Analysis of BER for transmission of image using QPSK and 16-QAM

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Abstract— Bit Error Rate is a critical issue in wiredand wireless communication. This paper analyzes and assesses Quadrature Phase Shift Keying (QPSK) and 16-QAM (Quadrature Amplitude Modulation) modulation techniques with respect to Bit Error Rate in presence of Gaussian, Rayleigh, and Rician noise. The primary aim of any communication system is to receive data with minimum errors as errors degrades system performance. This paper focusses on the effect of different types of noise for above mentioned modulation schemes under AWGN channel.The complete system is implemented in MATLAB and MATLAB Simulink.The results obtained from the Simulink models are used for the transmission of an image.

Keywords— BER, AWGN, Gaussian, Rayleigh, Rician,MATLAB Simulink

I. INTRODUCTION

In digital modulation, digital symbols are converted into waveforms that are compatible with the characteristics of the channel. Bandpass modulation converts information signal to sinusoidal waveform for digital modulation. Coherent and non-coherent modulation/demodulation is the basic types of bandpass modulation. Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), and Quadrature Amplitude Modulation (QAM) are specialized formats of these techniques [3]. In an ideal channel the transmitted signal from the transmitter will pass through channel upto the receiver, where it is demodulated to get a perfect representation of the original signal. However in reality the received signal consists of mixture of attenuated and reflected version of the transmitted signal [2]. In addition to these, the channel adds various types of noise to the signal. This affects the Bit Error rate of the system.

II. BIT ERROR RATE

The quality of transmission is decided by parameter, Signal to Noise ratio (SNR) in analog and by Bit Error Rate

$$P_e = \frac{1}{2}\, erfc\sqrt{\frac{E_b}{N_0}}$$

(BER) in digital. In digital communication, the ratio Eb/No, a normalized version of SNR as a figure of merit is used. Eb (bit energy) is signal power S times the bit time Tb. N0 (noise power spectral density) is noise power (N) divide by bandwidth (W). Since bit time and bit rate Rb are reciprocal, we can replace Tb with 1/Rb. [2]

$$\frac{Eb}{No} = \frac{ST_b}{N/W} = \frac{S/R_b}{N/W}$$

In Digital communication the number of bit errors is the number of received bits of a data stream altered due to noise, interference, distortion or bit synchronization errors. Bit error rate/ ratio (BER) is the number of bits in error per number of transferred bits in total during a studied time interval. BER is a unit less measure, expressed often as a percentage. The performance of each modulation technique is measured by calculating the BER in presence of different types of noise.

III. DIGITAL MODULATION SCHEMES

A digital signal can modulate amplitude, frequency, or phase of sinusoidal carrier wave. If the modulating waveform consists of NRZ rectangular pulses, then the modulated parameter will be switched or keyed from one discrete value to another. This results into three basic types of digital modulation schemes namely Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), and Phase Shift Keying (PSK) [4].

This paper deals with the types of PSK viz. BPSK, DPSK, QPSK and QAM. This section will describe these methods in detail.

1. BPSK: In BPSK, the carrier gets 0 or 180o phase shift with respect to two different voltage levels of binary modulating signal. If the sinusoid is of amplitude A, it has a power so that The transmitted signal is given by

$$v_{BPSK}\ (t) = b(t)\sqrt{2P_s}\cos\omega_0\ t$$

$$P_e = \frac{1}{2}\, erfc\sqrt{\frac{E_b}{N_0}}$$

Where b(t) is a stream of binary digits with voltage levels [6][7].

2. QPSK: When a data is transmitted using BPSK technique the channel bandwidth required is 2fb. The QPSK technique reduces that bandwidth to fb. It is a multilevel phase modulation. In this two successive bits in a bit stream are combined together to form a message and each message is represented by distinct value of phase shift of a carrier. The QPSK signal is represented as. Since there are 4 phases it is called as 4-PSK or Quadrature PSK systems [6][7].

$$v_{QPSK}(t) = \sqrt{2P_s}\cos\left[\omega_0 t + (2m+1)\frac{\pi}{4}\right] \;\; \ldots\ldots m = 0, 1, 2, 3$$

$$P_e = erfc\sqrt{\frac{E_b}{N_0}}$$

3. QAM: QAM improves the noise immunity of the system by allowing the signal vectors to differ, not only in their phase but also in amplitudes. It utilizes carrier phase shifting and synchronous detection to permit two DSB signals to occupy the same frequency band. The two DSB signals are orthogonal to each other.

$$P_e = 2(1 - \frac{1}{\sqrt{M}})\frac{1}{2}\, erfc\sqrt{\frac{E_b}{N_0}}$$

IV. NOISE AND CHANNELS IN COMMUNICATION SYSTEMS

A. Noise in Communication Systems

The term noise refers to unwanted electrical signals that are always present in electrical systems. The presence of noise superimposed on a signal tends to obscure the signal which limits the receiver's ability to mask correct symbol decisions, and thereby limits the rate of information transmission [2].

Contaminating noise in signal transmission usually has an additive effect in the sense that noise often adds to the information-bearing signal at various points between the source and the destination. For the purpose of analysis, all the noise will be lumped into one source added to the signal in the AWGN channel. So, in this paper, effect of various noise on BER of different modulation schemes have been studied. The various sources of noise used for this system are mentioned below:

1. Gaussian Noise: Various types of noise sources are gaussian and have a flat spectral density over a wide frequency range. Such a spectrum has all frequency components in equal proportion and is therefore called white gaussian noise otherwise it is non-white gaussian noise. The gaussian noise generator block

2. Rayleigh Noise: In digital communication, all are interested in the two dimensional noise. The noise can be characterized in two ways. A three dimensional picture is given by the product of two orthogonal gaussian distributions with the same standard deviation. Alternately, with the polar coordinates centered on the undeviated position of the state, the radial distribution of the noise is used to add discrete time white Gaussian noise in the channel

3. Rician Noise: Rician noise is signal-dependent and consequently separating signal from noise is a difficult task. It is problematic for low signal-to-noise ratio

B. AWGN channel

Incommunication theory it is often assumed that the transmitted signals are distorted by some noise. The most common noise to assume is additive Gaussian noise, i.e. the so called Additive White Gaussian Noise channel, AWGN. AWGN is the channel in which noise affects each transmitted symbol independently in the detection process of it. Such a channel is called memory-less channel. The term additive indicates that the noise is simply superimposed or added to signal that there are no multiplicative mechanisms at work. This channel is linear and time-invariant and its frequency response is flat for all the frequencies.

V.MATLAB SIMULINK MODELS

This section describes the simulation models of various digital modulation techniques. A Bernoulli Binary Generator feeds into digital modulation techniques (BPSK, QPSK, and QAM) used for transmission. To analyze the effect of noise, the modulated signal along with the Rayleigh, Gaussian and Rician noise is transmitted on the AWGN channel. The received signal is demodulated using various demodulation techniques and is used to calculate the bit error rate for transmission process. The BER is calculated by using the Monte Carlo simulations in MATLAB Simulink Tool. The models shown below indicate the effect of Gaussian Noise on the BER of BPSK, QPSK and 16 QAM. The BER for the effect of Rician and Rayleigh noise is calculated by replacing the Gaussian Noise block in MATLAB Simulink by Rician noise and Rayleigh noise blocks respectively.

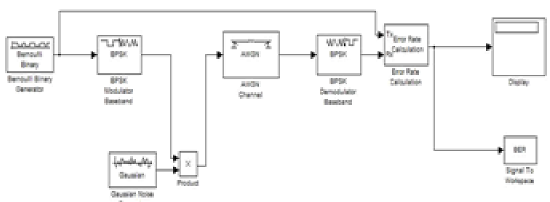

Fig. 1: Effect of Gaussian noise on BPSK

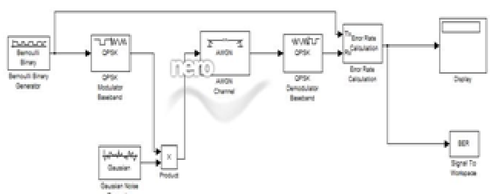

Fig.2. Effect of Gaussian noise on QPSK

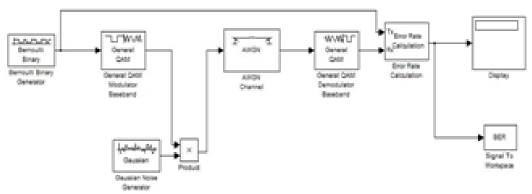

Fig.3. Effect of Gaussian noise on QAM

The Simulink models shown above are built to analyze the effect of different types of noise (Rayleigh, Gaussian, and Rician) on BER of BPSK, QPSK and QAM. The BER obtained for those Simulink models discussed below. Eb/N0 = 1and samples per frame=1000, are tabulated as follows:

TABLE I. EFFECT OF NOISE ON BER

Type of Modulation	**BER without noise**	**BER with Rayleigh Noise**	**BER with Gaussian Noise**	**BER with Rician Noise**
BPSK	0.048	0.479	0.496	0.465
QPSK	0.245	0.723	0.745	0.726
QAM	0.538	0.852	0.867	0.847

VI. RESULTS AND DISCUSSIONS

For the MATLAB Simulink Models, discussed above for Eb/N0 = 1 and samples per frame=1000, BER is tabulated asshown. From the given result TABLE I it is observed that 16-QAM is least affected by Noise. It can be observed that the difference between the BER of QPSK and 16- QAM without noise and BER with Noise is very less. So these modulation techniques are used for the transmission of image over AWGN.

If QPSK and QAM are used for the transmission of image the errors in the received image are less as BER is directly proportional to the errors introduced in the given data.The obtained results with Simulink model helped to select modulation technique for transmission of image.The QPSK and 16-QAM modulation techniques are used to transmit an image.The same image is transmitted using QPSK and 16 QAM by changing the values of Signal to Noise Ratio (SNR).

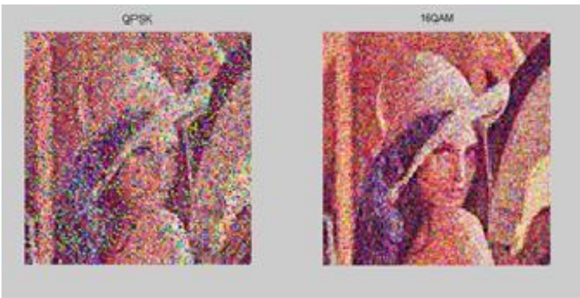

Fig.4. Received image using QPSK and 16-QAM for SNR=5

Fig.5. Received image using QPSK and 16-QAM for SNR=10

Fig.6. Received image using QPSK and 16-QAM for SNR=15

Fig.7. Received image using QPSK and 16-QAM for SNR=20

It can be observed that less the value of SNR, content of noise is more. From the above images it can be seen that for low values of SNR, the image transmitted using QPSK is affected more than the image transmitted using 16 QAM.

The reception of images is not affected much for higher values of SNR.

Therefore, the 16 QAM technique can be used for the effective transmission of multimedia over AWGN.

VII. CONCLUSION

In this paper effect of different types of noise on BER of various modulation schemes have been analyzed. Simulation study shows that the systems are least affected by Rician Noise as the Rician PDF (Probability Distribution Function) provides a better overall fit to the data than gaussian PDF. The table shows that BER value of QPSK technique is more in presence of additional noise. It is proved by transmitting the same image using QPSK and 16-QAM modulation techniques, in which the noise is least affected on the image transmitted using 16 QAM.

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