USEFUL ANTENNA DESIGN FORMULAS

I Earth Station Antenna Pointing Coordinates for Geostationary Satellites

R = 0.15126

LAT = Latitude of Earth Station site (North or South).

LHA = Local Hour Angle - longitude difference between satellite and Earth Station (East or West).

θ = Elevation angle to satellite from local horizon.

φ = Azimuth angle to satellite. East or West from South or North.

Υ = Polarization angle from local vertical.

DEC = Declination from Earth's axis.

HA = Hour angle. East or West from South or North.

$$\sin\theta = \frac{\cos(LAT)\cos(LHA) - R}{\sqrt{1 + R^2 - 2R\cos(LAT)\cos(LHA)}}$$

$$\tan\varphi = \frac{\tan(LHA)}{\sin(LAT)}$$

$$\tan\Upsilon = \frac{\sin(LHA)}{\tan(LAT)}$$

$$\tan(DEC) = \frac{\sin(LAT)}{\sqrt{43.923 + \cos^2(LAT) - 13.255\cos(LAT)\cos(LHA)}}$$

$$\sin(HA) = \frac{\sin(LHA)}{\sqrt{1 + 0.02277\cos^2(LAT) - 0.3018\cos(LAT)\cos(LHA)}}$$

$$\textit{Slant Range} = 14414\sqrt{3.389 - \cos(LAT)\cos(LHA)}\ \textit{Statute Miles}$$

II Reflector Surface Tolerances

For a reflector having only random errors, gain loss can be predicted by the formula:

$G/G_0 = \exp(-4\pi\sigma/\lambda)^2$

σ = Root-mean-squared surface tolerance

λ = wavelength

G = antenna power gain

G_0 = antenna power gain with no errors

For multi-paneled reflectors having regular or periodic errors additional gain losses will occur. Sidelobe degradation is also expected. For Earth Station antennas subject to the FCC sidelobe envelope requirement of G (θ) = 29-25 LOG (θ) dBi, where θ is the angle from boresight, it has been found that a maximum value of σ/λ of 0.02 corresponding to G/G_0 of 0.3 dB is necessary. In this case, regular errors must not exceed a peak-to-peak 0.02 wavelength limit to avoid FCC sidelobe non-compliance. These criteria are very much stricter than those for other antenna applications.

III Beamwidth Conversions

For a normal pencil beam antenna, beamwidths at various dB levels on the main beam can be related to the half-power (3 dB) beamwidth as follows:

$dB = 3[2\theta/HPBW]^2$

where dB refers to decibels down from the main beam peak, θ is the angle from boresight and HPBW is the total half-power beamwidth.

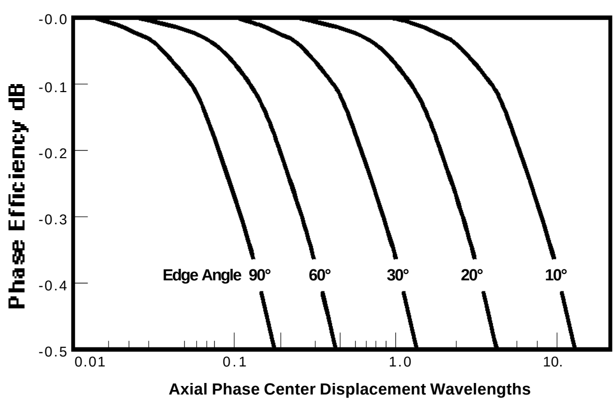
IV Mesh Reflectors

If perforated or mesh reflectors are used, some loss through the mesh is expected. Measurements have been made of a variety of commercial expanded meshes having diamond-shaped openings. Based on a criterium of -20 dB transmission loss limit, the following table summarizes the recommended upper operating frequency.

Maximum Opening Size, Inches	Maximum Recommended Operating Frequency, MHz
2-3/8	150
1-1/2	320
7/8	650
5/8	1300
3/8	2700
1/4	7000

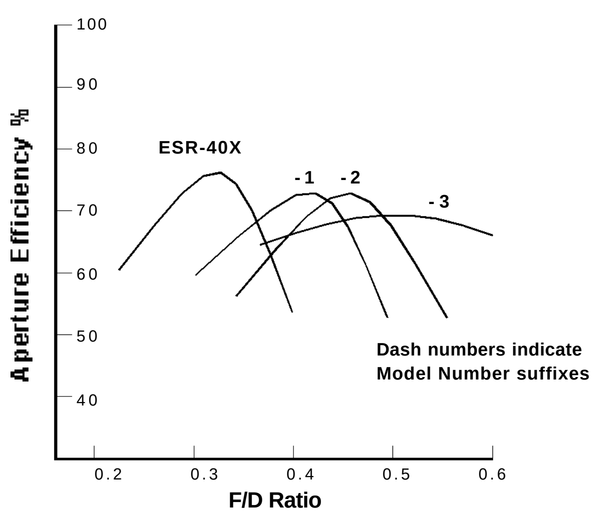
V Parabolic Reflector Axial Defocusing Losses

The following graph shows how reflector antenna gain is lost as the feed is displaced in or out along the focal axis. Note that large displacements can be made for long focal length (small aperture angle) reflectors such as Cassegrain systems. This graph is only slightly sensitive to the aperture amplitude distribution.



VII Aperture Efficiency vs. F/D Ratio

This graph shows the aperture efficiency of symmetrical reflector antennas when fed with standard Seavey Engineering prime focus feeds.



VI Axial Ratio of Imperfect Orthogonal Antennas

If the two ports of orthogonally polarized antennas such as crossed dipoles or dual polarized horns are fed with unequal amplitude and non-quadrature phase, the resulting axial ratio is shown in this graph.