ISOTROPIC RADIATOR

In general, isotropic radiator is a hypothetical or fictitious radiator. The isotropic radiator is defined as a radiator which radiates energy in all directions uniformly. It is also called isotropic source. As it radiates uniformly in all directions, it is also called omnidirectional radiator or unipole. Basically isotropic radiator is a lossless ideal radiator or antenna. Generally all the practical antennas are compared with the characteristics of the isotropic radiator. The isotropic antenna or radiator is used as reference antenna. Practically all antennas show directional properties i.e. directivity property. That means none of the antennas radiate energy in all directions uniformly. Hence practically isotropic radiator cannot exist

Consider that an isotropic radiator is placed at the centre of sphere of radius r. Then all the power radiated by the isotropic radiator passes over the surface area of the sphere given by $4\pi r^2$, assuming zero absorption of the power. Then at any point on the surface, the poynting vector P gives the power radiated per unit area in any direction. But radiated power travels in the radial direction. Thus the magnitude of the poynting vector P will be equal to radial component as the components in θ and ϕ-directions are zero i.e. $P_\theta = P_\phi = 0$. Hence we can write,

$$|\overline{P}| = P_r \qquad \qquad \ldots(1)$$

The total power radiated is given by,

$$P_{rad} = \iint \overline{P} \cdot d\overline{s}$$
$$= \iint P_r\, ds$$
$$= P_r \iint ds \qquad \qquad \ldots \because P_\theta = P_\phi = 0$$

Now this radial component P_r is the average power density component which can be denoted as P_{avg}.

$$\therefore \qquad P_{rad} = P_{avg}(4\pi r^2) \qquad \text{where } \iint ds = \text{surface area} = 4\pi r^2$$

$$\therefore \qquad \boxed{P_{avg} = \frac{P_{rad}}{4\pi r^2}\ W/m^2} \qquad \qquad \ldots(2)$$

where, P_{rad} = Total power radiated in watts, r = Radius of sphere in meters

P_{avg} = Radial component of average power density in W/m^2

Radiation intensity

In electromagnetism, radiation intensity describes the power density that an antenna creates in a particular solid angle. A solid angle is a section of the surface of the imaginary sphere around the antenna.

Given an antenna's power density P, radiation density is calculated by multiplying it with the square of the distance (r^2) from the antenna to the designated solid angle:

$$U = P \cdot r^2$$

This is so because unlike power density, radiation intensity does not depend on distance: because radiation intensity is defined as the power through a solid angle, the decreasing power density over distance (i.e. over r^2 of the imaginary sphere around the antenna) due to the inverse-square law is offset by the increasing area of the solid angle due to the same law. Therefore, power density can be converted to radiation intensity by multiplying it with r^2.

Radian

Radian is the ratio between the length of an arc and its radius. The radian is the standard unit of angular measure, used in many areas of mathematics.

Radian describes the plane angle subtended by a circular arc as the length of the arc divided by the radius of the arc. One radian is the angle subtended at the center of a circle by an arc that is equal in length to the radius of the circle.
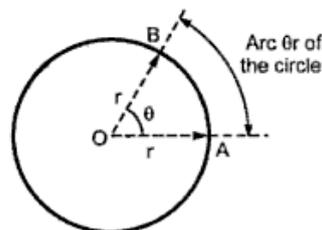

Fig 3 Representation of 1 radian plain angle

More generally, the magnitude in radians of such a subtended angle is equal to the ratio of the arc length to the radius of the circle; that is, $\theta = s/r$, where θ is the subtended angle in radians, s

is arc length, and r is radius. Conversely, the length of the enclosed arc is equal to the radius multiplied by the magnitude of the angle in radians; that is, $s = r\theta$.

It follows that the magnitude in radians of one complete revolution (360 degrees) is the length of the entire circumference divided by the radius, or $2\pi r / r$, or 2π. Thus 2π radian is equal to 360 degrees, meaning that one radian is equal to $180/\pi$ degrees.