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BER Performance Analysis of 1024-QAM over Fading Channels

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Abstract: In recent years, there has been a growing interest in transmitting voice, data, image and video signals over wireless communication channels. In wireless telecommunications, multipath is the propagation phenomenon that results in radio signals reaching the receiving antenna by two or more paths. Reasons of multipath are scattering, atmospheric ducting, reflection from terrestrial objects, such as mountains and buildings and ionospheric reflection and refraction which results in constructive and destructive interference, and phase shifting of the signal. This deterioration of signals caused by multipath is termed as fading. In the present work, the BER performance has been investigated for Rayleigh and Rician fading channels.

Keywords: Multipath; diversity; Rayleigh fading; Rician fading; bit error rate.

I. INTRODUCTION

QAM (Quadrature amplitude modulation) is a modulation scheme which transmits the data by changing the amplitude of two sinusoidal carrier waves, which are out of phase with each other by 90 degree.T he M-QAM, is more efficient by taking more bits per symbol for a given average energy. [1]

The fading may vary with time, geographical position or radio frequency and can be modelled as a random process. The performance of transmission system is examined by determining the bit error rate variation with change in signal to noise ratio under the three wireless channel models namely AWGN, Rayleigh and Rician model[2].

In case of Rayleigh fading, the signal passing through a communication channel will fade according to Rayleigh distribution. Rayleigh fading is modelled when there are many objects in the environment that scatter the radio signal before it reaches the receiver .It is considered as a good model for tropospheric and ionospheric signal propagation. Rayleigh distribution is statistically used to model a faded signal when there is no dominant path.

Let x_1, x_2, x_3,......,x_n be n statistically independent and identically distributed Gaussian random variables with zero mean and variance σ^2 then ,

Rayleigh distributed random variable R can be related to these Gaussian random variables as,

$$R=(x_1^2+ x_2^2\ x_3^2 +...+x_n^2)^{1/2} \qquad (1)$$

With n=2, the PDF of R is given by[3] as,

$$f_R(r) = \frac{r e^{\frac{-r^2}{2\sigma^2}}}{\sigma^2} \quad ; \ r \geq 0 \qquad (2)$$

The Rician distribution is used as a probabilistic model for radio propagation when there is dominant LOS signal. Let y_1, y_2, y_3,......,y_n be n statistically independent and identically distributed Gaussian random variables with mean m_1, m_2, m_3,......,m_n respectively and variance σ^2 then Rayleigh distributed random variable R_c can be related to these Gaussian random variables as,

$$R_c= (y_1^2+ y_2^2 +y_3^2 +...+y_n^2)^{1/2} \qquad (3)$$

With n=2, the PDF of R_c is given by[3] as,

$$f_{R_c}(r) = \frac{r e^{\frac{-(r^2+s^2)}{2\sigma^2}}}{\sigma^2} I_0\left(\frac{rs}{\sigma^2}\right) ; \ r \geq 0 \qquad (4)$$

Where, $s_1^2=m_1^2 + m_2^2 +...+m_n^2$

The K –factor for a Rician channel is defined as the ratio of the power in LOS component to the power in other(non LOS)multipath components. The K-factor is typically between 1 and 10.A K-factor of infinity means that there is only LOS component and no fading is experienced.

All the existing Rician channel simulation models in the literature assume that the line-of-sight component is either constant or non-zero[4]

Over the years, several studies and measurements have been undertaken in different locations for such channels and various models have been proposed for both the indoor and outdoor environments [5].

M.Patzold et.al. developed the model of the satellite channel with the time variations [6].

The relative motion between the transmitters and receivers results rapid time variation and significant Doppler shift. The Doppler shift is the random changes that take place in a channel incorporated as a consequence of a mobile user's movement. It is the apparent difference in frequency of the received signals from that of the transmitted signals when there is a relative motion between the transmitter and receiver. The amount of Doppler shift, df is given by [7] as,

$$df = v\cos\emptyset / c \qquad (5)$$

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Here, $\varnothing$ is the angle formed between the incident electromagnetic wave and the moving receiver, *v* is the mobile speed and *c* is speed of light.

II.RESULTS AND DISCUSSION

Fig.1 is showing the BER performance of 1024 QAM with Rayleigh fading channel at varying diversity orders. It clearly depicts that the performance improves as the diversity order is increased. This fact is revealed by the Table 1 also which is specifying the resulting bit error rates with varying diversity orders at fixed value of E_b/N_o which is set at 10 dB. It is clearly indicated that BER is highest at least value of diversity order and it is lowest at largest value of diversity order.

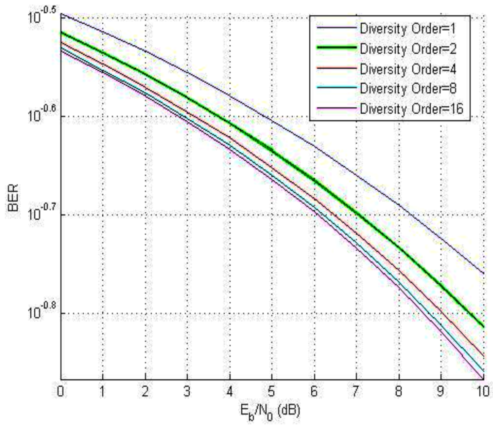

Fig.1 BER performance with Rayleigh fading

Table1.BER for Rayleigh Fading at E_b/N_o=10 dB

Diversity Order	BER
1	0.174
2	0.1536
4	0.1435
8	0.1385
16	0.136

Fig.2 is depicting the BER performance of 1024 QAM with Rician fading channel at varying values of K-factors assuming no diversity.It is observed that the performance improves as the K-factor is increased.

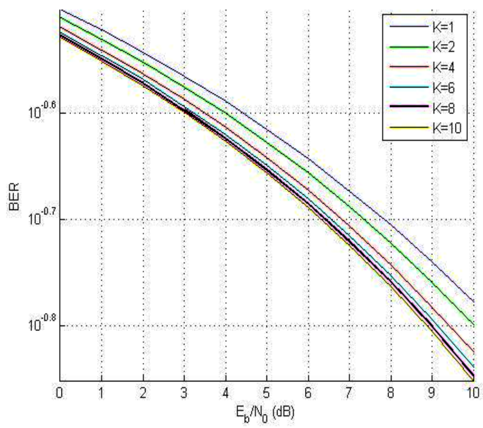

Fig.2 BER performance with Rician fading

This can be quantitatively observed in Table 2 also which is specifying the resulting bit error rates with varying K factors at fixed value of E_b/N_o which is set at 10 dB. It is clearly indicated that BER is highest at least value of K-factor and it is lowest at largest value of K-factor.

Table 2.BER for Rician Fading with no diversity at E_b/N_o=10 dB

K	BER
1	0.167
2	0.1591
4	0.1497
6	0.1451
8	0.1425
10	0.1408

III.CONCLUSION

In the present paper, the amount of degradation in the performance of communication system caused by Rayleigh and Rician fading has been investigated. It has been observed that the performance gets improved with the use of diversity and it keeps improving as the diversity order is increased. A significant impact of the K-factor on the performance with Rician fading has been observed. The performance improves as the K-factor is increased.

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