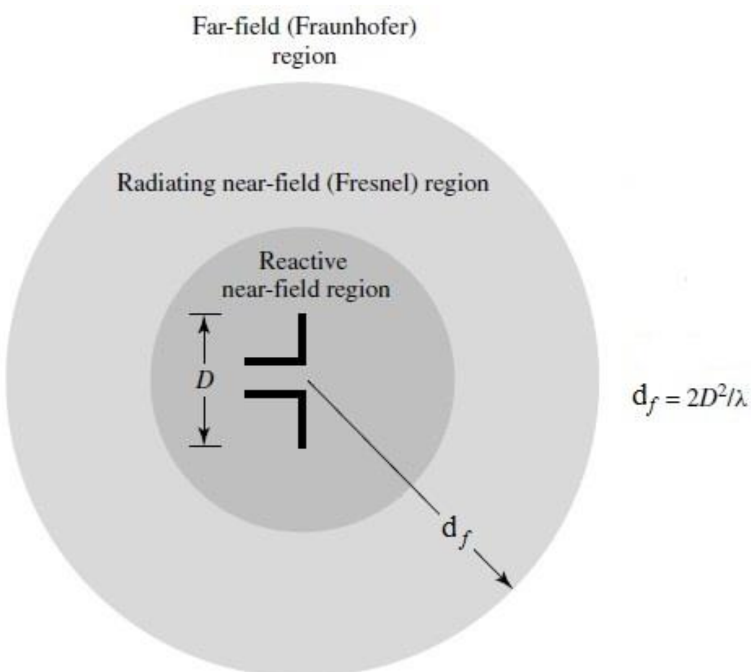

The far-field distance is given by

$$d_f = \frac{2D^2}{\lambda}$$

where D is the largest physical linear dimension of the antenna.

- Friis equation does not hold for $d = 0$. For this reason, large-scale propagation models use a close-in distance, d_0, as a known received power reference point.
- The received power, $P_r(d)$, at any distance $d > d_0$, may be related to P_r at d_0.
- The value $P_r(d_0)$ may be predicted from Friis equation, or may be measured in the radio environment by taking the average received power at many points located at a close-in radial distance d_0 from the transmitter.
- The reference distance must be chosen such that it lies in the far-field region, that is, $d_0 \geq d_f$, and d_0 is chosen to be smaller than any practical distance used in the mobile communication system. Thus, using Friis equation, the received power in free space at a distance greater than d_0 is given by

$$P_r(d) = P_r(d_0).\left(\frac{d_0}{d}\right)^2$$

where $d \geq d_0 \geq d_f$

- Because of the large dynamic range of received power levels, often *dBm* or *dBW* units are used to express received power levels. This is done by simply taking the logarithm of both sides and multiplying by 10.

For example, if P_r is in units of *dBm*, the received power is given by

$$P_r(d)\ dBm = 10\log\left[\frac{P_r(d_0)}{0.001\,W}\right] + 20\log\left(\frac{d_0}{d}\right)$$

where $P_r(d_0)$ is in units of watts.

Example 1

Find the far-field distance for an antenna with maximum dimension of 1*m* and operating frequency of 900 *MHz*.

Solution

Given:

Largest dimension of antenna, $D = 1m$,

Operating frequency, $f = 900\ MHz$,

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{900\times10^6} = 0.33m$$

$$d_f = \frac{2D^2}{\lambda} = \frac{2(1)^2}{0.33} = 6m$$

Example 2

If a transmitter produces 50 *watts* of power, express the transmit power in units of

a. *dBm*,
b. *dBW*.

If 50 *watts* is applied to a unity gain antenna with a 900 *MHz* carrier frequency, find the received power in *dBm* at a free space distance of 100*m* from the antenna. What is P_r *(10 km)*? Assume unity gain for the receiver antenna.

Solution:

Given:

$P_t = 50\ W$, $f = 900\ MHz$

(a)

$$P_t(dBm) = 10\log\left[P_t(mW)/(1\ mW)\right] = 10\log[50\times10^3] = 47\ dBm$$

(b)

$$P_t(dBm) = 10\log\left[P_t(W)/(1\ W)\right] = 10\log\left[50\right] = 17\ dBW$$

The received power is

$$P_r(d) = \frac{P_t G_t G_r}{L}\left(\frac{\lambda}{4\pi d}\right)^2$$

$$P_r(d) = \frac{50\times1\times1}{1}\left(\frac{0.33}{4\pi\times100}\right)^2 = 3.5\times10^{-6}W = 3.5\times10^{-3}mW$$

$$P_r(dBm) = 10\log P_r(mW) = 10\log(3.5\times10^{-3}\ mW) = -24.5\,dBm$$

The received power at 10 *km* can be expressed in terms of *dBm* as

$$P_r(10\,km) = P_r(100) + 20\log\left(\frac{100}{10000}\right) = -24.5\,dBm - 40\,dB = -64.5\ dBm$$

Example 3

Determine the isotropic free space loss at 4 *GHz* for the 3.5 *km* path to a receiver from transmitter.

Solution:

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{4\times10^9} = 0.075m$$

$$PL(dB) = -20\log\left(\frac{0.075}{4\pi\times3.5\times10^3}\right) = 115.4\ dB$$

4.3 Basic Propagation mechanisms

The physical mechanisms that govern radio propagation are complex and diverse, but generally attributed to the following three factors

1. Reflection
2. Diffraction
3. Scattering

1- Reflection

l Occurs when waves impinges upon an obstruction that is much larger in size compared to the wavelength of the signal

Example: reflections from earth and buildings , these reflections may interfere with the original signal constructively or destructively

2- Diffraction

l Occurs when the radio path between sender and receiver is obstructed by an impenetrable body and by a surface with sharp irregularities (edges)

Explains how radio signals can travel urban and rural environments without a line-of-sight path