Chapter 6
Feeds for Parabolic Dish Antennas
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Appendix 6A — Parabolic Dish Gain and Beamwidth

One common shortcut in antenna gain measurements is to approximate the gain from the 3 dB beamwidth. In some references[1], a formula is given:

$$\text{Gain} = \frac{41253}{\text{BW}_\phi \bullet \text{BW}_\theta}$$

where **BW** are the 3dB beamwidth in the *phi* and *theta* planes, usually horizontal and vertical polarization. This formula is very optimistic for two reasons: it assumes that side and back lobes contain negligible power, and that the antenna has no losses. In Chapter 1, a simple example with an average sidelobe level of –40 dB reduced the antenna efficiency to 19.5%, a gain reduction of 7 dB, so even apparently small sidelobes can significantly reduce gain. As for losses, it is intuitively obvious that putting a 3 dB attenuator in the feedline will not affect the pattern at all — beamwidth is not changed by losses, but gain and efficiency are reduced.

The formula is really an approximation for directivity:

$$Directivity \cong \frac{41253}{\text{BW}_\phi \bullet \text{BW}_\theta}$$

and

$$\text{Gain} = \eta \bullet Directivity$$

These simple formulas work pretty well for simple antennas, like horns They work because the beamwidth and gain are both related to the aperture, unless the flare angle is really bad.

However, for a dish, the aperture is fixed; only the feed is a variable. We would expect the beamwidth to be dominated by the aperture, while the gain is a function of illumination quality. Efficiency is, of course, gain divided by potential gain for the aperture.

In order to test this hypothesis, I calculated patterns for a 24 inch dish (f/D = 0.5) at 10.368 GHz with different illumination tapers, using Physical Optics routines from Milligan and Diaz[2]. The feed patterns are calculated for different diameters of corrugated cylindrical horns, which provide reasonably clean patterns. The last feed pattern was made asymmetric by removing the corrugations.

The results are summarized in the following table. As one might expect, an edge taper around 10 dB provides the best efficiency, about 70% calculated (I find that real dishes consistently measure 10 to 15 percentage points lower than these calculations, which isn't bad for the real world). However, the narrowest beamwidth, which would give the highest gain by the simple formula, comes from over-illumination, which yields the lowest gain and efficiency. The widest beamwidth comes from under — illumination, which reduces the effective aperture; the gain is much higher than the over-illuminated case. Finally, the asymmetric example further suggests that the beamwidth is a function of feed taper.

All have the patterns have pretty clean patterns with low sidelobes.

Beamwidth of 24" dish at 10.368 GHz

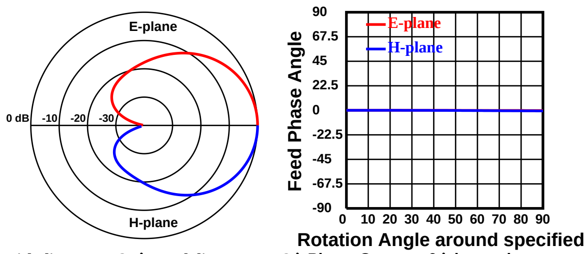
	FEED			DISH			
Illumination	**Edge Taper (dB)**		**best f/D**	**Gain**	**efficiency**	**3dB Beamwidth**	
	E	**H**		**dB**	**%**	**E**	**H**
good	10.5	11.3	0.47	34.9	70	3.1	3.15
over	6.2	8.6	0.34	33.2	47.5	2.95	3.1
under	21.5	17.7	0.68	34.3	61.5	3.7	3.5
asymmetric	20	10.6	0.55	34	57	3.6	3.05

References

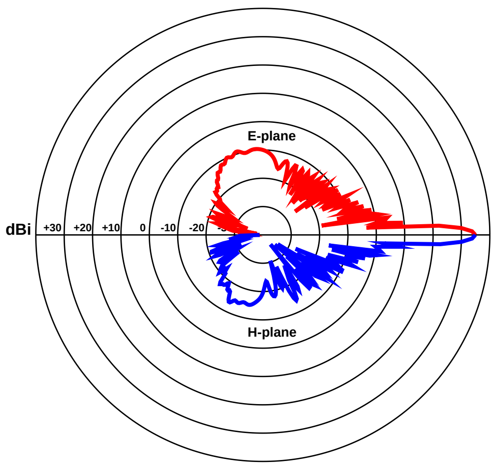
1. *EW and RADAR SYSTEMS ENGINEERING HANDBOOK*, Naval Air Warfare Center, http://ewhdbks.mugu.navy.mil/ANTENNAS.HTM

2. L. Diaz & T. Milligan, *Antenna Engineering Using Physical Optics*, Artech, 1996.

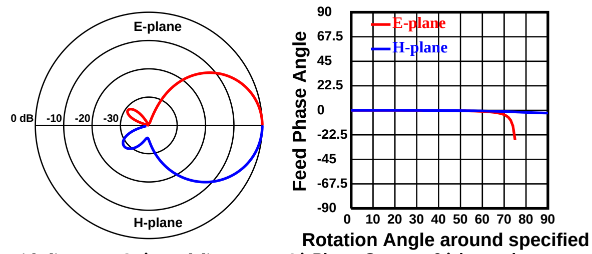
Parabolic Dish Gain & Beamwidth - 24" dish at 10.368 GHz



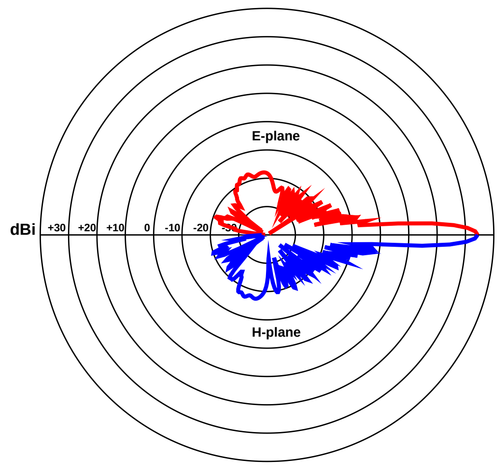
Dish diameter = 21 λ, Feed diameter = 1.2 λ Phase Center = 0 λ beyond aperture



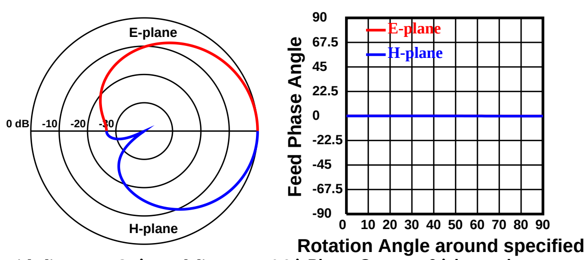
Radiation Pattern for Dish with Good Feed Illumination



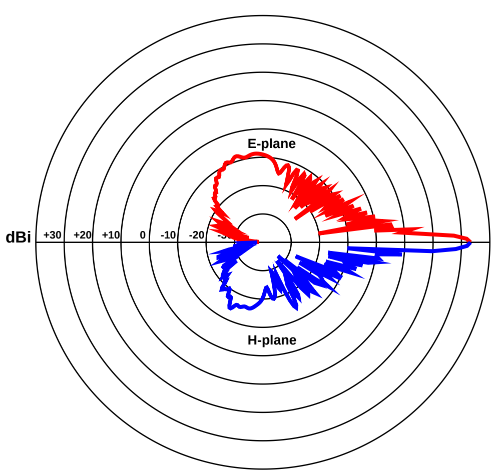
Dish diameter = 21 λ, Feed diameter = 1.6 λ Phase Center = 0 λ beyond aperture



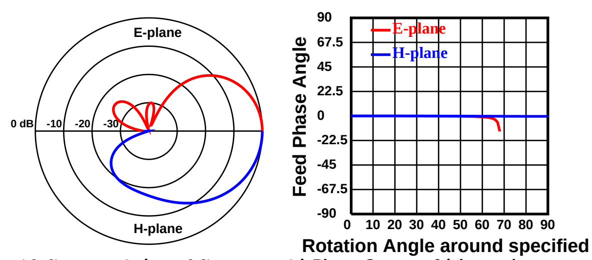
Radiation Pattern for Dish with Under-Illumination



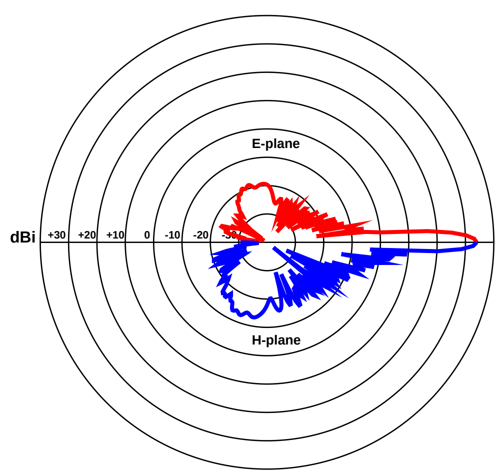
Dish diameter = 21 λ, Feed diameter = 0.9 λ Phase Center = 0 λ beyond aperture



Radiation Pattern for Dish with Over-illumination



Dish diameter = 21 λ, Feed diameter = 1.2 λ Phase Center = 0 λ beyond aperture



Radiation Pattern with Asymmetric Illumination

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