By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

AMSAT "Mode L" Antennas

This month we are going to cover AMSAT "Mode L" antennas. These antennas are like 435-MHz AMSAT antennas, but they are centered on 1270 MHz (photo 1).

Normally when a Yagi gets this long, its bandwidth becomes very small, which makes construction very, very critical. I've backed off about 1 dB from maximum gain to come up with an antenna that works across the entire 1240-MHz to 1300-MHz band. If you miss it by 30 MHz, it still works at 1269 MHz. (See figure 1.)

Measured gain at just over 16 dBiC is what you can expect from the typical 3–3.5-foot dish system on L-Band. Mathematically, the formulas say that you can get 20 dBiC from a 3.5-foot dish, but you are not going to get that 60% theoretical efficiency with the feed blocking much of a small dish.

Wood

When you mount a Yagi element to a metal boom, you have to adjust its length slightly to allow for the effects of the metal boom. Normally we just consider wood to have no effect and go on. As Ed Manuel, N5EM, unintentionally showed me several years ago, the effect is *not zero!* In this case, an L-Band ATV antenna was built using a 1" × 1" wood boom, which makes nearly one third of the element inside wood! This detuned the antenna nearly 50 MHz. Even the 1/2-inch width boom used in this month's design lowers the center frequency of the elements about 10 MHz. Therefore, don't substitute a stronger/wider wooden boom. One ham built this antenna using plastic "hot water" pipe, but I haven't had that antenna on the antenna range to measure how much the frequency was pulled.

Construction

The boom is made from 1/2" × 3/4" wood. You might try 1/2" × 1", but I think 1/2" × 1/2" would be too weak. Do not substitute a thicker wood where the elements pass through!

The elements were made from 1/8-inch diameter silicon bronze welding rod, which is relatively cheap from your local welding supply. However, 1/8-inch hobby tubing or 1/8-inch aluminum ground wire can also be used for the elements. Make sure the ends are flat and square. Now is a good time to buy that pair of calipers you've been meaning to get for some time. You're going to have to be very careful with the measurements for the elements. You need to be within .05 inch (approximately 1/16 inch). It's better to be a few thousandths short than a few thousandths long for the elements. I used a bench grinder to bring mine into tolerance.

For the boom, start your measurements at the reflector and work your way forward. Use a good tape measure and mark each element. Do not start at the reflector and measure off 1 inch for the driven element, then measure 1.1 inch from the driven element to the first director. After doing that 16 times, any cumulative error will be much worse than if you had just used a good tape measure.

I just drilled 1/8-inch holes in the booms and the 1/8-inch elements were nice, snug fits. The elements are secured with Super Glue®, epoxy, or a construction adhesive, such as Liquid Nails®.

The U-bolt works just fine, going through the wide part of the boom (photo 2 and figure 2). We can rotate polarization,

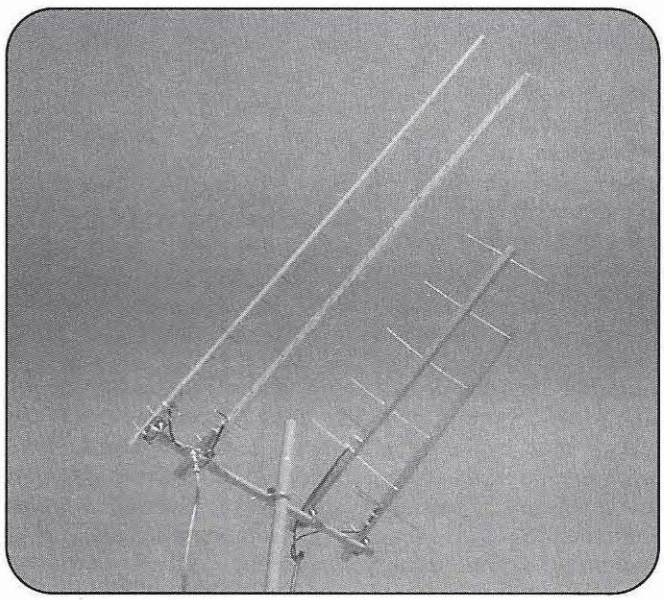

Photo 1. AMSAT Mode L antennas mounted for circular polarization.

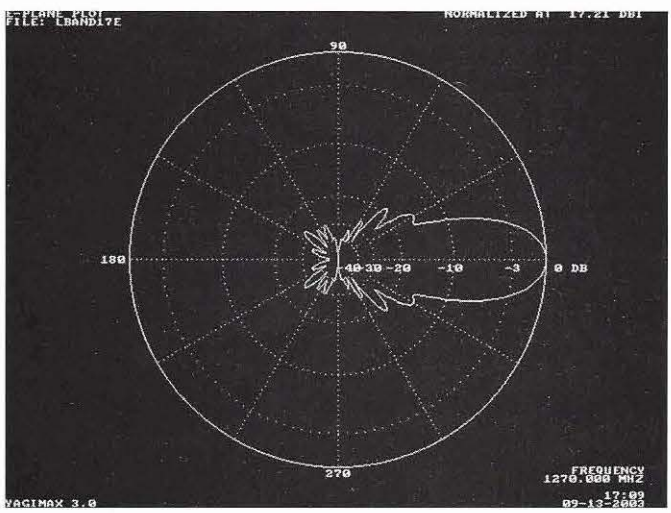

Figure 1. Computer plot of the 17-element Yagi.

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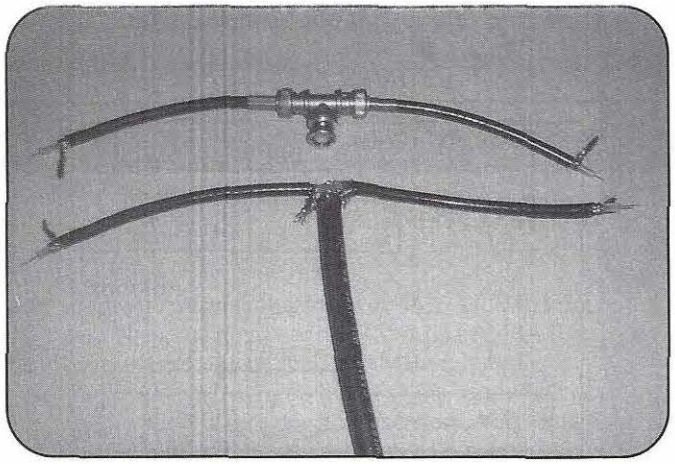


Photo 4. L-Band power dividers with splices and connections installed.

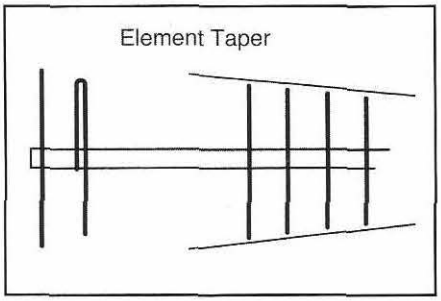


Figure 4. Element taper.

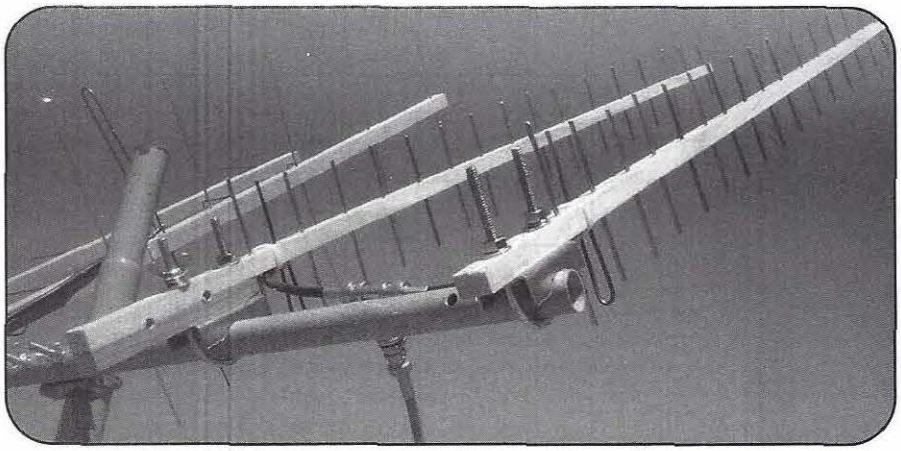


Photo 5. Linear mounting.

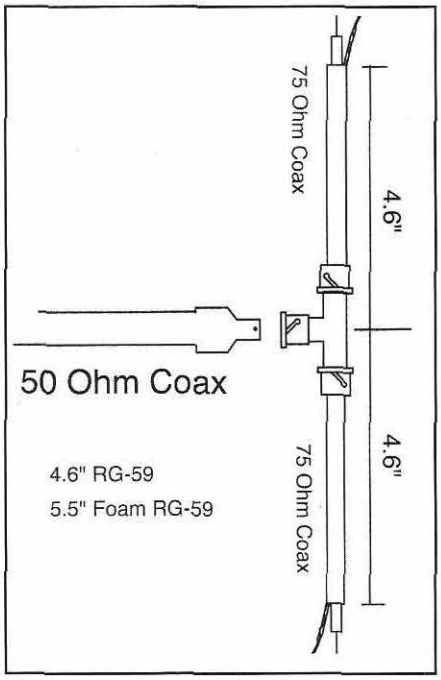
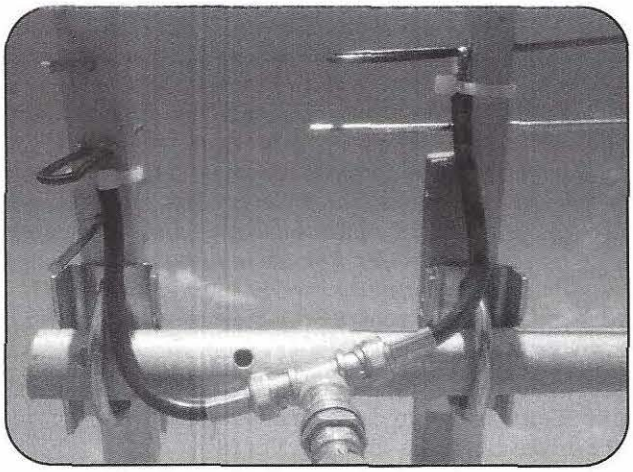


Figure 5. Power-divider dimensions.

Linear: Mount the antennas with the elements of both antennas oriented so that they are either vertical or horizontal (photo 5). Also, mount them so the elements are the same distance from the cross boom. We want the antennas to be in phase. Also make sure the loop side of the driven elements is on the same side of the booms. This configuration gives you 2 1/2 dB more signal on AMSAT, but there may be some rotation fading. In addition, it works great like this for 1250–1280 MHz.

ATV/Repeaters/Packet: This is also the way you would want to mount the antennas for a 1296-MHz SSB QSO, but these antennas are more centered for AMSAT. Gain will be down about 3 dB. Separation distance is how far you can space them without pulling out the power divider connections—about 7 inches.

Left Hand Circular Polarization (LHCP): Mount the antennas with one antenna 1/4 wave ahead of the other (photo 6 and figure 6). In this case, it will be the one with the extra block on the back. At 1269 MHz this will be 2.3 inches, or 6 cm. Mount the antennas 5 or 6 inches apart. This distance is not critical.



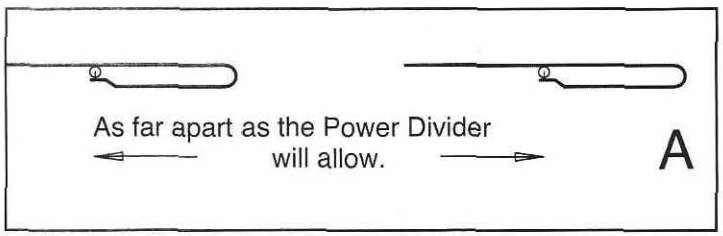


Figure 6. Looking back down the booms, driven-element positions for linear, LHCP, and RHCP.

Photo 6. Circular polarization mounting.

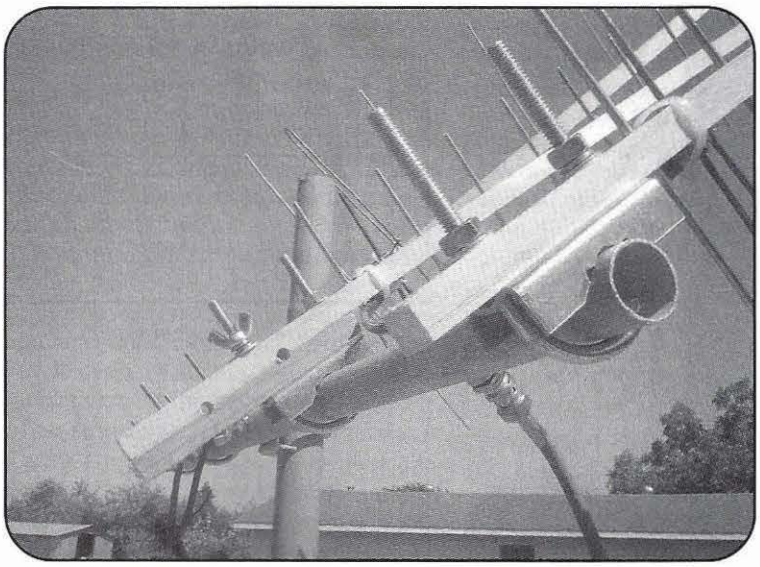
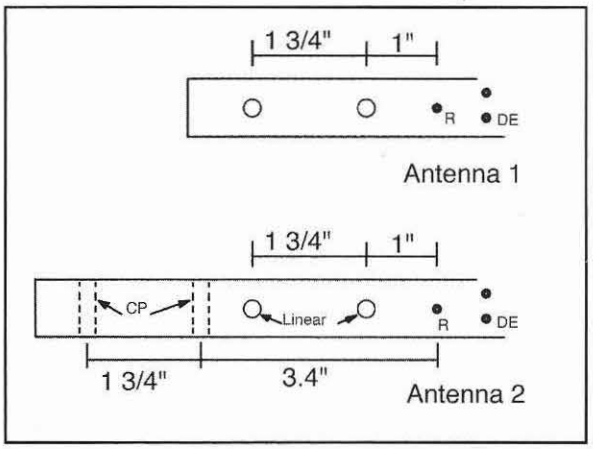


Photo 2. U-bolt mounting holes.

Figure 2. Mounting holes.



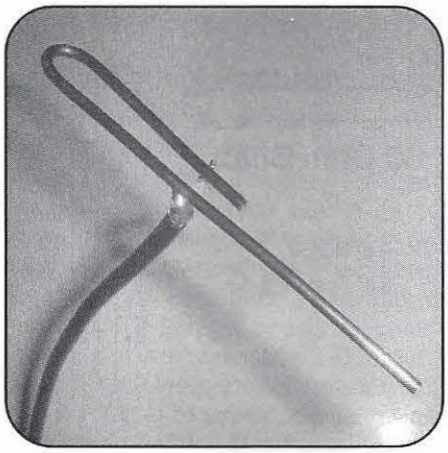


Photo 3. The driven element.

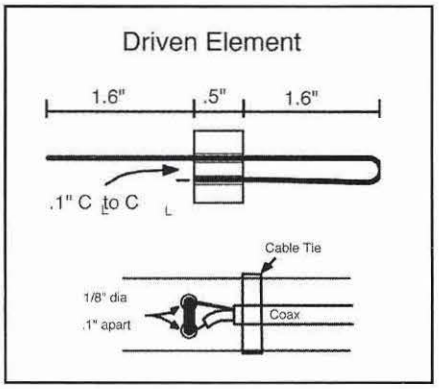


Figure 3. The driven element.

and drilling out the 1/2-inch side would make the boom just too weak. I glued on another section. A good glob of glue and a few finishing nails worked fine. Now you have enough thickness for the U-bolt holes.

Driven Element

The driven element is a "hair pin" or J of #10 bare copper wire (photo 3 and figure 3). Silicon bronze welding rod, 1/8-inch diameter, can be used, but it is a real problem to bend into shape. I tried bending 1/8-inch hobby tubing as the driven element once, but I didn't have much luck. Maybe if you have a hobby tubing bender, you might have fare better than I did.

With this antenna, I found it easier to solder the coax to the driven element and then mount it on the boom. Just watch your dimensions. Yes, the coax is slightly off center, and the ends overlap inside the wood. The capacitance of the ends inside the wood is actually helping the impedance matching. Simply built to the dimensions, your SWR should be less than 1.5:1 from 1250–1290 MHz. If you have access to an L-Band SWR meter, a network analyzer, or a spectrum analyzer with a tracking generator and a direction coupler, the return loss can be tweaked down to –30 dB. In SWR terms, that's about a 1.05 to 1 SWR. If you really want to tweak the antenna, I recommend putting 50-ohm coax on each antenna, and tune them one at a time. Then install the power divider.

Elements

For many of the elements, you need to make up six or eight elements of the same length. If you're like me, some are going to end up a tad short and some will be a smidgen long. This length difference is easy enough to see when you have the elements all lined up. You want the longer ones closest to the driven element and the shorter ones closest to the end of the antenna. In figure 4 you can see how this helps maintain the taper of the elements.

Painting

If you plan to have the antenna outdoors for extended periods of time, I recommend painting the booms with Spar Varnish or clear spray paint. Wet wood will detune the antenna.

Power Divider

We need to split the signal equally to both antennas, yet maintain the 50-ohm impedance, which is often done with a 1/4-wave power divider (photo 4 and figure 5). In this case, 1/4 wave is just long enough, so I'm using a 3/4-wave power divider made of 72-ohm coax. RG-59 and RG-59 foam have different velocity factors and need to be different lengths. The foam is electrically a better coax, but it's very easy to damage/melt it while soldering to the driven element. I built one out of 72-ohm RG-59 with 72-ohm BNC connectors. The second one is just soldered with short leads. My network analyzer couldn't see much of a difference between these two power dividers. If you care to make your own power-divider design, be my guest. Just make sure the runs of 50-ohm coax between the power divider and the antennas are of equal length.

Mounting

There are three ways this antenna system can be mounted, and we will cover the advantages of each.

Right Hand Circular Polarization (RHCP): Just flip one of the antennas 180 degrees. That is, flip it so the driven-element loop is coming out the other side of the boom. It really doesn't make a difference which antenna you flip. Mount the antennas 5 or 6 inches apart. This distance is not critical.

For you technical guys who could have written this article, yeah, the few inches of horizontal separation between the two antennas does mean that when looking 20–30 degrees off axis from the antenna, the antenna is elliptically polarized (sort of an egg-shaped circular polarization). The whole idea, though, is to point the antennas where they work best!

There are several fancy ways of generating switchable polarization. However, you can build several of these L-Band Cheap Yagis for the cost of just one coax relay.

Building it X Fashion

There are always several of you who want to build both antennas on the same boom. I'm not a fan of building them that way. The two antennas can easily be stored flat. The single X is going to get bent. With the two antennas, you can easily switch between three polarizations; the single X is going to be only one polarization, and in the case of the L-Band version, 48-inch long, 1/2-inch square wood is not going to be strong enough to support itself.

Dimensions for the 17-Element L-Band Yagis

Element	Position (in.)	Length (in.)
Reflector	0	4.6
Driven Element	1.0	see drawing
Dir 1	2.1	4.0
Dir 2	4.1	3.9
Dir 3	5.9	3.9
Dir 4	8.1	3.8
Dir 5	10.1	3.8
Dir 6	12.0	3.8
Dir 7	14.5	3.75
Dir 8	16.75	3.75
Dir 9	19.2	3.75
Dir 10	22.6	3.7
Dir 11	25.9	3.7
Dir 12	29.5	3.7
Dir 13	33.0	3.7
Dir 14	36.4	3.6
Dir 15	39.75	3.4

Finally

No matter how big I make an antenna, someone wants to make one bigger. Okay, here are the dimensions for a 20-element version, but I haven't had a chance to test it on the antenna range. It should have about 1 dB more gain. Good luck; you're on your own. (Let me know how it worked out.) Directors 14 and 15 are changed, and three new directors added. They are all still 1/8-inch in diameter. All other dimensions are the same.

	Length (in.)	Position (in.)
D14	3.7	36.4
D15	3.7	39.8
D16	3.7	43.2
D17	3.5	46.5
D18	3.4	49.9

You don't have to build two. Even a single antenna fed directly with 50-ohm coax can be used with good results on AMSAT Mode L, ATV, repeater, or any other 1240–1300 MHz service.

In the next issue we will cover horn antennas and other interesting topics. As always, I am interested in your comments and suggestions. ■

Letters, Letters . . . We Get Letters

From Jim: "Can you build dual polarization 'Cheap Yagis' on the same boom?"

It is possible to build two Cheap Yagis on the same wood boom and run two coaxes. I would suggest drilling the holes so that one is a few inches ahead of the other. At least that way you don't have two elements hitting each other as they pass through the center of the boom. There is another way, however!

For years I used the same 220-MHz Yagi on both SSB and FM. I mounted it at a 45-degree angle. Mathematically this means that gain is down 3 dB on both horizontal and vertical from a normally mounted Yagi, but just one feedline and half the wind load. I did need a coax switch in the shack to switch between my 220-MHz transverter and the 220-MHz FM rig. I said 220 MHz versus 222 MHz, which should give you an idea of how long ago this was.

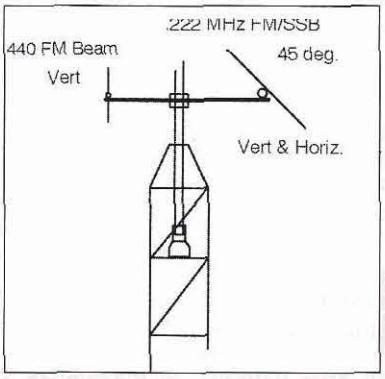


Figure 7. Using the same Yagi for both vertical and horizontal QSOs.