

LOG DISTANCE PATH LOSS OR LOG NORMAL SHADOWING MODEL

Log distance path loss model is a generic model and an extension to [Friis Free space model](#). It is used to predict the propagation loss for a wide range of environments, whereas, the Friis Free space model is restricted to unobstructed clear path between the transmitter & the receiver.



In the far field region of the transmitter ($d \geq d_f$), if $PL(d_0)$ is the path loss measured in dB at a distance d_0 from the transmitter, then the path loss (the loss in signal power measure in dB when moving from distance d_0 to d) at an arbitrary distance $d > d_0$ is given by

$$PL_{d_0 \rightarrow d}(dB) = PL(d_0) + 10n \log_{10} \left(\frac{d}{d_0} \right) + \chi \quad d_f \leq d_0 \leq d$$

$PL(d_0)$ = Path Loss in dB at a distance d_0

$PL_{d > d_0}$ = Path Loss in dB at an arbitrary distance d

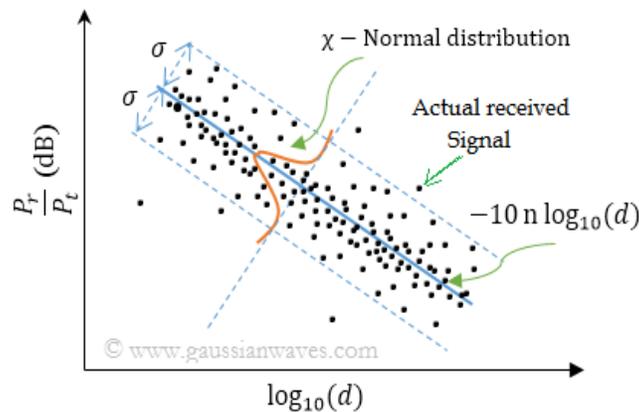
n = Path Loss exponent. See the table below that gives the path loss exponent for various environments.

χ = A zero-mean Gaussian distributed random variable (in dB) with standard deviation σ . This variable is used only when there is a shadowing effect. If there is no shadowing effect, then this variable is zero.

Taking log of the Normal (Gaussian)-variable results in the name “Log-Normal” fading.

| Environment | Path Loss Exponent (n) |
|-----------------------------------|------------------------|
| Free Space | 2 |
| Urban area cellular radio | 2.7 to 3.5 |
| Shadowed urban cellular radio | 3 to 5 |
| Inside a building – Line of Sight | 1.6 to 1.8 |
| Obstructed in building | 4 to 6 |
| Obstructed in Factory | 2 to 3 |

Usually to model real environments the shadowing effects cannot be neglected. If the shadowing effect is neglected, the Path Loss is simply a straight line (see the plot below). To add shadowing effect a zero-mean Gaussian random variable with standard deviation – σ is added to the equation. The actual path loss may still vary due to other factors. Thus the path loss exponent (modeling the slope) and the standard deviation of the random variable should be known precisely for a better modeling.



The Path Loss Exponent (PLE) table given above is for reference only. It may or may not fit the actual environment we are trying to model. PLE is an important parameter and it affects the system performance drastically. Usually PLE is considered to be known a-priori but mostly that is not the case. Care must be taken to estimate the PLE for the given environment before design & modeling. PLE estimation is done by equating the observed (empirical) values over several time instants to the established theoretical values. Refer [Srinivasa2009] for a literature on PLE estimation in large wireless networks.

Source: <http://www.gaussianwaves.com/2013/09/log-distance-path-loss-or-log-normal-shadowing-model/>