Offset Stress Dishes for EME

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Abstract: 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.

Introduction: This paper 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 1296 dxpedition stations had been using single long yagi antennas because of their small size and low weight. Unfortunately on 23 cm, single yagis have insufficient gain to allow CW contacts, exception possibly with the very largest stations. On 1296, CW still remains the preferred mode, if not the exclusive mode of most EME operators. Even using JT65, QSOs are not possible with many active stations. The major problem with yagi antennas is that they are linearly polarized, while almost all *regular* 23 cm EME stations are circularly polarized. The use of circular polarization provides an effective gain increase of 3 dB. Thus a reflector type antenna with a circular polarized feed can have half the *effective* area of a yagi and still have as much *effective* gain.

Dish antennas tend to be heavier and of greater size than yagis. Stress dish designs can at least partially solve the problem of weight. For small dishes, aperture blockage by the feed can be a concern. An offset dish eliminates the 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 I thus decided to construct such an antenna.

As it turns out, aperture blockage is not a problem on 1296, except for very small dishes (< 4' dia.). However, if you are flying, the length of the longest piece of your antenna can be an issue. The spokes (petals) of an offset dish can be twice the length of a conventional dish. Thus, a full dish can be packed in a container of half the length, and cause less attention at an airport. When I made my next dxpedition trips, I decided to use a conventional dish.

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

Fig. 1 - 7.5' offset dish.

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

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

where X is radius of the reflector, Y is the depth, and f is the focal distance. The shape of the curve for example of a 7' diameter dish with a focal distance to diameter ration (f/d) of 0.55 is shown in Figure 2. The deeper a dish, the shorter the focal distance and the wider the beam width of the optimum feed antenna.

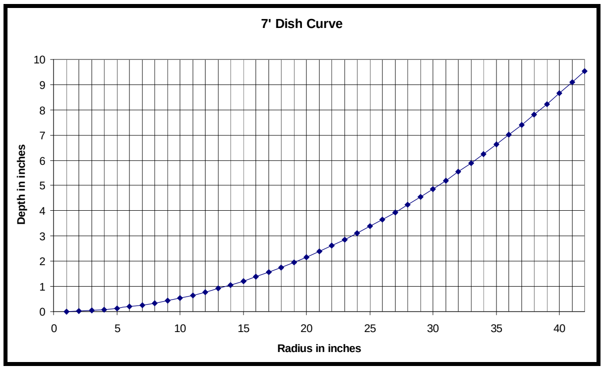
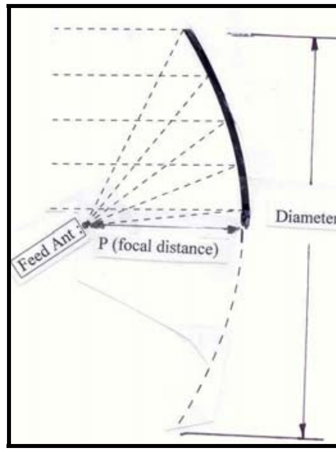


Fig. 2 – Curve of 7' dish with f/d = 0.55.

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 located. The feed can be located to one side of the reflector, where little or no RF energy is present – as shown in Figure 3a. The feed must still be located at the focal point of the parabolic curve. The feed must also have higher gain, since it should *ideally* only illuminate the reflector area. (As noted, the offset dish is only a *fraction* of the full dish. Hence the feed antenna must have higher gain to produce a smaller beam). The table in Figure 3b shows the relationship between the f/d of a complete reflector, and the f/d for which the feed should be designed to properly illuminate an offset dish. As can be seen, a deeper dish should be used to keep the focal distance a reasonable length.



Surface f/d	Reflector f/d
0.90	0.46
0.85	0.44
0.80	0.43
0.75	0.41
0.70	0.40
0.60	0.36
0.55	0.34
0.50	0.32
0.45	0.30
0.40	0.28

Fig. 3 – a) The feed is located to one side of the reflector, b) Relationship between reflector f/d and equivalent f/d for feed.

The offset dish besides having greater efficiency than a convention dish has an added advantage for EME. It can be mounted very close to the ground and still fully track the Moon.

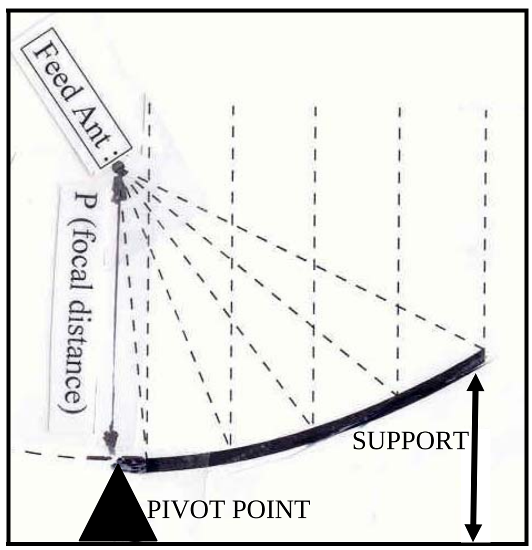


Fig. 4 - The offset dish can be laid on ground (pointing up) when not in use.

Consequently, a relatively small mount can be used, and the dish can be laid on the ground when not in use.

To partially overcome the problem of the "longest piece", the center hub of the reflector can be extended. Figure 1 shows that if you start bending at a 1” offset, the length of spoke can be reduced by about a third.

Construction: To demonstrate the stress offset dish concept, a reflector with a radius of 7.5’ was fabricated for use on 1296. If the reflector were complete, it would correspond to a dish of 15’ in diameter. In the 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’ lengths of ½” x ¾” wood molding stock – readily available at the local Home Depot. These *spokes* were attached to a hub made from a 1’ radius wedge shaped (quarter of a circle) piece of ½” plywood with two bolts.

Fig. 5 - The *spokes* are attached to a plywood center hub with two bolts.

A 3’ overlap was used. It would have been preferable to make channels into which the wooden spokes could be inserted for attachment. (I used this method of attachment for a 70 cm 20’ portable stress dish that I produced more than 20 years ago). This arrangement is stronger and makes assembly and disassembly quicker – but with only five spokes, the added time was not considered significant. The hub could have been increased in size to 2.5’. This change would have allowed the spokes to be reduced to a more convenient 5’ length. A rim around the outside of the reflector was made with 3.5’ lengths of ½” x ½” wood modeling stock with two small (8-32) bolts as shown in Figure 6.

Fig. 6 - An outside rim is formed from 3.5’ lengths of ½” x ½” modeling strips.

The 3.5’ 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°. (This beamwidth matches reasonably well a dual dipole feed). Using equation 1 shows the dish’s focal distance is about 4.5’.

A 3.5’ length of 2” x 3” lumber was used for the main feed support.

Fig. 7 - The dish is attached to the feed support by a 2” x 2” block

This piece was attached to the plywood center section using a small wood block. Nylon ropes were run from 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'. The feed support was used for attaching the dish to the mount.

Feed Antenna: Orthogonal dual dipoles with a quadrature hybrid to produced circular polarization were used as the feed antenna. Dual dipoles were chosen because of their relative small size. (An IMU horn would be an excellent choice of feed for this reflector, but its size and weight could be a problem, if it is to be carrier as luggage). The feed was attached to about a 1' length of 1" x 1". This was attached to a second approximately 1.5' length of 1" x 1" using a single 3/8" bolt, which was in turn attached to the feed support by another single 3/8" bolt. Extra mounting holes were drill 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. Feed mounting details are shown in Figure 8.

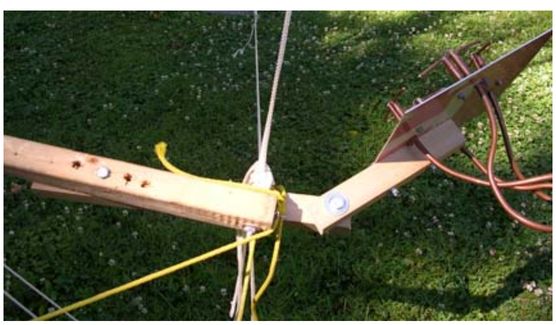


Fig. 8 - The feed is mounted using several supports to allow optimum positioning

Covering: The dish was covered with Aluminum screening. This material is available in the US in 3' width by 25' long rolls, which is sufficient to cover the dish, for relatively low cost. The screening was first rolled over the top 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 9.

Fig. 9 - Aluminum screening is tie to the spokes using wire

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 gage (~ #24) wire. The wire is run through the mesh and around the spokes and then wrapped (tied) together. The process of attaching the mesh takes only a few minutes. The Aluminum mesh can be removed and rolled around the 4' 2" x 3" members for transport/shipping.

Use on 432: It is much harder to make a case for the use of a dish reflector on 70 cm, where linear polarization is almost exclusively used, and the reflector diameter must become quite large (> ~15') to compete with even a single long yagi. Nevertheless, an offset dish's ability to be mounted near the ground, low cost, and ease of construction, merits its consideration. To evaluate an offset dish on 432, the equivalent of a conventional 20' dish is under construction. It uses a central hub fabricated from a 4' x 6' piece of plywood, to allow spokes 16.5' in length to reach 20'. Seven main spokes and two optional smaller spokes are used to produce the surface, and are made from 1" x 2" redwood. The outer rim is made from 5.5' lengths of ½" x ¾" wood molding stock. This concept is illustrated in Figure 10 a and b.

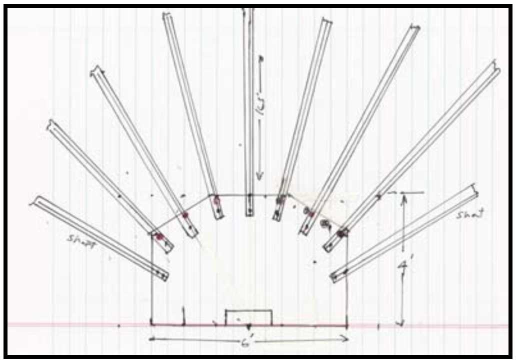


Fig. 10a - The *spokes* (6 long and 2 optional short) are attached to a 4' x 6' plywood hub.

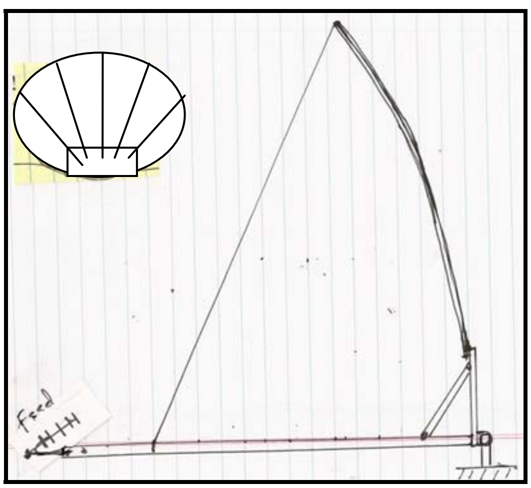


Fig. 10b – Side view of 70 cm offset dish.

A 9' length of 2" x 3" 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 wirers. Since polarization is linear on 432, 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" is a good compromise for 432, although even a 2" spacing should work.

Testing: The offset dish for 1296 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 > 3 dB more than a 15' loop yagi that was used as a reference. It is presently assembled and being used for EME from my backyard. The bigger offset dish should be assembled shortly and will also be tested off the Moon from my backyard.

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' offset dish provides performance equivalent to about an 8' diameter circular dish, yet can be disassembled into a small lightweight package.

References:

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