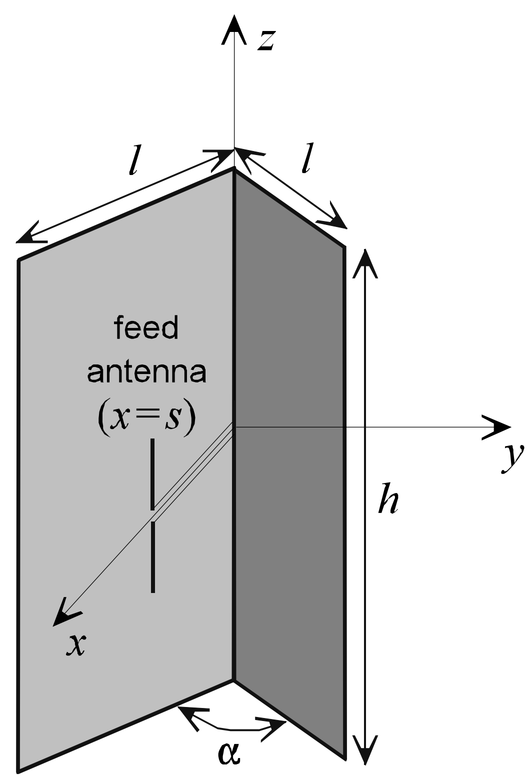
Reflector Antennas

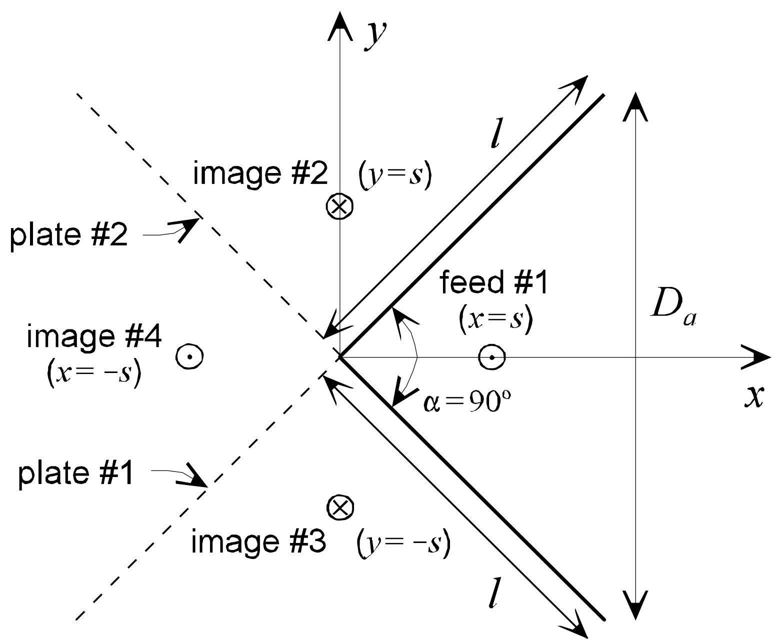
A *reflector antenna* utilizes some sort of reflecting (conducting) surface to increase the gain of the antenna. A typical reflector antenna couples a small feed antenna with a reflecting surface that is large relative to wavelength. Reflector antennas can achieve very high gains and are commonly used in such applications as long distance communications, radioastronomy and high-resolution radar.

Corner Reflector

The corner reflector antenna shown below utilizes a reflector formed by two plates (each plate area = $l \times h$) connected at an included angle α. The feed antenna, located within the included angle, can be one of many antennas although simple dipoles are the most commonly used.



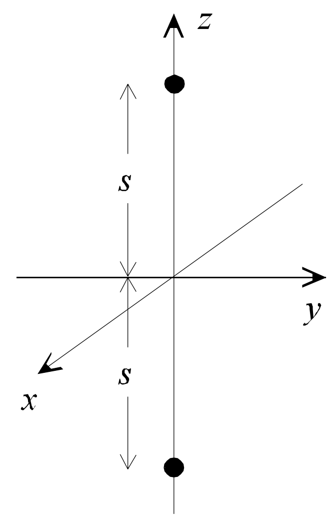
The most commonly used included angle α for corner reflectors is 90^o. The electrical size of the aperture (D_a) for the corner reflector antenna is typically between one and two wavelengths. Given a linear dipole as the feed element of a 90^o corner reflector antenna, the far field of this antenna can be approximated using image theory. If the two plates of the reflector are electrically large, they can be approximated by infinite plates. This allows the use of image theory in the determination of the antenna far field.



For analysis purposes, the current on the feed element is assumed to be *z*-directed. The image element #2 represents the image of the feed element (#1) to plate #1. Together, elements #1 and #2 satisfy the electric field boundary condition on plate #1. Similarly, image element #3 represents the image of the feed element to plate #2. In order for image element #2 to satisfy the electric field boundary condition on plate #2, an additional image element (#4) is required. Note that the inclusion of image element #4 also allows image element #3 to satisfy the electric field boundary condition on plate #1. The system of four elements (four-element array) yields the overall field within the included angle of the reflector antenna ($-45^o \leq \phi \leq 45^o$). The four- element array can be treated as 2 two-element arrays (a two-element array along the *x*-axis and the two-element array along the *y*-axis).

Given a two-element array aligned along the z-axis with equal amplitude, equal phase elements which are separated by a distance 2s, the resulting array factor was found to be

$$AF = 2\cos(ks\cos\theta)$$



If we rotate this 2-element array so that it lies along the x-axis, we must transform the array factor according to

$$\cos\theta \quad \Rightarrow \quad \cos\psi = \boldsymbol{a}_r \cdot \boldsymbol{a}_x = \sin\theta\cos\phi$$

which yields

$$AF_1 = 2\cos(ks\sin\theta\cos\phi)$$

Similarly, rotating the two-element array so that it lies along the y-axis, and noting that the current is opposite to that of the array along the x-axis, we find

$$\cos\theta \quad \Rightarrow \quad \cos\psi = \boldsymbol{a}_r \cdot \boldsymbol{a}_y = \sin\theta\sin\phi$$

$$AF_2 = -2\cos(ks\sin\theta\sin\phi)$$

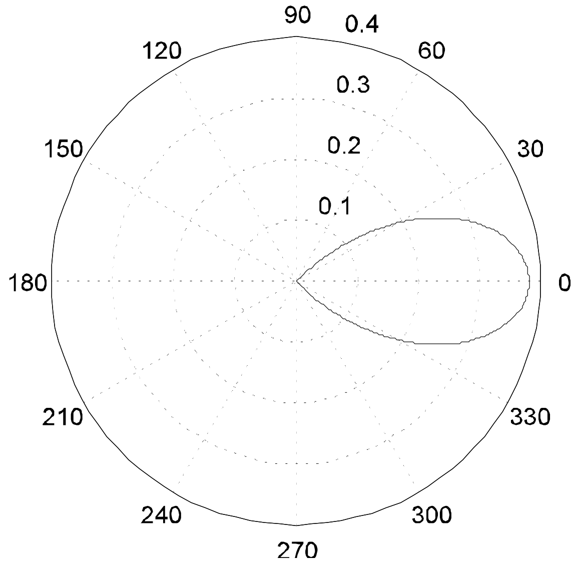
The overall array factor for the 90° corner reflector becomes

$$AF = 2\left[\cos(ks\sin\theta\cos\phi) - \cos(ks\sin\theta\sin\phi)\right]$$

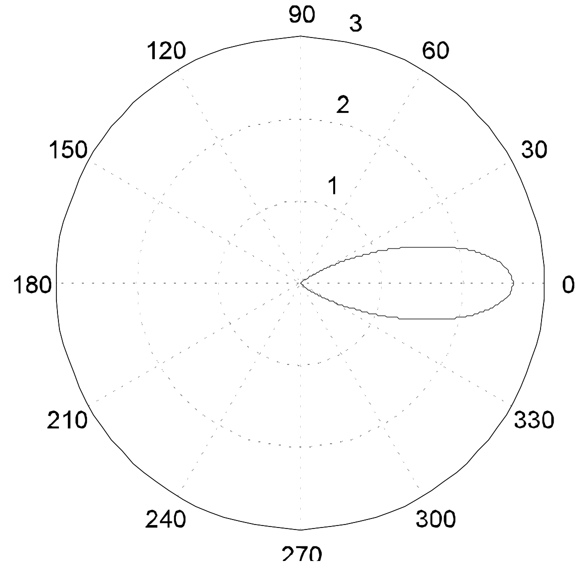
In the azimuth plane ($\theta = \pi/2$), the 90° corner reflector array factor is

$$AF = 2\left[\cos(ks\cos\phi) - \cos(ks\sin\phi)\right]$$

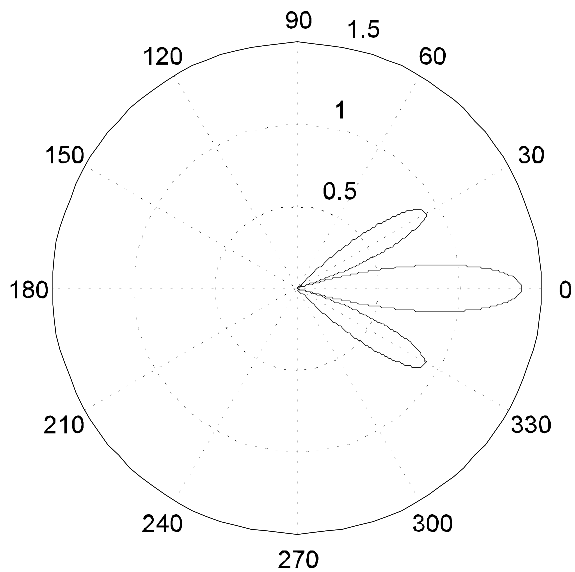
The corner reflector array factor can be shown to be quite sensitive to the placement of the feed element, as would be expected. The following plots show the azimuth plane array factor for various feed spacings.



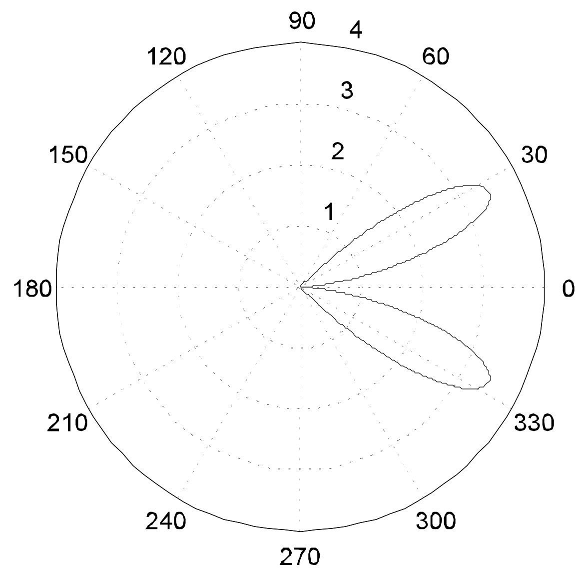
$s = 0.1\lambda$



$s = 0.7\lambda$



$s = 0.8\lambda$



$s = 1.0\lambda$

A variety of reflecting surface shapes are utilized in reflector antennas. Some reflector antennas employ a parabolic cylinder as the reflecting surface while a more common reflecting surface shape is the paraboloid (parabolic dish antenna). The so-called *Cassegrain* antenna uses dual reflecting surfaces (the main reflector is a paraboloid, the sub-reflector is a hyperboloid).