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Analysis of Bit Error Rate of different M-ary PSK Modulation Schemes in AWGN Channel

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Abstract : The increase in multimedia services on mobile wireless communication has resulted in great advancement of the wireless communication field in the recent times. One of the widely used techniques is digital modulation technique which allows digitized data to be carried or transmitted via the analog radio frequency (RF) channels. The data transfer rate should be maximum for uninterruptable communication. But with high rate there is greater probability of error. This paper emphasizes on the error probability of M-ary PSK modulation techniques in Additive White Gaussian Noise (AWGN) Channel. In order to get a better understanding of the M-ary PSK system, a Simulink-based simulation system is designed for M-ary PSK for M= 5,6,7,8 and 9 using Matlab Simulink [8]. This paper proves that increasing of M results in increase of BER. The results are analyzed on the basis of BER plot.

Key Words : M-PSK, Bit Error Rate, Data rate, Bit energy, Signal energy, AWGN channel.

I. INTRODUCTION

The advances over the last several decades in hardware and digital signal processing have made digital transceivers much cheaper, faster, and more power-efficient than analog transceivers. More importantly, digital modulation offers a number of other advantages over analog modulation, including higher data rates, powerful error correction techniques, resistance to channel impairments, more efficient multiple access strategies, and better security and privacy. Digital modulation and detection consist of transferring information in the form of bits over a communications channel. The bits are binary digits taking on the values of either 1 or 0. The main considerations in choosing a particular digital modulation technique are [1]

- High data rate
- High spectral efficiency (minimum bandwidth occupancy)
- High power efficiency (minimum required transmit power)
- Robustness to channel impairments (minimum probability of bit error)
- Low power/cost implementation.

Often these are conflicting requirements, and the choice of modulation is based on finding the technique that achieves the best tradeoff between these requirements the different modulation techniques are amplitude shift keying (ASK), frequency shift keying (FSK), Phase shift keying (PSK) and Quadrature Amplitude Modulation (QAM). The use of amplitude modulated analog carriers to transport digital information in case of ASK is a relatively low quality, low cost type of digital modulation and therefore is seldom used except for very low speed telemetry circuits. Compare to PSK or QAM, FSK has a poorer error performance and consequently is seldom used for high-performance digital radio systems. So, PSK is the commonly used digital modulation technique. The PSK schemes have constant envelope and frequency but discontinuous phase transitions from symbol to symbol. Phase shift keying: In phase shift keying, the phase of the carrier is varied to represent two or more different signal elements. Both peak amplitude and frequency remain constant as the phase changes [2].

Binary PSK is the simplest form of PSK. In BPSK, the pair of signals S_1 (t) and S_2(t) used to represent binary symbols 1 and 0,respectively, is defined by

$$S_1(t) = \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t)$$

$$S_2(t) = \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t+\pi) = -\sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t) \qquad \text{……………(i)}$$

where $0 \le t \le T_b$ and E_b is the energy transmitted signal energy per bit [3].

The average probability of symbol error or, equivalently, the bit error rate for BPSK is [3]

$$P_e = \frac{1}{2}\,\text{erfc}\left(\sqrt{\frac{E_b}{N_o}}\right) \qquad \text{……………......(ii)}$$

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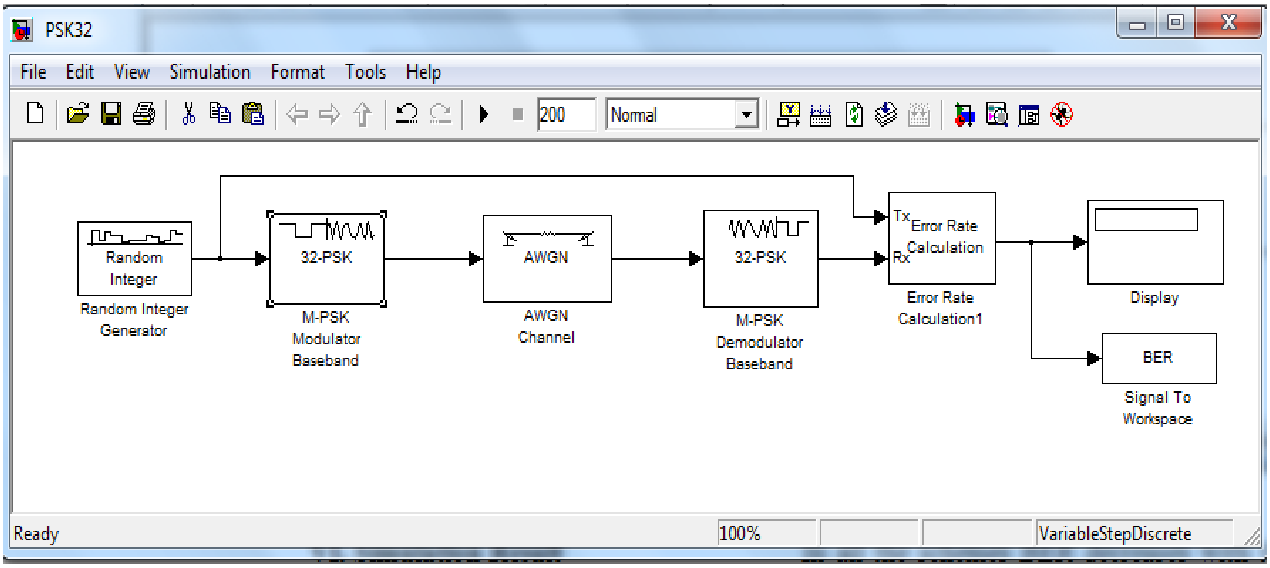

Fig 1: Simulation Model of M-PSK

II. M -ary PSK (MPSK)

In an M-ary signaling scheme, two or more bits are grouped together to form symbols and one of M possible signals, s_1 (t), s_2 (t)… S_M (t) is transmitted during each symbol period of duration Ts. Usually, the number of possible signals is $M = 2^n$ where n is an integer [4].

M-ary modulation schemes have better bandwidth efficiency but they have less power efficiency. For example, a 16-PSK system requires a bandwidth that is$\log_2 16 = 4$ times smaller than a BPSK system, whereas its BER performance is significantly worse than BPSK since in the signal constellation the signals are packed more closely [4].

In M-ary PSK, the carrier phase takes on one of M possible values, namely $\Theta_i = 2(i-1)\,\pi/M$, where i = 1, 2,…..M. The modulated waveform can be expressed as

$$S_i(t) = \sqrt{\frac{2E_s}{T_s}}\cos(2\pi f_c t+\frac{2\pi}{M}(i-1)), \quad 0 \le t \le T_s \text{ and } i = 1,2,\ldots\ldots M \quad \ldots\ldots\text{(iii)}$$

Where $E_s = (\log_2 M)\,E_b$ is the energy per symbol and $T_s = (\log_2 M)T_b$ is the symbol period[4] .

III. BIT ERROR RATE

In digital modulation techniques, due to some noise, interference, and distortion the received bits are altered .So bit error rate is defined as the no of error bits divided by total no of transmitted [5].

$$\text{Bit Error Rate (BER)} = \frac{\text{No of bits in error}}{\text{Total no of transferred bits}} \quad \ldots\text{(iv)}$$

The performance of modulation is calculated measuring BER with assumption that system is operating with Additive white Gaussian noise. Modulation schemes which are capable of delivering more bits per symbol are more immune to errors caused by noise and interference in the channel. Moreover, errors can be easily produced as the number of users is increased and the mobile terminal is subjected to mobility. Thus, it has driven many researches into the application of higher order modulations [6].

IV. AWGN CHANNEL

In communication systems, the most common type of noise added over the channel is the Additive White Gaussian Noise (AWGN). It is additive because the received signal is equal to the transmitted signal plus the noise. It is white because it has a constant power spectral density. It is Gaussian because its probability density function can be accurately modeled to behave like a Gaussian distribution. It is noise because it distorts the received signal. Because the bandwidth of the signal is very less as compare to the bandwidth of the AWGN channel. The higher the variance of the noise, the more is the deviation of the received symbols with respect to the constellation set and, thus, the higher is the probability to demodulate a wrong symbol and make errors [7].

V. Simulation Model

Simulation model of M-PSK (where M is 32, 64, 128, 256 and 512) as baseband modulation along with AWGN is shown in Fig 1.

The model begins with the Random Integer Generator block which generates uniformly distributed random integers in the range [0, *M*-1], where *M* is the M-ary number. Then the uniformly generated random integer is then fed to baseband modulator on which M-PSK modulation is performed with a large carrier. The output is a baseband representation of the

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modulated signal. The modulated signal is then passed through the AWGN channel which adds white Gaussian noise to a real or complex input signal. This block inherits its sample time from the input signal. On the receiver end the demodulator receives the copy of the original signal, which is now affected due to ISI and noise in the channel and bit error rate is calculated. The demodulated signal is also a baseband representation. Next we have error rate calculator in which the transmitted and received signal are compared and the difference is treated as "error". The error rate, total number of transmitted bits and total number of error bits are displayed by display block.

VI. SIMULATION RESULT

In this paper we have provided a comparative study of Bit Error Rate (BER) between different M-PSK (32-PSK, 64-PSK, 128-PSK, 256-PSK and 512-PSK) schemes in AWGN channel through [8]. Fig 2 shows the bit energy to noise energy i.e. E_b/N_o Vs Bit Error Rate i.e. BER plot of different M-PSK schemes.

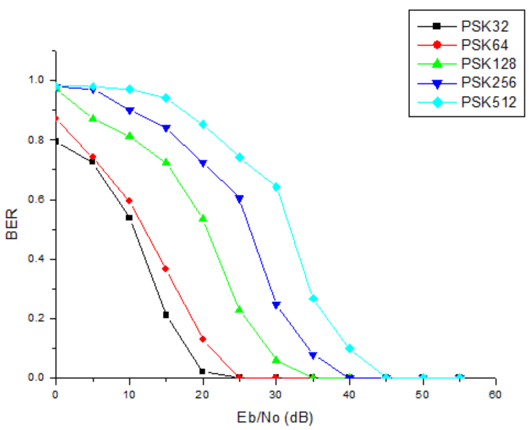

Fig 2: E_b/N_o Vs BER plot of M-PSK

In all the schemes BER decreases with the increase in the E_b/N_o value. Increasing the E_b/N_o value means increasing the signal power with respect to noise energy. The error rate is increasing as the value of M increases i.e. BER of 64-PSK is higher than BER of 32-PSK, BER of 128-PSK is higher than BER of 64-PSK and so on i.e. $BER_{512\text{-}PSK} \geq BER_{256\text{-}PSK} \geq BER_{128\text{-}PSK} \geq BER_{64\text{-}PSK} \geq BER_{32\text{-}PSK}$ .The error rate becomes constant after a certain value of E_b/N_o in all through the normal AWGN channel. The value of M increases means more number of bits is combined to make a symbol & these bits are packed more closely in signal constellation

VII. Conclusion

M-ary modulation techniques provide better bandwidth efficiency than other low level modulation techniques. As the value of M i.e. number of bits in symbol increases bandwidth utilization is increases. Also as communication range increases between a transmitter & receiver lower order modulation techniques are preferred over higher order modulation techniques [9].In this paper, the comparison between different M-PSK(M = 32,64,128,256 and 512) modulation schemes in normal AWGN channel using of MATLAB/Simulink is done. By analyzing the graphical representation of E_b/N_o Vs BER of these M-PSK schemes we can conclude that error rate increases as the value of M increases i.e. number of bits in symbol increases. High level modulation techniques are always preferred for high data rate. So we can conclude that as the error rate increases with increasing M; lower level should be used for long distance communication and vice versa. For providing high data rate over long distance efficiently more error correcting techniques have to be used and there should be always a trade-off between error rate & data rate.

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