Antennae Flash Card

Definitions

`Isotropic Antenna:` Radiates equally in all directions.

`Directional Antenna:` Radiates in a particular direction.

`Omnidirectional Antenna:` Radiates in a plane. **Major lobe** is in a plane. **NO BACK LOBE**

`Major Lobe:` The **primary region** in which the **antenna radiates and receives** electromagnetic energy.

`Half Power Bandwidth:` Angular width of major lobe, from **max** to **3db** down.

`First Null Beam Width:` Width of major lobe.

`Front to back ratio:` Ratio of gain from major lobe to back lobe.

`Beam Width:` The ability of the system to separate two adjacent targets.

$$\Omega_A = \iint_{\theta=0\ \phi=0}^{\phi=2\pi\ \theta=2\pi} \mathrm{P}(\theta, \phi)\, d\theta\ d\phi$$

`Beam Area:` The **solid angle** through which **all of the power radiated by antenna** would stream if $\mathrm{P}(\theta, \phi)$ is maintained its maximum value over Ω_A and was 0.

`Radiation Intensity:` Power radiated by antenna per **unit solid angle**.

$$Radiation\ Intensity = \frac{E^2 r^2}{2\eta}$$

$$P_{red} = \iint_{\theta\ \phi} U sin\theta\ d\theta\ d\phi = \int U\ d\Omega$$

`Beam efficiency:` Ratio of main beam area to the total beam area.

$$\Omega_A = \Omega_m + \Omega_M$$
$$\epsilon_m = \frac{\Omega_m}{\Omega_A}$$

`Directivity:` The ratio of **total solid angle** of the sphere to **beam solid angle.** Or it is the measure of the concentration of radiated power in a particular direction. $D \geq 1$

`Gain:` Measure of ability of antenna to direct energy in a particular direction as **compared to an isotropic antenna.**

`Aperture:` Area through which power is radiated or received.

`Effective Aperture:` Ratio of the **available power at the terminals** of the antenna to the **power flux density of a plane wave** incident upon the antenna, which is matched to the antenna in terms of polarization.

$$\epsilon_p = \frac{A_e}{A_p}$$

`Effective Height:` Provides an indication as to **how much of the antenna is involved in radiating or receiving.**

`Antenna Temperature:` Measure of noise received by an antenna.

$$P_{received} = k.T_{ant}.B$$
$$B\ is\ the\ effective\ bandwidth$$
$$k\ is\ the\ boltzman\ constant$$
$$T_{ant}\ is\ the\ antenna\ temperature$$

`Relation between` **`Directivity`** `and` **`Gain`** `:`

$$D = \frac{U(\theta, \psi)_{max}}{U(\theta, \psi)_{avg}}$$

$$\mathrm{P}(\theta, \psi)_{avg} = \frac{1}{4\pi} \iint_{\theta=0\ \phi=0}^{\theta=2\pi\ \phi=2pi} \mathrm{P}(\theta, \phi) sin\theta\, d\theta\ d\phi$$
$$d\Omega = sin\theta\ d\theta\ d\phi$$

$$D = \frac{\mathrm{P}(\theta, \phi)_{max}}{\frac{1}{4\pi} \iint_{0\ 0}^{2\pi\ 2\pi} \mathrm{P}(\theta, \phi)\, d\Omega}$$

$$\mathrm{P}(\theta,\phi)_{max} = 1$$

$$and \iint_{\theta=0\ \phi=0}^{\theta=2\pi\ \phi=2pi} \mathrm{P}(\theta,\phi) sin\theta\, d\theta\, d\phi = \Omega_A$$

$$\therefore D = \frac{4\pi}{\Omega_A}$$

Antenna Field Zones

`Reactive Near Field Region:` Portion of the field region immediately surrounding the antenna where in the reactive field predominates.

$$R < 0.62\sqrt{\frac{L^3}{\lambda}}$$

Objects within this region will result in coupling with the antenna and distortion of the ultimate far field antenna pattern.

`Radiating Near Field Region:` The region between the reactive near field region, and the far field region.

$$0.62\sqrt{\frac{L^3}{\lambda}} < R < \frac{2L^2}{\lambda}$$

- Antenna pattern is taking shape but it is not truly formed.
- The radiation field predominates the reactive field.
- The electric and magnetic field vectors are not orthogonal.

`Far Field Region:` The region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna.

$$R > \frac{2L^2}{\lambda}$$

- The wavefront becomes approximately planar.
- The radiation pattern is completely formed and does not vary with distance.

- The E and H field vectors are orthogonal to each other.

Different types of Antenna

1. `Loop Antenna:`
    - `Small Loop Antenna:` When the overall length of loop is less than $\frac{\lambda}{10}$.
        - Null is **Perpendicular** to the plane of the loop
        - Less radiation resistance.
        - Less radiation efficiency.
    - `Large Loop Antenna:` Length of loop is greater than $\frac{\lambda}{10}$.
        - **Radiates** perpendicular to plane of loop.
        - Relatively high radiation resistance and radiation efficiency.
    - `Applications:` Used in Applications with **low gain**.
        - HF 3 → 30 MHz
        - VHF 30 → 300 MHz
        - UHF 300 → 3k MHz
        - Microwave frequencies 1k → 100 G Hz

2. `Helical Antenna:` The conductor is wound into helical shape and is fed with respect to ground.
    - `Modes of Operation`
        - `Normal Mode:` The Radiation pattern is perpendicular to the axis of Helix. The dimensions are less than λ.
            - Narrow Bandwidth and poor efficiency
        - `Axial Mode:` The radiation pattern is in the direction of the axis of helix. $\frac{3}{4}\lambda < \pi D < \frac{4}{3}\lambda$
            - Large bandwidth and good efficiency

        - Directivity increases
        - It acts like a end fire array
- `Application:`
    - AM broadcast
    - Null down AC line noise
    - Decrease TV sweep harmonics
    - RFID

3. `Yagi-Uda Antenna:`

- Directional antenna
- High operating frequency above 10 MHz
- Can be used for 40-80 km distance
- It Has two types of elements:

  — Active element [Driven element]

  — Parasitic elements [Reflector, Directors]
- `Advantages:`
    - High gain of about 9 dB
    - High front to back ratio
    - Cheap
    - Light Weight
- `Disadvantages:`
    - For high gain level, the antenna becomes very long.
    - Gain limitation is about 20 dB
- `Applications:`
    - Home TV receiver.
    - Point to Point communication.

4. `Horn Antenna:`
    - Constructed using flaring of waveguide.
    - Increases the directivity
    - Improves impedance matching
    - It is a directional antenna, so it can be utilized for long distance communications.
    - Flaring in the direction of the E-plane vector produces sectorial E-plane horn, similarly for sectorial H-plane horn.
    - Flaring in both direction leads to pyramidal horn.
    - The Radiation pattern is in the form of spherical wavefronts.
    - `Applications:`
        - Feed for parabolic Reflector
        - Short Range RADAR

5. `Parabolic Reflector Antenna:`
    - Highly directional antenna
    - Used for very long distance communication, such as satellite communication.
    - Applicable to microwave frequency range.
    - Consists of two types of elements:
        - Active element (feed antenna)
        - Parasitic element (Reflector)
    - **Parabolic Reflector** converts spherical wavefronts into planar wavefronts. Due to this, it is a highly directive antenna.

`Center Feed Parabolic Reflector`	`Offset Feed Parabolic Reflector`
Less Cross Polarization	No blockage due to feed

Difficult to use for low noise application due to isolation	Cross-polarization occurs
Blockage due to feed	

- `Applications:`
  - Radio Astronomy
  - Microwave communication
  - Satellite communication
  - Deep Space communication

6. `Patch Antenna:`
   - Metallic patch placed on dielectric material and supported by ground plane
   - Frequencies above 100 MHz
   - The length of metal patch is $\lambda/2$.
   - The energy is radiated from the edge of the patch.
   - The radiation pattern is broad.
   - `Advantages:`
     - Most widely used antenna
     - Can be easily fabricated on a PCB
     - Installation is very easy due to low size, weight and cost
   - `Disadvantages:`
     - Low radiation power and narrow frequency bandwidth.
   - `Applications:`
     - Used in space aircraft applications
     - Low profile antenna applications