Transmission of phase modulated signal over different fading channels

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Abstract: This paper presents the evaluation of BPSK modulation scheme over different fading channels. The Rayleigh and Rician fading channels r compared with AWGN channel. All the three channels exhibit waterfall curve that is with the increasing SNR there is decrement in the BER. Simulations are performed and demonstrate the effectiveness based on recovered data bits, the obtained bit error rates are analysed, compared and discussed at different SNR values. Result shows that Rician channel performed better than the Rayleigh channel in error free AWGN channel and best performance from all three channel model.

***Keywords**: AWGN;Rician fading channel; Rayleigh fading channel; BPSK; BER and SNR.*

I. Introduction

A communication channel refers either to a physical transmission medium such as a wire, or to a logical connection over multiplexed medium such as a radio channel in telecommunications and computer networking. A channel is used to convey an information signal, for example a digital bit stream, from one or several senders (or transmitters) to one or several receivers. A channel has a certain capacity for transmitting information, often measured by its bandwidth in Hz or its data rate in bits per second. Communicating data from one location to another requires some form of pathway or medium. These pathways, called communication channels, use two types of media :cable(twisted-pair wire, cable, and fiber-optic cable) and broadcast (microwave, satellite, radio, and infrared). Cable or wire line media use physical wires of cables to transmit data and information Twisted-pair wire and coaxial cables are made of copper, and fiber-optic cable is made of glass. In information theory, a channel refers to a theoretical channel model with certain error characteristics. In this more general view, a storage device is also a kind of channel, which can be sent to (written) and received from (reading). A channel can be modeled physically by trying to calculate the physical processes which modify the transmitted signal. For example, in wireless communications the channel can be modeled by calculating the reflection off every object in the environment. A sequence of random numbers might also be added in to simulate external interference and/or electronic noise in the receiver.In electronics and telecommunications a transmitter or radio transmitter is an electronic device which produces radio waves with an antenna. The transmitter itself generates a radio frequency current, which is applied to the antenna. When excited by this alternating current, the antenna radiates radio waves. Transmitters are necessary component parts of all electronic devices that communicate by radio, such as radio and television broadcasting stations, phones, walkie, wireless computer networks, Bluetooth enabled devices, garage door openers, two-way radios in aircraft, ships, spacecraft, radar sets and navigational beacons. The term transmitter is usually limited to equipment that generates radio waves for communication purposes; or radiolocation, such as radar and navigational transmitters. Generators of radio waves for heating or industrial purposes, such as microwave ovens or diathermy equipment, are not usually called transmitters, even though they often have similar circuits.

II. Wireless Channel Model

Wireless communication is now become an important part in our daily life and it is widely used in the technology development areas. Assembling of the various channels can be done accurately because the performance and the design of the channels depend upon the accuracy of the simulation. In the wireless communication field, fading is the important consideration because it tells about the fading patterns in the various conditions. There is no such model which tells about the environment. A signal that has chosen should be error free, or close to being error free. If the signal is error free then the high quality of voice and data transmission can be done. The main issue arises while the development of the application is that the selection of the fading model. The analysis based on the BPSK will give the idea which helps for the application development in the market. There are three main basic fading channel models i.e. Additive White Gaussian Noise (AWGN), Line of Sight (Rician) and Non-Line of Sight (Rayleigh) Fading Channel models.

a) Rayleigh Fading Channel

It occurs due to the multilink reception. In Rayleigh fading model the effect of the environment spreading to a larger area on a radio signal. It is one of the cheapest models of the signal propagation (i.e. for ionosphere and troposphere). Rayleigh fading is most applicable when there is no dominant propagation along a line of sight between transmitter and receiver. If the channel impulse response will be modeled as a Gaussian process with respect to the distribution of the individual components and if the process has zero mean and phase lie between 0 to 2π radians. Then, the probability density function can be given by:

$$P_R(R) = \frac{R}{e^2}\, e - \frac{R^2}{2\sigma^2} \ , \ 0 \le R < \alpha \tag{1}$$

b) Rician Fading Channel

Rician Fading is a part of Rayleigh fading with the introduction of a strong line of sight path in the Rayleigh fading environment.

Rician fading is worthy for satellite communications and is acceptable for some urban scenarios. Rician fading is a type of small-scale fading because the probability of deep fades is less than that in the Rayleigh-fading case. The probability density function of the amplitude is a Rician distribution and is mathematically expressed as follows:

$$P_R(R) = \frac{R}{e^2}\, e - \frac{R^2+A^2}{\sigma^2}\, I_0\left(\frac{RA}{\sigma^2}\right),\quad 0 \leq R < \alpha \tag{2}$$

c) Additive White Gaussian Noise Channel

For the case of Doppler Effect between a moving source and stationary receiver, narrowband data model is used to model the received signal at the antenna arrays. It presumes that the enclosure of the signal wave front inseminating across the antenna array necessarily remains constant. This model is valid for the signals having bandwidth much smaller than the carrier frequency. According to above hypothesis, the received signal can be written as

$$\mathrm{H(t) = A(\Theta)b(t) + N(t)} \tag{3}$$

Where, A(Θ) is the array manifold vector and N(t) is AWGN with zero mean and two-sided power spectral density given by $N_0/2$.

III. Binary Phase Shift Keying (BPSK) Modulation

Binary Phase Shift Keying (BPSK) is a two phase modulation scheme, where the 0's and 1's in a binary message are represented by two different phase states in the carrier signal: $\theta = 0^\circ$ for binary 1 and $\theta = 180^\circ$ for binary 0.In digital modulation techniques, a set of basic functions are chosen for a particular modulation scheme. Generally, the basic functions are orthogonal to each other. Basis functions can be derived using Gram Schmidt orthogonalization. Once the basic functions are chosen, any vector in the signal space can be represented as a linear combination of them. In BPSK, only one sinusoid is taken as the basis function. Modulation is achieved by varying the phase of the sinusoid depending on the message bits. Therefore, within a bit duration T_b, the two different phase states of the carrier signal are represented as,

$$\begin{aligned} s_1(t) &= A_c \cos(2\pi f_c t), \qquad 0 \leq t \leq T_b \quad \text{for binary 1} \\ s_0(t) &= A_c \cos(2\pi f_c t + \pi), \quad 0 \leq t \leq T_b \quad \text{for binary (} \end{aligned} \tag{4}$$

where, A_c is the amplitude of the sinusoidal signal, f_c is the carrier frequency (Hz), t being the instantaneous time in seconds, T_b is the bit period in seconds. The signal $s_0(t)$ stands for the carrier signal when information bit $a_k = 0$ was transmitted and the signal $s_1(t)$ denotes the carrier signal when information bit $a_k = 1$ was transmitted. The constellation diagram for BPSK will show two constellation points, lying entirely on the x axis (in phase). It has no projection on the y axis (quadrature). This means that the BPSK modulated signal will have an in-phase component but no quadrature component. This is because it has only one basis function. It can be noted that the carrier phases are 180° apart and it has constant envelope. The carrier's phase contains all the information that is being transmitted.

IV. Results and Discussion

Figure 1 shows the BER vs SNR plot for BPSK modulation techniques using different channel model.So,from the figure it can be seen that AWGN has a BER of 0.035 at SNR 9 dB, Rician fading channel has a BER of 0.055 at SNR 9.2 dB and Rayleigh fading channel has a BER of 0.075 at SNR 9.7 dB. It can be seen that for light of sight communication BER decreases as shown by the Rician fading curve. Similarly, for non-line of sight communication BER increases as shown by the Rayleigh fading curve. The BER for error free channel is least as shown by the AWGN curve.

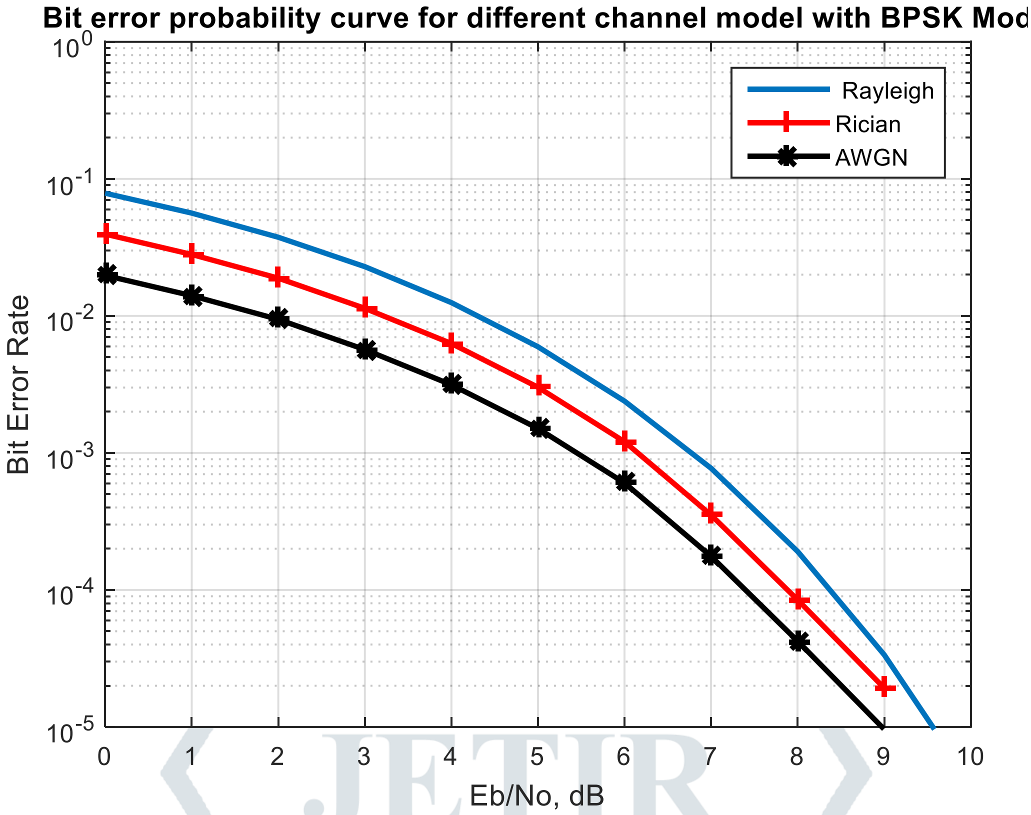

Figure 1: BER vs SNR curve for BPSK modulation using different channel model

V. Conclusion

In this paper, Monte Carlo simulation were used in the downlink to demonstrate the performance of different channel model with BPSK modulation technique. Simulations were performed at AWGN, Rician and Rayleigh fading channel. Result shows that Rician channel performed better than the Rayleigh channel in an error fading environment. While AWGN had better performance in error free environment. BER and SNR tools were used to evaluate the graphical performance. Moreover, with the implementation of this technique, it can be used for next generation wireless communication.

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