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Ber Performance of M-Ary Fsk, Psk and Pam On Awgn & Fading Channels

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ABSTRACT *Modern wireless Communication system use digital modulation schemes because of its many advantages over the analog modulation schemes. In this paper we analyze various M-ary FSK, M-ary PSK and M-ary PAM modulation schemes using simulink model of MATLAB taking BER as measure of performance when the system is subjected to AWGN and fading channel. Based on these performances a modulation scheme is suggested that provides low BER at low SNR. The simulation results for these methods show that the performance of the system is good in case of AWGN channel as compared to other fading channels. Multipath fading is the very important factors that affect the performance of a communication system. Simulations are used to compare the performance and tradeoffs of M- ary techniques, including analysis of BER in the presence of Additive White Gaussian Noise (AWGN) and multipath fading environment. The performance of different M-ary FSK, M-ary PSK and M-ary PAM methods are comparing for various types of the fading channels using the MATLAB simulation.*

KEYWORDS : M-ARY Modulation, FSK, PSK, PAM, MATLAB

INTRODUCTION

I. Introduction In digital communication systems, there are several digital modulation schemes that have been proposed. These digital modulation schemes include basic schemes such as MFSK (M-ary Frequency Shift Keying), MPSK (M-ary Phase Shift Keying), MPAM (M-ary Pulse Amplitude Modulation), MQAM (M-ary Quadrature Amplitude Modulation), and GMSK (Gaussian Minimum shift Keying). Modulation is generally used in wireless communication for data transmission. It is the process in which a property of carrier signal is varied in proportion to the message signal. In Digital Modulation digital symbols are transmitted in the form of waveforms that are compatible with the characteristics of the channel. In digital carrier systems, baseband pulses modulate a high-frequency carrier. The probability of error is depends only on the pulse energy.

The objective of this paper is to analyze the key characteristics and performance of M-ary FSK M-ary PSK and M-ary PAM for various channels. The performance analysis of digital communication systems over the lognormal channels remains challenging and mathematically intractable [1]. The Signal to noise ratio (SNR) knowledge at the receiver end can help in improving the performance of the receiver algorithms and it can be used for changing modulation format to achieve better performance. There are many interesting SNR estimation techniques available in the literature [2]. A Rayleigh channel is considered when there are different signal paths between the transmitter and receiver, none of which dominates. This means that all the paths can vary and affect the overall signal at the receiver [3]. The line of sight path is the strongest signal path that travels directly from the transmitter to receiver. Due to direct path, the effect of Rician fading on the transmitted signal will be less than in the case of Rayleigh fading [3] The goal for the next generation of mobile communications system is to seamlessly integrate a wide variety of communication services such as high speed data, video and multimedia traffic as well as voice signals [4]. Any data which is transmitted in a channel will incur loss. This loss of data is due to many factors comprising atmospheric, power loss and et cetera. Due to the loss in the channel the indigenous signal is not fully recovered at the receiver. The amount of signal lost is a measure of efficiency of the channel. Lower the loss better is the efficiency and vice versa. This loss in measured in terms of bits lost in the transmission [5]. Exact analysis of symbol error probability (SEP) has been presented for M-ary differentially encoded/ differentially decoded phase shift keying (MDPSK) and coherent M-ary phase shift keying (MPSK), transmitted over Rician fading channel using *N* branch receive diversity with maximal-ratio-combining (MRC) [6,7,8,9]. In an M-ary signaling scheme, we may send one of M possible signals s1(t), s2(t)…sm(t), during each signaling interval of duration Ts. For almost all applications, the number of possible signals $M=2^n$, where n is an integer. The symbol duration Ts=nTb, where Tb is the bit duration. In pass-band data transmission these signals are generated by changing the amplitude, phase, frequency of a sinusoidal carrier in M discrete steps thus we have M-ary ASK, M-ary PSK and M-ary FSK digital modulation [10]. Bit error rate (BER) of a communication system is defined as the ratio of number of error bits and total number of bits transmitted during a specific period. It is the likelihood that a single error bit will occur within received bits, independent of rate of transmission. In our simulations, we have considered the most commonly used channels: the Additive White Gaussian. Noise (AWGN) channel where the noise gets spread over the whole spectrum of frequencies [11].

The equation representing a frequency shift keying modulation is shown as follows in equation: -

$$x(t)=\begin{cases}\sin(2\pi f_1 t) & for\ bit\ 1\\ \sin(2\pi f_2 t) & for\ bit\ 0\end{cases}$$

Where $x(t)$ is the modulated signal;

$\sin(2\pi f_1 t)$ is the carrier signal A; $\sin(2\pi f_2 t)$ is the carrier signal B.

The performance of a FSK signal is evaluated by means of the bit error probability p_e or Bit Error Rate, BER as expressed in equation for coherent FSK and equation for non-coherent FSK.

Coherent FSK $p_e = T\sqrt{\frac{E}{No}}$

Non-coherent FSK

$$P_e=\frac{1}{2}e^{-\frac{1}{2}\frac{E}{No}}$$

In non-coherent FSK, the instantaneous frequency is shifted between two discrete values. In coherent FSK, there is no phase discontinuity in the output signal.

The simplest form of phase shift keying is the binary phase shift keying (BPSK). It uses two symbols to represent binary logic '0' and '1' which is segments of a sinusoid of the same frequency but differ in their phase. Because the two symbols can be distinguished if their

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phases differ by as much as possible, they are invariably separated by 180°. The equation representing a phase shift keying modulation is shown as follows in equation : -

$$x(t) = \begin{cases} \sin(2\pi f) & for\ bit\ 1 \\ \sin(2\pi f + \pi) & for\ bit\ 0 \end{cases}$$

Where $x(t)$ is the modulated signal; $\sin(2\pi f)$ is the carrier signal.

The bit error probability p_e for BPSK is expressed in equation.

BPSK

$$p_e = T\sqrt{2.\frac{E}{No}}$$

Pulse amplitude modulation (PAM) allows the narrowband of an analog signal to be transferred as a digital signal in quantized discrete time signal at a fixed bit rate over a digital transmission system.

M-ary is a term derived from the word binary. M simply represents a digit that corresponds to the number of conditions, levels, or combinations possible for a given number of binary variables.

For example, a digital signal with four possible conditions (voltage levels, frequencies, phases, and so on) is an M-ary system where M = 4. If there are eight possible conditions, M = 8 and so forth. The number of bits necessary to produce a given number of conditions is expressed mathematically as

$$N = \log_2 M$$

where N = number of bits necessary

M = number of conditions, levels, or combinations possible with N bits

Equation can be simplified and rearranged to express the number of conditions possible with N bits as $2^N=M$

For example, with one bit, only $2^1 = 2$ conditions are possible. With two bits, $2^2 = 4$ conditions are possible, with three bits, $2^3 = 8$ conditions are possible, and so on.

In this section, study of M-ary FSK schemes i.e. BFSK, QFSK, 8-FSK M-ary PSK schemes i.e. BPSK, QPSK, 8-PSK and M-ary PAM schemes i.e. BPAM, QPAM, 8-PAM are performed on AWGN, Rayleigh and Rician fading channels. The results are obtained using MATLAB in terms of bit error rate. Bit error rate analysis is done using received and transmitted data for different levels of noise (SNR) added in the channel.

Table: 1. BER of M-ary FSK, M-ary PSK and M-ary PAM for AWGN channel

SNR	BER For M=2			BER For M=4			BER For M=8		
	BFSK	BPSK	BPAM	QFSK	QPSK	QPAM	8FSK	8PSK	8PAM
0	0.4383	0.4717	0.48	0.669	0.6849	0.7021	0.8007	0.7937	0.8483
1	0.4255	0.4717	0.479	0.6548	0.6757	0.6953	0.7827	0.7874	0.844
2	0.4103	0.4717	0.4765	0.6348	0.6667	0.6871	0.765	0.7813	0.8393
3	0.3952	0.4717	0.4755	0.6102	0.6667	0.679	0.7398	0.7813	0.8341
4	0.3738	0.4762	0.4753	0.5787	0.6623	0.6726	0.7093	0.7692	0.829
5	0.3488	0.4762	0.4747	0.5453	0.6329	0.6647	0.675	0.7634	0.824
6	0.3295	0.4762	0.4745	0.5123	0.625	0.6578	0.6368	0.7576	0.8178
7	0.3108	0.4762	0.4744	0.4823	0.6211	0.6526	0.601	0.7634	0.8112
8	0.2913	0.4739	0.4737	0.4452	0.6211	0.6461	0.5547	0.7576	0.8062
9	0.2717	0.4762	0.4742	0.4123	0.6135	0.6438	0.5052	0.7519	0.7983
10	0.2523	0.4739	0.4734	0.3792	0.6135	0.6402	0.4627	0.7299	0.7938

Table: 3. BER of M-ary FSK, M-ary PSK and M-ary PAM for Rician channel

SNR	BER For M=2			BER For M=4			BER For M=8		
	BFSK	BPSK	BPAM	QFSK	QPSK	QPAM	8FSK	8PSK	8PAM
0	0.3841	0.4695	0.4811	0.6008	0.7732	0.7159	0.7372	0.8929	0.8572
1	0.3661	0.4566	0.4814	0.5746	0.7692	0.7113	0.7074	0.883	0.8538
2	0.3466	0.4505	0.4815	0.5467	0.7691	0.7066	0.6774	0.8621	0.8513
3	0.3289	0.4505	0.482	0.5145	0.7813	0.7005	0.6391	0.8696	0.8472
4	0.3108	0.4608	0.482	0.4796	0.7692	0.6946	0.5995	0.8621	0.8457
5	0.2933	0.4608	0.4828	0.4491	0.7691	0.6903	0.5577	0.8403	0.8418
6	0.2755	0.4525	0.4848	0.4199	0.7519	0.686	0.5125	0.833	0.8358
7	0.2586	0.4505	0.4826	0.3921	0.7519	0.6818	0.4733	0.8547	0.8328
8	0.2446	0.4505	0.4831	0.3646	0.7519	0.6807	0.437	0.8547	0.8317
9	0.2314	0.4505	0.4836	0.3441	0.7576	0.676	0.4011	0.8475	0.8286
10	0.2198	0.4505	0.4836	0.3255	0.7576	0.6739	0.3761	0.8475	0.8242

The results are plotted using MATLAB in terms of bit error rate for different values of SNR.

Figure 1 presents a comparative study of BFSK, 4FSK, and 8FSK for AWGN channel. Figure 2 presents a comparative study of BFSK, 4FSK, and 8FSK for Rayleigh channel. And Figure 3 presents a comparative study of BFSK, 4FSK, and 8FSK for Rician channel.

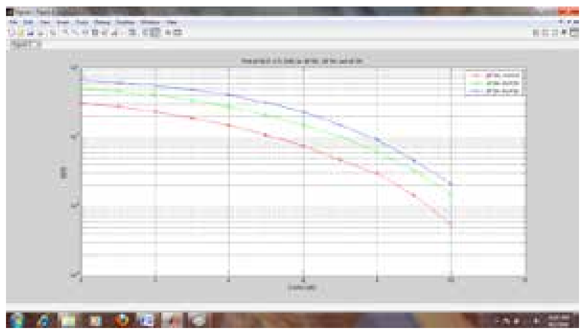

Figure 1: BER performance of AWGN channel for BFSK, 4FSK, 8FSK.

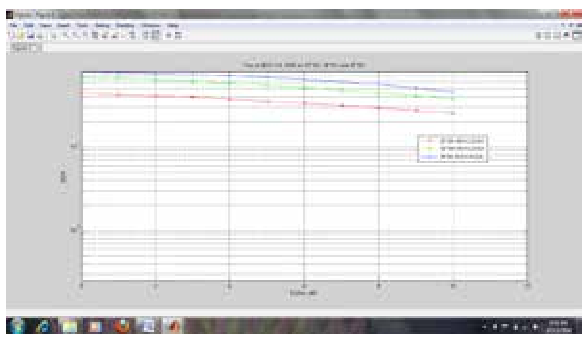

Figure 2: BER performance of Rayleigh fading channel for BFSK, 4FSK, 8FSK

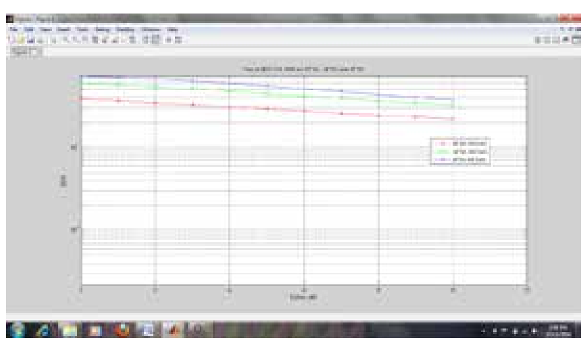

Figure 3: BER performance of Rician fading channel for BFSK, 4FSK, 8FSK

Figure 4 presents a comparative study of BPSK, QPSK, and 8PSK for AWGN channel. Figure 5 presents a comparative study of BPSK, QPSK, and 8PSK for Rayleigh channel. And Figure 6 presents a comparative study of BPSK, QPSK, and 8PSK for Rician channel.

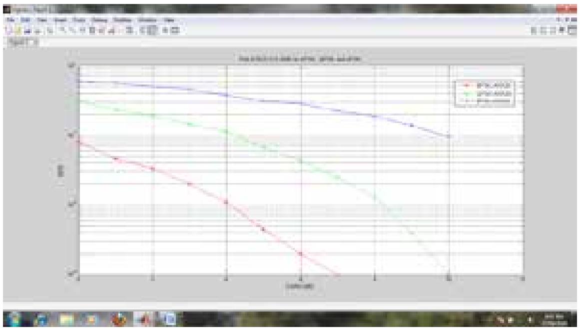

Figure 4: BER performance of AWGN channel for BPSK, QPSK, 8-PSK.

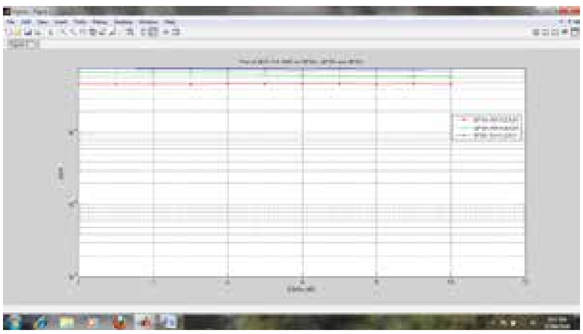

Figure 5: BER performance of Rayleigh fading channel for BPSK, QPSK, 8-PSK

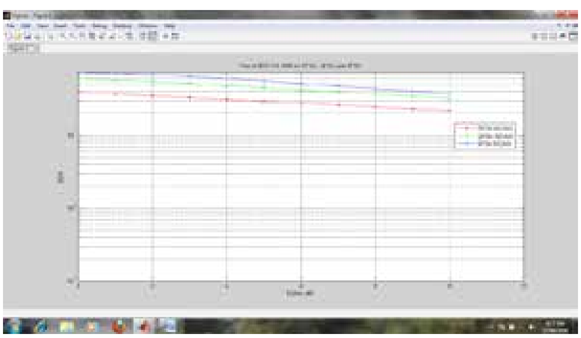

Figure 6: BER performance of Rician fading channel for BPSK, QPSK, 8-PSK

Figure 7 presents a comparative study of BPAM, QPAM, and 8PAM for AWGN channel. Figure 8 presents a comparative study of BPAM, QPAM, and 8PAM for Rayleigh channel. And Figure 9 presents a comparative study of BPAM, QPAM, and 8PAM for Rician channel.

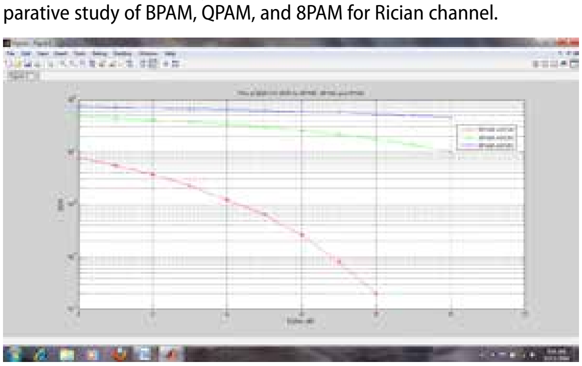

Figure7: BER performance of AWGN channel for BPAM, QPAM, 8-PAM.

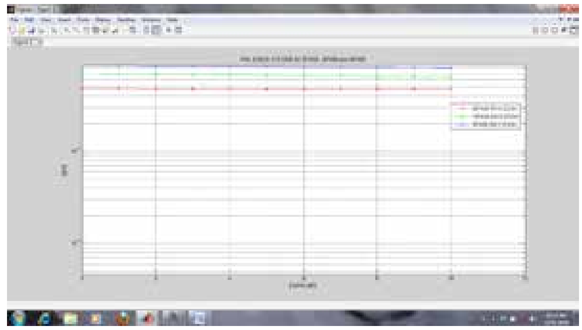

Figure 8: BER performance of Rayleigh fading channel for BPAM, QPAM, 8-PAM

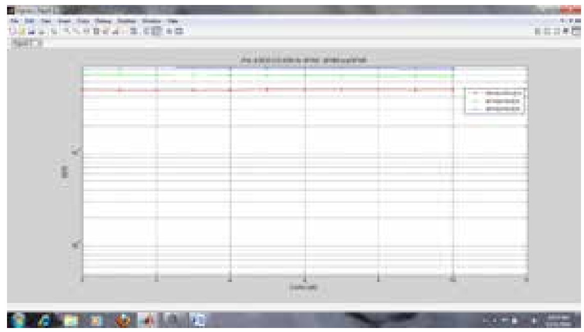

Figure 9: BER performance of Rician fading channel for BPAM, QPAM, 8-PAM

Figure 1, figure 4 and figure7 presents a comparative study of M-ary FSK, M-ary PSK and M-ary PAM for AWGN channel, Figure 2, figure 5 and figure 8 presents a comparative study of M-ary FSK, M-ary PSK and M-ary PAM for Rayleigh channel and Figure 3 figure 6 and figure 9 presents a comparative study of M-ary FSK, M-ary PSK and M-ary PAM for Rician fading channel.

Conclusion

This paper is based on simulation using MATLAB. The simulation will be done using simulink model of MATLAB. First, the model is simulated under Additive White Gaussian Noise (AWGN). Then, the channel is simulated with Rayleigh and Rician fading channel. The performance of the M-ary FSK, M-ary PSK and M-ary PAM modulation schemes are studied. The performance analysis is based on BER and Signal-to-Noise ratio. Thus, suitable modulations techniques will be determined and concluded based on BER that will be plotted as a function of SNR. Result show that as compare to QFSK and 8FSK, BFSK scheme work well in AWGN, Rayleigh and Rician fading channels. As compare to QPSK and 8PSK, BPSK scheme work well in AWGN, Rayleigh and Rician fading channels. Result also show that as compare to QPAM and 8PAM, BPAM scheme work well in AWGN, Rayleigh and Rician fading channels. For M-ary FSK, M-ary PSK and M-ary PAM the Rician channel has the worst performance as this channel is much affected by noise. The Rayleigh channel BER performance lies between AWGN channel and Rician channel. For AWGN channel BPSK gives better results however Rayleigh and Racian channel BFSK gives better results compare to other modulation methods.

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