

Modelling and Simulation of Multipath Fading Channels for Comparative Analysis of Different M-Array Modulation Schemes

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Abstract

The wireless sector has experienced apparent annual growth rates in recent years. Wireless services provide access to the most rural communities through communications. The wireless revolution has been triggered and supported by several important factors: the development of microelectronics, smart broadband networks, the positive response of users and the favorable regulatory climate around the world [1-2].

The purpose of this paper is to study M-ary digital modulation schemes based on the error performance that is very important in the current communication scenario. The demand for higher data rates and better bandwidth performance is increasing day by day, but the overall allocation of bandwidth is limited. Therefore, it is essential to study the modulation schemes that give the best result. M-ary modulation schemes offer better bandwidth performance than other modulation techniques and provide higher bit rates.

We then study how path and fading affect the modulated signals and the degradation of the symbol error rate due to these multipath paths and different fading channels. This section deals with signal degradation due to the distribution of Rayleigh, Rician and Nakagami-m. This whole study is very important if it is considered for the wireless environment and if everyone knows that the current world is wireless. Another necessary study is how diversity will improve the degradation of attenuated signals. By applying diversity to the end of the receiver, the version of the incoming signal gives the best SNR. In this proposed work, the modeling and simulation of multipath fading channels are performed and the comparison of different modulation techniques is performed by Rayleigh, Rician and Nakagami-m, with MRC diversity combining for range of diversity order N and modulation order M .

Keywords: Digital Communication System, Fading channels, Antenna Diversity Techniques, M-array modulation scheme, multipath-fading channel.

Introduction

The wireless communications industry has been experiencing phenomenal annual growth rates over the past several years. This degree of growth reflects the tremendous demand for commercial communications services such as analog and digital cellular telephony, and Personal Communications Services (PCS) including high speed data, full motion video, Internet access, on-demand medical imaging, real-time road maps, and anytime, anywhere video conferencing.

In many applications, wireless telecommunications can eliminate the high costs of installing and maintaining traditional wired systems. Beyond the arena of mobile communications, there are numerous wireless applications including Wireless

local area networks (WLANs), Bluetooth, Local Multipoint Distribution Systems (LMDS), satellite communications and radio frequency identification (RFID) operating at frequencies extending into the millimeter-wave regime (>30 GHz). One of the innovative techniques being developed to meet this increasing demand for higher data rates, better QoS, fewer dropped calls, higher network capacity and user coverage is use of multiple antennas to improve energy/spectral efficiency. Antenna diversity reception techniques are used extensively in fading channels to reduce the effect of flat fading on system performance, including both fixed terminals and mobile communications systems.

Double Digital System and M-Array Modulation Schemes

Digital Communication System

The main work of digital communication system is to transfer digital data from the transmitter to receiver efficiently and reliably. A basic digital communication system can be represented with the block diagram shown in Fig.1.

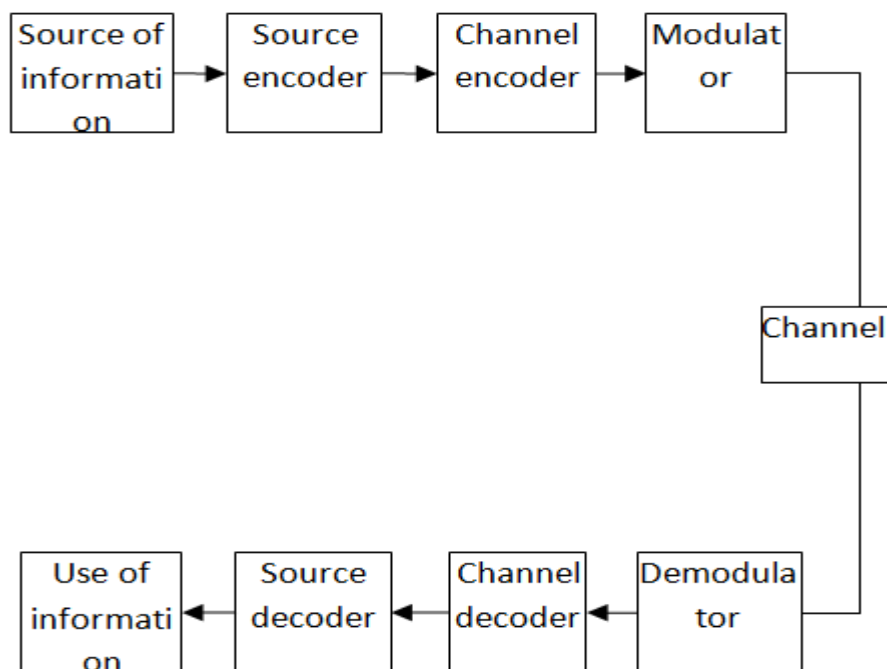


Fig.1 Block diagram of a digital communication system

The digital communication system consists of three main blocks: the digital modulator, digital demodulator, and communication medium. Other elements included in the block diagram are for encoding, interleaving, and encryption. Digital modulation schemes are classified into two large categories: constant envelope and non-constant envelope. Under constant envelope class, there are three subclasses: FSK, PSK, and CPM. Under non-constant envelope class, there are three subclasses: ASK, QAM and other non-constant envelope modulations. Among the listed schemes ASK, PSK, and FSK are basic modulations, and MSK, GMSK, CPM, MHPM, and QAM, etc. are advanced schemes.

Fading Channel Modelling and Antenna Diversity Techniques

Fading Channel Characterization and Modelling

Radio-wave propagation through wireless channels is a complicated phenomenon characterized by various effects, such as multipath and shadowing. A precise mathematical description of this phenomenon is either unknown or too complex

for tractable communication systems analyses. However, considerable efforts have been devoted to the statistical modeling and characterization of these different effects. The result is a range of relatively simple and accurate statistical models for fading channels which depend on the particular propagation environment and the underlying communication scenario.

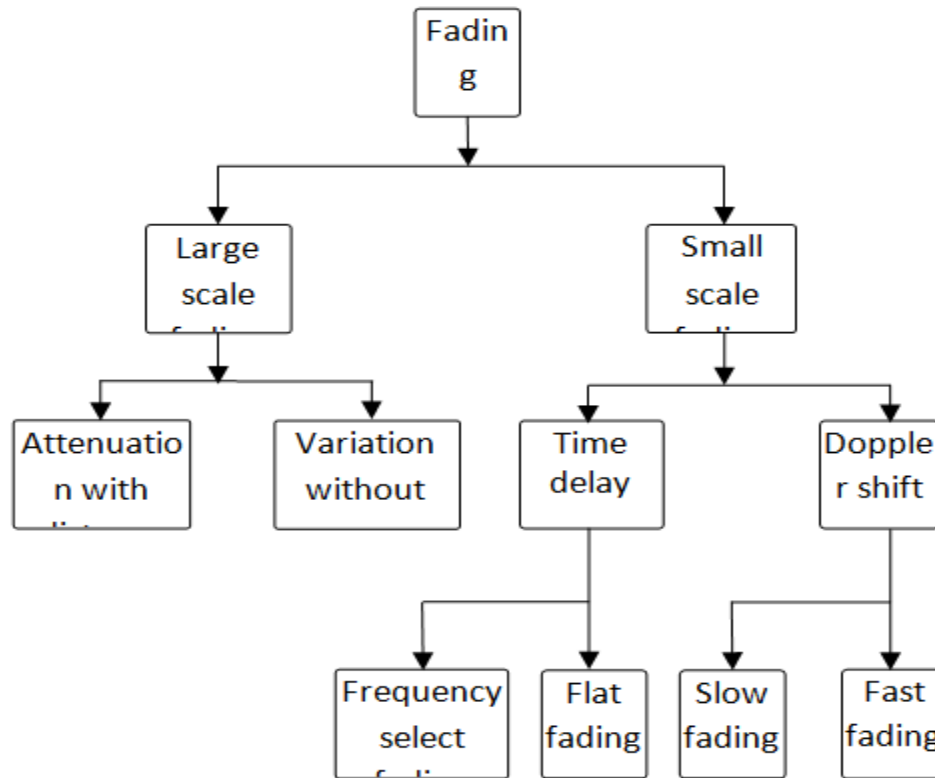


Fig.2 Fading channel manifestations

When a received signal experiences fading during transmission, both its envelope and Phase fluctuate over time. For coherent modulations, the fading effects on the phase can severely degrade performance unless measures are taken to compensate for them at the receiver. Most often, analyses of systems employing such modulations assume that phase effects due to fading are perfectly corrected at the receiver, resulting in what is referred to as coherent demodulation. For non-coherent detection, phase information is not needed at the receiver and therefore the phase variation due to fading does not affect the performance. Hence performance analyses for both coherent and non-coherent detection over fading channels requires only knowledge of the fading envelope statistics.

Error Performance of Different M-Array Modulation Scheme

Error Performance

The error performance, which is discussed in this thesis, is mainly caused due to the channel noise. Channel noise is introduced anywhere between the transmitter output and the receiver input.

Modulation schemes are chosen or designed according to channel characteristic in order to optimize their performance. Additive white Gaussian noise (AWGN) channel is a universal channel model for analyzing modulation schemes. In this

model, the channel does nothing but add a White Gaussian noise to the signal passing through it. Then the received signal is represented as

Where r is the received signal, s is the transmitted signal, and n is the additive white Gaussian noise. We calculate error performance which caused by n with zero mean and σ^2 as variance.

System Performance Measures

Average Signal-to-Noise Ratio

Signal-to-noise ratio (SNR) is the most common performance measure characteristic of a digital communication system. SNR is measured at the output of the receiver and is directly related to the data detection process. The term noise in average signal-to-noise ratio refers to the ever-present thermal noise at the input to the receiver and the word average means to statistical averaging over the probability distribution of the fading[12].

Where γ denotes the instantaneous SNR at the receiver output and $f(\gamma)$ denotes the probability density function.

Average Symbol Error Probability:

This performance criterion average symbol error probability (SEP) is the one that is most revealing about the nature of the system behaviour. The primary reason for the difficulty in evaluating average SEP lies in the fact that the conditional SEP is, in general, a nonlinear function of the instantaneous SNR, the nature of the nonlinearity being a function of the modulation/detection scheme employed by the system.

Performance Comparison

In Fig.3-9 we show performance comparison for different modulation techniques is made under Rayleigh, Rician and Nakagami-m fading with MRC diversity combining for range of diversity order N and modulation order M .

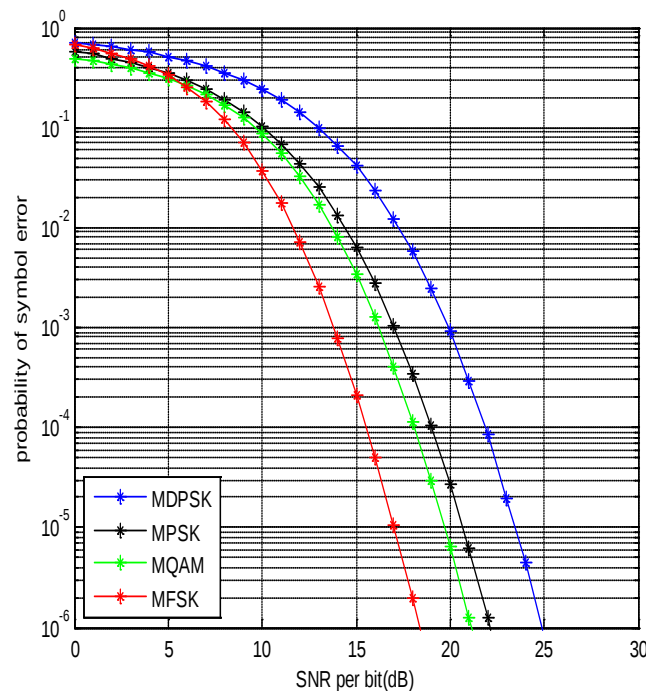


Fig.3 SEP comparison of MFSK, MQAM, MPSK and MDPSK for $M=8$, $K=0$ and $N=10$

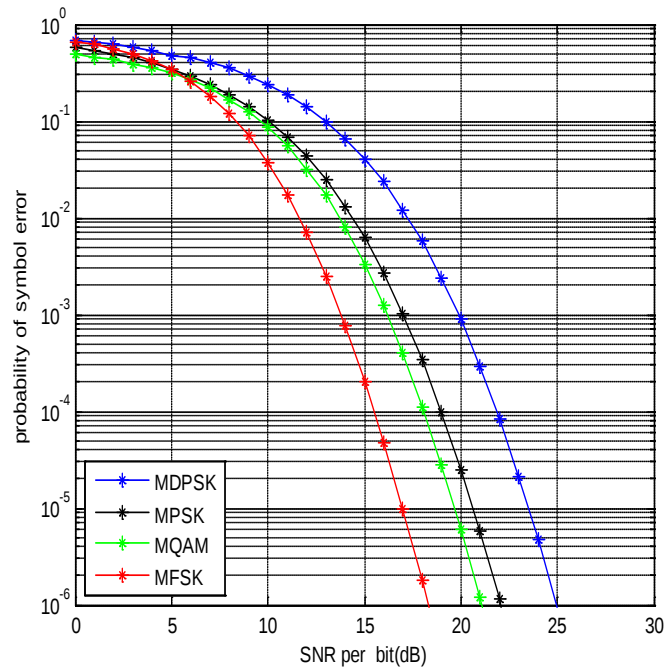


Fig.4 SEP comparison of MFSK, MQAM, MPSK and MDPSK for $M=8$, $K=2$ and $N=10$

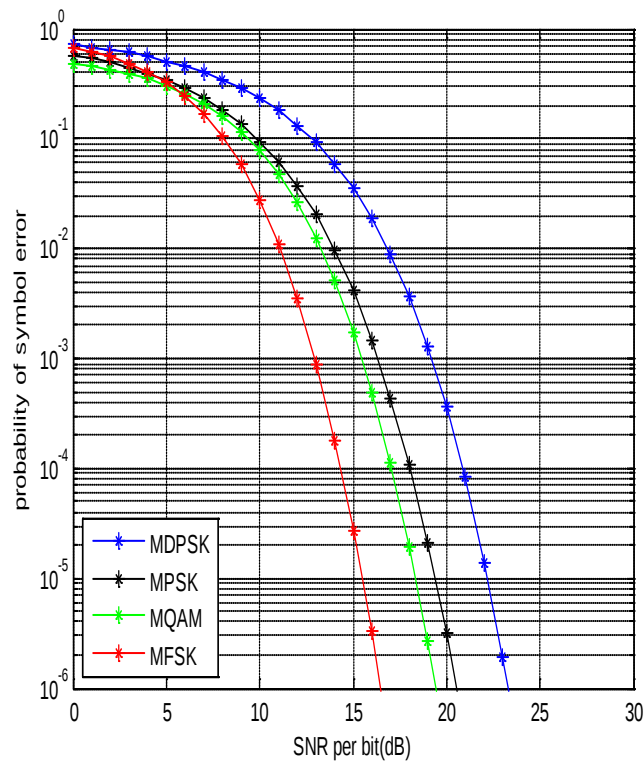


Fig.5 SEP comparison of MFSK, MQAM, MPSK and MDPSK for $M=8$, $m=2$ and $N=10$

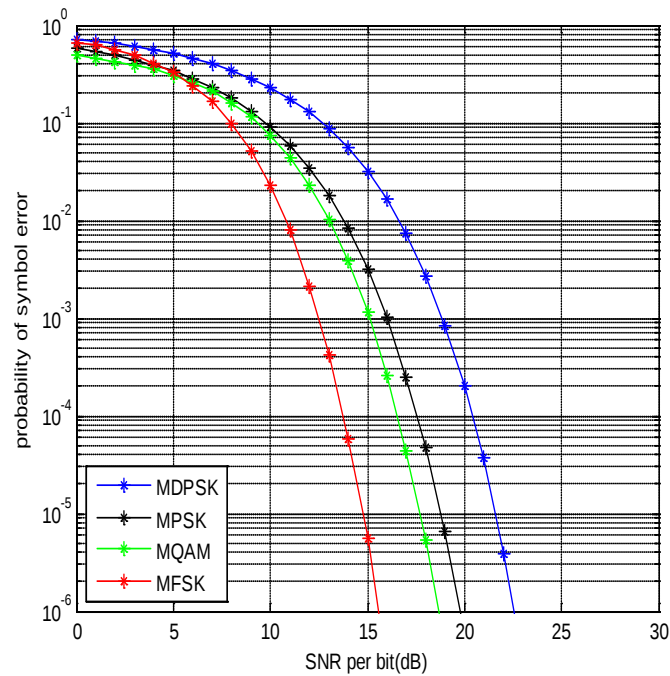


Fig.6 SEP comparison of MFSK, MQAM, MPSK and MDPSK for $M=8$, $m=4$ and $N=10$

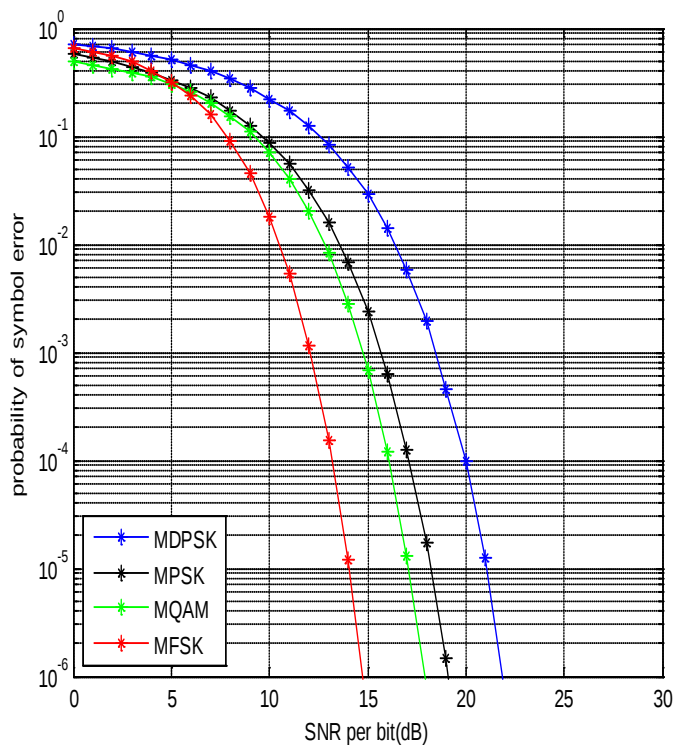


Fig.7 SEP comparison of MFSK, MQAM, MPSK and MDPSK for AWGN ($M=8$)

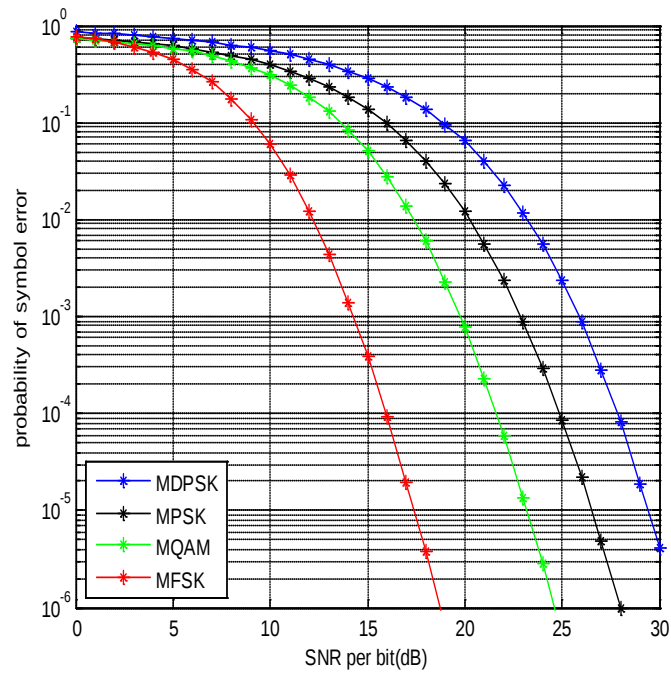


Fig.8 SEP comparison of MFSK, MQAM, MPSK and MDPSK for M=16, K=0 and N=10

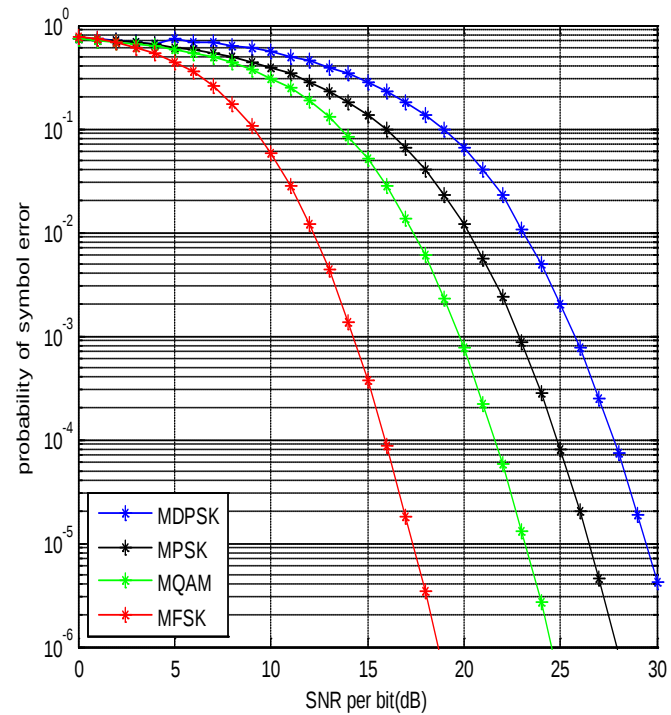


Fig.9 SEP comparison of MFSK, MQAM, MPSK and MDPSK for M=16, K=2 and N=10

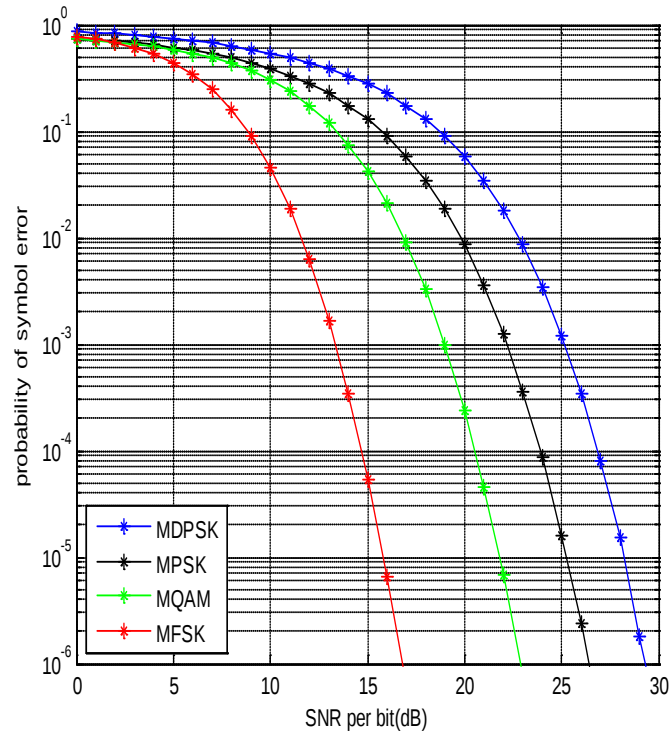


Fig.10 SEP comparison of MFSK, MQAM, MPSK and MDPSK for M=16, m=2 and N=10

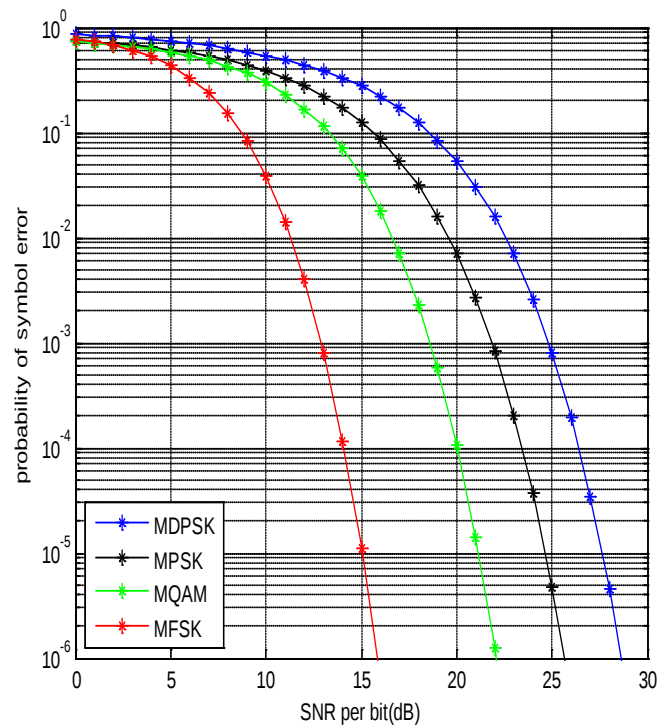


Fig.11 SEP comparison of MFSK, MQAM, MPSK and MDPSK for M=16, m=4 and N=10

Table 1: Comparison of SEP for MPSK for different values of M and N (SNR=20)

Values of K, m and N	Symbol Error Probability	
	MPSK	
	M=8	M=16
K=0 & N=1	0.0324	0.1099
K=0 & N=10	2.668e-05	0.0121
K=2 & N=1	0.0156	0.0695
K=2 & N=10	2.529e-06	0.0119
m=2 & N=1	0.0056	0.0508
m=2 & N=10	3.1620 e-06	0.0087
K=inf	5.253e-08	0.0057

Table 2: Comparison of SEP for MFSK for different values at M and N (SNR=20)

Values of K, m and N	Symbol Error Probability	
	MFSK	
	M=8	M=16
K=0 & N=1	0.0256	0.0322
K=0 & N=10	5.0902e-08	9.8735e-08
K=2 & N=1	0.0113	0.0146
K=2 & N=10	4.5318e-08	8.7985e-08
m=2 & N=1	0.0024	0.0035
m=2 & N=10	4.4909 e-11	9.4001 e-11
K=inf	6.7506e-22	1.4466e-21

Table 3: Comparison of SEP for MQAM for different values of M and N (SNR=20)

Values of K, m and N	Symbol Error Probability	
	MQAM	
	M=8	M=16
K=0 &N=1	0.0268	0.0727
K=0 &N=10	6.381e-06	7.812e-04
K=2 &N=1	0.0157	0.0466
K=2 &N=10	6.072e-06	7.614e-04
m=2& N=1	0.0044	0.0022
m=2&N=10	2.8363 e-07	2.4058 e-04
K=inf	2.963e-10	3.632e-05

Table 4: Comparison of SEP for MDPSK for different values of M and N (SNR=20)

Values of K, m and N	Symbol Error Probability	
	MDPSK	
	M=8	M=16
K=0 &N=1	0.0614	0.1906
K=0 &N=10	9.052e-04	0.0644
K=2 &N=1	0.0391	0.1515
K=2 &N=10	8.860e-04	0.0642
m=2& N=1	0.0180	0.1224
m=2&N=10	3.6495e-04	0.0513
K=inf	9.756e-05	0.0502

Conclusion and Future Work

The focus of this proposed work is on the mathematical analysis of the M-ary modulation schemes over frequency non-selective slowly fading environment with N-branch receiver diversity using maximal ratio combining (MRC) technique. The error performance is based on MGF approach which is better in terms of applicability.

This paper begins with an elaborate discussion of the M-ary modulation schemes as, M-ary Phase shift keying, M-ary Frequency shift keying, M-ary Quadrature Amplitude modulation, Differential M-ary phase shift keying with their constellation diagrams. Later elaborate discussion of the small scale fading models, and antenna diversity combining techniques and goes on to underline the importance of study of MRC diversity combining in different fading channels. Subsequently, a detailed introduction to error probability analysis is presented and the usefulness of our MGF approach in analyzing SEP is highlighted.

It mainly contains the analysis of the probability of error of the M-ary signals over Rician and Nakagami-m fading channel. From the curves and the mathematical analysis of the signals it is observed that as the number of signals or number of M increases ($M \geq 0, 1, 2 \dots M$), the error probability or more clearly the probability of Symbol error rate is increased. It was also observed that the M-ary Frequency Shift Keying is giving the best probability of error over AWGN channel. All this analysis is very much important for the basic analysis of any communication system, as the digital M-ary modulation offers much more advantages than other modulation schemes. A generic approach for the accurate performance evaluation of transmit diversity (also known as simulcast transmission) over fading channels is also an interesting future research topic.

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