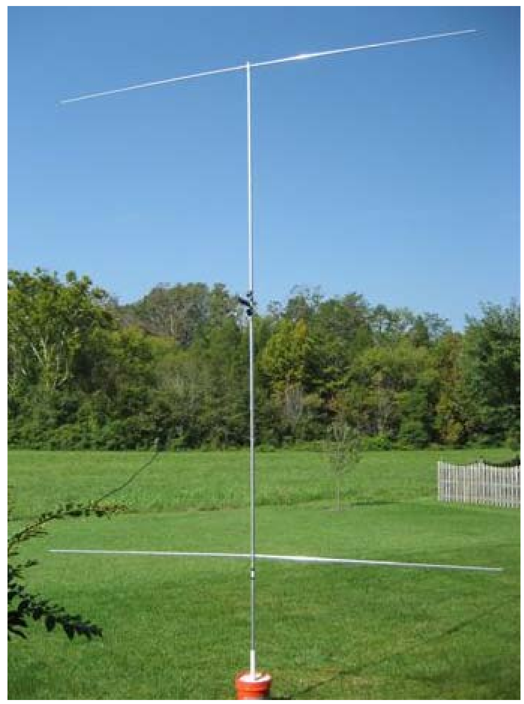
Sigma-40XK

A closer look at Force 12's 10-40 meter vertical dipole



This antenna was a first for me. Except for a couple of Hamsticks, all of my antennas are homebrew. I'm always looking for antennas that work well and can be set up easily and this one caught my eye. The Sigma-40XK[1] is advertised as being an efficient vertical antenna requiring no radials and a 21° take-off angle. The antenna is tuned for each band (10m to 20m) by changing the length of the T-bar elements. For the 30m and 40m bands, the T-bars are left at the 20m length, and loading coils are placed in series with the balun. Also, a hairpin matching coil is placed across the feedpoint. The dual T-bars represent top hats or capacity hats and allow a dipole to be shortened to 25% of a full size dipole[2]. The usual SHVD (short hatted vertical dipole) has three, four, or eight horizontal spokes at each end with a perimeter element joining the tips of the spokes[3]. Hat sizes grow smaller with increasing numbers of spokes. The minimum number of spokes is two and this is the method used for the Sigma series.

First Impressions

Patience is required after placing your order. After paying first, my antenna took about eight weeks to show up, and from what I understand, this is a big improvement from previous delivery times. The antenna was packed well and sustained no damage during shipment. All tubing was deburred and taped together. The two insulators are solid fiberglass, one inch diameter. All holes are predrilled and will line up if you follow the hand lettered characters on the parts. I noticed that the center fiberglass insulator was splintered on the back side of the inner two holes. This is a result of drilling through a piece without a backstop.

The welding of the ¾" OD tubing at the T-bars was well done, but the ¾" tubing was dented in several places making it difficult to insert the 5/8" tubing. One inch cuts were made on the ends of the tubing with compression clamps provided to tighten the inserted 5/8 inch tubing. On the T-bars I found that the compression clamps would strip out before a solid clamp was made. I fixed this by using a hacksaw to widen the kerfs and installed new stainless steel clamps. Either due to the welds or the dents, the 5/8" tubing will not insert into the T-bars the full three inches, but about 2-3/4 inches. This affects the total T-bar exposed element length.

The manual assumes that the user knows how the feedpoint goes together. There are no close-ups or drawings on this assembly. The pictures in the manual show a balun that does not match the one included with the antenna.

The balun I received consists of a length of coax with solder rings on one end, three ferrite chokes slipped over the coax, and then terminated in a female PL-259 connector (which I have never seen before). The assembly is secured with wire ties to a length of plastic which is bolted to the center insulator. The quality is excellent as all exposed coax is sealed in heat shrink and the soldering was well done.

The 10-24 x 2 inch stainless steel hardware is too long. I would have preferred shorter screws to prevent mishaps while raising and lowering the antenna. I replaced these with 1-½" long stainless steel screws. The hex nuts and lock washers were replaced with stop nuts.

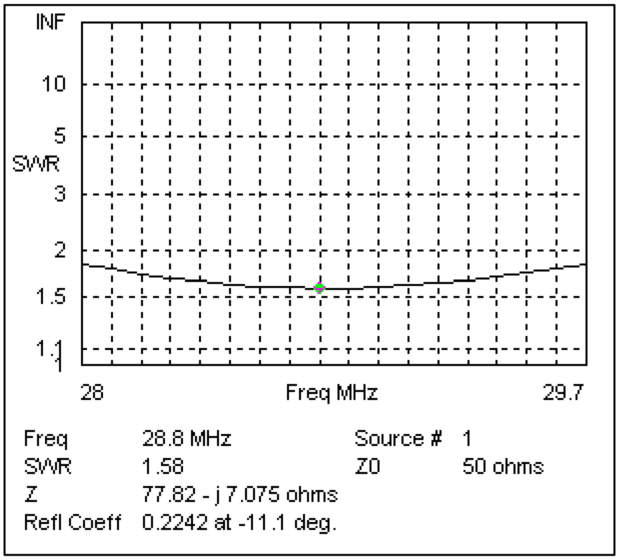
Modeling & Testing

EZNEC 4.0 was used to model the antenna for each band. This, along with SWR measurements made with an MFJ-259B analyzer, is presented for each band. The coax should ideally leave the antenna at a right angle for 20 feet or so. In practice, the 50 feet of (new) Wireman CQ118 RG8X coax droops at approximately 45° from the antenna feedpoint. All T-bar element lengths are measured from the outside diameter of the 1-3/8" tubing (with three rivets). If you prefer to reference to the vertical tubing centerline add 0.6875 or 11/16 inch to the T-bar lengths.

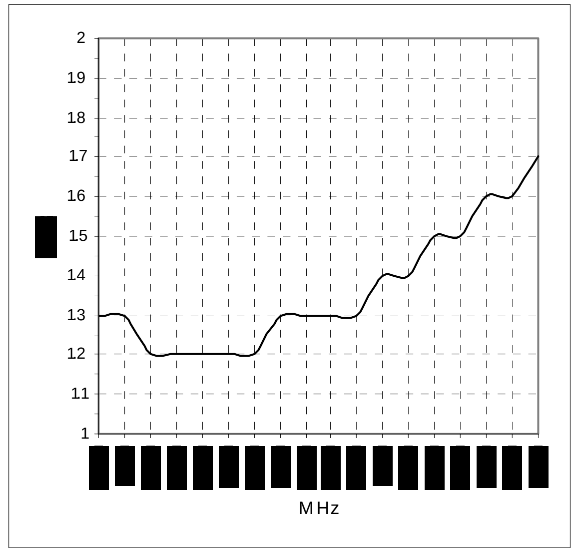
The antenna was mounted by placing the lower mast into a two foot length of 1-¼" PVC pipe. The pipe was centered in a 5-gallon bucket filled with concrete. In heavy winds the antenna should be guyed at three points. The reader may note that the 10m and 12m SWR measurements are somewhat lower than the EZNEC models. I suspect that this is partly due to coax losses at higher frequencies.

10 Meters

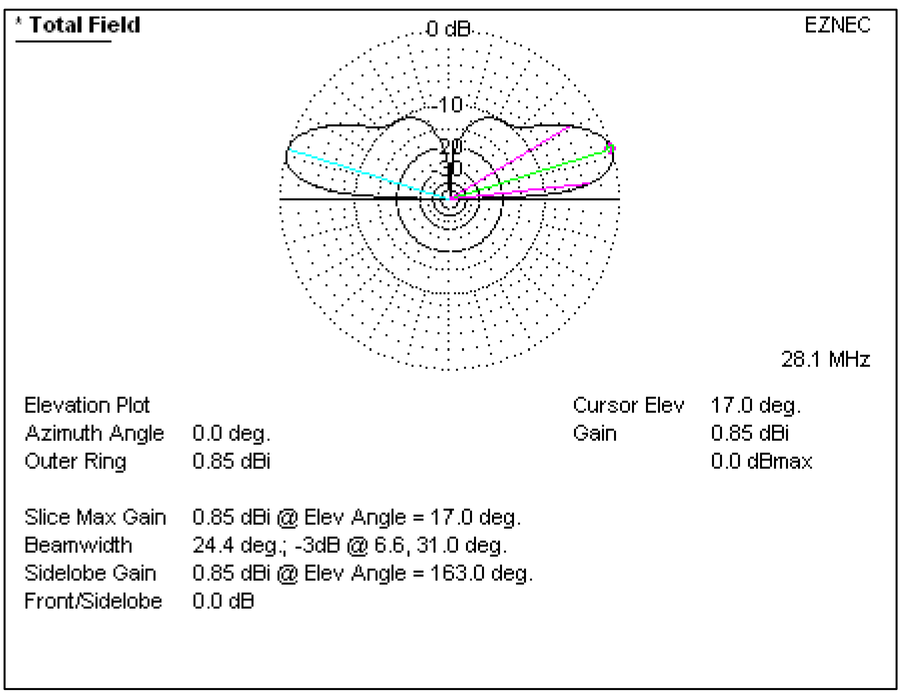
This configuration uses the minimum T-bar length of 3 inches per side. Shorting wires connect the antenna elements to the balun.



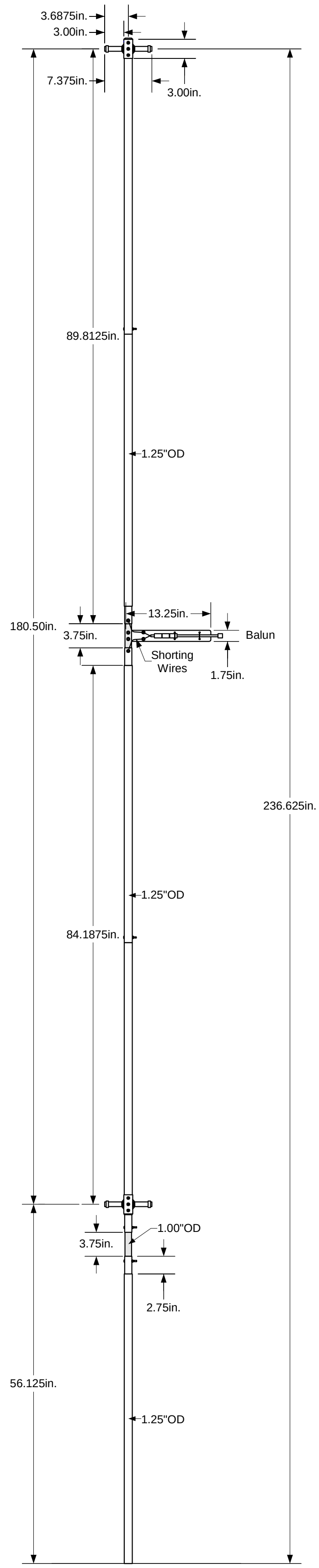
EZNEC 4.0 prediction of SWR



Measured SWR

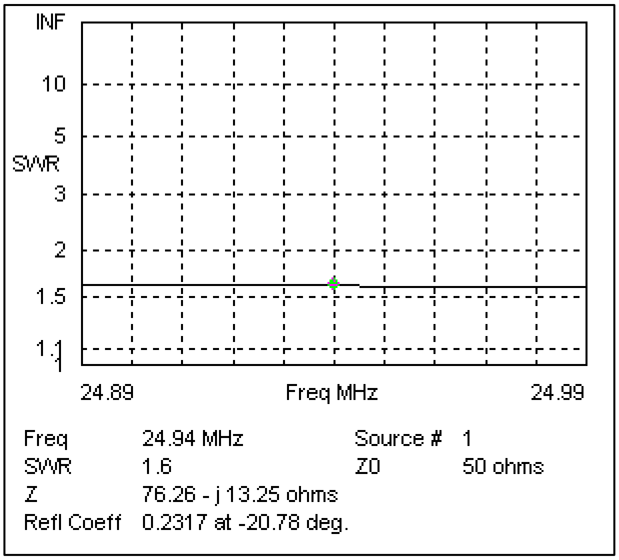


EZNEC 4.0 Elevation plot

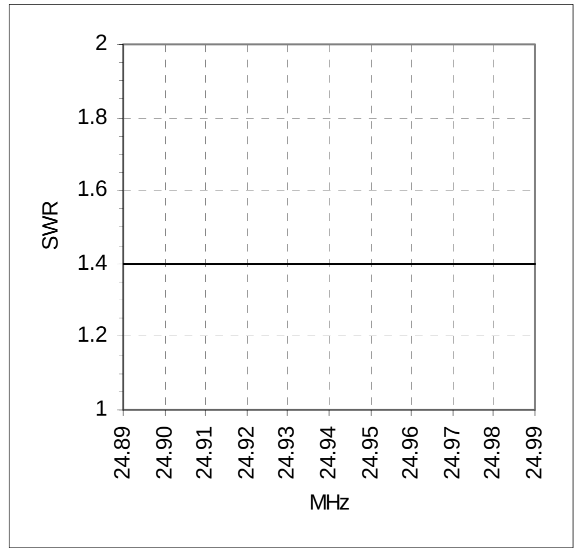

3.6875in.
3.00in.
7.375in.
3.00in.
89.8125in.
1.25"OD
13.25in.
180.50in.
3.75in.
Balun
Shorting
Wires
1.75in.
236.625in.
1.25"OD
84.1875in.
1.00"OD
3.75in.
2.75in.
56.125in.
1.25"OD

12 Meters

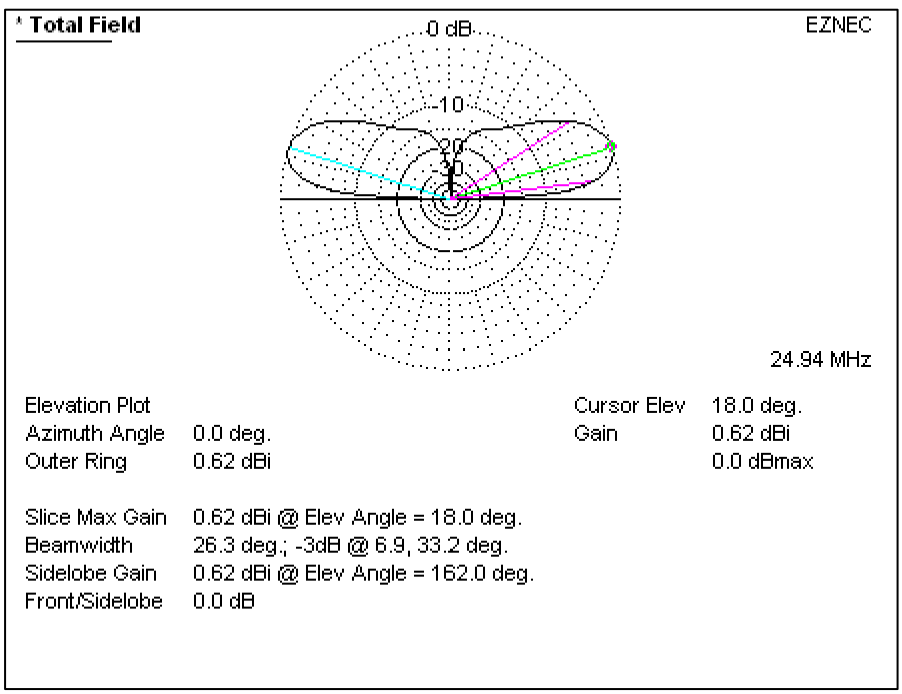
This configuration uses a T-bar length of 14-¼ inches per side. Shorting wires connect the antenna elements to the balun.



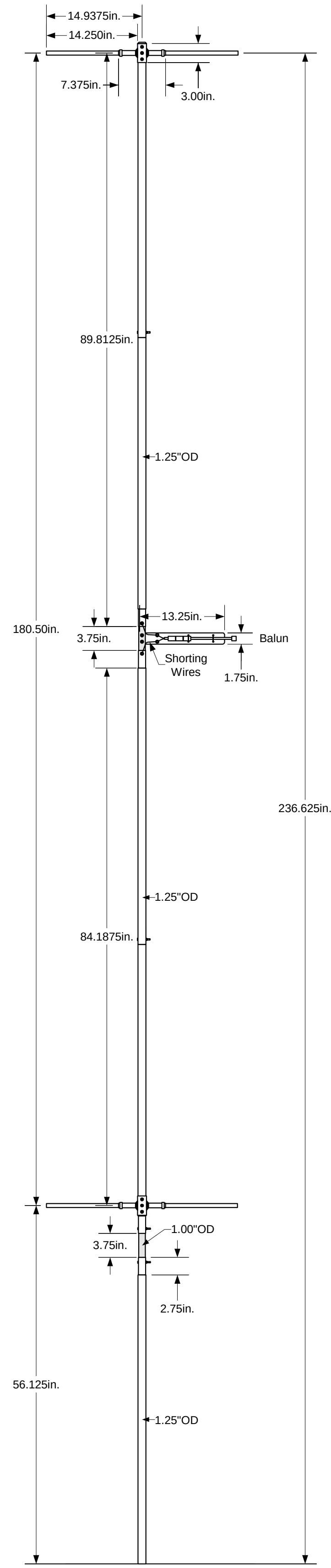
EZNEC 4.0 prediction of SWR



Measured SWR

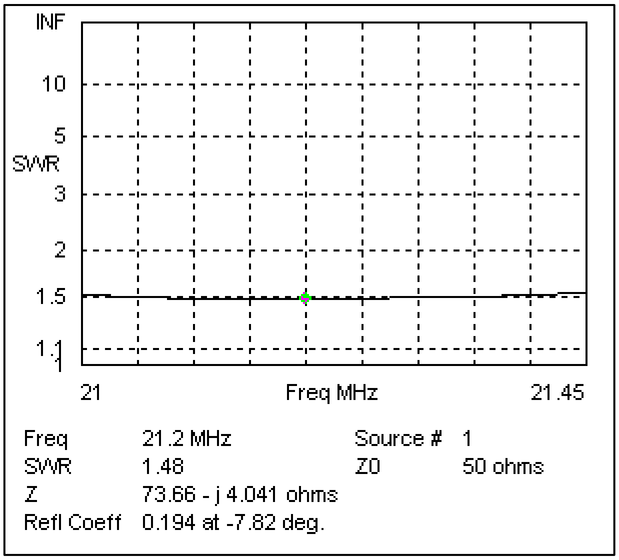


EZNEC 4.0 Elevation plot

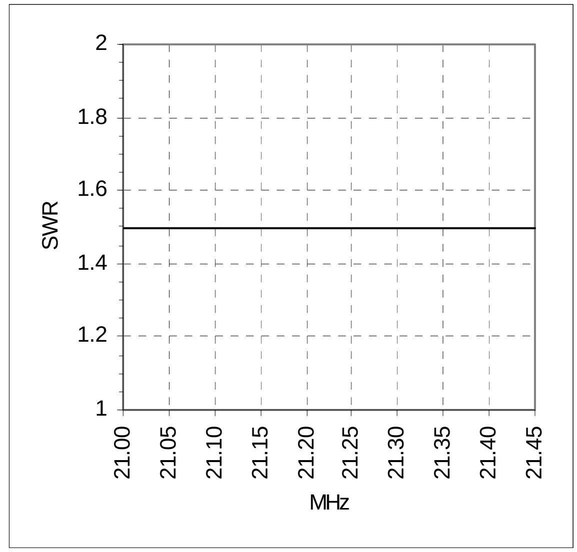

14.9375in.
14.250in.
7.375in.
3.00in.
89.8125in.
1.25"OD
13.25in.
Balun
180.50in.
3.75in.
Shorting
Wires
1.75in.
236.625in.
1.25"OD
84.1875in.
1.00"OD
3.75in.
2.75in.
56.125in.
1.25"OD

15 Meters

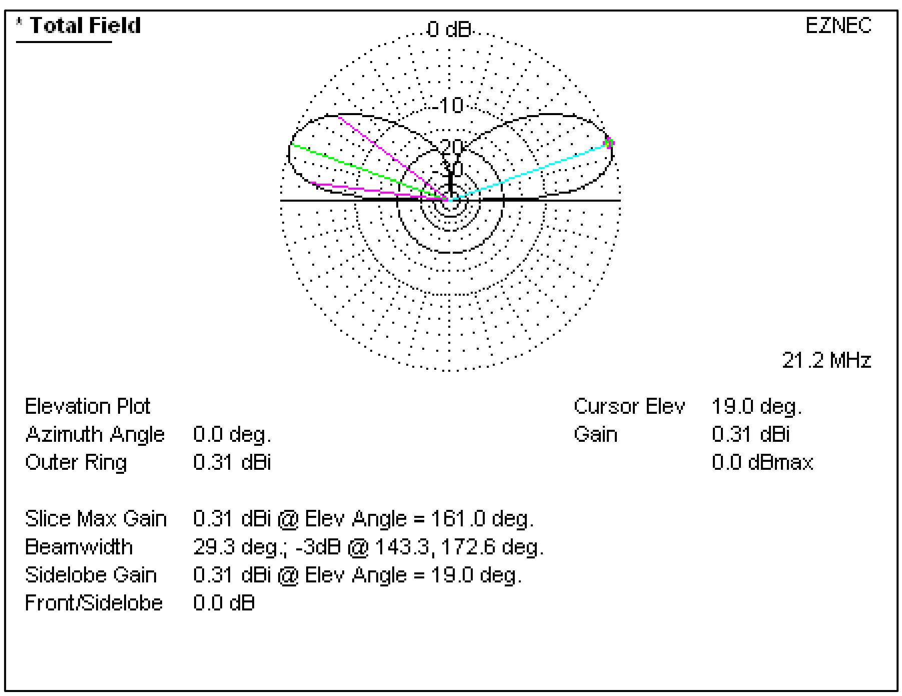
This configuration uses a T-bar length of 29-1/8” inches per side. Shorting wires connect the antenna elements to the balun.



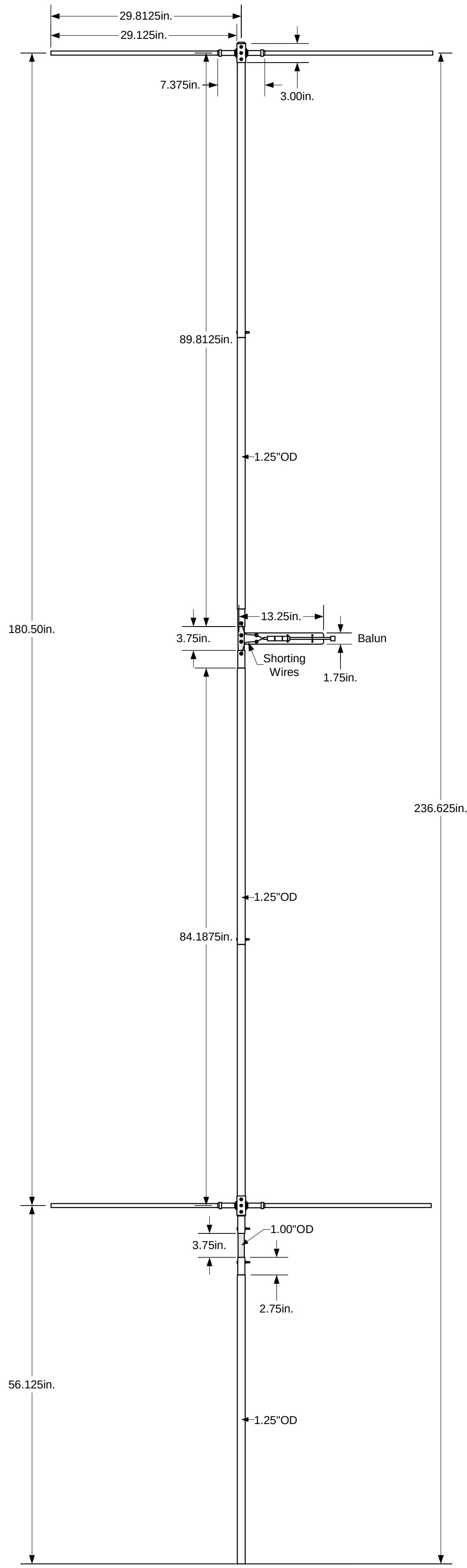
EZNEC 4.0 prediction of SWR



Measured SWR

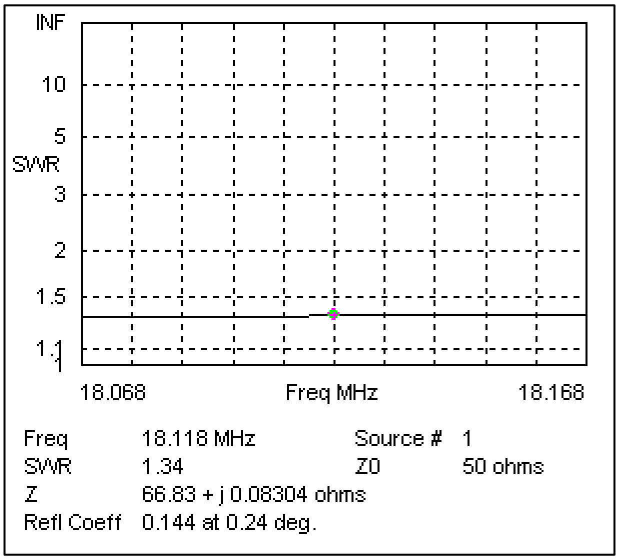


EZNEC 4.0 Elevation plot

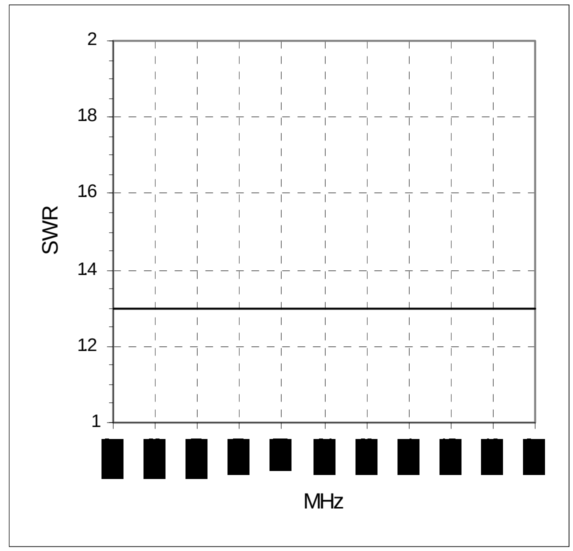

29.8125in.
29.125in.
7.375in.
3.00in.
89.8125in.
1.25"OD
13.25in.
3.75in.
Balun
Shorting Wires
1.75in.
180.50in.
236.625in.
1.25"OD
84.1875in.
1.00"OD
3.75in.
2.75in.
56.125in.
1.25"OD

17 Meters

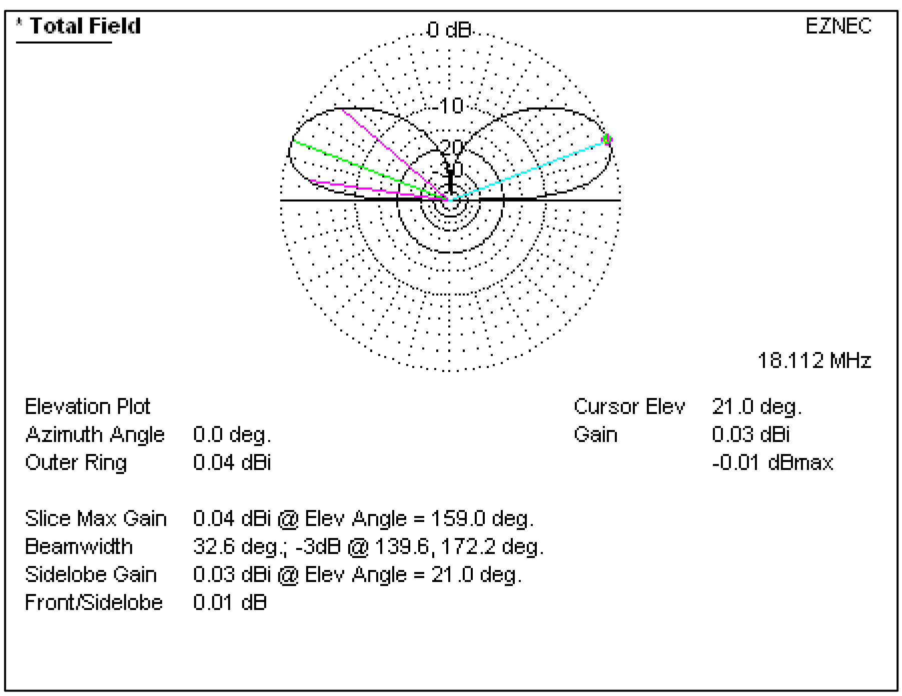
This configuration uses a T-bar length of 47-¼ inches per side. This involves trimming the 48" pieces slightly. At 48 inch per side, the SWR is 1.6:1. Shorting wires connect the antenna elements to the balun.



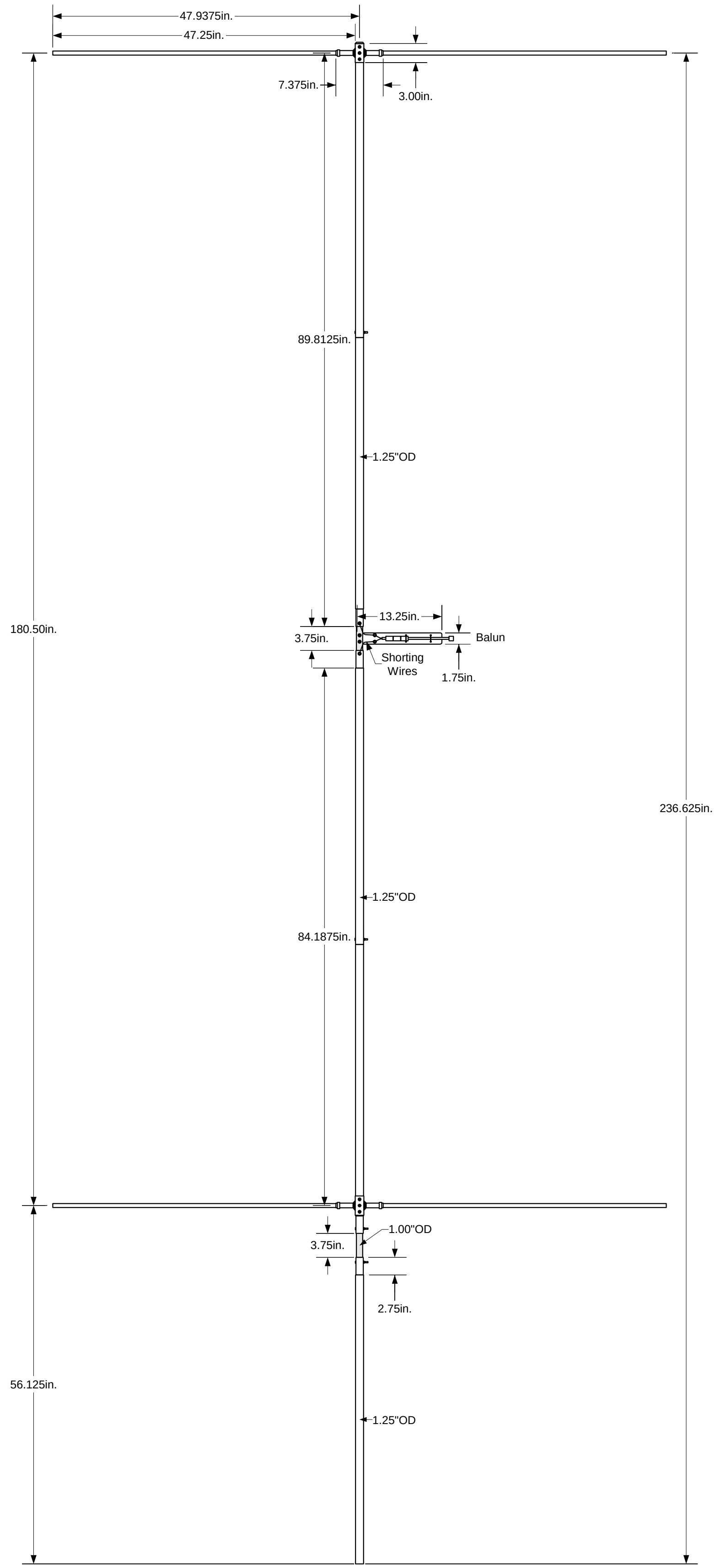
EZNEC 4.0 prediction of SWR



Measured SWR

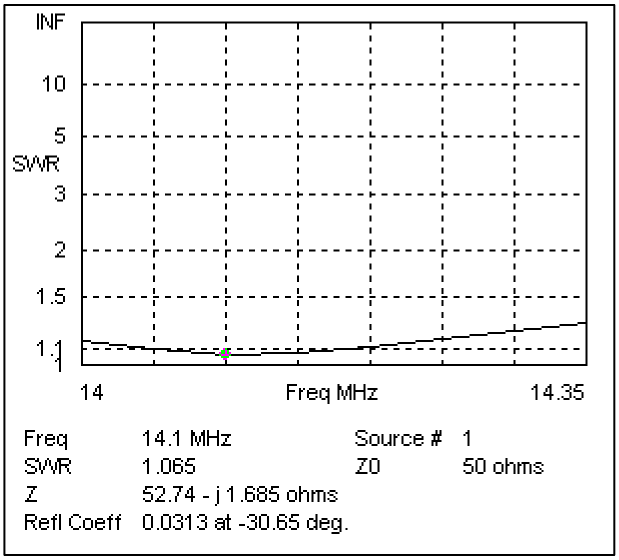


EZNEC 4.0 Elevation plot

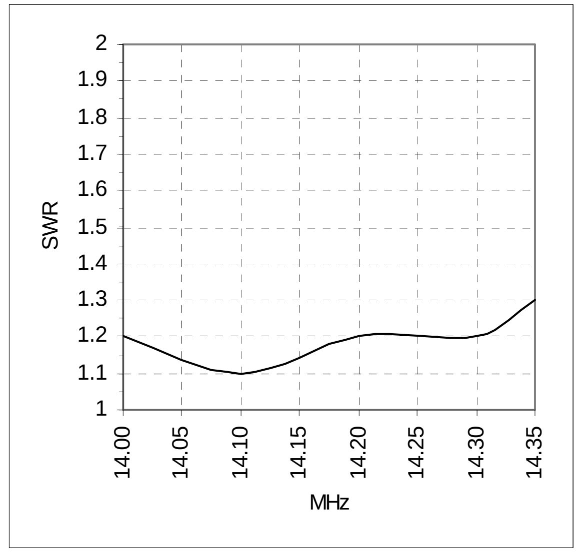

47.9375in.
47.25in.
7.375in.
3.00in.
89.8125in.
1.25"OD
13.25in.
3.75in.
Balun
Shorting Wires
1.75in.
180.50in.
236.625in.
1.25"OD
84.1875in.
1.00"OD
3.75in.
2.75in.
56.125in.
1.25"OD

20 Meters

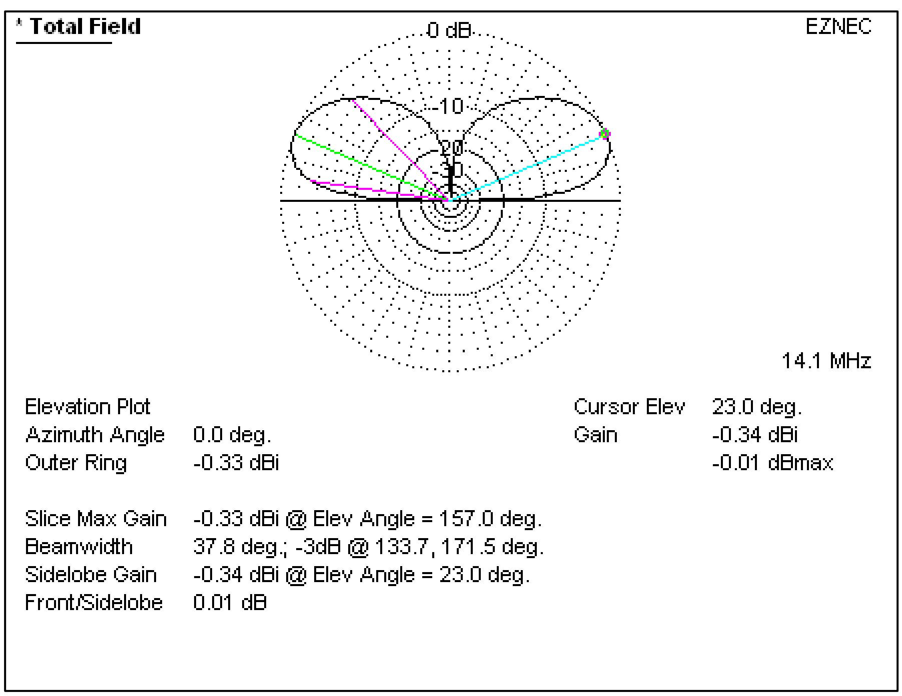
This configuration uses a T-bar length of 83 inches per side. Shorting wires connect the antenna elements to the balun.



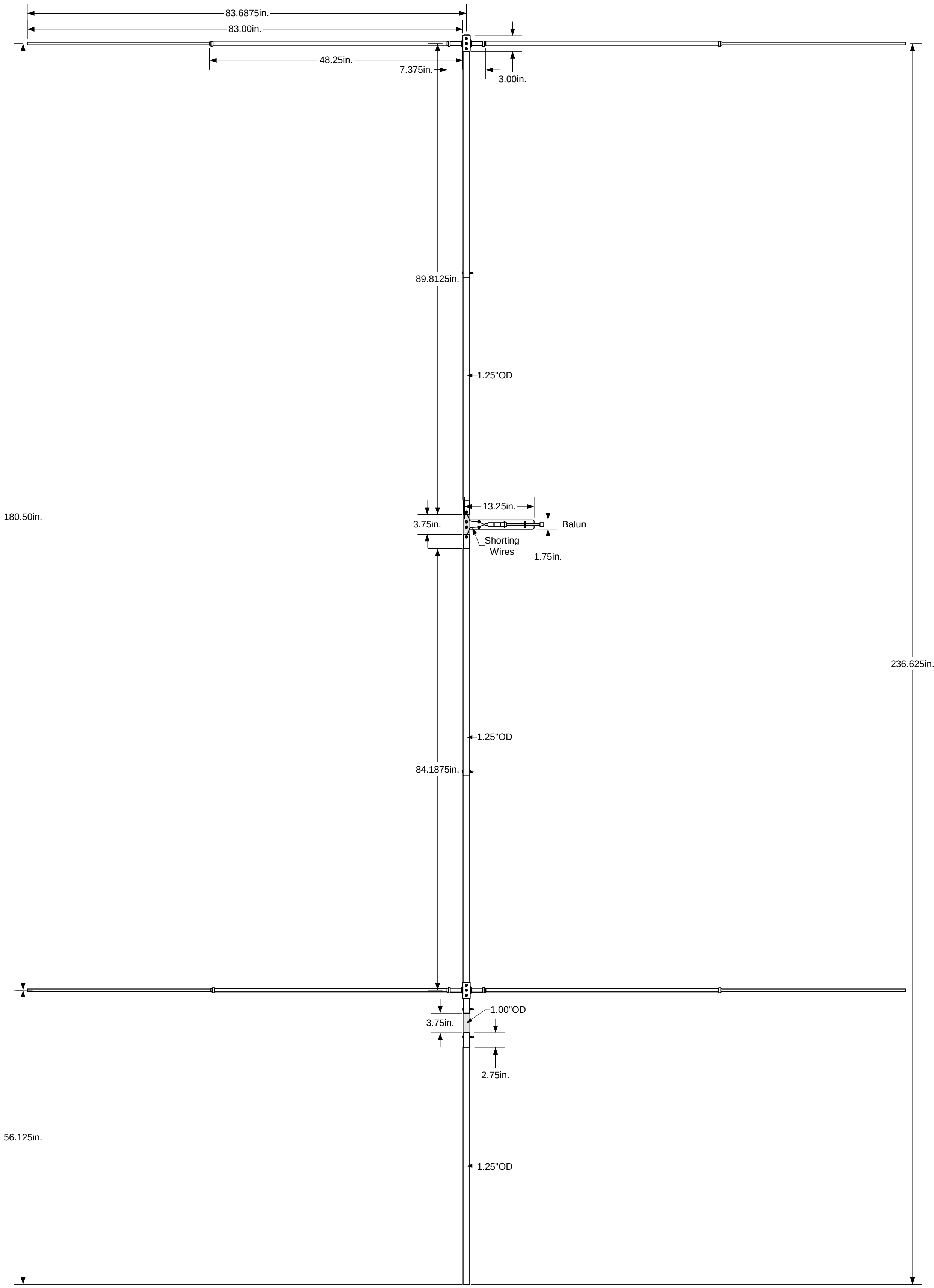
EZNEC 4.0 prediction of SWR



Measured SWR

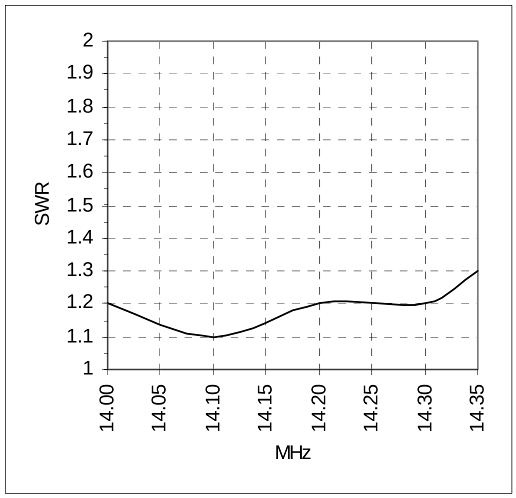


EZNEC 4.0 Elevation plot

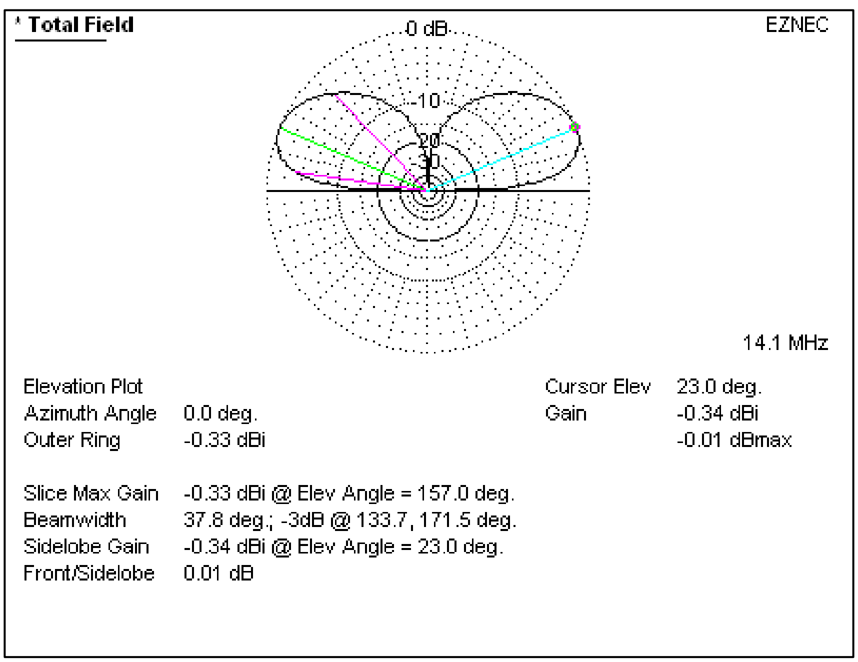

83.6875in.
83.00in.
48.25in.
7.375in.
3.00in.
89.8125in.
1.25"OD
13.25in.
3.75in.
Balun
Shorting Wires
1.75in.
180.50in.
236.625in.
1.25"OD
84.1875in.
1.00"OD
3.75in.
2.75in.
56.125in.
1.25"OD

30 Meters

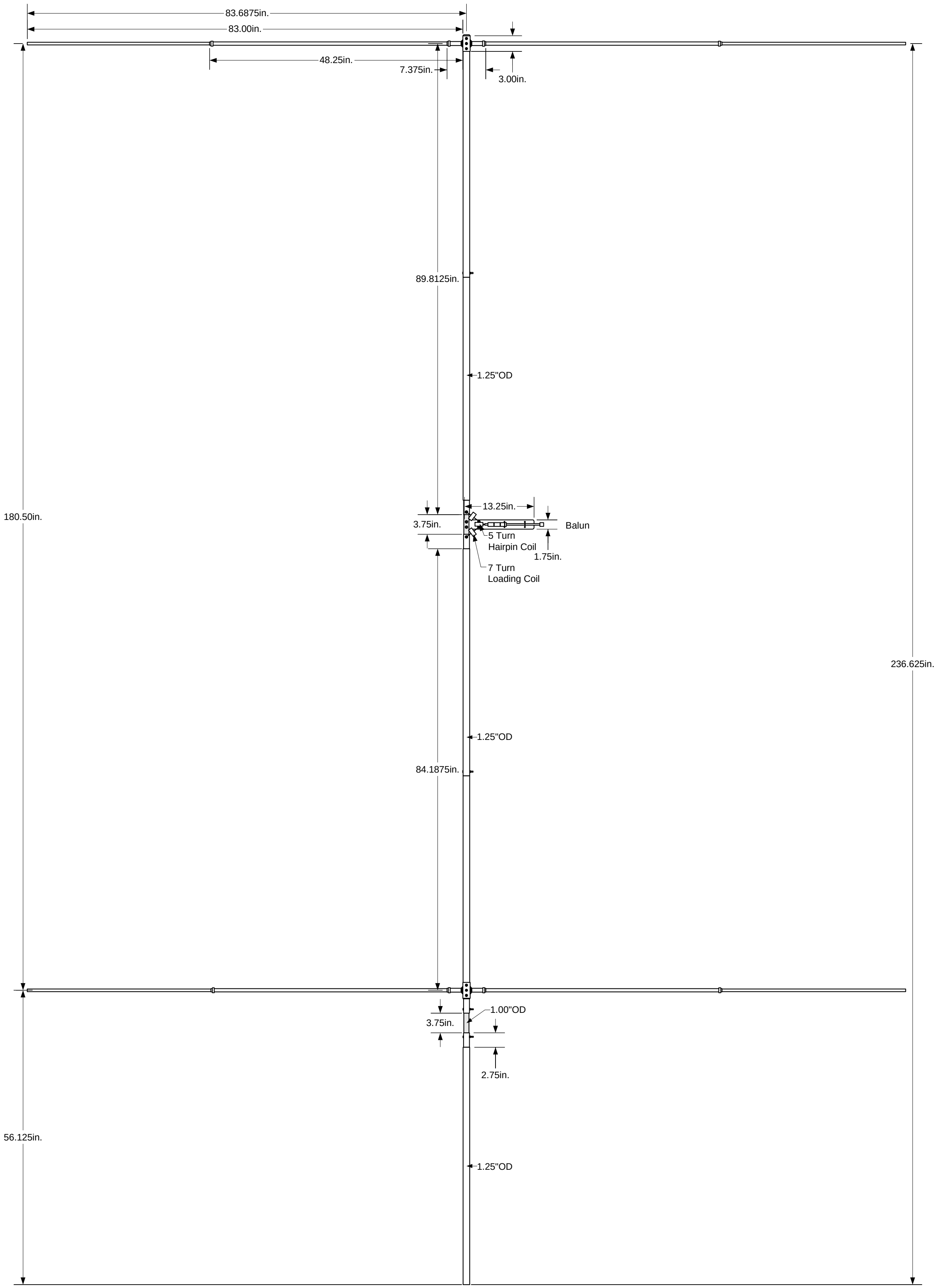
This configuration uses a T-bar length of 83 inches per side. Two 7-turn loading coils connect the antenna elements to the balun, and a 5-turn hairpin match coil is placed across the antenna elements. Spread the 5-turn hairpin coil to ¼ inch spacing (coil to coil) or until a satisfactory SWR is obtained. Vary the spacing on the two 7-turn loading coils to move the lowest SWR into the band center or area of interest. All coils are 1.5" ID and made from THHN insulated 12 gauge solid wire with ring terminals on each end. The coils are included in the EZNEC models but their R+jX values were highly modified to get the model resonance near 50 ohms. I will address this coil modeling issue as time allows.



Measured SWR

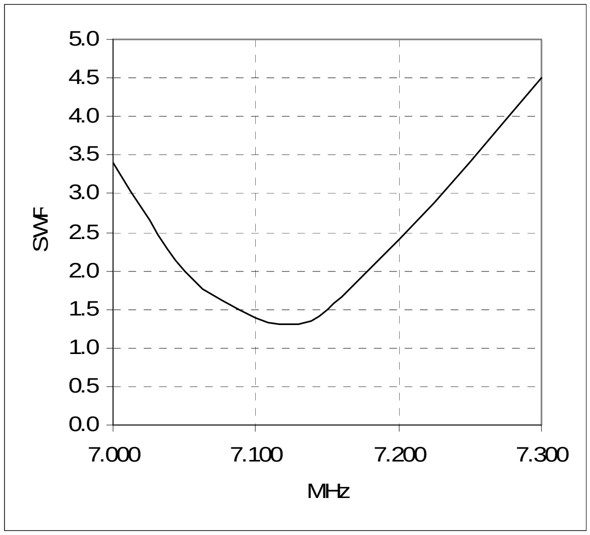


EZNEC 4.0 Elevation plot

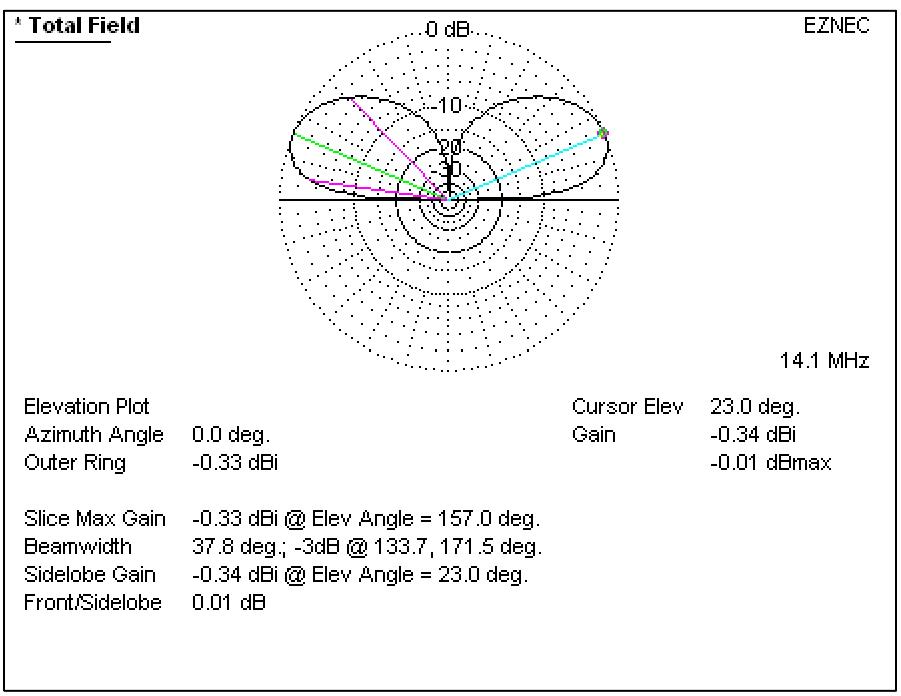

83.6875in.
83.00in.
48.25in.
7.375in.
3.00in.
89.8125in.
1.25"OD
180.50in.
13.25in.
3.75in.
Balun
5 Turn
Hairpin Coil
1.75in.
7 Turn
Loading Coil
236.625in.
1.25"OD
84.1875in.
1.00"OD
3.75in.
2.75in.
56.125in.
1.25"OD

40 Meters

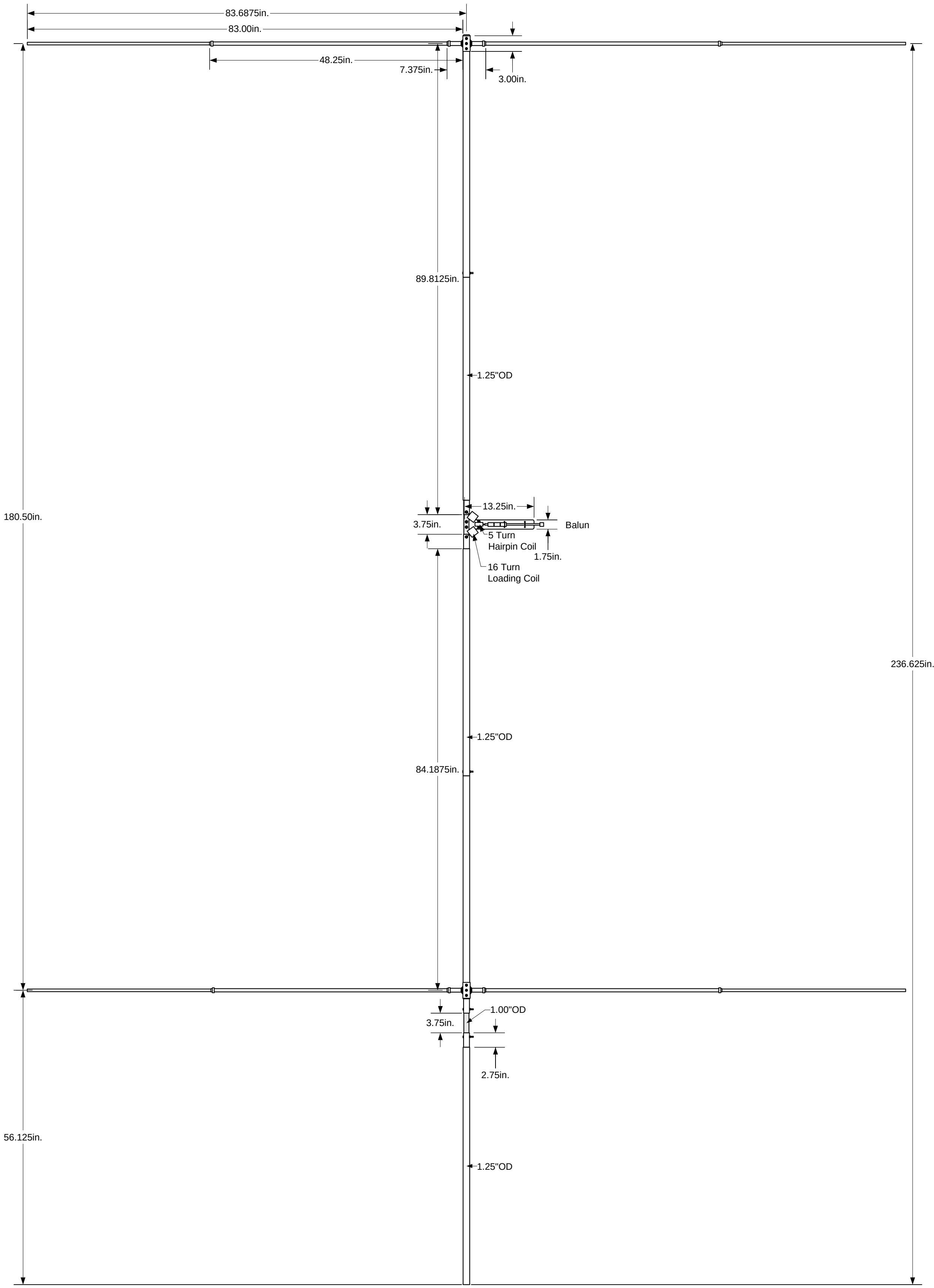
This configuration uses a T-bar length of 83 inches per side. Two 16-turn loading coils connect the antenna elements to the balun, and a 5-turn hairpin match coil is placed across the antenna elements. Spread the 5-turn hairpin coil to ¼ inch spacing (coil to coil) or until a satisfactory SWR is obtained. Vary the spacing on the two 16-turn loading coils to move the lowest SWR into the band center or area of interest.



Measured SWR



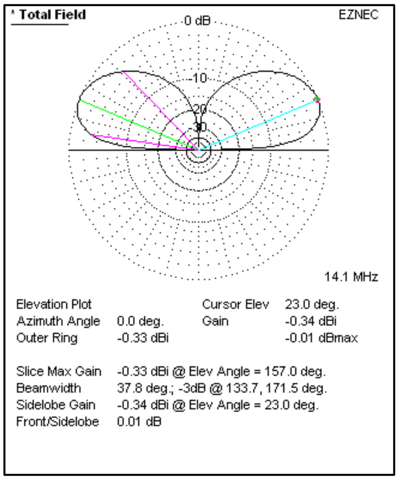
EZNEC 4.0 Elevation plot

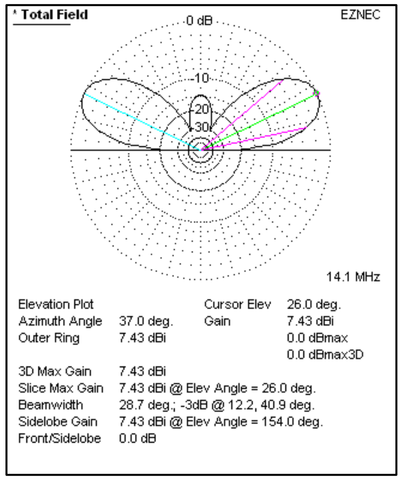

83.6875in.
83.00in.
48.25in.
7.375in.
3.00in.
89.8125in.
1.25"OD
13.25in.
3.75in.
Balun
5 Turn
Hairpin Coil
1.75in.
16 Turn
Loading Coil
180.50in.
236.625in.
1.25"OD
84.1875in.
1.00"OD
3.75in.
2.75in.
56.125in.
1.25"OD

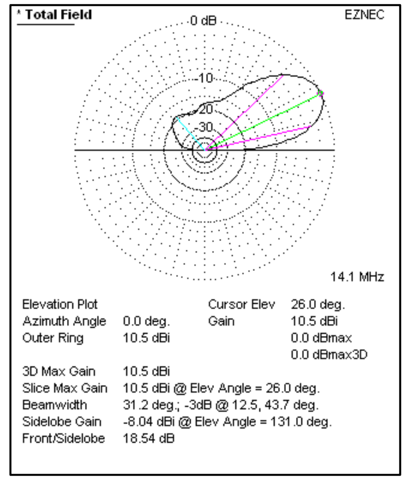
Summary

According to EZNEC 4.0, the average take-off angle over average ground for bands 10m-40m is 20.6°. This take-off angle is not optimum, as most DX work calls 10° or less, especially during marginal conditions or pile-ups. In general "the higher, the better" proves to be true as it decreases the take-off angle[4].

Comparisons were made between the Sigma-40XK (20m), G5RV, and a 20m wire Moxon at 35 feet. Elevation plots reveal that the Sigma has a TOA of 23°, while the G5RV and Moxon are 26°.

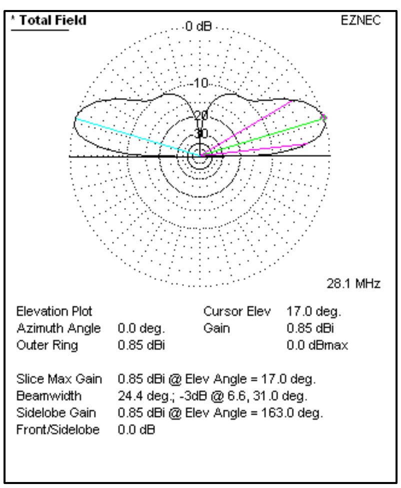


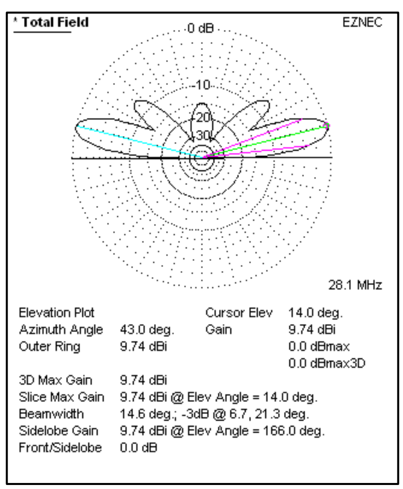


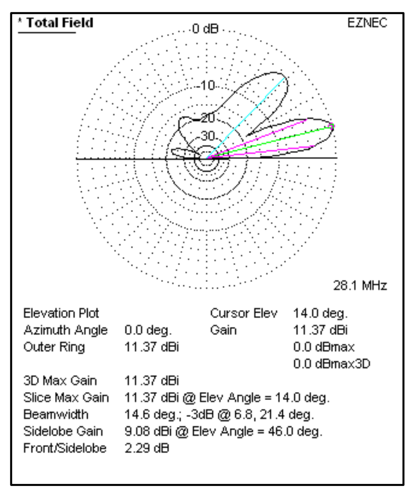


Sigma-40XK (20m) G5RV 20m Moxon

Another comparison was made for 10 meters. Elevation plots reveal that the Sigma has a take-off angle of 17°, while the G5RV and 10m Moxon are 14°.







Sigma-40XK (10m) G5RV 10m Moxon

On 20 meters, raising the Sigma to a height of 10 feet shifts the SWR resonance slightly and lowers the take-off angle to 20°. On 10 meters, the takeoff angle drops to 14°. This can be accomplished by hanging the antenna from a tree limb.

In order to try a different feeding method, I removed the balun and connected 25 feet of 450Ω ladder line directly to the antenna. Feedline coupling was a little more noticeable with the ladder line so it was pulled almost 90° away from the antenna. The ladder line terminates to a Budwig HQ-1 connector, a 1:1 choke balun, and then 50 feet of RG-8X coax to an LDG AT-100Pro tuner. With the Sigma setup for 20m, I measured the SWR with the analyzer and began tuning. I noticed some trouble tuning 17m so I extended the T-bar arms to their maximum and added the hair-pin coil. The results are show in Figure 1.

The Sigma-40XK was designed to be mounted with the lower T-bar four feet off the ground. And, while the antenna has no gain and a fair take-off angle, its most appealing features are portability, small footprint, and multiband 50Ω coverage. On-the-air results with the Sigma-40XK were good. I could work any signal I could hear and the ladder line and auto tuner setup makes it a breeze to change bands. This antenna will definitely be among those that I take for portable use such as camping and field day. Because of its small size and low profile I am looking for a semi-permanent place to mount it in the back yard, invisible to the neighborhood restriction watchers.

Allen Baker, KG4JJH
kg4jjh@arrl.net

Table 1

MHz	SWR	R	X	Tuner SWR
3.500	10.5:1	3	5	No tune
3.600	10.8:1	3	7	No tune
3.700	10.8:1	3	10	No tune
3.800	11.1:1	2	13	No tune
3.900	11.1:1	2	17	No tune
4.000	11.1:1	1	20	No tune
7.000	12.4:1	3	67	1:1
7.100	13.1:1	3	78	1:1
7.200	14:1	3	92	1:1
7.300	14.4:1	3	109	1.7:1
10.100	10.3:1	0	33	1:1
10.125	10.3:1	0	32	1:1
10.150	10.3:1	0	31	1:1
14.000	6.3:1	50	151	1:1
14.100	6.1:1	71	169	1.3:1
14.200	5.9:1	118	190	1:1
14.300	5.7:1	207	188	1:1
14.350	5.7:1	261	168	1:1
17.068	5.3:1	7	29	1:1
17.112	5.3:1	7	28	1:1
17.168	5.4:1	6	26	1:1
21.000	5.9:1	13	64	1:3
21.100	5.7:1	15	69	1:1
21.200	5.7:1	18	75	1.7:1
21.300	5.7:1	22	82	1:1
21.400	5.7:1	26	89	1.2:1
21.450	5.7:1	30	93	1.2:1
24.890	4.8:1	7	27	1:1
24.990	4.7:1	6	24	1:1
28.000	1.1:1	54	6	1:1
28.100	1.2:1	46	9	1:1
28.200	1.3:1	40	9	1:1
28.300	1.4:1	35	8	1:1
28.400	1.6:1	32	9	1:1
28.500	1.8:1	29	8	1:1
28.600	2.0:1	28	10	1:1
28.700	2.2:1	27	14	1:1
28.800	2.4:1	26	18	1:1
28.900	2.6:1	26	33	1:1
29.000	2.9:1	26	28	1:1
29.100	3.1:1	26	34	1:1
29.200	3.3:1	28	40	1:1
29.300	3.5:1	29	47	1:1
29.400	3.8:1	31	54	1:1
29.500	4.0:1	34	62	1:1
29.600	4.2:1	38	71	1:1
29.700	4.4:1	43	81	1:1

Notes

[1] Sigma-40XK, Force 12; http://force12inc.com/sigma40XKinfo-001.htm
[2] *Verticals Without Vertigo*, L.B. Cebik, W4RNL; http://www.cebik.com/fdim/fdim4.html
[3] *A Triangle for the Short Vertical Operator*, L.B. Cebik, W4RNL; http://www.cebik.com/gp/vhat.html
[4] *What Difference Does height Make?*, L.B. Cebik, W4RNL; http://www.cebik.com/a10/ant5.html