Antenna Characteristics

Antenna Gain

Independent of the use of a given antenna for transmitting or receiving, an important characteristic of this antenna is the gain. Some antennas are highly directional; that is, more energy is propagated in certain directions than in others. The ratio between the amount of energy propagated in these directions compared to the energy that would be propagated if the antenna were not directional (Isotropic Radiation) is known as its gain. When a transmitting antenna with a certain gain is used as a receiving antenna, it will also have the same gain for receiving.

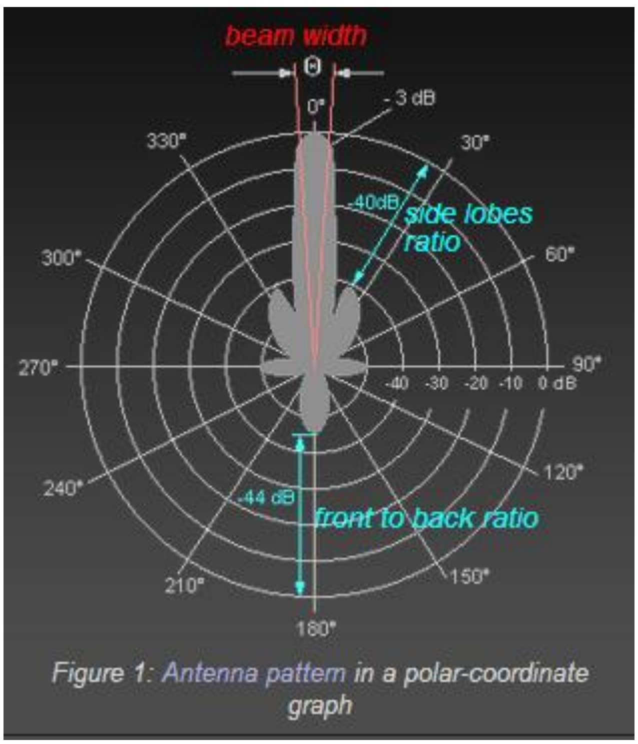

Figure 1: Antenna pattern in a polar-coordinate graph

Antenna Pattern

Most radiators emit (radiate) stronger radiation in one direction than in another. A radiator such as this is referred to as anisotropic. However, a standard method allows the positions around a source to be marked so that one radiation pattern can easily be compared with another.

The energy radiated from an antenna forms a field having a definite radiation pattern. A radiation pattern is a way of plotting the radiated energy from an antenna. This energy is measured at various angles at a constant distance from the antenna. The shape of this pattern depends on the type of antenna used.

To plot this pattern, two different types of graphs, rectangular-and polar-coordinate graphs are used. The polar-coordinated graph has proved to be of great use in studying radiation patterns. In the polar-coordinate graph, points are located by projection along a rotating axis (radius) to an intersection with one of several concentric, equally-spaced circles. The polar-coordinate graph of the measured radiation is shown in Figure 1.

The main beam (or main lobe) is the region around the direction of maximum radiation (usually the region that is within 3 dB of the peak of the main beam). The main beam in Figure 1 is northbound.

The sidelobes are smaller beams that are away from the main beam. These sidelobes are usually radiation in undesired directions which can never be completely eliminated. The sidelobe level (or sidelobe ratio) is an important parameter used to characterize radiation patterns. It is the maximum value of the sidelobes away from the main beam and is expressed in Decibels. One sidelobe is called backlobe. This is the portion of radiation pattern that is directed opposing the main beam direction.

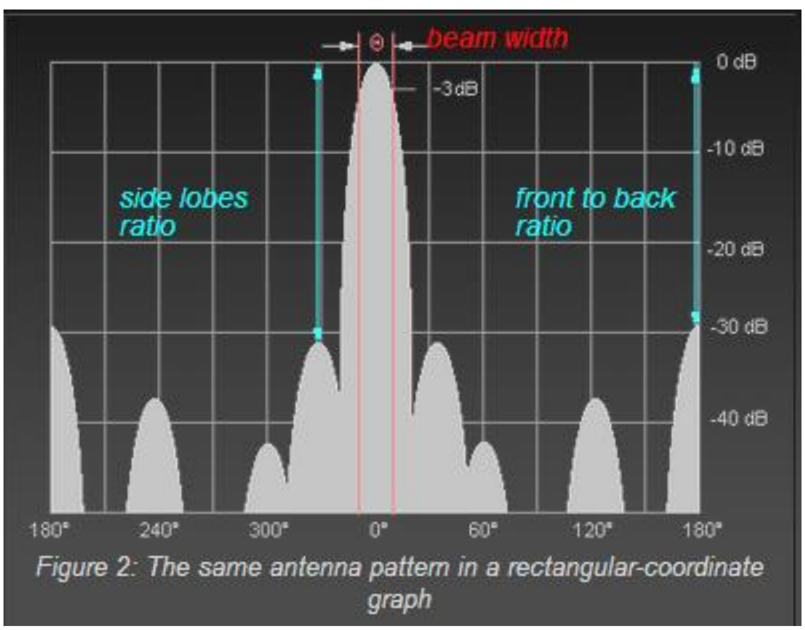

Figure 2: The same antenna pattern in a rectangular-coordinate graph

The now following graph shows the rectangular-coordinated graph for the same source. In the rectangular-coordinate graph, points are located by projection from a pair of stationary, perpendicular axes. The horizontal axis on the rectangular-coordinate graph corresponds to the circles on the polar-coordinate graph. The vertical axis on the rectangular-coordinate graph corresponds to the rotating axis (radius) on the polar-coordinate graph. The measurement scales in the graphs can have linear as well as logarithmic steps.

For the analysis of an antenna pattern the following simplifications are used:

Beam Width

The angular range of the antenna pattern in which at least half of the maximum power is still emitted is described as a „Beam With". Bordering points of this major lobe are therefore the points at which the field strength has fallen in the room around 3 dB regarding the maximum field strength. This angle is then described as beam width or aperture angle or half power (- 3 dB) angle - with notation Θ (also φ). The beamwidth Θ is exactly the angle between the 2 red marked directions in the upper pictures. The angle Θ can be determined in the horizontal plane (with notation ΘAZ) as well as in the vertical plane (with notation ΘEL).

Major and Side Lobes (Minor Lobes)

The pattern shown in the upper figures has radiation concentrated in several lobes. The radiation intensity in one lobe is considerably stronger than in the other. The strongest lobe is called major lobe; the others are (minor) side lobes. Since the complex radiation patterns associated with arrays frequently contain several lobes of varying intensity, you should learn to use appropriate terminology. In general, major lobes are those in which the greatest amount of radiation occurs. Side or minor lobes are those in which the radiation intensity is least.

Front-to-Back Ratio

The front-to-back ratio of an antenna is the proportion of energy radiated in the principal direction of radiation to the energy radiated in the opposite direction. A high front-to-back ratio is desirable because this means that a minimum amount of energy is radiated in the undesired direction.

Aperture

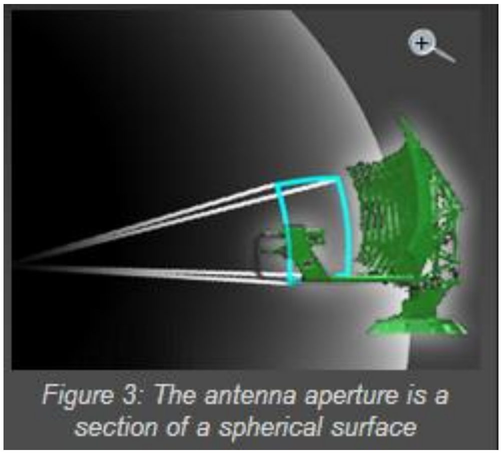

Figure 3: The antenna aperture is a section of a spherical surface

The effective aperture of an antenna Ae is the area presented to the radiated or received signal. It is a key parameter, which governs the performance of the antenna. The gain is related to the effective area by the following relationship:

$G = 4\pi * Ae / \lambda 2$; $Ae = Ka*A$ (1)

Where: λ = wave length

Ae = effective antenna aperture

A = physical area of the antenna

Ka = antenna aperture efficiency

The aperture efficiency depends on the distribution of the illumination across the aperture. If this is linear then Ka= 1. This high efficiency is offset by the relatively high level of sidelobes obtained with linear illumination. Therefore, antennas with more practical levels of sidelobes have an antenna aperture efficiency less than one (Ae< A).

Source: http://www.radartutorial.eu/06.antennas/an05.en.html