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BER Performance for M-ARY Digital Communication

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Abstract: ***Next Generation Wireless Communication System demands for higher data rate and is continuously rising; there is always a need to develop more efficient wireless communication systems. In this paper, the BER performances is shown analytically and by means of simulation for Rayleigh fading multipath channels and AWGN Gaussian channel for M-ARY PSK and M-ARY QAM. The performance of Additive White Gaussian Noise channel with Rayleigh fading in terms of BER is compared. The main focus is to investigate how much improvements of BER is occurred using M-ARY PSK and M-ARY QAM for AWGN channel and Rayleigh fading channel. In order to choose the most suitable modulation, several criteria such as power efficiency, bandwidth efficiency, and bit error rate are used for evaluation. This paper focuses on error performance of phase modulation schemes in different channel conditions and on the method to reduce bit error rates.***

Keywords: M-ARY Modulation, BER, Constellation, Error vector, Noise

1. Introduction

M-QAM is a well known modulation technique use in wireless communication. In wireless communication fading phenomenon is a boundary condition. So the practice for combating fading in wireless communication over such a time varying channel is to use diversity technique. Due to the high spectral efficiency M-QAM is an attractive modulation technique for wireless communication [4]. MDPSK and MPSK are also two modulation technique use in wireless communication. For different values of Rican parameter symbol error probability is different. So that performance varies with the change of Rican parameter (when k= 0 then it is called Rayleigh when k = α then it is called AWGN). It is also true for the change of diversity and message signal. Exact analysis of symbol error probability has been presented for M-ARY differentially encoded/ differentially decoded phase shift keying and coherent M-ARY phase shift keying, transmitted over Rican fading channel using *N* branch receive diversity with maximal - ratio - combining. Our analysis has followed the same track for MQAM and the simplicity of the SEP expression used has resulted in simple closed form expression of the SEP of *N* order diversity at Rican fading channel. For different conditions this three modulation technique shows different characteristics [1]. The goal of our analysis is to highlight the performance by comparing them in different working conditions.

2. Channel

In communications, the AWGN channel model is one in which the only impairment is the linear addition of wideband or white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude [7]. The model does not account for the phenomena of fading, frequency selectivity, interference, nonlinearity or dispersion. However, it produces simple, tractable mathematical models which are useful for gaining insight into the underlying behavior of a system before these other phenomena are considered. AWGN is commonly used to simulate background noise of the channel under study, in addition to multipath, terrain blocking, interference, ground clutter and self interference that modern radio systems encounter in terrestrial operation.

In mobile radio channels, the Rayleigh distribution is commonly used to describe the statistical time varying nature of the received envelope of an individual multipath component [7]. It is well known that the envelope of the sum two quadrature Gaussian noise signals obeys a Rayleigh distribution.

3. Digital Modulation

Digital modulation schemes transform digital signals into waveforms that are compatible with the nature of the communications channel. There are two major categories of digital modulation. One category uses a constant amplitude carrier and the other carries the information in phase or frequency variations. The other category conveys the information in carrier amplitude variations and is known as amplitude shift keying. The past few years has seen a major transition from the simple amplitude modulation and frequency modulation to digital techniques such as Quadrate Phase Shift Keying, Frequency Shift Keying, Minimum Shift Keying and Quadrate Amplitude Modulation [3]. For designers of digital terrestrial microwave radios, their highest priority is good bandwidth efficiency with low bit-error-rate. The RF spectrum must be shared, yet every day there are more users for that spectrum as demand for communications services increases. Digital modulation schemes have greater capacity to convey large amounts of information than analogue modulation schemes [1]. Over the past few years a major transition has occurred from simple analogue Amplitude Modulation and Frequency/Phase Modulation to new digital modulation techniques. Examples of digital modulation include:FSK, QPSK, QAM, MSK, etc.

4. BER Expression M-Ary Psk

The BER is found by finding the probability of error for each symbol, summing these together and dividing by the number of symbols in the constellation and the number of bits per symbol [6]. This is shown in the BER expressions using the approximated symbol error where e_{Ii} and e_{Qi} are the error vector components for the *i*–th symbol in the constellation and $\varepsilon_I$and $\varepsilon_Q$are factors used to represent the values of the I and Q channel noise variances with respect to unity. These factors are equal to the eigen values of the noise covariance matrix after transformation by the down converter [4].

Table 1: M-ARY PSK

M-ARY	For (PSK)		BER
	M	µ	
QPSK	4	2	¼ Q $[(2\ E_b/N_0)^{1/2}]$
8 -PSK	8	3	(1/12)Q $[(6E_b/N_0)^{1/2}$ Sin(π/8)]
16 - PSK	16	4	(1/32)Q $[(8E_b/N_0)^{1/2}$ Sin(π/16)]
32 - PSK	32	5	(1/80)Q $[(10E_b/N_0)^{1/2}$ Sin(π/32)]
64 - PSK	64	6	(1/192)Q $[(12E_b/N_0)^{1/2}$ Sin(π/64)]

The general expression for the probability of a PSK symbol error is given by:

$P(E)_i$=Q{bCos[L_1]-aSin[L_1]}+Q{aSin[L_2]-bCos[L_2]}

and the BER is given by:

$P_B(E) = (1/\mu M)\sum_{i=1}^{M} P(E)i$

for a constellation of *M* symbols and µ bits per symbol.

5. BER Expression M-Ary QAM

The BER is found by finding the probability of error for each symbol, summing these together and dividing by the number of symbols in the constellation and the number of bits per symbol [5]. This is shown in the BER expressions using the approximated symbol error where $e_{Ii}$and $e_{Qi}$are the error vector components for the *i*–th symbol in the constellation and $\varepsilon_I$and $\varepsilon_Q$are factors used to represent the values of the the I and Q channel noise variances with respect to unity [6] . These factors are actually equal to the eigenvalues of the noise covariance matrix after transformation by the down converter [3].

Table 2: M-ARY QAM

M-ary	For (QAM)			BER
	M	µ	σ_a^2	
8 -QAM	8	3	6	5/6Q $[(2\ E_b/N_0)^{1/2}]$
16 - QAM	16	4	10	3/4Q $[(4\ E_b/5N_0)^{1/2}]$
32 - QAM	32	5	20	7/10Q $[(\ E_b/2N_0)^{1/2}]$
64 - QAM	64	6	42	7/12Q $[(\ 2E_b/7N_0)^{1/2}]$

6. Simulation Analysis and Result

A bit error rate is defined as the rate at which errors occur in a transmission system. This can be directly translated into the number of errors that occur in a string of a stated number of bits [2]. The definition of bit error rate can be translated into a simple formula:

BER = Number of errors / Total number of Bits sent

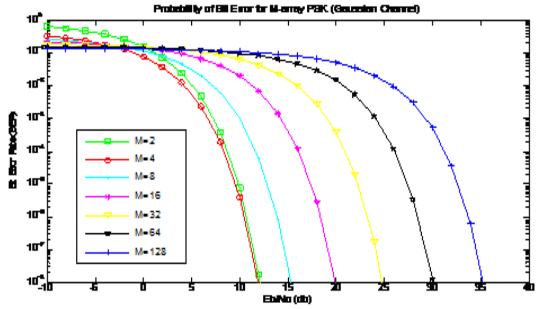

Figure 1: Probability of Bit Error for M-ARY PSK (Gaussian Channel)

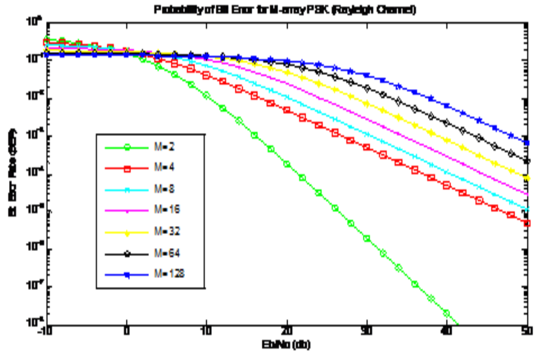

Figure 2: Probability of Bit Error for M-ary PSK (Rayleigh Channel)

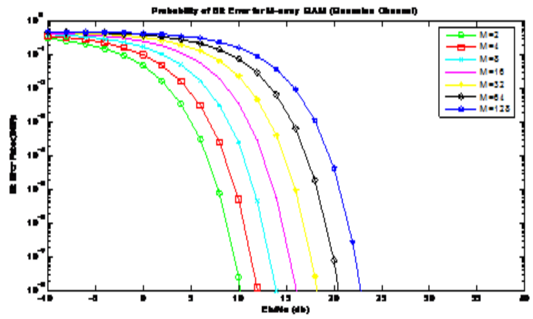

Figure 3: Probability of Bit Error for M-ARY0 QAM (Gaussian Channel)

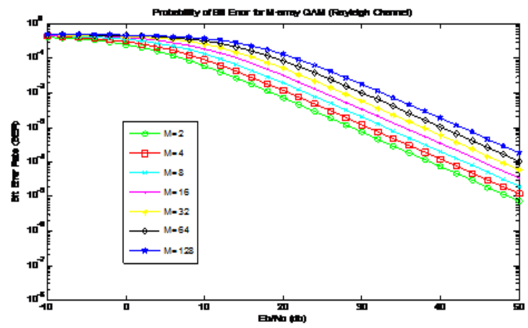

Figure 4: Probability of Bit Error for M-ARY QAM (Rayleigh Channel)

7. Conclusion

The work described in this paper has involved the investigation and analysis of several imperfections in a frequency conversion subsystem, and the effect of these on the BER performance of *M*–QAM and *M*–PSK modulation schemes. By the help of simulation and mathematical calculation we compare BPSK and QPSK systems, Bit error rate performance and concluded that BPSK requires 3 dB less of signal to noise ratio than QPSK to achieve the same

BER. This outcome will hold true only if we consider BER in terms of SNR per carrier. In terms of signal to noise ratio per bit the BER is same for both QPSK and BPSK. Also the distance between the constellation points matters a lot after calculation we concluded that more the distance between the constellation, lesser is the chance of a constellation point getting decoded incorrectly. The distance between the constellation points for 16 QAM modulations is around 1.6 times the value for 16 PSK modulations. This implies that for the same symbol error rate, 16 QAM modulation requires only 4.19 dB lesser signal to noise ratio Es/No,when compared with 16 PSK modulation.

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