Quad Driven Uda-Yagi "Quagi" Antennas

(last update: 12 Mar 2011)

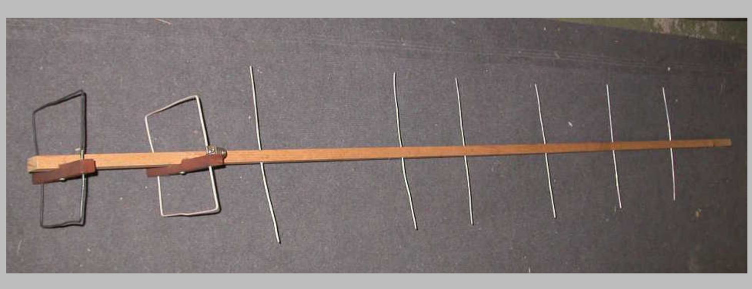
A Quagi antenna is a variation on the venerable Uda-Yagi, which dates back 1926. A Quagi antenna uses the same strategy as a Uda-Yagi, using a refltector, a driven element, and then a number of director elements. However, a Quagi constructs the reflector and the driven elements as "quads" rather than as linear elements. In a Quagi the first two elements of the antenna are quads, the directors are all simple straight wire elements, as in the traditional Uda-Yagi design.

The name Quagi is a simple contraction of Quad-Yagi.

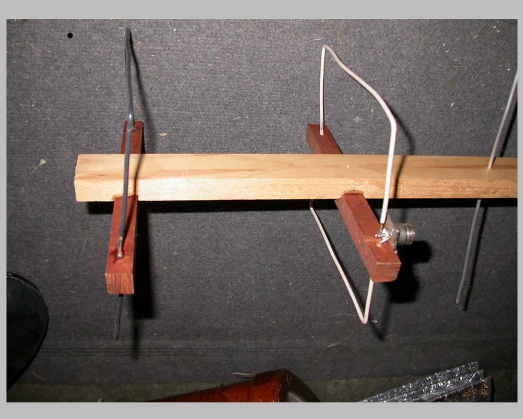
There is a "Quad" class of antennas. They come in single elements, and as arrays. A Quad antenna is typically a single wire formed into a square. The dimensions of the square are adjusted so that the antennas resonates at the intended frequency of operation.

Note that both the Quad and the Uda-Yagi antennas are resonant antennas. If one tries to use them outside of their design frequency limits, results will be poor at best. During transmission the reflected power from the antenna may well cause radio damage.

Here is an example of the ARRL Quagi antenna:



Here is a close up of the reflector and the driven element:

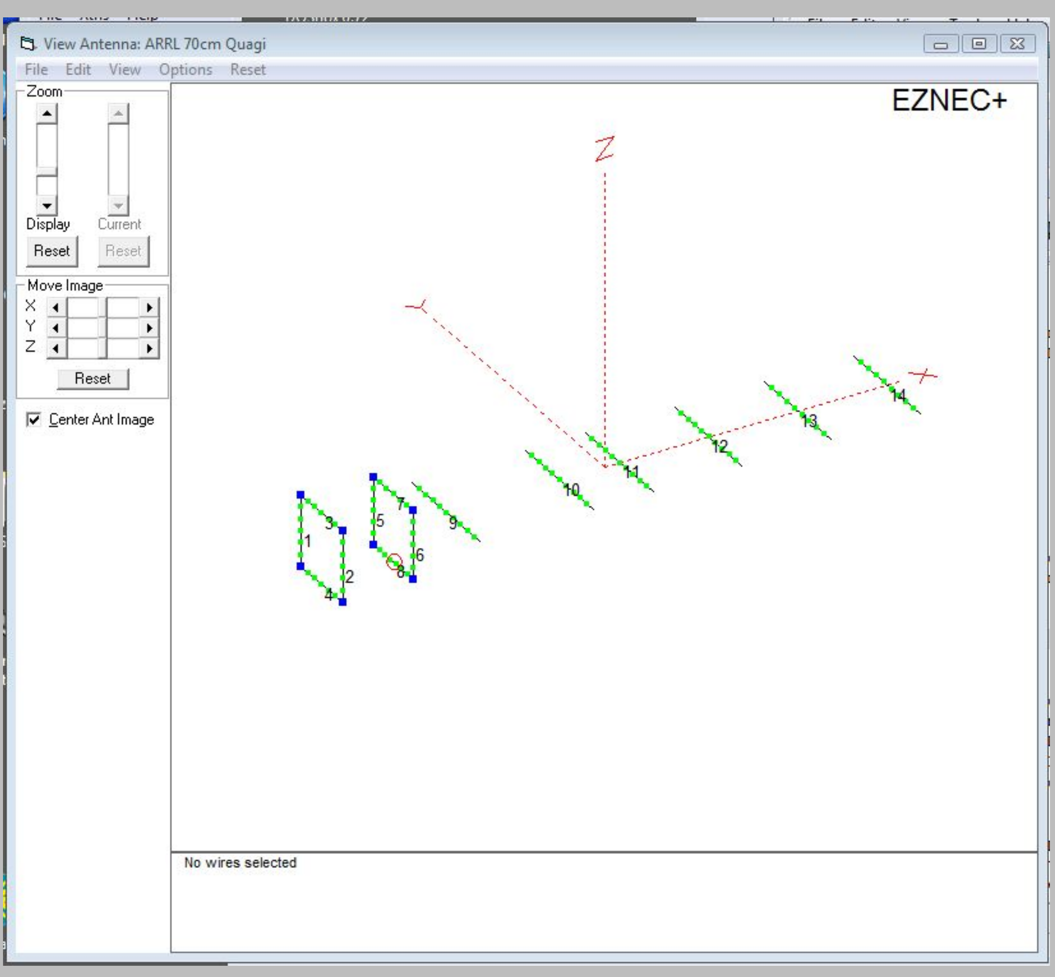


This antenna was built according to the description on page 18-31 of the ARRL Antenna Book 16th ed., which is loaded with practical information. The most recent edition is the 21st.

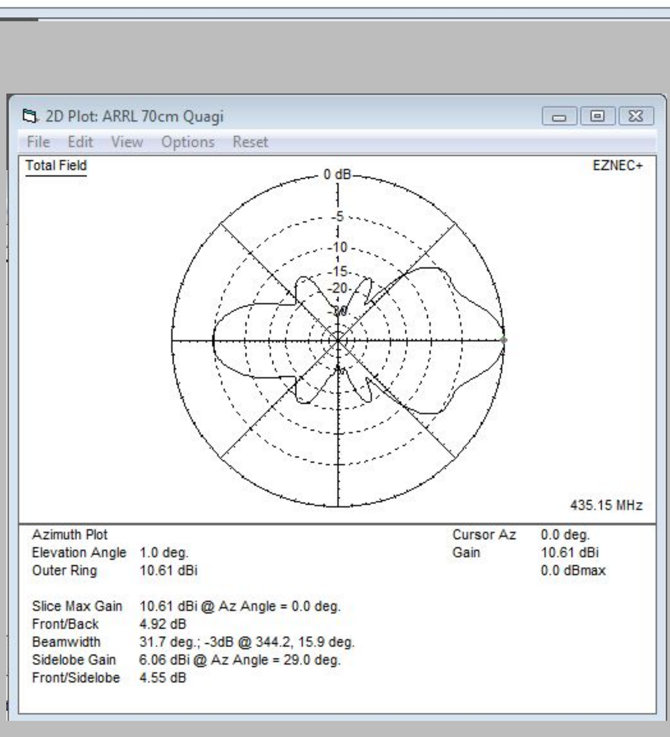
Simulating The Quagi Antenna In NEC2

The first thing to do is to enter the afore mentioned Quagi antenna into the simulator of choice. AA1ZB has a license for EZNEC 5.0 with the default NEC2 engine, so the ARRL Quagi will be entered into that. Here's a link to the EZNEC wire definitions for the ARRL Quagi model in pdf form.

This is a veiw of the antenna in EZNEC:



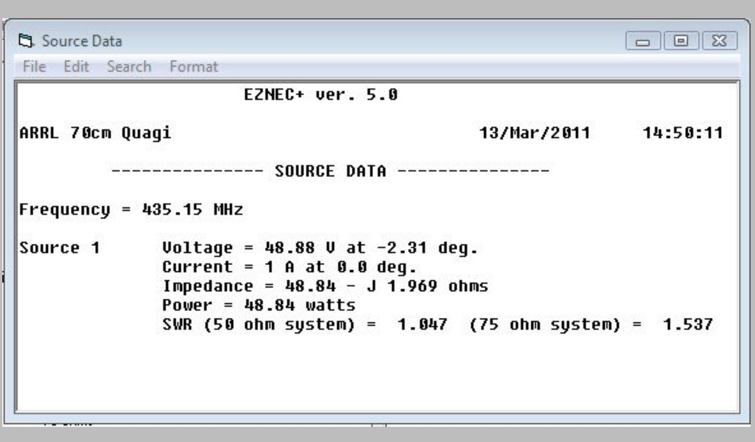
And here's the results of a simulation at 435 MHz:



In this graph we are looking down onto the antenna with the directors in the horizontal position. The reflector and driven element quads are to the left. The directors run off to the right. The highest gain is to the right, in the direction of the directors, at 10.61 dBi.

Of note in these results is the low front-to-back ratio of 4.92 dBi. This is a low front-to-back ratio. Many Uda-Yagi, and Quad array designs have front-to-back ratios of up to 25 dBi. This design is losing quite a bit of power out the back of the antenna.

One other thing to check is the source impedance:



Source Data
File Edit Search Format

EZNEC+ ver. 5.0

ARRL 70cm Quagi 13/Mar/2011 14:50:11

--------------- SOURCE DATA ---------------

Frequency = 435.15 MHz

Source 1 Voltage = 48.88 V at -2.31 deg.
Current = 1 A at 0.0 deg.
Impedance = 48.84 - J 1.969 ohms
Power = 48.84 watts
SWR (50 ohm system) = 1.047 (75 ohm system) = 1.537

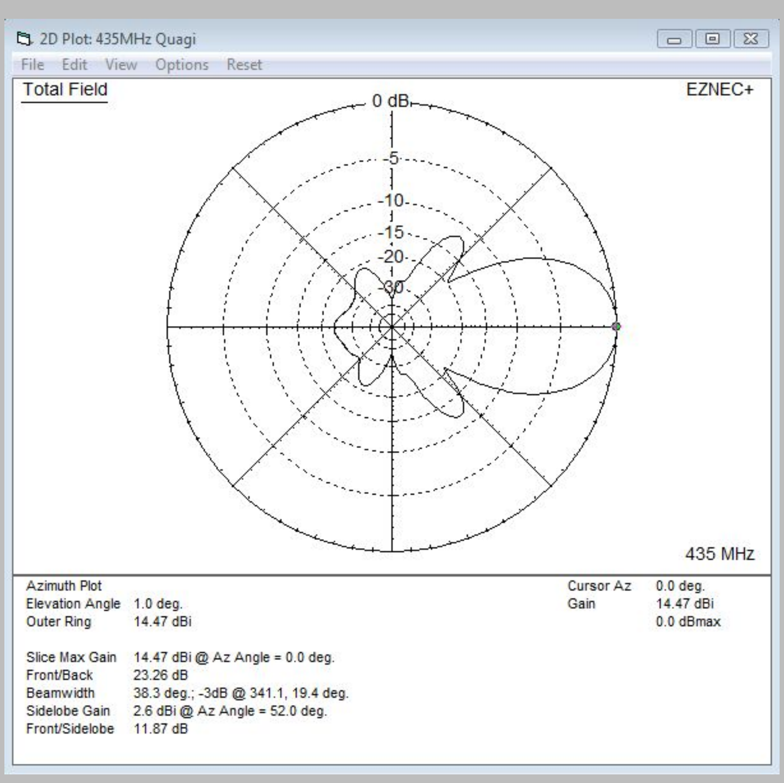
This is a pretty good match to 50 Ω coaxial cable but the gain is modest and the front-to-back ratio is pretty low.

An Optimized Quagi

The previous antenna was copied out of the literature. Using that design as a basis, can we improve the performance?

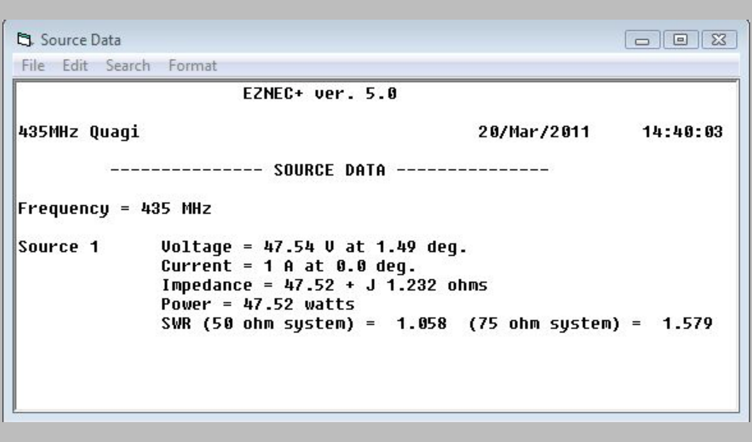
Of coarse we can. NEC makes it pretty easy.

Shown below is the same antenna with some tweaks to crank up the gain, and improve the front-to-back ratio.



The antenna has gone from a ho-hum performer to one with some serious specs. First off the front-to-back ratio now rivals the kind of rejection (25 dB) talked about in the literature. Its front-to-back ratio of 23.26 dB is quite good. Second, the gain of 14.47 dBi is as good as some Uda-Yagi antennas of twice the number of directors.

What about the match?



Source Data
File Edit Search Format

EZNEC+ ver. 5.0

435MHz Quagi 20/Mar/2011 14:40:03

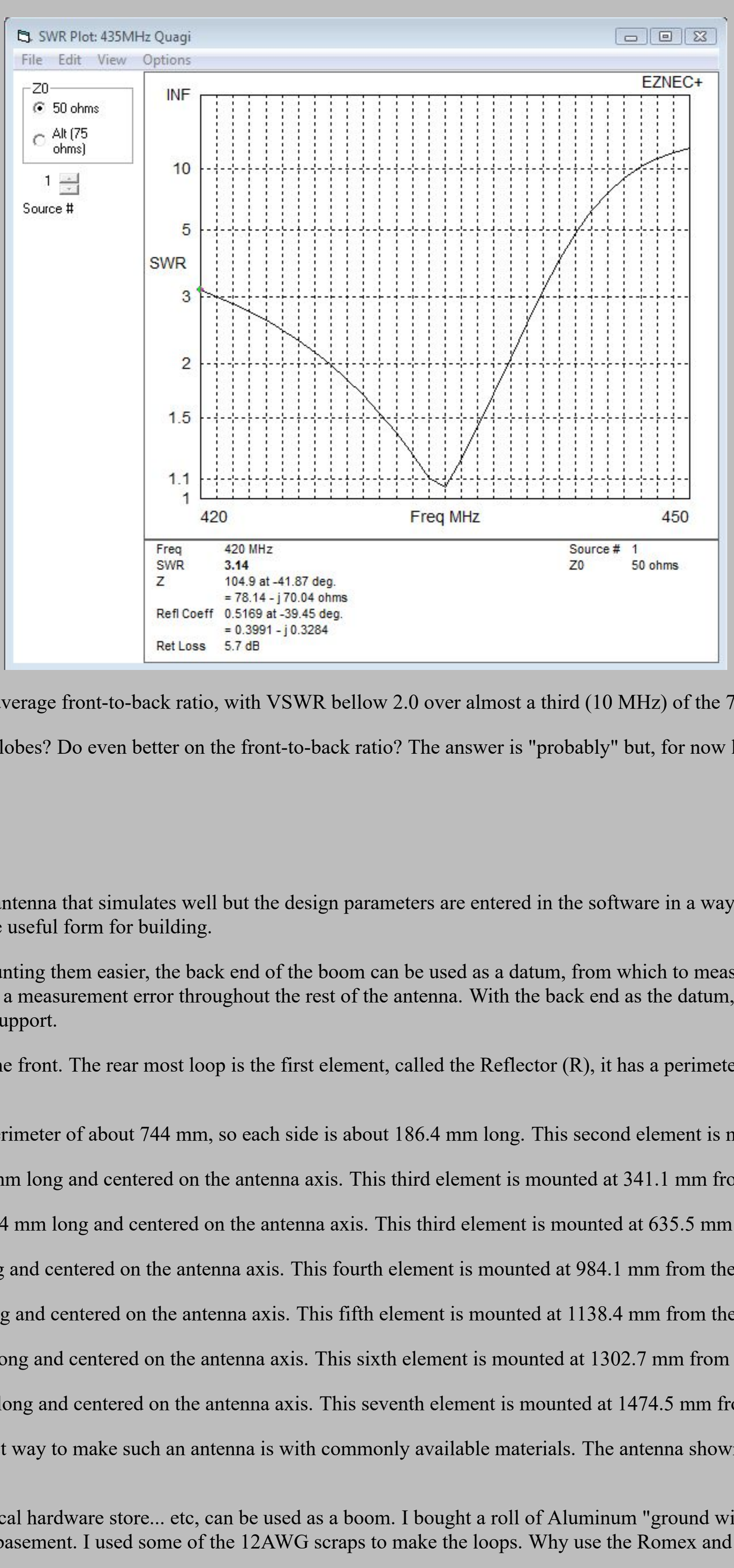
--------------- SOURCE DATA ---------------

Frequency = 435 MHz

Source 1 Voltage = 47.54 V at 1.49 deg.
Current = 1 A at 0.0 deg.
Impedance = 47.52 + J 1.232 ohms
Power = 47.52 watts
SWR (50 ohm system) = 1.058 (75 ohm system) = 1.579

Again we have a decent match.

And finally a VSWR graph:



So the antenna now has some serious gain, and a better than average front-to-back ratio, with VSWR bellow 2.0 over almost a third (10 MHz) of the 70 cm band. Not too shabby.

Could we tweak out the reactance? Could we reduce the side lobes? Do even better on the front-to-back ratio? The answer is "probably" but, for now lets move on to one method of construction.

Constructing An Optimized Quagi

To build an antenna, we need some dimensions. We have an antenna that simulates well but the design parameters are entered in the software in a way that is good for the software, and not so good for building things. We will need to turn the software numbers into a more useful form for building.

The first two elements of the antenna are loops. To make mounting them easier, the back end of the boom can be used as a datum, from which to measure where all the elements will be located. Always measuring from the datum helps prevent us from propagating a measurement error throughout the rest of the antenna. With the back end as the datum, the first element the Reflector, can be located 20 mm up so that there is plenty of room to cut a grove to mount the loop support.

The elements in the antenna are numbered from the back to the front. The rear most loop is the first element, called the Reflector (R), it has a perimeter of about 770 mm, so each side is about 192.4 mm long. It is mounted at 20 mm from the datum.

The second loop, the so called Driven Element (DE), has a perimeter of about 744 mm, so each side is about 186.4 mm long. This second element is mounted at 232.8 mm from the datum.

The third element, is the first of the directors D1, it is 300.4 mm long and centered on the antenna axis. This third element is mounted at 341.1 mm from the datum.

The forth element, is the second of the directors D2, it is 300.4 mm long and centered on the antenna axis. This third element is mounted at 635.5 mm from the datum.

The fifth element, is the third director D3, it is 296.8 mm long and centered on the antenna axis. This fourth element is mounted at 984.1 mm from the datum.

The sixth element, is the forth director D4, it is 295.2 mm long and centered on the antenna axis. This fifth element is mounted at 1138.4 mm from the datum.

The seventh element, is the fifth director D5, it is 295.2 mm long and centered on the antenna axis. This sixth element is mounted at 1302.7 mm from the datum.

The seventh element, is the sixth director D6, it is 290.6 mm long and centered on the antenna axis. This seventh element is mounted at 1474.5 mm from the datum.

There is no point in making anything complicated. The easiest way to make such an antenna is with commonly available materials. The antenna shown in this article uses less than $20 of materials. I have quite a bit of material stock left over for more Quagi experiments.

A length of 1x2, available from Home Depot, Lowes, your local hardware store... etc, can be used as a boom. I bought a roll of Aluminum "ground wire" from Radio Shack for use as Directors. I also have lots of "Romex" pieces, 12AWG and 14AWG, laying around in my basement. I used some of the 12AWG scraps to make the loops. Why use the Romex and not the Aluminum? Because it can be soldered to an N connector for the feed line, and to itself to make a loop.

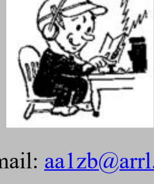
The loop mounts were cut from some Mahogany 1/2 x 1/2 that the previous owners of my house had left behind when they moved out. For all I know it had been left behind to them as well. The loop mounts could just as well been ripped from the 1x2.

The notches for the loop mounts were made with a small table saw, but could just as easily been done with a circular saw.

With wood based antennas, it is best to apply something to protect the wood from the weather. This antenna was not intended for full time outdoor use. It was built as an experiment, being one of the first antennas I had ever constructed. At one time it had a "pistol grip" 1x2 stub at the balance point, so that it could easily be wielded by hand.

Other Materials

The same dimensions can be used with all metal construction or with isolated metal construction. The metal of choice is Aluminum for its light weight, and manageable corrosion properties. With all metal construction the loop supports should be non-conductive. While I have conceptual designs for all metal construction, I have yet to implement one. There are several all metal Uda-Yagi designs in the amateur literature which could be adapted to this Quagi design.



e-mail: aa1zb@arrl.net

Image thanks to ARRL