19AIE204 “Introduction to communication systems”

Project Report

Log Distance / Normal Shadowing pathloss model

Bachelor of Technology
in
Artificial Intelligence & Engineering

Submitted by Group No.: 9

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OBJECTIVE

To implement log distance pathloss and log normal shadowing pathloss models using MATLAB. And to plot the pathloss vs distance graph using both the models for various propagation environments like free space, shadowed urban cellular radio, obstructed in building or factory etc.

BLOCK DIAGRAM & DESCRIPTION

While going via the propagation path to the receiver, a broadcast signal undergoes changes. Fading is the term used to describe the effect of these changes. A signal in open space takes one path and reaches the receiver with little attenuation. This is not the case when a signal encounters impediments along its course of propagation. Instead, the signal is reflected, diffracted, and scattered by the objects along its path.

The fading phenomena are divided into two categories. There are two types of fading: large-scale fading and small-scale fading. The term "large-scale fading" refers to the signal level at the receiver after travelling a long distance (hundreds of wavelengths). Signal attenuation owing to signal propagation over long distances and diffraction around massive objects in the propagation channel causes wide-scale fading. The signal level at the receiver after meeting impediments near (several wavelengths to fractions of wavelengths) the receiver is referred to as small scale fading.

Path loss models are a type of large-scale fading model that is used to calculate the power loss of a radio signal as it travels away from the transmitter. Path loss modules, which are submodules of the radio medium module, implement path loss models. The most common route loss model is free space path loss, which computes attenuation along a single line-of-sight propagation channel using the inverse square law. This is a simplistic model that is only realistic in some instances, such as when modelling satellite-to-satellite communications. It's also handy if the simulation's focus isn't on radio propagation accuracy because of its low processing cost (e.g., for testing protocols.). However, there are several more path loss models available which are suitable for various other scenarios.

The log-distance path loss model is a radio propagation model that estimates path loss inside buildings and densely populated areas over time. It's a variation on Friis' free space concept. It can forecast propagation loss in a variety of situations, whereas the Friis free space model is limited to an unobstructed clear path between the transmitter and receiver. The model includes random shadowing effects caused by signal obstructions such as hills, trees, and buildings. The log normal shadowing model is another name for it. A stochastic path loss model in which power levels follow a lognormal distribution is known as lognormal shadowing. The observed signal levels at a particular transmitter-receiver separation exhibit a gaussian distribution above the far dependent mean in this scenario.

If PL(d0) is the path loss at a distance of d0 metres from the transmitter in the far field area for distances exceeding df, then the path loss at any distance d>d0 is given by

$$[P_L(d)]dB = [P_L(d_0)]dB + 10\,n\,log_{10}\left(\frac{d}{d_0}\right) + \chi$$

$$for\ d_f \leq d_0 \leq d$$

Here,
PL(d) is the total path loss in decibels (dB) at an arbitrary distance d meter.
PL(d0) is the path loss in decibels(dB) at the reference distance calculated using Friis free-space path loss model. The reference path loss PL(d0) is also known as close-in reference distance.

d is the length of the propagation path.
d0 is the reference distance, usually 1 km (or 1 mile) for a large cell and 1 m to 10 m for a microcell.
n is the path loss exponent that depends on the type of propagation environment.
χ is a zero-mean Gaussian distributed random variable with standard deviation σ expressed in dB, used only when there is a shadowing effect. If there is no shadowing effect, then this variable is zero.

The importance of choosing the correct reference distance d0 cannot be overstated. In addition, the path-loss exponent(n) value varies depending on the environment.

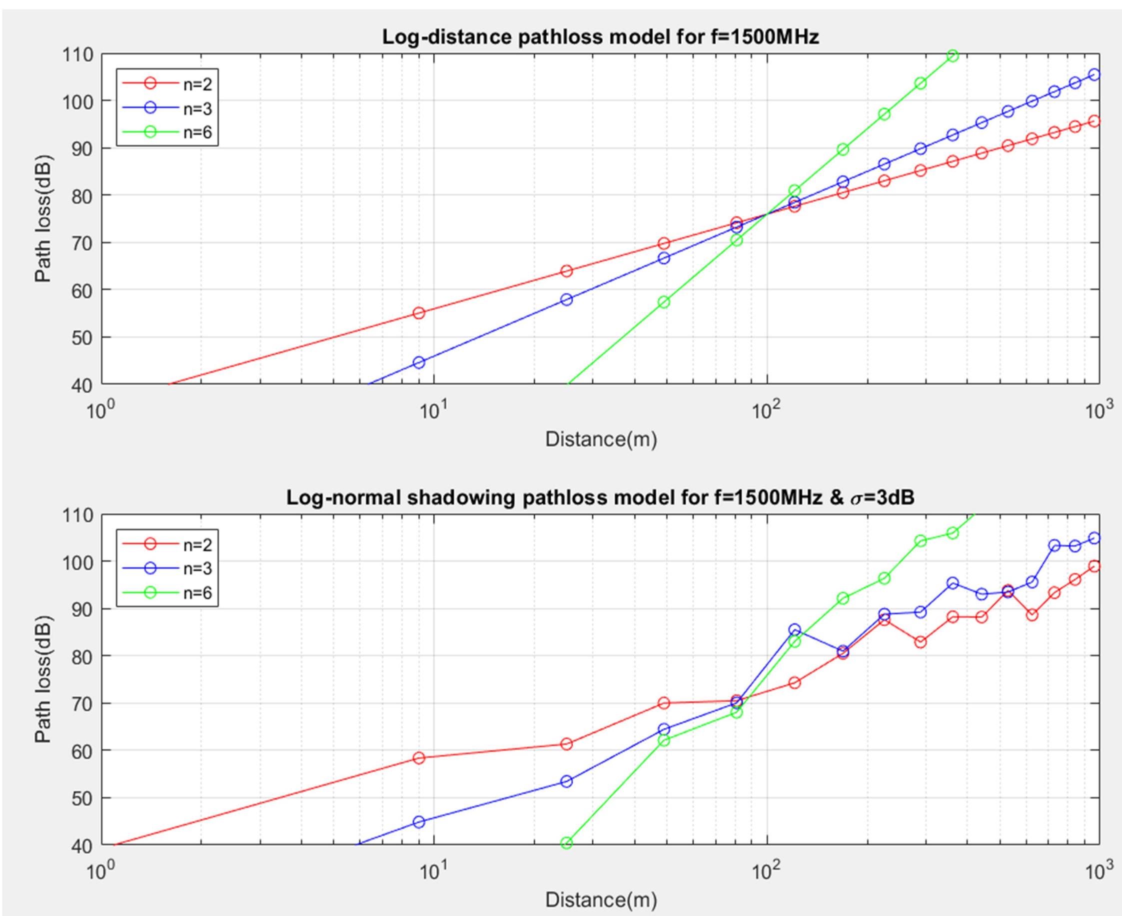
Environment	Path Loss Exponent (n)
Free space	2
Urban area cellular radio	2.7 to 3.5
Shadowed urban cellular radio	3 to 5
Inside a building - line-of-sight	1.6 to 1.8
Obstructed in building	4 to 6
Obstructed in factory	2 to 3

The path-loss exponent (PLE) numbers listed above may or may not be appropriate for the scenario we're attempting to simulate. PLE is usually assumed to be known a priori, but this is not always the case. Before designing and modelling, it's important to estimate the PLE for the particular context. PLE is calculated by comparing observed (empirical) values across several time instants to theoretical values.

In most cases, shadowing effects cannot be ignored when modelling real-world settings. The Path Loss is simply a straight line if the shadowing effect is ignored. A zero mean Gaussian random variable with standard deviation is added to the equation to add the shadowing effect. Other things may still affect the real route loss. For improved modelling, the path loss exponent and the random variable's standard deviation should be determined accurately.

SIMULATION RESULT

Simulated results for both log distance pathloss and log normal shadowing pathloss models are as follow.



INFERENCE

From the above, we can see that figure-I shows the received signal power when there is no shadowing effect and figure-II shows the received signal power when shadowing exists. The results are generated with frequency of transmission f =1500MHz, reference distance d0 =100m, standard deviation of the log-normal shadowing σ =3dB for three different environments which has PLE n=2,3,6. The distance d is taken as an array which contains squares of the first 30 odd numbers. The graphs are plotted by taking x-axis as the distance and y-axis as the path loss in decibels(dB). The results clearly illustrate that the graph for the log distance pathloss model is just a straight line, whereas the log-normal shadowing model introduces randomness in the received signal power, putting us closer to reality.

CONCLUSION

Log distance pathloss and log normal shadowing pathloss models are implemented using MATLAB. Pathloss vs Distance graphs are plotted using both the models for various propagation environments like free space, shadowed urban cellular radio, obstructed in building or factory etc. From the above results it is clear that the graph is simply straight line for log distance pathloss and the graph is in randomness for log-normal shadowing model which is close to reality.

Appendix (MATLAB Code)

```
clc;clear;close all;
f=1.5e9;
d0=100;
sigma=3;
d=(1:2:31).^2;
n=[2 3 6];
for k=1:3
   logdist(k,:)=logdist_or_lognorm_PL_M(f,d,d0,n(k));
   lognorm(k,:)=logdist_or_lognorm_PL_M(f,d,d0,n(k),sigma);
end
subplot(2,1,1)
semilogx(d,logdist(1,:),'r-o',d,logdist(2,:),'b-o',d,logdist(3,:),'g-o')
grid on
axis([1 1000 40 110])
title(['Log-distance pathloss model for f=',num2str(f/1e6),'MHz'])
xlabel('Distance(m)'),ylabel('Path loss(dB)')
legend('n=2','n=3','n=6',"location","northwest")
subplot(2,1,2)
semilogx(d,lognorm(1,:),'r-o',d,lognorm(2,:),'b-o',d,lognorm(3,:),'g-o')
grid on
axis([1 1000 40 110])
title(['Log-normal shadowing pathloss model for f=',num2str(f/1e6),'MHz & \sigma=',
```

```
num2str(sigma), 'dB'])
xlabel('Distance(m)'),ylabel('Path loss(dB)')
legend('n=2','n=3','n=6',"location","northwest")
function PL=logdist_or_lognorm_PL_M(fc,d,d0,n,sigma)
   lamda=299792458/fc;
   PL=-20*log10(lamda/(4*pi*d0))+10*n*log10(d/d0);
   if nargin>4
      PL=PL+sigma*randn(size(d));
   end
end
```

---THE END---