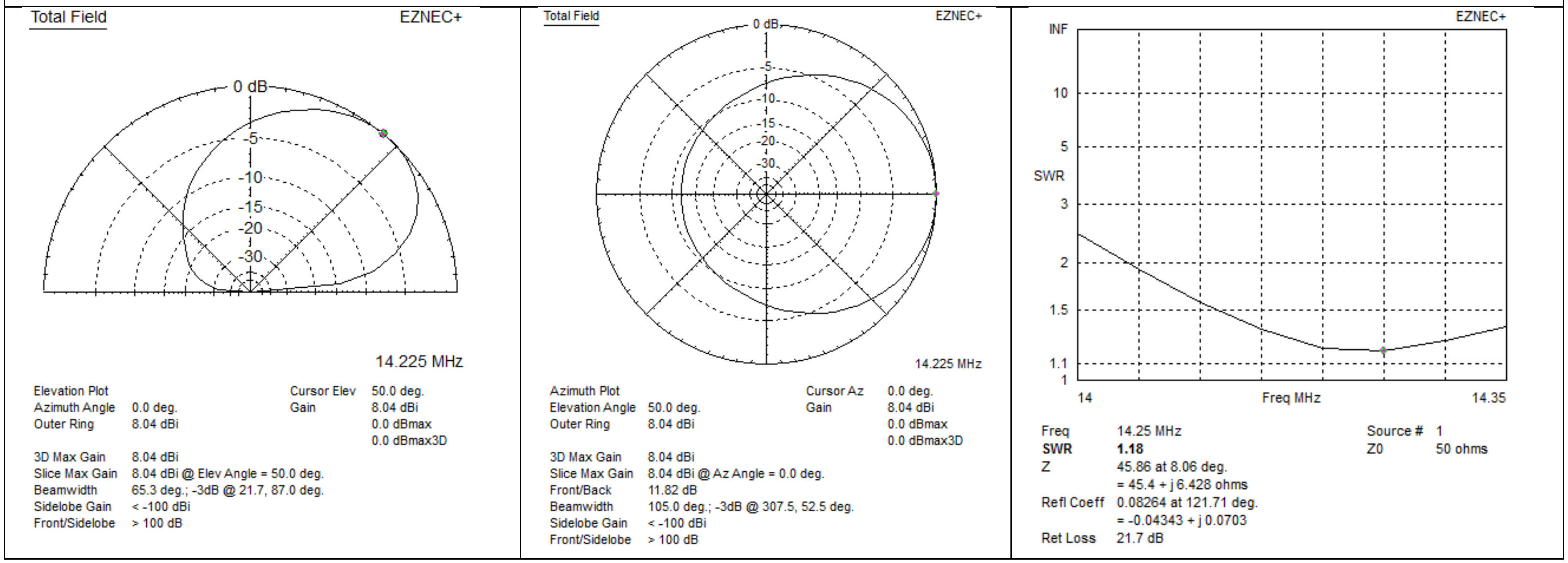
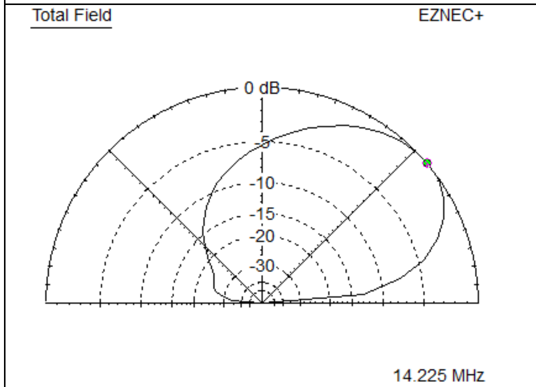
Moxon Antenna Modeling Part II

Since the attempt to model a TriBand version of this antenna was a bust, I thought I would take a look at the effect of height above ground on the antenna. Since this will primarily be a Field Day antenna, I am just looking for a reasonable low angle of radiation. This is because my primary interest would be domestic contacts. So here go. I will start with the 20m version of the antenna at 15 feet above a nominal ground and raise the antenna in 5 ft increments and see how the performance changes.

20m Moxon 15 ft above Ground

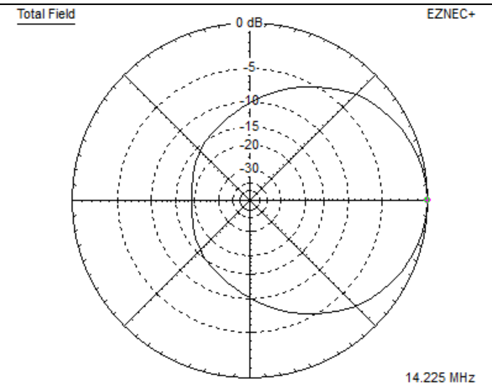


20m Moxon 20 ft above Ground



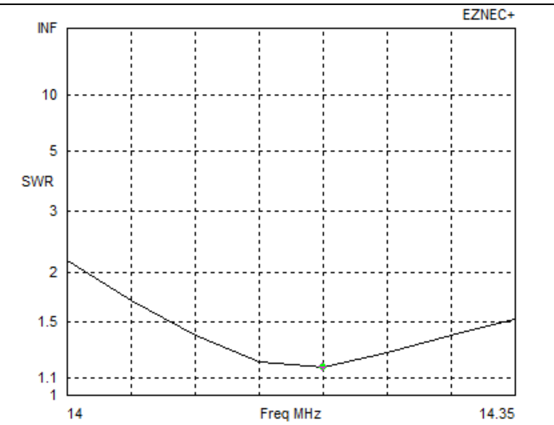
Elevation Plot		Cursor Elev	40.0 deg.
Azimuth Angle	0.0 deg.	Gain	8.85 dBi
Outer Ring	8.85 dBi		0.0 dBmax
			0.0 dBmax3D

3D Max Gain 8.85 dBi
Slice Max Gain 8.85 dBi @ Elev Angle = 40.0 deg.
Beamwidth 55.9 deg.; -3dB @ 18.7, 74.6 deg.
Sidelobe Gain < -100 dBi
Front/Sidelobe > 100 dB



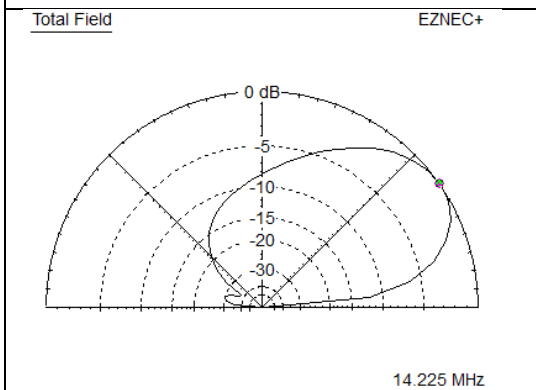
Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	40.0 deg.	Gain	8.85 dBi
Outer Ring	8.85 dBi		0.0 dBmax
			0.0 dBmax3D

3D Max Gain 8.85 dBi
Slice Max Gain 8.85 dBi @ Az Angle = 0.0 deg.
Front/Back 19.19 dB
Beamwidth 91.0 deg.; -3dB @ 314.5, 45.5 deg.
Sidelobe Gain < -100 dBi
Front/Sidelobe > 100 dB



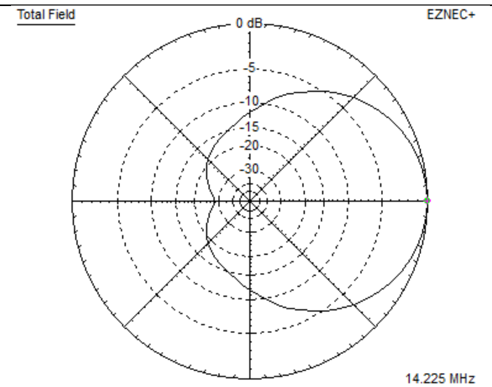
Freq	14.2 MHz	Source #	1
SWR	**1.17**	Z0	50 ohms
Z	46.53 at 7.72 deg.		
	= 46.11 + j 6.25 ohms		
Refl Coeff	0.07641 at 118.16 deg.		
	= -0.03606 + j 0.06737		
Ret Loss	22.3 dB		

20m Moxon 25 ft above Ground



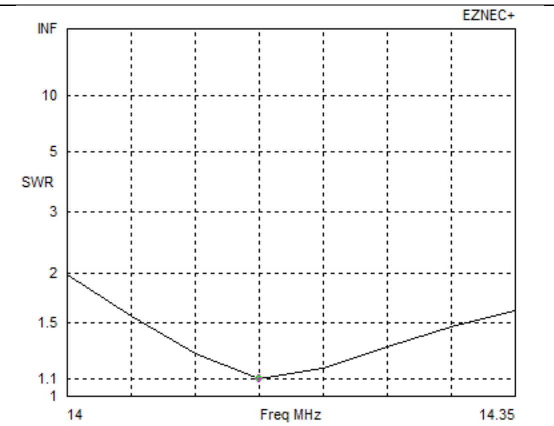
Elevation Plot		Cursor Elev	35.0 deg.
Azimuth Angle	0.0 deg.	Gain	9.47 dBi
Outer Ring	9.47 dBi		0.0 dBmax
			0.0 dBmax3D

3D Max Gain 9.47 dBi
Slice Max Gain 9.47 dBi @ Elev Angle = 35.0 deg.
Beamwidth 45.3 deg.; -3dB @ 16.2, 61.5 deg.
Sidelobe Gain -20.15 dBi @ Elev Angle = 165.0 deg.
Front/Sidelobe 29.62 dB



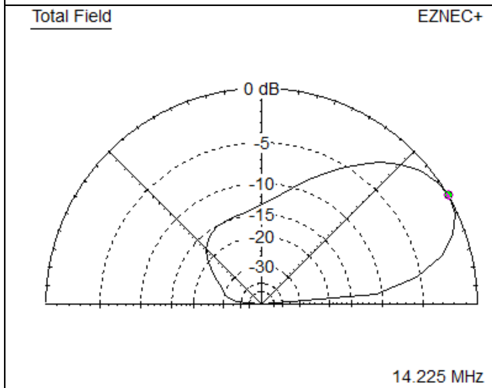
Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	35.0 deg.	Gain	9.47 dBi
Outer Ring	9.47 dBi		0.0 dBmax
			0.0 dBmax3D

3D Max Gain 9.47 dBi
Slice Max Gain 9.47 dBi @ Az Angle = 0.0 deg.
Front/Back 27.4 dB
Beamwidth 86.4 deg.; -3dB @ 316.8, 43.2 deg.
Sidelobe Gain < -100 dBi
Front/Sidelobe > 100 dB

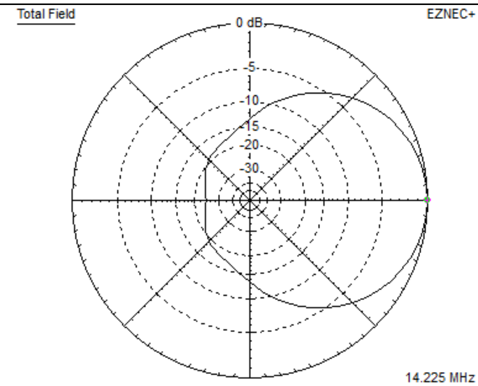


Freq	14.15 MHz	Source #	1
SWR	**1.1**	Z0	50 ohms
Z	45.7 at 2.19 deg.		
	= 45.66 + j 1.746 ohms		
Refl Coeff	0.04887 at 157.03 deg.		
	= -0.045 + j 0.01907		
Ret Loss	26.2 dB		

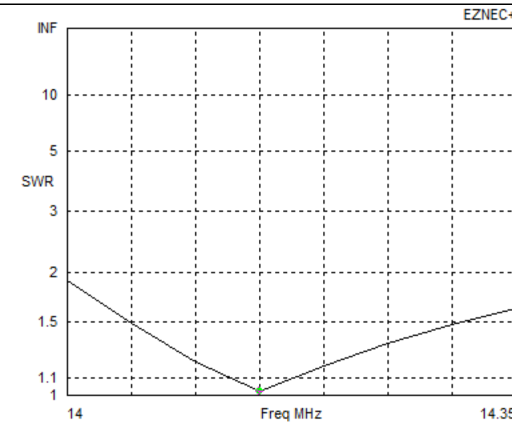
20m Moxon 30 ft above Ground



Elevation Plot		Cursor Elev	30.0 deg.
Azimuth Angle	0.0 deg.	Gain	10.06 dBi
Outer Ring	10.06 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	10.06 dBi		
Slice Max Gain	10.06 dBi @ Elev Angle = 30.0 deg.		
Beamwidth	36.8 deg.; -3dB @ 14.2, 51.0 deg.		
Sidelobe Gain	< -100 dBi		
Front/Sidelobe	> 100 dB		

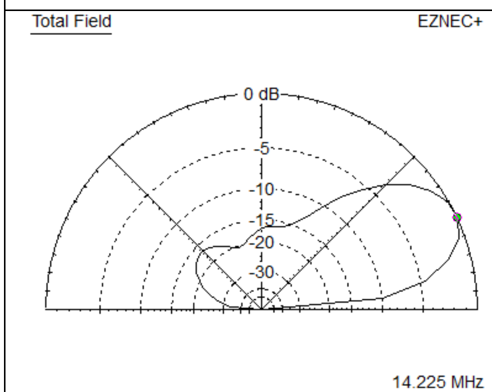


Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	30.0 deg.	Gain	10.06 dBi
Outer Ring	10.06 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	10.06 dBi		
Slice Max Gain	10.06 dBi @ Az Angle = 0.0 deg.		
Front/Back	24.0 dB		
Beamwidth	83.4 deg.; -3dB @ 318.3, 41.7 deg.		
Sidelobe Gain	< -100 dBi		
Front/Sidelobe	> 100 dB		

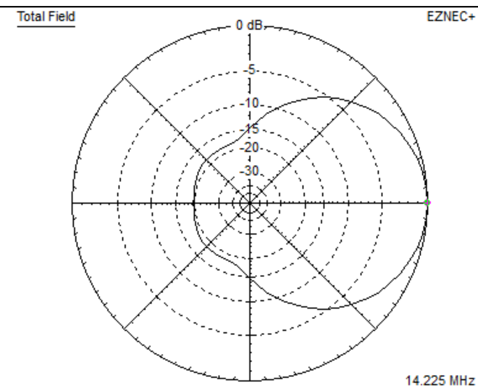


Freq	14.15 MHz	Source #	1
SWR	**1.024**	Z0	50 ohms
Z	49.34 at 1.14 deg.		
	= 49.33 + j 0.9788 ohms		
Refl Coeff	0.01194 at 123.81 deg.		
	= -0.006642 + j 0.009919		
Ret Loss	38.5 dB		

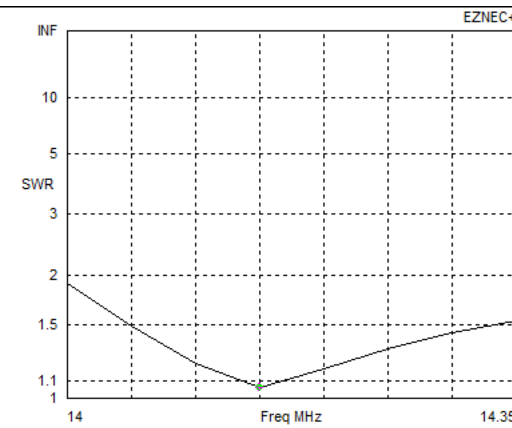
20m Moxon 35 ft above Ground



Elevation Plot		Cursor Elev	25.0 deg.
Azimuth Angle	0.0 deg.	Gain	10.61 dBi
Outer Ring	10.61 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	10.61 dBi		
Slice Max Gain	10.61 dBi @ Elev Angle = 25.0 deg.		
Beamwidth	30.6 deg.; -3dB @ 12.8, 43.4 deg.		
Sidelobe Gain	-5.86 dBi @ Elev Angle = 135.0 deg.		
Front/Sidelobe	16.47 dB		

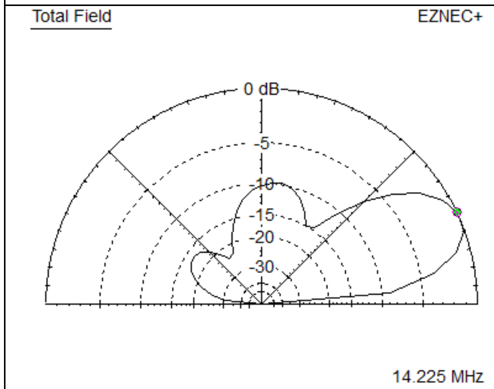


Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	25.0 deg.	Gain	10.61 dBi
Outer Ring	10.61 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	10.61 dBi		
Slice Max Gain	10.61 dBi @ Az Angle = 0.0 deg.		
Front/Back	19.72 dB		
Beamwidth	81.6 deg.; -3dB @ 319.2, 40.8 deg.		
Sidelobe Gain	-7.58 dBi @ Az Angle = 130.0 deg.		
Front/Sidelobe	18.19 dB		



Freq	14.15 MHz	Source #	1
SWR	**1.062**	Z0	50 ohms
Z	52.12 at -2.48 deg.		
	= 52.07 - j 2.251 ohms		
Refl Coeff	0.02997 at -46.11 deg.		
	= 0.02078 - j 0.0216		
Ret Loss	30.5 dB		

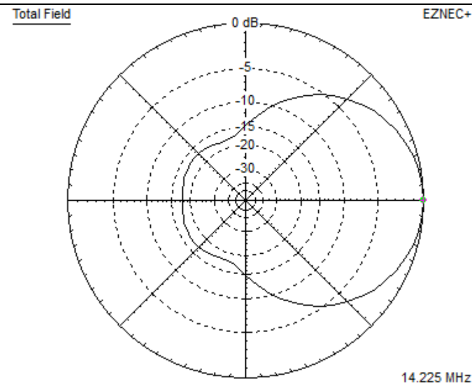
20m Moxon 40 ft above Ground



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 10.93 dBi

Cursor Elev 25.0 deg.
Gain 10.93 dBi
0.0 dBmax
0.0 dBmax3D

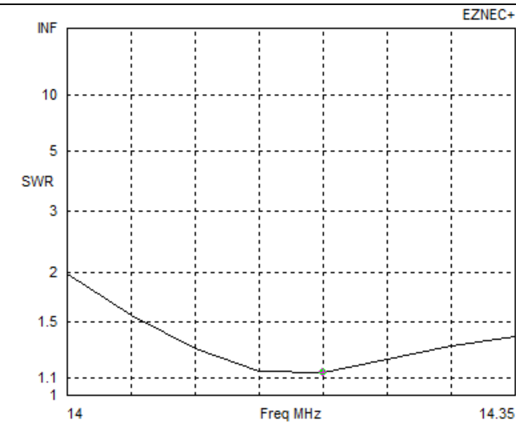
3D Max Gain 10.93 dBi
Slice Max Gain 10.93 dBi @ Elev Angle = 25.0 deg.
Beamwidth 26.2 deg.; -3dB @ 11.4, 37.6 deg.
Sidelobe Gain 1.14 dBi @ Elev Angle = 80.0 deg.
Front/Sidelobe 9.79 dB



Azimuth Plot
Elevation Angle 25.0 deg.
Outer Ring 10.93 dBi

Cursor Az 0.0 deg.
Gain 10.93 dBi
0.0 dBmax
0.0 dBmax3D

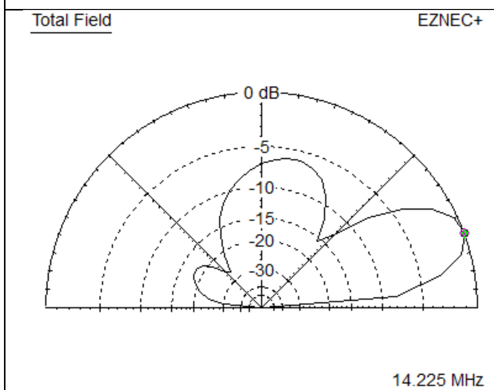
3D Max Gain 10.93 dBi
Slice Max Gain 10.93 dBi @ Az Angle = 0.0 deg.
Front/Back 17.62 dB
Beamwidth 81.8 deg.; -3dB @ 319.1, 40.9 deg.
Sidelobe Gain -5.88 dBi @ Az Angle = 140.0 deg.
Front/Sidelobe 16.81 dB



Freq 14.2 MHz
SWR **1.13**
Z 56.22 at -2.6 deg.
= 56.16 - j 2.55 ohms
Refl Coeff 0.06281 at -21.1 deg.
= 0.0586 - j 0.02261
Ret Loss 24.0 dB

Source # 1
Z0 50 ohms

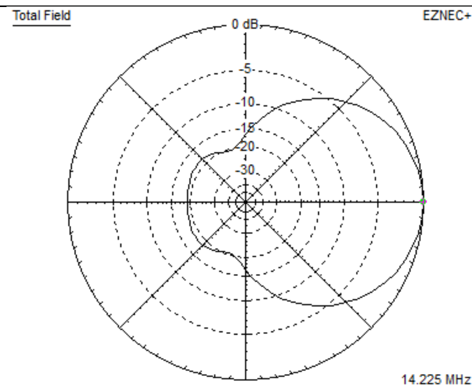
20m Moxon 45 ft above Ground



Elevation Plot
Azimuth Angle 0.0 deg.
Outer Ring 11.01 dBi

Cursor Elev 20.0 deg.
Gain 11.01 dBi
0.0 dBmax
0.0 dBmax3D

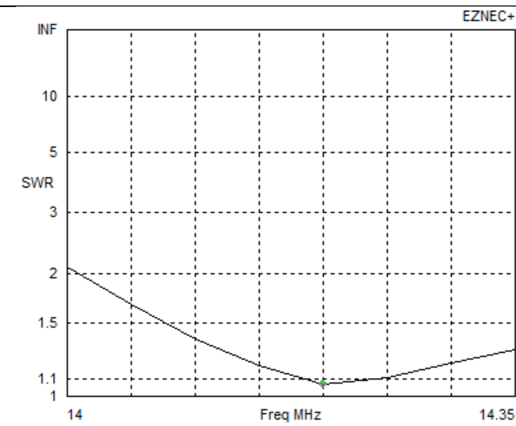
3D Max Gain 11.01 dBi
Slice Max Gain 11.01 dBi @ Elev Angle = 20.0 deg.
Beamwidth 23.0 deg.; -3dB @ 10.0, 33.0 deg.
Sidelobe Gain 4.91 dBi @ Elev Angle = 75.0 deg.
Front/Sidelobe 6.1 dB



Azimuth Plot
Elevation Angle 20.0 deg.
Outer Ring 11.01 dBi

Cursor Az 0.0 deg.
Gain 11.01 dBi
0.0 dBmax
0.0 dBmax3D

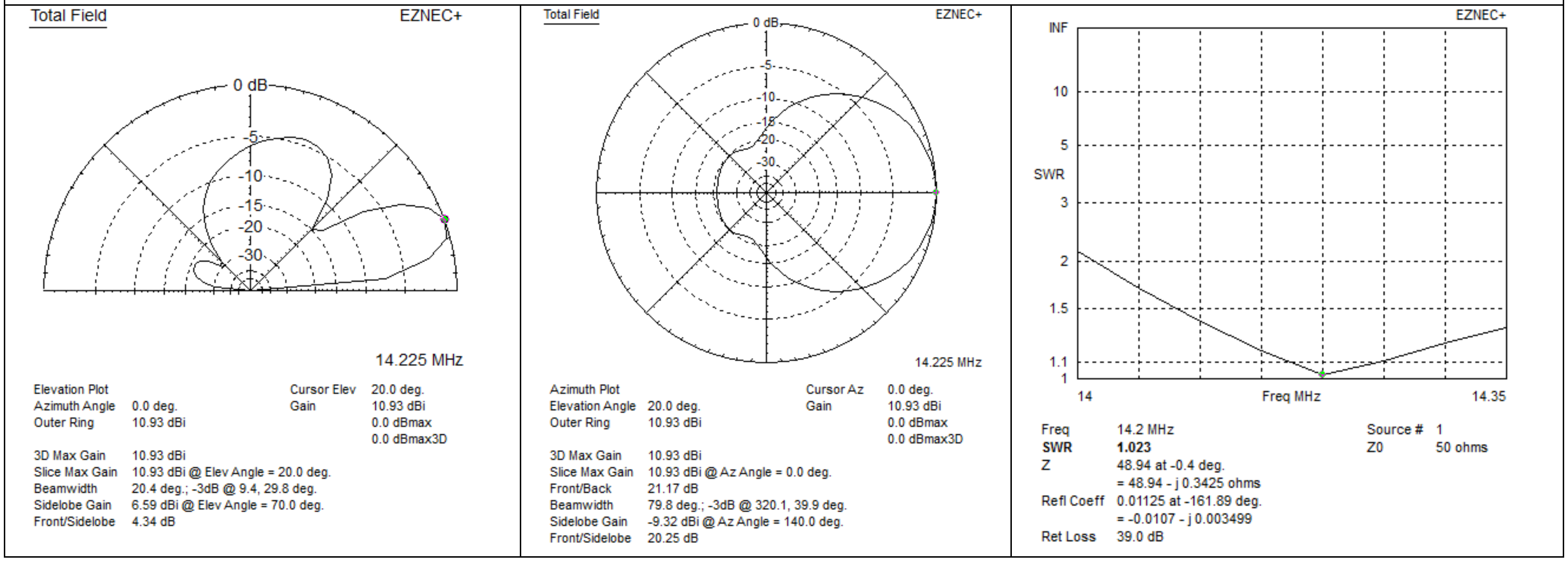
3D Max Gain 11.01 dBi
Slice Max Gain 11.01 dBi @ Az Angle = 0.0 deg.
Front/Back 19.1 dB
Beamwidth 80.2 deg.; -3dB @ 319.9, 40.1 deg.
Sidelobe Gain -7.31 dBi @ Az Angle = 145.0 deg.
Front/Sidelobe 18.32 dB



Freq 14.2 MHz
SWR **1.07**
Z 51.55 at -3.46 deg.
= 51.46 - j 3.114 ohms
Refl Coeff 0.03387 at -63.16 deg.
= 0.01529 - j 0.03022
Ret Loss 29.4 dB

Source # 1
Z0 50 ohms

20m Moxon 50 ft above Ground



I could have continued to increase the height of the antenna, but it would have become impractical to have a Field Day Mast that height. Below is a summary of the results:

Height Above Ground	Wavelength Above Ground	Gain	Front/Back Ratio	Take-Off Angle
15 ft	0.22 λ	8.04 dBi	11.82 dB	50°
20 ft	0.29 λ	8.85 dBi	19.19 dB	40°
25 ft	0.36 λ	9.47 dBi	27.4 dB	35°
30 ft	0.43 λ	10.06 dBi	24.0 dB	30°
35 ft	0.51 λ	10.61 dBi	19.72 dB	25°
40 ft	0.58 λ	10.93 dBi	17.62 dB	25°
45 ft	0.65 λ	11.01 dBi	19.1 dB	20°
50 ft	0.72 λ	10.93 dBi	21.17 dB	20°

How we really have to put these numbers into perspective. On a properly calibrated radio one S-unit is a 6 dB change. So, if we are looking at the change in forward gain we only see about a change of 3 dB or 1/2 an S-unit. You will generally never hear that. If you look at the Front/Back ratio we might actually hear a difference in the antennas. This antenna will have a change of about 2 S-units from 15 ft to 30 ft. You could likely hear this difference. It is interesting that we now are more concerned about what we will not hear than what we will hear. Aren't antennas interesting.

Below is a simplified example of the effect of take-off angle. This is from Army Field Manual 6-02.53.

Take off Angle (Degrees)	***Distance***	
	F2 Region Daytime	***F2 Region Nighttime***
	miles	***miles***
0	2000	2800
5	1500	2300
10	1200	1800
15	900	1400
20	700	1100
25	600	1000
30	450	825
35	400	700
40	350	600
45	275	500
50	250	425
60	160	275
70	95	180
80	50	90
90	0	0

Taking our same example antenna, the following circuit distances would like likely:

Height Above Ground	Take-Off Angle	F2 Region Daytime	F2 Region Nighttime
15 ft	50°	250 miles	425 miles
20 ft	40°	350 miles	600 miles
25 ft	35°	400 miles	700 miles
30 ft	30°	450 miles	825 miles
35 ft	25°	600 miles	1000 miles
40 ft	25°	600 miles	1000 miles
45 ft	20°	700 miles	1100 miles
50 ft	20°	700 miles	1100 miles

Now if you have ever work on HF you are probably scratching your heading and thinking that this is just not right. Guess what, you are sort of right. The math does work out this way, but again when we get practical, we have to come back to the S-Meter again. If you look at the elevation plot and look for the -6 dB points lower than the peak you see that for a one S-unit change we can go from 10° take off angle to a 60° take off angle. Going back to our chart above this antenna at 35 ft is easily usable for path distance in the day of 160 miles to 120 miles. At night the antenna system would b usable from 275 miles to 1800 miles. I want to stress that this is a very theoretical examination of the antenna. The performance will vary greatly depending on actual atmospheric conditions. By the way, this does not consider the more obscure propagation modes. This is one reason that the Big-Gun D stations will have stacks of antenna for the same band at different heights. This allows them to pick the best take-off angle for the signal they are attempting to receive.

Well that wraps up this exercise. I am not sure where this will head next, but I might try multiple antennas on the same mast but with different bands at different heights.