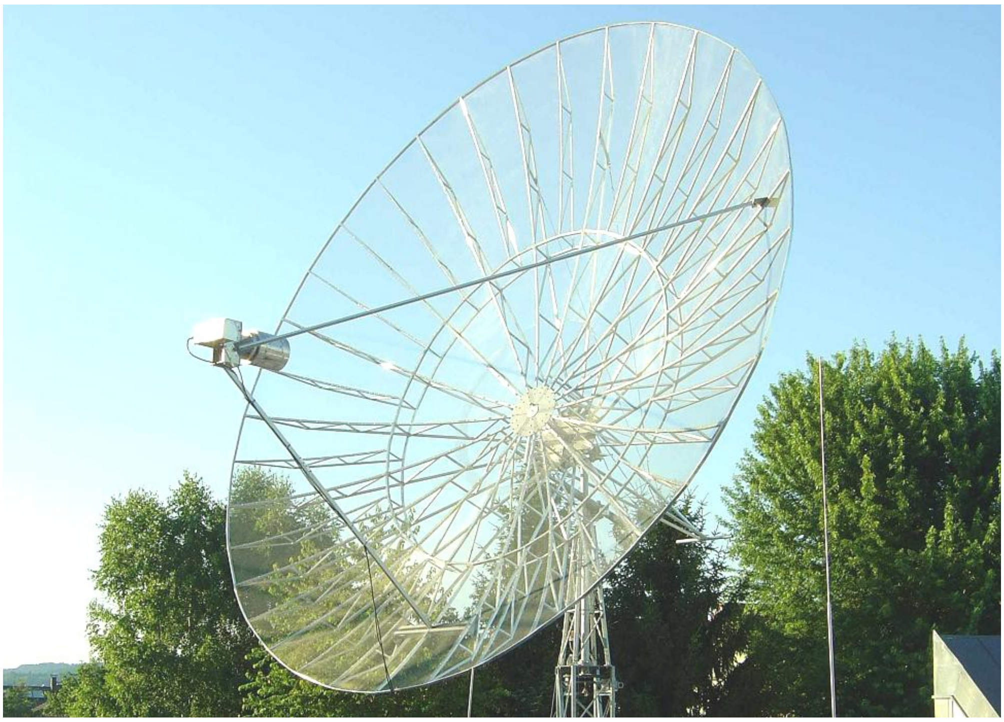
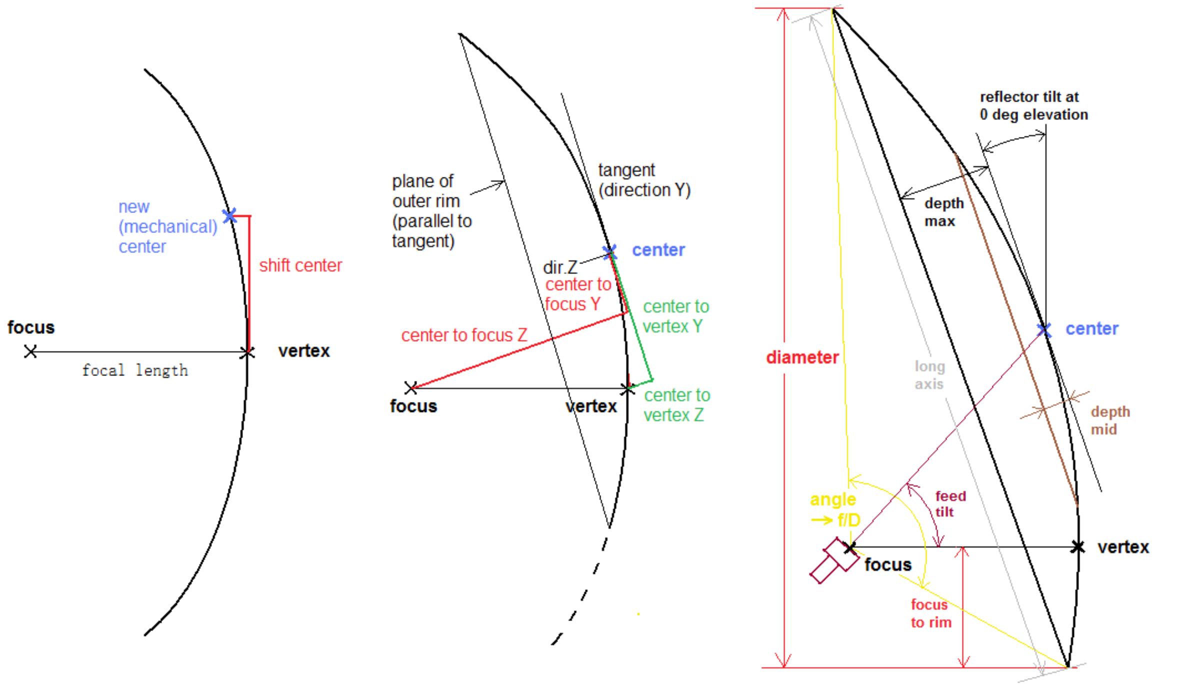
HOMEBUILT 7,3m OFFSET DISH
by Hannes Fasching OE5JFL



1. Introduction

Several years ago I had experienced very good results of EME stations using offset dishes, especially on receive. This can be easily explained by well-known reasons: There is no blocking by the feed, and because of a more upward-looking feed, the spillover picks up less ground noise.
To learn about the improvements in practice, I extended the upper part of a 2.8m prime focus dish. The performance was quite good, so I presented this project and its results at the 2012 EME conference in Cambridge.
But in fact this was more or less a startup project, as I was already thinking about building a larger offset dish. Of course blocking by the feed has less influence the larger the dish is, but the advantage of less spillover noise pickup by the feed is still present. A large dish also has the convenience of an easy access, as you have the feed close to the ground.
An additional reason for starting this project was that (as far as I know) no member of the EME community has built a large offset dish himself before. ;-)
A prime focus dish is relatively easy to build. You only need one simple formula, choose the diameter and the f/D ratio, and you can calculate the dimensions of the ribs, which all have the same shape.
The story is completely different with the offset dish. As the mechanical center of the dish is now outside the vertex, the curvature and the length of the ribs are different. Only right and left side are identical, which results in pairs of ribs of the same shape.
I had hoped to find a helpful formula in some antenna book or on the internet for designing a dish fitting into all desired parameters, but I wasn't lucky. So although I do not like programming at all, I had no choice...
The instrumentation and visualization software Labview is not the very best for calculating the ribs for a dish, but I am somewhat used to it and it contains all the mathematical functions needed for this project.

The results of the calculations seemed reasonable, but to be honest, I did not totally trust my own formulas. Therefore I decided to build a model, covered the surface with aluminium kitchen foil and placed a small strong LED at the focus. I could observe a nice light spot at the wall in the predicted direction.
Later I simulated the offset dish including the feed with NEC to have an additional confirmation. The main lobe and also the gain from the simulation fit my expectations.
Conventinal prime focus dish designs usually have the mechanical center (hub for fixing the ribs) at the vertex of the paraboloid. With my program **'Ofs_calc_jfl'** I can choose the focal length, the depth of the dish, and then shift the mechanical center upwards to achieve an offset dish. The program provides the rib dimensions as a chart.



Steps from a prime focus dish to an offset dish. Input and output parameters of the program.

If the focus at 0 deg elevation is not higher than the lowest point of the rim, it is a true offset ('focus to rim' < = 0). In the case of (0 < 'focus to rim' < diameter/2) the dish is more or less offset, which you can consider as a hybrid.
I suggest to change the parameters 'focal length', 'depth max' and 'shift center' step by step, until you achieve the diameter and f/D of the dish of your choice.
The number of ribs is of course your decision. The parameter 'depth mid' should be around 25% of 'depth max', which will result in the middle rim having around half of the dimensions of the outer rim.
The parameter 'focus to rim' tells you the distance between the lowest part of the dish and the focal point.
Furthermore, the program calculates the coordinates of the focus and the vertex in respect to the mechanical center. This is important to know, as the line between the vertex and the focus is the direction of radiation.
The shape of the outer rim is elliptical. The long axis streching from the top of the reflector to the bottom, and the short axis is corresponding to the dish diameter. Looking frontally into the dish at 0 deg elevation, you see an exact circle due to the tilted ellipse.
The feed must be tilted upwards and should be directed towards the mechanical center for best efficiency.
The ribs are arranged around the mechanical center in equidistant angles. The program's

output is a chart containing the rib dimensions you need. The right way to use the chart is explained below on the example of the rib at 60 deg. The rib at -60 deg (=300deg) has the same shape. The rib at 10 deg is the same as at 350 deg e.t.c. Only the ribs at 0 deg (top) and 180 deg (bottom) are unique.
The top line at the chart below shows the angle (0=top), in the column on the very right the radius values can be read out. The last value of the other columns represents the radius of the tip (lower yellow mark), the value above shows the radius of the middle ring (lower blue mark).The rib at 60 deg is marked in red, together with the radius column.
The example chart below shows a dish with 2.4m focal length, the center is shifted to 1.6m above the vertex and the dish is 0.8m deep. This results in 5.69 m diameter, a long axis of 6m and an effective f/D ratio 0.457. The longest rib (to top) is 3.266m long, the shortest 2.731m at 150 deg.
The yellow mark at the very top means the maximum depth of the dish, the blue mark at the left side de depth at the middle ring.

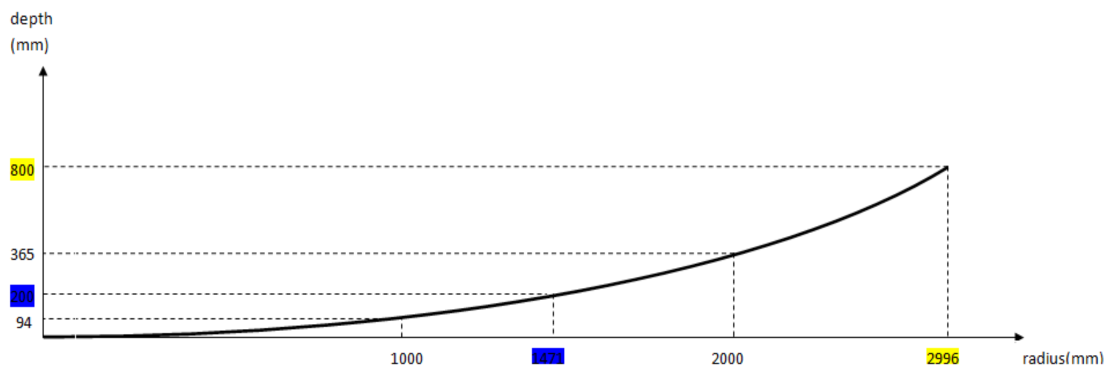
number ribs 24 | focal length 2,40 | shift center 1,60 | depth max 0,800 | f/D 0,457 | angle 114,7 | refl.tilt 18,4 | feed tilt 36,9 | long axis 5,998 | diameter 5,691

radius step 0,20
depth mid 0,200
center to vertex Y 1,60
center to vertex Z 0,25
center to focus Y 0,84
center to focus Z 2,53
focus to rim altitude (0 deg elev) 1,25

0	15	30	45	60	75	90	105	120	135	150	165	180	0
4	4	4	4	4	4	4	4	4	4	4	4	4	200
14	14	14	15	15	16	16	16	16	15	15	15	15	400
31	31	32	33	34	35	36	36	35	35	34	33	33	600
54	55	56	58	60	62	63	64	63	62	61	60	60	800
84	85	87	90	94	97	99	100	99	98	97	95	95	1000
120	121	124	129	134	139	143	144	144	143	141	139	138	1200
161	163	167	174	182	189	194	197	197	196	193	191	190	1400
208	211	217	226	236	246	254	258	260	258	256	253	252	1600
261	264	272	284	297	310	321	328	331	330	327	325	324	1800
319	322	333	348	365	382	397	407	411	412	409	407	405	2000
382	386	399	418	440	462	481	494	502	503	502	499	498	2200
450	456	471	493	521	548	572	591	601	605	605	603	601	2400
523	530	548	575	608	642	673	696	711	718	719	718	717	2600
601	609	630	663	702	743	781	1411	1409	1415	1423	1430	1433	2800
683	692	717	756	1471	1442	1422	2782	2750	2735	2731	2732	2733	3000
770	780	1535	1504	2996	2907	2834	0	0	0	0	0	0	3200
1567	1558	3180	3092	0	0	0	0	0	0	0	0	0	3400
3266	3243	0	0	0	0	0	0	0	0	0	0	0	0

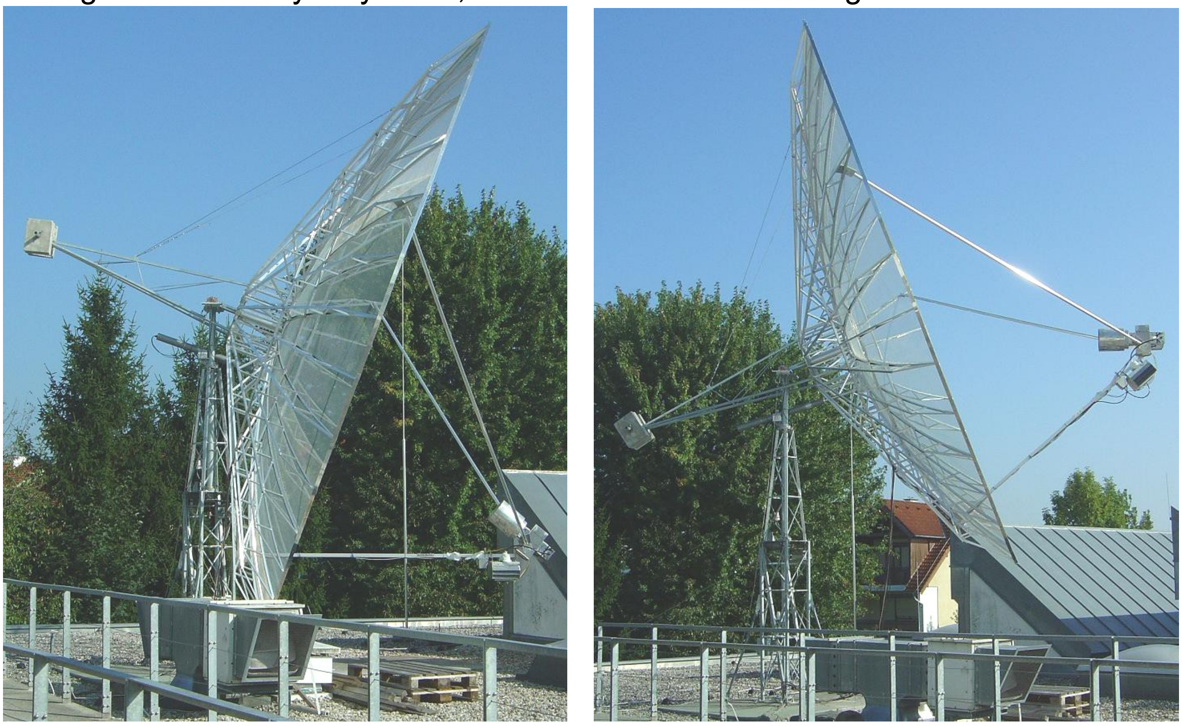
Chart for the rib dimensions (depth at given radius and angle)

The figure below shows the form of the rib for the 60° position with 2.996 m length and the inner ring at 1.471m. The depth at 1m radius is 94mm and the depth at 2m radius 365mm.



Rib form (excerpt from the chart above)

The photo on the left illustrates how easily the feed can be reached if the dish is at 0 deg elevation. At 40 deg of elevation, as it can be seen on the photo on the right, the spillover sees ground noise by only 50 %, because the feed is looking into horizontal direction.



Dish at 0 deg elevation and 40 deg elevation

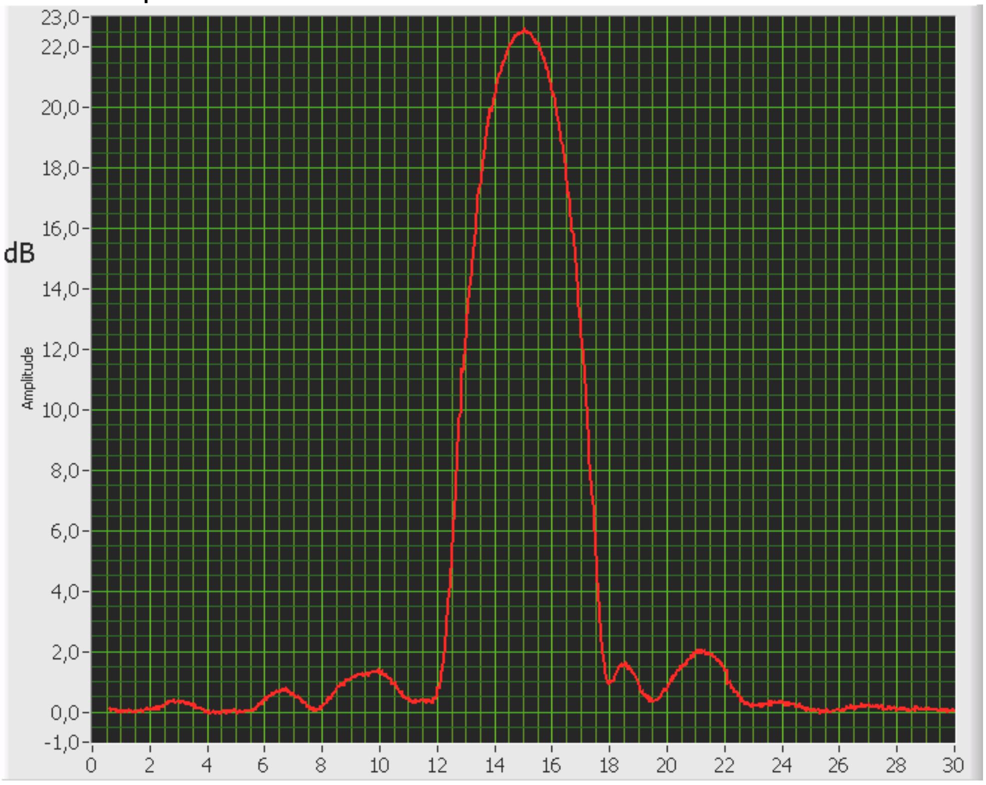
Shortest and longest rib

2. Measurements and results

The dish is equipped with the same RA3AQ feed horn I used for my former 5m prime focus dish. For the first measurements on 23cm I also had the same preamplifier.

The 7.3m offset dish with a slightly lower f/D has 3dB more gain compared to the 5m prime focus dish. Sun noise has been 15.5 dB with the 5m dish at SFI 65. With the 7.3m dish I got 21.5dB at SFI 104. Considering 3dB more gain and 2dB more SFI sun noise should

have been 20.5dB, so I received 1dB more than with a prime focus dish. This is a quite good coincidence, which I had estimated before based on less ground noise.
Since I am using a new preamplifier and I measured a good 22.5dB at SFI 107, as you can see at the sun noise plot.



23cm sun noise plot @ SFI 107   7.3m offset dish OE5JFL

Moon noise is 0.85 dB. Occasionally I can see my own echoes on the waterfall with 100mW at the feed. I can hear my own echoes using 1W power almost all the time.
I have not yet tested the dish on higher frequencies, but as it is filled with a 6.3mm mesh I expect a good performance up to 6cm.
I was interested if I can use it on 2m as well, although the diameter is smaller than four wavelength on this band. So I placed a 3 element quad in the focus, the 23cm horn was looking through the reflector of the quad.
From the simulation with NEC I could expect a gain of 19dBi for the dish. At home I have a 13 element yagi, NEC simulation of this antenna resulted in 16dBi.
Both antennas are 2km apart from each other, and both are horizontally polarized. I performed measurements during a weekend with high activity and periods and without extra noise, to have the same receiving environment on both systems.
The MAP65 decodes were 2 to 5 dB better on the dish than on the yagi with signals in the range of -20.
Thus the dish has about the same performance on 144 MHz as a 4 x 8 element yagi group. The gain is not that big, but it is a nice side effect of the dish that you also can play with it on 2m with a small additional amount of hardware.
I guess you can even use a 6m dish with good success on 2m. In this case I am sure that the offset construction is a big advantage.
Sun noise was 1dB lower on 23cm with the additional 2m feed, this is the penalty for having an extra band. **But as already mentioned earlier, the easy access to the feed point makes it possible to change feeds quickly.**