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Bit Error Rate Assessment of Digital Modulation Schemes on Additive White Gaussian Noise, Line of Sight and Non Line of Sight Fading Channels

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ABSTRACT: *Digital modulation techniques are the fundamental building blocks of the physical interface of all digital communication systems. Techniques such as Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), Differential Phase shift Keying (DPSK) and Quadrature Amplitude Modulation (QAM) are very important parts of the implementation of modern communications systems, especially for broadband wireless communications. In this paper, evaluation of three digital modulation schemes i.e. 16-QAM, 64-QAM and 16-DPSK in terms of Bit Error Rate (BER) is performed on Additive White Gaussian Noise (AWGN), Line of Sight (Rician) and Non Line of Sight (Rayleigh) Fading Channels. Among the three digital modulation schemes, 16-QAM is showing better performance as compared to 64-QAM and 16-DPSK.*

KEYWORDS : *ASK, AWGN, DPSK, FSK, PSK, QAM*

I. INTRODUCTION

In the recent times for fast growing wireless technologies, the performance of the devices (transmission in IEEE 802.11b) like transmission and receiving systems is very important. So we have to analyse the parameters, component, and structures of the channels. The performance of the data transmission and receiver can be evaluated by bit error rate (BER) and signal to noise ratio (SNR). In wireless systems, there are many techniques to determine the SNR [1]. Rayleigh and Rician distribution are one of the important parameters with are used to compare the performance indices. These parameters help to analyse the detection and decoding of the signal power and strength.

The remaining paper is organized as follows. In section II, channel models are described. In section III, fading is given. In section IV Modulation Techniques are explained and simulation results are given in section V. The paper is concluded in section VI.

II. 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 [2]. 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 DPSK and QAM will give the idea which helps for the application development in the market [3].

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.

1. Rayleigh Fading Channel

Rayleigh fading 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 model 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 modelled 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 [4]. Then, the probability density function can be given by:

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

2. 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 [4]. The probability density function of the amplitude is a Rician distribution and is mathematically expressed as follows:

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

3. 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 [4]. This model is valid for the signals having bandwidth much smaller than the carrier frequencyf_c. According to above hypothesis, the received signal can be written as

$$H(t) = A(\theta)\, b(t) + N(t) \tag{3}$$

Where, $A(\theta)$ 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. FADING

Fading refers to the disturbance or distortion, when a signal is experienced over any propagation media. Fading is also defined as the signal loss which is caused either in phase or amplitude due to the some changes in the channel response. In wireless communication, a multilink propagation is sometimes referred as multilink fading. In order to know about the fading, first we have the knowledge about the multilink. As we know about that in wireless communication the multilink phenomenon can give the result into the radio signal by taking it into two or more path at the receiver side. Fading channel is defined as during signal transmission the communication channel which goes through the various fading phenomenon is known as fading channel [6]. By using multipath signal, the multiple signals will be calculated by the vector sum of the entire signal. The four main causes of fading are Doppler shift, reflection, diffraction and scattering. Doppler shift is the phenomenon which occurs when wave energy like sound or radio waves travels from two objects, the wavelength can seem to be changed if one or both of them are moving. For the body in motion, with the variation of distance between transmitter and receiver, the received frequency of a transmitter differs from the sent frequency, which comes up with a Doppler shift [7]. This effect is more pronounced for the variation of sound between a moving source and a stationary observer.When an EM wave fall on an object that generates larger wavelength as compare to the wavelength of the propagating wave, this phenomenon is known as reflection. Reflection mainly occurs from the earth surface and from the buildings and walls. Diffraction is a phenomenon, they will occur when a wave strikes with an obstacle and diffraction helps to measure the coherence. If beam of light illuminate rough surface some of the light is removed from the beam and redistribution in all direction. This angular redistribution is called scattering.

1. Fading on the basis of effect of multilink

Large scale fading is defined as the fading which depends upon the location with respect to objects or it shows clearly in case of the short distance of the transmitter or the receiver. A continuous variation in the phase and amplitude occurs when a signal moves from a distance in the order of wavelength or it can also say that the small scale fading refer to the changes occur in the position of the transmitter and receiver in order of wavelength [8]. These changes are very small.

2. Fading on the basis of the Doppler spread effect

Slow fading occurs when the minimum time required for the channel is large to change its magnitude from its previous value relative to the delay behaviour of the channel. Slow fading can also be formed by shadowing. In shadowing, when large buildings or hills create problem for the path of the main signal of the transmitter and receiver, the received power is obtained by shadowing can be modelled by using log -distance path loss or log-normal distribution. The minimum time required for the channel is to change its magnitude from its previous value relative to the delay behaviour of the channel is known as Fast fading.

IV. MODULATION TECHNIQUES

Modulation may be defined as the process by which some characteristic of a signal called carrier is varied in accordance with the instantaneous value of another signal called modulating signal. Signals which contain information are known as modulating signals. The carrier frequency is greater than the modulating frequency. Also the receiver recreates the original message signal from the transmitted signal after propagation through the channel. This process of recreating the original signal is known as demodulation [9].

Good bit error rate performance, less power consumption and good spectral efficiency are the Properties of modulation techniques. In digital system, the message signal is to be transmitted is digital in nature or we can say that the transmission of the information in digital form. There are various types of modulating schemes involves in the communication system like Phase shift keying(PSK), Frequency shift keying(FSK), Minimum shift keying(MSK), Quadrature phase shift keying(QPSK) and Quadrature amplitude modulation(QAM).

1. 16-Quadrature Amplitude Modulation

It is the encoding of the carrier wave by variation of the both carrier wave and a quadrature carrier of the amplitude that is 90^o out of phase with the main carrier with respect to the two signals. The amplitude and the phase of the carrier wave are simultaneously changed according to the information that has to transmit. In 16-QAM, there are four values of I and four values of Q occurs, this gives the total of 16 possible signal. Since 16 = 24, four bits per symbol can be sent. This consists of two bits for I and Q each. The symbol rate is one fourth of the bit rate. The 16-QAM modulation produces a spectrally efficient transmission. This modulation is more efficient than BPSK, QPSK or 8PSK.

2. 64-Quadrature Amplitude Modulation

64-QAM is same as of 16-QAM but in this 64 possible combinations are given out with each symbol represents six bits ($2^6 = 64$). 64-QAm is quite complex modulation scheme as compare to 16-QAM but it gives high efficiency. This modulating technique is mainly used for sending data downstream over a coaxial cable network. It supports up to 26-28 mbps peak transfer rates over a single 6-MHz channel [9].

3. 16-Differential Phase Shift Keying

In 16-DPSK, change in phase of the carrier wave takes place. In DPSK high state contains only one and half cycle. Differential shift keying is a modulating technique in which information can be coded by taking phase difference. In the transmitter side, each symbol is modulated with respect to the previous one, for BPSK 0 represents no change and 1 represents 180 degrees out of phase. In the receiver side, the current value can be demodulated by taking previous value as a reference. But here we talk about the 16-DPSK and 64-DPSK modulating technique to analyse Bit error rate (BER) and Signal noise ratio (SNR) [9].

V. SIMULATION RESULTS

In this section, the evaluation of three digital modulation schemes i.e. 16-QAM, 64-QAM and 16-DPSK is performed on Additive White Gaussian Noise (AWGN), Line of Sight (Rician) and Non Line of Sight (Rayleigh) Fading Channels. The results are plotted using MATLAB in terms of bit error rate.

1. Bit Error Rate (BER) Comparison on Rayleigh Fading Channel

Figure 1 shows Comparison of BER performance of 16-DPSK, 64-QAM and 16-QAM on Rayleigh Fading Channel. It is clear from the figure 1 that 16-QAM modulation technique shows better performance than 64-QAM and 16-DPSK on Rayleigh Fading Channel.

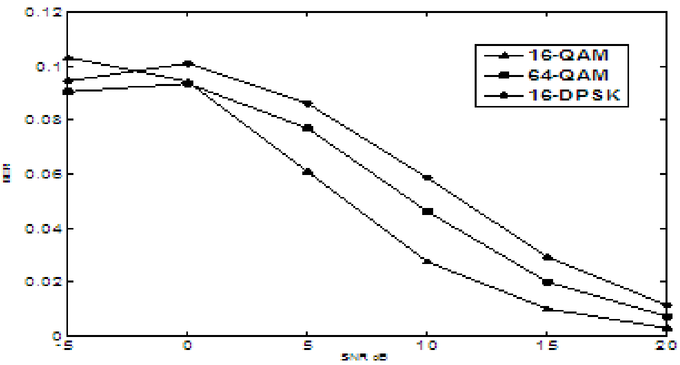

Fig1. BER v/s SNR plot between 16-DPSK, 64-QAM and 16-QAM on Rayleigh Fading Channel

2. Bit Error Rate (BER) Comparison on Rician Fading Channel

Figure 2 shows Comparison of BER performance of 16-DPSK, 64-QAM and 16-QAM on Rician Fading Channel. It is clear from the figure 2 that 16-QAM modulation technique shows better performance than 64-QAM and 16-DPSK on Rician Fading Channel.

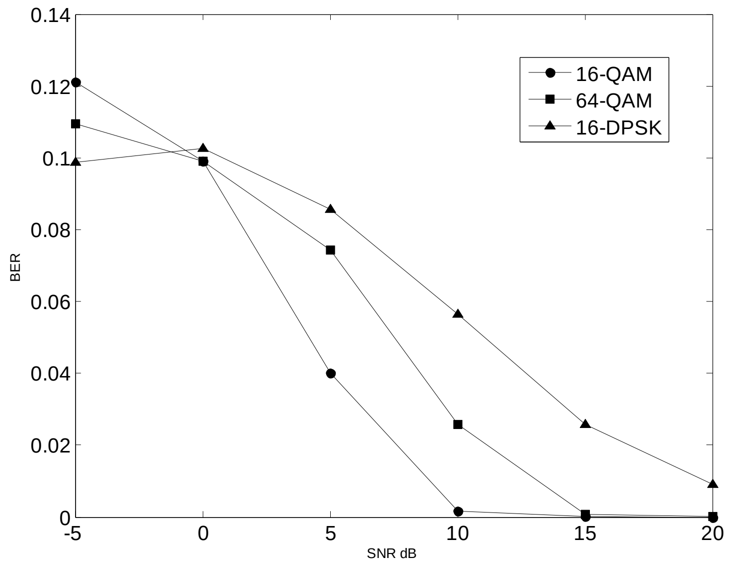

Fig2. BER v/s SNR plot between 16-DPSK, 64-QAM and 16-QAM on Rician Fading Channel

3. Bit Error Rate (BER) Comparison on Additive White Gaussian Noise (AWGN) Channel

Figure 3 shows Comparison of BER performance of 16-DPSK, 64-QAM and 16-QAM on AWGN Channel. It is clear from the figure 3 that 16-QAM modulation technique shows better performance than 64-QAM and 16-DPSK on AWGN Channel.

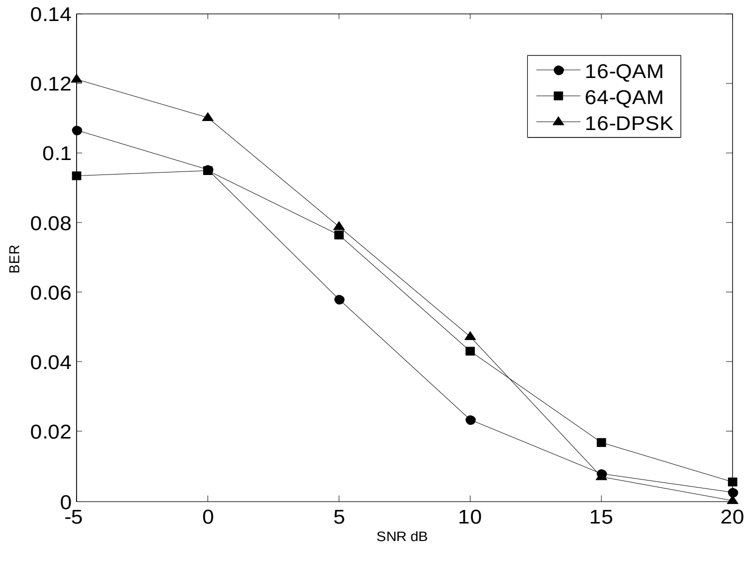

Fig3. BER v/s SNR plot between 16-DPSK, 64-QAM and 16-QAM on AWGN Fading Channel

VI. CONCLUSION

In this paper, evaluation of three digital modulation schemes i.e. 16-QAM, 64-QAM and 16-DPSK in terms of Bit Error Rate (BER) is performed on Additive White Gaussian Noise (AWGN), Line of Sight (Rician) and Non Line of Sight (Rayleigh) Fading Channels. Among the three digital modulation schemes, 16-QAM is showing better performance as compared to 64-QAM and 16-DPSK on AWGN, Rician and Rayleigh fading channel.

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