Weekend Antennas No. 4
A Simple 70cm Satellite Antenna

Dave Long's excellent talk "Satellites for Beginners" at Radio Technology in Action has renewed interest in low-earth orbit satellites like AO-51 (Amsat Echo). Several of these are quite easily worked using FM transceivers with the uplink in the 2m band and the downlink in the 70cm band.

The 70cm downlink is usually the more critical in terms of antenna requirements because the satellite's transmitter is relatively low-powered and because path loss increases with frequency. Amsat estimates the path loss for the 2m AO-51 uplink to be 145dB and the path loss for the 70cm downlink to be 155dB. With the satellite's transmitter operating at 1W output, an antenna gain of about 10 dBi is required to hear the satellite at its maximum range of 3,000km. On the other hand, even with only a 5W transmitter, an antenna with no gain (0 dBi) would suffice for the uplink

This column describes an easily constructed antenna that performs well as a 70cm antenna for satellite use. By orienting it vertically or horizontally it can also be used to access terrestrial repeaters or for simplex communications. The antenna, a corner reflector, is particularly easy to construct because – unlike Yagis – almost all the dimensions are non-critical. The only critical dimension is the length of the driven element, which is simply adjusted for minimum SWR.

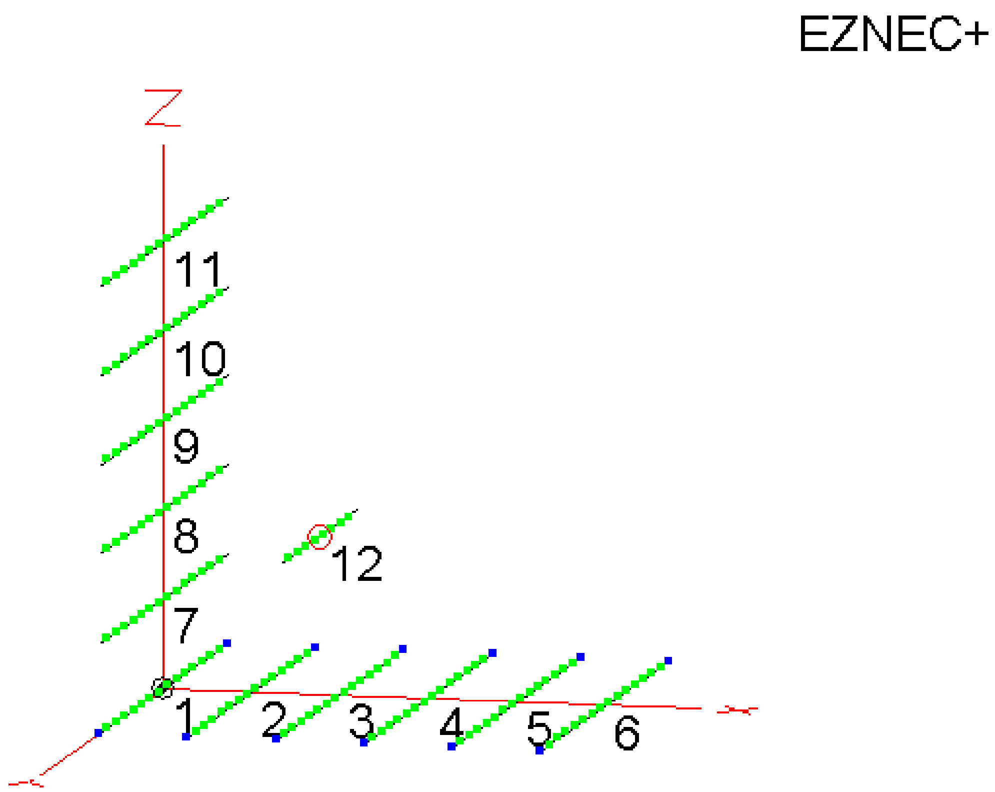

Figure 1 – Layout of the Corner Reflector

Figure 1 shows the layout of the antenna. It consists of a driven element (wire number 12 in the diagram) backed by horizontal and vertical reflectors. The horizontal-plane reflectors (wires 1 to 6) meet the vertical-plane reflectors (wires 7-11) to form a 90-degree "corner" at the bottom left of the antenna, which is why it is called a "corner reflector". The reflector elements should be spaced not more than 1/8 wavelength apart, and should be at least 0.6 wavelengths long. However the exact length and spacing of the reflectors is not critical.

Construction

Figure 2 shows the mechanical construction of the antenna.

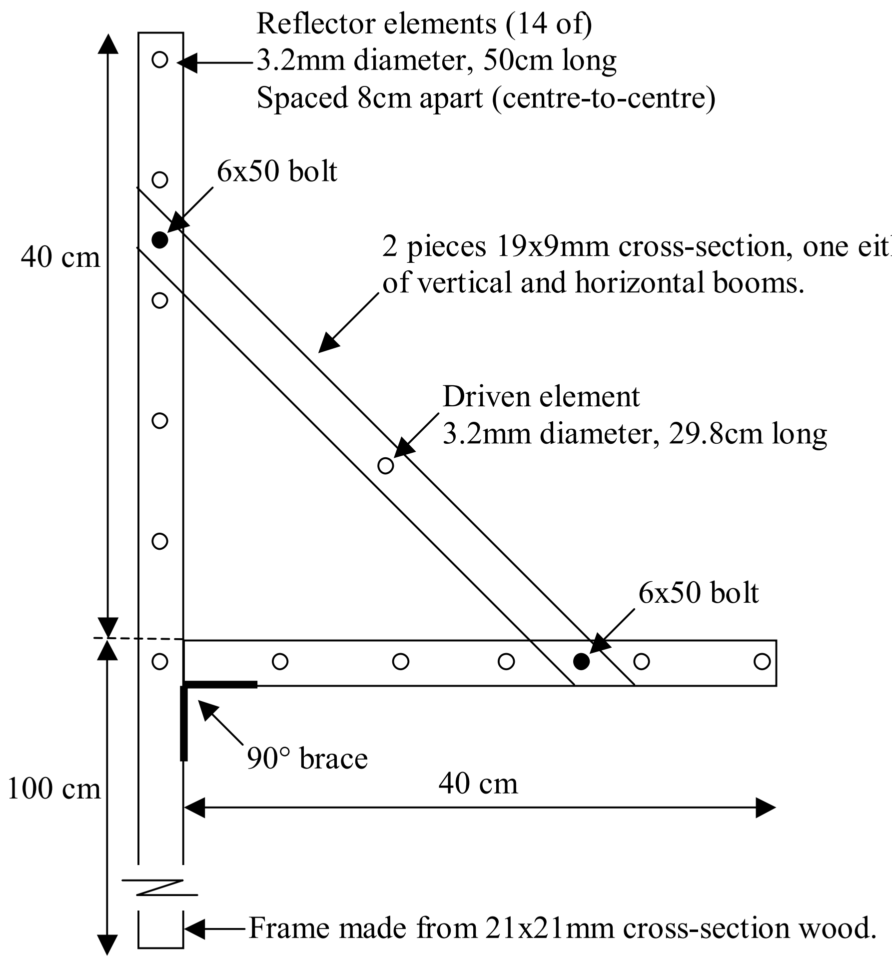

Figure 2 – Construction Details

To build it you will need

- ❑ A 1.8m length of 21mm x 21mm cross-section wood.
- ❑ A 1m length of 19mm x 9mm cross-section wood.
- ❑ 12 aluminium welding rods, approx. 3.2mm diameter and 50cm long.
- ❑ A 90-degree corner brace.
- ❑ Wood screws and two 6 x 50mm bolts with washers and nuts.

Cut a 40cm piece from the 21mm x 21mm cross-section wood. Drill five 3.5mm holes in this piece, 8cm apart (from centre to centre), starting 1cm from one end and ending 7cm from the other end. The holes should be just large enough for the welding rods to fit snugly.

Drill six 3.5mm holes in the remaining 1.4m length of 21mm x 21mm, starting 1cm from one end, 8cm apart (from centre to centre). Attach the 40cm piece at right angles to the 1.4m piece using the 90-degree corner brace. The holes in the 40cm piece should be lined up with the last of the holes in the 1.4m length (see Figure 2).

Cut the 1m length of 19x9mm into two equal halves. Attach these diagonally between the vertical and horizontal members of the frame, one on either side of the frame, using 6x50mm bolts. The centre of both the bolt holes should be 28cm from the bottom-left reflector element, which places the bolts mid-way between the forth and fifth reflector elements. Once the bolts are in place, cut these diagonal pieces flush with the sides of the vertical and horizontal members.

Drill 3.5mm holes through the centre of both of the diagonal pieces. These holes support the driven element and it is important that they line up precisely, so it is best to drill both holes together. Cut one of the aluminium welding rods to exactly 29.8cm long, insert it through the holes you have just drilled so that the middle of the element is midway between the two diagonal members, and epoxy it into place.

Insert the 13 reflector elements into their holes and epoxy them in place. The exact length of the elements is not critical, provided they are at least 41cm long and are all about the same length. Mine came in 50cm lengths, so I used them like this.

Once the epoxy has cured cut a 5mm gap in the centre of the driven element. Attach the coax screen to one side, and the braid to the other. Unfortunately ordinary solder does not bond aluminium effectively. I crimped a couple of lugs onto either side of the driven element, and soldered the coax to these and then covered the crimps with a layer of epoxy to shield it from the elements. Alternatively, if you can find some zinc/tin solder you should be able to solder directly to the aluminium.

Finally, coat the entire wooden structure with a couple of coats of wood seal, varnish or paint to waterproof it.

If you have access to an SWR meter or antenna analyzer that works on the 70cm band, then you can trim the driven element for minimum SWR (in this case, it might be wise to start with a 31cm driven element). Since I didn't have access to a suitable SWR meter, I just cut the element to exactly 29.8cm and checked that my 70cm rig was able to put full power into it through the entire band, so the SWR can't be too bad! Unlike other directional antennas, the element lengths are not critical, so provided the radio is able to deliver power into the antenna, you can be confident that the antenna will function correctly.

Performance

Figure 3 shows the elevation pattern of the antenna when it is mounted 5m above ground.

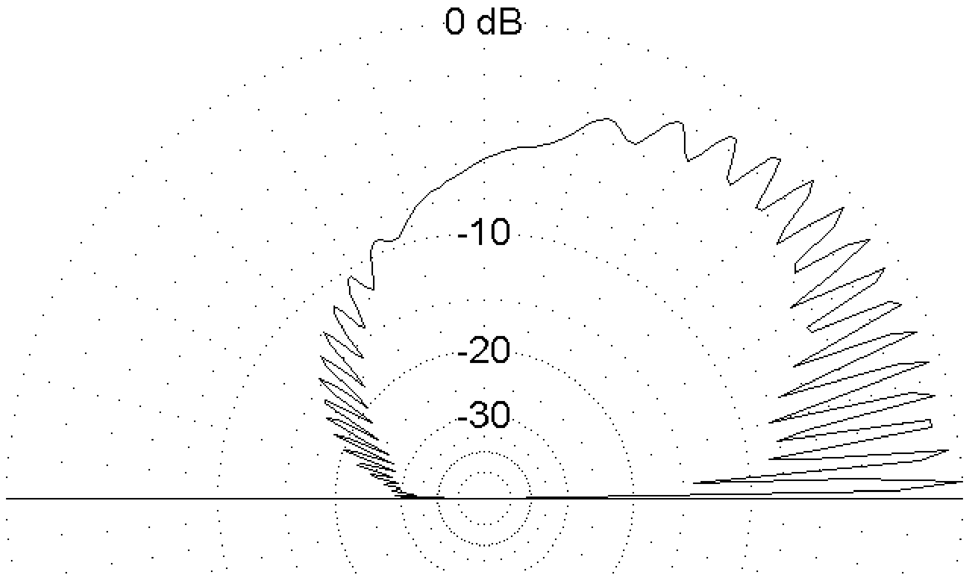

Figure 3 – Elevation pattern at 435MHz mounted 5m above ground.

Maximum gain is 10.36 dBi at an elevation angle of 2 degrees. However as you can see, the antenna provides significant gain at all elevation angles up to 90 degrees, which is ideal for satellite work. The is some variation in gain due to ground reflections, but this is much less pronounced than it is for most horizontally-polarized antennas, thanks to the effect of the horizontal reflector plane immediately below the driven element.

Figure 4 – Azimuth pattern at 30 degrees elevation

Figure 4 shows the azimuth pattern at an elevation angle of 30 degrees. Maximum gain is 9.8dBi, the -3dB beamwidth is 85 degrees and the front/back ratio 20 dB.

Note that the antenna is horizontally polarized. Those familiar with satellite operation may ask whether a circularly-polarized antenna would not be a better choice? Well yes and no. If you know the polarization of the received signal, then a circularly polarized antenna with the correct handedness (right-hand or left-hand) would be ideal. However in the case of AO-51 there are two UHF transmitters, and to maximize the isolation between the antenna systems, one uses left-circular polarization (LCP) while the other uses right-circular polarization (RCP). Typically, the LCP antenna is used for the digital downlink, and the RCP antenna for the voice downlink, although this is configuration-dependent. So the ideal solution would be to have two antennas, one LCP and one RCP, or a single antenna with switchable polarization. However this would add substantial additional complexity, so I chose instead to use linear polarization and accept the 3 dB penalty that this will give with a circularly polarized signal of either handedness. This was taken into account when calculating the required gain.

Figure 5 – The finished antenna

The antenna could be turned on its side to give vertical polarization for repeater use, or could be tilted downwards by 45 degrees so the two reflector planes are 45 degrees above and below horizontal to maximize low-angle radiation for terrestrial weak-signal work. I mounted mine on an ancient Hy-Gain AR-22XL rotator and have started happily exploring the wonderful world of satellites.

