Propagation Model For Wireless Communications

Muhammad Kusban
Electrical Engineering,
Muhammadiyah Surakarta University
Surakarta, Indonesia
Email : muhammadkusban@gmail.com
+62 271 717417

***Abstract*--Wireless technologies have had an enormous impact on networking in recent years. It can create new business opportunities and allow users to communicate and share data in a new fashion. Wireless network decrease installation cost, reduce the deployment time of a network and overcome physical barrier problems inherent in wiring. In this article, we give a presentation of wireless propagation in atmosphere. We discuss in depth the characteristics of propagation. To complement the analysis, we give an account of experiments performed in Matlab-based.**

Keywords: propagation, wireless communication, physical barrier, Matlab-based.

I. INTRODUCTION

Propagation is a term used to describe the signal transmitted from the sending station to receiving stations. Related variables between the receiver and sender station are distance and frequency. Conditions are ideal, when transfer between the two stations is no barrier as well as the frequency moves above the salt water[1]. In the Earth's atmosphere, there area variety of gases that form layers around the earth with a different thickness. Each has a different propagation effects. Layer near the earth is denser than the layers above it, as well as varying levels of temperature are directly proportional to the distance of the earth. Layer that has a constant temperature while making the distance away from the earth is called the troposphere which has a thickness of 0 -10 km. Stable temperature in the layer with a thickness of 10-20 km layer called the tropopause. A height of up to 60 km is the stratosphere, where temperature increases with altitude. Region with the maximum temperature in the sub layer of stratosphere is called stratopause. And then a layer of 70 - 650 km above stratopause is ionosphere layer. In the ionosphere layer, sub - divided upper layer from the bottom, namely: Dlayer (layer of Robert Watson - Wyatt), Elayer (Kennelly-Heaviside layer), and Flayer (Appleton layer, it is divided into F1 and F2). Dlayer is formed only during the day, while at night this layer is lost. Dlayer is used to reflect low frequency waves.

Critical frequency is the highest frequency that will be returned to earth when the waves are emitted toward the ionosphere. Said to be a critical frequency because his layer is the boundary layer to reflect the waves back to earth, if not then the reflected wave can be lost through this layer to higher layers and information will be lost. In radio broadcasts often heard the term f(2) day time critical frequency that also abbreviated f0, it is the frequency at the critical point of the F2 layer, while the symbol f0E is the critical frequency in layer E. There is a term maximum usable frequency (mouf) i.e. conditions radio broadcasting in the ionosphere that is not returned to earth because frequency emitted vertically upward exceeds the threshold value, then made a point of transmitting near horizontal, it will be beamed back to Earth more powerful. The amount of emission angle is called the angle of radiation, while transmitting HF bands into the ionosphere is known as angle of incidence.

Near vertical incidence skywave (NVIS or cloud warming) is the art of emitting waves into the ionosphere in an almost upright position but can still be reflected back to earth. This condition is necessary to obtain short beam area surrounding the transmitter antenna.

II. STUDY REFERENCES

Tam and Tran [6] stated that it is important to characterize the indoor radio propagation channel to ensure satisfactory performance of a wireless communication system. Site measurements can be costly; propagation models have been developed as a suitable low-cost alternative.The existing models can be classified into two major classes: statistical models rely on measurement data; site-specific propagation models are based on electromagnetic wave propagation theory.

In analyzing the propagation of wireless is often used for mobile systems. There are three components of the phenomenon of propagation : multipath fading, shadowing, and large-scaleloss. Multipath propagation causes the fluctuation between the phase and amplitude when the vehicle moves through areas with different wave lengths. Shadowing is used to describe the transmitter antenna is moved.

Propagation is very influential on the use of wireless communication protocols. For long distance propagation resulted in an uninterrupted path (path loss), the farther the distance between sender and receiver resulting in received signal strength decreases. For the short distance occur the fading that is the fluctuations of the received signal caused by the short distance between the sender and receiver. In areal situation, many factors that affect propagation : reflection or change in wave direction generally occurs in a very remote transmitter with the receiver so that signals received two pieces of the signal from the LOS (line of sight) and the signal from the reflection, diffraction, and scattering.

In the study of the propagation between points A and B, both in optical and radio communications involving wave motion, always contains the Fresnel (Fresnel zone) consisting of various forms of ellipse known as Fresnel ellips oids, each having a focal point A and B result in gin the arbitrary point M has the equation:

$$AM + MB = AB + n\frac{\lambda}{2} \qquad (1)$$

N is the number of ellips oid, while for n = 1 relates to the first Fresnel ellips oid. Radius of an ellips oid between the sender and the receiver is expressed by the equation:

$$R_n = \left[\frac{n\lambda d_1 d_2}{d_1 + d_2}\right]^{1/2} \qquad (2)$$

This simplifies to:

$$R_n = 550\left[\frac{n d_1 d_2}{(d_1 + d_2)f}\right]^{1/2} \qquad (3)$$

f is frequency (MHz) and d_1 and d_2 is the distance in km between transmitter and receiver at which point the radius of ellips oid (meters) was calculated.

A. Rayleighdistribution

Rayleigh distribution is a continuous distribution generated when the overall magnitude of the vector associated with the direction of its components. Rayleigh distribution as an example application (taken from the inventor Lord Rayleigh) is the analysis of wind speeds that were analyzed in a 2D orthogonal vector components with each component are not mutually correlated with each other.

$$f(x;\sigma) = \frac{x}{\sigma^2} e^{-\frac{x^2}{2\sigma^2}}, x \geq 0 \qquad (4)$$

For the parameters $\sigma > 0$

$$F(x) = 1 - e^{-\frac{x^2}{2\sigma^2}}, x \in (0, \infty) \qquad (5)$$

B. Rice distribution

Rice distribution or rician distribution (named by its inventor Stephen O. Rice) is used for the value distribution of absolute value in a random variable with mean is not zero.

$$f(x|v,\sigma) = \frac{x}{\sigma^2} exp\left(\frac{-(x^2 + v^2)}{2\sigma^2}\right) I_0\left(\frac{xv}{\sigma^2}\right) \qquad (6)$$

C. Fading time scales large and small

Reflect or that reflects the presence of a signal from the transmitter to the receiver causes a range of signaling pathways. As a result the receiver received signal with a signal range multipath, each signal has a different path that has the attenuation, delay, and phase shift. As a result, produce a signal that weaken and streng then the power at the receiver. Signal reception at the receiver that has strong impact damage is called deep fading that can result in miscommunication. The value of the signal envelope fading moment (short-time scales in milliseconds) is the joint distribution of Rayleigh (NLOS) and the Rice distribution (LOS). The mean value for both distributions can be considered constant for a very short time scale. However, many encountered in practice be a time-scale random so using log normal distribution primarily to the large time scale (seconds). Can be summed upin the fading with time scales : large scale fading is also called the shadow fading, using equations log normal distribution and small scale fading which gave rise to two phenomena, namely: multipath and Doppler shifts.

D. Doppler Effect

Doppler Effect (Doppler shift) is used to honor the Austrian physicist Christian Doppler, used to assess the relative frequency of large moves in the state. A frequency that comes over the left has a higher value. At the time ofthe observer approaches the source frequency, each successive wave crestis emitted from a position closer to the observer than the previous wave. Therefore each wave takes slightly less time to reach the observer than the previous wave. Therefore the time the between the arrival of successive wave crestsat the observer is reduced, Causing an increase of in the frequency. When the mobile moves toward the transmitter with a velocity v , the maximum value of Doppler stated:

$$\int_d^{max} = \frac{v}{\lambda} \qquad (7)$$

For the path n, moving with a Doppler shift angle α_n stated :

$$\int_d^{n} = \frac{v}{\lambda}\cos(\alpha_n) \qquad (8)$$

C_n does not change its value significantly over short distances, so fading is mainly influenced on phase variation that caused by Doppler shifts. By using the formula Clarke, modeling the probability wave is came together from all directions, otherwise the signal spectrum is stated :

$$S_E(f) = \frac{1.5}{\pi f_m \sqrt{1 - \left[\frac{f - f_c}{f_m}\right]^2}} \qquad (9)$$

E. Delay multipath

The reflected signals with different angles of arrival directions result in multipath signals with different delay. The amount of the delay is expressed as the average power as a function of delay time.

- Mean delay continue

$$\mu_\tau = \frac{\int_0^\infty \tau\phi(\tau)d\tau}{\int_0^\infty \phi(\tau)d\tau} \qquad (10)$$

- RMS delay continue

$$\sigma_T = \sqrt{\frac{\int_0^\infty (\tau-\mu_\tau)^2\phi(\tau)d\tau}{\int_0^\infty \phi(\tau)d\tau}} \qquad (11)$$

- Mean delay discrete

$$\bar{\tau} = \frac{\sum_k P(\tau_k)\tau_k}{\sum_k P(\tau_k)} \qquad (12)$$

- RMS delay discrete

$$\sigma_T = \sqrt{\overline{\tau^2} - (\bar{\tau})^2}$$
$$\overline{\tau^2} = \frac{\sum_k P(\tau_k)\tau_k^2}{\sum_k P(\tau_k)} \qquad (13)$$

Two scenarios that might occur in wireless propagation:

a) Strong signal was in conjunction with a number of signal multipath echoes in LOS conditions (line of sight).
b) A number of weak multipath echoes received and at the same time no strong direct signal received in the condition of non-line of sight (NLOS).

Condition (a) occurred in open country or a particulars pot in the middle of the city as a cross roads or a clearly visible block its base station. Also the condition (a) can occur when there are no strong signals in LOS but strong signal from smooth surfaces. Modeling such conditions can use a rice distribution under the assumption that the variation of the RF signalis received.

Condition (b) is often found in urban environments with many buildings. These conditions cause the LOS signal is blocked by buildings so that the signal is received as a reflection from those buildings in multipath. Such conditions can also occur within the scope of which many of the trees or the woods. Modeling can thus use the Rayleigh distribution.

The existence of reflector, scattering, and mobile terminals is resulted in a variety of signals received at the receiver. Signal received in the form of distorted signals with amplitude, phase and angle of arrival with a different resulting of streng then or weaken.

III. MATLAB SIMULATION

In this case, the author uses the Matlab software for simulation work. Such as urban areas in some place where there are building blocks or areas of dense jungle that block direction of propagation of wireless. This situation can be compared with the Rayleigh distribution. As for the Rice distribution modeling can be given as open areas in the city where the signal from the Base Station (BS) is not reflected among the BS but is reflected by smooth surface in the middle of the city.

In this modeling, voltage received or field strength represented in the time domain. In order to perform measurements of the propagation channel, the speed of the object should be constant value. Signal data modeling is using 2 GHz and the value of the received signal in dBm.

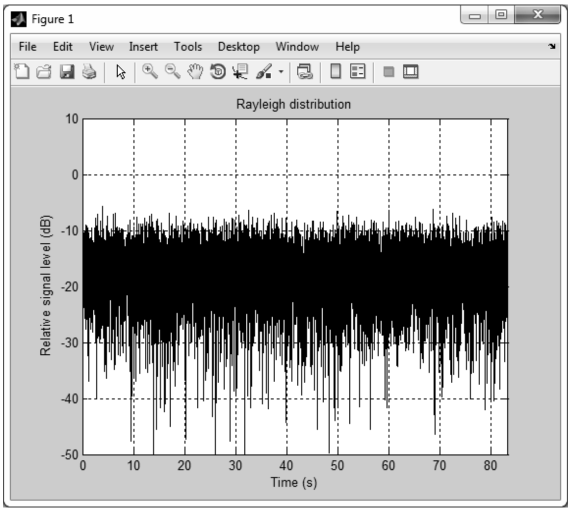

FIGURE 1.RAYLEIGH DISTRIBUTED,FREQUENCY 12000 HZ AND MOBILE SPEED 10MS.

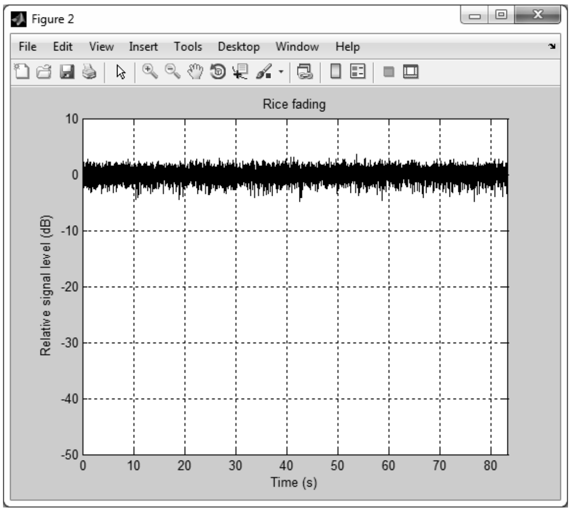

FIGURE 2.RICE DISTRIBUTED,FREQUENCY 12000 HZ AND MOBILE SPEED 10MS.

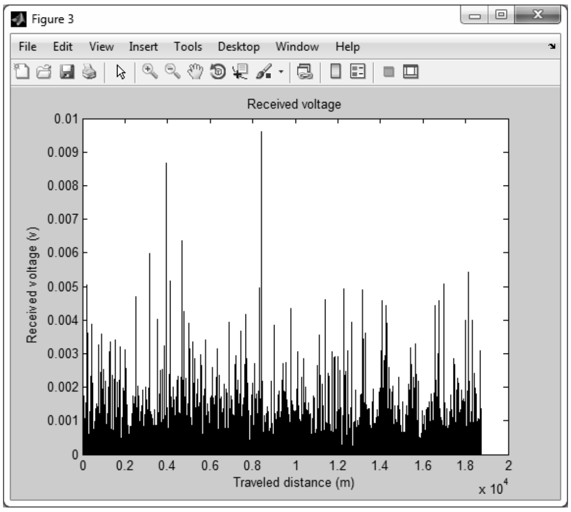

FIGURE 3. FREQUENCY CARRIER 2000 MHZ, VELOCITY 10 MS DENGAN AVERAGE POWER =-20

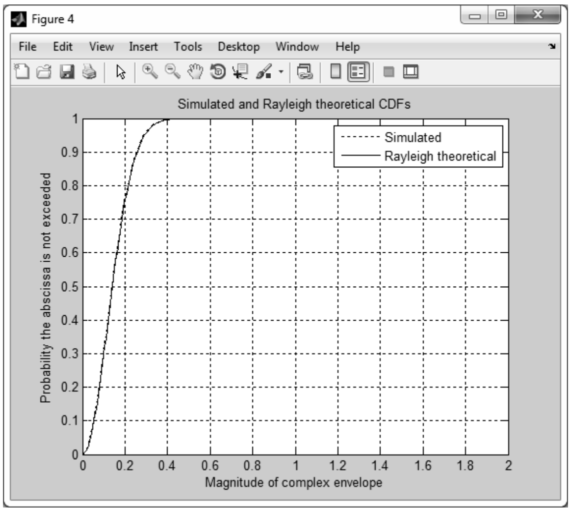

FIGURE 4.SIMULATED SERIES CDF AND RAYLEIGH THEORETICAL CDF.

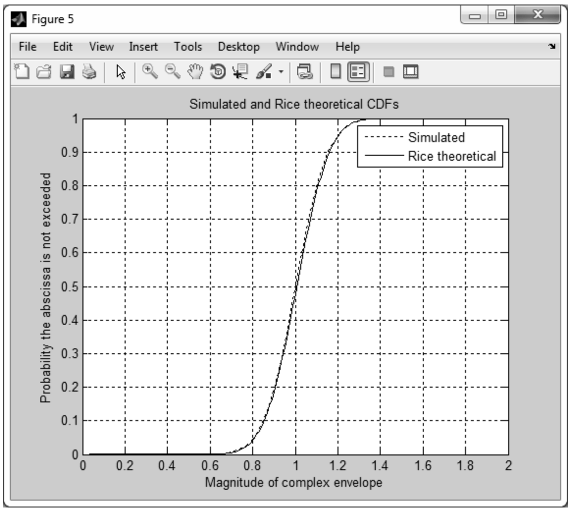

FIGURE 5.SIMULATED SERIES CDF AND RICE THEORETICAL CDF.

TABLE 1. SIMULATION WITH ANY SAMPLE TO GET VALUE OF MEAN FAST VARIATIONS (A IN DB), STANDART DEVIATION ON SLOW VARIATIONS (B IN DB), AND MEAN OF SLOW VARIATIONS (C IN DB).

Sample	A	B	C
5	1.0086	6.5465	46.7982
6	1.0104	6.5181	46.8189
7	1.0126	6.4912	46.8388
8	1.0154	6.4645	46.8586
9	1.0183	6.4374	46.8789
10	1.0217	6.4094	46.8999
11	1.0253	6.3802	46.9218
12	1.0291	6.3498	46.9445
13	1.0332	6.3181	46.9682

REFERENCES

[1] Sean D. Gilbert. An Introduction to HF Propagation.http://www.hfradio.org.uk/hfprop.pdf

[2] Propagation characteristic observed in macro/micro cells. eeweb.poly.edu/faculty/bertoni/docs/05OutdoorObserve.ppt

[3] Lewis Girod, 24 September 1999,'Radio Propagation', CSCI 694

[4] Prof. Andrea Goldsmith, Winter 2010, 'Multiuser wireless systems and network', EE360.

[5] David Browne, 'wireless propagation',

[6] Tam W. K and Tran V. N, Propagation modeling for indoor wireless communication, Dept. of Commun. & Electron. Eng., Melbourne Inst. Of Technol,. Vic.