

Wireless Channel Modeling Techniques: A review

Gurjot Singh Gaba*, Sandeep Kumar Arora, Akhil Gupta, Shakti Raj Chopra
Lovely Professional University, Jalandhar, Punjab, India (144411)
gurjot.17023@lpu.co.in

Abstract:

This paper discusses the execution investigation of Rayleigh and Rician blurring channel models. Investigation of the channel models are for all intents and purposes did as far as outage likelihood, source likelihood, BER and SNR. Source and outage likelihood has been processed to look at the signal discovery attributes under various models. Further, channel estimation has been done through various strategies which incorporate least square (LS), Least Square Modified (LSMod), Minimum Mean Square Error (MMSE). The outcomes got can be utilized to streamline the functionality of the network.

Keywords: fading, wireless, channel modeling, BER.

1. Introduction

When a signal travels from transmitter to the receiver, the characteristics of signal changes when it travels due to reflection and refraction, hence suffer from multipath fading. There are several factors which influence such as how the channel behaves such as climatic conditions changes, speed of transmission and reception, distance between them etc. The instantaneous signal strength can be calculated by large and small scale models where large scale models help in depiction of average RSSI which depends on the distance between T_x and R_x . The small scale model on the other hand represents the variations in the signal strength. However, error measurement of the channel depends upon LoS, reflections, refraction, diffraction and scattering before it arrives at receiver. Fading occurs in wireless communication due to different components which arrive at receiver at different time which may lead to phase difference between transmitted and received components and may be frequency shifted also. Channel estimation is required in MIMO-OFDM which includes estimation of bits transmitted as well as received. Estimation of various channel models is performed in this article. Assumption in the Rayleigh fading channel is that fading occurs due to variations in amplitudes and phases. The simulation has been carried out in MATLAB and analysis is performed in terms of outage, source probability, BER and SNR.

2. Types of Channel Model

(i) *Rayleigh Fading Channel:*

Rayleigh distribution model is a model where there is no line of sight communication between transmitter and receiver. It is a special case of stochastic model [1]. When scattering of dominant component does not take place, then there will be zero mean and phase between 0 and 2π radian.

(ii) *Rician Fading Channel:*

The small scale fading distribution is said to be Rician when there is line of sight propagation. All the multipath components are superimposed on a dominant signal in this fading. It usually occurs when one of path is comparatively stronger than the other. As the line of sight component of signal gets more faded then the attributes of the signal changes from Rician to Rayleigh.

3. Algorithms for Channel Estimation

(i) *Least Square:*

This approach finds the approximate solution in minimizing the sum of squares of the errors which were present in unit equation.

$$H(ls) = AB \quad (1)$$

Where, A = input
B = output
H(ls) = channel matrix;

(ii) *Minimum Mean Square:*

It is a common method to estimate quality of channel. It is generally preferred for signals with low SNR values. This model is estimated by using the equation

$$MSE = E\{(H - H(ls))^{H(H-H(ls))}\} \quad (2)$$

Where,

H = channel matrix
H(ls) = LS algorithm's channel matrix
MSE = Mean Square Error

(iii) *Least Square Modified:*

This is the best approach which is preferred most of the times like in data fitting. It minimizes the sum of squared residuals. The equation represents the value:

$$Hest = \frac{(Hest_{(i)} + Hest_{(i+1)})}{2} \quad (3)$$

Where

Hest_(i) = estimated channel matrix for ith value
Hest_(i+1) = estimated channel matrix for (i+1)th value
Hest = estimated channel matrix

4. Performance Analysis: Rayleigh Fading Channel Model

The received signal can be expressed:

$$s(t) = a_i \sum_{i=1}^n \cos(\omega_c t + \omega_{di} t + \phi_i) \quad (4)$$

Where,

n is the number of paths,
 $\phi = [0, 2\pi]$

This equation is rewritten in terms of phase and quadrature component:

$$s(t) = I(t) \cos \omega_c t + \phi_i(t) \sin \omega_c t \quad (5)$$

Where,

$$I(t) = \sum_{i=1}^n a_i \cos(\omega_{di}(t) + \phi_i)$$

$$\phi(t) = \sum_{i=1}^n a_i \sin(\omega_{di}(t) + \phi_i)$$

When n is large, f(r) can be written as

$$f(r) = \frac{r}{\sigma^2} e^{-r^2/2\sigma^2} \quad (6)$$

Where σ^2 is time-averaged power of received signal before envelope detection. As it is clear from the figure 1, that with increase in the threshold power, there is increase in outage probability i.e. decrease in probability for better detection of the signal [2].

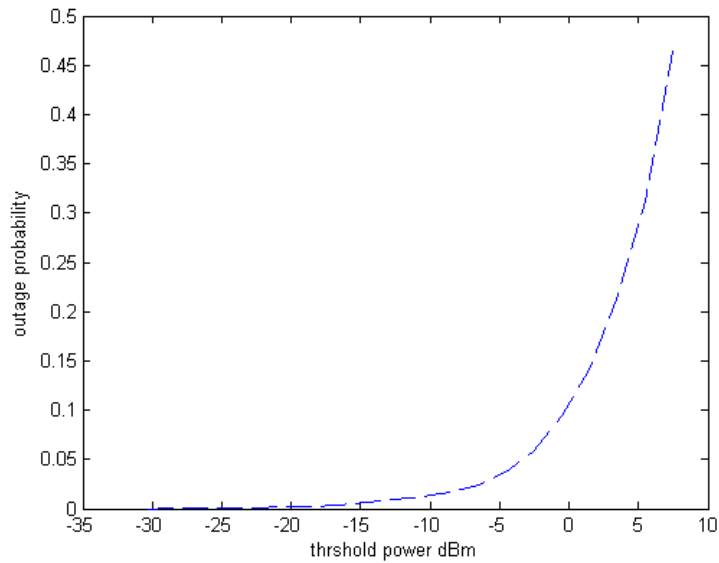


Fig. 1. Outage Probability for Rayleigh Fading Channel [2]

BER is defined as the bits in error with respect to total bits transmitted through the channel. BER should be preferably low. In order to do channel estimation in OFDM, the optimized parameters need to be considered for proper synchronization. Let us consider $N = 64$ and pilot = 64 for simulation in MATLAB.

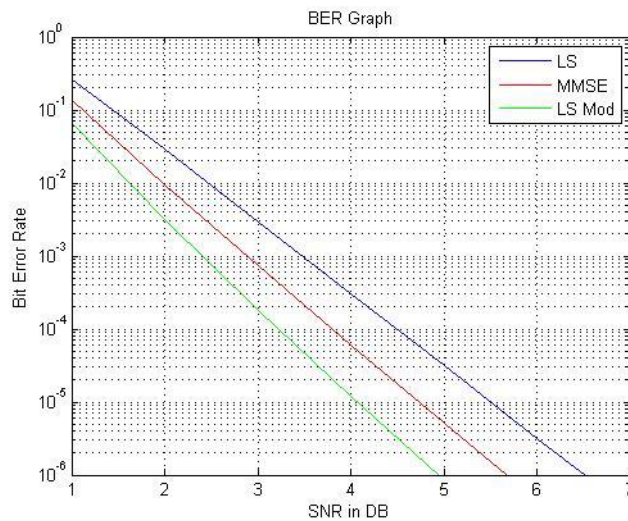


Fig. 2. SNR vs. BER [3]

Figure 2 clearly depicts the BER vs. SNR plot using the three methods namely LS, MMSE, LS Mod [3]. LS Mod has the least BER so it is better method for channel estimation in Rayleigh fading.

5. Performance Analysis: Rician Fading Channel Model

For Rician channel [4] the expression of signal received can be given as:

$$s(t) = \sum_{i=1}^{n-1} a_i \cos(\omega_c t + \omega_{di}(t) + \phi_i) + k_d \cos(\omega_c t + \omega_d t) \tag{7}$$

ω_d is doppler shift along line of sight path

Where, k_d is strength of direct component

$$f(r) = \frac{r}{\sigma^2} e^{\left\{ \frac{-r^2 + kd^2}{2\sigma^2} \right\}} I_0 \left\{ \frac{rkd}{\sigma^2} \right\} \tag{8}$$

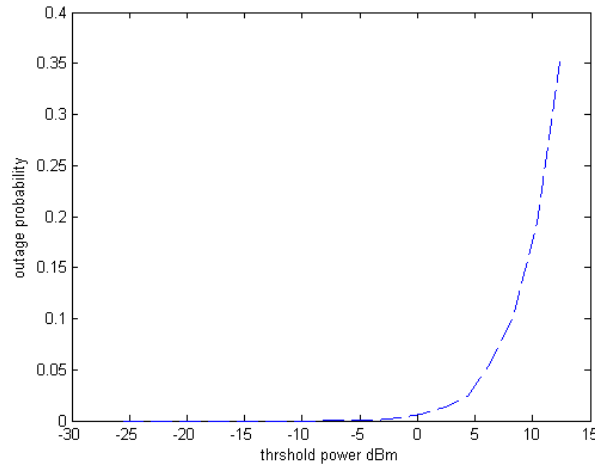


Fig. 3. Outage Probability for Rician Fading Channel [2]

Let $N = 64$ and pilot = 64. Now the simulation of this channel clearly shows the figure of Bit Error Rate vs. Signal to Noise Ratio in the figure 4.

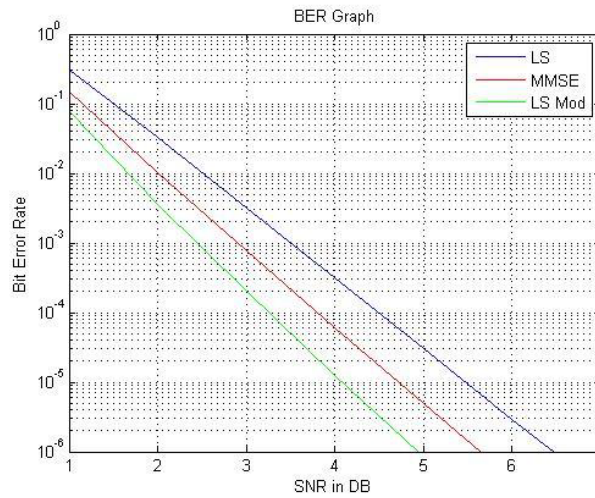


Fig. 4. Signal to Noise Ratio vs. Bit Error Rate [3]

Table 1 portrays the comparison of BER values for different techniques considered in Rician and Rayleigh channel models. It is found that for low SNR, BER is less in

Rayleigh model as compared to Rician model. The preferred technique is LS Mod as it encounters the minimum BER in Rayleigh modelling for channel estimation.

Table 1. Comparison of BER [3]

Channel model	LS algorithm	MMSE algorithm	LS Mod
Rayleigh	0.2664	0.1385	0.0666
Rician	0.3070	0.1516	0.0768

6. Conclusion

In this paper, we have done channel estimation for MIMO-OFDM systems of the two different channel models namely Rayleigh and Rician. This was performed via three methods which include LS, MMSE and LS Mod. LS method is the simplest method but does not go well where low SNR values come in picture. MMSE can be used for lower SNR but is very complex. So LS Mod is preferred over the other two. Moreover the BER for Rayleigh is smaller in comparison to Rician. But on other hand, Outage likelihood for Rician fading channel is less than the Rayleigh due to Line of sight component present between the transmitter and receiver.

References

- [1] L. Hanzo, Y. Akhtman, and L. Wang, M.Jiang, "MIMO-OFDM for LTE, Wi-Fi and WiMAX," Wiley-IEEE Press, pp. 496-504, 2011.
- [2] S. Kumar, P.K. Gupta, G, Singh, D.S. Chauhan, "Performance analysis of Rayleigh and Rician fading channel models using MATLAB simulation," International Journal of Intelligent Systems and Applications, vol. 5, no. 9, pp. 94-102, 2013
- [3] K. Vidhya, K.R.S. Kumar, "BER performance of AWGN, Rayleigh and Rician Channel," International Journal of Advanced Research in Computer and Communication Engineering, vol. 2, no. 5, pp. 2058-2067, 2013
- [4] Theodore S. Rappaport, "Wireless communications principles and practice," Pearson, Second edition, 2001.