Low-Cost Horn Antennas for 23-cm EME

With the recent increase in 23-cm EME activity, WD5AGO challenged himself to build cheap and effective antennas to demonstrate to his students. In this article he describes how he built and analyzed two large horn antennas.

By Thomas Henderson,* WD5AGO

What is the best antenna for EME (Earth-Moon Earth) contacts? This is an online topic that crops up from time to time. "Lowest cost" was added to another posting. The band of interest is 23 cm. Looking at the station log sheets, the most commonly used antenna for this band is the parabolic reflector (dish) followed by the Yagi. Common is not quite accurate, as out of the hundreds of EME contacts on this band only a couple were made with Yagi antennas. The only other antenna tested for 23-cm EME, in the receive mode only, was a mid-size 15-dBi horn. It appears then the dish wins out, and with a high-efficiency feedhorn it is tough to beat.

Which is the easiest, lowest cost antenna to construct? Value analysis of each of the antennas noted above was made. A starting point would be to determine the antenna gain needed to make EME contacts. Over fifty 23-cm EME stations have excess gain and power levels to communicate with low-power stations. This includes the small, commonly used 3-m dish. Over a dozen of those high-gain/high-power stations will have over 10 dB gain to spare when communicating with the 3-m dish. This would place a minimum receiving antenna gain targeted around 20 dBi. At this gain level, reception of larger EME stations should be possible, and with 250 watts or more of power, contacts could also be made. For a 20-dBi gain antenna to have a higher EME success rate, though, the ability to use circular polarization would be desirable. Communication from linear to circularly polarized antennas encounters a loss of about 3 dB, which cuts into our margin of success.

*3017 N. 2nd Street, Broken Arrow, OK 74012
e-mail: <THenders@tulsacc.edu>

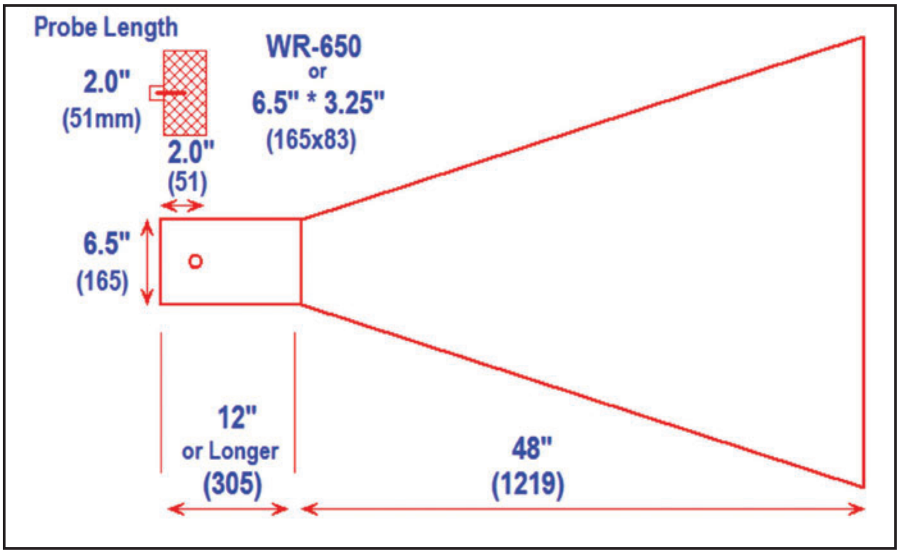

Figure 1. 23-cm linearly polarized 20-dBi horn antenna.

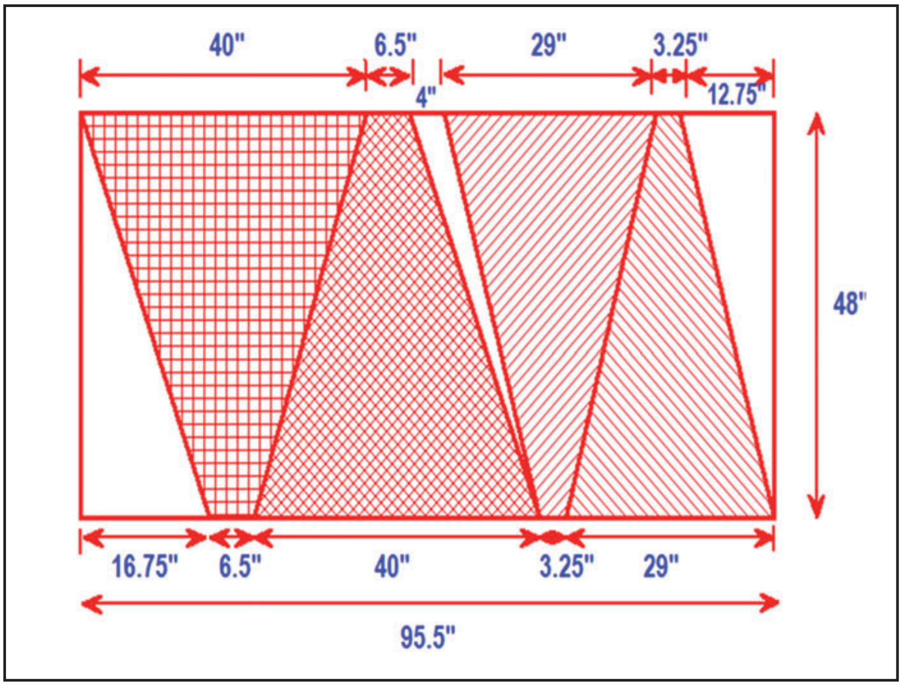

Figure 2. Pattern for linear horn construction from a single sheet (48" × 96") of material.

Figures 3 & 4. Inside of foam/aluminum horn with taped seams. Outside of low-cost horn antenna.

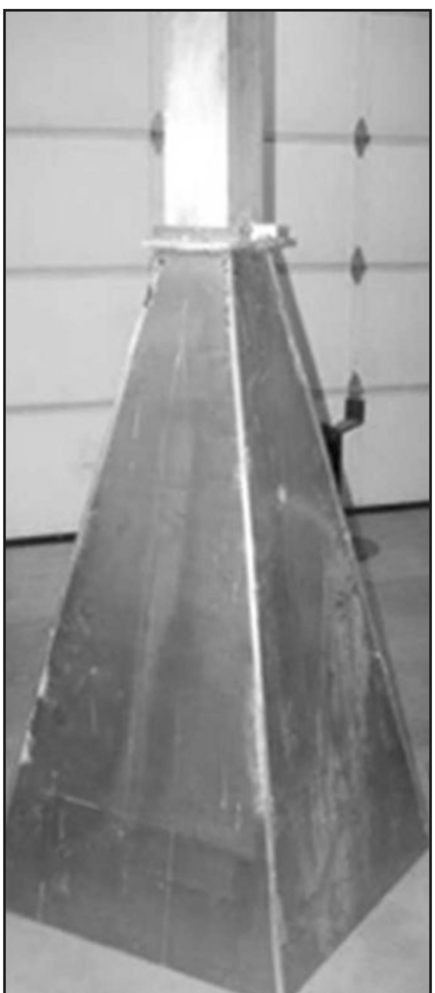

Figure 5. CP horn antenna using all-aluminum construction.

The prime focus dish is well understood. With advancements in feedhorn designs, efficiencies up to 67% are possible with antenna temperatures (Ta) in the range of 30°K as calculated and measured on a 20λ diameter dish.[1] With a dish diameter of 10λ (about 2.4 m on the 23-cm band), gain is approximately 28 dBi. At a diameter of 1 m, the dish offers about 20 dBi of gain, which is the planned target. As the dish's diameter is reduced, though, Ta will rise due to a higher percentage of feedhorn blockages. Building and mounting the dish is where the labor and cost come into play. Despite the added mechanical construction, if a small used dish is available, then the dish is the value winner.

Yagis were also analyzed. The antenna temperature for the Yagi was much higher than other antennas tested, but its light weight and portability have advantages. The success of students at Tulsa Community College (where I am the manager and an operator of the college's amateur radio club) was noted in building 70-cm Yagis for the EME test with Arecibo in Peurto Rico last year. A 23-cm test Yagi was built, but it was determined that this was not the way to go for the beginning builder. Constructing and tuning Yagis on 70 cm is far easier than on 23 cm. Besides, one criterion is for the antenna to be easily converted to circular polarization with low losses, which is where the Yagi falls short at higher frequencies.

The horn is one of the oldest antenna designs from which to choose. The horn antenna is known for having a low-noise temperature but lower efficiency for its size and material usage as compared to a properly illuminated dish. A look at optimum-gain charts for a 20-dBi horn illustrates a horn size of 4 feet long and an aperture of approximately 3 feet square. This gain is assuming 50% efficiency. This is about the same gain per aperture size as a 1-m dish, although more surface material is needed for a horn. After further research, it was decided to build and analyze two large horn antennas.

The first horn was constructed by students with the design goals of simplicity and low-cost construction. To keep the horn simple, linear polarization was utilized, therefore allowing nearly any horn shape to be used. After evaluating the horn length versus construction techniques of round, square, and rectangle waveguide sizes, the rectangular horn was favored. This is also known as a pyramidal horn. A set of dimensions for an optimized 20-dBi gain horn were given.[2, 3] Suitable materials to be used for the horn ranged from plywood coated with a conductive paint to galvanized hardware cloth (cage mesh wire). The lowest cost and easiest approac, though, was to use a single 48" × 96" sheet of foam-siding insulation backed with aluminum film. The sheet cost under $15. The original horn aperture dimensions were adjusted in order to cut four complete patterns from the single sheet. The new dimensions (figures 1 and 2 shown in inches and mm) should produce a gain of about 20 dBi. A $10 roll of aluminum tape from a home-improvement store was used to hold the seams together with the aluminum film placed on the inside of the horn (figure 3). Duct tape was used to reinforce the outside edges (figure 4). The project took less than one hour to complete.

The second horn antenna construction design goal was to use circular polarization (CP). A horn with symmetry is needed. Round and square horn prototypes were constructed. There are round, dual-mode horn designs that have very low antenna temperatures. After constructing round prototypes, noting higher than an aperture size of 20 inches, a larger square horn was easier to construct. In an effort to test and analyze antenna temperature, the square CP horn was made slightly longer than the standard optimized size pyramidal horn. The horn input is 6" × 6"