Large Diameter Reflectors Antennas for 47 GHz

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Introduction

Since completion of the first 24 GHz EME QSOs my efforts have concentrated on developing EME capability for 47 GHz. There are many challenges to be conquered but notable among them is the lack of "large diameter" parabolic dishes that will provide reasonable performance at this frequency. The following will describe the testing and results to date with standard 4, 6 and 8 foot diameter offset reflector dishes, in the hope that others will be able to make use of these and smaller dishes to good advantage.

The Challenges of 47 GHz Dish Antennas

The biggest challenge of a reflector antenna is the need to maintain the surface accuracy of +/- 1/16 th of a wavelength (rms) over the entire surface area, in order that the loss in gain is less than 1 dB. With a wavelength of 6.3 mm at 47 GHz, this represents an accuracy requirement of +/- 0.4 mm (~0.016 inches). It is probably unreasonable to expect that many large (in terms of wavelengths) dishes have been built to such tolerances. Most commercial metal reflectors are spun to the level of accuracy required by the designed operating frequency. There would be considerable manufacturing effort wasted to do any more than this. Dishes that are made by stamping or molding may be capable of better accuracy since all reflectors are made by the same "One Step" manufacturing process rather than by individual machining.

In preparing for 24 GHz EME, I had the good fortune to acquire a Prodelin 2.7 m (8 ft) offset feed dish originally intended for 14/12 GHz remote broadcast uplinks. Looking like one of the direct broadcast mini-dishes, this reflector is very flat and in theory might provide very high efficiency and perhaps even as much gain as the larger 3.0m centre fed Andrew dish (see figure 1). A fringe benefit of the offset fed dishes is the ability to locate all the electronics at the feed point without introducing blockage of the dish’s capture area. Initial Sun noise checks with the reflector using a sub optimum feed were encouraging and a proper feed with much higher gain for the shallow (f/D=0.7) reflector was required.

Figure 1 2.4 m Offset Reflector for 24/47 GHz

Figure 2 1.2 m Offset TVRO Reflector

Using one of W1GHZ's computer programs a higher gain W2IMU feedhorn was created using plumbing parts and sheet copper. Please see Figure 3 that shows the details 24 GHz "large" W2IMU feedhorn.

The results with the final "large" W2IMU feedhorn, carefully optimized in front of the reflector were 2.3 dB of moon noise (previously 0.6 dB) and 15 dB of Sun noise! This was truly outstanding and the basis of much optimism for possible use on 47 GHz and I proceeded to evaluate the 2.4m reflector. I realistically believed that the 2.4 m reflector was unlikely to have the performance required at 47 GHz and that a 1.2 m reflector would be the minimum size required for 47 GHz EME. An efficient 1.2m dish on 47 GHz will have about the same beamwidth as the 2.4 m dish at 24 GHz and this is also probably the largest size that might be found with sufficient surface characteristics. During this preparation period I was able to acquire 1.2 and 1.8 m offset reflectors to include in the evaluation. Although these smaller reflectors differed slightly in outward appearance, having reflectors with a "crackled" surface vs. a very smooth "gel coat" surface on the 2.4 m reflector , these reflectors were originally manufactured by Prodelin. The back of the 1.2 and 1.8 m reflectors is reinforced by plastic webbing as shown in figure 4. My 1.2 m reflector is gray in color and identified as part of a General Instrument 12 GHz TVRO system. There are a lot of similar 1.2 m reflectors available from surplus in the Minneapolis area.

A receive converter with a 5 dB Noise Figure was developed and another "large" W2 IMU design was created using available "standard dimension" and silver plated brass stock as shown in Figures 4. The transition section was created by drilling with 1/4 & 1/2inch bits and then transitioning with a modified 1/2 inch bit tapered to the correct angle.

Dish Performance Measurements

Sun Noise was used to compare dish performance. This technique has long been used by the "432 MHz and Above EME Group" and has been described by W1GHZ for smaller 5.7 GHz and 10 GHz reflectors. The Sun Noise Results achieved by VE4MA, Al W5LUA, Gary AD6FP and W0EOM are shown below. All stations had similar receivers in the same 4-5 dB Noise Figure range. These values should be compared to the W0EOM 2 ft dish. As this antenna is believed to be near optimum.

Call	Description	Sun Noise (dB)	Comments
W5LUA	15 inch Prime Focus	1.4	Designed for 39 GHz
W5LUA	24 Inch Prime Focus	2.5	Designed for 39 GHz
VE4MA	1.2m (4 ft) Offset	3.6	Original
W0OEM	2 ft	4.1	Benchmark Reference
VE4MA	1.8 m (6 ft) Offset	5.0	
AD6FP	3 ft Precision (95 GHz)	5.2	Poor Illumination
W5LUA	3.0 m 10 ft	5.7	24 GHz EME dish
VE4MA	1.2m (4 ft) Offset	6.4	Foil added
VE4MA	2.4 m (8 ft) Offset	6.9	24 GHz EME dish
VE4MA	1.2m (4 ft) Offset	7.1	Foil + Round Head Bolts

Discussion of Results

While I will not go into a rigorous comparison, two (2) things were clear from the results:

1. The 1.2, 1.8 and 2.4 m diameter reflectors (all) showed increasing gain (S/N), with the 2.4 m dish shows slightly less than one might think. There is some "gain compression" expected in the largest reflector as the expected beamwidth of all reflectors is less than the subtended diameter of the moon. Thus the normally expected linear increase in the Moon/Sun noise S/N ratio will tend to plateau. Please see the 10 GHz EME article by DF7FJ available at the PA0EHG WEB page http://home.wxs.nl/~alphe078/whatis.htm

2. All of the offset reflectors seemed to be lacking gain in comparison with W0EOM's 2 ft dish .

In contemplating the results it appeared that the basic reflector accuracy is good however the efficiency of the actual reflector surface was suspect. This could be due to one of 2 factors:

- possible dielectric losses in the surface plastic
- the quality of the metallic reflector.

Dielectric losses in the surface plastic

On the one-piece antenna the outer surface is a gel coat. This is normally used in the marine industry where boats are manufactured using a hand laminating process. The mold in these processes is waxed to allow removal of the finished part and then a gel coat is applied to the mold. This is a polyester material very similar to the resin used on the laminating process. It is usually colored and varies in thickness depending on the application.

Quality of the metallic reflector.

The metallic reflection surface could be formed using a metallic paint or a wire mesh. Either way the reflector surface was not designed for this frequency. Later upon closer examination it was found that the reflector is composed of wire mesh with a .010" strand diameter and has 16-18 strands per inch in both the vertical and horizontal directions. This mesh is buried underneath the gel coat and cracked finish plastic layer Although it seems that it would be adequate, apparently it is not. Prodelin actually offers a reflector rated to 30 GHz but it is not known how this differs and it has not been tested.

Subsequent Changes and Re-Tests at VE4MA

The 1.2 m (4 ft) dish was subjected to further tests. A thin layer of standard "domestic" aluminum foil was glued to the plastic surface using waterproof wallpaper adhesive. I wanted to be able to remove it ! The results were remarkable with an improvement in Sun noise from 3.6 dB to 6.4 dB and an improvement in gain of approximately 3.3 dB ! The actual improvement may be better but is masked by Sun noise compression effects.

Looking for further possible improvements and bothered by the 8 hex head 1/4 inch mounting bolts that sit on the reflector surface, I substituted round headed bolts and achieved a further 0.7 dB of increased sun noise ! Now the 4 ft dish is achieving more sun noise than my 2.4 m (8 ft) 24 GHz EME dish on 47 GHz.

Time has not permitted further tests on the 1.8m (6 ft) or 2.4 m (8ft) reflectors. The wallpaper adhesive has been found to be unsuitable for long term use, as air bubbles later developed under the foil.

A word of caution…the sun on bare aluminum foil will create a huge amount of heat! If used permanently a white flat latex paint (primer) should be used to diffuse the reflected heat.

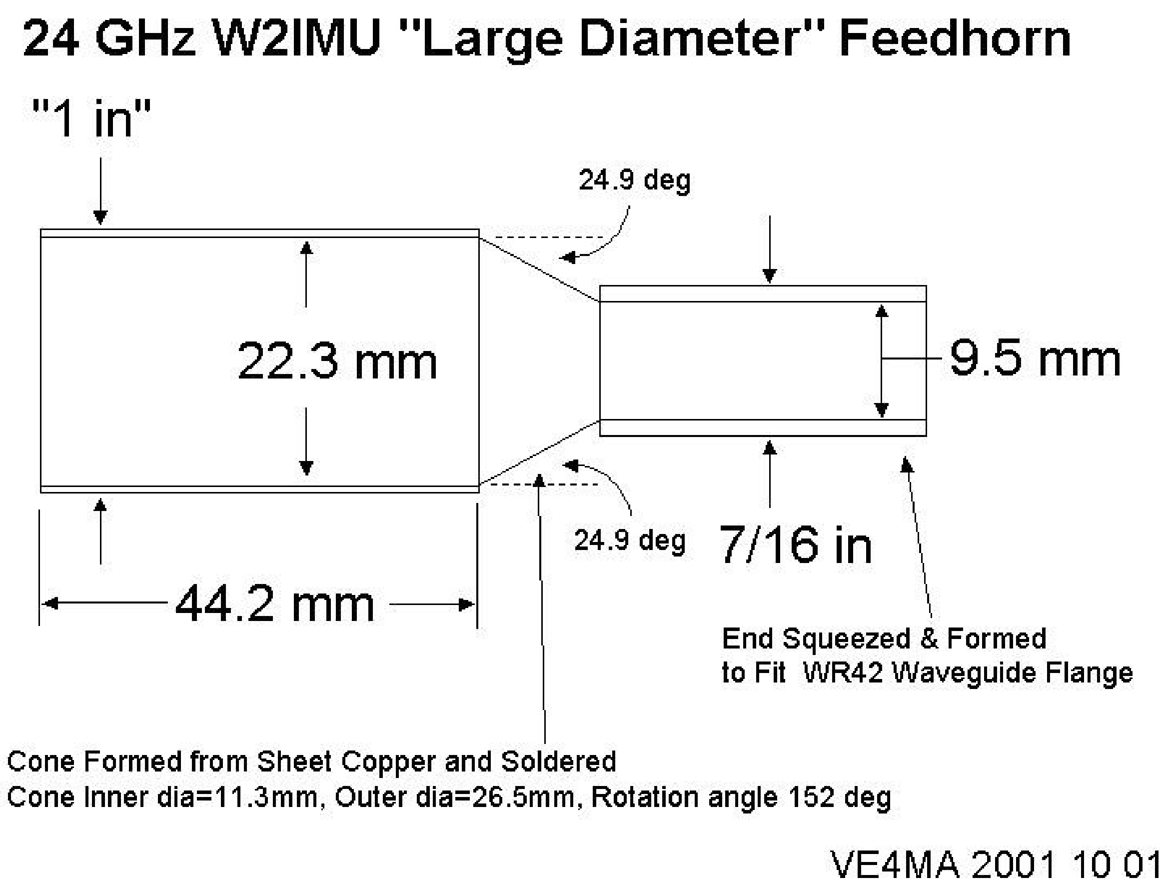
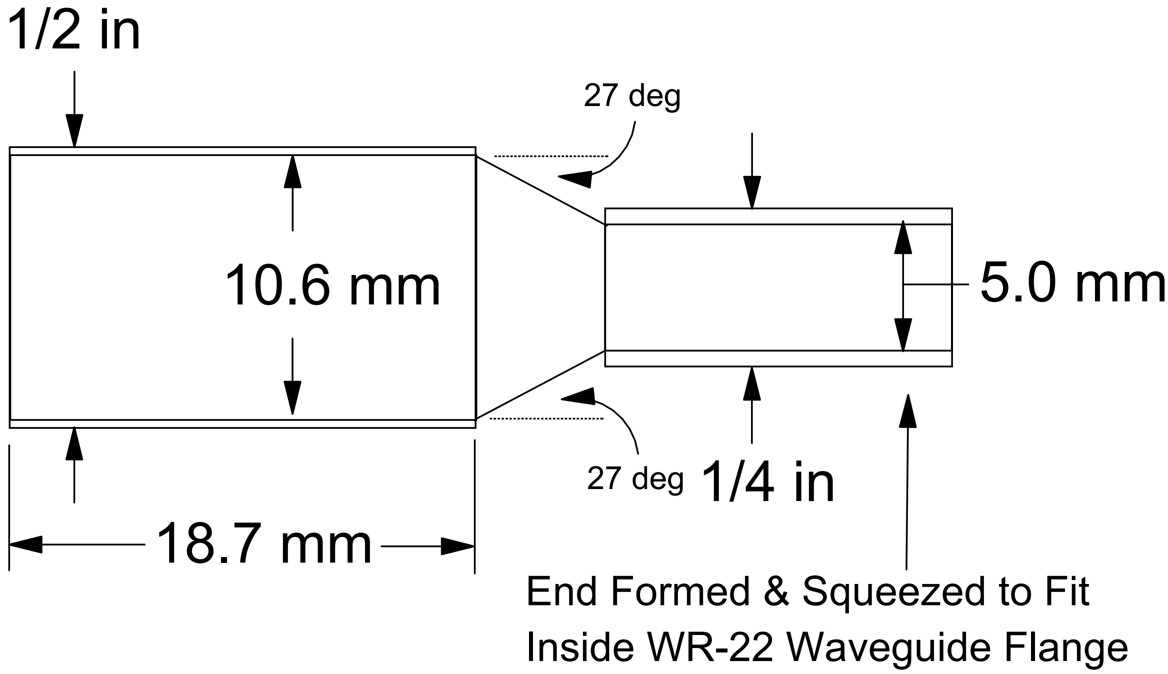


Figure 3   24 GHz "Large Diameter " W2IMU Feedhorn

47 GHz W2IMU "Large Diameter" Feedhorn



47 GHz "Large Diameter" W2IMU Feedhorn Transition Section

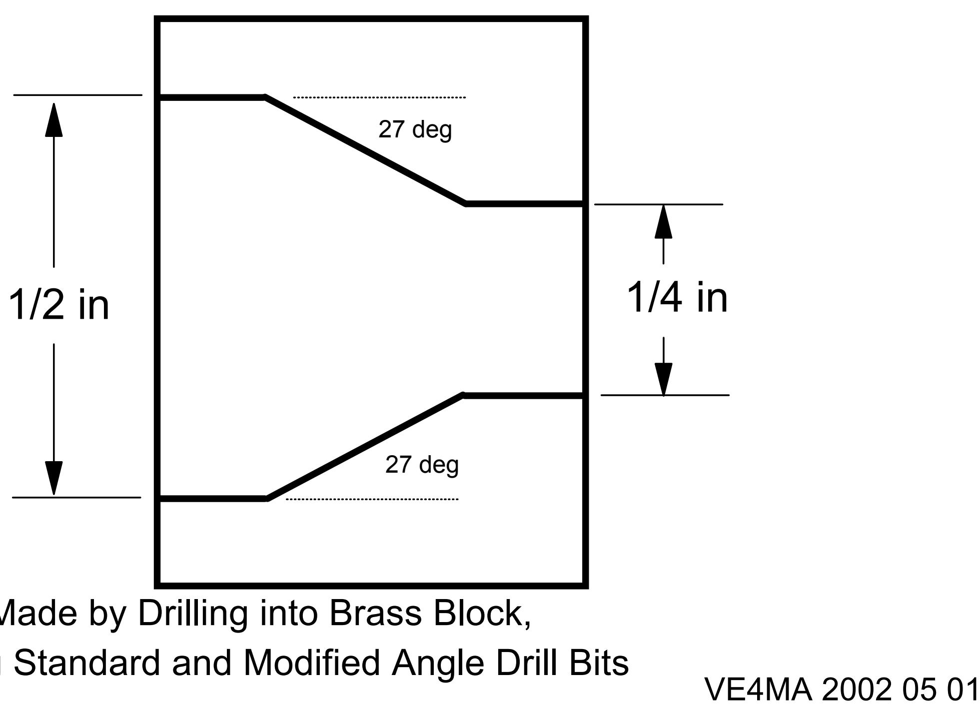


Figure 4 47 GHz Feedhorn