Gaining Extra dBs from a Small Dish

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Several years ago I saved a 2 m dish from going to scrap, and my first intention was to use it for terrestrial QSOs on 23 cm. It consisted of 12 ribs and aluminium panels. The focal length was 1.2m, resulting in a f/D of 0.6. As most feed designs are for lower f/D, I decided to extend the diameter to 2.8m and replace the solid panels by 8mm mesh for lower wind load.

So the new f/D ratio was 0.43 and I chose the RA3AQ feed designed for f/D=0.5. My experience with this feed had already been very good, and although I was aware that it would lose a little on transmit because of under-illumination, I preferred the advantage of reduced noise pickup on receive.

Original dish: diameter 2.8m, f/D=0.43, 12 ribs

Operating on tropo I already experienced that I could hear a lot more than I could work, because for transmit I had only a Mitsubishi module M57762 at the feed.

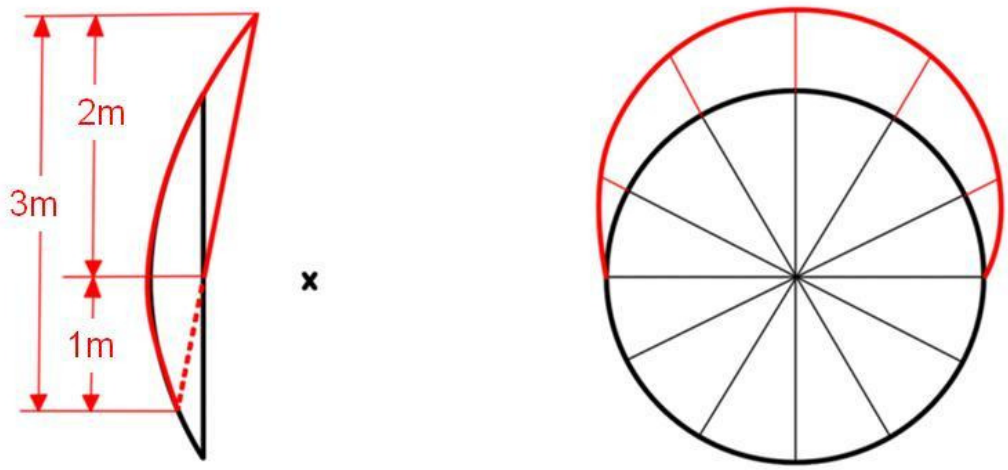
Sun noise measurements were promising, so I gave EME a try, and surprisingly I could even see traces of my own EME echoes on the waterfall graph with my 15W transmit power. After a couple of JT65 QSOs, the first highlight was a random CW QSO with DL0SHF in the ARRL contest.

Comparing the receive performance of my system with the results of other stations using about the same dish size, I mostly found good agreement. But PA7JB was an exception. He is using an offset dish, and watching the reports he gave on JT mode, I noticed he was receiving in average several dB better than he ‘should’ have done, although he was using the same good preamplifier as many of the rest of the crowd. Beside that I remembered the big success RW3BP had with his offset dish. Of course he had squeezed out every tenth of a dB wherever he could, but from my feeling a big part of his overall improvement was the offset dish.

In the meantime I had my 500W SSPA ready up at the antenna and could now work the bigger stations without problems on CW, but with smaller equipped stations it was not so easy. My own echoes were audible all the time, but I always felt that some more dB would lift me above a certain limit, where I could make QSOs much easier.

Looking at my dish and the whole construction many times, I tried to find a good possibility to increase the dish size without too complicated mechanical modifications. Increasing the diameter further the same way I had done before, would have resulted in an even lower f/D ratio and another feed for better illumination. The main problem was that there was no space left at the lower part of the dish, and I wanted to avoid making a new mast.

At one moment I had the idea to extend the upper part of the dish, and tilt the feed for optimum illumination.



Modified dish: 5 ribs extended, effective diameter 3.0m max, effective f/D=0.41

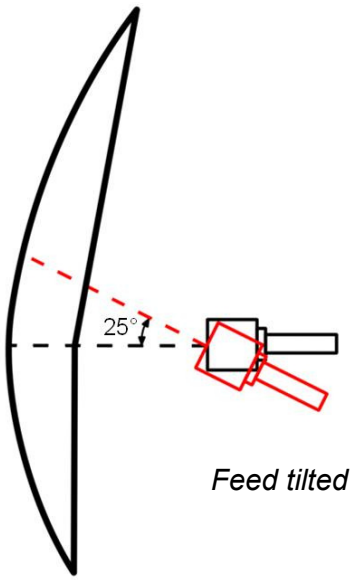
The additional hardware was not very much. Only 5 of the 12 ribs needed extension, a new outer rim was necessary, and some more mesh. Of course it was a compromise to what diameter I could extend the dish without getting too much instability to the structure. In my case I felt the optimum would be to extend the dish size to an effective diameter of 3.0 m. I achieved this by extending the radius of the upper part by 0.6m, from 1.4m to a new value of 2.0m. As you see from the drawing, the new offset dish is using only 1.0m from the lower part of the original dish. In principle the lowest 0.4m of the original dish is not needed, but is retained because it acts as a screen from ground noise and probably helps to increase gain by a few tenths of a dB.

The focal length of the new dish is still 1.2 m, exactly the same as before, so the f/D ratio of the new 3.0m dish is effectively around 0.41.

The centre of the new dish has moved up by 0.5m, so I had to tilt the feed upwards by 25 deg to achieve optimum illumination again. I did this by fixing a rod with its tip at the phase centre of the dish, and rotated the rear end of the feed downward while the remained centred at the same position.

Of course this is not a true offset dish, but somewhat between the original prime focus and a true offset design. But at least the feed is not in the centre of radiation any more, causing less feed blocking, which is especially important with small dishes like this one.

From increasing the dish size from 2.8m to 3.0 m, reducing feed blocking and retaining some additional surface in the lower part, I calculated the gain to be around 1 dB more. Not much, but when you are at the limit, 1 dB more on transmit can help you to complete a QSO.



Feed tilted for best illumination

On receive I expected even more improvement, because tilting the feed upward means less noise pickup from the ground. Calculating the spill-over around the dish, my guess was a further 1 dB additionally on receive, so 2dB in total. This depends of course on the quality of the preamplifier.

I managed to make the modification within a couple of days, but unfortunately the solar flux was not constant during that time. Nevertheless I made sun noise measurements before the extension of the dish, then with extension but the feed not tilted yet, and at last with the tilted feed.

The extension alone resulted in 0.5dB increase, but when I tilted the feed for optimum illumination I noticed 1.5dB increase additionally. So all together I got the 2dB increase that I had predicted.

Sun noise measurements:

1. Before modification:	5th July 2011, SFI=85	10.5 dB
2. Extended surface, feed not tilted:	11th July 2011, SFI=91	11.5 dB
3. Extended surface, feed tilted:	15th July 2011, SFI=94	13.5 dB

The improvement on the transmit side is more difficult to measure. I tried to achieve realistic results by measuring and averaging the signal strength of my own echoes many times before and after the modification. Of course I did pay attention to have about the same moon conditions as elevation and azimuth for same noise pickup and compensated differences in moon distance. Taking all those factors into account, I have 3 dB better echoes now, so that means 1 dB increase on transmit.

Even more impressive to me was that my wife could only hear my CW echoes on rare occasions before, and now can hear them nearly every time! So maybe even slightly more than 3dB improvement….

But what are all sorts of calculations and measuring compared to real EME traffic? I was active during the ARRL Contest 2011 only on 23 cm, and wanted to learn what is possible with my new specially modified 3.0 m dish and 500W at the feed. Well, I could make 69 random QSOs, all in CW, which is not so bad I think. Even more satisfying was the receive side, as I could hear more than 100 different stations.

To increase the size of a big dish in the same way is of course much more difficult, and it will probably not show the same improvement because for example feed blocking has much less influence.

But for stations who are presently using dish sizes of 3.0 m or less, I think it is an easy way to gain a couple of extra dBs from their system and increase the success rate of EME QSOs the same way.

For me it was a nice experience to think about a solution first, then try something new and relatively simple, and finally confirm my calculations by measurements.

If maybe somebody will try the same modification, please let me know about the results.