Radar Systems - Antenna Parameters

An **Antenna** or Aerial is a transducer, which converts electrical power into electromagnetic waves and vice versa.

An Antenna has the following parameters –

- Directivity
- Aperture Efficiency
- Antenna Efficiency
- Gain

Now, let us discuss these parameters in detail –

Directivity

According to the standard definition, "The ratio of maximum radiation intensity of the subject Antenna to the radiation intensity of an isotropic or reference Antenna, radiating the same total power is called the **Directivity**."

Though an Antenna radiates power, the direction in which it radiates matters is of much significance. The Antenna under study is termed as **subject Antenna**. Its radiation intensity is focused in a particular direction, while it is transmitting or receiving. Hence, the Antenna is said to have its directivity in that particular direction.

- The ratio of radiation intensity in a given direction from an Antenna to the radiation intensity averaged over all directions, is termed as **Directivity**.
- If that particular direction is not specified, then the direction in which maximum intensity is observed, can be taken as the directivity of that Antenna.
- The directivity of a non-isotropic Antenna is equal to the ratio of the radiation intensity in a given direction to the radiation intensity of the isotropic source.

Mathematically, we can write the expression for Directivity as –

$$Directivity = \frac{U_{Max}\,(\theta, \phi)}{U_0}$$

Where,

$U_{Max}\,(\theta, \phi)$ is the maximum radiation intensity of subject Antenna

U_0 is the radiation intensity of an isotropic Antenna.

Aperture Efficiency

According to the standard definition, **"Aperture efficiency** of an Antenna is the ratio of the effective radiating area (or effective area) to the physical area of the aperture."

An Antenna radiates power through an aperture. This radiation should be effective with minimum losses. The physical area of the aperture should also be taken into consideration, as the effectiveness of the radiation depends upon the area of the aperture, physically on the Antenna.

Mathematically, we can write the expression for Aperture efficiency ϵ_A as

$$\epsilon_A = \frac{A_{eff}}{A_p}$$

Where,

A_{eff} is the effective area

A_P is the physical area

Antenna Efficiency

According to the standard definition, **"Antenna Efficiency** is the ratio of the radiated power of the Antenna to the input power accepted by the Antenna."

Any Antenna is designed to radiate power with minimum losses, for a given input. The efficiency of an Antenna explains how much an Antenna is able to deliver its output effectively with minimum losses in the transmission line. It is also called **Radiation Efficiency Factor** of the Antenna.

Mathematically, we can write the expression for Antenna efficiency ηe as −

$$\eta_e = \frac{P_{Rad}}{P_{in}}$$

Where,

P_{Rad} is the amount of power radiated

P_{in} is the input power for the Antenna

Gain

According to the standard definition, **"Gain** of an Antenna is the ratio of the radiation intensity in a given direction to the radiation intensity that would be obtained if the power accepted by the Antenna were radiated isotropically."

Simply, **Gain** of an Antenna takes the Directivity of Antenna into account along with its effective performance. If the power accepted by the Antenna was radiated isotropically (that means in all directions), then the radiation intensity we get can be taken as a referential.

- The term **Antenna gain** describes how much power is transmitted in the direction of peak radiation to that of an isotropic source.
- Gain is usually measured in **dB**.
- Unlike Directivity, Antenna gain takes the losses that occur also into account and hence focuses on the efficiency.

Mathematically, we can write the expression for Antenna Gain G as −

$$G = \eta_e D$$

Where,

η_e is the Antenna efficiency

D is the Directivity of the Antenna