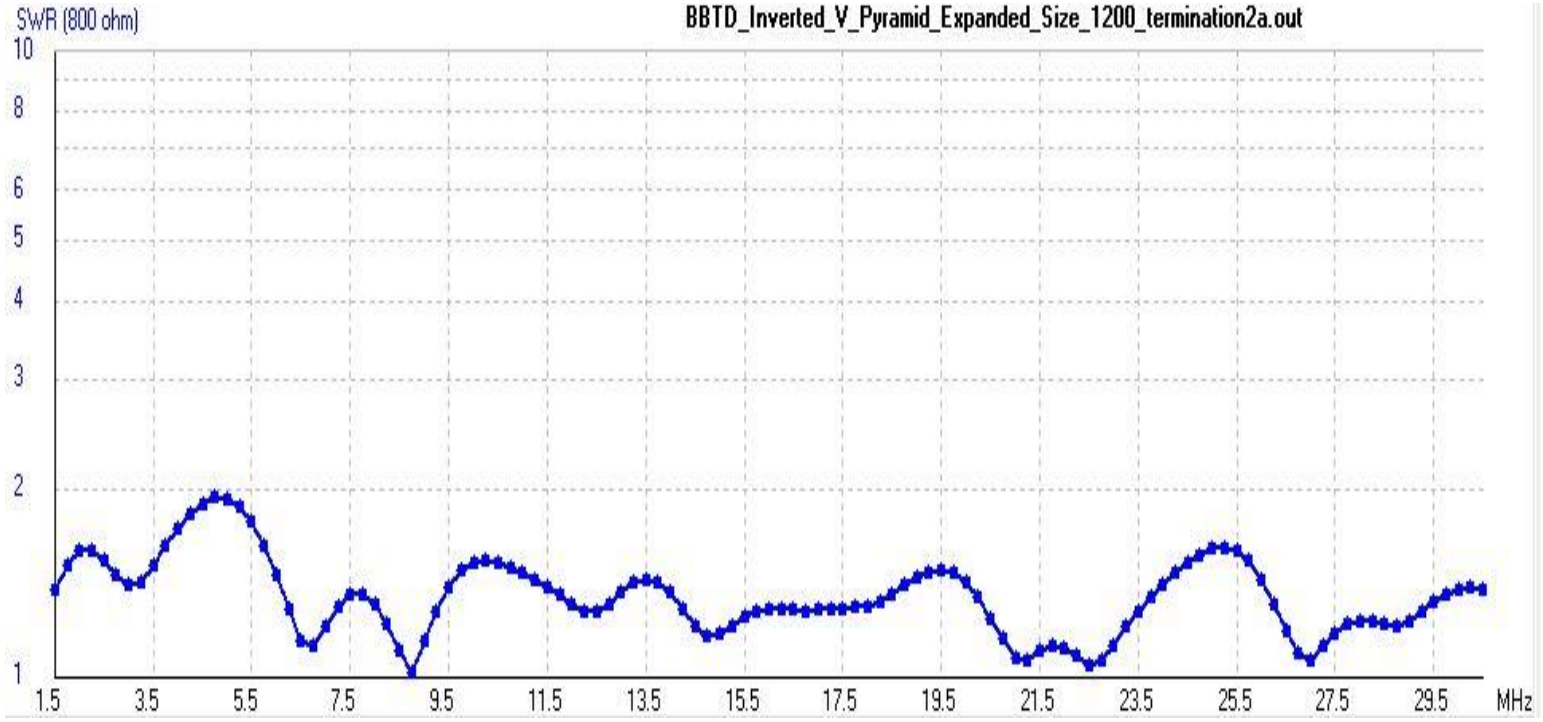
Optimization of the BBTD Antenna, Pyramid Configuration

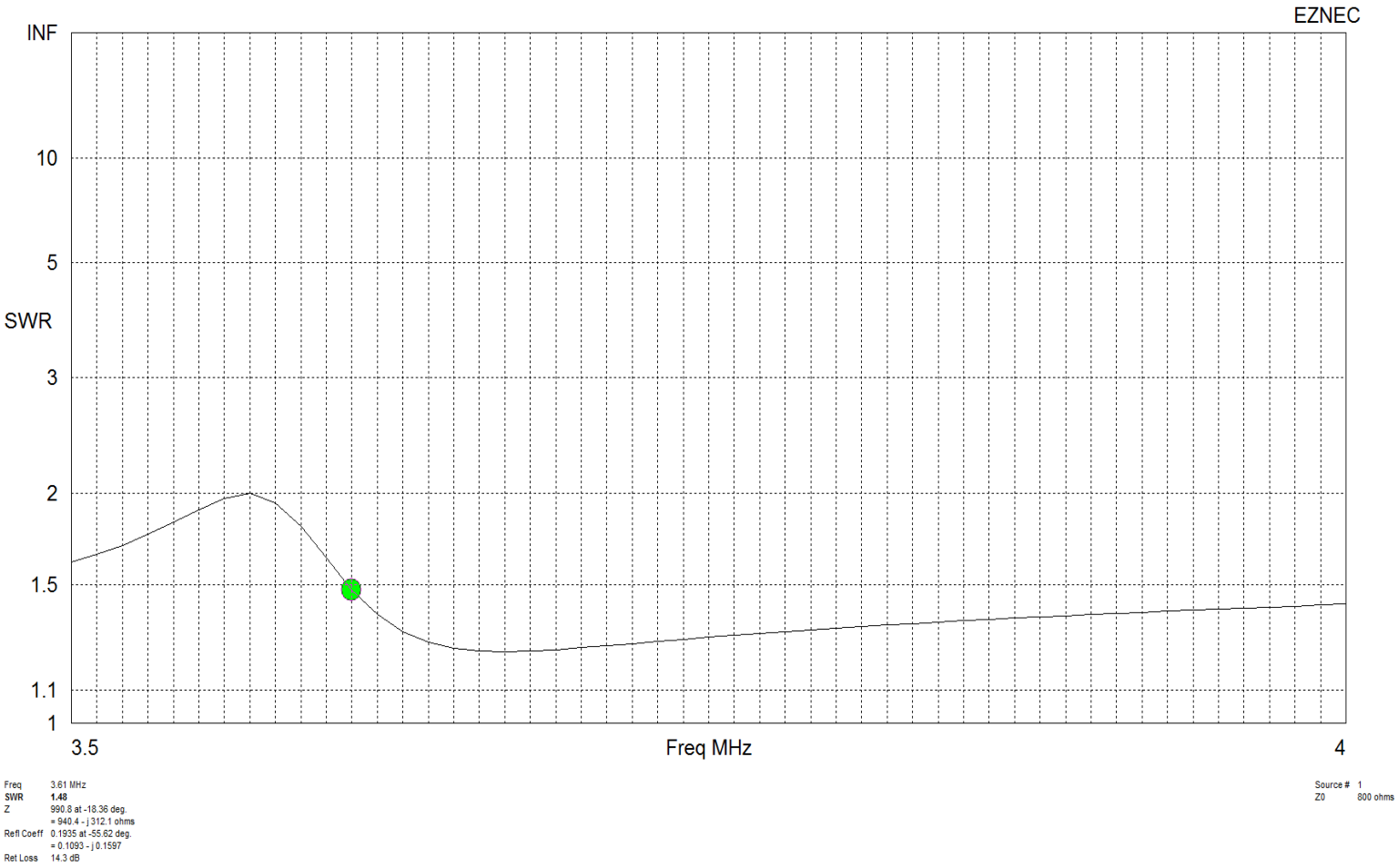
By Mel K6KBE 9/10/2018

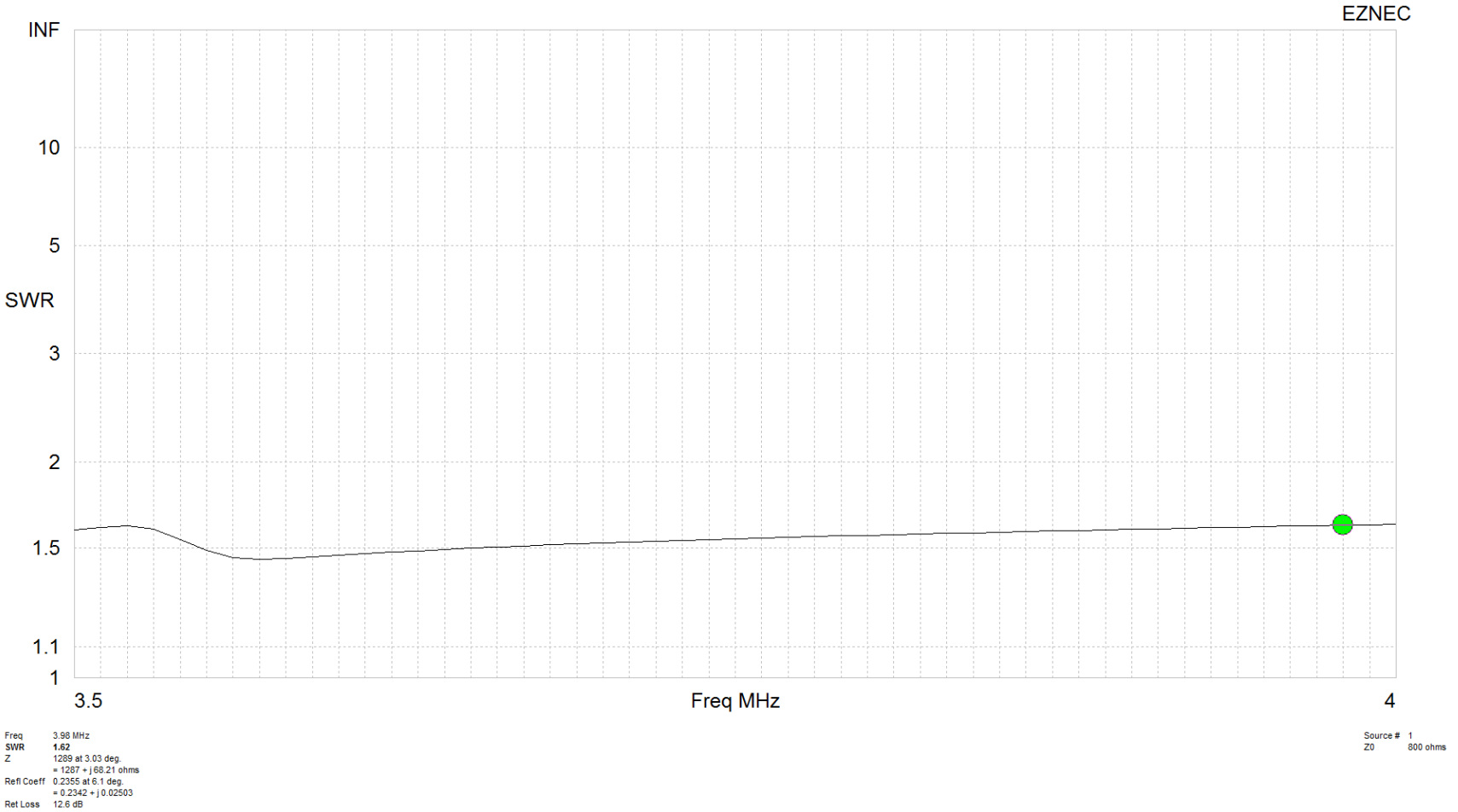
I followed KQ6XA Bonnie's design for the Pyramid version of the BBTD and modeled then installed it on my test range. Performance was as she predicted. While doing the extensive modeling of the BBTD, I wanted to improve the SWR and attacked the excursions above 1.5:1 in the original design. Going back to the work by ON4AA with a loaded element in the antenna to move the sweet spot of operation on the fundamental band, I started experimenting with placing a capacitor in one of the legs. It put a smooth slope in the 80 meter section and I moved the 1.5:1 peak to ~3.6 MHz and the rest of the band under 1.35:1. See the expanded 75/80 meter plots, and the broad band where the higher bands are under ~1.5:1. The value of the cap in this case 175 pF, easily moves the major <1.5:1 up in the band. A little more capacitance and I could have had the whole bottom of the 80 meter band and had the SWR ~1.6:1:1. Finally I experimented with putting two caps, one on each side of the feed legs. That is the final configuration that is up now at my QTH.

Here is Bonnie's plot of one of her original designs for reference.



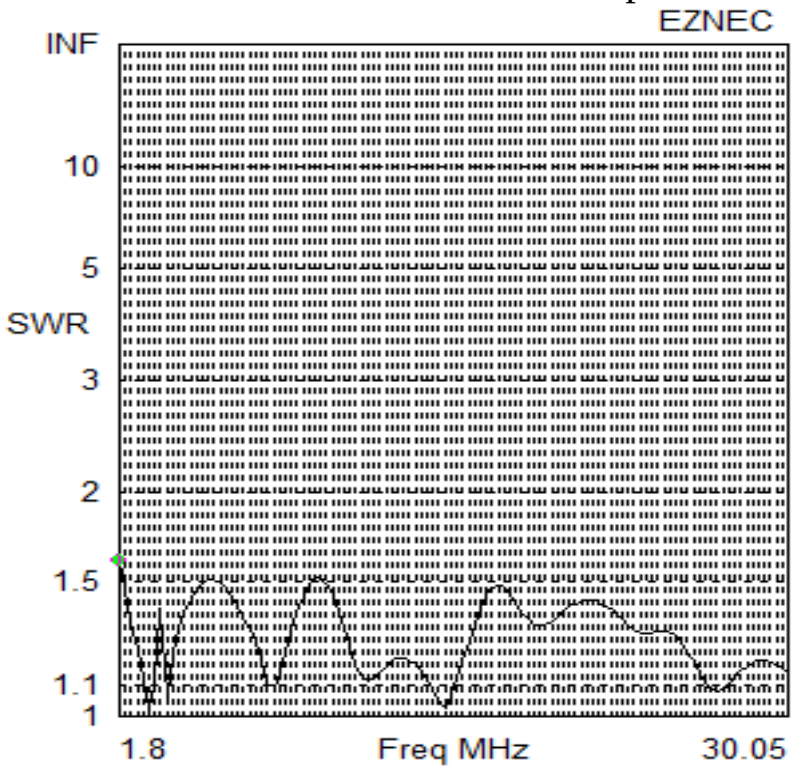
Here is my expanded plot of 75/80 meters for the high end with 175 pF in one leg:





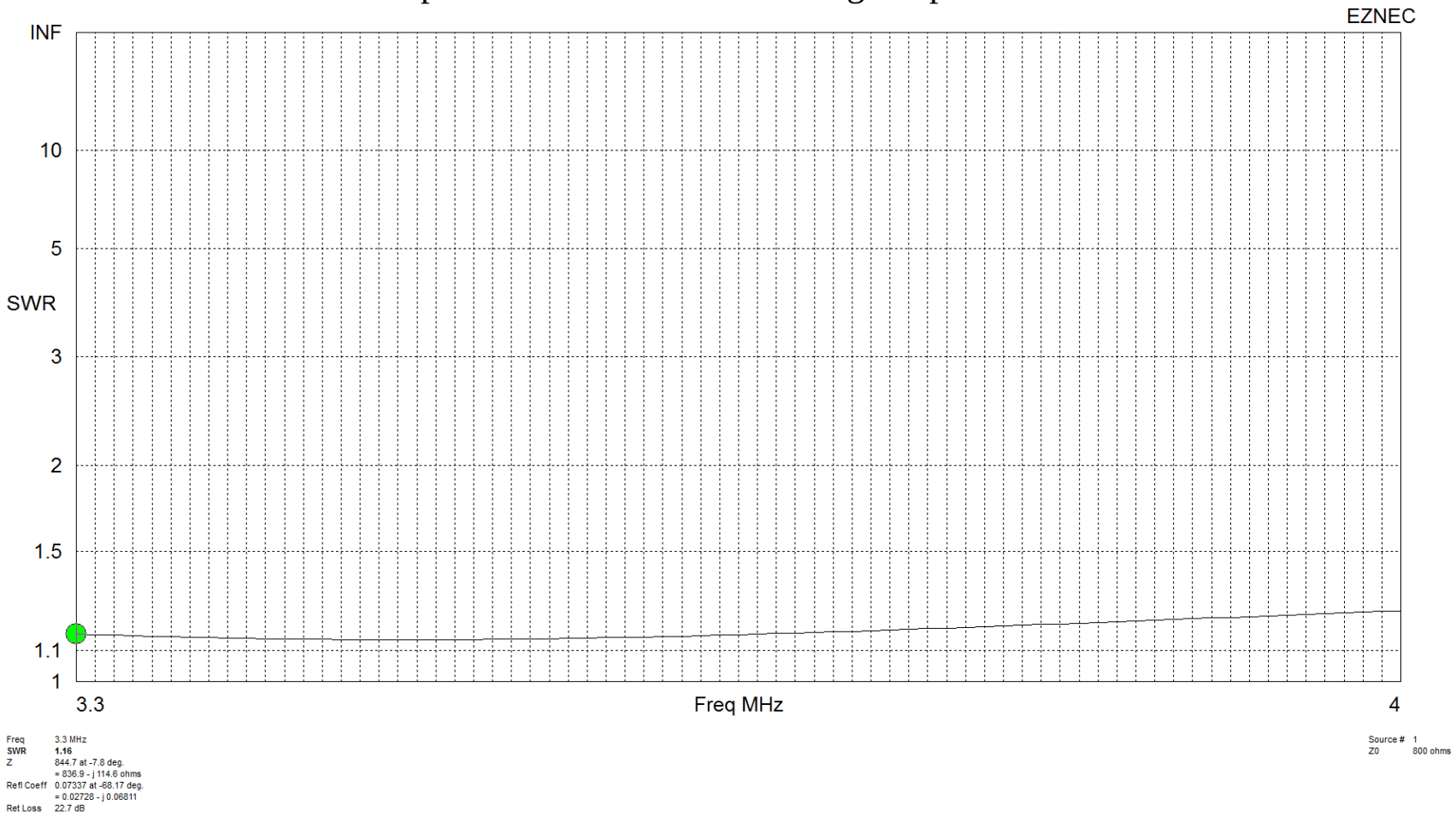
And here with more capacitance for the whole band with 425 pF same position on the leg.

And below the full bands with the cap installed for high end of 75/80 meters..

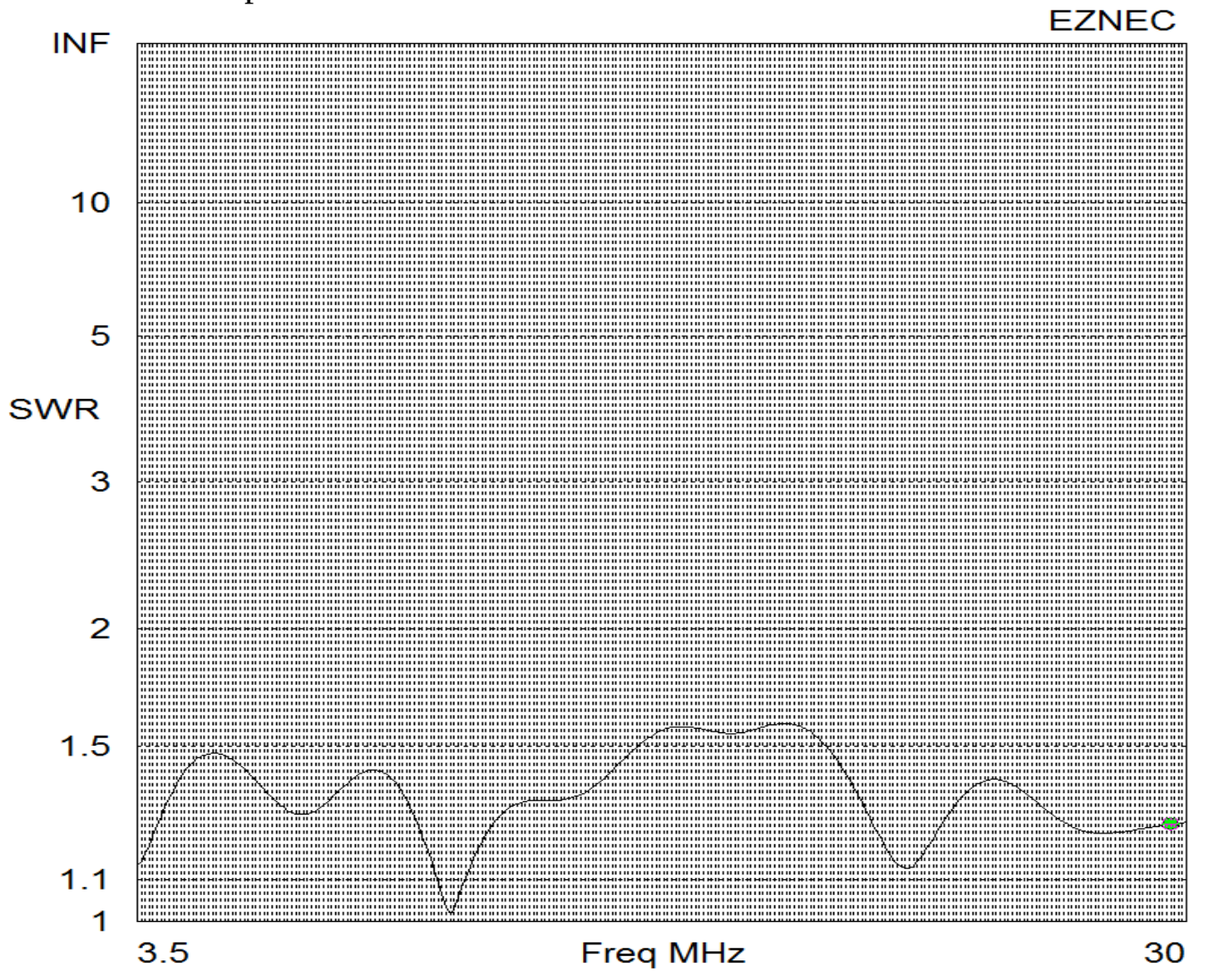


Freq	1.8 MHz	Source #	1
SWR	**1.6**	Z0	800 ohms
Z	821.3 at -26.0 deg. = 738.2 - j 360 ohms		
Refl Coeff	0.2312 at -86.56 deg. = 0.01386 - j 0.2308		
Ret Loss	12.7 dB		

Here is the antenna with 2 caps. One 50% on each feed leg 200pF.



Here is the full spectrum 3.5-29.6



Freq	29.6 MHz
SWR	**1.25**
Z	956.9 at -7.49 deg.
	= 948.7 - j 124.8 ohms
Refl Coeff	0.1107 at -35.92 deg.
	= 0.08968 - j 0.06496
Ret Loss	19.1 dB

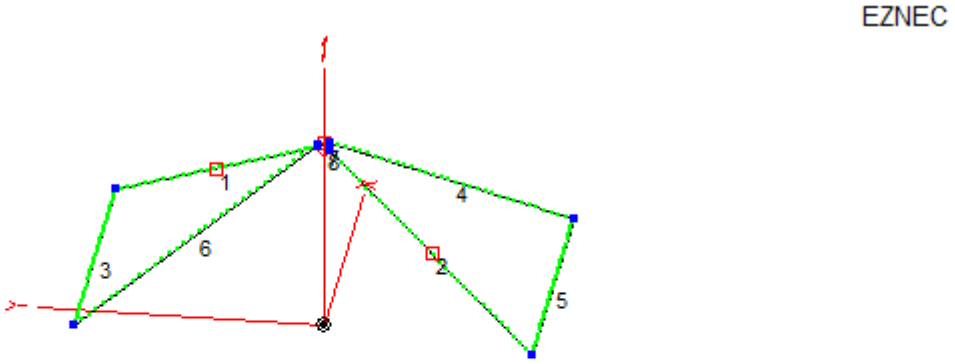
Source #	1
Z0	800 ohms

Tabulation by band on the test range with the VNA-2180.

1.8 MHz	2.24:1
3.5	1.14:1
4.0	1.21:1
5.3	1.47:1
5.4	1.47:1
7.0	1.32:1
7.3	1.29:1
10.1	1.36:1
14.0	1.32:1
14.4	1.33:1
18.1	1.55:1
21.0	1.48:1
21.5	1.38:1
25.0	1.38:1
28.0	1.22:1
29.6	1.25:1

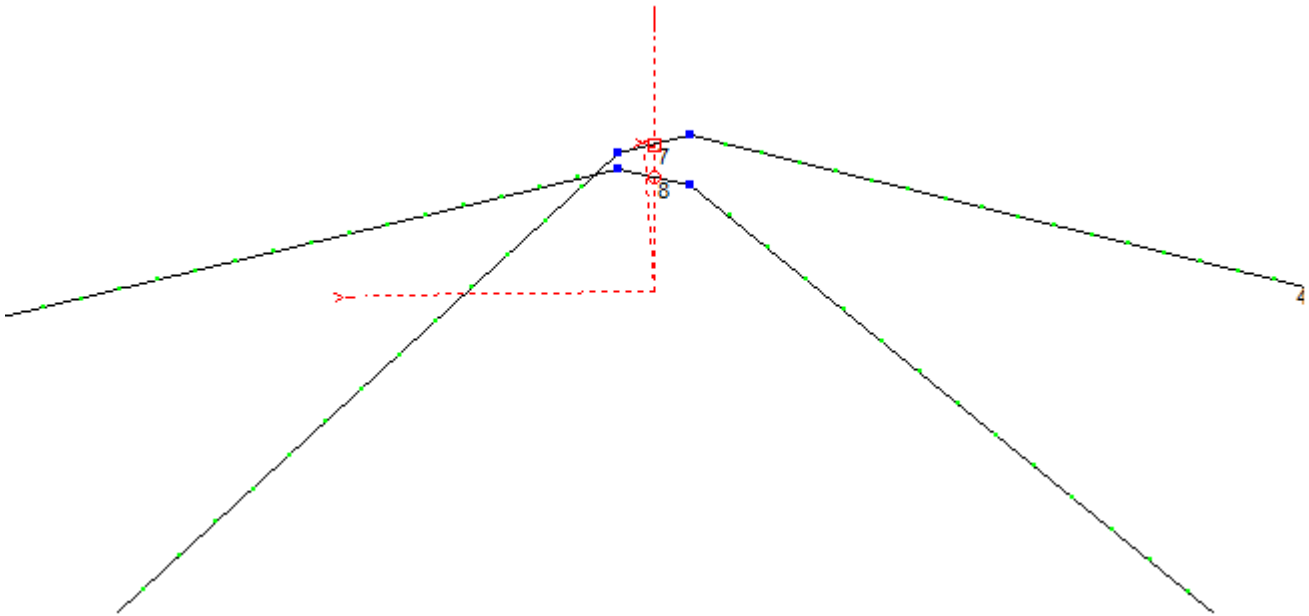
I felt that this was a better compromise.

And the full description on EZNEC



All leg lengths Number 1-6 are 45 feet long and the cross over at the peak number 7,8 are 2 feet. The 1200 ohm termination is on the top cross over and the 16:1 balun and feedline is on the bottom crossover.

EZNEC



EZNEC ver. 5.0

BBTDV11/02/2018 11/2/2018 12:26:30 PM

---------- ANTENNA DESCRIPTION ----------

Frequency = 3.5 MHz
Wire Loss: Copper -- Resistivity = 1.74E-08 ohm-m, Rel. Perm. = 1

---------- WIRES ----------

No.	End 1 Coord. (ft)			End 2 Coord. (ft)			Dia (in)	Segs	Insulation	
	Conn.	X	Y	Z	Conn.	X	Y	Z			Diel C	Thk(in)
1	W8E1	0.5,	1,	30	W3E1	22.5,	35,	9	#18	33	1	0
2	W8E2	-0.5,	-1,	30	W5E2	-22.5,	-35,	9	#18	33	1	0
3	W1E2	22.5,	35,	9	W6E2	-22.5,	35,	9	#18	33	1	0
4	W7E2	0.5,	-1,	31	W5E1	22.5,	-35,	9	#18	33	1	0
5	W4E2	22.5,	-35,	9	W2E2	-22.5,	-35,	9	#18	33	1	0
6	W7E1	-0.5,	1,	31	W3E2	-22.5,	35,	9	#18	33	1	0
7	W6E1	-0.5,	1,	31	W4E1	0.5,	-1,	31	#18	1	1	0
8	W1E1	0.5,	1,	30	W2E1	-0.5,	-1,	30	#18	1	1	0

Total Segments: 200

---------- SOURCES ----------

No.	Specified Pos. Wire #	% From E1	Actual Pos. % From E1	Seg	Amplitude (V/A)	Phase (deg.)	Type
1	8	50.00	50.00	1	1	0	I

---------- LOADS (RLC Type) ----------

No.	Specified Pos. Wire #	% From E1	Actual Pos. % From E1	Seg	R (ohms)	L (uH)	C (pF)	R Freq (MHz)	Type
1	7	50.00	50.00	1	1200	Short	Short	0	Ser
2	1	50.00	50.00	17	Short	Short	200	0	Ser
3	2	50.00	50.00	17	Short	Short	200	0	Ser

No transmission lines specified
No transformers specified
No L Networks specified
Ground type is Real, High-Accuracy

---------- MEDIA ----------

No.	Cond. (S/m)	Diel. Const.	Height (ft)	R Coord. (ft)
1	0.005	13	0	0

The antenna in the final configuration is a real performer. Terminated antennas have a mixed review on performance, mainly due to the lack of refinement.

Here are the radiation gains/losses for the ham bands from the EZNEC model.

1.8 MHz -21.3 dBi
3.8 MHz -6.7 dBi
5.35 MHz -2/07 dBi
7.2 MHz 0.95dBi
10/1 MHz 3.32 dBi
14.2 MHz 1.49 dBi
18.1 MHz 2.5 dBi
21.25 MHz 2.6 dBi
25 MHz 3.77 dBi
28.4 MHz 4.51 dBi

Not bad for a broad band antenna 45 X 70 feet and only 31 feet tall. As with all of my work, it is always an ongoing design and perfection effort. 73.