

6m 5-Element LFA Yagi Antenna

Build this loop fed beam with 11 dBi gain and 23 f/b ratio

A never ending quest for the optimum 6m antenna led me to try a Loop Fed Array Yagi¹. This design, pioneered by Justin Johnson, G0KSC, claims lower noise and a better 50Ω impedance match than conventional Yagi's by using a loop for the driven element. Justin has many designs featured on his website but cautions builders that his published SWR curves are based on his use of the NEC-4 (Numerical Electromagnetics Code) modeling engine. Since my EZNEC 4 antenna software uses the NEC-2 engine I decided to build one of his designs that modeled well on my software. Additionally, I was eager to try out my new Christmas present, a YouKits model FG-01 antenna analyzer².

The Yagi has a 15'-9" boom and breaks down into pieces no longer than 66" for portability. The mast is 1-1/2" square aluminum, with 5/8" OD and 1/2" OD aluminum tubing elements. The EZNEC 4 model predicts a free space gain of 11 dBi with a front-to-back ratio of 22.5 dB at 50.150 MHz. When mounted at a 25 foot elevation, the gain and front-to-back ratio are predicted to be 16.2 dBi and 25.2 dB, respectively.

Elements

Elements REF, DE2, DIR1, DIR2, and DIR3 are fashioned from 5/8" OD aluminum tubing and are halved and joined in the center with a 6" piece of 1/2" OD tubing. Two thread-cutting screws per element fasten the center 1/2" OD tubing to the 5/8" OD tubing. Driven element DE1 is joined in the center by a 1/2" OD x 6" long piece of solid fiberglass. This creates a more stable element than leaving the ends open between the tubing clamps. Stainless steel 8-32 x 1-1/2" hardware secures the tubing to the fiberglass and the coax to the feed point.

Tube Bending

The outer portions of the driven element loop (DE1 and DE2) use 1/2" OD tubing with the 90° bends made using a tubing bender. I used a Ridgid 408 bender but did not have success making the bends without breaking the 6063-T832 aluminum alloy. I tried a length of Home Depot tubing (type and temper unknown) and it bent perfectly. I am not sure why this happened as the 6063-T832 temper is supposed to be the best for bending.

I learned that the tube bender radius refers to the tubing centerline, not the inside radius of the bend. The method I used was to find the center of a 1/2" OD x 36" long tube. Place two marks, spaced 18-5/16" apart, and centered on the tube. Extend these two lines to form a ring all the way around the tube. (I chucked the tubing in my drill and held a marker on the tube). Insert the tubing into the bender and line up the bender zero index line with one of the rings drawn around the tube and latch the tube down. Make the bend using slow and constant pressure until a 90° angle has been achieved. Do not bend all the

way to the 90° bend mark when bending softer tubing such as copper or aluminum or you will over-bend. All tubing will exhibit spring back after a bend has been completed. The amount of spring back depends on the bend angle, bend radius, tubing material, and wall thickness. Remove the tube from the bender and insert the other end into the bender, align the drawn ring, latch the tube, and prepare to make the second bend. To ensure that both bends are parallel, view across the top of the bender and line up the first bend parallel to the bender die assembly. Refer to the drawings for more tube bending dimensions and details. Stainless steel tubing clamps secure the inner 5/8" OD tubing to the outer 1/2" OD elements.

To reduce interference from the coax, a hole is drilled through the boom in front of the feed point and the coax is fed through the hole to the bottom of the boom. Grommets are installed in the top and bottom holes to prevent insulation damage. A five turn loop x 3" diameter choke balun is wound at this point and secured to the bottom of the boom. Seal the exposed coax to prevent moisture ingress.

Element Clamps

Element clamps are 5/8" OD pneumatic tubing clamps made by the Stauff Corporation³. These green polypropylene clamps are used in the G0KSC InnovAntennas⁴ and are recommended as having the least effect on VHF frequencies as they contain no carbon. Do not use the zinc plated hardware that came with the clamps as the top plate adds more metal near the element and is not needed. Each clamp mounts on the boom and boom angles using 1/4-20 stainless steel socket head cap screws and lock washers. The boom and boom angle clamp mounting holes are tapped for 1/4-20 threads.

Boom

The 15'-9" boom is made from three pieces of 1-1/2" square x 63" aluminum tubes joined together with 12" sections of 1-3/8" OD aluminum tubing and hardware. The 12" sections of 1-3/8" tubing fit snugly inside the boom and are fastened using two 10-32 x 2" screws and lock nuts on each side of the joint. To facilitate an easier assembly and disassembly, drill the boom and joiner tube holes using a 1/8" bit all the way through. Disassemble the joined section and redrill all holes using a 0.201" bit and then clean up the holes on the inside and outside using a file.

Mast to Boom Bracket

Square booms present a challenge for mounting a boom to a mast without drilling holes through the boom. Square U-bolts are not readily available in the right size so the mounting bracket was made using aluminum angles, stainless steel 1/4-20 hardware, and two V-saddle clamps. This method was chosen to allow the antenna's balance point to be adjusted later by sliding the bracket back and forth.

Construction

All aluminum tubing and angles were rough cut with a band saw with a metal cutting blade. Tubing ends and angle edges were then deburred and trimmed to final size using a table sander and a file. If desired, the aluminum can be cleaned up with a steel wool pad.

The tubing clamp mounting holes are spaced at an odd value (0.201") so I prepared and printed a drill template. Cut out the templates and temporarily fastened them using a glue stick. Mark the centerlines on the boom and angles and place each template at the desired location. Center punch the hole locations, drill 0.201" OD holes, and thread each hole using a 1/4-20 tap.

EZNEC 4 Modeling

I modeled the antenna in EZNEC 4 and was gratified with an extremely low SWR from 50 to 50.5 MHz (Figure 1). The free space model indicates a gain of 11.01 dBi and 22.56 dB F/B ratio at 50.150 MHz (Figure 2). In reference to a free space dipole (2.15 dBi), the LFA Yagi gain is 8.86 dBd. For the region of interest (50 to 50.5 MHz), the free space gain and SWR are relatively flat with a 24.3 dB F/B peak at 50.0 MHz. With the antenna mounted at 25 feet elevation over average ground the modeled gain is 16.21 dBi, 25.16 dB F/B, with an 11° take-off angle (Figures 3 & 4). Figure 5 shows the gain, F/B ratio, and SWR on one linear chart.

Initial Assembly & Adjustment

For portability, the antenna breaks down into easily transportable pieces:

- 3 each – 1 1/2" square x 63" boom pieces (with joiners attached)
- 2 each – 1-3/8"OD x 12" boom joiners
- 2 each – 5/8"OD x 58-3/8" REF elements
- 2 each – 5/8"OD x 45" DE1 elements
- 2 each – 5/8"OD x 45-1/4" DE2 elements
- 2 each – 5/8"OD x 54-7/16" DIR1 elements
- 2 each – 5/8"OD x 52-1/8" DIR2 elements
- 2 each – 5/8"OD x 51-1/8" DIR3 elements
- 2 each – 1/2"OD x 21-13/16" x 8" DE1/DE2 bent elements

Be sure to label each piece to speed assembly time. Assemble the boom using 1-3/8" OD x 12" aluminum tubing. Two 1-1/2" x 2" x 1/8" aluminum angles are mounted on the side of the boom for the DE1 tubing clamps. The 5/8" OD element halves are secured to a 1/2" OD x 6" aluminum tube. The 5/8" OD driven element halves are secured to a 1/2" OD x 6" fiberglass rod with 1/2" separation. Loosen the tubing clamp screws and place each completed element in the clamp taking care to center the element in the clamp and tighten the screws.

Use a square to ensure that the elements are at right angles to the boom. Place hose clamps at the ends of the driven element tubes, insert each 1/2" OD aluminum bent end piece and tighten the hose clamps when the bent end centerline is 49-1/4" from the center of the boom. An easier measurement is from the far side of the boom to the outer end of the bent tube, or 50-1/4". The SWR may be adjusted later by loosening the hose clamps and sliding the bent ends in and out.

Initial Testing

The antenna weighed in at 19-1/2 pounds and was initially assembled and mounted at two feet off the ground. The FG-01 antenna analyzer was connected and revealed that the

resonance was around 50.4 MHz. Knowing that this frequency will increase as the antenna is mounted higher, I extended the outer portions of the driven elements (DE1 and DE2) by ½” and the resonance indicated 50 MHz. Boom sag was approximately one inch on each end, and, according to the EZNEC model, does not affect performance.

The next test was conducted with the antenna up 25 feet on my AB-952 mast. The assembled antenna withstood 40 mph winds during several storms with no damage. The driven element dimension from the far side of the boom to the outer side of the bent tube was 50-3/4”. The FG-01 antenna analyzer was used to generate the data in Figure 6. This pocket sized unit displays SWR and impedance on a color display. The analyzer was a pleasure to use and is perfect for tuning antennas.

On the Air

As luck would have it the only activity on 6m was local (less than 50 miles) for the few days I had the antenna up in the back yard. Neighborhood restrictions prevent me from leaving it up for more than a week, so I will be making additional progress reports when the band opens and I am able to install the antenna for longer durations at a portable site.

Summary

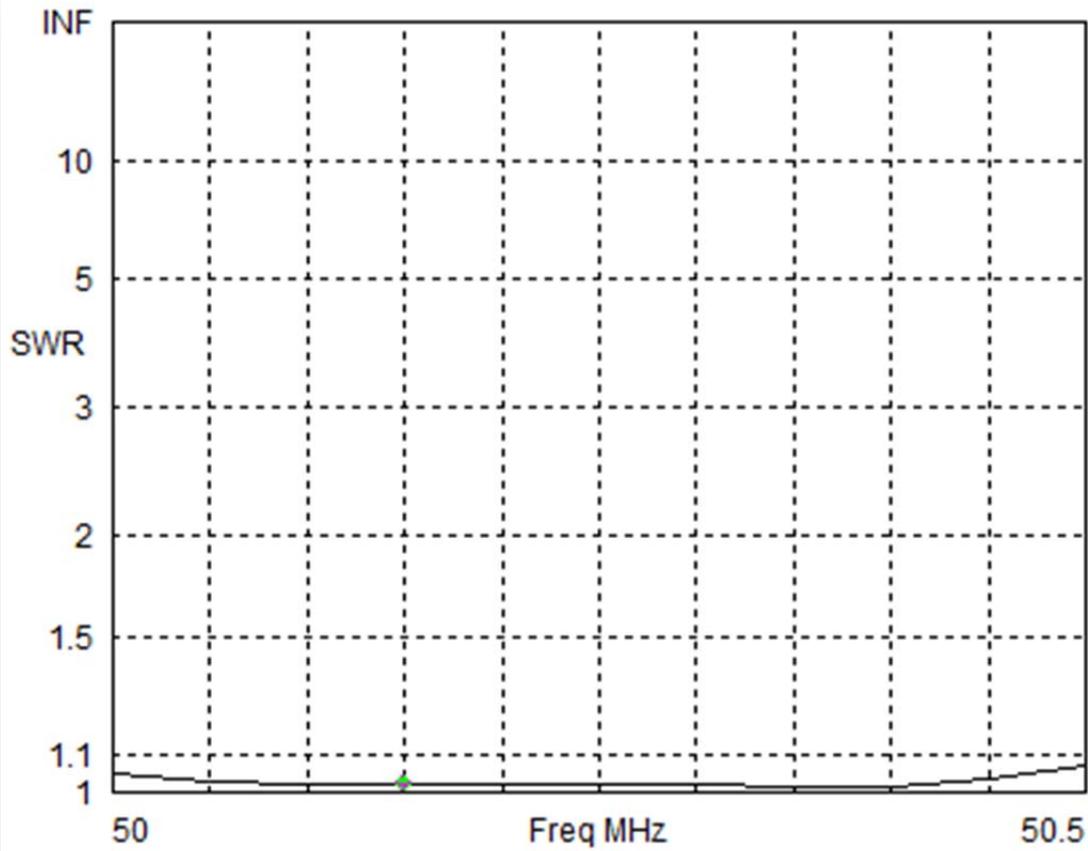
This is my first LFA Yagi and initial performance indicates that this antenna will be a big improvement over my 6 dBi gain 6m Moxon⁵. The modeled Loop Fed Array delivers an outstanding 50Ω match with an average impedance of 50.01 – j0.86Ω from 50 to 50.5 MHz.

The process of tube bending is not difficult once the basics are understood and should not deter would-be builders. As is, the antenna can be broken down into manageable pieces for portability, or it can be built with longer components for permanent installations. To aid in construction and setup, detailed drawings are available on my website.

GL & 73,
Allen, KG4JJH
<http://www.kg4jjh.com>

References

1. *Revolutionary ‘Loop Fed Array’ Yagi Antenna Feed System*, Justin Johnson, G0KSC, http://www.vinecom.co.uk/dubus_lfa.pdf
2. Ten-Tec, YouKits FG-01 Antenna Analyzer, <http://www.tentec.com/products/FG%252d01-Antenna-Analyzer.html>
3. Tubing Clamps, Stauff Corporation, <http://www.stauffusa.com/customer/stcorp/catalog/clamps.htm>
4. InnovAntennas, <http://www.innovantennas.com/>
5. KG4JJH Amateur Radio Projects, <http://www.kg4jjh.com/6moxon.html>



Freq	50.15 MHz	Source #	1
SWR	1.021	Z0	50 ohms
Z	50.89 - j 0.5487 ohms		
Refl Coeff	0.01037 at -31.31 deg.		

Figure 1
Free space modeled SWR

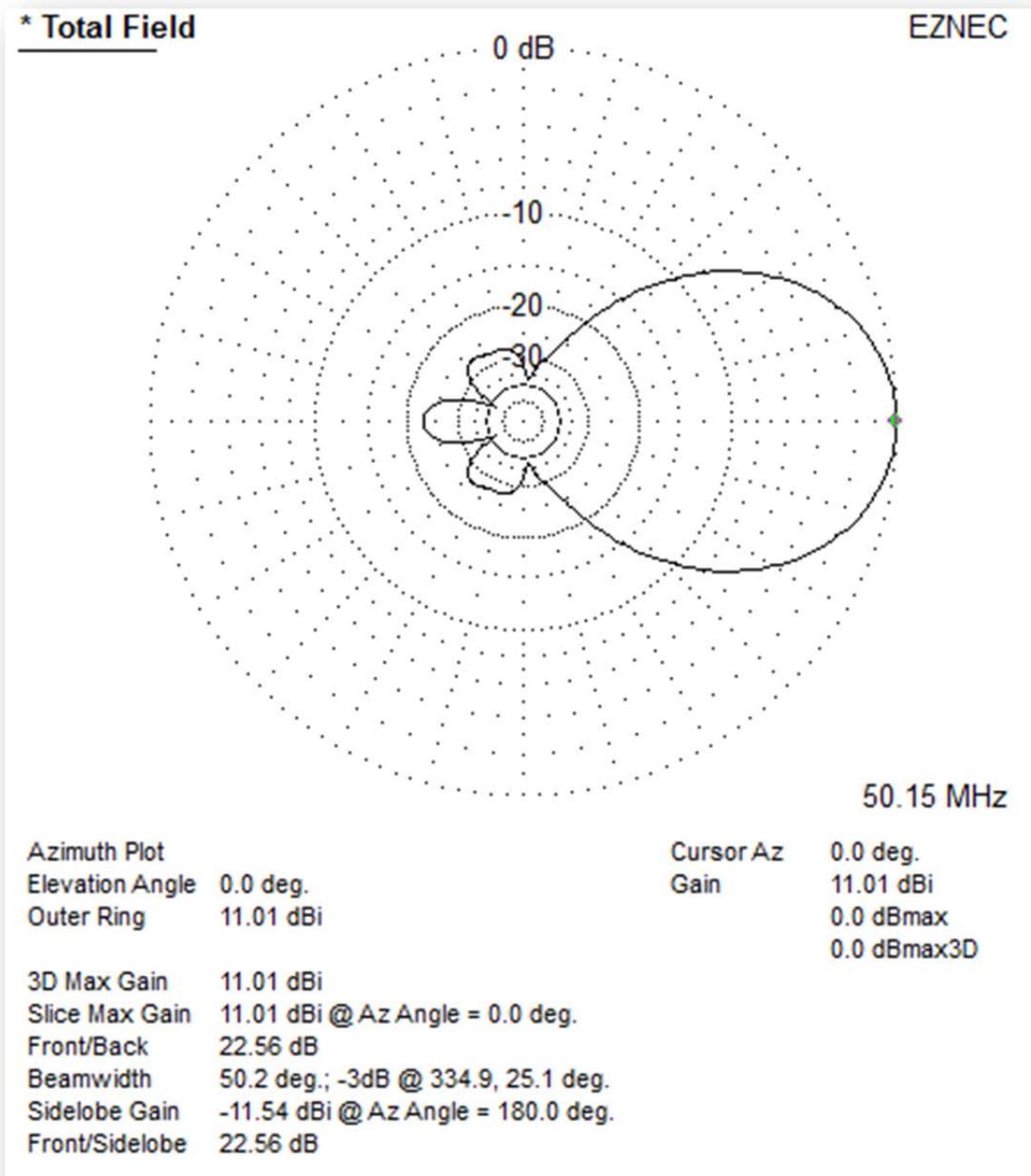


Figure 2
Free space modeled azimuth plot

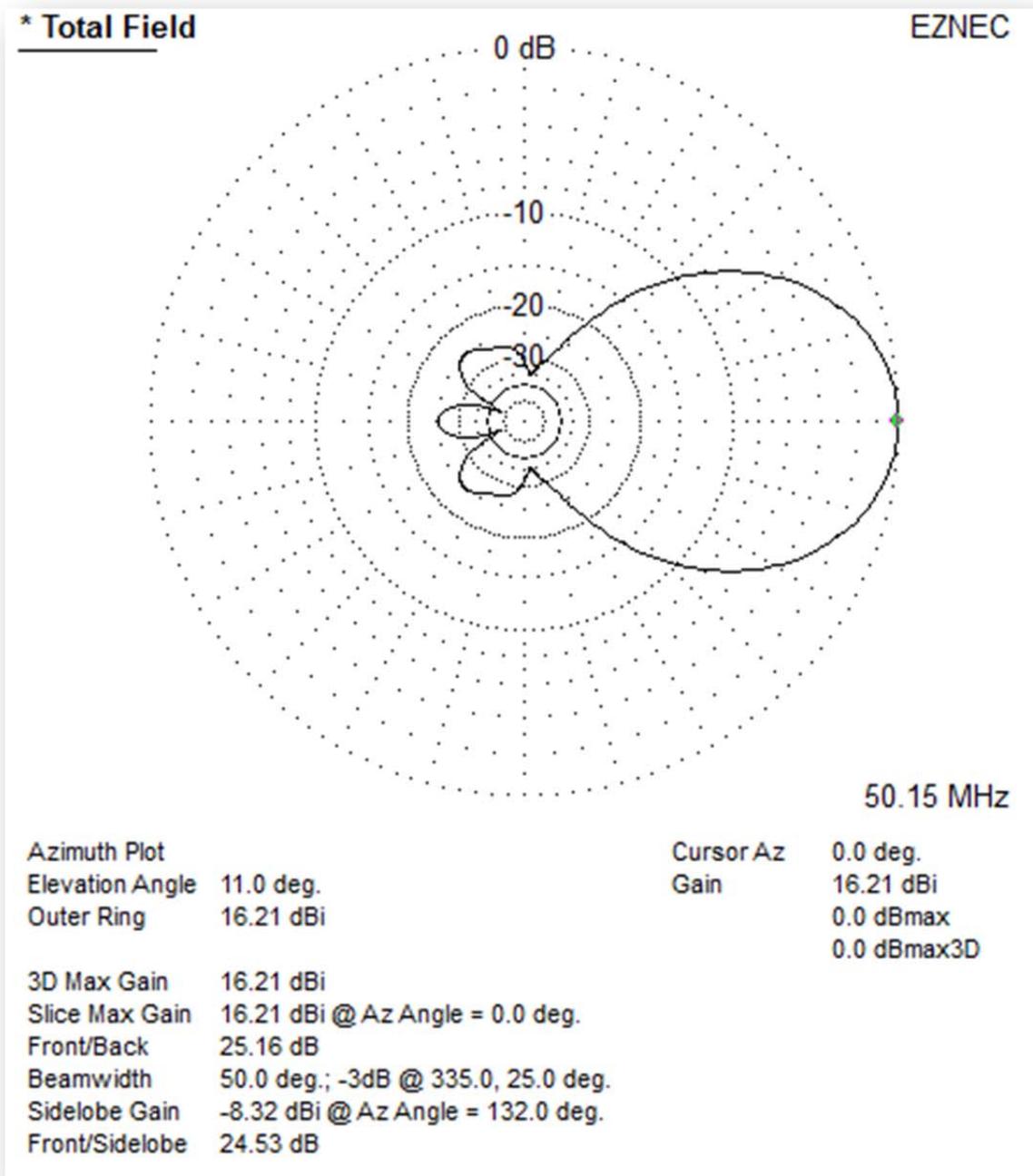


Figure 3
Modeled azimuth plot for 25 foot elevation over average ground

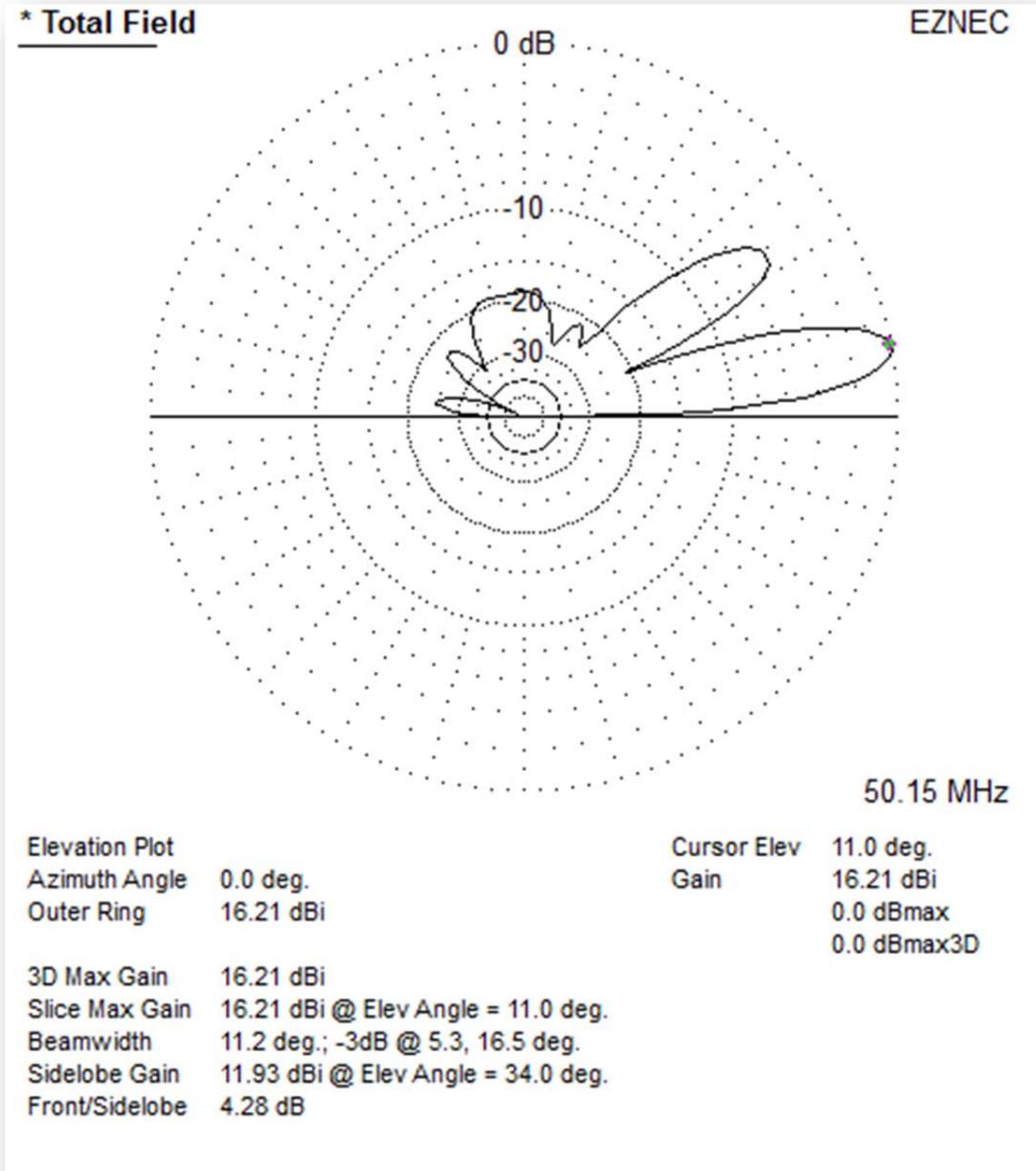


Figure 4
Modeled elevation plot for 25 foot elevation over average ground

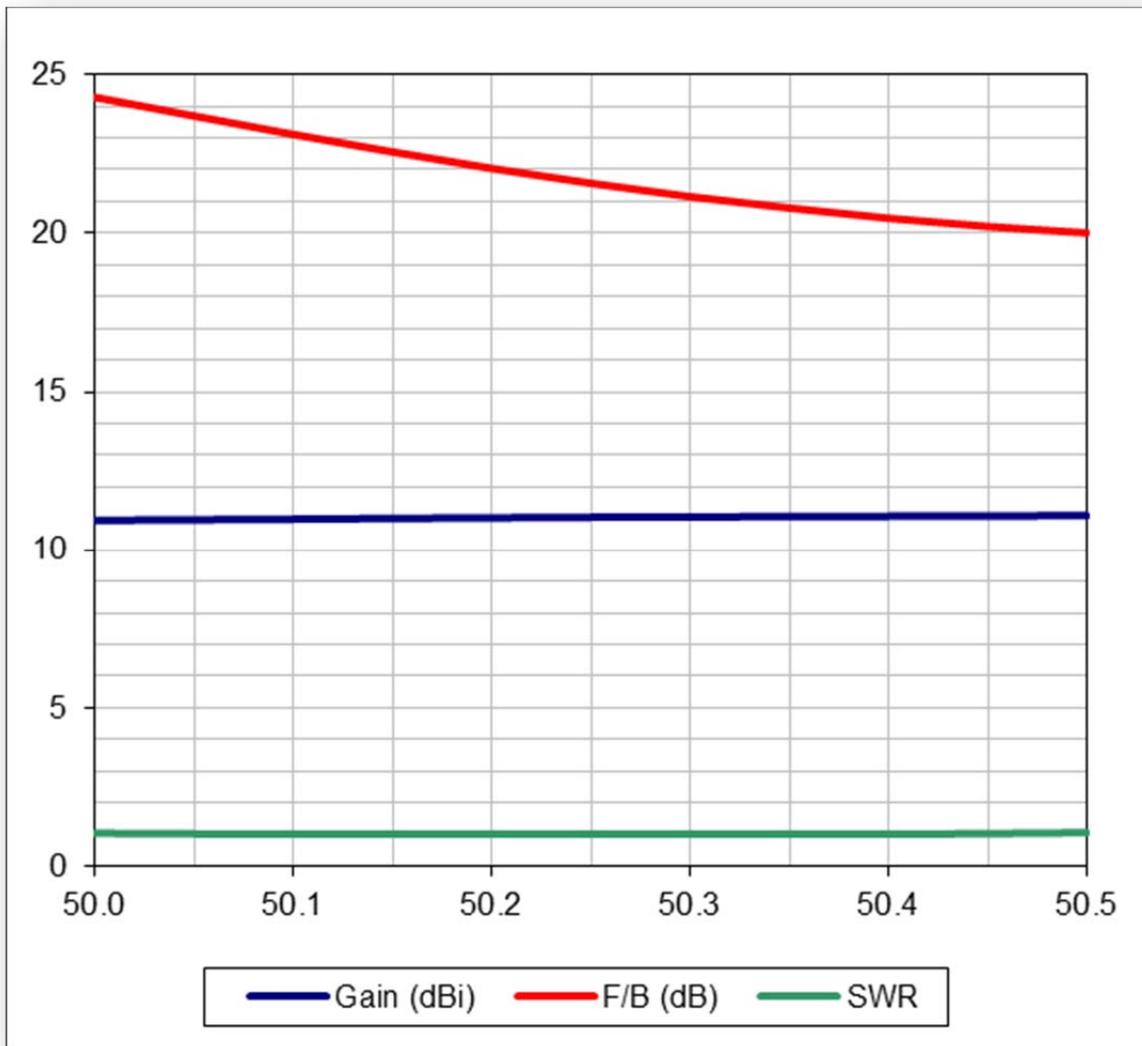


Figure 5
Modeled free space Gain, F/B Ratio, and SWR

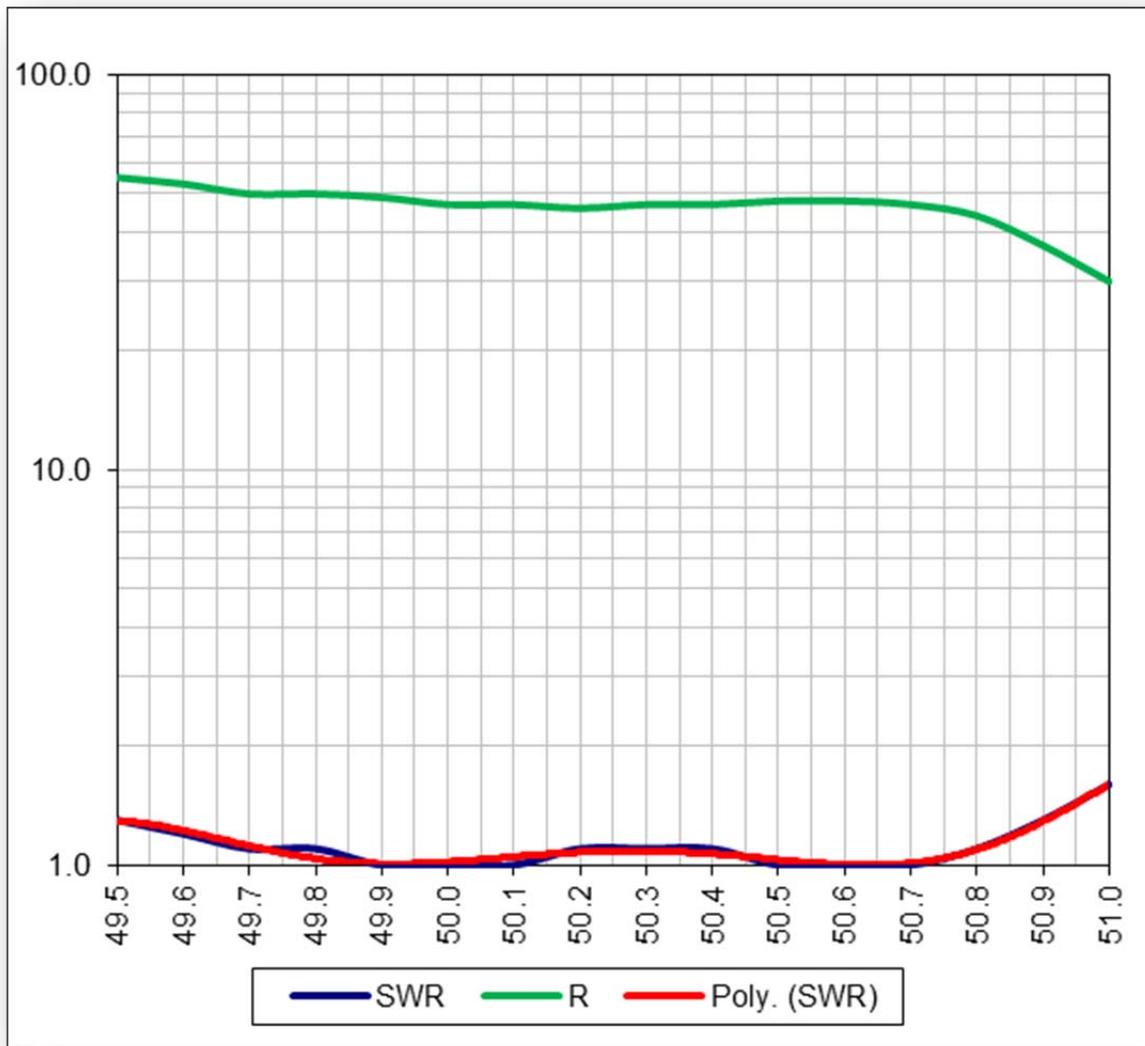


Figure 6
 Measured SWR and Impedance at 25 foot elevation over average ground
 (The red curve is a smoothing of the measured SWR)