Small Dishes for Portable 1296 EME
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Abstract: There is growing interest in 1296 EME dxpeditions. This paper discusses two light weight stress dish designs that have sufficient gain to allow CW EME QSOs with moderate sized stations and JT QSOs with smaller stations, but which can also be transported as luggage on an airliner. The first is a conventional 7' diameter dish that can be carried with mount in a 3.5' x 0.5' x 0.5' package. The second is a slightly larger sized and gain offset dish.

Introduction: A year ago, I had the opportunity to travel to Bermuda. There had never been a QSO on 1296 MHz EME from Bermuda and I decided to change this dubious status. I hand-carried all the electronics. Since my Bermuda trip, this same dish has also been used for a 1296 dxpedition to the Bahamas.

Figure 1. The complete EME station fit in one box and a carry-on bag.

Choice of Antenna: Although the use of JT65 has allowed EME QSOs to be made with a single yagi on 23 cm, I wanted to have an antenna that would allow QSOs with stations on CW. CW remains the preferred, if not the exclusive mode of many 23 cm EME operators. Based on past history, an antenna with the aperture of at least a 2 m dish or greater seemed required.

Previously I had built a 7.5' offset stress dish that I intended but have not yet used on a dxpedition. This offset dish (OD) worked well in tests and could have been used for this dxpedition. I decided to try a conventional dish (CD). My reasons were two fold. Firstly, I could make the petals of a CD dish smaller. Both dishes were based on an approximate 7' diameter. The petals of the OD dish were about 7.5' long, while those of the CD were only half this size. This allowed the full dish to be package in a container of half the length and cause less attention at the airport. Secondly, I felt that I could more easily find the moon with a CD. I had found that with the feed mounting arrangement of the OD, it was not always obvious where to point the dish. (There was no chance of a visible moon during the Bermuda dxpedition). It seemed that using the CD would eliminate a potential cause of error.

Figure 2. 7.5' offset dish.

For small size dishes, feed blockage can reduce antenna efficiency. The OD concept eliminates the feed blockage problem and is an major advantage of this design. Sometime in the future I plan to make side by side comparisons of the two designs.

Virtually all 23 cm EME stations use circular polarization. The use of circular polarization provides an effective gain increase of 3 dB over a linearly polarized antenna. Both CDs and ODs can be easily fed circularly polarized and provide lots of gain, but they also provide considerable additional weight and size. Stress dish designs can solve the problem of weight. Considering the pros and cons, I decided to use the CD approach for the Bermuda trip, but plan to try the offset dish for another trip in the near future.

Stress Dish: The concept of a parabolic stress dish goes back to my high school days when I conceived and built a 30' dish that I believe is the first stress dish design. Later I used a 20' stress dish for many 432 EME dxpeditions. This dish is still in use and was last used by W2WD for his 70 cm dxpedition to Nebraska in 2002.

Figure 3. 20' stress dish on first Delaware dxpedition in the 80's.

A CD of 7' diameter was decided upon as compromise between portability and gain. The surface was produced from eight 40.5" lengths of ½" x ¾" wood molding stock - readily available at the local Home Depot. Each *spoke* has two holes drilled at 0.5" and 2" in from the outer end. These dish *spokes* are attached to an octagonal shaped center hub made from a 1' square piece of 1" plywood by cutting off 3.5" at the 4 corners. Each *spoke* overlaps the hub by 3" and is clamped in place using two small pieces of wood made from the same stock as the *spokes* – see Figure 4. (It would have been preferable to make channels into which the wood spokes could be inserted for attachment. I used this method of attachment for the 20' stress dish shown in Figure 3. This arrangement is stronger and makes assembly and disassembly quicker, but with only eight spokes the added effort was not considered necessary).

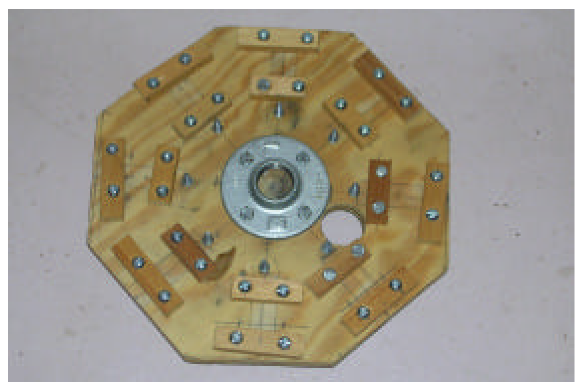

Figure 4. The *spokes* are attached to the plywood center hub with 2 wood clamps.

Two 1" pipe flanges are bolted to the center of the top and bottom of the hub for respectively attaching the feed support and mounting the dish. A 1" hole was also cut into the hub to allow access for the feed line and control cables.

A rim around the outside of the reflector is formed from eight 32.5" lengths of the ½" x ¾" wood modeling stock with mounting holes 0.5" in from each edge. Each *rim segment* is attached to one of the *spokes* using a 10-32 eyebolt (placed in the outer end hole) to form a *petal* of the dish.

Figure 5. A *petal* is formed from a *spoke*, *rim segment* and aluminum screening.

A 10-32 bolt is used to fasten the *rim segment* to the adjacent *spoke* by the lower hole (at the time of the dish assembly). A trapezoidal shaped piece of aluminum screening is also attached to the *spoke* – see Figure 5. (For shipping, the *rim segment* is moved over the *spoke* and the aluminum screening rolled around the 2 pieces with the eye bolt left in place as in Figure 6).

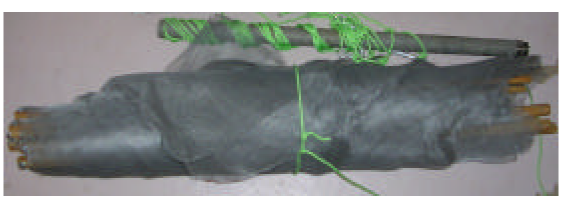

Figure 6. For travel the aluminum screening is rolled around the *spokes* and *rim segments*.

The length of the *rim segment* is critical and must be correctly calculated (cord of a circle) and cut to achieve the desired dish shape. (Wood dimensions are given to the closest ¼" and should not need greater precision). Its length was chosen to produce a reflector with an f/d ratio of about 0.55. (This f/d matches reasonably well the dual dipole feed chosen for use with the dish). The relationship between the diameter and depth of a parabolic reflector is given by the equation:

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

where X is radius of the reflector, Y is the depth and P is the focal distance. The shape of the curve used for this dish is shown in Figure 7. The deeper the dish, the shorter the focal distance and the wider the beam width of the optimum feed antenna. The length of the overlapping *spoke* and hub is longer than the diameter of the dish and integrates out to be 43.5" from which the 40.5" *spoke* length is determined. The two holes in the *rim segment* are place 0.5" in from the ends and are 31.5" apart.

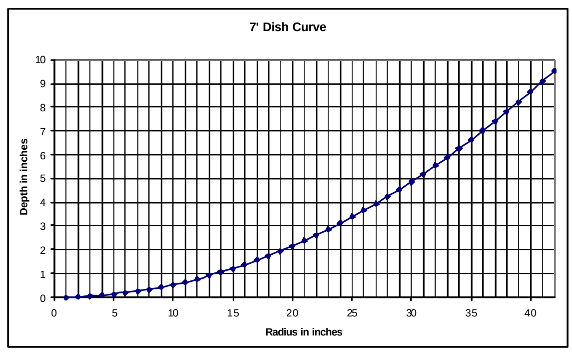

Figure 7. Shape of the dish's curve.

The dish's focal length is about 46.25" long. To keep the dish light in weight, a 1.25" diameter aluminum pole is used as the main support for the feed antenna. One end of this pole is cross slit and attached to a 1" pipe nipple with a hose clap. The pole can then be screwed into the pipe flange as shown in Figure 8. Eight holes are drilled into the opposite end and used to secure 8 ropes that are used to pull up the *spokes*. These ropes guy the *spokes* and facilitate the dish assembly, but are not tightened to the point where they distorted the dish shape. The dish shape should be set by the length of the *rim segments*.

Figure 8. Installation of feed support.

Feed Antenna: The feed pole is extended with a hook made from four lengths of 1" square aluminum stock that was used to hold the feed antenna at the center of the dish. A feed formed from orthogonal dual dipoles with a quadrature hybrid was used to produce circular polarization. The dual dipoles were chosen because of their relatively small size. An IMU horn would be an excellent choice for a feed antenna, but would add significantly to the size and weight and be difficult to transport.

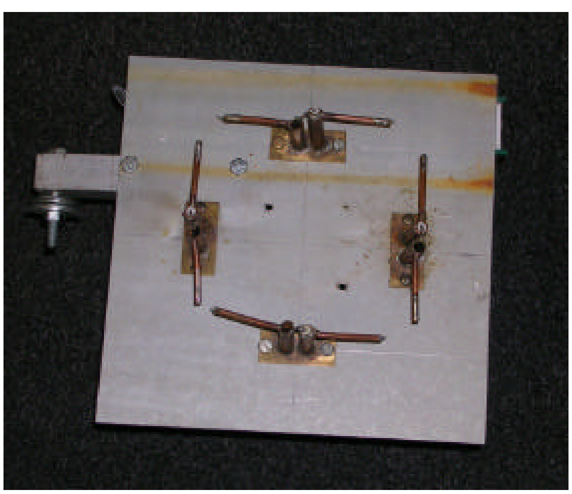

Figure 9. Dual dipole feed antenna.

Mount: An AZ-EL mount is assembled from 1" plumbing fittings. Only a tee and an elbow connected with two nipples are required. The components of the mount are shown in Figure 10.

Figure 10. The mount is made from 1" plumbing fittings.

One nipple connects the flange at the back of the dish to one end the tee. The second nipple connects the center of the tee to the elbow and serves as the elevation axis bearing. Two additional nipples are used to allow aluminum poles to screw into the mount (in an identical fashion to the feed support pole). One is for the vertical support mast, which connects to the other side of the elbow and provides the azimuth axis bearing. The other connects a pole for counter weight to the opposite end of the tee, as can be seen in Figure 13. This pole was secured with a rope to hold the elevation angle. Figure 13 also shows the inclinometer used for elevation readout and the protractor (white cylinder) used for azimuth readout.

Covering: The dish is covered with aluminum screening. This material is available in the US in 3' width by 25' long rolls. Two rolls were needed to cover the dish. The screening is cut into eight trapezoidal pieces - one for each *petal*. One side of the screening is attached to a *spoke* with wire (~ #24) stitching. The screening pieces are made wide enough to overlap the next spoke, but are not connected. Neither is the screening attached to the *rim segments*. When a *rim segment*, during the assembly of the dish, is bolted to the adjacent *spoke*, it is also used to bolt the aluminum screen in place. A hole is placed in the screening to facilitate this process. After all the *petals* are in place, a few short lengths of wire are run through the mesh and used to temporarily tie the screening pieces to their corresponding *rim segment* and the adjacent *spoke*.

CD Assembly: The dish can be assembled (or disassembled) in less than an hour by a single person. The main vertical mast is first tied to a rigid structure. I had intended to use the railing on the balcony of my hotel room for this purpose, but had to change my plans. I ended up using a picnic table to hold the mast.

Figure 11. Start of dish assembly.

The mount is screwed into the mast and then the center hub of the dish is screwed to the mount. The mount is set so that the hub is pointing vertically, and the center feed support pole screwed to the hub. A *spoke* is next slid under the clamps on the hub and bolted in place. This process is repeated until all the remaining 7 *spokes* (and *petals*) are attached. (I added screw stops, so that the *spokes* would always be at the correct depth). The ropes from the center support are attached to the corresponding eyebolt on the end of the *spokes*. Small turn buckles with hooks are used to attach the ropes. The *rim segments* of each *petal* are then moved so they are at a right angle to the *spokes* and bolted to the adjacent *spoke* along with the aluminum mesh. Extra wire is used complete the attachment of and smooth out the mesh as already discussed. Finally the feed assembly is bolted to the center support pole and the preamps, relays and feedline connected.

Figure 12. The *spokes* (*petals*) are attached to the center hub one at a time.

Figure13. Completed dish and mount.

CD Testing/Operation: The dish was basically constructed in a single weekend with no time for testing before the trip. Sun noise was measured for the first time in Bermuda. I used the reflection of the sun on the dish to calibrate my tracking system. It was gratifying to hear a significant increase in noise level when the sun's shadow was at the center of the reflector, but I did not have a way of quantifying the actual level.

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Offset Dishe Option: ODs are just a portion of a parabola of revolution (CD). The antenna described in this paper uses slightly less than a quarter of a conventional dish reflector. By using only part of a normal *full* dish as 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 14. 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 OD is only a *fraction* of the full dish. Hence the feed antenna must have higher gain to produce a smaller beam). Likewise, a deeper dish (smaller equivalent f/d ratio) should be used for the offset reflector to keep the feed antenna to a reasonable size.

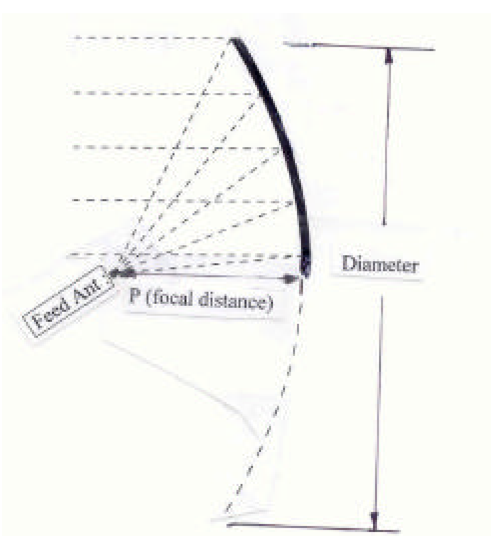

Figure 14. The feed is on one side.

The OD besides having greater efficiency than a CD antenna has an added advantage for EME. It can be mounted with its center gravity very close to the ground and still fully track the moon. This allows a relatively small mount to be used and makes a polar mount a good choice with an OD.

OD Construction: It was decided as compromise between portability and gain to construct a reflector with a radius of 7.5'. This would correspond to a CD of 15' in diameter. In the case of our OD, only a quarter of a CD's surface is used as shown in Figure 15. This surface was produced from five 7.5' lengths of ½" x ¾" wood molding stock – same material as used for the CD. These *struts* were attached to a 1' radius wedge shaped (quarter of a circle) piece of ½" plywood with two bolts. A 3' overlap was used.

Figure 15. The *struts* are attached to a square plywood center with two bolts.

A rim around the outside of the reflector was made with 3.5' length of ½" x ½" wood modeling stock with two small (8-32) bolts as shown in Figure 16. 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).

Making the reflector deeper, see equation (1), will allow a wider beam feed to be used. The dish's focal distance is about 4.5'.

Figure 16. An outside rim is formed from 3.5' length modeling strip.

The dish's focal length is about 4.5' long. A 3.5' length of 2" x 3" lumber was used for the main feed support. 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 strut. The length of these lines was adjusted so that the radius (X distance) of each strut was 7.5'. It was discovered that the pull of struts was bending the feed support (and plywood center section). To counter this effect, a second 3' length of 2" x 3" was added in the direction opposite to the struts and at a right angle to the feed support. The feed support was guyed to this add support to correct its bending as shown in Figure 17. The feed support was also used for attaching the dish to the mount.

<u>OD Feed Mounting:</u> The feed antenna was attached to about a 1' length of 2" x 2". This was attached to a 2nd approximately 1.5' length of 2" x 2" 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 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 18.

Figure 17. The dish is attached to the feed support by a 2" x 2" block.

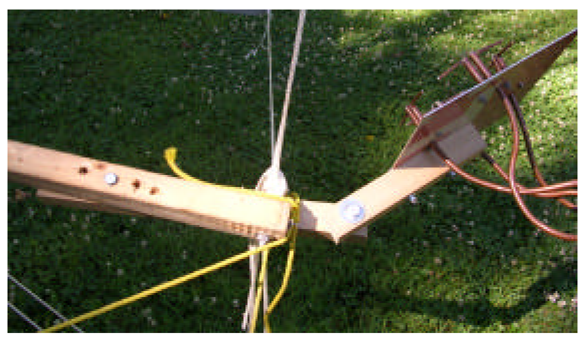

Figure 18. The feed mount uses several supports to allow optimum positioning.

<u>OD Covering:</u> The OD is covered with Aluminum screening as was the CD. In the case of the OD, 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 19. 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 struts using wire as in the CD case.

Figure 19. Screening is tie to the struts.

Testing: The OD was originally constructed in a single weekend and tested for sun noise. The dish appeared to work as planned and yielded > 8 dB of sun noise. This was > 3 dB more than a 15' loop yagi that was used as a comparison antenna.

Conclusions: A small stress dish, both CD and OD, appear a good choice for 23 cm dxpeditions where the antenna is to be transported as luggage on a commercial airliner. The dishes described in this paper should be considered for this purpose. The designs discussed in this paper are starting points that can be modified and tailored using available materials to specific station needs. Both designs offer a relatively inexpensive and simple way of obtaining an antenna for potable EME operation on 1296. They both provide enough gain to make both CW and JT EME QSOs, yet can be disassembled into a small lightweight package.

References:

1] A. Katz, "K2UYH Report," 432 and Above EME Newsletter, June, 2004, http://www.nitehawk.com/rasmit/NLD/eme0406.pdf.

2] A. Katz, "Small Station EME on 70 and 23 cm Using JT44/65," http://www.nitehawk.com/rasmit/jt44_50.html.

3] B. Fritsche, "DL3OCH Report," 432 and Above EME Newsletter, March, 2004 http://www.nitehawk.com/rasmit/NLD/eme0305.pdf.

4] P. Wade, "W1GHZ Online Microwave Antenna Handbook, Chapter 5, http://www.w1ghz.cx/antbook/app-5a.pdf.

5] A. Katz, "20' Portable Stress Dish," 432 and Above EME Newsletter, Oct. 1980, http://www.qsl.net/pa3csg/Boek/BoekH3/art3-8.htm.

Appendix: CD/Mount Parts List

1 - Hub of 1'x1"x1" plywood with corners cutoff at 3.5" in and holes drilled as shown in Figure 4.

16 - 2"x0.5"x0.75" wood molding stock clamps with holes drilled 0.75" in from the ends.

8 - *Spokes* of 40.5"x0.5"x0.75" wood molding stock with holes drilled at 0.5" and 2" in from one end.

8 - *Rim segments* of 32.5"x0.5"x0.75" wood molding stock with holes drilled at 0.5" from both ends.

8 – Trapezoidal shaped pieces of aluminum screening cut as shown in Figure 5.

40 – ¼" bolts 2.5" long, nuts and washers.

8 – 10-32 eye bolts, nuts and washers.

8 – 10-32 bolts 1.5" long, nuts and washers.

2 – Aluminum poles 1.25" dia x ~ 3'.

1 – Aluminum pole 1.25" dia x ~ 1.5'.

5 – 1" pipe nipples.

2 - 1" pipe flanges for mounting on hub.

1 – I" pipe tee.

1 – 1" pipe elbow

3 – Hose clamps.

50' – Nylon rope.