Parabolic Antenna Gain

- An overview or tutorial about parabolic reflector gain, the parabolic antenna gain equation or formula, and the practical factors affecting the gain of the parabolic dish gain antenna.

Parabolic reflector antennas, often called parabolic dishes are normally used in applications where gain and directivity are of paramount importance. Satellite TV reception, microwave links and other satellite links are prime examples of where parabolic reflector gain is used.

The parabolic reflector antenna is ideal for high gain applications. At microwave frequencies where these antennas are normally used, they are able to produce very high levels of gain, and they offer a very convenient and robust structure that is able to withstand the rigors of external use, while still being able to perform well. Many other types of antenna design are not practicable at these frequencies.

High gain parabolic reflector antennas come in a variety of sizes. The most commonly seen are those used for satellite television reception. However parabolic antennas are used in many other applications. Parabolic reflector antennas are also often seen on microwave towers for communications. Larger ones still can often be seen on TV broadcast stations where signals need to be transmitted up to a broadcast satellite and where performance is paramount. Even larger antennas may also be used for other communications or even space research applications. Some these parabolic antennas are many tens of meters across.

The one common feature of all these examples is the parabolic antenna gain, or parabolic dish gain. While the larger antennas have greater levels of parabolic antenna gain, the performance of all these antennas is of prime importance.

Factors affecting parabolic antenna gain

There are a number of factors that affect the parabolic antenna gain. These factors include the following:

1. Diameter for the parabolic reflector antenna reflecting surface
2. Surface accuracy
3. Quality of illumination of the reflecting surface
4. Frequency or wavelength of the signal being received or transmitted
**Parabolic antenna gain**

The parabolic antenna gain can easily be calculated from a knowledge of the diameter of the reflecting surface, the wavelength of the signal, and a knowledge or estimate of the efficiency of the antenna.

The parabolic reflector antenna gain is calculated as the gain over an isotropic source, i.e. relative to a source that radiates equally in all directions. This is a theoretical source that is used as the benchmark against which most antennas are compared. The gain is quoted in this manner is denoted as dBi.

The standard formula for the parabolic reflector antenna gain is:

\[
\text{Gain } G = 10 \log_{10} \left( \frac{k \pi D}{\lambda^2} \right)
\]

where
- \(G\) is the gain over an isotropic source in dB
- \(k\) is the efficiency factor which is generally around 50% to 60%, i.e. 0.5 to 0.6
- \(D\) is the diameter of the parabolic reflector in metres
- \(\lambda\) lambda is the wavelength of the signal in metres

From this it can be seen that very large gains can be achieved if sufficiently large reflectors are used. However when the antenna has a very large gain, the beamwidth is also very small and the antenna requires very careful control over its position. In professional systems electrical servo systems are used to provide very precise positioning.

**Optimizing parabolic antenna gain**

To provide the optimum illumination of the reflecting surface, the level of illumination should be greater in the centre than at the sides. It can be shown that the optimum situation occurs when the centre is around 10 to 11 dB greater than the illumination at the edge. Lower levels of edge illumination result in lower levels of side lobes.

The reflecting surface antenna forms a major part of the whole system. In many respects it is not as critical as may be thought at first. Often a wire mesh may be used. Provided that the pitch of the mesh is small compared to a wavelength it will be seen as a continuous surface by the radio signals. If a mesh is used then the wind resistance will be reduced, and this provides significant advantages.