CONSTRUCTION

How To Build A Broad-Band 5-Element, 20 Meter Yagi

At some point in every amateur's life there comes a time to step up and away from the rest of the crowd. W6NGZ presents us with a project that will let you do just that.

BY JACK REEDER*, W6NGZ

As a long-time antenna experimenter, builder, and designer, I decided it was about time to try my luck at using the computer to come up with an antenna that would be guided by principles that would eliminate some of the guesswork.

My first step was to obtain the software program YAGIMAX[1] written by Lew Gordon, W4VX. It's an easy program, because it's user friendly. It allows you to design and stack Yagies and run graphics, but you must use dimensions that are realistic when you are designing.

Since I was using a homebrew 4-element, 20 meter Yagi on a 35 foot boom, I decided to design a 4-element beam, using a boom length of 40 feet. Forty foot, 3 inch diameter aluminum irrigation pipe is readily available and quite inexpensive.

I spent many hours trying every spacing arrangement and element length possible. These designs had reasonably good gain,

*1331 N. Abrego Dr., Green Valley, AZ 85614

[1]YAGIMAX, by Lew Gordon, K4VX, P.O. Box 105, Hannibal, MO 63401

Freq. (MHz)	Gain (dBi)	F/B (dB)	Impedance (ohms)	VSWR	Radiation Resistance
14.000	10.04	20.09	30.35–j8.71	1.32	32.9
14.020	10.07	21.01	30.46–j7.99	1.29	32.5
14.040	10.09	22.03	30.53–j7.23	1.26	32.2
14.060	10.12	23.19	30.56–j6.45	1.23	31.9
14.080	10.14	24.52	30.56–j5.62	1.19	31.6
14.100	10.17	26.10	30.56–j4.77	1.16	31.3
14.120	10.20	28.02	30.55–j3.88	1.13	31
14.140	10.22	30.50	30.55–j2.96	1.10	30.9
14.160	10.25	33.98	30.58–j2.03	1.06	30.7
14.180	10.28	39.84	30.65–j1.10	1.03	30.7
14.200	10.30	47.29	30.77–j.18	1.00	30.8
14.220	10.32	40.68	30.95+j.69	1.03	31
14.240	10.35	34.54	31.20+j1.49	1.06	31.3
14.260	10.36	31.05	31.53+j2.18	1.08	31.8
14.280	10.38	28.65	31.91+j2.70	1.10	32.1
14.300	10.39	26.85	32.32+j2.99	1.12	32.7
14.320	10.40	25.46	32.71+j2.97	1.12	33
14.340	10.41	24.37	32.97+j2.57	1.12	33.2
14.360	10.41	23.53	32.94+j1.75	1.10	33
14.380	10.40	22.92	32.40+j.52	1.06	32.4
14.400	10.40	22.53	31.09–j.96	1.03	31.1

Table I– Characteristics plotted for the 5-element 20 meter Yagi antenna.

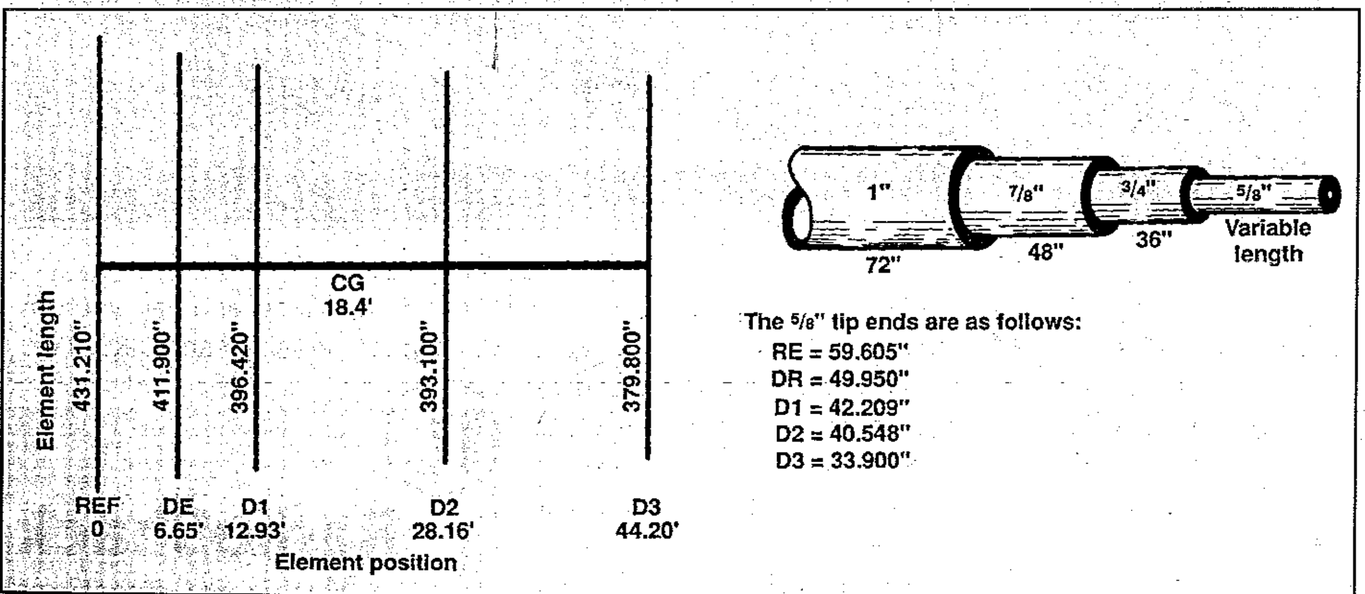
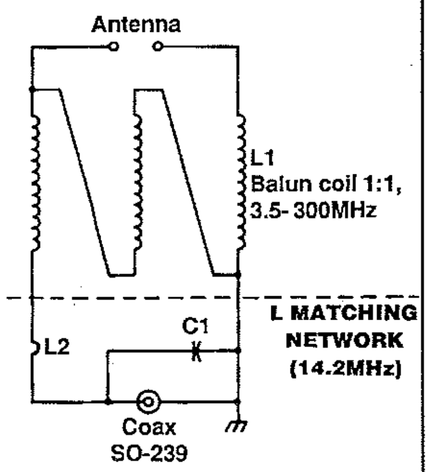


Fig. 1– Physical dimensions and spacing for the antenna. CG refers to the center of gravity. (See text for construction details.)



NOTES:

L1 = 12 turns #14, formvar, 1¼" dia PVC

L2 = 1 turn #14, formvar, 1¼" dia PVC

C1 = 1000V fixed mica (capacitor value as required)

Fig. 2– Schematic diagram for the balun and L matching network.

although the FB and SWR left something to be desired. Out of desperation I added a fifth element, placing it at a very unconventional spot between the reflector and driven element. The added element was now the driven element, and we had very close spacing between reflector, driven element, and director #1. This was a bit of luck, and I could tell on my trusty PC I was really on to something good.

Within a few minutes the 5-element Yagi was completely designed. I also designed a 5-element on a 42 foot boom. Both of these 20 meter designs have excellent FB and the SWR is better than 1:1.3 over the entire 20 meter band.

I completed these designs in November 1991. A short time later I mailed the hard copies to Lew Gordon, who placed the designs in YAGIMAX software. I am pleased to have these designs in YAGIMAX, and they are designated 520NGZ40.inp and 520NGZ42.inp.

A few of these designs were built, and many similar designs began to appear using spacings R-DE-D1 of .15 to .18 WL. The physical size and performace are very close to the computer calculations. These designs using this close spacing are becoming popular and are being accepted at this date.

In November 1994, with a new 486 computer and the latest YAGIMAX software #337, I worked on new designs with boom lengths of 40 to 50 feet for 20 meters (.58 to .7 WL). I hit on a design with a boom length of 44.2 feet (.64 WL) that really caught my attention. Table I shows calculations for gain, FB, impedance, VSWR, and radiation resistance. The radiation resistance (impedance) of this Yagi only varies between 30.7 and 33.2 ohms. This is only 2.5 ohms variation over the entire 20 meter band, which makes for an easy match and very low SWR. Note in Table I the FB is better than 20 dB over the bandwidth and peaks at approximately 60 dB. It is truly a broadband Yagi.

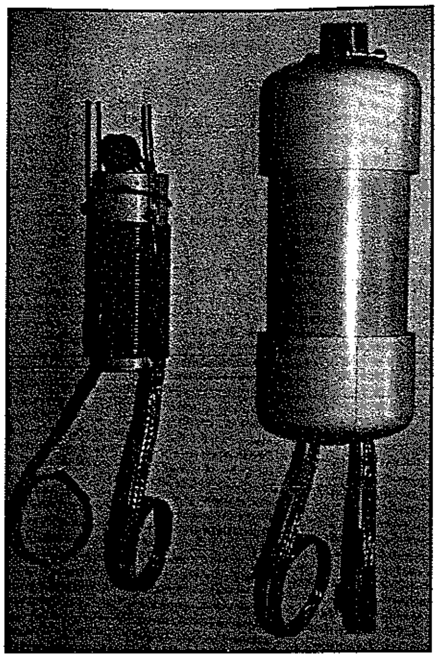
The physical dimensions are shown in fig. 1. Should you construct this Yagi and use elements of a different diameter, the taper will have to be calculated to arrive at the correct element lengths. All the elements are built the same length except for the 5/8 inch tip ends shown in the lower portion of fig. 1. The overall element lengths are also shown in fig. 1, as are the spacing dimensions.

To construct the Yagi use aluminum plates and U-bolts. They work quite well. The plate size should be 3/8 inch thick, 5 1/2 inches wide, and 7 inches long. These plate dimensions were used in the taper calculations. You may use your choice of the feed and matching systems; hairpin, gamma, and T-match are all acceptable. If you choose to use the hairpin match, the driven element should be shortened by approximately 2 1/2 inches to obtain a negative reactance required for the hairpin match.

This design has been checked out on another software analyzer program. The dimensions are very very close to those shown in fig. 1.

I use a split driven element with a homebrew balun and L circuit to match the Yagi (see fig. 2). These are two separate circuits: a trifilar (three wires wound parallel) air balun 1:1 that covers 3.5 to 30 MHz, and an L circuit, which is a different matter. This circuit matches the 50 ohm coax feed line to the 30 ohm Yagi. The balun is wound on PVC pipe, 1 1/4 inch OD. The L-circuit one-turn coil (shown in fig. 2, L2) should also be wound on the same pipe. Start the turn at 1 inch below the end of the balun and reverse the windings in the opposite direction from the winding of the balun. This L circuit is frequency limited, but is plenty broad enough to cover the 20 meter band.

The L circuit along with the balun can now be adjusted to match the antenna's impedance. This can be done at the workbench. Place a 30 ohm noninductive resistor across the balun output. Use a variable capacitor with short leads in the circuit, shown in fig. 2, C1. Dip the capacitor while feeding the circuit with your transceiver using only very low power—approximately 1 watt—to prevent blowing the resistor. The dip will occur on your transceiver SWR meter. The transceiver must be set at the antenna design frequency while running this test. With your test meter, check the capacity of the variable capacitor. Next solder a fixed mica capacitor of the same capacity in the L circuit. The fixed capacitor should be rated at 1000 volts. I have found that by using a small variable capacitor (3-340PF) instead of the fixed capacitor, the L circuit is much better and easier to adjust. Use a variable capacitor with a screwdriver slot and drill a small hole in the PVC to adjust the capacitor.



The completed balun is shown on the left just prior to encapsulation. The unit is housed and protected in PVC as shown on the right.

I have used this feed system for a number of years and like it very much. The insertion loss of the balun and L circuit has been tested with two baluns and L circuits attached together back to back, measuring the loss with a Bird wattmeter into a 50 ohm dummy load. The result is divided by two, which gives the correct insertion loss of one balun. This was found to be .16 dB for 20 meters.

The balun and L circuit may be placed in PVC pipe and sealed (see photo). The photo shows the balun and L circuit prepared to be placed in the 2 inch PVC pipe. Also shown is the completed circuit sealed in the pipe. Coax fitting SO-239 is placed on the outside of the pipe cap using four 6-32 screws and nuts. Solder the circuit to the coax connector. Solder two braided wires, 12 inches long, to the output of the balun. Drill two small holes in the other PVC end cap. Slip the balun inside the pipe and glue the cap in place. Pull the two braided wires through the holes in the other cap. Glue this cap in place. Now pull the slack tight on the two braided wires. Any excess length of the two wires can be trimmed off when attaching the balun to the antenna. Place silicone around the coax fitting and the two holes where the braided wire passes through the cap. Let the silicone dry for several hours.

How does this antenna perform? Just like the computer predicted—broad band, low SWR, excellent FB, and good gain. The Yagi checks out about the same as Table I illustrates.

I have always been fascinated by antennas and have built tribanders, log Yagis, delta loops, quads, and stacked quads. However, I always return to the monoband Yagi. In the past it was a lot of guesswork and a lot of adjusting, but now the computer eliminates all the guesswork. Build this Yagi. You're sure to like it! ■