Log-distance path loss model

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The **log-distance path loss model** is a radio propagation model that predicts the path loss a signal encounters inside a building or densely populated areas over distance.

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Applicable to / Under conditions [edit]

The model is used to predict the propagation loss for a wide range of environments

Mathematical formulation [edit]

The model [edit]

Log-distance path loss model is formally expressed as:

$$PL = P_{Tx_{dBm}} - P_{Rx_{dBm}} = PL_0 + 10\gamma \log_{10} \frac{d}{d_0} + X_g,$$

where

PL is the total path loss measured in Decibel (dB)

$P_{Tx_{dBm}} = 10 \log_{10} \frac{P_{Tx}}{1mW}$ is the transmitted power in dBm, where

P_{Tx} is the transmitted power in watt.

$P_{Rx_{dBm}} = 10 \log_{10} \frac{P_{Rx}}{1mW}$ is the received power in dBm, where

P_{Rx} is the received power in watt.

PL_0 is the path loss at the reference distance d_0. Unit: Decibel (dB)

d is the length of the path.

d_0 is the reference distance, usually 1 km (or 1 mile).

γ is the path loss exponent.

X_g is a normal (or Gaussian) random variable with zero mean, reflecting the attenuation (in decibel) caused by flat fading[*citation needed*]. In case of no fading, this variable is 0. In case of only shadow fading or slow fading, this random variable may have Gaussian distribution with σ standard deviation in dB, resulting in log-normal distribution of the received power in Watt. In case of only fast fading caused by multipath propagation, the corresponding gain in Watts $F_g = 10^{\frac{-X_g}{10}}$ may be modelled as a random variable with Rayleigh distribution or Ricean distribution.[1]

Corresponding non-logarithmic model [edit]

This corresponds to the following non-logarithmic gain model:

$$\frac{P_{Rx}}{P_{Tx}} = \frac{c_0 F_g}{d^\gamma}$$

where

$c_0 = d_0^\gamma 10^{\frac{-L_0}{10}}$ is the average multiplicative gain at the reference distance d_0 from the transmitter. This gain depends on factors such as carrier frequency, antenna heights and antenna gain, for example due to directional antennas; and

$F_g = 10^{\frac{-X_g}{10}}$ is a stochastic process that reflects flat fading. In case of only slow fading (shadowing), it may have log-normal distribution with parameter σ dB. In case of only fast fading due to multipath propagation, its amplitude may have Rayleigh distribution or Ricean distribution.

Empirical coefficient values for indoor propagation [edit]

Empirical measurements of coefficients γ and σ in dB have shown the following values for a number of indoor wave propagation cases.[2]

Building Type	Frequency of Transmission	γ	σ [dB]
Vacuum, infinite space		2.0	0
Retail store	914 MHz	2.2	8.7
Grocery store	914 MHz	1.8	5.2
Office with hard partition	1.5 GHz	3.0	7
Office with soft partition	900 MHz	2.4	9.6
Office with soft partition	1.9 GHz	2.6	14.1
Textile or chemical	1.3 GHz	2.0	3.0
Textile or chemical	4 GHz	2.1	7.0, 9.7
Metalworking	1.3 GHz	1.6	5.8
Metalworking	1.3 GHz	3.3	6.8

References [edit]

1. ^ Julius Goldhirsh; Wolfhard J. Vogel. "11.4". *Handbook of Propagation Effects for Vehicular and Personal Mobile Satellite Systems*.
2. ^ *Wireless communications principles and practices*, T. S. Rappaport, 2002, Prentice-Hall

Further reading [edit]

- *Introduction to RF propagation*, John S. Seybold, 2005, Wiley.
- *Wireless communications principles and practices*, T. S. Rappaport, 2002, Prentice-Hall.

See also [edit]

- ITU Model for Indoor Attenuation
- Radio propagation model
- Young model

Categories: Radio frequency propagation