Offset Stress Dishes for EME

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This paper discusses the use of stress offset dishes for 432 and 1296 MHz EME, and describes their construction. It shows that this type of antenna can be easily and inexpensively constructed, and that the offset design offers advantages not only in gain for a given area, but also in mounting as it can be placed very close to the ground.

This is an update of a paper written in 2004 on the construction of a small offset dish for portable operation on 1296 EME. At the time, many DXpedition stations on this band had been using single long Yagi antennas because of their small size and low weight. Unfortunately single Yagis on 23 cm have insufficient gain to allow CW contacts, except possibly with the very largest stations, and even using JT65, QSOs are not possible with many active stations. The major problem is that Yagi antennas are linearly polarized but the world standard for 23 cm EME is circular polarization so the Yagi suffers a 3 dB penalty in contacting almost any regular user of the band. If the DXpedition station can change to a reflector antenna with the same *effective* capture area as the long Yagi, but with a circular polarized feed, there will be an *effective* gain increase of 3 dB.

Dish antennas tend to be heavier and larger than Yagis, but stress dish designs can at least partially solve the problem of weight. For small dishes, aperture blockage by the feed can also be a concern. An offset dish eliminates that feed blockage problem, and generally provides higher gain efficiency than a conventional dish. It seemed that a circularly fed, offset stress dish would be an ideal antenna for portable 1296 EME operation, and back in 2004 I thus decided to construct such an antenna.

As it turns out, aperture blockage is not a problem on 1296 MHz, except for very small dishes (< 4 ft dia.). Also the length of the longest spokes (petals) of an offset dish can be twice the length of a conventional dish and this can be an issue if you are flying to your DXpedition destination, After first looking at this problem in 2004, I continued to use a conventional dish when I made my next DXpedition trips,

More recently, however, I have revisited my old offset dish design and concluded that it can have advantages over a conventional dish.

Figure 1: 7.5 ft offset stress dish

Dish Basics

The relationship between the diameter and depth of a parabolic reflector is given by the equation:

$$X^2 = 4fY \quad (1)$$

where X is radius of the reflector, Y is the depth, and f is the focal distance. For example, Figure 2 shows the shape of the curve of a 7 ft diameter dish with a focal distance to diameter ratio (f/D) of 0.55. The deeper the dish (for a given diameter), the shorter is the focal distance and the wider the beamwidth of the optimum feed antenna.

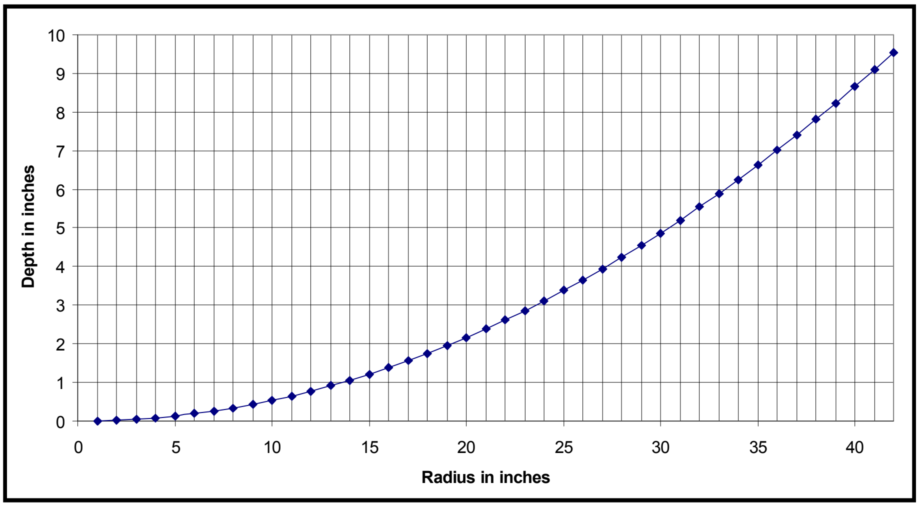


Figure 2: Profile of 7 ft dish with f/D = 0.55

Offset dishes

Offset dishes are just a portion of a parabola of revolution (conventional parabolic dish). The antennas discussed in this paper use about a quarter of a conventional dish reflector. By using only part of a normal *full* dish for the reflector, the feed antenna can be moved away from the center of the reflector, where most of the RF energy is directed and is then radiated forward. The feed must still be located at the focal point of the parabolic curve, but it can be located to one side of the reflector, where little or no RF energy is present, as shown in Figure 3.

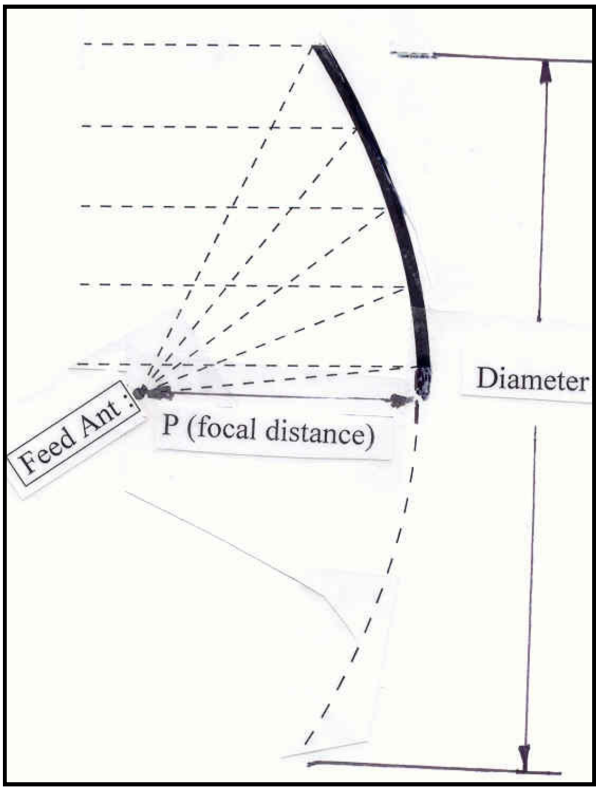


Figure 3: Offset feed is located to one side of the reflector

The feed for an offset dish must also have higher gain and narrower beamwidths, since it should *ideally* only illuminate the reflector area. (As noted, the offset dish is only a *fraction* of the full dish.) The table below shows the relationship between the f/D of an offset reflector, and the equivalent f/D of a conventional dish for which the feed should be selected to properly illuminate an offset dish. As can be seen, a feed designed for a deeper dish should be used to keep the focal distance a reasonable length.

f/D of offset reflector	**Equivalent f/D of complete paraboloid for feed design**
0.90	0.46
0.85	0.44
0.80	0.43
0.75	0.41
0.70	0.36
0.60	0.34
0.55	0.32
0.45	0.30
0.40	0.28

Besides having greater efficiency than a conventional dish, the offset dish has an added advantage for EME. It can be mounted very close to the ground and still fully track the Moon. Consequently, a relatively small mount can be used, and the dish can be laid back onto the ground when not in use.

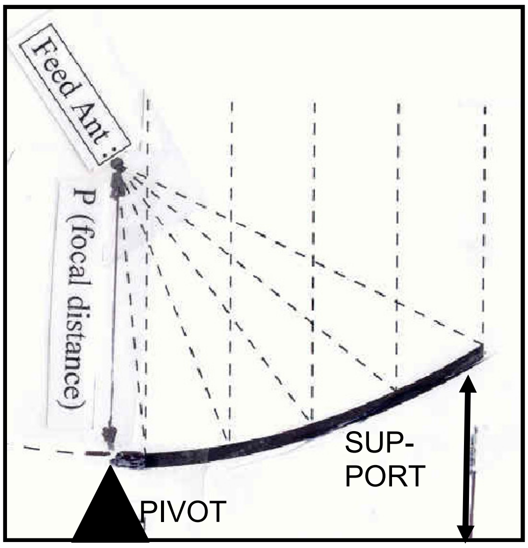


Figure 4: Offset dish can be laid on the ground (pointing up) when not in use.

7.5 ft Stress Dish for 1296 MHz

Stressed framework

I have been using and promoting conventional stress dishes since my high school days. To demonstrate the stress *offset* dish concept, a reflector with a radius of 7.5 ft was fabricated for use on 1296 MHz. If the reflector were complete, it would correspond to a dish of 15 ft diameter. In this case of an offset dish, only a quarter of a conventional dish's surface is used. This surface was produced from just five 7.5 ft spokes, made from ½ x ¾-inch wood molding stock – readily available at the local Home Depot.

The hub was a quadrant (90°) section of 1 ft radius cut from ½-inch plywood and each spoke was attached with two bolts with a 3-inch overlap as shown in Figure 5. For portable use it would have been preferable to make channels in the hub, into which the wooden spokes could be inserted for attachment. I used this method of attachment for a 70 cm 20 ft portable stress dish more than 20 years ago and it is both stronger and quicker to assemble and disassemble; but with only five spokes, the added time was not considered significant.

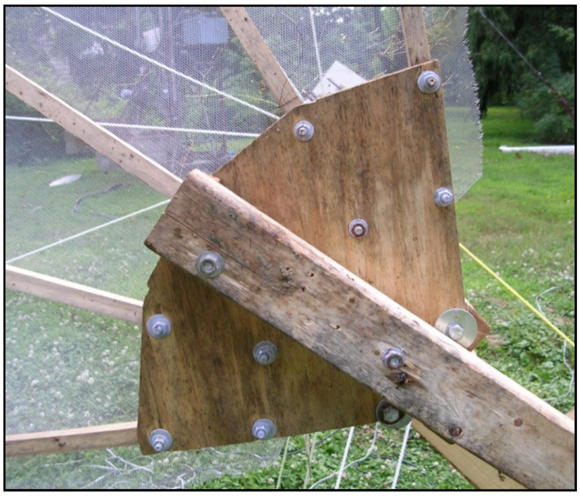


Figure 5: Spokes are attached to a plywood center hub with two bolts each.

The hub could also have been increased in radius to 2.5 ft. This change would have allowed the spokes to be reduced to a more convenient 5 ft length.

A rim around the outside of the reflector was made with 3.5 ft lengths of ½ x ½-inch wood modeling stock with two small (8-32) bolts as shown in Figure 6. The 3.5 ft length was chosen to produce a reflector with an equivalent (full reflector) f/D ratio of about 0.3. This corresponds to a feed beamwidth of about 90° which matches reasonably well to the orthogonal dual dipole feed described below. Equation 1 shows that the dish's focal distance is about 4.5 ft.

Figure 6: An outside rim is formed from 3.5-ft lengths of ½" x ½-inch modeling strips.

The main feed support was a 3.5-ft length of 2x3-inch lumber, and was also used for attaching the dish to the mount. The feed support was fixed at right-angles to the plywood hub using a small 2x2-inch wooden block. Nylon lines were run from the end of the feed support to eye bolts at the ends of each spoke. The length of these lines was adjusted so that the radius (**X** distance) of each spoke was 7.5 ft.

Figure 7: Hub attached to support by a 2x2-inch block

Dish surface

The dish was covered with aluminum screening. This material is available in the USA in rolls of 3 ft width by 25 ft long, which is sufficient to cover the whole dish at relatively low cost. The screening was first rolled over the outer part of the stressed dish and cut to the required size. The remaining screening was flipped over to match the cut end with the shape of the dish, and rolled over the center portion of the dish. This process was repeated a third time for the bottom section – see Figure 8. One of the extra corner pieces from the top was used to cover the small remaining area at the bottom (vertex) of the reflector.

The screening is attached to the spokes using small gauge (~ #24) wire. The wire is run through the mesh and around the spokes and then tied) together. The process of attaching the mesh takes only a few minutes. The aluminum mesh can be removed and rolled around the 3x2-inch members for transport shipping.

Figure 8: Aluminum screening is tied to spokes using wire

Feed Antenna

A W2IMU horn would be an excellent choice of feed for this reflector, but its size and weight would be a problem if it were carried as luggage. Instead, orthogonal dual dipoles were used as the feed antenna with a quadrature hybrid to produce circular polarization. This feed was chosen because of its relatively small size and light weight. Feed mounting details are shown in Figure 9. The reflector plate was attached to a 1 ft length of 1x1-inch stock, which was then attached by a single ⅜-inch pivot bolt to an extension of the feed support (approximately 1.5 ft of 1x1-inch stock, again attached by a ⅜-inch bolt). Extra mounting holes were drilled in the feed support to allow the position of the feed to be raised or lowered. This arrangement provided several degrees of freedom in adjusting the position of the feed for optimum performance.

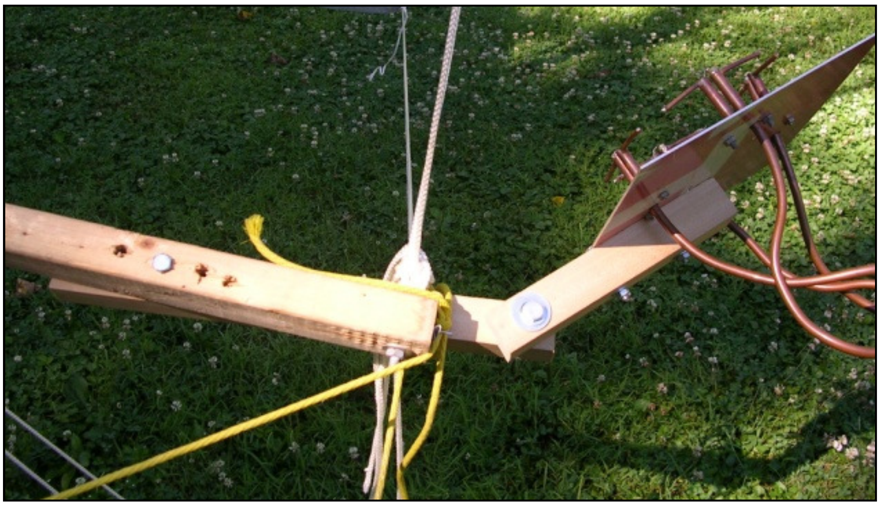


Figure 9: To allow optimum positioning, the feed is mounted on an adjustable pivoted support

Testing

The offset dish for 1296 MHz was originally constructed in a single weekend and tested for Sun noise. The dish worked as planned and yielded > 8 dB of Sun noise. This was more than 3 dB better than a 15-ft Loop Yagi that was used as a reference. This little dish is presently assembled and being used for EME from my backyard. A bigger offset dish should be assembled shortly and will also be tested off the Moon from my backyard.

Use on 432 MHz

It is much harder to make a case for the use of a dish reflector on 70 cm, where linear polarization is the world standard and the reflector diameter must become quite large (greater than about 15 ft) to compete with even a single long Yagi. Nevertheless, the advantages of an offset dish – low cost, ease of construction and the ability to be mounted near the ground – merit some consideration.

To evaluate the construction of larger offset stress dishes, the equivalent of a conventional 20 ft dish for 432 MHz is under construction.

This concept is illustrated in Figure 10. It uses a central hub fabricated from a 4 x 6 ft piece of plywood, to allow spokes 16.5 ft in length to reach out to a radius of 20 ft. Seven main spokes and two optional smaller spokes are used to produce the surface, and are made from 1x2 in redwood. The outer rim is made from 5.5 ft lengths of ½ x ¾-inch wood molding stock.

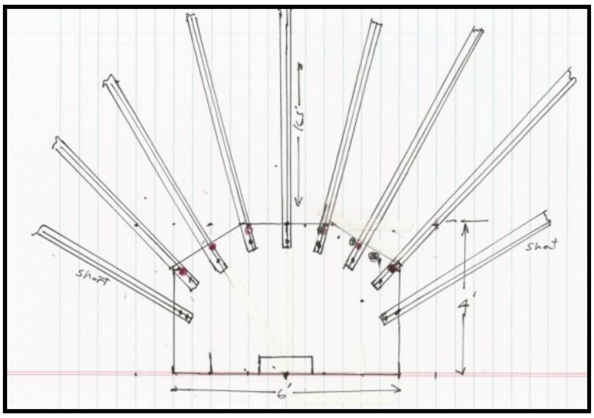
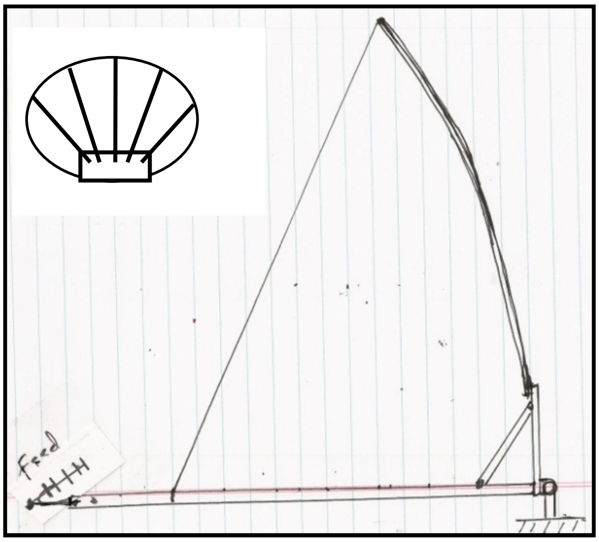


Figure 10: 70 cm offset stress dish

(a*) Six long spokes and two optional short spokes are attached to a 4 x 6 ft plywood hub.*



(b) Side view.

A 9 ft length of 2x3-inch lumber was used for the main feed support. I have not yet decided on the surface covering. An appealing option is to use many parallel wires. Since polarization is linear on 432 MHz, only conductors in line with the E-field are needed. Such an arrangement is very light weight and inexpensive, but may be very time consuming to implement. A wire spacing of about 1 inch is a good compromise for 432 MHz, although even a 2-inch spacing should work.

Conclusion

The offset dish designs shown in this paper offer a relatively inexpensive and simple way of producing antennas for 70 and 23 cm EME. They are particularly useful for temporary and portable operation because they can be quickly assembled and taken apart. They also can be mounted very close to the ground and with a relatively simple mount. The 7.5 ft offset dish provides performance equivalent to about an 8 ft diameter circular dish, yet can be disassembled into a small lightweight package.

References

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