Basics of Antenna

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Antennas I

- An antenna can be defined as an electrical conductor or system of conductors used either for radiating electromagnetic energy or for collecting electromagnetic energy.
- For transmission of a signal, radio-frequency electrical energy from the transmitter is converted into electromagnetic energy by the antenna and radiated into the surrounding environment (atmosphere, space, water).
- For reception of a signal, electromagnetic energy impinging on the antenna is converted into radio-frequency electrical energy and fed into the receiver.
- In two-way communication, the same antenna can be and often is used for both transmission and reception.

Antennas II

- This is possible because any antenna transfers energy from the surrounding environment to its input receiver terminals with the same efficiency that it transfers energy from the output transmitter terminals into the surrounding environment, assuming that the same frequency is used in both directions.
- Put another way, antenna characteristics are essentially the same whether an antenna is sending or receiving electromagnetic energy.

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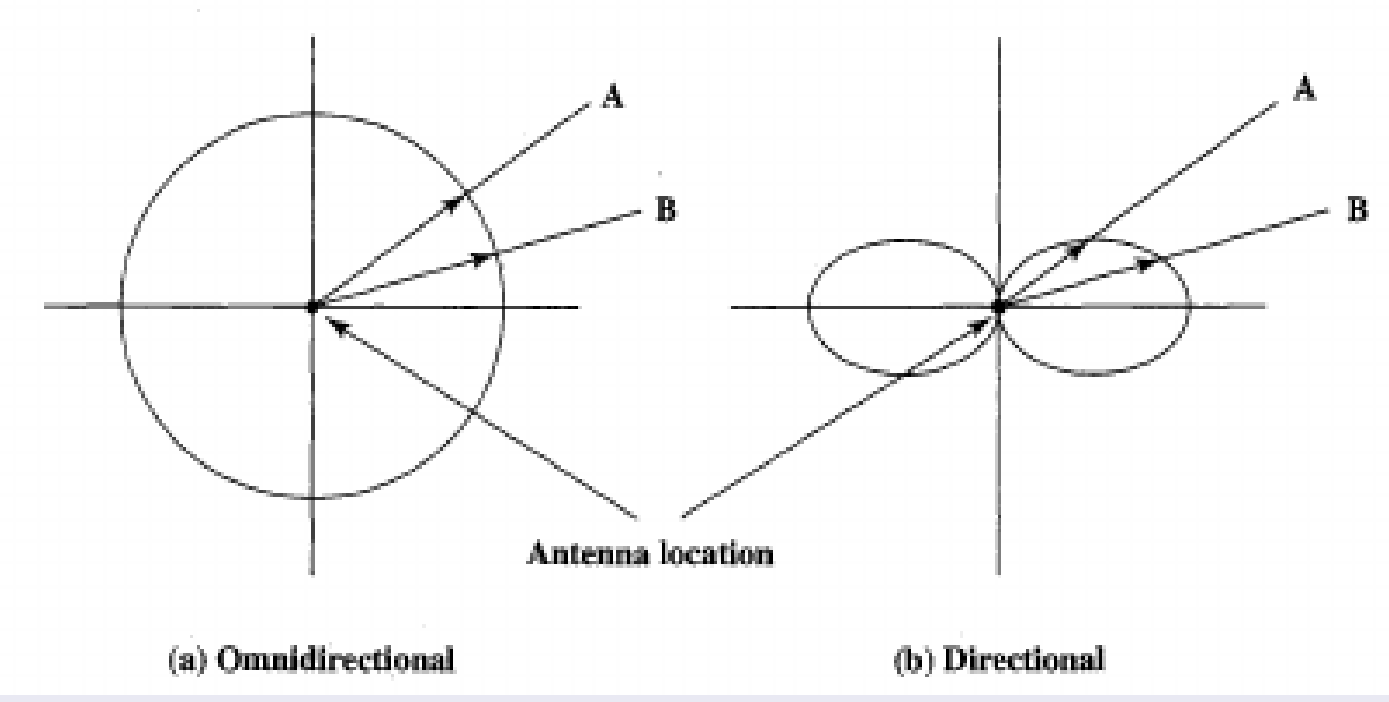
Radiation Patterns I

- An antenna will radiate power in all directions but, typically, does not perform equally well in all directions.
- A common way to characterize the performance of an antenna is the radiation pattern, which is a graphical representation of the radiation properties of an antenna as a function of space coordinates.
- The simplest pattern is produced by an idealized antenna known as the isotropic antenna.
- An isotropic antenna is a point in space that radiates power in all directions equally.
- The actual radiation pattern for the isotropic antenna is a sphere with the antenna at the center.
- However, radiation patterns are almost always depicted as a two-dimensional cross section of the three-dimensional pattern.

Radiation Patterns II

Idealized Radiation Patterns



Radiation Patterns III

- The pattern for the isotropic antenna is shown in Figure (a).
- The distance from the antenna to each point on the radiation pattern is proportional to the power radiated from the antenna in that direction.
- Figure (b) shows the radiation pattern of another idealized antenna.
- This is a directional antenna in which the preferred direction of radiation is along one axis.
- The actual size of a radiation pattern is arbitrary.
- What is important is the relative distance from the antenna position in each direction.
- The relative distance determines the relative power.

Radiation Patterns IV

- To determine the relative power in a given direction, a line is drawn from the antenna position at the appropriate angle, and the point of intercept with the radiation pattern is determined.
- Figure shows a comparison of two transmission angles, *A* and *B*, drawn on the two radiation patterns.
- The isotropic antenna produces an omnidirectional radiation pattern of equal strength in all directions, so the *A* and *B* vectors are of equal length.
- For the antenna pattern of Figure (b), the *B* vector is longer than the *A* vector, indicating that more power is radiated in the *B* direction than in the *A* direction, and the relative lengths of the two vectors are proportional to the amount of power radiated in the two directions.

Radiation Patterns V

- The radiation pattern provides a convenient means of determining the beam width of an antenna, which is a common measure of the directivity of an antenna.
- The beam width, also referred to as the half-power beam width, is the angle within which the power radiated by the antenna is at least half of what it is in the most preferred direction.
- When an antenna is used for reception, the radiation pattern becomes a reception pattern. The longest section of the pattern indicates the best direction for reception.

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- Omnidirectional - Radio waves are used for multicast communications, such as radio, television, paging systems etc.
- Directional - Microwaves are used for unicast communication such as cellular telephones, satellite networks, wireless LANs etc.
  - Dipole
  - Horn
  - Yagi-Uda
  - Parabolic Reflector

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- Antenna gain is a measure of the directionality of an antenna.
- Antenna gain is defined as the power output, in a particular direction, compared to that produced in any direction by a perfect omnidirectional antenna (isotropic antenna).
- The increased power radiated in a given direction is at the expense of other directions.
- In effect, increased power is radiated in one direction by reducing the power radiated in other directions.
- It is important to note that antenna gain does not refer to obtaining more output power than input power but rather to directionality.
- A concept related to that of antenna gain is the effective area of an antenna.
- The effective area of an antenna is related to the physical size of the antenna and to its shape.

- The relationship between antenna gain and effective area is

$$G = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi f^2 A_e}{c^2} \tag{1}$$

where,

$G =$ antenna gain
$A_e =$ effective area
$f =$ carrier frequency
$c =$ speed of light ($\approx 3 \times 10^8\ m/s$)
λ = carrier wavelength