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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}} = 10log₁₀

P

T
x

1
m
W

{\displaystyle {\frac {P_{Tx}}{1mW}}}

 is the transmitted power in **dBm**, where

P_{Tx} is the transmitted power in **watt**.

P_{Rx_{dBm}} = 10log₁₀

P

R
x

1
m
W

{\displaystyle {\frac {P_{Rx}}{1mW}}}

 is the received power in dBm, where

P_{Rx} is the received power in watt.

PL₀ 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<sup>−

X

g

10

{\displaystyle -{\frac {X_{g}}{10}}}</sup> 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:

$$\frac{P_{Rx}}{P_{Tx}} = \frac{c_0F_g}{d^\gamma}$$

where

*c*₀ = *d*₀^{*γ*}10<sup>−

L

0

10

{\displaystyle -{\frac {L_0}{10}}}</sup> 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<sup>−

X

g

10

{\displaystyle -{\frac {X_g}{10}}}</sup> 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	<i>γ</i>	<i>σ</i> [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]

- ↑ Julius Goldhirsh; Wolthard J. Vogel. **"11.4"** 📖. *Handbook of Propagation Effects for Vehicular and Personal Mobile Satellite Systems*.
- ↑ *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](#)

This page was last modified on 12 March 2014 at 02:26.

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