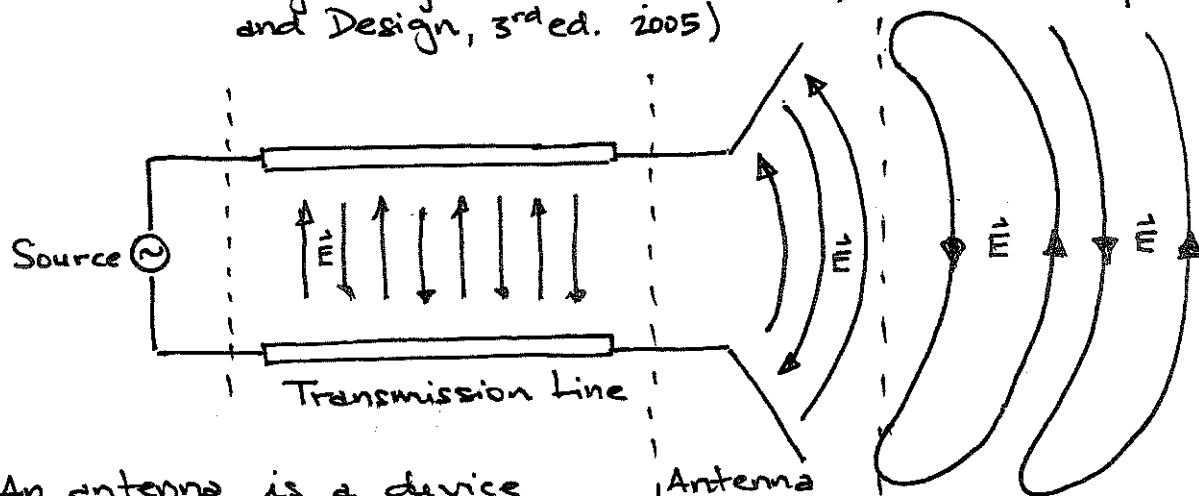


ANTENNA FUNDAMENTALS

Antenna - a means for radiating or receiving radio waves (IEEE Std. 145-1983)

- transitional structure between free-space and a guiding device (C. Balanis, Antenna Theory: Analysis and Design, 3rd ed. 2005)



An antenna is a device that provides a transition between a guided wave (in a transmission line or a waveguide) and a propagating wave (usually in free-space), and focuses the electromagnetic energy into particular directions. An antenna also serves as an impedance matching device between the transmission line and free-space.

Fundamental Parameters

radiation pattern - mathematical function or graphical representation of the radiation properties of the antenna as a function of space coordinates. In most cases, the radiation pattern is determined in the far-field region and is represented as a function of the directional coordinates. Radiation properties include power flux density, radiation intensity, field strength, directivity, phase or polarization. [1]

- half-power beamwidth - angle between half-power points, relative to the maximum, separated by the maximum. This means 0.707 of the maximum field strength, 0.50 of the maximum power (in linear scale), and -3 dB of the maximum power in dB scale

field regions - the space surrounding the antenna is usually subdivided into three regions: (a) reactive near-field, (b) radiating near-field (Fresnel) and far-field (Fraunhofer) [2].

Radiating near-field (Fresnel)

Reactive near-field



Far-field (Fraunhofer)

$$R_1 = 0.62 \sqrt{D^3/\lambda}$$

$$R_2 = 2D^2/\lambda$$

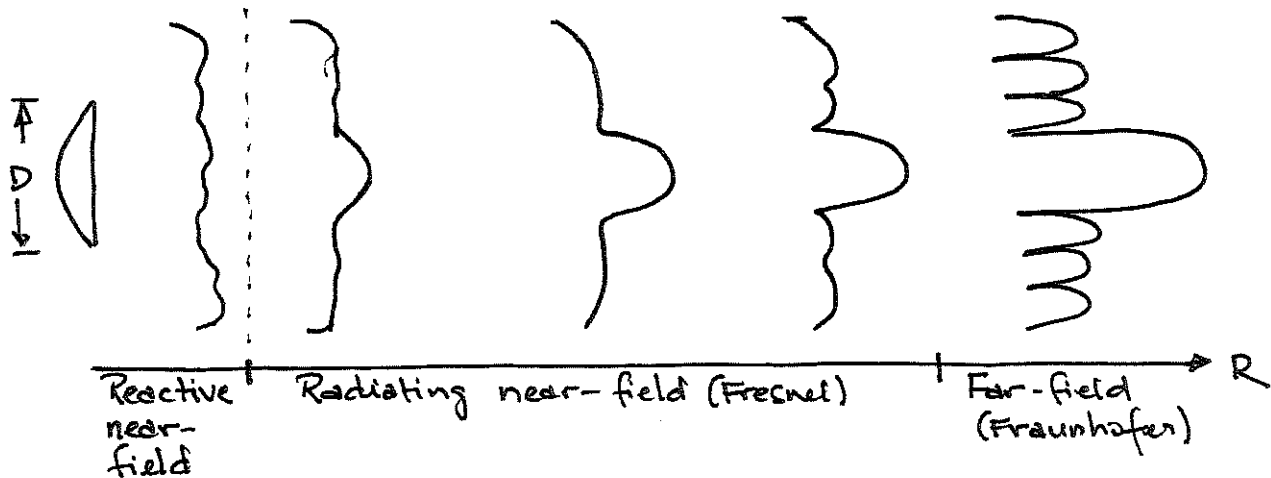
$\lambda \equiv$ wavelength

$D \equiv$ largest dimension of antenna

Reactive near-field - that portion of the near-field region immediately surrounding the antenna wherein the reactive field predominates. [1].

Radiating near-field - that region of the field of an antenna between the reactive near-field region and the far-field region wherein radiation fields predominate and wherein the angular field distribution is dependent upon the distance from the antenna. [1].

Far-field - that region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna [1].



Directivity - the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. The average radiation intensity is the total power radiated by the antenna divided by 4π . [1]

$$D(\theta, \phi) = \frac{U(\theta, \phi)}{U_0} = \frac{U(\theta, \phi)}{P_{rad}/4\pi}$$

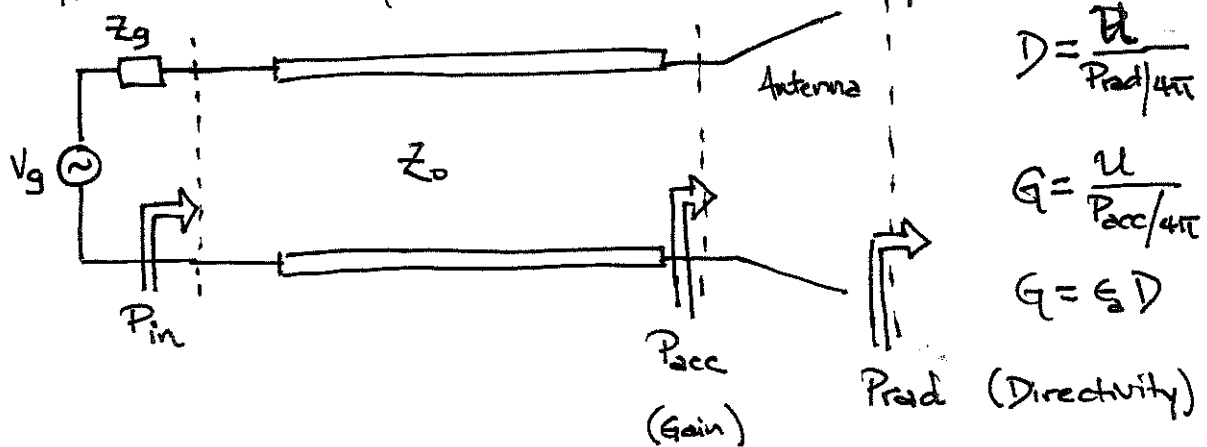
The directivity is a measure of the focusing ability of the antenna, compared to an isotropic antenna

Isotropic antenna - a fictitious antenna that radiates the power equally in all directions. The radiation pattern of an isotropic antenna is a sphere.

Gain - the ratio of the radiation intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically. The radiation intensity corresponding to isotropically radiated power is equal to the power accepted (input) by the antenna divided by 4π . []

$$G(\theta, \phi) = \frac{U(\theta, \phi)}{P_{acc}/4\pi}$$

The gain includes the losses in the antenna. It does not include any effect of the impedance mismatch of the system.



Antenna efficiency - since the antennas are made out of real conductors and insulators, part of the energy accepted by the antenna is converted to heat in the antenna. Therefore, the power radiated by the antenna is smaller than the power accepted. The antenna efficiency is used to relate the accepted power with the radiated power, and is a measure of the losses in the antenna.

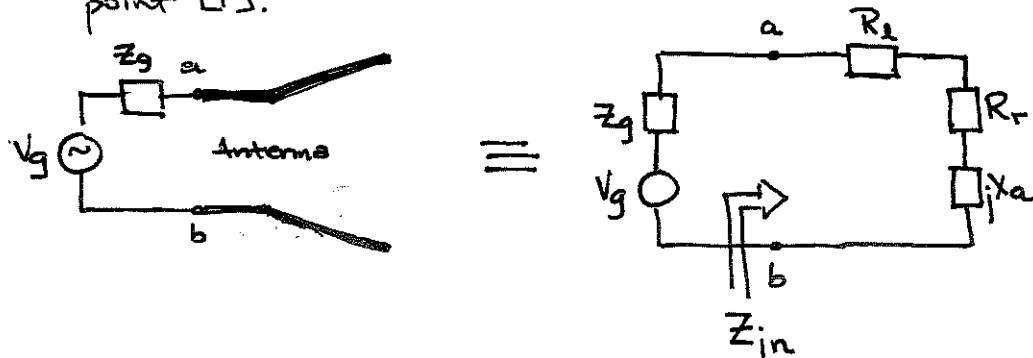
$$P_{rad} = \epsilon_s P_{acc}$$

$$0 \leq \epsilon_s \leq 1$$

$\epsilon_s \equiv$ antenna efficiency

Polarization - polarization of an antenna is the polarization of the wave transmitted (radiated) by the antenna. The polarization of the wave is the figure traced, as a function of time, by the tip of the electric field vector as observed along the direction of propagation.

Input Impedance - the impedance presented by an antenna at its terminals, or the ratio of the voltage to current at a pair of terminals or the ratio of the appropriate components of the electric to magnetic fields at a point [1].



$R_r \equiv$ radiation resistance - represents the energy transmitted (radiated) to space in transmit mode, and the energy scattered (re-radiated) by the antenna in the receiving mode

$R_e \equiv$ loss resistance - represents the energy lost as heat in the antenna

$X_a \equiv$ antenna reactance - represents the energy stored in the antenna vicinity

[1] IEEE Standard Definitions of Terms for Antennas; IEEE Std 145-1983

[2] C.A. Balanis, Antenna Theory: Analysis and Design, 3rd ed, John Wiley & Sons, 2005.