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Performance Analysis for M-ARY PSK and M-ARY QAM in Gaussian Noise & Raying Fading with Wireless Mesh Networks

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ABSTRACT

As the demand for transmitting variable and high data rates rise, the need to develop more proficient wireless communication systems increases.Thesis aims to find issues that may affect the performance of meshed wireless networks. There is no denying the fact that out of the wireless technologies being used in today's environment, the wireless mesh technology is one of the most advanced and can be viewed as the technology of the future. The main problem with wireless networks is making them security. This area is also considered as it improves the performance of the whole network. Also the network should be scalable to properly utilize the frequency and get optimal performance. This is required for the successful delivery of data packets. In this paper the performance of M ary–QAM and M ary–PSK modulation schemes has been analyzed. In this work the BER (Bit Error Rate) 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 (AWGN) 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, a few criteria such as bit error rate, power efficiency, and bandwidth efficiency are used for evaluation. This work focuses on error performance of phase modulation schemes in different channel conditions and on the method to reduce bit error rates.

INDEX TERMS: WMNs, BER/SER, PSK, MARY, QAM, AWGN, RAYLEIGH FADING CHANNEL

1. INTRODUCTION:

Wireless mesh network is the key technology for present generation in wireless networking for providing fast and hassle free services to users. Nodes in wireless mesh networks comprise mesh routers and mesh clients. Each node operates as a host and as a router, forward packets on behalf of other nodes that may not be in within direct wireless transmission range.

Connectivity between nodes in wireless mesh networks is automatically established and maintained among the nodes which makes wireless mesh network a dynamically, self-organized, and self-configured wireless network. This type of feature bring many advantages such as low cost installation , low maintenance cost, robustness and reliable service coverage.

The most commonly used technology in day to day life such as desktops, laptops, PDA's, Pocket PC's, Phones are based on conventional nodes equipped with Wireless Network Interface Cards (NIC's) which in turn can connect to wireless mesh routers. Nodes without a wireless NIC can still access wireless mesh networks by connecting to wireless mesh routers through other technologies such as Ethernet. In other ways, gateway or bridge functionalities in mesh networks enable integration of wireless mesh networks with various existing wireless networks such as Cellular networks, wireless sensors, wireless-fidelity (Wi-Fi) and worldwide inter-operability for microwave access (Wi-MAX).

Figure 1: Network Architecture of wireless mesh network

With the evolution to Third and Fourth-Generation (3G & 4G) systems, wireless communications networks are expected to support various multimedia services such as voice, data and video, which require multirate transmission and large bandwidth. Major improvements in the current state of wireless technology are necessary. Fourth and future generation systems promise unparalleled wireless access in ways that have never been possible before. Multi-megabit Internet entrance, interactive web session and simultaneous voice data access with multiple parties at the same time are some of the attractive features of 4G.

A communications system necessarily consists of three parts: a transmitter, a receiver, and a channel. A simple block diagram of a communications system is shown below in Fig. 2

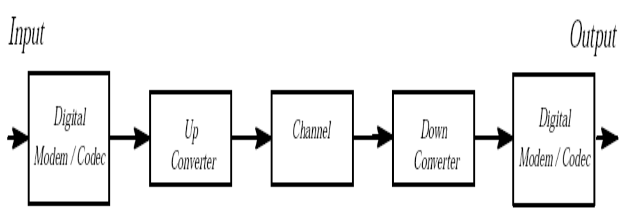

Figure 2: Communication system

The transmitter takes a signal, whether analog or digital, and formats it for transmission over the channel. A wireless channel can be water, air, or vacuum, and may contain obstructions such as buildings, terrestrial features, or planets, depending on the medium. The receiver captures the transmitted signal and performs signal processing, changing it from a form that can be transmitted over the channel into a form that can be viewed, heard, or stored [24]. All of these system components introduce degradation to the transmitted signals; furthermore each system has a limit on the number of signals that can be transmitted. By carefully studying and compensating for the degradation caused by the system components, and by carefully designing the signal processing within a communications system, the number of signals that can be transmitted at one time can be maximized while the signals' degradation can be minimized.

2. LITERATURE REVIEW:

Muhammad Islam et al. (2010) [8] analyzed basic modulation techniques used in mobile and wireless systems. Based on this analysis a PSK modulation scheme for SDR is proposed to pick the constellation size that offers the best reconstructed signal quality for each average SNR. Simulation results of signal transmissions confirm the effectiveness of our proposed PSK modulation scheme. The performance of the modulation technique is evaluated when the system is subjected to noise and interference in the channel.

Syed Md. Asif et al. (2005-09) [9] presented the results of a newly developed hybrid Simulated Annealing –Direct search Algorithm (SADS) for the optimization of mechanism synthesis for function generation problem and proposes a hybrid optimization method based on the fusion of the Simulated annealing (SA) and Rosenbrock Search (RS), derivative-free type method of optimization, in which the SA is used with the RS to increase its search capability which combines the advantages of the global optimization technique and a classical non linear programming techniques. An overview of hybrid SADS algorithm is presented and applied to dimensional synthesis of a planer four bar system which is carried out to minimize the objective function formulated from the structural error at the accuracy points. Zhiquan Bai and Dongfeng Yuan (2008) [10] analyzed system performance of turbo trellis coded modulation (TTCM) is presented and analyzed through computer simulations over two distinctive channels, AWGN and Rayleigh fading channels. The co-designed TTCM method is used and the performance of different mapping strategies based on UP (ungerboeck partitioning), MP (mixed partitioning) and GP (gray partitioning), of the signal constellation of the TTCM system is given. Our simulation results show that the co-designed TTCM with UP can obtain better performance than TTCM with MP and GP in both AWGN and Rayleigh fading channels.

Jian Li et al. (2008) [11] worked unified framework is presented to evaluate the exact bit error probability (BEP) of *M*-ary pulse amplitude modulation (PAM) and quadrature amplitude modulation (QAM) over additive white Gaussian noise (AWGN) channel for any bit-mapping technique. Some Tight approximations are also provided for both of modulation schemes. By using these results, we obtain the exact and tight approximate BEP expressions for maximal-ratio combining (MRC) and selection combining (SC) in Rayleigh fading.

Hen-Geul Yeh and Victor R. Ramirez (2007) [12] presented the implementation results of an M-ary PSK and QAM OFDM system via algorithms and simulations. Which shows that an OFDM system performance can be affected and/or improved based on the algorithms used. Moreover, it defines that the DSP software-based system is flexible and interoperable for different modulation with variable data rate. The performance of the implemented OFDM system is evaluated in three areas: the Bit Error Rate (BER) vs E_b/N_o, the processing speed vs data transmitted per OFDM symbol length, and the processing speed vs the M-ary PSK or QAM modulation scheme by using several types of FFT (radix-2 and split-radix) algorithms and modulation schemes (BPSK, QPSK, 16-QAM, and 64-QAM). The implementation is done in Matlab and in the DSP TMS320VC5416 code composer studio (CCS).

Jigisha N. Patel et al. (2007) [13] In wireless communication, gave concept of parallel transmission of symbols is applied to achieve high throughput and better transmission eminence. OFDM is one of the techniques for parallel transmission. The idea of OFDM is to divide the total transmission bandwidth into a number of orthogonal subcarriers in order to transmit the symbols using these subcarriers in parallel. They proposed OFDM system design is simulated using MATLAB simulink toolbox. The digital modulation techniques such as M-PSK (M-ary Phase Shift Keying) and M-QAM (M-ary Quadrature Amplitude Modulation), provide way of parallel transmission to analyze the BER performance of designed OFDM system. The above schemes used in OFDM system can be selected on the basis of the requirement of power or spectrum efficiency and BER analysis.

Jun Li et al. (2005) [14] considered single-user transmission over a Rayleigh flat fading channel, in which the Channel State Information (CSI) is known by the receiver . Subject to average transmit power constraint, we study the capacity of an AWGN channel with Rayleigh fading. Under an independently id distributed fading assumption ,the lower and the upper bound of the channel capacity are given and proved and they are compared to the capacity results numerically computed. Besides, an approximation result of such channel capacity is projected, and by conducting numerical comparison it is shown that our suggested approximation result has a better performance in approximating Rayleigh fading channels capacity than the bounds given over. Additionally, the channel capacity with outage probability is discussed and compared with different outage probabilities.

Guang-Chong Zhu et al. (2001) [15] proposed robust soft-decision channel-optimized vector quantization (COVQ) scheme for turbo coded additive white Gaussian noise (AWGN) and Rayleigh fading channels is proposed, The log likelihood ratio (LLR) generated by the turbo decoder is exploited via the use of a q-bit scalar soft-decision demodulator. The concatenation of the turbo encoder, modulator, and Additive White Gaussian Noise channel or Rayleigh fading channels, turbo decoder with q-bit soft decision demodulator is used as an expanded discrete memory less channel (DMC). A COVQ scheme for this expanded discrete channel is designed. Numerical results specify substantial recital improvements over traditional tandem coding systems, the COVQ schemes are designed for hard-decision demodulated turbo coded channels (q=1), as well as performance gains over a recent soft decoding COVQ scheme.

3. PROBLEM DEFINATION:

There may be degrade in performance of the network by using phase shift key to calculate the bit error rate. Various types of issues can occur by using these techniques. These issues are throughput, connectivity, scalability, radio techniques, compatibility and security.

Throughput is defined as the number of data packets transmitted by the sender and received by the receiver in a grant time. Throughput can decrease if network design is inappropriate, the route is unclear, a faulty link is present or if there is overcrowding in the path.

Connectivity is a significant factor for network performance is mesh connectivity. Mesh connectivity should be done in such a way that it could self organize in case of problems or errors.

Scalability is absolutely necessary for every network. Some problems that can happen if the network is not scalable are that the routing protocol may not be able to find a dependable route for data transmission.

Radio techniques is also important and critical. Wireless mesh networks are to a great extent based upon radio signals sent to or from participating nodes. Most problems occur when the radio fails to catch a signal or is searching in some other direction.

Compatibility can be done with mesh routers with integration of heterogeneous wireless networks. Wireless meshed networks have to be compatible both to mesh and conventional clients.

Security is very important for all networks. WMN topology has a distributed style. As the architecture becomes more distributed, the security issues in the network increase. Until now there has been not many security schemes relevant to WMNs. The reason for this is that there is no need to draw and promote the public key to the nodes. This brings about it more pertaining to look at the security nature of the WMNs.

4. BER Calculation For M-ary PSK& M-ARY QAM

BER Expressions for *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. 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 υ_I and υ_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 eigenvalues of the noise covariance matrix after transformation by the down converter.

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

$$P(E)_i \approx Q\{b\cos[L_1] - a\sin[L_1]\} + Q\{a\sin[L_2] - b\cos[L_2]\} \quad (4.1)$$

and the BER is given by:

$$P_B(E) = \frac{1}{\mu M}\sum_{i=1}^{M} P(E)_i \quad (4.2)$$

for a constellation of *M* symbols and µ bits per symbol. Expressions for *a, b, L*1 and *L*2 are given below for QPSK, 8–PSK, 16–PSK, 32–PSK, and 64–PSK.

8–PSK

8–PSK has *M* = 8 symbols with µ = 3.

$$a = \sqrt{\frac{6E_b}{\nu_I N_0}}\, e_{Ai}\cos\left[\frac{\pi}{8}(2i-1) + e_{\phi i}\right] \quad (4.3)$$

$$b = \sqrt{\frac{6E_b}{\nu_Q N_0}}\, e_{Ai}\sin\left[\frac{\pi}{8}(2i-1) + e_{\phi i}\right] \quad (4.4)$$

$$L_1 = \arctan\left\{\left(\frac{\nu_I}{\nu_Q}\right)\tan\left[\frac{\pi}{4}(i-1)\right]\right\} \quad (4.5)$$

.

$$L_2 = \arctan\left\{\left(\frac{\nu_I}{\nu_Q}\right)\tan\left[\frac{\pi i}{4}\right]\right\} \quad (4.6)$$

For the case of ideal transmission the BER is given by:

$$P_B(E) \approx \frac{1}{12} Q\left[\sqrt{\frac{6E_b}{N_o}}\sin\left(\frac{\pi}{8}\right)\right] \quad (4.7)$$

16-PSK

16–PSK has *M* = 16 symbols with µ = 4.

$$a = \sqrt{\frac{8E_b}{\nu_I N_0}}\, e_{Ai}\cos\left[\frac{\pi}{16}(2i-1) + e_{\phi i}\right] \quad (4.8)$$

$$b = \sqrt{\frac{8E_b}{\nu_Q N_0}}\, e_{Ai}\sin\left[\frac{\pi}{16}(2i-1) + e_{\phi i}\right] \quad (4.9)$$

$$L_1 = \arctan\left\{\left(\frac{\nu_I}{\nu_Q}\right)\tan\left[\frac{\pi}{8}(i-1)\right]\right\} \quad (4.10)$$

$$L_2 = \arctan\left\{\left(\frac{\nu_I}{\nu_Q}\right)\tan\left[\frac{\pi i}{8}\right]\right\} \quad (4.11)$$

For the case of ideal transmission the bit error probability is given by:

$$P_B(E) \approx \frac{1}{32} Q\left[\sqrt{\frac{8E_b}{N_o}}\sin\left(\frac{\pi}{16}\right)\right] \quad (4.12)$$

32-PSK

32–PSK has *M* = 32 symbols with µ = 5.

$$a = \sqrt{\frac{10E_b}{\nu_I N_0}}\, e_{Ai}\cos\left[\frac{\pi}{32}(2i-1) + e_{\phi i}\right] \quad (4.13)$$

$$b = \sqrt{\frac{10E_b}{\nu_Q N_0}}\, e_{Ai}\sin\left[\frac{\pi}{32}(2i-1) + e_{\phi i}\right] \quad (4.14)$$

$$L_1 = \arctan\left\{\left(\frac{\nu_I}{\nu_Q}\right)\tan\left[\frac{\pi}{16}(i-1)\right]\right\} \quad (4.15)$$

$$L_2 = \arctan\left\{\left(\frac{\nu_I}{\nu_Q}\right)\tan\left[\frac{\pi i}{16}\right]\right\} \quad (4.16)$$

For the case of ideal transmission the bit error probability is given by:

$$P_B(E) \approx \frac{1}{80} Q\left[\sqrt{\frac{10E_b}{N_o}}\sin\left(\frac{\pi}{32}\right)\right] \quad (4.17)$$

64 PSK

64–PSK has *M* = 64 symbols with µ = 6.

$$a = \sqrt{\frac{12E_b}{\nu_I N_0}}\, e_{Ai}\cos\left[\frac{\pi}{64}(2i-1) + e_{\phi i}\right] \quad (4.18)$$

$$b = \sqrt{\frac{12E_b}{\nu_Q N_0}}\, e_{Ai}\sin\left[\frac{\pi}{64}(2i-1) + e_{\phi i}\right] \quad (4.19)$$

$$L_1 = \arctan\left\{\left(\frac{\nu_I}{\nu_Q}\right)\tan\left[\frac{\pi}{32}(i-1)\right]\right\} \quad (4.20)$$

$$L_2 = \arctan\left\{\left(\frac{\nu_I}{\nu_Q}\right)\tan\left[\frac{\pi i}{32}\right]\right\} \quad (4.21)$$

For the case of ideal transmission the bit error probability is given by:

$$P_B(E) \approx \frac{1}{192} Q\left[\sqrt{\frac{12E_b}{N_o}}\sin\left(\frac{\pi}{64}\right)\right] \quad (4.22)$$

BER Expressions for *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. 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 υ_I and υ_Q are factors used to represent the values of the the I and Q channel noise variances with respect to unity. These factors are actually equal to the eigenvalues of the noise covariance matrix after transformation by the down converter.

8-QAM

The complex baseband symbols are represented bya_{Ii} + ja_{Qi} where:

$a_{Ii} \in \{\pm\ 1,\ \pm\ 3\}$ and

$a_{Qi} \in \{\pm\ 1\}$.

For the 8–QAMconstellation discussed here, μ= 3 and $\overline{\sigma}_a^2 = 6$.

The BER is given by:

$$P_B(E) \approx \frac{1}{24}\sum_{i=1}^{4}\left[Q\left((1+e_{Ii})\sqrt{\frac{E_b}{\nu_I N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{E_b}{\nu_Q N_o}}\right)\right]$$
$$+\frac{1}{24}\sum_{i=5}^{8}\left[Q\left((1+e_{Ii})\sqrt{\frac{E_b}{\nu_I N_o}}\right) + Q\left((1-e_{Ii})\sqrt{\frac{E_b}{\nu_I N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{E_b}{\nu_Q N_o}}\right)\right] \quad (4.23)$$

where $e_{Ii}$and $e_{Qi}$are the error vector components for the *i*–th symbol in the constellation and assuming that symbols numbered from 1 to 4 are type I and 5 to 8 are type IIA.For the ideal case of zero error vectors and equal I and Q channel noise variances the probability of error is given by:

$$P_B(E) \approx \frac{8}{24}Q\left(\sqrt{\frac{E_b}{N_o}}\right) + \frac{12}{24}Q\left(\sqrt{\frac{E_b}{N_o}}\right)$$
$$\approx \frac{5}{6}Q\left(\sqrt{\frac{E_b}{N_o}}\right) \quad (4.24)$$

16–QAM

The complex baseband symbols are represented by a_{Ii}+ja_{Qi} where a_{Ii} and a_{Qi} ϵ{± 1, ± 3}. There are 4 type I decision regions, 4 type IIA, 4 type IIB decision regions, and 4 type III decision regions. For the 16–QAM constellation discussed here, μ = 4 and $\overline{\sigma}_a^2 = 10$. The BER is given by:

$$P_B(E) \approx \frac{1}{64}\sum_{i=1}^{4}\left[Q\left((1+e_{Ii})\sqrt{\frac{4E_b}{5\nu_I N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{4E_b}{5\nu_Q N_o}}\right)\right]$$
$$+\frac{1}{64}\sum_{i=5}^{8}\left[Q\left((1+e_{Ii})\sqrt{\frac{4E_b}{5\nu_I N_o}}\right) + Q\left((1-e_{Ii})\sqrt{\frac{4E_b}{5\nu_I N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{4E_b}{5\nu_Q N_o}}\right)\right]$$
$$+\frac{1}{64}\sum_{i=13}^{16}\left[Q\left((1+e_{Ii})\sqrt{\frac{4E_b}{5\nu_I N_o}}\right) + Q\left((1-e_{Qi})\sqrt{\frac{4E_b}{5\nu_Q N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{4E_b}{5\nu_Q N_o}}\right)\right.$$
$$\left.+\frac{1}{64}\sum_{i=9}^{12}\left[Q\left((1+e_{Ii})\sqrt{\frac{4E_b}{5\nu_I N_o}}\right) + Q\left((1-e_{Qi})\sqrt{\frac{4E_b}{5\nu_Q N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{4E_b}{5\nu_Q N_o}}\right)\right]\right. \quad (4.25)$$

where e_{Ii} and $e_{Qi}$are the error vector components for the *i*–th symbol in the constellation and assuming that symbols numbered from 1 to 4 are type I, 5 to 8 are type IIA, 9 to 12 are type IIB, and 13 to 16 are type III. For the ideal case of zero error vectors and equal I and Q channel noise variances the probability of error is given below.

$$P_B(E) \approx \frac{8}{64}Q\left(\sqrt{\frac{4E_b}{5N_o}}\right) + \frac{12}{64}Q\left(\sqrt{\frac{4E_b}{5N_o}}\right) + \frac{8}{64}Q\left(\sqrt{\frac{4E_b}{5N_o}}\right) + \frac{12}{64}Q\left(\sqrt{\frac{4E_b}{5N_o}}\right)$$
$$\approx \frac{3}{4}Q\left(\sqrt{\frac{4E_b}{5N_o}}\right) \quad (4.26)$$

32-QAM

For the 32–QAMconstellation discussed here, μ = 5 and $\overline{\sigma}_a^2 = 20$

The BER is given by:

$$P_B(E) \approx \frac{1}{160}\sum_{i=1}^{4}\left[Q\left((1-e_{Ii})\sqrt{\frac{E_b}{2\nu_I N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{E_b}{2\nu_Q N_o}}\right) + Q\left((1+e_{Ii})\sqrt{\frac{E_b}{2\nu_I N_o}}\right)\right.$$
$$\left.-Q\left\{(1-e_{Ii})\sqrt{\frac{E_b}{2\nu_I N_0}}\sin\left[\arctan\left(\frac{\nu_I}{\nu_Q}\right)\right] + (1+e_{Qi})\sqrt{\frac{E_b}{2\nu_Q N_0}}\cos\left[\arctan\left(\frac{\nu_I}{\nu_Q}\right)\right]\right\}\right]$$
$$+\frac{1}{160}\sum_{i=5}^{8}\left[Q\left((1-e_{Qi})\sqrt{\frac{E_b}{2\nu_Q N_o}}\right) + Q\left((1+e_{Ii})\sqrt{\frac{E_b}{2\nu_I N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{E_b}{2\nu_Q N_o}}\right)\right.$$
$$\left.-Q\left\{(1-e_{Qi})\sqrt{\frac{E_b}{2\nu_Q N_0}}\sin\left[\arctan\left(\frac{\nu_I}{\nu_Q}\right)\right] + (1+e_{Ii})\sqrt{\frac{E_b}{2\nu_I N_0}}\cos\left[\arctan\left(\frac{\nu_I}{\nu_Q}\right)\right]\right\}\right]$$
$$+\frac{1}{160}\sum_{i=9}^{12}\left[Q\left((1+e_{Ii})\sqrt{\frac{E_b}{2\nu_I N_o}}\right) + Q\left((1-e_{Ii})\sqrt{\frac{E_b}{2\nu_I N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{E_b}{2\nu_Q N_o}}\right)\right]$$
$$+\frac{1}{160}\sum_{i=13}^{16}\left[Q\left((1+e_{Ii})\sqrt{\frac{E_b}{2\nu_I N_o}}\right) + Q\left((1-e_{Qi})\sqrt{\frac{E_b}{2\nu_Q N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{E_b}{2\nu_Q N_o}}\right)\right]$$
$$+\frac{1}{160}\sum_{i=17}^{32}\left[Q\left((1+e_{Ii})\sqrt{\frac{E_b}{2\nu_I N_o}}\right) + Q\left((1-e_{Qi})\sqrt{\frac{E_b}{2\nu_Q N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{E_b}{2\nu_Q N_o}}\right)\right.$$
$$\left.+Q\left((1-e_{Ii})\sqrt{\frac{E_b}{2\nu_I N_o}}\right)\right] \quad (4.27)$$

For the ideal case of zero error vectors and equal I and Q channel noise variances the probability of error is given below.

$$P_B(E) \approx \frac{24}{160}Q\left(\sqrt{\frac{E_b}{2N_o}}\right) + \frac{24}{160}Q\left(\sqrt{\frac{E_b}{2N_o}}\right) + \frac{64}{160}Q\left(\sqrt{\frac{E_b}{2N_o}}\right)$$

$$\approx \frac{7}{10}Q\left(\sqrt{\frac{E_b}{2N_o}}\right) \quad (4.28)$$

64-QAM

For the 64–QAMconstellation discussed here, μ = 6 and $\overline{\sigma_a^2} = 42$.

The BER is given by:

$$P_B(E) \approx \frac{1}{384}\sum_{i=1}^{4}\left[Q\left((1+e_{Ii})\sqrt{\frac{2E_b}{7\nu_I N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{2E_b}{7\nu_Q N_o}}\right)\right]$$

$$+\frac{1}{384}\sum_{i=5}^{16}\left[Q\left((1+e_{Ii})\sqrt{\frac{2E_b}{7\nu_I N_o}}\right) + Q\left((1-e_{Ii})\sqrt{\frac{2E_b}{7\nu_I N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{2E_b}{7\nu_Q N_o}}\right)\right]$$

$$+\frac{1}{384}\sum_{i=17}^{28}\left[Q\left((1+e_{Ii})\sqrt{\frac{2E_b}{7\nu_I N_o}}\right) + Q\left((1-e_{Qi})\sqrt{\frac{2E_b}{7\nu_Q N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{2E_b}{7\nu_Q N_o}}\right)\right]$$

$$+\frac{1}{384}\sum_{i=29}^{64}\left[Q\left((1+e_{Ii})\sqrt{\frac{2E_b}{7\nu_I N_o}}\right) + Q\left((1-e_{Qi})\sqrt{\frac{2E_b}{7\nu_Q N_o}}\right) + Q\left((1+e_{Qi})\sqrt{\frac{2E_b}{7\nu_Q N_o}}\right)\right.$$

$$\left. + Q\left((1-e_{Ii})\sqrt{\frac{2E_b}{7\nu_I N_o}}\right)\right] \quad (4.29)$$

For the ideal case of zero error vectors and equal I and Q channel noise variances the probability of error is given below.

$$P_B(E) \approx \frac{8}{384}Q\left(\sqrt{\frac{2E_b}{7N_o}}\right) + \frac{36}{384}Q\left(\sqrt{\frac{2E_b}{7N_o}}\right) + \frac{36}{384}Q\left(\sqrt{\frac{2E_b}{7N_o}}\right) + \frac{144}{384}Q\left(\sqrt{\frac{2E_b}{7N_o}}\right)$$

$$\approx \frac{7}{12}Q\left(\sqrt{\frac{2E_b}{7N_o}}\right) \quad (4.30)$$

6. Simulation and BER analysis

Flowchart of Fading

In order to transmit, it is significant to simulate the channel. Wireless channels are impaired by fading and noise which will be simulated here separately along with their flowcharts. This channel is affected by Rayleigh fading due to Doppler Effect. The simulation of Rayleigh fading channel was done by Smith's model. A block diagram of Smith's method is shown in Fig.6.1:

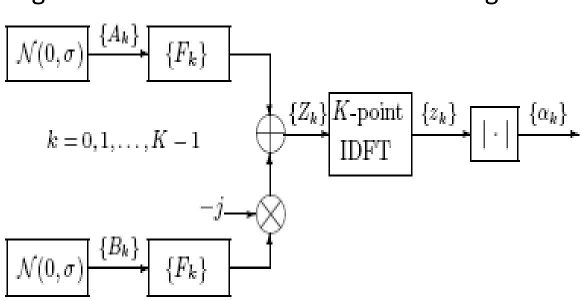

Figure 6.1: Smiths Model

Simulation of Gaussian Noise

This channel is affected by Gaussian noise. It is very easy to simulate Gaussian noise in Matlab. The "rand" command was used to generate normally distributed noise as shown in the Fig.6.2 below.

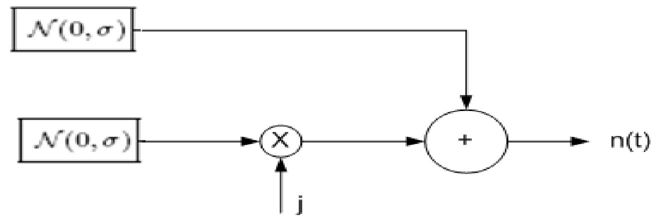

Figure 6.2: Noise Simulation Flowchart

In this work I simulate the effects of AWGN and Rayleigh fading channels in MATLAB .The results presented are derived from analytical closed form expressions developed in the previous chapters. The aim of the results is to quantify the effects of quadrature hybrid errors that can occur as part of the frequency conversion process on various M–QAM and M–PSK modulation schemes.

6.1 Probability of Bit Error for M-ary PSK (Gaussian Channel)

The following equations are used to evaluate the probability of bit error rate for M-ary PSK in Gaussian channel:

M = 2^k or k = $\log_2 M$

$$Symbol\ error\ rate = Q\left(\left(\sqrt{2*k*\frac{E_b}{N_0}}\right)*\frac{\sin(\frac{\pi}{M})}{\sqrt{2}}\right)$$

Where E_b/N_0 is in Watts.

Bit error rate=Symbol error rate/2

Then, these equations are used in MATLAB to generate m-file for the Probability of Bit Error for M-ary PSK in Gaussian channel as follow. Finally, the Fig. generated is:

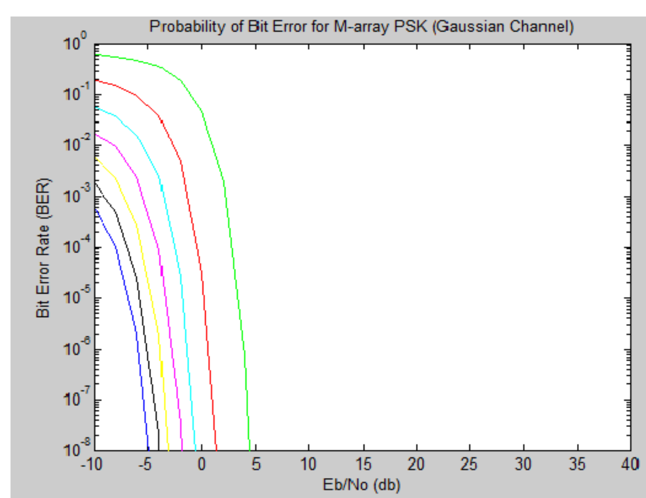

Figure 6.2: Probability of Bit Error for M-ary PSK (Rayleigh Channel)

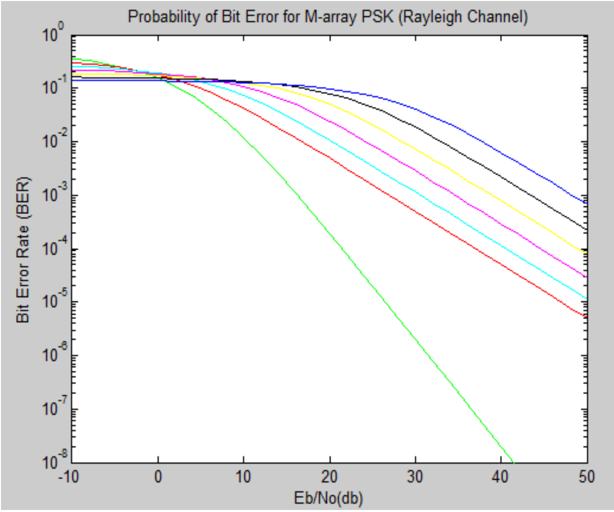

Figure 6.3: Probability of Bit Error for M-ary QAM (Gaussian Channel)

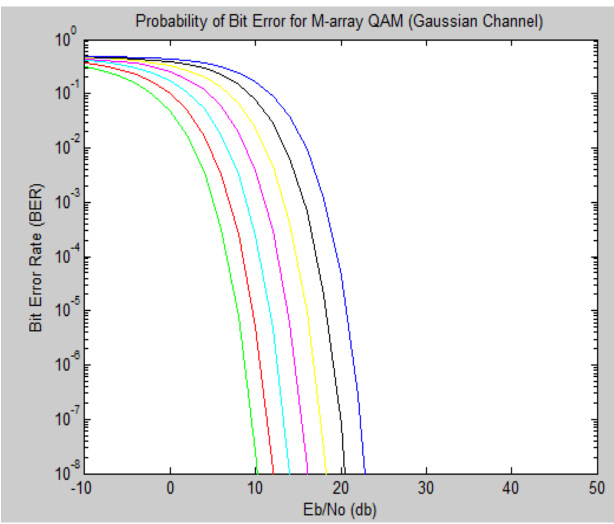

Figure 6.4: Probability of Bit Error for M-ary QAM (Rayleigh Channel)

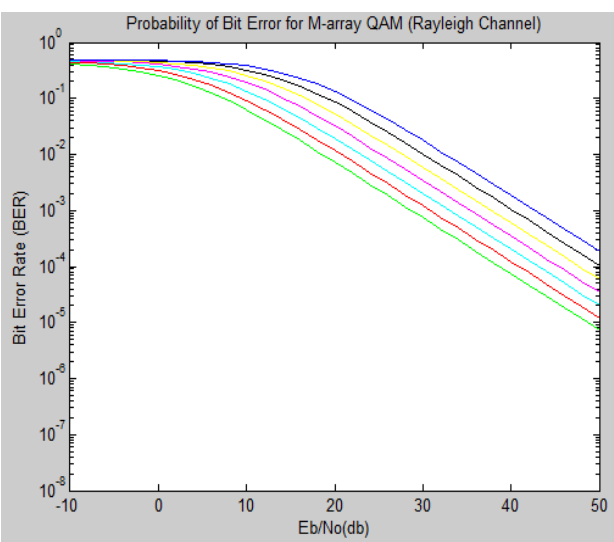

Figure 6.5: Probability of Bit Error for M-ary QAM (Rayleigh Channel)

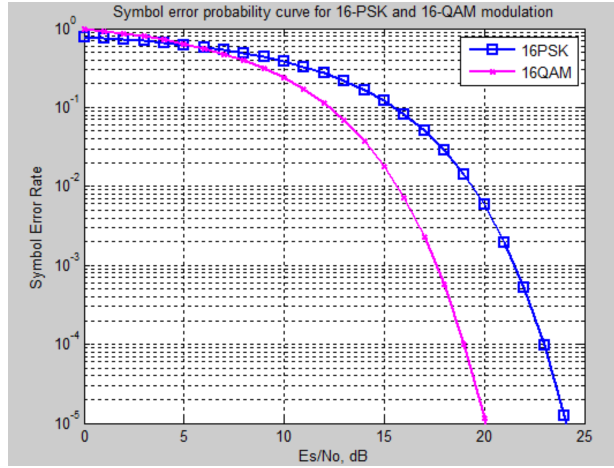

Figure 6.6: Symbol Error Rate Probability Curve For 16 PSK &16 QAM

7. CONCLUSION AND FUTURE WORK:

The work described in this Dissertation has involved the investigation and analysis of several IF 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 I 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 type of 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 point's matters a lot after calculation I concluded that more the distance between the constellation, slighter 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. The results presented here have served to quantify some of the effects of non-ideal frequency conversion on various PSK and QAM modulation schemes. The results generally show that low order schemes such as QPSK can be used in a communications system with up converters and down converters built to physically realisable performance specifications without appreciable BER degradation. Without loss of data and with proper communication we can send packets from sender to destination, implying an error free performance of the network. Security of the network is also a key performance parameter.

There are many other potential causes of implementation loss in frequency conversion stages that were not tackled in this work. Potential areas for investigation are the effect of filter group delay and bandwidth, and amplifier nonlinearities, on higher order modulation schemes. All of the results were obtained assuming a static AWGN channel. Further work could analyse the effects of a time varying and/or fading channel. This could be incorporated into an overall system simulation model.

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