A Modified Dual Dipole Dish Feed for 432 MHz

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Summary: When a linear feed is used to illuminate a dish the surface reflection affects the feed VSWR. This paper describes experimental modifications to a dual dipole feed for 432 MHz to achieve a good match when the feed is mounted in a 6m dish.

1. Feed description. The dual dipole feed has been a popular way of illuminating dishes at 432 MHz since the early days of amateur EME activity. It originates in an antenna developed as a gain standard , known as the EIA standard, and it has the useful property that the E and H plane beam widths are very similar out to about 120 degrees, the -12dB points. The optimum F/D ratio for this feed is about 0.45 (ref.1) but I have used it to successfully illuminate dishes from 0.5 to 0.38 F/D.

The feed consists of two half-wave dipoles spaced at half a wavelength and arranged to be a quarter wavelength above a one-wavelength square ground plane. (More often, a circular ground plane is used.) There are at least two ways of constructing the feed, the method that I have used, shown in the picture, has the virtue that it is rotatable about a single axis at the centre and has low mass allowing fast rotation. Rotation of the feed to give control over the polarisation is the major advantage of dish reflector antennas on 432 MHz where Faraday rotation and spatial rotation can greatly attenuate the EME signal. The alternative method to switch between two orthogonaly polarised pairs of dipoles, each fed by a power divider. I will now describe my arrangement in some more detail.

The two dipoles are folded so that the impedance at their terminals is around 280 ohms. Each is transformed, though a quarter wave transformer with two small spacer blocks, to 100 ohms so that the two in parallel present 50 ohms at the centre. The whole of this structure is made of 4.3mm copper rod and the shorting bars at the ends of the dipoles are silver soldered.

The balun is a Pawsey stub type and the arm of the stub which carries the coax extends through the reflector in a simple sleeve bearing so that it can be rotated by a motor and gearbox. Also on the shaft is a gearing to a potentiometer which forms one side of a Wheatstone bridge to give an indication of the shaft position at the operating position.

This arrangement has very low losses, there are no cable runs and the whole thing is virtually an air-spaced construction. Obviously, it cannot be used in a dual band 1296/432 feed arrangement but that is its only disadvantage.

2. VSWR Issues. I have used this feed for about 34 years on several different dishes but I had always been slightly bothered by the fact that out of the dish the VSWR could be tweaked (by a little alteration of the transformer spacing) to be pretty low, about 1.13:1; but it degraded to about 1.5:1 when the feed was mounted at the focus. Now, I knew the cause, it was the reflected power from the dish surface intercepted by the feed and I knew that one way to cure it was to fit a so called vertex plate at the centre to reflect the right amount of energy in the correct phase to cancel the general reflection… but this would not be a good thing when the dish was used at the higher bands.

The magnitude of the reflection can be predicted, (ref 2), as follows:

The reflection coefficient T, introduced by the presence of the paraboloid is given by

$$T = g L / 4 \, Pi \, F,$$

Where g is the gain of the feed and L the wavelength and F the focal length.

For this feed g = 9.6dBi and F = 2.25m and L = 0.7m and so T = 0.24 which is a VSWR of 1.6:1, a reasonable agreement with what I was seeing.

Why was I bothered? Well, I wanted the low noise preamplifier to be driven from a good 50 ohm source. I also have a long feed line on transmit with a couple of small discontinuities in it and so the VSWR seen at the transmitter tends to alter somewhat with a small alteration in the line length….and maybe I'm getting fussy as I get older!

Another way to restore the match is to modify the feed itself by altering its impedance matching arrangements when mounted in the dish so as to end up with a low VSWR at the feed terminals.

3. Experiments and results. I set the feed up in the dish, elevated at about 10 degrees and arranged a work platform so that I could easily get to it. On the ground I had an HP 8746B S parameter test set arranged so that I was just looking at the magnitude of the reflection displayed on a spectrum analyser which was visible from the work platform. This equipment is my standard way of looking at VSWR (it actually provides the return loss) but there is no reason why a simple, but good quality, directional coupler or a directional wattmeter could not be used. For safety reasons the RF level must be kept low and the feed should not be touched when fed with RF.

I then set about experimenting to lower the VSWR…I tried some pieces of dielectric, actually ceramic substrate, Er = 10, in between the transformer arms close to the dipoles (obviously it did not fill the space so the effective Er was much lower) but after a bit of fiddling I saw the VSWR start to improve. I then cut some 65mm long Teflon slugs from 25 mm material, drilled them longitudinally to take the transformer bars , cut them and then fitted them together on the bars with a couple of Teflon screws so it formed a sort of slug tuner. Finally, I fitted a temporary variable short stub at the junction to the Pawsey stub (temporary means two pieces of aluminium wire with croc clips on the end, and a small shorting bar.) Adjusting the three parts, taking care to keep the slugs in the same position with respect to each dipole, soon bought the VSWR down to the 1.13:1 region.

The slugs finally ended up about 45mm from each dipole; the stub at the centre, when permanently fitted, was made from 3.25mm copper wire, spaced at 18mm and was 85mm long from the Pawsey to the short circuit, which was silver soldered.

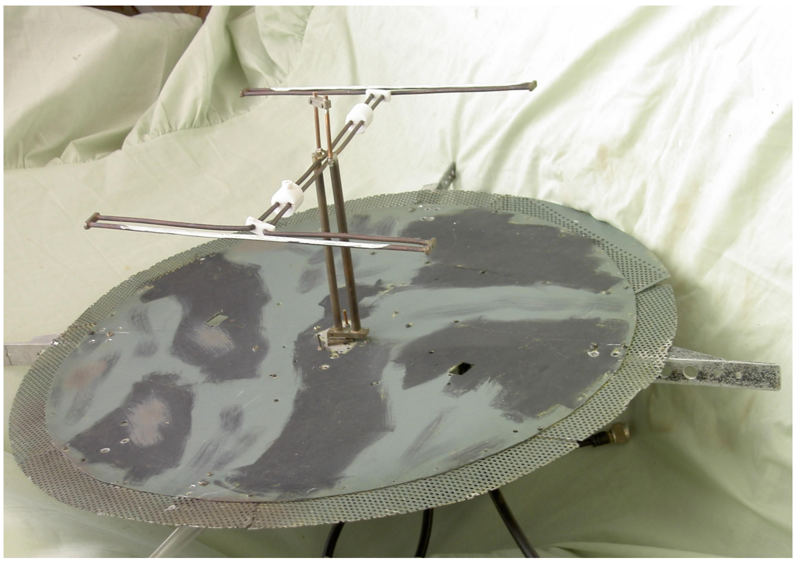
4. Comment. Was it all worth doing? Well I think so, it's hard to do before and after tests at this level but I sense the receive performance is slightly better and certainly the transmitter is happier. I have also noticed that a small squint ,0.2 beamwidth, in the pointing angle compared to the 1296 boresight has now gone but I can't explain why this modification would do this unless the dipole feed excitation is now better balanced.

Finally, I hope this narrative is of some help to those who use dual dipole feeds in their dishes.

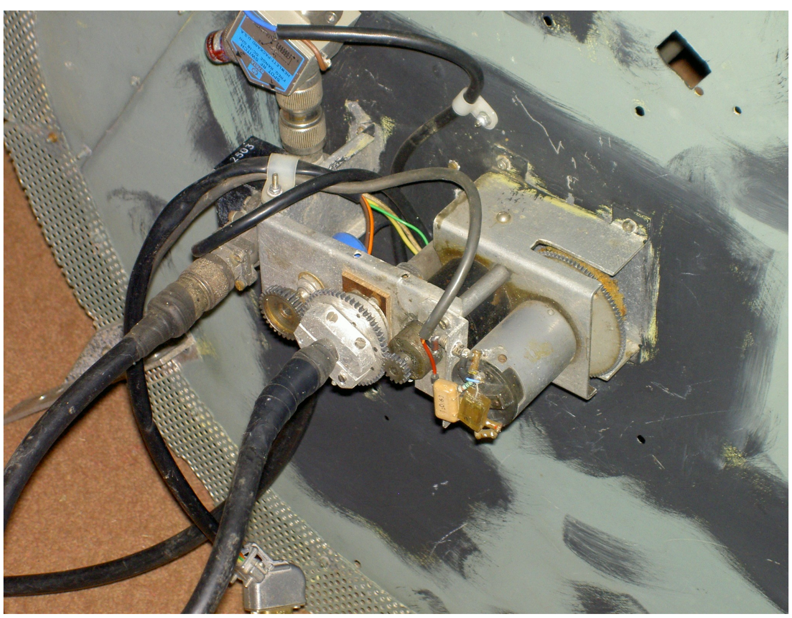
Ref 1 "Deep dish horns revisited" Barry Malowanchuk VE4MA Dubus 4/89 pp11-15
Ref 2 "Antenna Engineering Handbook" R.C. Johnson, pp 17.20-17.21

Appendix. Feed dimensions… Note that these are in mm.

Folded dipole length , inside the end shorting bars 331mm.
Folded dipole spacing 12.7mm,Spacing between dipoles 335mm.
Spacing of transformer rods 12.7mm (approx)
Spacing above ground plane 183mm
Pawsey stub length 174mm, diameter 9.5mm, spacing 19mm
Shorting plate 42x15mm, silver soldered
Other dimensions are in the text.



Front view of the feed.



Rear view of feed showing rotation mechanism