ANTENNA FUNDAMENTALS

Introduction:

Antennas are metallic structures designed for radiating and receiving electromagnetic energy. An antenna acts as a transitional structure between the guiding device (e.g. waveguide, transmission line) and the free space. The official IEEE definition of an antenna as given by Stutzman and Thiele follows the concept: “That part of a transmitting or receiving system that is designed to radiate or receive electromagnetic waves”.

How an Antenna radiates?

In order to know how an antenna radiates, let us first consider how radiation occurs. A conducting wire radiates mainly because of time-varying current or an acceleration (or decelerations) of charge. If there is no motion of charges in a wire, no radiation takes place, since no flow of current occurs. Radiation will not occur even if charges are moving with uniform velocity along a straight wire. However, charges moving with uniform velocity along a curved or bent wire will produce radiation. If the charge is oscillating with time, then radiation occurs even along a straight wire.

The radiation from an antenna can be explained with the help of Figure 1 which shows a voltage source connected to a two conductor transmission line. When a sinusoidal voltage is applied across the transmission line, an electric field is created which is sinusoidal in nature and these results in the creation of electric lines of force which are tangential to the electric field. The magnitude of the electric field is indicated by the bunching of the electric lines of force. The free electrons on the conductors are forcibly displaced by the electric lines of force and the movement of these charges causes the flow of current which in turn leads to the creation of a magnetic field.

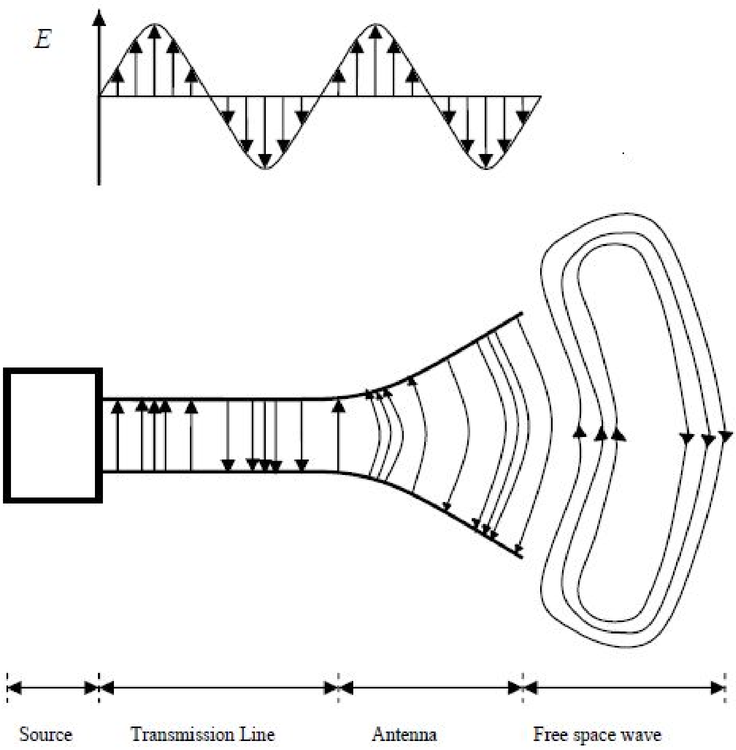

Fig 1 Radiation from an antenna

Due to the time varying electric and magnetic fields, electromagnetic waves are created and these travel between the conductors. As these waves approach open space, free space waves are formed by connecting the open ends of the electric lines. Since the sinusoidal source continuously creates the electric disturbance, electromagnetic waves are created continuously and these travel through the transmission line, through the antenna and are radiated into the free space. Inside the transmission line and the antenna, the electromagnetic waves are sustained due to the charges, but as soon as they enter the free space, they form closed loops and are radiated.

Near and Far Field Regions

The field patterns, associated with an antenna, change with distance and are associated with two types of energy: - radiating energy and reactive energy. Hence, the space surrounding an antenna can be divided into three regions.

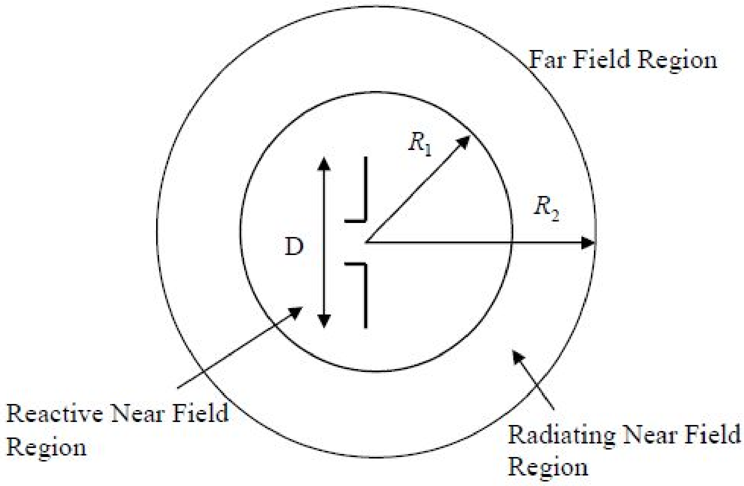

Fig 2 Field regions around the antenna

The three regions shown in Fig 2 are:

Reactive near-field region: In this region, the reactive field dominates. The reactive energy oscillates towards and away from the antenna, thus appearing as reactance. In this region, energy is only stored and no energy is dissipated. The outermost boundary for this region is at a distance $R_1 = 0.62[D^3 / \lambda]^{1/2}$ where, R_1 is the distance from the antenna surface, D is the largest dimension of the antenna and λ is the wavelength.

Radiating near-field region (also called Fresnel region): This is the region which lies between the reactive near-field region and the far field region. Reactive fields are smaller in this field as compared to the reactive near-field region and the radiation fields dominate. In this region, the angular field distribution is a function of the distance from the antenna. The outermost boundary for this region is at a distance $R_2 = 2D^2 /\lambda$ where, R_2 is the distance from the antenna surface.

Far-field region (also called Fraunhofer region): The region beyond $R_2 = 2D^2 /\lambda$ is the far field region. In this region, the reactive fields are absent and only the radiation fields exist. The angular field distribution is not dependent on the distance from the antenna in this region and the power density varies as the inverse square of the radial distance in this region.

Source : http://msk1986.files.wordpress.com/2013/09/7ec1_antenna-wave-propagation_unit-1.pdf