FACTORS THAT PRODUCE THE MEASURED FIELD STRENGTH

Field strength is the measure of power density at any given point. The main units of field strength are dBµ V/m, dBµ µV and dBµ. The dBµ V/m unit measures power density of radio waves, which is preferred by radio engineers.

There are three factors that work together to produce the measured field strength: free space loss or path loss, log normal fading and multipath or Rayleigh fading.

Free Space Loss or path loss

Free Space Loss or path loss is the attenuation experienced by the signal over a certain distance. Figure 1.1 demonstrates the path loss relationship with respect to frequency and distance.

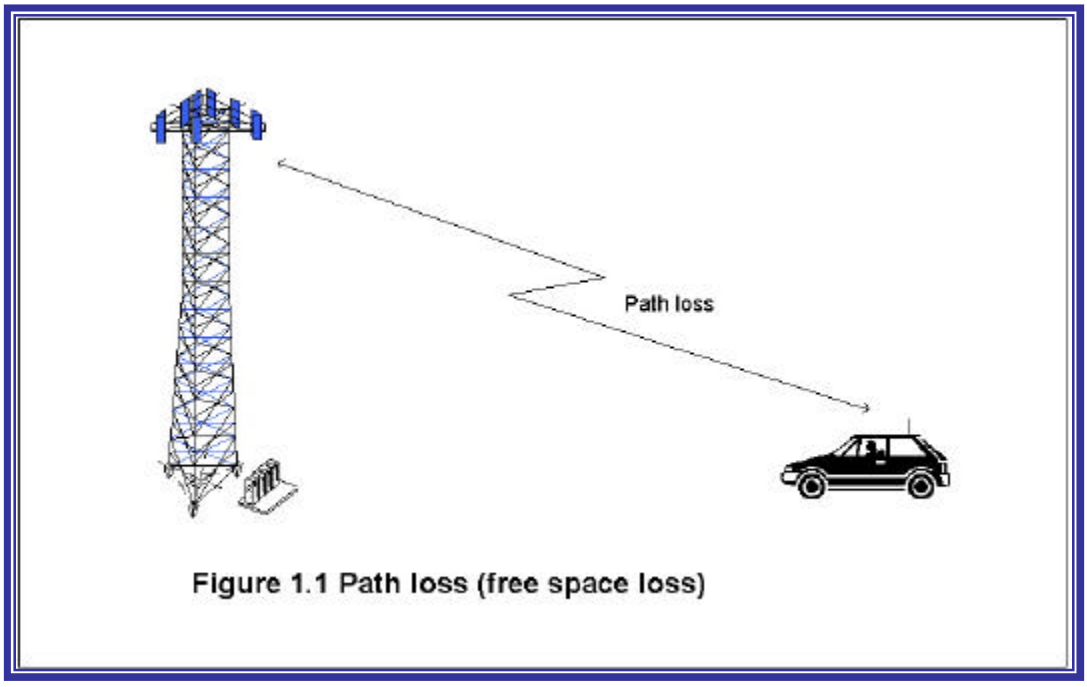

Figure 1.1 Path loss (free space loss)

The free space loss equation is:

$$\mathbf{FSL = 36.58 + 20 \times \log R + 20 \times \log f_c}$$

Where FSL is the free space loss, in dB
R is the distance from the cell site, in miles
f_c is the transmit frequency, MHz

Log Normal Fading

Log Normal Fading is shown in Figure 1.2. This process is called log normal fading because the field strength distribution follows a curve that is a normally distributed curve, provided the field strength is measured logarithmically.

Log- normal is the result of shadowing from fixed local obstructions. The distance between log- normal fades is comparable to the dimensions of the things that cause the shadowing. Slow fades are 50 to 300 feet in length, and can vary about +/- 10dB along the shadow.

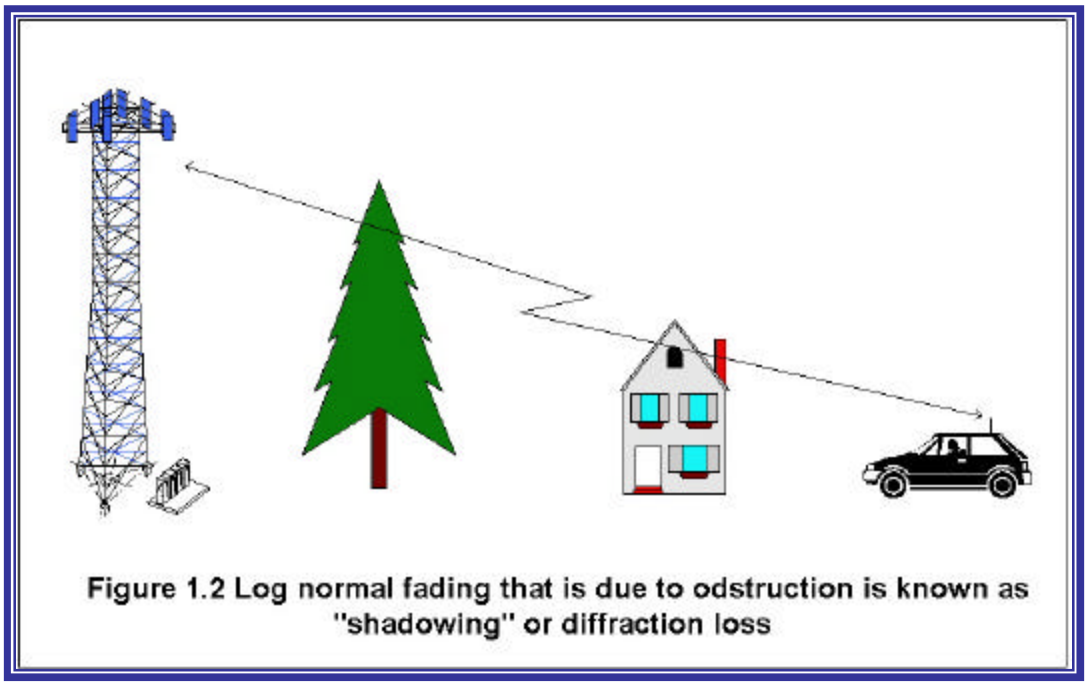

Figure 1.2 Log normal fading that is due to odstruction is known as "shadowing" or diffraction loss

Multipath or Rayleigh fading

Multipath or Rayleigh fading is a most important feature of mobile communications to some significant extent. Rayleigh fading is the phenomenon that results in radio signals' reaching the receiving antenna by two or more paths. The reflected signals are randomly phased and add together to form a combined wave with random phase and amplitude. The received signal can vary by 30 dB within a few inches.

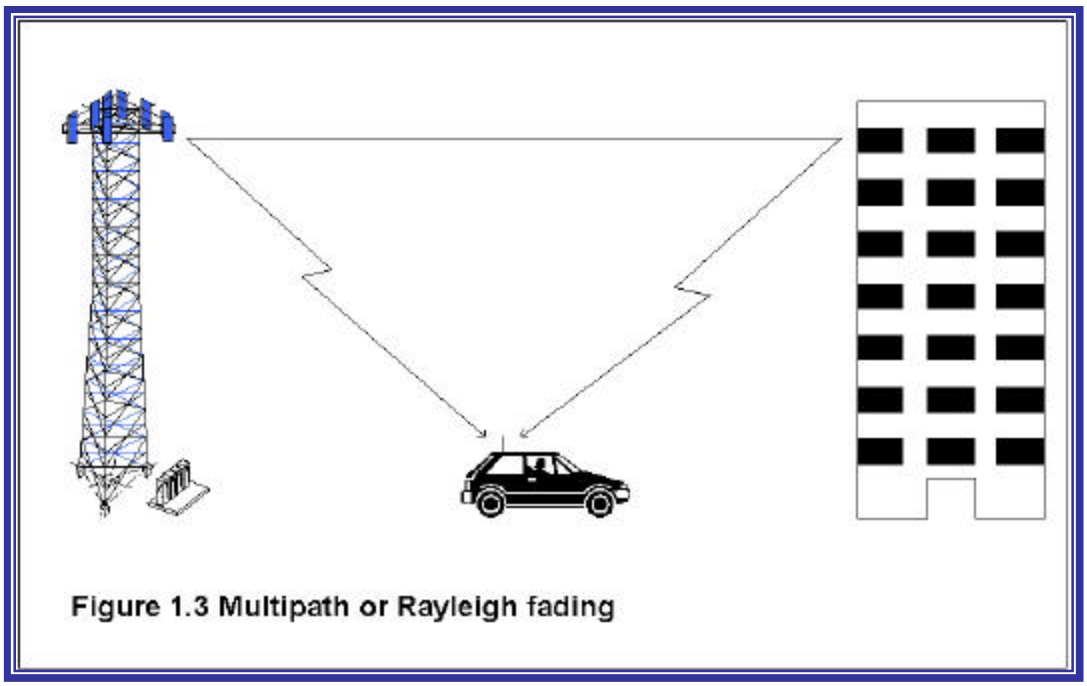

Figure 1.3 Multipath or Rayleigh fading

An empirical formula for the cumulative effect of these three types of fading is given in *Recommendations and Reports of the CCIR*, 1982, Volume V, Report 567-2 as

$$P_L = 69.55 + 26.16 \log f - 13.82 \log h_1 - a(h_2) + (44.9 - 6.55 \log h_1) \log d$$

Where P_L is the path loss in dB
f is the frequency in MHz
h_1 is the base station antenna height in meters
h_2 is the receiver antenna height in meters
$a(h_2) = (1.1 \log f - 0.7)\, h_2 - (1.56 \log f - 0.8)$
d is the distance in kilometers

Reference:

1. Neil J. Boucher, "The Cellular Radio Handbook Second Edition", pp. 75-77.
2. Clint Smith, P.E and Curt Gervelis, "Cellular System Design and Optimization", pp. 16, 1996.