

1. Influence of water on vertical antenna

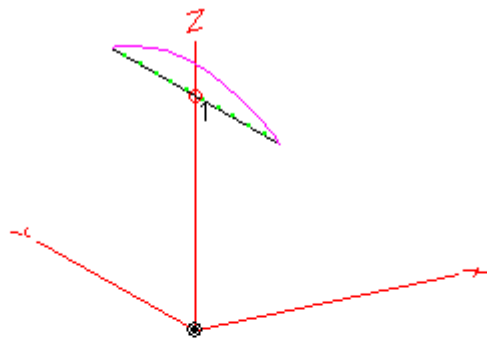
Conclusions:

- Fresh water provides very little help, a bit lowered TOA
- Sea water gives almost 5dB gain plus lower angle of radiation, effect is up to 3 S-units on low angles
 - Water line shall be less than $\frac{1}{2}$ wavelengths from the antenna
- Antenna elevation from water provides no advantage
 - (elevated radials are ok)

2. Influence of nearby water on horizontal antenna

80m dipole up 30m

average ground

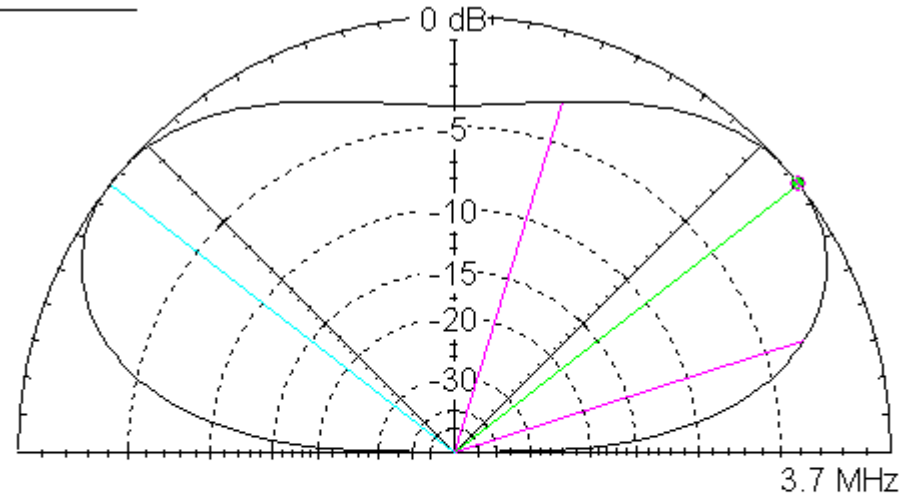


Average ground
5mS, $\epsilon=13$

EZNEC

Total Field

EZNEC



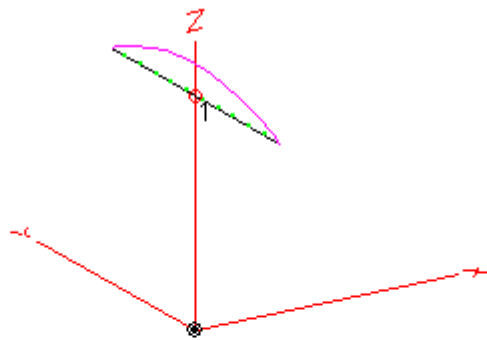
Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 6.39 dBi

Cursor Elev 38.0 deg.
Gain 6.39 dBi
0.0 dBmax

Slice Max Gain 6.39 dBi @ Elev Angle = 38.0 deg.
Beamwidth 55.1 deg.; -3dB @ 17.7, 72.8 deg.
Sidelobe Gain 6.39 dBi @ Elev Angle = 142.0 deg.
Front/Sidelobe 0.0 dB

80m dipole up 30m

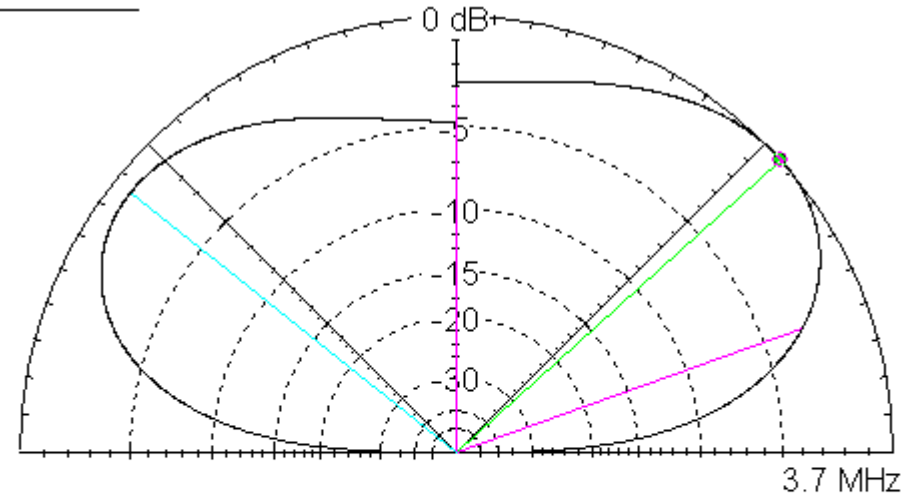
$x < 0$ is average ground, $x > 0$ is sea 0m down



EZNEC

Total Field

EZNEC



Elevation Plot

Azimuth Angle 0.0 deg.

Outer Ring 7.2 dBi

Cursor Elev 42.1 deg.

Gain 7.2 dBi

0.0 dBmax

Slice Max Gain 7.2 dBi @ Elev Angle = 42.1 deg.

Beamwidth 70.4 deg.; -3dB @ 19.6, 90.0 deg.

Sidelobe Gain 6.39 dBi @ Elev Angle = 141.4 deg.

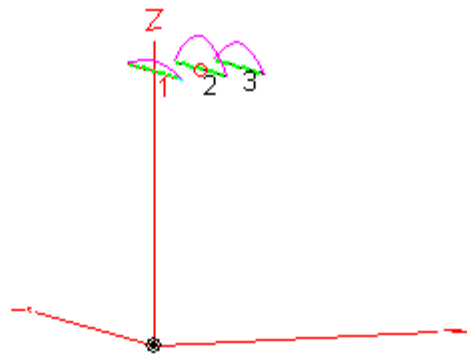
Front/Sidelobe 0.81 dB

$X < 0m, Z = 0, Average\ ground$
5mS, $\epsilon = 13$

$X > 0m, Z = 0m, Sea\ water$
2S, $\epsilon = 80$ (Baltic Sea)

0.8dB sea water gain

3-el yagi up 21m average flat ground

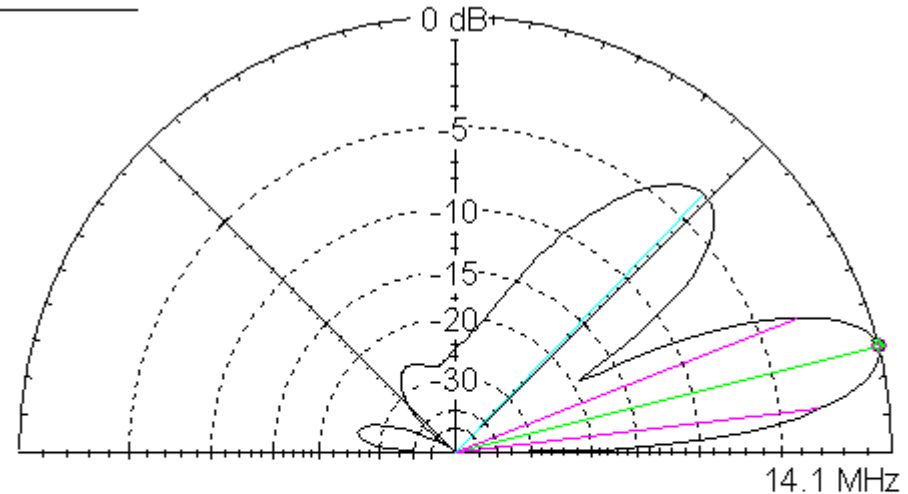


Average ground
5mS, $\epsilon=13$

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 13.41 dBi

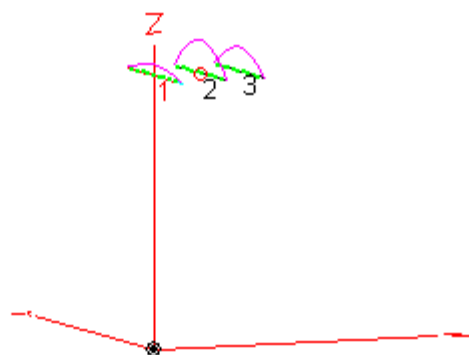
Cursor Elev 14.0 deg.
Gain 13.41 dBi
0.0 dBmax

Slice Max Gain 13.41 dBi @ Elev Angle = 14.0 deg.
Beamwidth 14.6 deg.; -3dB @ 6.8, 21.4 deg.
Sidelobe Gain 9.99 dBi @ Elev Angle = 46.0 deg.
Front/Sidelobe 3.42 dB

water gain reference

3-el yagi up 21m

fresh water 50m away



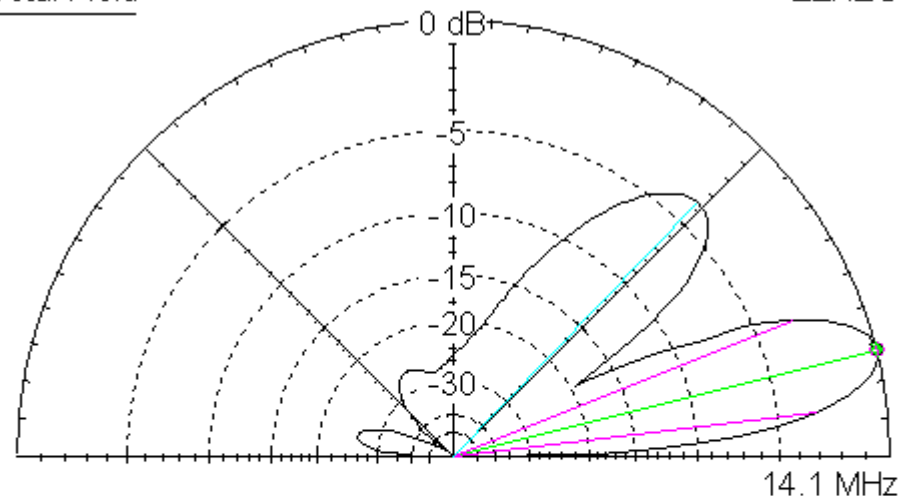
X<50m, Z=0, Average ground
5mS, $\epsilon=13$

X>50m, Z=0, Fresh water
5mS, $\epsilon=80$

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 13.7 dBi

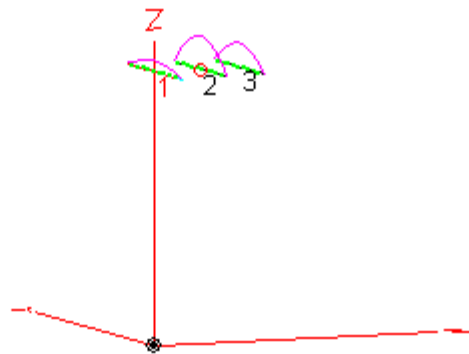
Cursor Elev 14.0 deg.
Gain 13.7 dBi
0.0 dBmax

Slice Max Gain 13.7 dBi @ Elev Angle = 14.0 deg.
Beamwidth 14.8 deg.; -3dB @ 7.0, 21.8 deg.
Sidelobe Gain 9.99 dBi @ Elev Angle = 46.0 deg.
Front/Sidelobe 3.71 dB

0.3dB fresh water gain

3-el yagi up 21m

fresh water 0m away



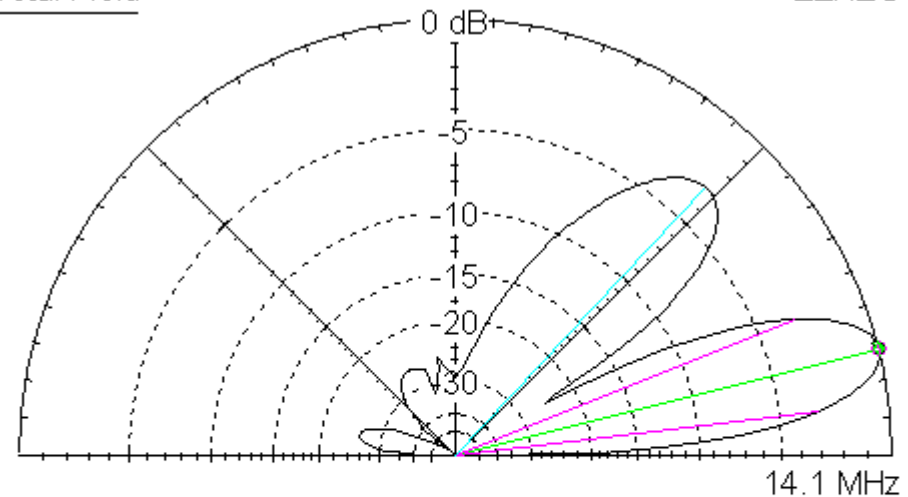
X<0m, Z=0, Average ground
5mS, $\epsilon=13$

X>0m, Z=0, Fresh water
5mS, $\epsilon=80$

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 13.7 dBi

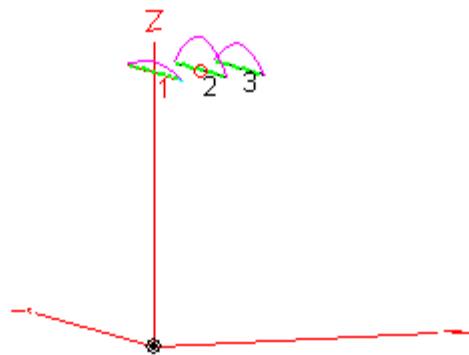
Cursor Elev 14.0 deg.
Gain 13.7 dBi
0.0 dBmax

Slice Max Gain 13.7 dBi @ Elev Angle = 14.0 deg.
Beamwidth 14.8 deg.; -3dB @ 7.0, 21.8 deg.
Sidelobe Gain 10.71 dBi @ Elev Angle = 47.0 deg.
Front/Sidelobe 2.99 dB

0.3dB fresh water gain

3-el yagi up 21m

sea water 0m away



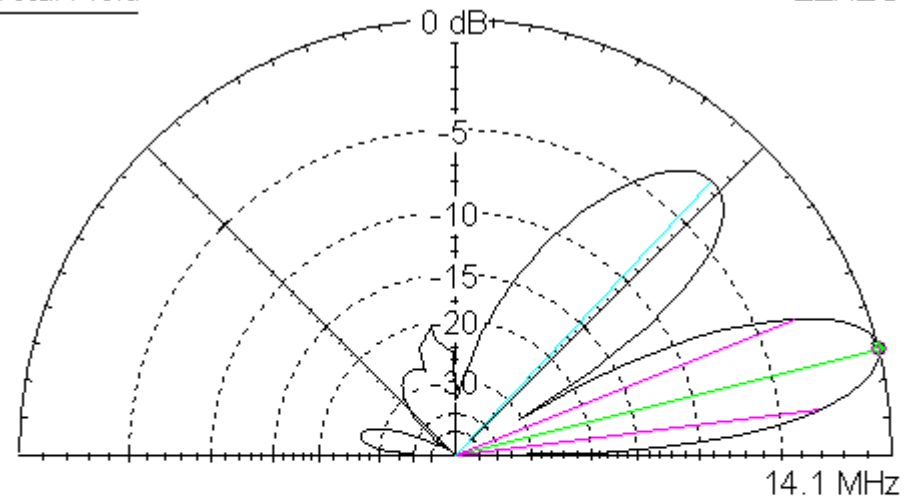
X<0m, Z=0, Average ground
5mS, $\epsilon=13$

X>0m, Z=0m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 13.91 dBi

Cursor Elev 14.0 deg.
Gain 13.91 dBi
0.0 dBmax

Slice Max Gain 13.91 dBi @ Elev Angle = 14.0 deg.
Beamwidth 14.8 deg.; -3dB @ 7.1, 21.9 deg.
Sidelobe Gain 11.32 dBi @ Elev Angle = 47.0 deg.
Front/Sidelobe 2.59 dB

0.5dB sea water gain

2. Influence of nearby water on horizontal antenna

Conclusions:

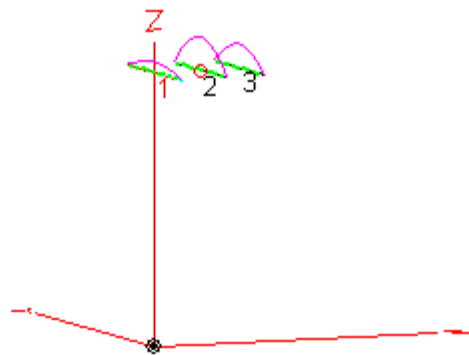
- Fresh water has practically no influence
- Even sea water increases gain only by 1/2dB
- Horizontal antennas depend very little on quality of ground

Seaside QTH provides very little advantage, when using horizontal antennas

3. Influence of steep coast on horizontal antenna



3-el yagi 14100kHz up 21m sea water 0m away, 0m down (reference)



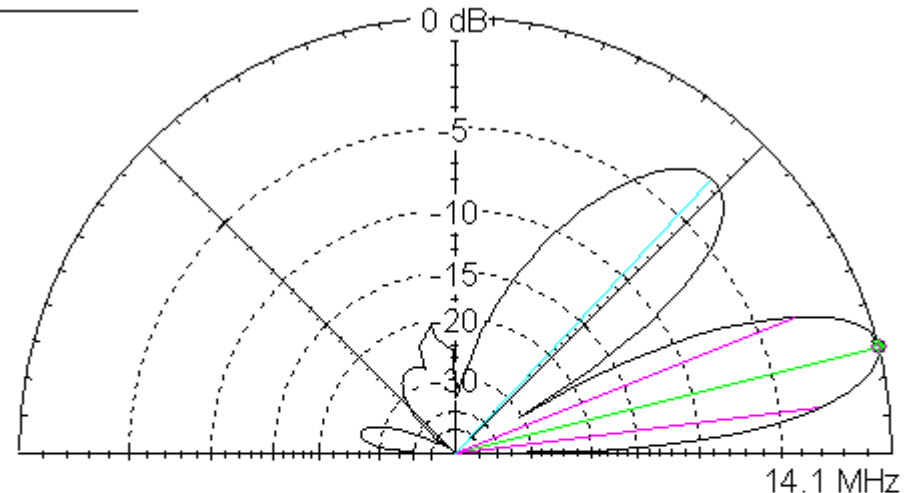
X<0m, Z=0, Average ground
5mS, $\epsilon=13$

X>0m, Z=0m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 13.91 dBi

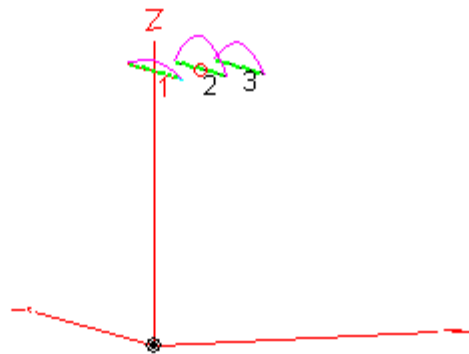
Cursor Elev 14.0 deg.
Gain 13.91 dBi
0.0 dBmax

Slice Max Gain 13.91 dBi @ Elev Angle = 14.0 deg.
Beamwidth 14.8 deg.; -3dB @ 7.1, 21.9 deg.
Sidelobe Gain 11.32 dBi @ Elev Angle = 47.0 deg.
Front/Sidelobe 2.59 dB

cliff gain reference

3-el yagi up 21m

sea water 20m away, 20m down



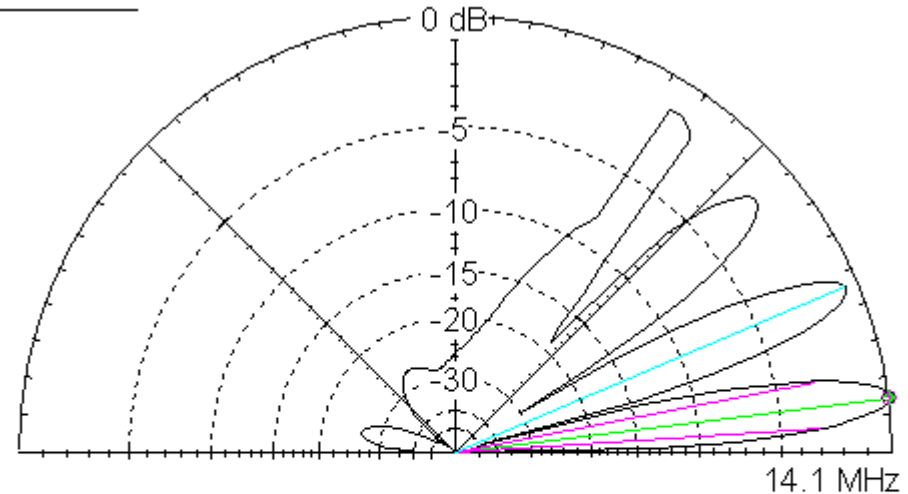
X<20m, Z=0, Average ground
5mS, $\epsilon=13$

X>20m, Z=-20m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 14.07 dBi

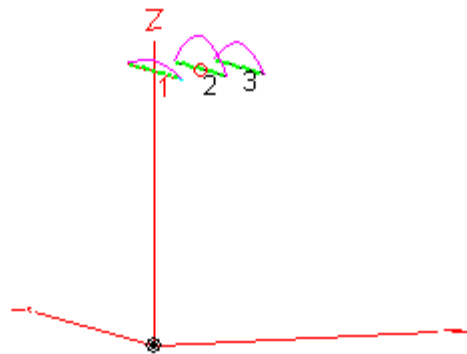
Cursor Elev 7.0 deg.
Gain 14.07 dBi
0.0 dBmax

Slice Max Gain 14.07 dBi @ Elev Angle = 7.0 deg.
Beamwidth 7.4 deg.; -3dB @ 3.7, 11.1 deg.
Sidelobe Gain 13.53 dBi @ Elev Angle = 23.0 deg.
Front/Sidelobe 0.54 dB

0.16dB cliff gain
7deg lowered TOA

3-el yagi up 21m

sea water 20m away, 40m down



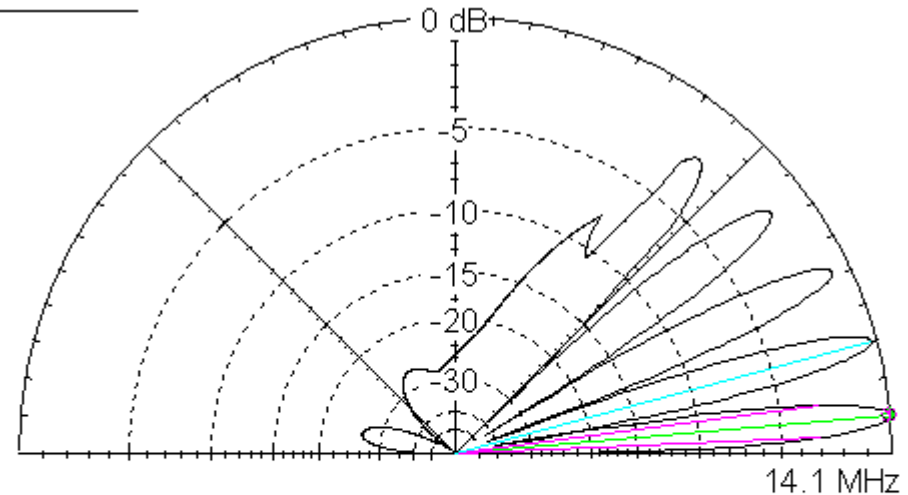
X<20m, Z=0, Average ground
5mS, $\epsilon=13$

X>20m, Z=-40m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 14.13 dBi

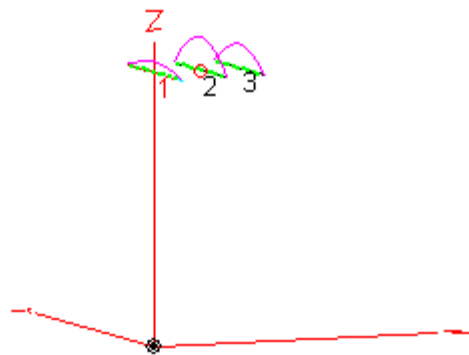
Cursor Elev 5.0 deg.
Gain 14.13 dBi
0.0 dBmax

Slice Max Gain 14.13 dBi @ Elev Angle = 5.0 deg.
Beamwidth 5.0 deg.; -3dB @ 2.5, 7.5 deg.
Sidelobe Gain 13.89 dBi @ Elev Angle = 15.1 deg.
Front/Sidelobe 0.25 dB

0.22dB cliff gain
9deg lowered TOA

3-el yagi up 21m

sea water 40m away, 40m down



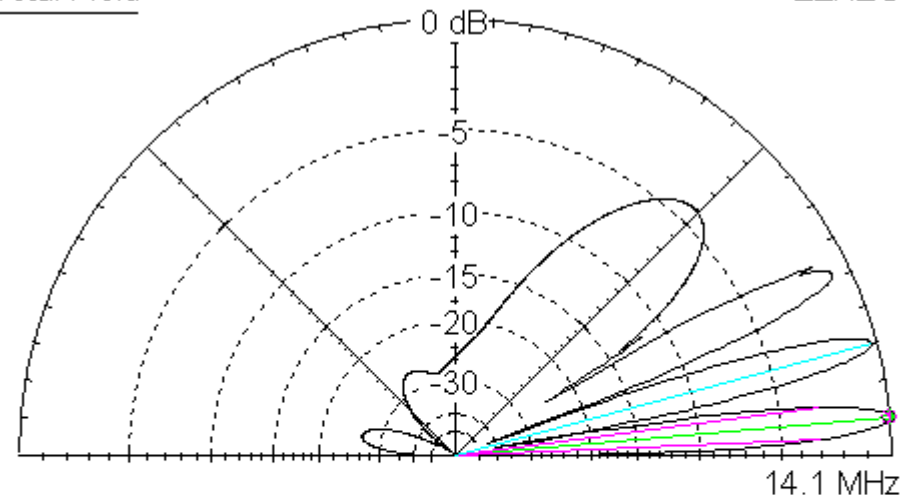
X<40m, Z=0, Average ground
5mS, $\epsilon=13$

X>40m, Z=-40m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 14.13 dBi

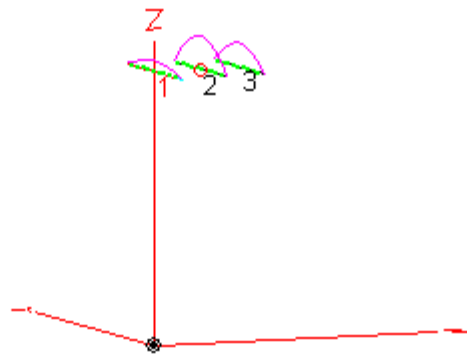
Cursor Elev 5.0 deg.
Gain 14.13 dBi
0.0 dBmax

Slice Max Gain 14.13 dBi @ Elev Angle = 5.0 deg.
Beamwidth 5.0 deg.; -3dB @ 2.5, 7.5 deg.
Sidelobe Gain 13.89 dBi @ Elev Angle = 15.1 deg.
Front/Sidelobe 0.25 dB

0.22dB cliff gain
9deg lowered TOA

3-el yagi up 21m

sea water 80m away, 40m down



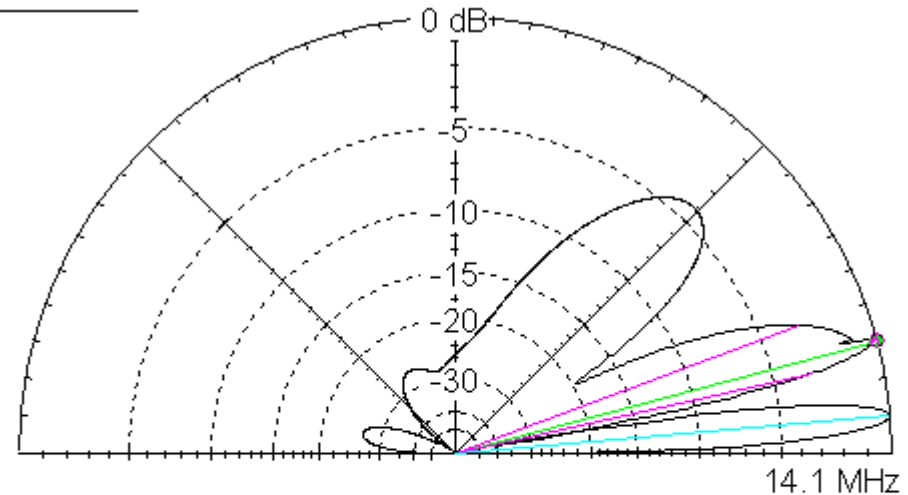
X<80m, Z=0, Average ground
5mS, $\epsilon=13$

X>80m, Z=-40m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 14.17 dBi

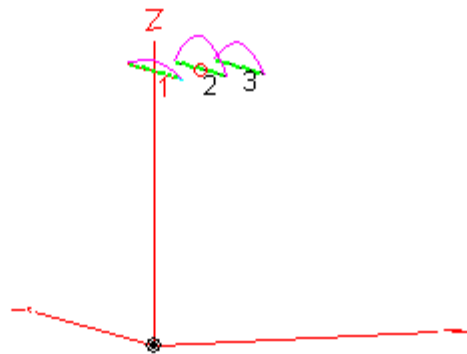
Cursor Elev 14.8 deg.
Gain 14.17 dBi
0.0 dBmax

Slice Max Gain 14.17 dBi @ Elev Angle = 14.8 deg.
Beamwidth 7.8 deg.; -3dB @ 12.7, 20.5 deg.
Sidelobe Gain 14.13 dBi @ Elev Angle = 5.0 deg.
Front/Sidelobe 0.03 dB

0.26dB cliff gain
additional 7deg lower TOA

3-el yagi up 21m

sea water 120m away, 40m down



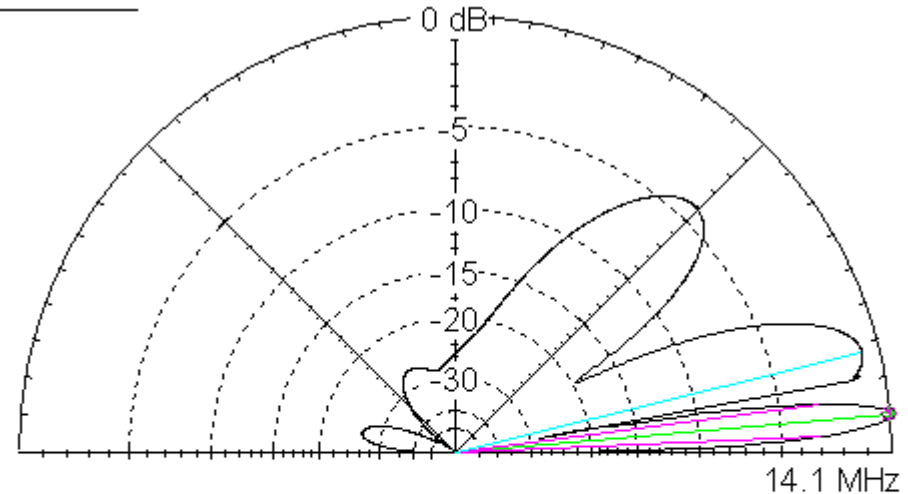
X<120m, Z=0, Average ground
5mS, $\epsilon=13$

X>120m, Z=-40m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 14.13 dBi

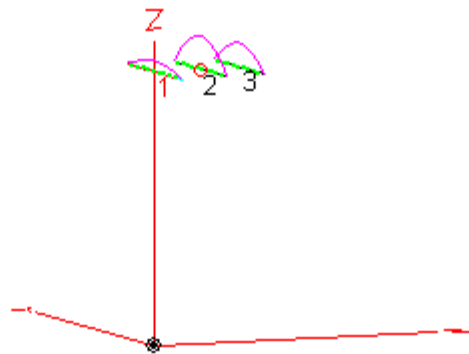
Cursor Elev 5.0 deg.
Gain 14.13 dBi
0.0 dBmax

Slice Max Gain 14.13 dBi @ Elev Angle = 5.0 deg.
Beamwidth 5.0 deg.; -3dB @ 2.5, 7.5 deg.
Sidelobe Gain 13.41 dBi @ Elev Angle = 13.8 deg.
Front/Sidelobe 0.72 dB

0.22dB cliff gain
9deg lowered TOA

3-el yagi up 21m

sea water 200m away, 40m down



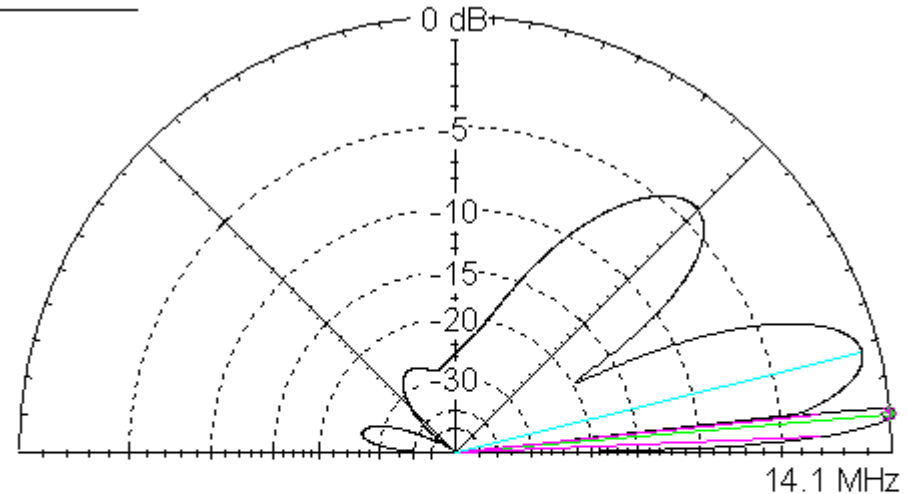
X<200m, Z=0, Average ground
5mS, $\epsilon=13$

X>200m, Z=-40m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 14.13 dBi

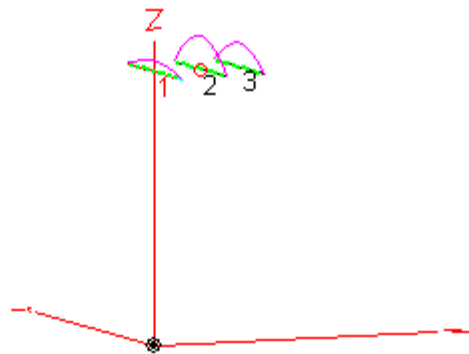
Cursor Elev 5.0 deg.
Gain 14.13 dBi
0.0 dBmax

Slice Max Gain 14.13 dBi @ Elev Angle = 5.0 deg.
Beamwidth 3.6 deg.; -3dB @ 2.5, 6.1 deg.
Sidelobe Gain 13.41 dBi @ Elev Angle = 13.8 deg.
Front/Sidelobe 0.72 dB

0.22dB cliff gain
9deg lowered TOA

3-el yagi up 21m

sea water 300m away, 40m down



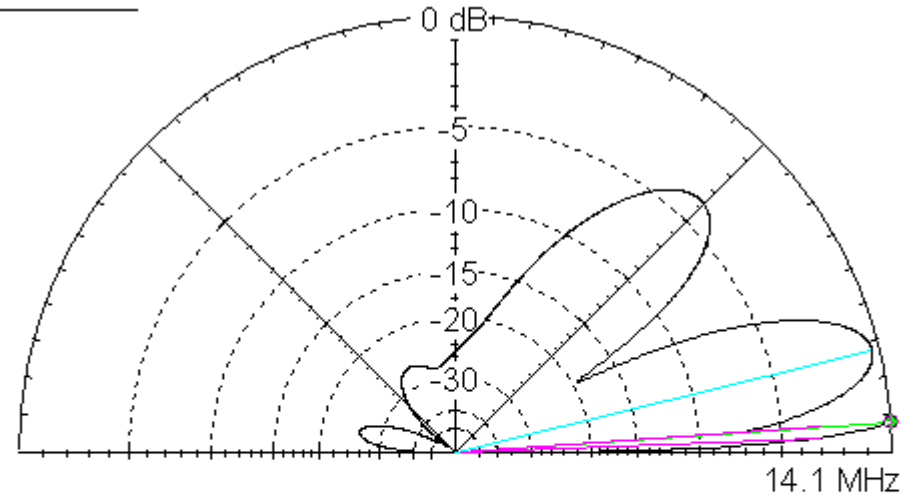
X<300m, Z=0, Average ground
5mS, $\epsilon=13$

X>300m, Z=-40m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 13.71 dBi

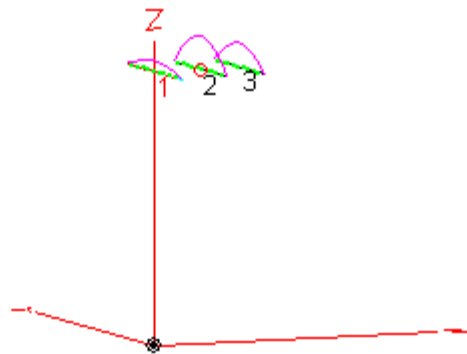
Cursor Elev 4.0 deg.
Gain 13.71 dBi
0.0 dBmax

Slice Max Gain 13.71 dBi @ Elev Angle = 4.0 deg.
Beamwidth 1.7 deg.; -3dB @ 2.3, 4.0 deg.
Sidelobe Gain 13.41 dBi @ Elev Angle = 13.8 deg.
Front/Sidelobe 0.3 dB

-0.2dB cliff gain
additional 10deg lower TOA

3-el yagi up 21m

sea water 40m away, 100m down



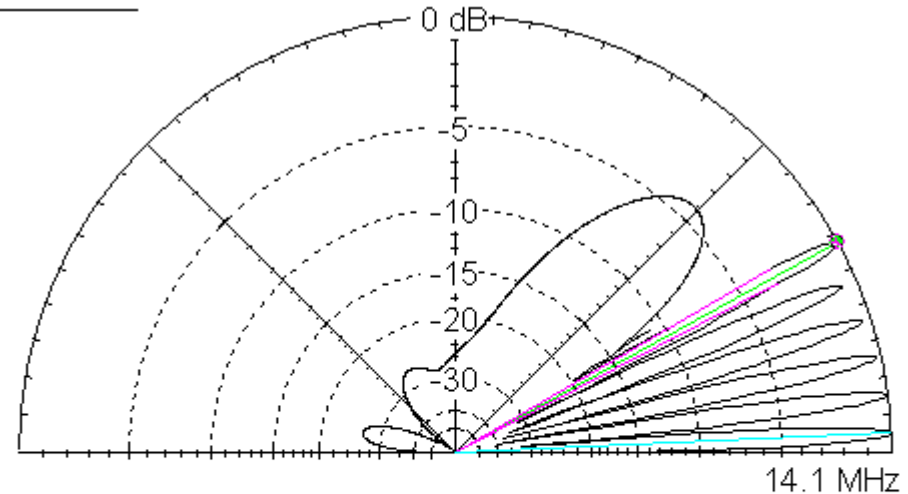
X<40m, Z=0, Average ground
5mS, $\epsilon=13$

X>40m, Z=-100m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 14.17 dBi

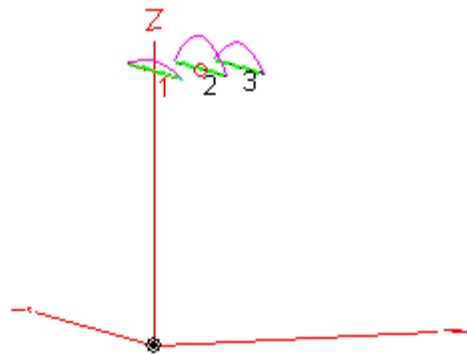
Cursor Elev 28.7 deg.
Gain 14.17 dBi
0.0 dBmax

Slice Max Gain 14.17 dBi @ Elev Angle = 28.7 deg.
Beamwidth 2.5 deg.; -3dB @ 27.6, 30.1 deg.
Sidelobe Gain 14.16 dBi @ Elev Angle = 2.5 deg.
Front/Sidelobe 0.01 dB

0.26dB cliff gain
multiple TOA down to 2.5deg

3-el yagi up 21m

sea water 100m away, 100m down



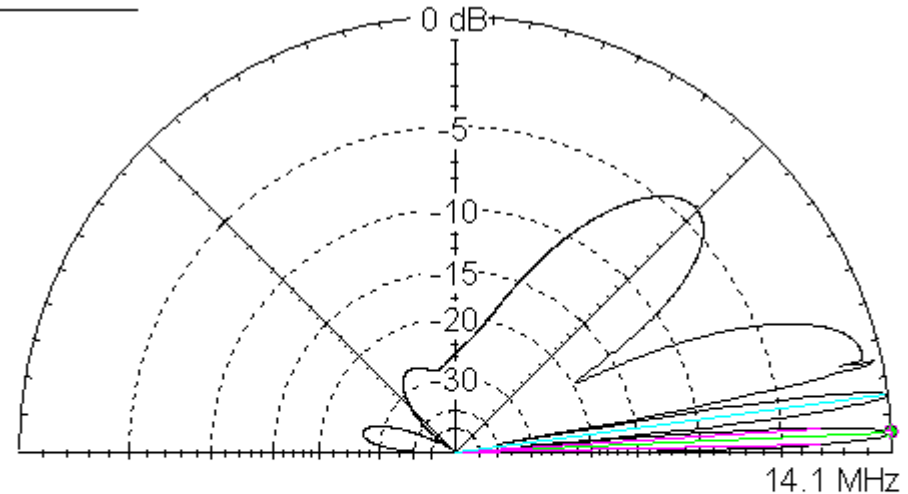
X<100m, Z=0, Average ground
5mS, $\epsilon=13$

X>100m, Z=-100m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 14.16 dBi

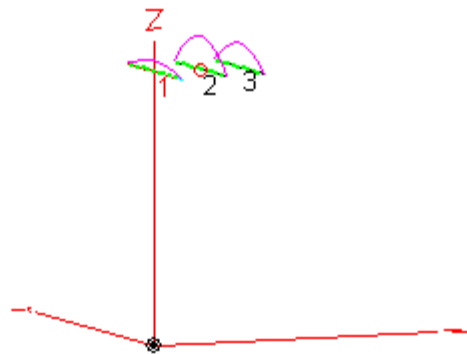
Cursor Elev 2.5 deg.
Gain 14.16 dBi
0.0 dBmax

Slice Max Gain 14.16 dBi @ Elev Angle = 2.5 deg.
Beamwidth 2.5 deg.; -3dB @ 1.3, 3.8 deg.
Sidelobe Gain 14.09 dBi @ Elev Angle = 7.6 deg.
Front/Sidelobe 0.07 dB

0.25dB cliff gain
11.5deg lowered TOA
Multiple TOA's

3-el yagi up 21m

sea water 200m away, 100m down



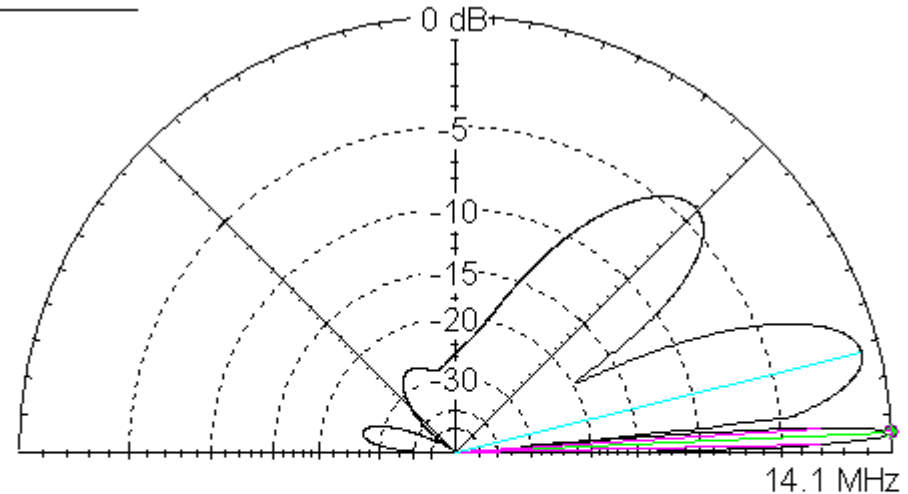
X<200m, Z=0, Average ground
5mS, $\epsilon=13$

X>200m, Z=-100m, Sea water
2S, $\epsilon=80$ (Baltic Sea)

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 14.16 dBi

Cursor Elev 2.5 deg.
Gain 14.16 dBi
0.0 dBmax

Slice Max Gain 14.16 dBi @ Elev Angle = 2.5 deg.
Beamwidth 2.5 deg.; -3dB @ 1.3, 3.8 deg.
Sidelobe Gain 13.41 dBi @ Elev Angle = 13.8 deg.
Front/Sidelobe 0.75 dB

0.25dB cliff gain
11.5deg lowered TOA

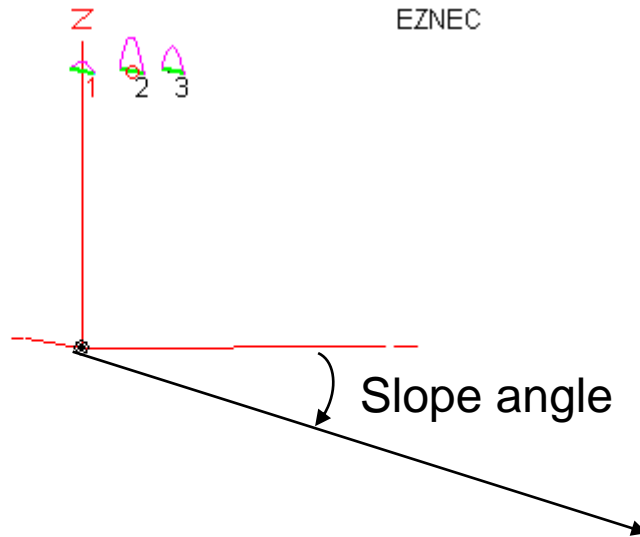
3. Influence of steep cliff on horizontal antenna

Conclusions:

- Nearby cliff has the same influence as tower height
 - Lower TOA
 - a bit more gain
- Distance to cliff can be quite long for low TOA's
 - In the example
 - Antenna height 1 lamda
 - Cliff height 2 lamda
 - >Cliff distance can be up to 6 lamda
- Distance to cliff lowers secondary lobes
- Deep reflector can be any type of soil, doesn't need to be sea water

4. Influence of sloping terrain on horizontal antenna

TOA of Hill Top QTH

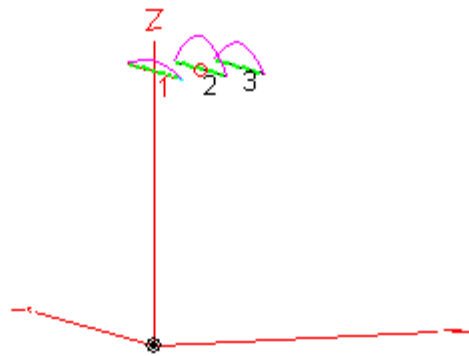


$TOA = TOA \text{ (on flat surface)} - \text{slope angle}$

This can become even negative which is not useful

5. Influence of stacking

3-el yagi 1 wavelength high average flat ground

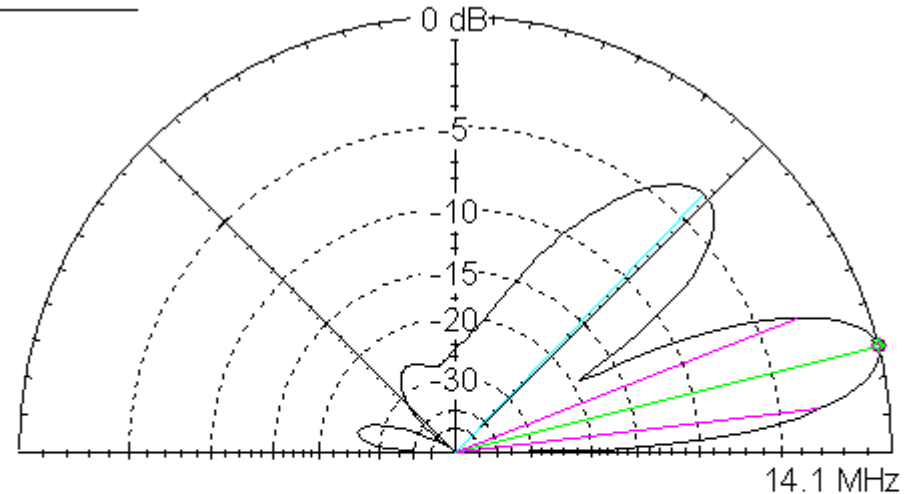


Average ground
5mS, $\epsilon=13$

Total Field

EZNEC

EZNEC

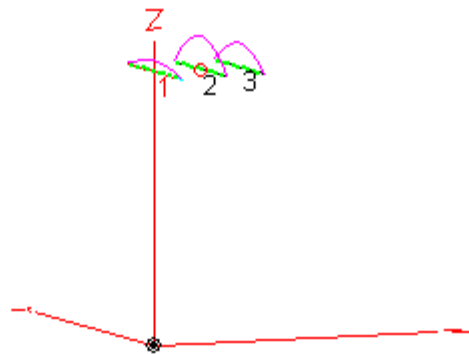


Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 13.41 dBi

Cursor Elev 14.0 deg.
Gain 13.41 dBi
0.0 dBmax

Slice Max Gain 13.41 dBi @ Elev Angle = 14.0 deg.
Beamwidth 14.6 deg.; -3dB @ 6.8, 21.4 deg.
Sidelobe Gain 9.99 dBi @ Elev Angle = 46.0 deg.
Front/Sidelobe 3.42 dB

3-el yagi 1.5 wavelength high average flat ground

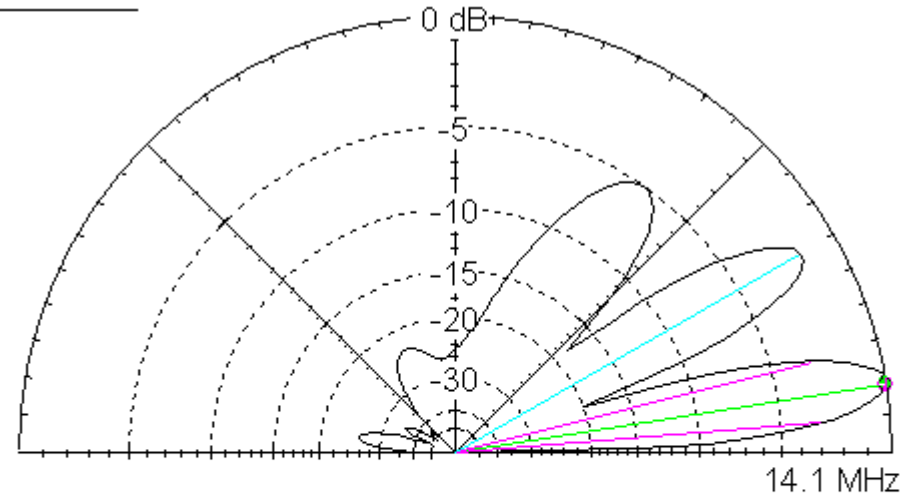


Average ground
5mS, $\epsilon=13$

Total Field

EZNEC

EZNEC

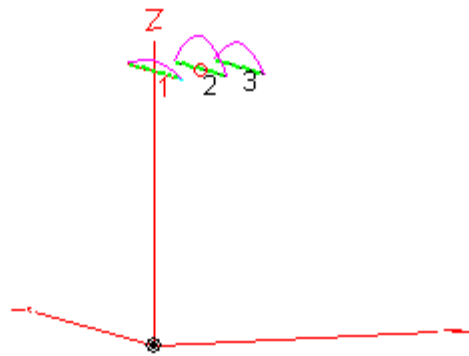


Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 13.69 dBi

Cursor Elev 9.0 deg.
Gain 13.69 dBi
0.0 dBmax

Slice Max Gain 13.69 dBi @ Elev Angle = 9.0 deg.
Beamwidth 9.6 deg.; -3dB @ 4.7, 14.3 deg.
Sidelobe Gain 12.09 dBi @ Elev Angle = 30.0 deg.
Front/Sidelobe 1.6 dB

3-el yagi 2 wavelength high average flat ground

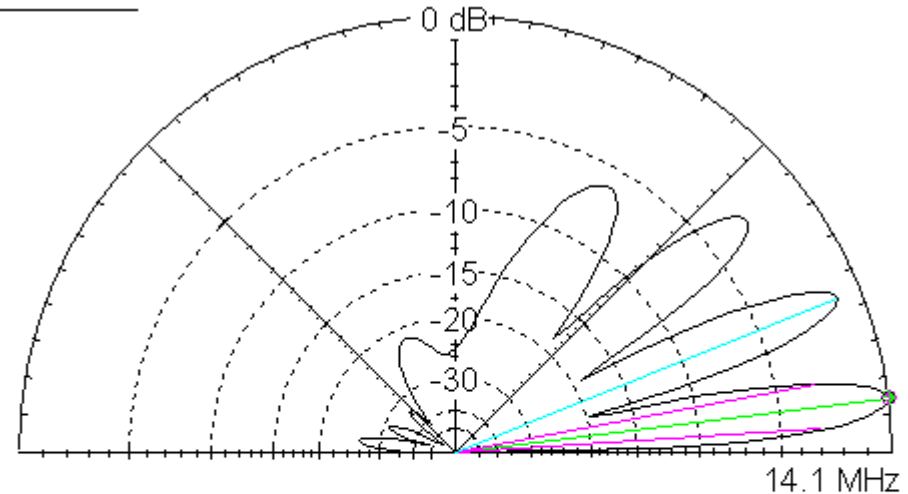


Average ground
5mS, $\epsilon=13$

Total Field

EZNEC

EZNEC



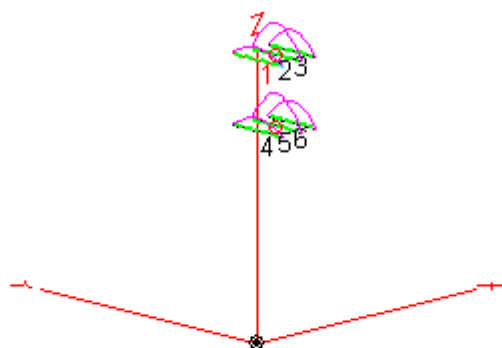
Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 13.84 dBi

Cursor Elev 7.0 deg.
Gain 13.84 dBi
0.0 dBmax

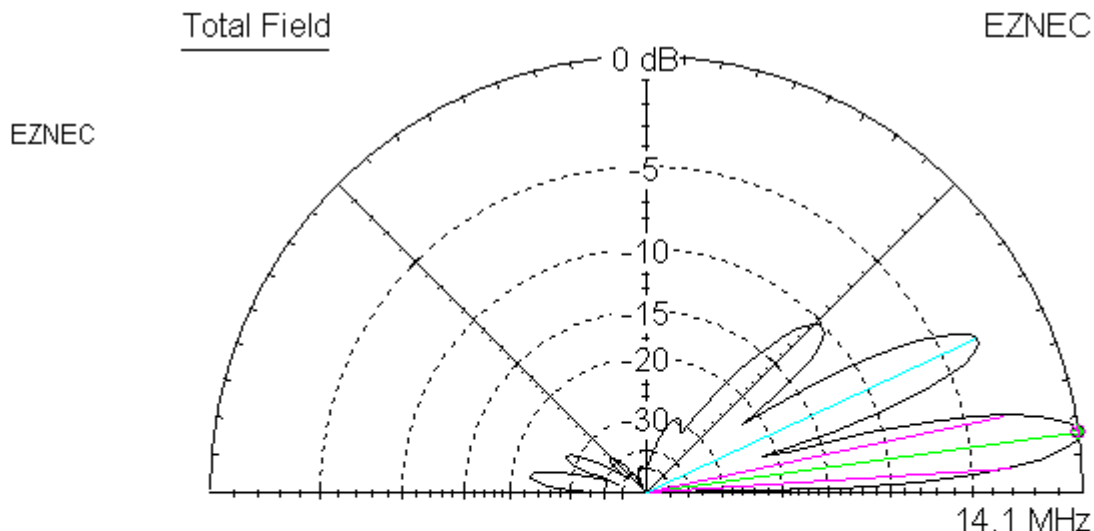
Slice Max Gain 13.84 dBi @ Elev Angle = 7.0 deg.
Beamwidth 7.1 deg.; -3dB @ 3.6, 10.7 deg.
Sidelobe Gain 12.82 dBi @ Elev Angle = 22.0 deg.
Front/Sidelobe 1.02 dB

Stacked 2x 3-el yagi's

1.5 and 2.0 wavelength high



Average ground
5mS, C=13



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 16.2 dBi

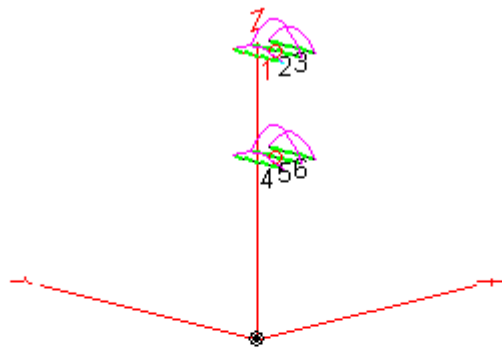
Cursor Elev 8.0 deg.
Gain 16.2 dBi
0.0 dBmax

Slice Max Gain 16.2 dBi @ Elev Angle = 8.0 deg.
Beamwidth 8.2 deg.; -3dB @ 3.9, 12.1 deg.
Sidelobe Gain 13.06 dBi @ Elev Angle = 25.0 deg.
Front/Sidelobe 3.14 dB

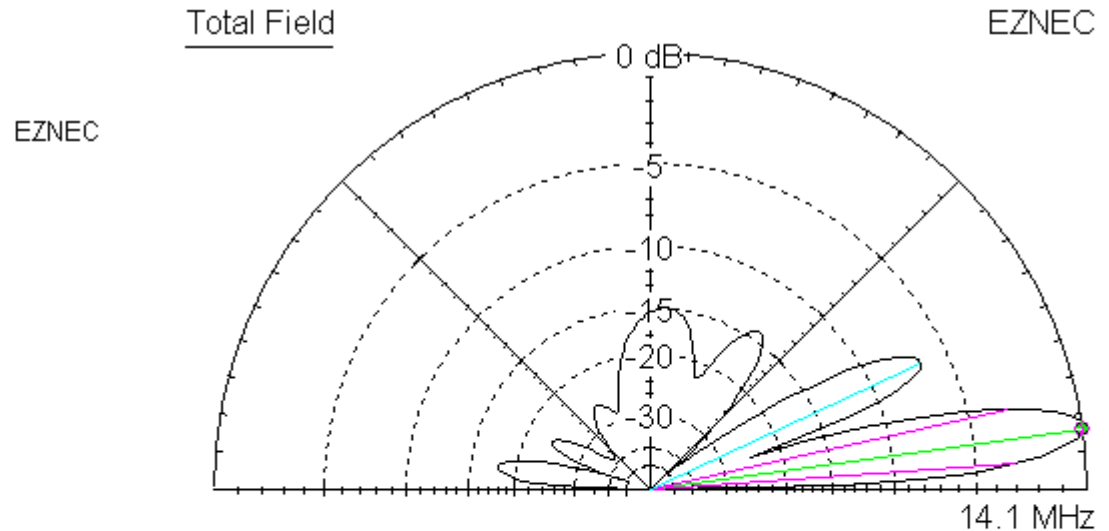
2.36dB stacking gain

Stacked 2x 3-el yagi's

1.25 and 2.0 wavelength high



Average ground
5mS, C=13



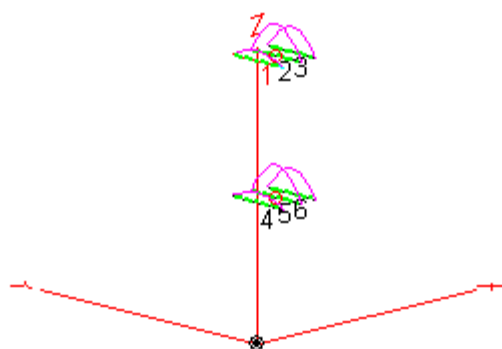
Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 16.49 dBi

Slice Max Gain 16.49 dBi @ Elev Angle = 8.0 deg.
Beamwidth 8.6 deg.; -3dB @ 4.1, 12.7 deg.
Sidelobe Gain 10.0 dBi @ Elev Angle = 25.0 deg.
Front/Sidelobe 6.49 dB

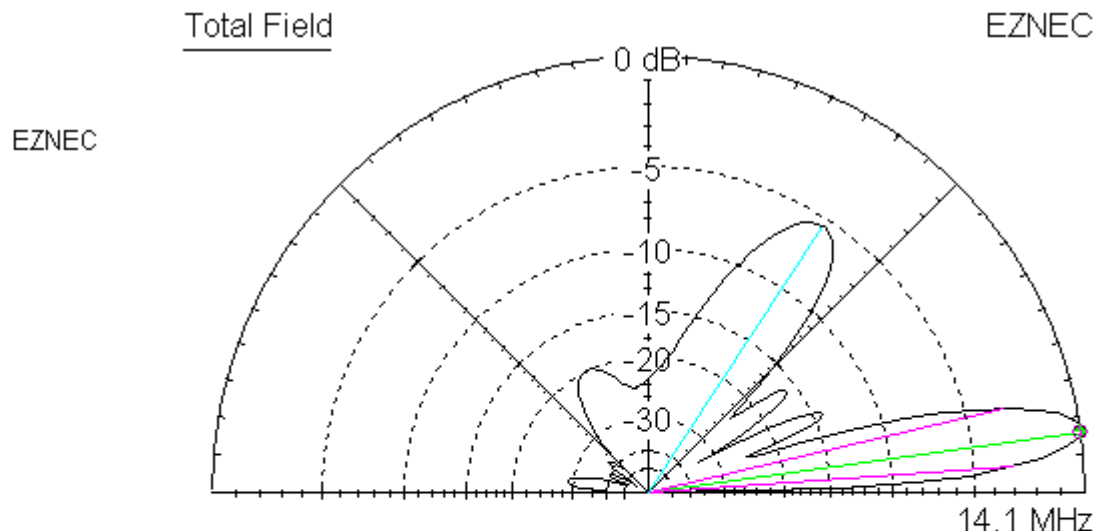
Cursor Elev 8.0 deg.
Gain 16.49 dBi
0.0 dBmax

2.65dB stacking gain

Stacked 2x 3-el yagi's 1.0 and 2.0 wavelength high



Average ground
5mS, $\epsilon=13$



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 15.75 dBi

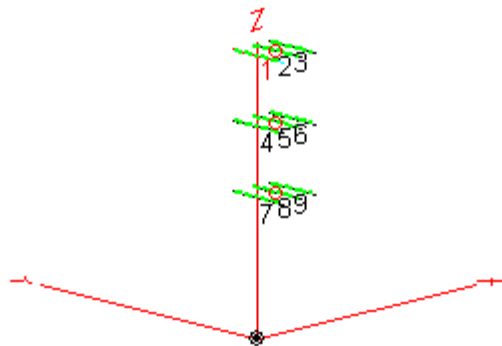
Cursor Elev 8.0 deg.
Gain 15.75 dBi
0.0 dBmax

Slice Max Gain 15.75 dBi @ Elev Angle = 8.0 deg.
Beamwidth 9.0 deg.; -3dB @ 4.1, 13.1 deg.
Sidelobe Gain 10.31 dBi @ Elev Angle = 57.0 deg.
Front/Sidelobe 5.44 dB

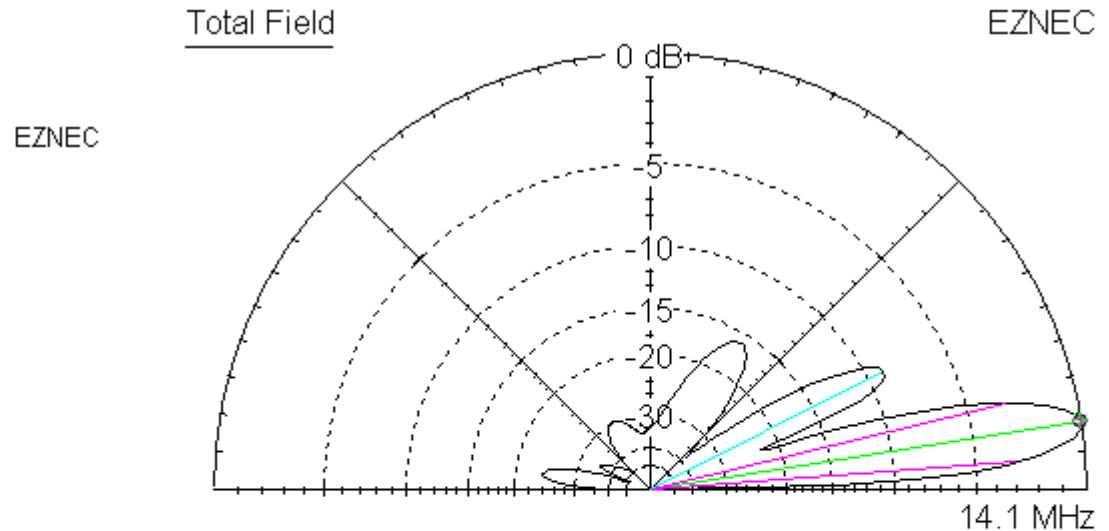
1.91dB stacking gain

Stacked 3 x 3-el yagi's

1.0, 1.5 and 2.0 wavelength high, equal powers



Average ground
5mS, C=13



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 17.25 dBi

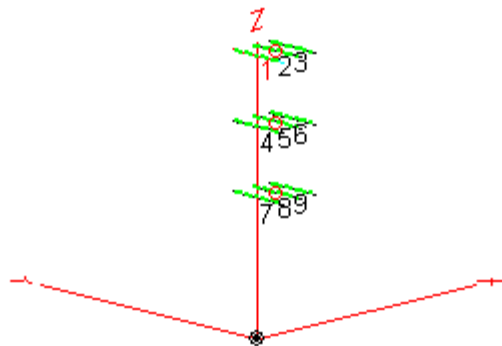
Cursor Elev 9.0 deg.
Gain 17.25 dBi
0.0 dBmax

Slice Max Gain 17.25 dBi @ Elev Angle = 9.0 deg.
Beamwidth 9.2 deg.; -3dB @ 4.3, 13.5 deg.
Sidelobe Gain 8.46 dBi @ Elev Angle = 27.0 deg.
Front/Sidelobe 8.79 dB

3.41dB stacking gain

Stacked 3 x 3-el yagi's

1.0, 1.5 and 2.0 wavelength high, powers 1:2:1

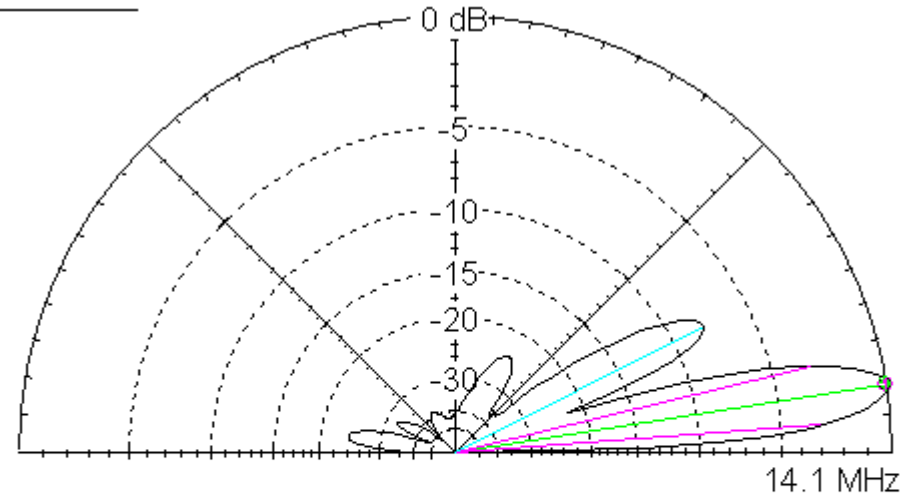


Average ground
5mS, C=13

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 17.21 dBi

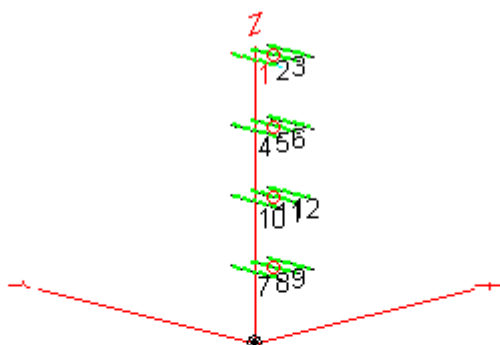
Cursor Elev 9.0 deg.
Gain 17.21 dBi
0.0 dBmax

Slice Max Gain 17.21 dBi @ Elev Angle = 9.0 deg.
Beamwidth 9.3 deg.; -3dB @ 4.3, 13.6 deg.
Sidelobe Gain 9.53 dBi @ Elev Angle = 27.0 deg.
Front/Sidelobe 7.68 dB

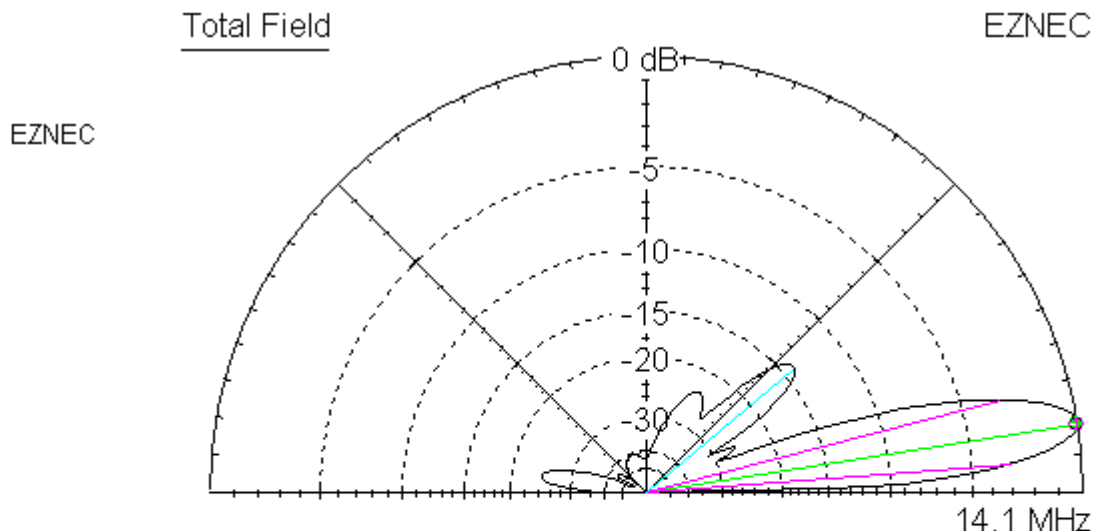
3.37dB stacking gain

Stacked 4 x 3-el yagi's

0.5, 1.0, 1.5 and 2.0 wavelength high, equal powers



Average ground
5mS, $\epsilon=13$



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 17.34 dBi

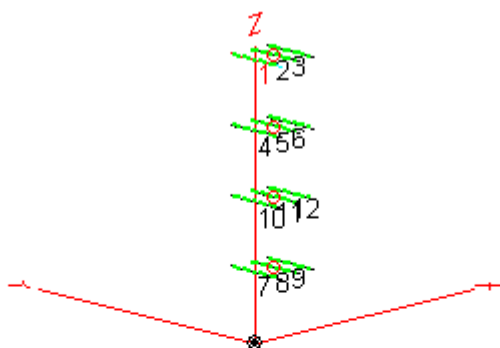
Cursor Elev 9.0 deg.
Gain 17.34 dBi
0.0 dBmax

Slice Max Gain 17.34 dBi @ Elev Angle = 9.0 deg.
Beamwidth 10.1 deg.; -3dB @ 4.5, 14.6 deg.
Sidelobe Gain 3.36 dBi @ Elev Angle = 40.0 deg.
Front/Sidelobe 13.98 dB

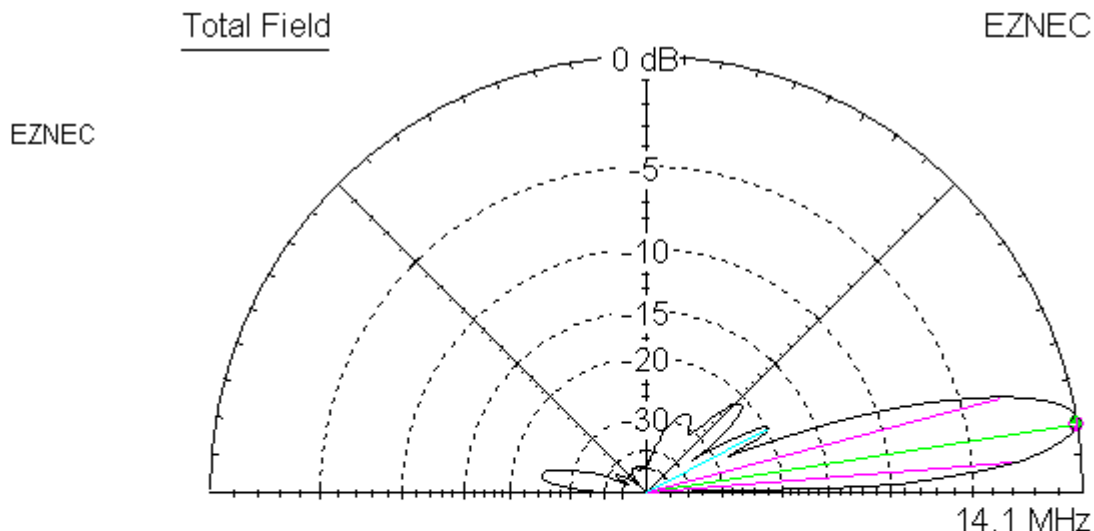
3.50dB stacking gain

Stacked 4 x 3-el yagi's

0.5, 1.0, 1.5 and 2.0 wavelength high, powers 1:2:2:1



Average ground
5mS, $\epsilon=13$



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 17.39 dBi

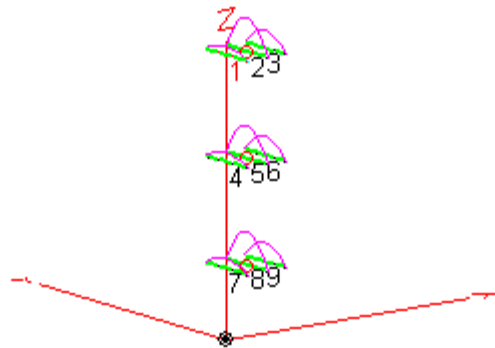
Cursor Elev 9.0 deg.
Gain 17.39 dBi
0.0 dBmax

Slice Max Gain 17.39 dBi @ Elev Angle = 9.0 deg.
Beamwidth 10.4 deg.; -3dB @ 4.6, 15.0 deg.
Sidelobe Gain -2.45 dBi @ Elev Angle = 28.0 deg.
Front/Sidelobe 19.83 dB

3.55dB stacking gain

Stacked 3 x 3-el yagi's

0.5, 1.25 and 2.0 wavelength high, powers 1:1:1

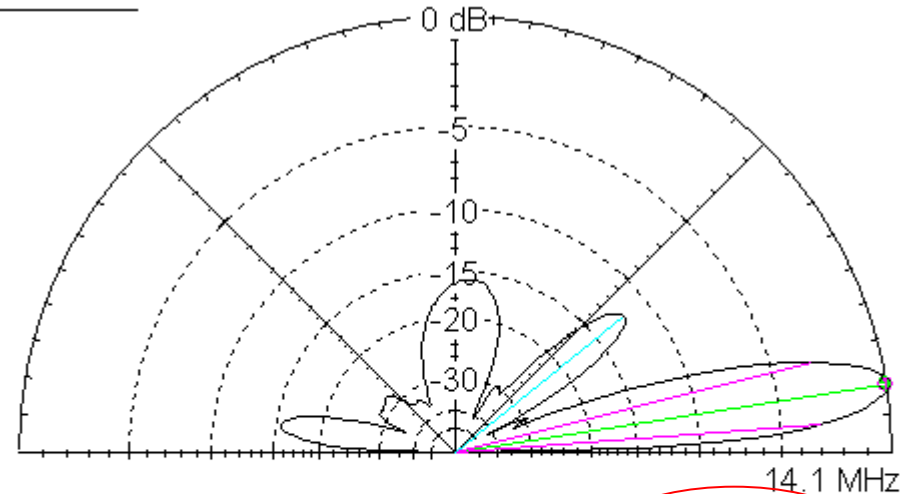


Average ground
5mS, $\epsilon=13$

Total Field

EZNEC

EZNEC

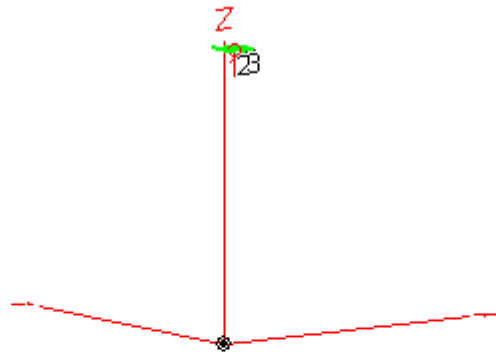


Elevation Plot	
Azimuth Angle	0.0 deg.
Outer Ring	16.79 dBi
Slice Max Gain	16.79 dBi @ Elev Angle = 9.0 deg.
Beamwidth	9.8 deg.; -3dB @ 4.4, 14.2 deg.
Sidelobe Gain	4.81 dBi @ Elev Angle = 39.0 deg.
Front/Sidelobe	11.98 dB

Cursor Elev	9.0 deg.
Gain	16.79 dBi
	0.0 dBmax

2.95dB stacking gain

3-el yagi's, up 84m up 4.0 wavelength

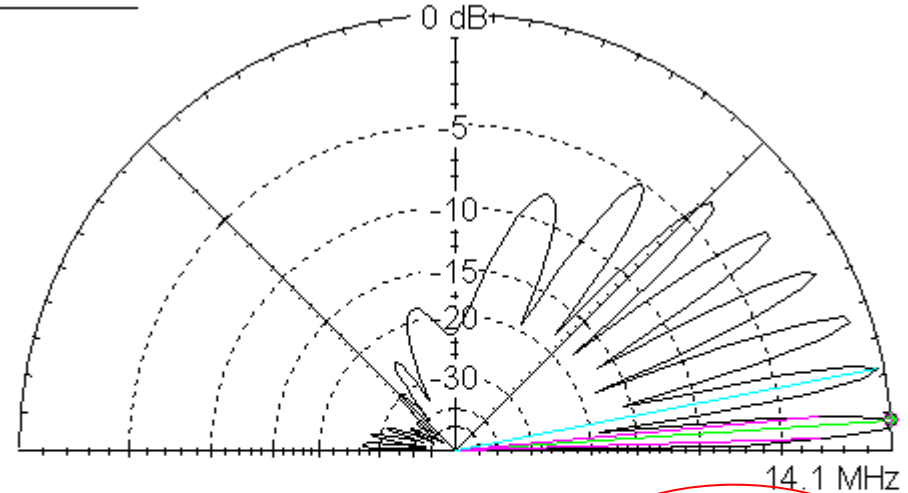


Average ground
5mS, C=13

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 13.88 dBi

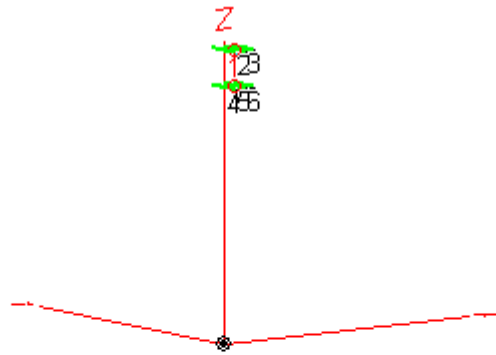
Cursor Elev 4.0 deg.
Gain 13.88 dBi
0.0 dBmax

Slice Max Gain 13.88 dBi @ Elev Angle = 4.0 deg.
Beamwidth 3.5 deg.; -3dB @ 1.8, 5.3 deg.
Sidelobe Gain 13.61 dBi @ Elev Angle = 11.0 deg.
Front/Sidelobe 0.27 dB

stacking gain reference

Stacked 2 x 3-el yagi's, highest up 84m

3.5 - 4.0 wavelength high in 0.5 wl steps, equal powers

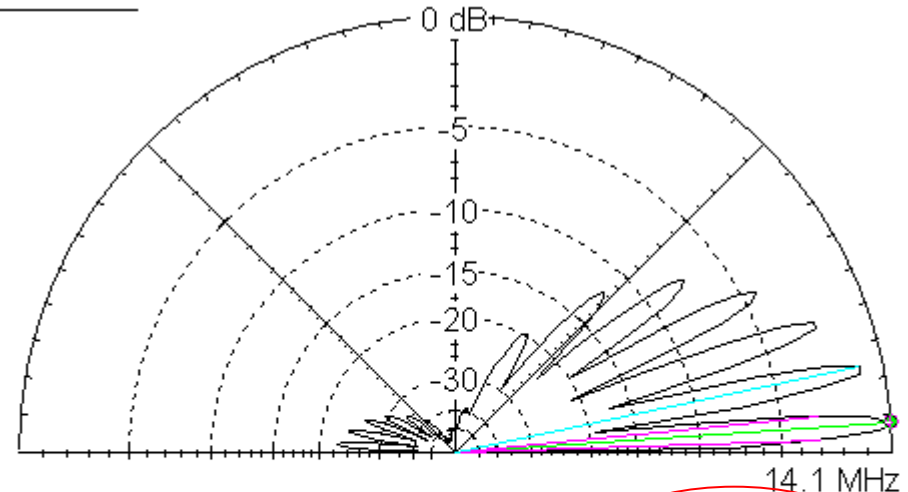


Average ground
5mS, $\epsilon=13$

Total Field

EZNEC

EZNEC



14.1 MHz

Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 16.57 dBi

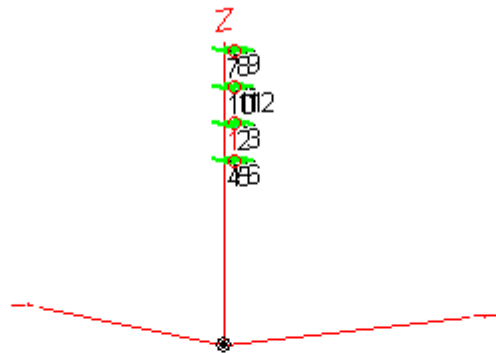
Cursor Elev 4.0 deg.
Gain 16.57 dBi
0.0 dBmax

Slice Max Gain 16.57 dBi @ Elev Angle = 4.0 deg.
Beamwidth 3.8 deg.; -3dB @ 1.9, 5.7 deg.
Sidelobe Gain 15.63 dBi @ Elev Angle = 12.0 deg.
Front/Sidelobe 0.94 dB

2.68dB stacking gain

Stacked 4 x 3-el yagi's, highest up 84m

2.5 - 4.0 wavelength high in 0.5 wl steps, equal powers

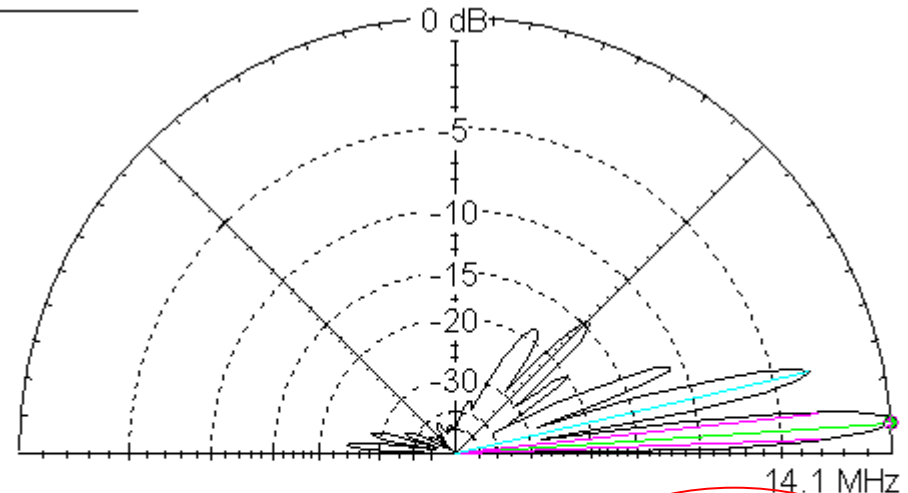


Average ground
5mS, $\epsilon=13$

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 19.11 dBi

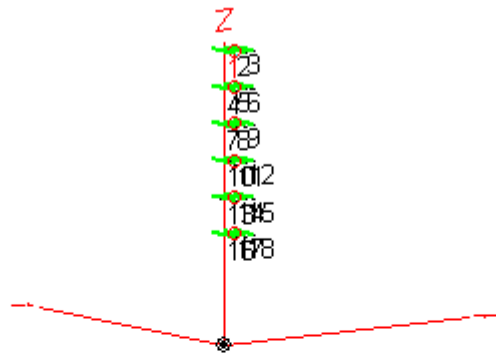
Slice Max Gain 19.11 dBi @ Elev Angle = 4.0 deg.
Beamwidth 4.3 deg.; -3dB @ 2.1, 6.4 deg.
Sidelobe Gain 15.96 dBi @ Elev Angle = 13.0 deg.
Front/Sidelobe 3.16 dB

Cursor Elev 4.0 deg.
Gain 19.11 dBi
0.0 dBmax

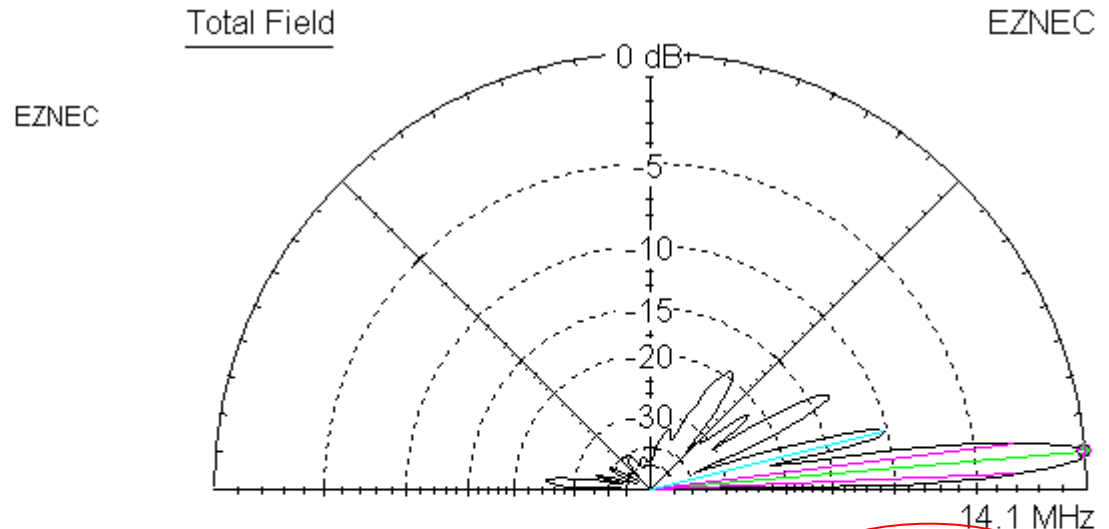
5.23dB stacking gain

Stacked 6 x 3-el yagi's, highest up 84m

1.5 - 4.0 wavelength high in 0.5 wl steps, equal powers



Average ground
5mS, $\epsilon=13$



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 20.16 dBi

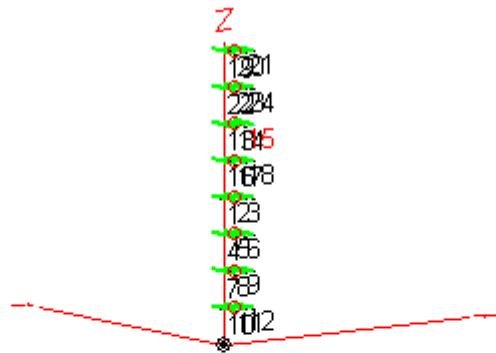
Cursor Elev 5.0 deg.
Gain 20.16 dBi
0.0 dBmax

Slice Max Gain 20.16 dBi @ Elev Angle = 5.0 deg.
Beamwidth 4.9 deg.; -3dB @ 2.4, 7.3 deg.
Sidelobe Gain 10.0 dBi @ Elev Angle = 14.0 deg.
Front/Sidelobe 10.17 dB

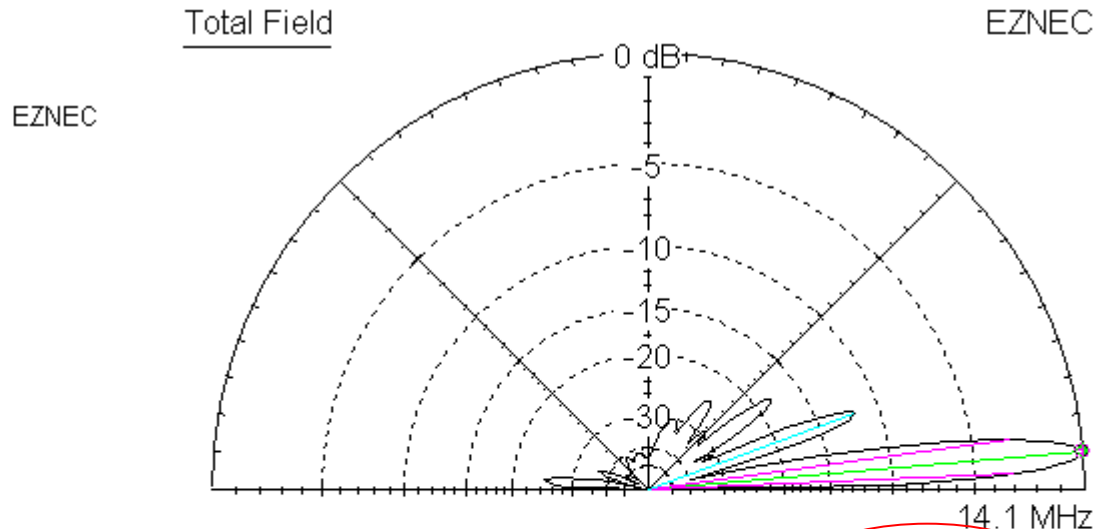
6.28dB stacking gain

Stacked 8 x 3-el yagi's, highest up 84m

0.5 - 4.0 wavelength high in 0.5 wl steps, equal powers



Average ground
5mS, $\epsilon=13$



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 20.08 dBi

Cursor Elev 5.0 deg.
Gain 20.08 dBi
0.0 dBmax

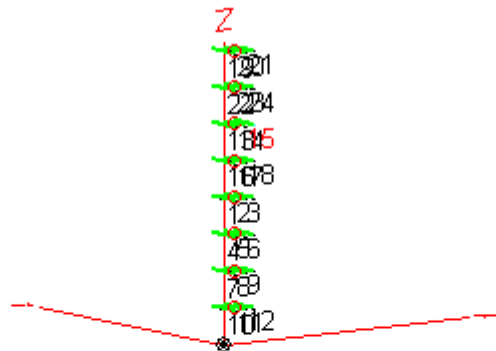
Slice Max Gain 20.08 dBi @ Elev Angle = 5.0 deg.
Beamwidth 5.3 deg.; -3dB @ 2.5, 7.8 deg.
Sidelobe Gain 8.27 dBi @ Elev Angle = 20.0 deg.
Front/Sidelobe 11.82 dB

6.20dB stacking gain

Stacked 8 x 3-el yagi's, highest up 84m

0.5 - 4.0 wavelength high in 0.5 wl steps

tapered currents: 1/1/1.2/1.41/1.41/1.2/1/0.5

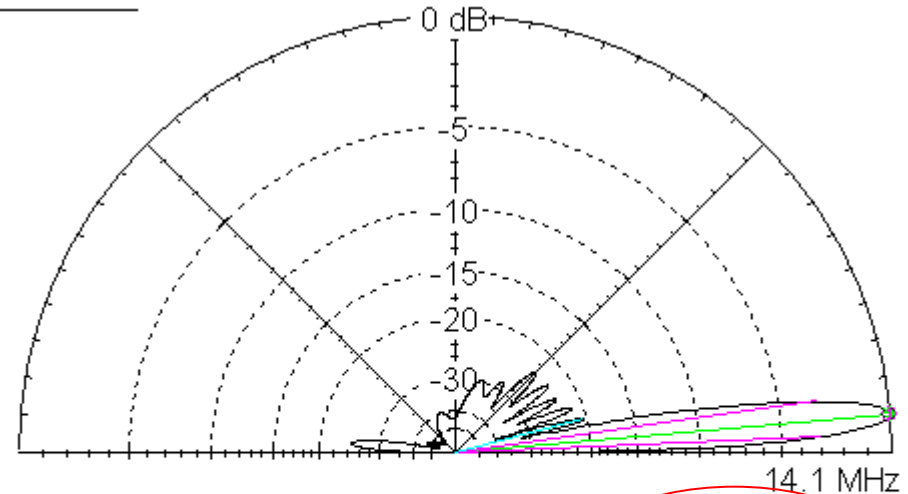


Average ground
5mS, C=13

Total Field

EZNEC

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 20.33 dBi

Cursor Elev 5.1 deg.
Gain 20.33 dBi
0.0 dBmax

Slice Max Gain 20.33 dBi @ Elev Angle = 5.1 deg.
Beamwidth 5.5 deg.; -3dB @ 2.5, 8.0 deg.
Sidelobe Gain -0.13 dBi @ Elev Angle = 14.5 deg.
Front/Sidelobe 20.46 dB

6.45dB stacking gain

5. Stacking horizontal antennas

Conclusions:

- Highest antenna dictates the take-off-angle TOA
- Ideal stacking distance is $\frac{1}{2}$ wavelengths
- For best sidelobe attenuation all heights $n \times 0.5 \times \text{wavelength}$, $n=1,2,..$ are needed
- Stacking gain is generated by the highest $\frac{3}{4}$ of antennas
 - The lowest $\frac{1}{4}$ of antennas contribute mainly to sidelobe attenuation
 - In very high stacks levels 0.5 and 1λ can be omitted
- Power tapering improves sidelobe attenuation with stacks of 3 and higher

6. Mutual coupling of different band antennas

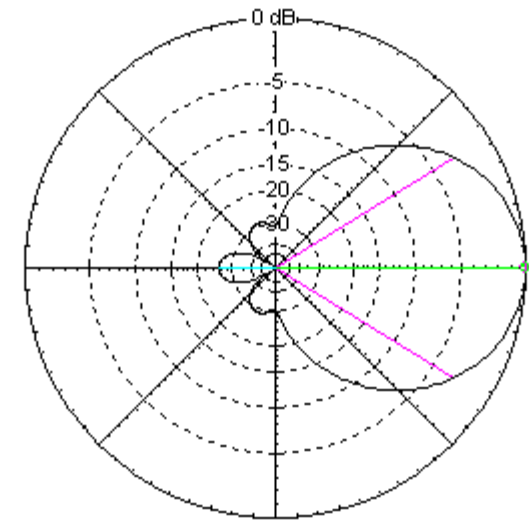
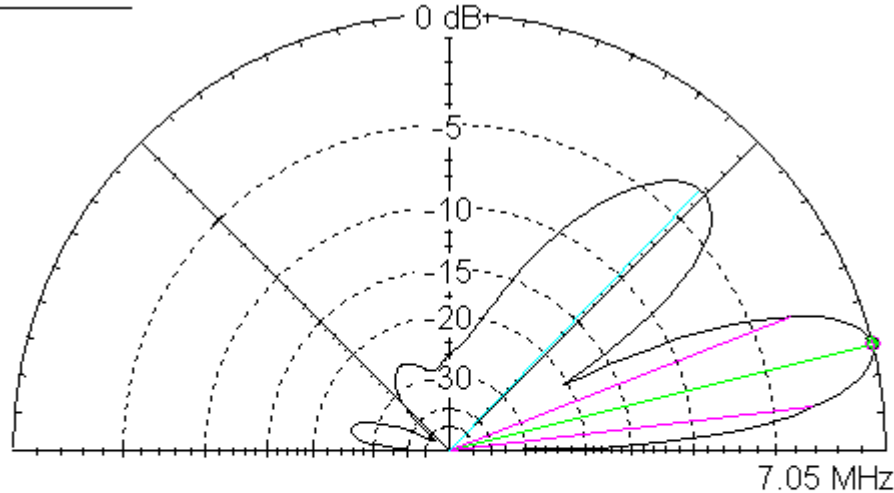
How close can other band antennas be installed?

Influence to higher band

3-el 40m yagi, 42m high no other antennas

Total Field

EZNEC Total Field



EZNEC

7.05 MHz

Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 13.5 dBi

Cursor Elev 14.0 deg.
Gain 13.5 dBi
0.0 dBmax

Azimuth Plot
Elevation Angle 14.0 deg.
Outer Ring 13.5 dBi

Cursor Az 0.0 deg.
Gain 13.5 dBi
0.0 dBmax

Slice Max Gain 13.5 dBi @ Elev Angle = 14.0 deg.
Beamwidth 14.6 deg.; -3dB @ 6.8, 21.4 deg.
Sidelobe Gain 10.25 dBi @ Elev Angle = 46.0 deg.
Front/Sidelobe 3.25 dB

Slice Max Gain 13.5 dBi @ Az Angle = 0.0 deg.
Front/Back 25.37 dB
Beamwidth 63.2 deg.; -3dB @ 328.4, 31.6 deg.
Sidelobe Gain -11.87 dBi @ Az Angle = 180.0 deg.
Front/Sidelobe 25.37 dB

reference

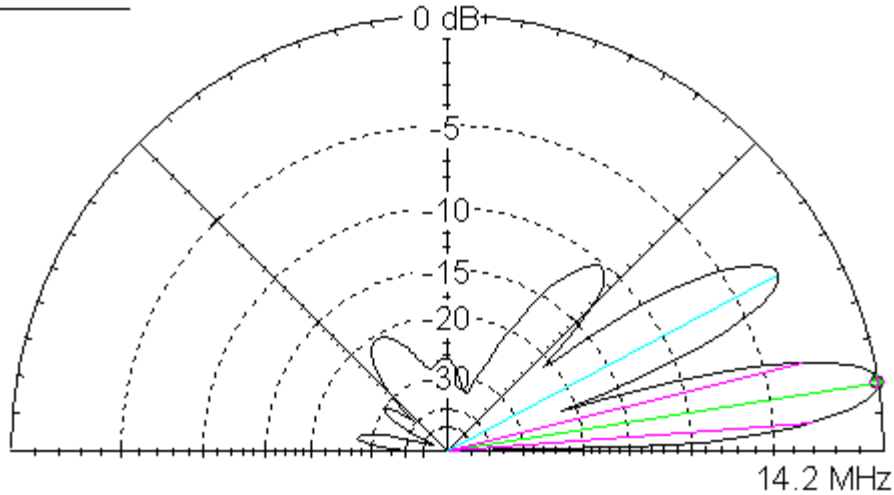
reference

Influence to higher band

4-el 20m yagi, 32m high, no other antennas

Total Field

EZNEC Total Field



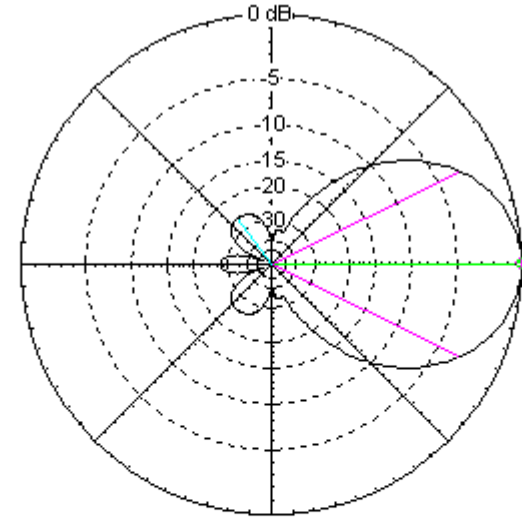
Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 16.1 dBi

Cursor Elev 9.0 deg.
Gain 16.1 dBi
0.0 dBmax

Slice Max Gain 16.1 dBi @ Elev Angle = 9.0 deg.
Beamwidth 9.4 deg.; -3dB @ 4.5, 13.9 deg.
Sidelobe Gain 13.47 dBi @ Elev Angle = 28.0 deg.
Front/Sidelobe 2.63 dB

reference

EZNEC



14.2 MHz

Azimuth Plot
Elevation Angle 9.0 deg.
Outer Ring 16.1 dBi

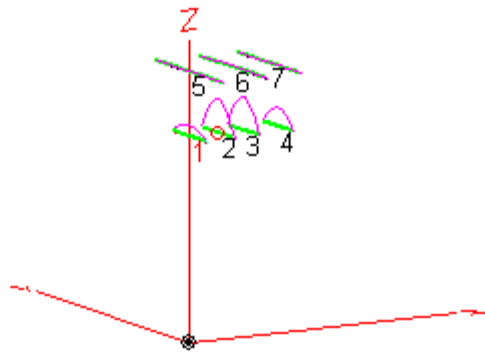
Cursor Az 0.0 deg.
Gain 16.1 dBi
0.0 dBmax

Slice Max Gain 16.1 dBi @ Az Angle = 0.0 deg.
Front/Back 27.28 dB
Beamwidth 52.2 deg.; -3dB @ 333.9, 26.1 deg.
Sidelobe Gain -9.27 dBi @ Az Angle = 127.0 deg.
Front/Sidelobe 25.38 dB

reference

Influence to higher band

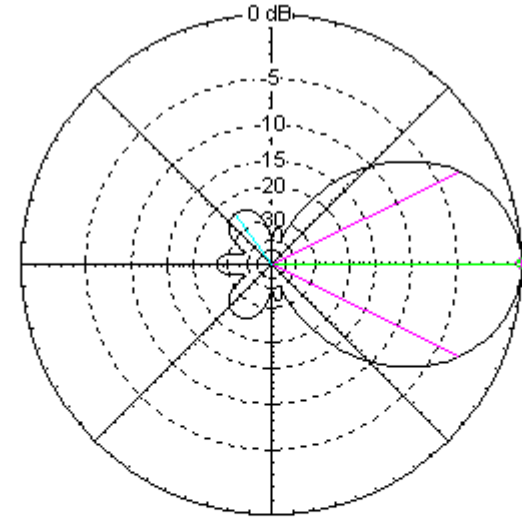
7050kHz@42m / 14200kHz@32m **10m dist**



EZNEC

Total Field

EZNEC



14.2 MHz

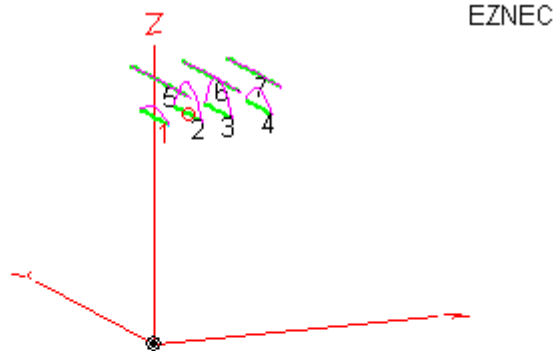
Azimuth Plot
Elevation Angle 9.0 deg.
Outer Ring 16.07 dBi

Cursor Az 0.0 deg.
Gain 16.07 dBi
0.0 dBmax

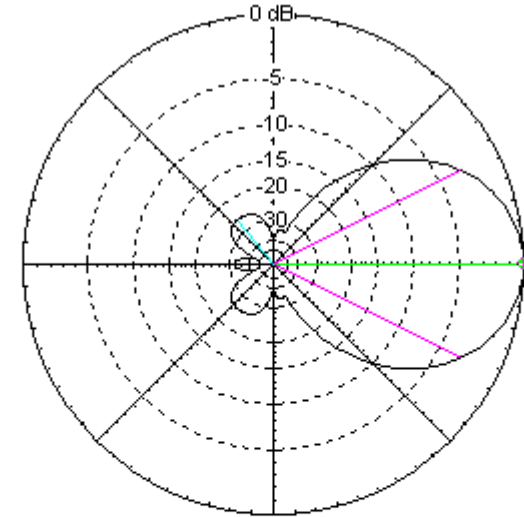
Slice Max Gain 16.07 dBi @ Az Angle = 0.0 deg.
Front/Back 25.97 dB
Beamwidth 51.8 deg.; -3dB @ 334.1, 25.9 deg.
Sidelobe Gain -7.88 dBi @ Az Angle = 125.0 deg.
Front/Sidelobe 23.95 dB

Influence to higher band

7050kHz@37m / 14200kHz@32m **5m dist**



Total Field



EZNEC

14.2 MHz

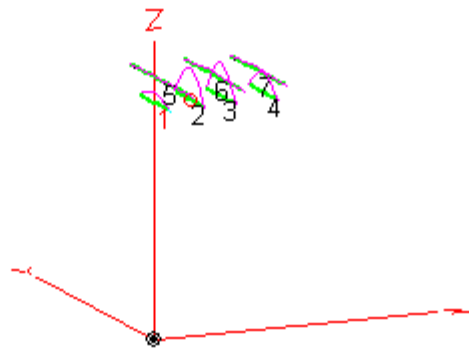
Azimuth Plot
 Elevation Angle 9.0 deg.
 Outer Ring 15.85 dBi

Cursor Az 0.0 deg.
 Gain 15.85 dBi
 0.0 dBmax

Slice Max Gain 15.85 dBi @ Az Angle = 0.0 deg.
 Front/Back 31.85 dB
 Beamwidth 52.6 deg.; -3dB @ 333.7, 26.3 deg.
 Sidelobe Gain -9.49 dBi @ Az Angle = 129.0 deg.
 Front/Sidelobe 25.34 dB

Influence to higher band

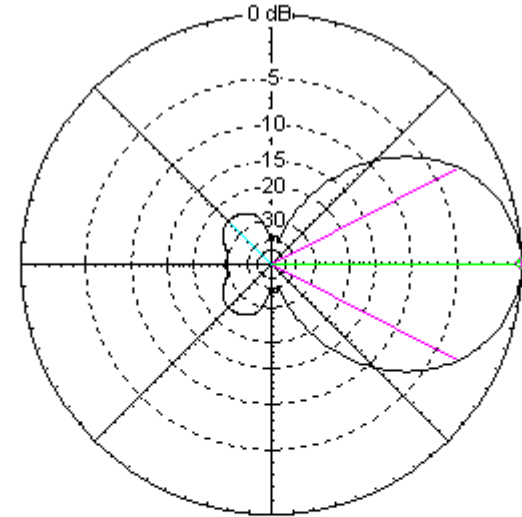
7050kHz@35m / 14200kHz@32m **3m dist**



EZNEC

Total Field

EZNEC



14.2 MHz

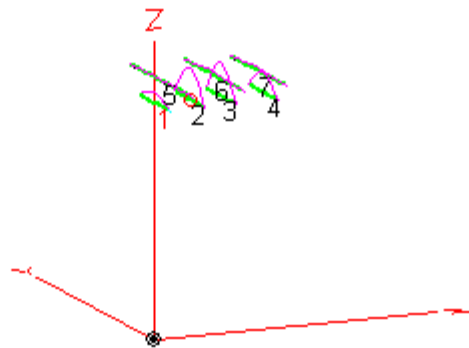
Azimuth Plot
Elevation Angle 9.0 deg.
Outer Ring 15.64 dBi

Cursor Az 0.0 deg.
Gain 15.64 dBi
0.0 dBmax

Slice Max Gain 15.64 dBi @ Az Angle = 0.0 deg.
Front/Back 29.27 dB
Beamwidth 54.4 deg.; -3dB @ 332.8, 27.2 deg.
Sidelobe Gain -8.63 dBi @ Az Angle = 135.0 deg.
Front/Sidelobe 24.27 dB

Influence to higher band

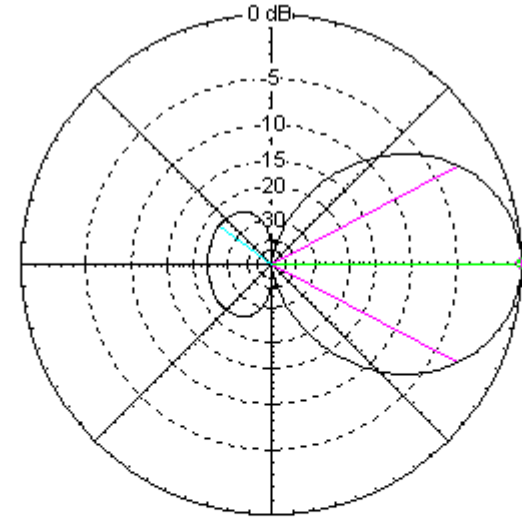
7050kHz@34m / 14200kHz@32m **2m dist**



EZNEC

Total Field

EZNEC



14.2 MHz

Azimuth Plot
Elevation Angle 9.0 deg.
Outer Ring 15.4 dBi

Cursor Az 0.0 deg.
Gain 15.4 dBi
0.0 dBmax

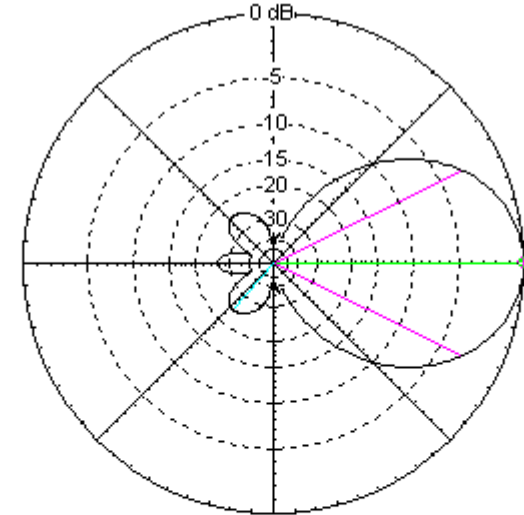
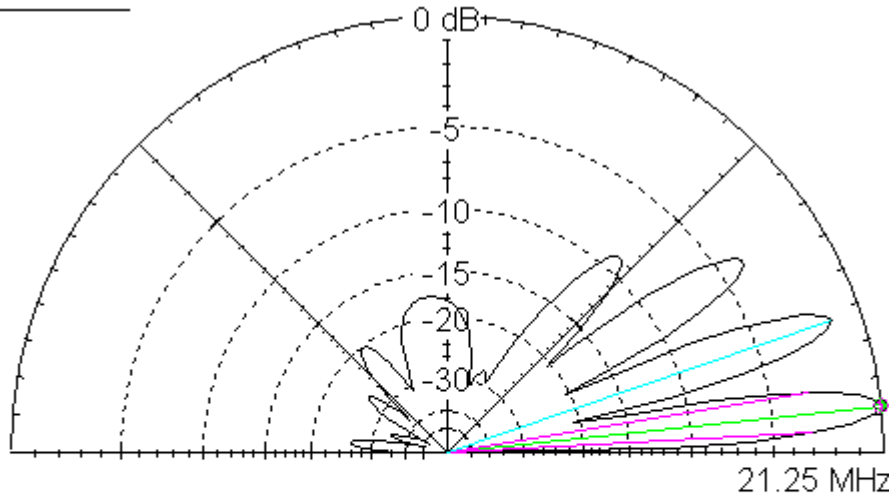
Slice Max Gain 15.4 dBi @ Az Angle = 0.0 deg.
Front/Back 23.29 dB
Beamwidth 56.2 deg.; -3dB @ 331.9, 28.1 deg.
Sidelobe Gain -7.69 dBi @ Az Angle = 144.0 deg.
Front/Sidelobe 23.09 dB

4-el 21250kHz@32m, no other antennas

Total Field

EZNEC Total Field

EZNEC



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 16.24 dBi

Cursor Elev 6.0 deg.
Gain 16.24 dBi
0.0 dBmax

Azimuth Plot
Elevation Angle 6.0 deg.
Outer Ring 16.24 dBi

Cursor Az 0.0 deg.
Gain 16.24 dBi
0.0 dBmax

Slice Max Gain 16.24 dBi @ Elev Angle = 6.0 deg.
Beamwidth 6.2 deg.; -3dB @ 3.1, 9.3 deg.
Sidelobe Gain 14.97 dBi @ Elev Angle = 19.0 deg.
Front/Sidelobe 1.26 dB

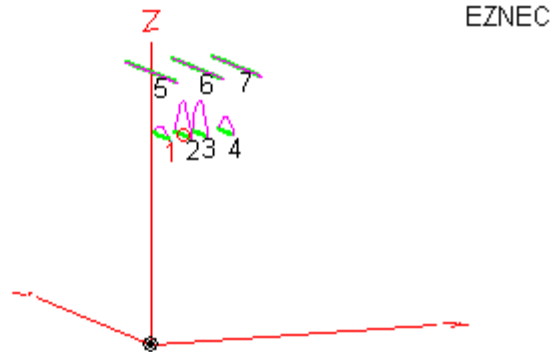
Slice Max Gain 16.24 dBi @ Az Angle = 0.0 deg.
Front/Back 25.73 dB
Beamwidth 52.2 deg.; -3dB @ 333.9, 26.1 deg.
Sidelobe Gain -7.71 dBi @ Az Angle = 229.0 deg.
Front/Sidelobe 23.95 dB

reference

reference

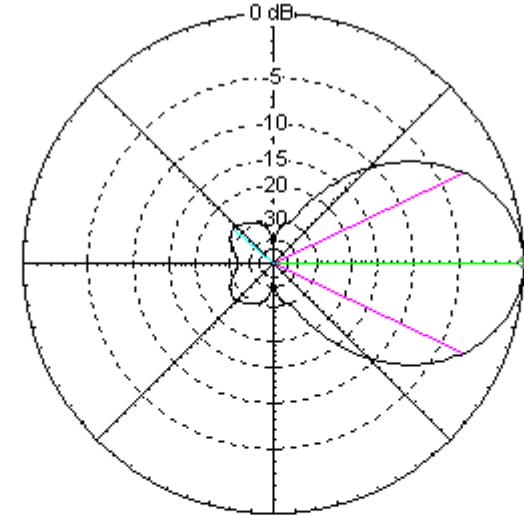
Influence to higher band

7050kHz @42m / 21250kHz@32m **10m dist**



Total Field

EZNEC



21.25 MHz

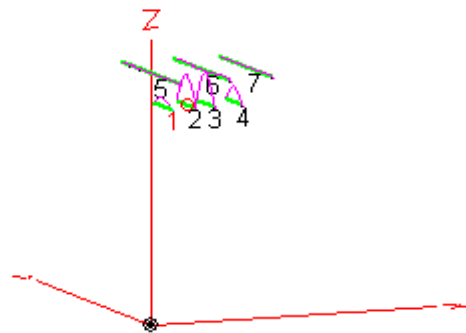
Azimuth Plot
Elevation Angle 6.0 deg.
Outer Ring 16.57 dBi

Cursor Az 0.0 deg.
Gain 16.57 dBi
0.0 dBmax

Slice Max Gain 16.57 dBi @ Az Angle = 0.0 deg.
Front/Back 33.44 dB
Beamwidth 50.8 deg.; -3dB @ 334.6, 25.4 deg.
Sidelobe Gain -10.2 dBi @ Az Angle = 139.0 deg.
Front/Sidelobe 26.77 dB

Influence to higher band

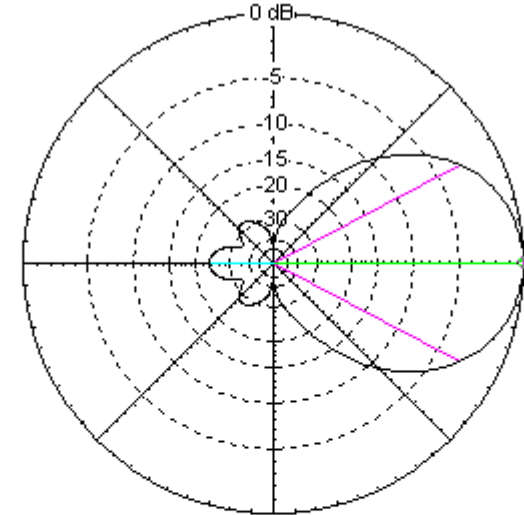
7050kHz @37m / 21250kHz@32m **5m dist**



EZNEC

Total Field

EZNEC



21.25 MHz

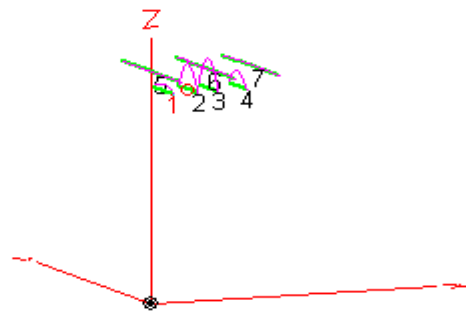
Azimuth Plot
Elevation Angle 6.0 deg.
Outer Ring 15.8 dBi

Cursor Az 0.0 deg.
Gain 15.8 dBi
0.0 dBmax

Slice Max Gain 15.8 dBi @ Az Angle = 0.0 deg.
Front/Back 23.42 dB
Beamwidth 56.0 deg.; -3dB @ 332.0, 28.0 deg.
Sidelobe Gain -7.62 dBi @ Az Angle = 180.0 deg.
Front/Sidelobe 23.42 dB

Influence to higher band

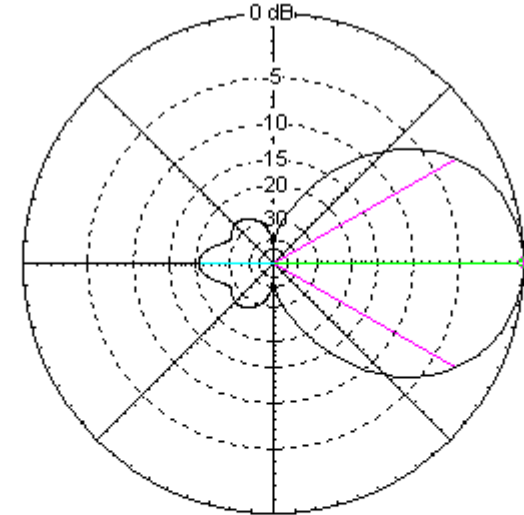
7050kHz @35m / 21250kHz@32m **3m dist**



EZNEC

Total Field

EZNEC



21.25 MHz

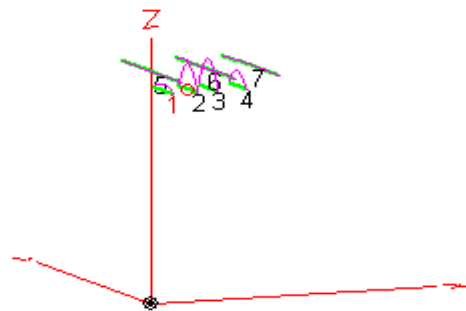
Azimuth Plot
Elevation Angle 6.0 deg.
Outer Ring 15.25 dBi

Cursor Az 0.0 deg.
Gain 15.25 dBi
0.0 dBmax

Slice Max Gain 15.25 dBi @ Az Angle = 0.0 deg.
Front/Back 20.79 dB
Beamwidth 59.6 deg.; -3dB @ 330.2, 29.8 deg.
Sidelobe Gain -5.54 dBi @ Az Angle = 180.0 deg.
Front/Sidelobe 20.79 dB

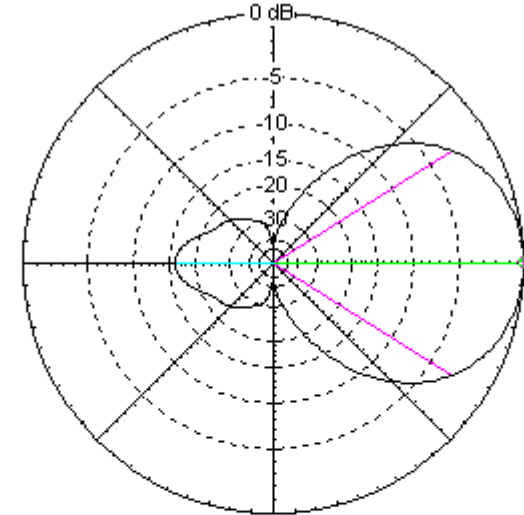
Influence to higher band

7050kHz @34m / 21250kHz@32m 2m dist



EZNEC

Total Field



EZNEC

21.25 MHz

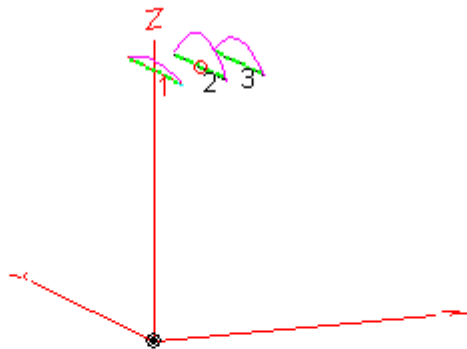
Azimuth Plot
Elevation Angle 6.0 deg.
Outer Ring 14.69 dBi

Cursor Az 0.0 deg.
Gain 14.69 dBi
0.0 dBmax

Slice Max Gain 14.69 dBi @ Az Angle = 0.0 deg.
Front/Back 16.0 dB
Beamwidth 64.8 deg.; -3dB @ 327.6, 32.4 deg.
Sidelobe Gain -1.31 dBi @ Az Angle = 180.0 deg.
Front/Sidelobe 16.0 dB

Influence to lower band

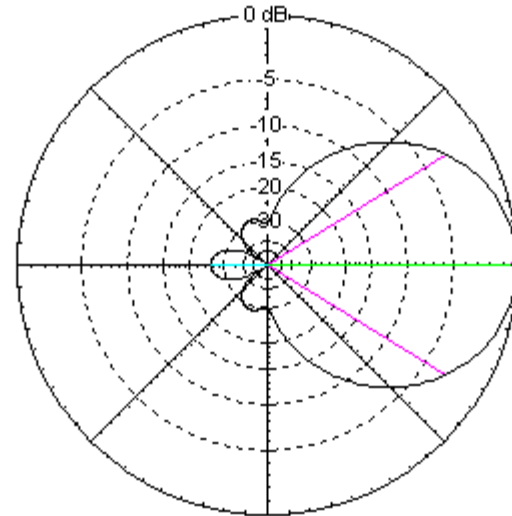
3-el yagi 7050kHz@42m, no other antennas



EZNEC

Total Field

EZNEC



7.05 MHz

Azimuth Plot

Cursor Az

Elevation Angle 14.0 deg.

0.0 deg.

Outer Ring 13.5 dBi

Gain

13.5 dBi

0.0 dBmax

Slice Max Gain 13.5 dBi @ Az Angle = 0.0 deg.

Front/Back 25.37 dB

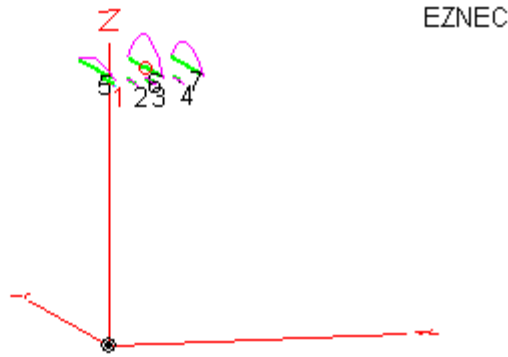
Beamwidth 63.2 deg.; -3dB @ 328.4, 31.6 deg.

Sidelobe Gain -11.87 dBi @ Az Angle = 180.0 deg.

Front/Sidelobe 25.37 dB

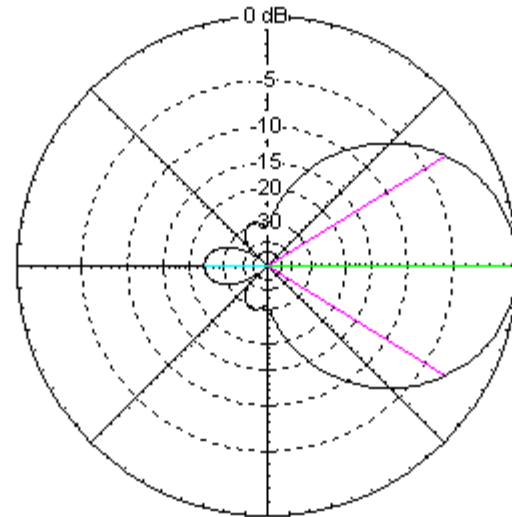
Influence to lower band

7050kHz @42m / 21250kHz@40m **2m dist**



Total Field

EZNEC



7.05 MHz

Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	14.0 deg.	Gain	13.49 dBi
Outer Ring	13.49 dBi		0.0 dBmax
Slice Max Gain	13.49 dBi @ Az Angle = 0.0 deg.		
Front/Back	23.56 dB		
Beamwidth	63.0 deg.; -3dB @ 328.5, 31.5 deg.		
Sidelobe Gain	-10.07 dBi @ Az Angle = 180.0 deg.		
Front/Sidelobe	23.56 dB		

6. Mutual coupling of different bands

Conclusions:

- Lower band suffers very little, even when spacing is 0.05λ
- Higher band lose gain and F/B when lower band antenna is too close
 - With distances less than 0.5λ there is a risk for losing performance
 - In the example of 20/40m 0.15λ was about the limit
 - In the example of 15/40m 0.3λ was about the limit
- Every case should be studied separately, it is impossible to give accurate guidance