$$W' = I^2 \cdot R \qquad \text{... (1)}$$

Assuming all the power dissipated in the form of electromagnetic waves, then we can write,

$$R = \frac{W'}{I^2} \qquad \text{... (2)}$$

The resistance which relates power radiated by radiating antenna and the current flowing through the antenna is a fictitious resistance. Such resistance is called radiation resistance of antenna and it is denoted by R_{rad} or R_r, or R_o.

Note: The radiation resistance is a fictitious resistance such that when it is connected in series with antenna dissipates same power as the antenna actually radiates. But practically the energy supplied to the antenna is not completely radiated in the form of electromagnetic waves, but there are certain radiation losses due to the loss resistance denoted by $R_{loss.}$ Thus the total power is given by,

$$W = W' + W'' = \text{Ohmic loss} + \text{Radiation loss}$$

$$W = I^2 R_{rad} + I^2 R_{loss}$$

$$\mathbf{W = I^2(R_{rad} + R_{loss})} \qquad \text{...(3)}$$

Note: The radiation resistance of antenna depends on antenna configuration, ratio of length and diameter of conductor used, location of the antenna with respect to ground and other objects.

Beamwidth

Half Power Beam Width (HPBW) of an antenna-

The main beam is the angular region where primarily the radiation goes. The effective width of the antenna main beam called the HPBW is defined as the angular separation between directions where the field reduces to 1/√2 of its maximum value. Since the power density of a wave is proportional to the square of the electric field, when the electric field reduces to 1/√2 of its maximum value, the power density reduces to 1/2 of its maximum value. That is, the power density reduces by 3-dB. The HPBW therefore is also referred to as the 3-dB Beam width. There two HPBWs, one for the E-plane pattern and other for the H-plane pattern. For the Hertz dipole, the E-plane HPBW is 90^0 and the H-plane HPBW is not defined since the radiation pattern is constant in the H-plane.

The HPBW is a better measure of the effective width of the main beam of the antenna compared to BWFN because there are situations when the effective width of the antenna beam changes but the BWFN remains same.

Side-Lobe Level (SLL)

The local maxima in the radiation pattern are called the side-lobes of the radiation pattern.

Since ideally the antenna should radiate along the direction of the main beam the side-lobes essentially indicate the leakage of power in undesired directions. The side-lobes in general is an undesirable feature in a radiation pattern.

The ratio of the main beam to the highest side-lobe is called the SSL of the radiation pattern. For a good communication antenna the SLL lies in the range of 30-40 dB

Bandwidth

The bandwidth of an antenna refers to the range of frequencies over which the antenna can operate correctly. The antenna's bandwidth is the number of Hz for which the antenna will exhibit an SWR less than 2:1. The bandwidth can also be described in terms of percentage of the center frequency of the band.

$$BW = 100 \times (F_H - F_L) / F_C$$

where, F_H is the highest frequency in the band, F_L is the lowest frequency in the band, and F_C is the center frequency in the band. In this way, bandwidth is constant relative to frequency. If bandwidth was expressed in absolute units of frequency, it would be different depending upon the center frequency. Different types of antennas have different bandwidth limitations.

Polarization

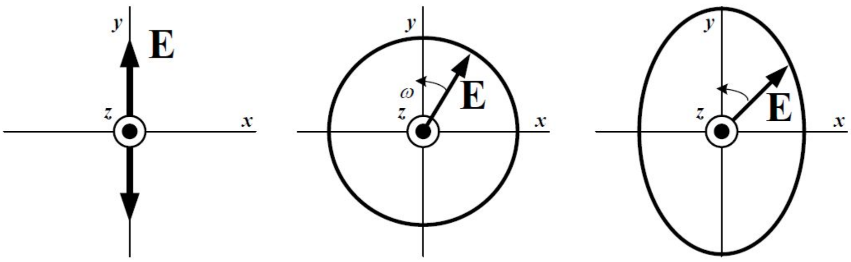
The polarization of the EM field describes the orientation of its vectors at a given point and how it varies with time. In other words, it describes the way the direction and magnitude of the field vectors (usually **E**) change in time. Polarization is associated with TEM time-harmonic waves where the **H** vector relates to the **E** vector simply by

$$\mathbf{H} = \hat{\mathbf{r}} \times \mathbf{E} / \eta$$

In antenna theory, we are concerned with the polarization of the field in the plane orthogonal to the direction of propagation—this is the plane defined by the vectors of the far field. Remember that the far field is a quasi-TEM field.

Hence the polarization is the locus traced by the extremity of the time-varying field vector at a fixed observation point.

According to the shape of the trace, three types of polarization exist for harmonic fields: linear, circular and elliptical. Any polarization can be represented by two orthogonal linear polarizations, (E_x , E_y) or (E_H, E_V), whose fields are out of phase by an angle of δ_L.



(a) linear polarization (b) circular polarization (c) elliptical polarization

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