Horn antennas

In spite of dubious claims by antenna designers and manufactures, there is no such thing as free lunch. Since gain is proportional to aperture, large antennas have more gain than smaller antennas. However, a large antenna with poor efficiency is a waste of metal and money.

Aperture

- The function of the receiver antenna is to gather energy from the electromagnetic field radiated by the transmitter antenna.
- This antenna area that gather electromagnetic field is called the aperture.
- The aperture is related to, and often closely approximates, the physical area of the antenna.
- In some antenna designs the effective aperture, A_e, is less than the physical area A of the antenna.
- So there is an efficiency factor, *n,* that must be applied.
- An antenna with large aperture has more gain than smaller one; just as it capture more energy from the passing wave.
- In most cases a high gain-transmitter antenna also exhibits a high receiving aperture.

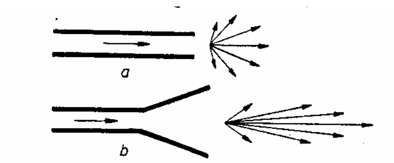
Relationship of gain and aperture:

Efficiency factor

- We know that a isotropic transmitting antenna radiates uniformly in all directions, so it is a simple matter of spherical geometry to calculate how much of that power should be arriving over the hole ***aperture area*** at the receiving antenna.
- Now if we actually ***measure*** how much power is being received at the receiving antenna.
- The received power can never be greater than the aperture at the receiving antenna.
- The ***ratio of actual power received and the calculated power*** is the efficiency factor, *n,* assuming free space propagation.

- If n=1, we have lossless antenna.
- For a horn antenna, 50 % efficiency is cited as typical.

Horn antenna



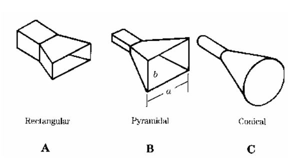
A open wave guide (a) actually works as an antenna, but it gives impedance mismatch between the wave guide and the free space, and as result radiates in many directions.

The impedance match can be enhanced if the open wave guides end (a) is formed as a horn (b). It gives a more concentrated beam, enforced by the larger area, aperture.

Horn antenna

The gain of an horn antenna is proportional to the area, *A,* of the open flange and inversely proportional to the square of the wavelength ●:

$$A = ab \qquad G = \frac{10A}{\lambda^2}$$



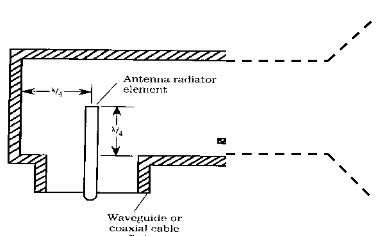
-3 dB beam-width for vertical extent:

$$\Phi_v = \frac{51\lambda}{b}$$

-3 dB beam-width for horizontal extent:

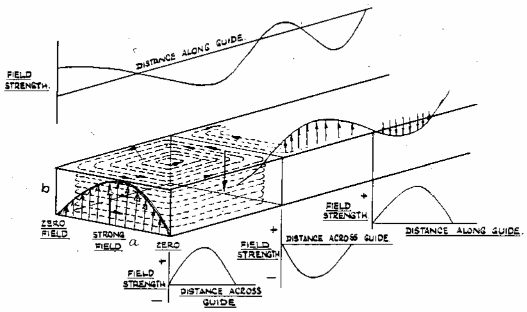
$$\Phi_h = \frac{70\lambda}{a}$$

Horn antenna



The actual antenna element in a horn antenna is often a quarter wavelength antenna inside the wave guide.

Horn antenna

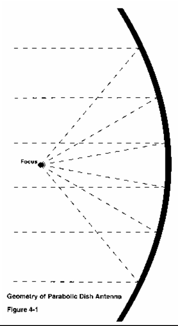


Parabolic “dish” antennas

Parabolic “dish” antennas

- At microwave frequencies, it becomes possible to use reflector antennas.
- Reflector antennas are possible at lower frequencies also but with longer wavelengths, the antennas would be so large that they become impractical.
- The parabolic reflector is the most widespread of all the microwave antennas.
- A parabolic dish antenna can provide very high antenna gain, a small 0.6 meter parabolic dish antenna can give 30 dBi in antenna gain.

Parabolic “dish” antennas



A ***parabolic dish antenna*** works the same way as a reflecting optical telescope. Electromagnetic waves arrives on parallel paths from a distance source and are reflected by a “mirror” to a common point, called ***focus***.

When a ray is reflects from a mirror (a flat surface) the angle of the leaving path is the same as angle of the arriving path. However, if the surface is curved, two parallel incident rays leaves at different angles

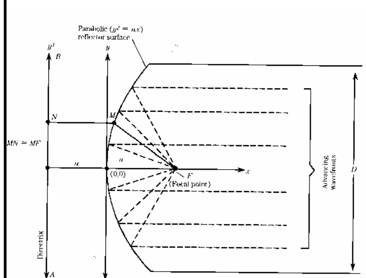
If the curve is parabolic, $y=ax^2$, then all reflected rays meet at one point.

A dish is such a parabolic curve rotated around an axis which passes through the focus and the center of the curve.

Parabolic “dish” antennas

- One difficulty is finding a point source, since any antenna, even an dipole at 10 GHz, is much bigger than a point.
- Even if we were able to find a point source, it would radiate equally in all directions so the energy that was not radiated towards the reflector would be wasted.
- It is very common to use a horn in combination with a parabolic dish, as solution to the previous problem.

Parabolic “dish” antennas



Gain:

$$G = \frac{k(\pi D)^2}{\lambda^2}$$

Effective aperture:

$$A_e = k\pi(D/2)^2$$

-3 dB beam-width:

$$\Phi = \frac{70\lambda}{D}$$

Focal length:

$$F = \frac{D^2}{16d}$$

Parabolic “dish” antennas

The dish surface is positioned such that the center is at origin (0,0) of an x-y coordinate system. For purposes of defining the surface we place a second axis called directrix (y’) a distance behind the surface, equal to the focal length (u).

The paraboloid surface follows the function y2=4ux, and has the property that a line from the focal point F to any point on the surface is the same length as a line from the same point to the directrix (MN=MF).

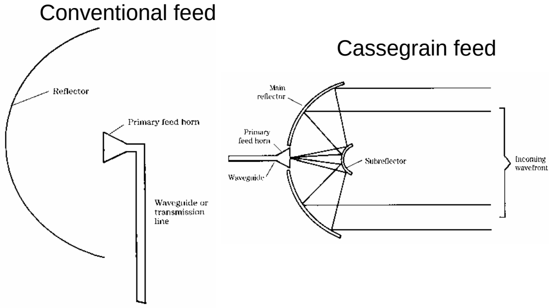
If a radiator is placed at the focal point F, then it will illuminate the reflector surface, causing wave fronts to be propagated away from the surface in phase.

Similarly, wave fronts, intercepted by the reflector surface, are reflected to the focal point.

Parabolic “dish” antennas

Conventional feed

Cassegrain feed

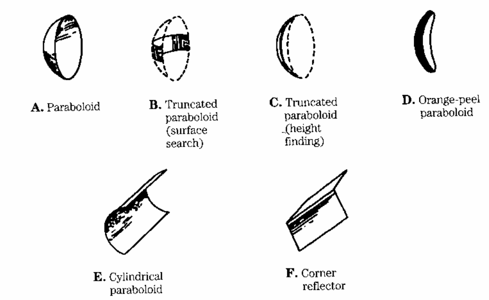


Parabolic “dish” antennas

diameter (meter)	efficiency 100 %	90 %	80 %	70 %	60 %	50 %
0,5	35.96	35.50	34.99	34.41	33.75	32.96
1.0	41.98	41.53	41.02	40.44	39.77	38.98
1.5	45.51	45.05	44.54	43.96	43.29	42.50
2.0	48.00	47.55	47.04	46.46	45.79	44.99

Diameter	Gain	Beam width
1,8 m	44,4 dB	1,05 grader
2,8 m	48 dB	0,68 grader
3,2 m	49 dB	0,6 grader
4,6 m	51 dB	0,4 grader

Other reflector antennas



Antennas are simple !