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Performance Analysis of QAM and QPSK in AWGN and Multipath Fading Channel

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Abstract: ***To deliver multimedia content application over the cellular networks, high data rate modulation scheme is one of the important criteria besides good error coding. However, the implementation of high data rate modulation techniques that have good bandwidth efficiency in W-CDMA cellular communication requires perfect modulators, demodulators, filter and transmission path that are difficult to achieve in practical radio environment. 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.QAM and QPSK are considered as one of the most commonly used modulation schemes for wireless communication now a days. The performance analysis of these modulation schemes are carried out in terms of Bit Error Rate (BER) versus Signal to Noise Ratio (SNR) in AWGN and Multipath Rayleigh Fading channel .The transmission of signal from base station to mobile station using Quadrature Phase Shift Keying (QPSK) and M-ary Quadrature Amplitude modulation (QAM) modulation scheme are consider in WCDMA system. In this paper it will be proved that for increased value of M the data rate will be increased but with a increasing value of BER but QPSK will perform better than M-ary QAM.***

Index Terms- AWGN, DSSS, Multipath Rayleigh Fading, CDMA, BER, SNR, QPSK, 16-QAM.

I. INTRODUCTION

GMSK digital modulation technique is most commonly used in GSM (Global System for Mobile Communication).It can only transmit data rate of 1 bit per symbol. So it is quite sure that this kind of modulation scheme is not suitable for the next generation communication system. So, it is obvious to study the performance of new modulation technique that could deliver higher data rate effectively in a multipath fading and AWGN channel. Digital modulation schemes are most commonly used today because of its many advantages over the analog modulation schemes. The choice of modulation technique varies with applications according to its requirement. Digital modulation technique has different performance characteristics i.e. power efficiency, Bandwidth efficiency, Error rate, cost etc which are contradictory to each other. At the same time we cannot optimize each character.

In [1] it has been reported that the performance of M-ary modulations schemes like M-PSK, M-QAM, and MFSK for transmitting audio signal over Additive Gaussian Noise (AWGN) channel is better than low level modulation techniques in terms of bit error probability as a function of SNR. The error performance of 4-PAM, 8-PSK and 16-QAM over AWGN channel has been studied in [2] and it has shown that error performance is improving as the value M increases.

In [3] comparative performance analysis of basic M-ary PSK modulation schemes like BPSK, QPSK and 8-PSK in AWGN channel has been done and it has shown that error rate increases with the increase value of M.

In [4] the performance analysis only done for 64-QAM modulation technique and it is found that the average throughput increases as the SIR increase. Moreover, increasing the channel estimation error variance reduces the average throughput. Most of the articles investigate the error performance in AWGN channel with low level M-ary modulation schemes. Practically now a days there is a huge demand of such communication system which can provide higher data rate with mobility. Higher data rate means more numbers of bits should be sending per second, which can be obtain by increasing the value of M in M-ary modulation schemes and to provide the mobility wireless communication is the best option.

The research of this project is focused on the study and the performance measurement of high data rate modulation schemes at those channels which are subjected to Multipath Rayleigh Fading and Additive White Gaussian Noise (AWGN). Modulation Schemes that will be studied are M-ary QAM and QPSK. The performance study will be carried out by varying the chip rate of pseudo-noise generator. W-CDMA (Wideband Code Division Multiple Access) scheme will also be studied by comparing some certain number of users under static and dynamic environment that are subjected to AWGN and multipath Rayleigh fading. The performance of fading channels in W-CDMA system are based on Bit Error Rate (BER) W-CDMA system at downlink transmission and Signal-to-Noise ratio (SNR).There will be three W-CDMA wireless cellular system models that will used in this project.

The models are:

1. W-CDMA system in AWGN channel.
2. W-CDMA system in AWGN and Multipath Rayleigh Fading.
3. Multi-user W-CDMA system in AWGN and Multipath Rayleigh Fading.

II. SIMULATION METHODOLOGY

Throughout this project, we set the bit rate of 384Kbps for the signal generator. The flow chart is something like below-

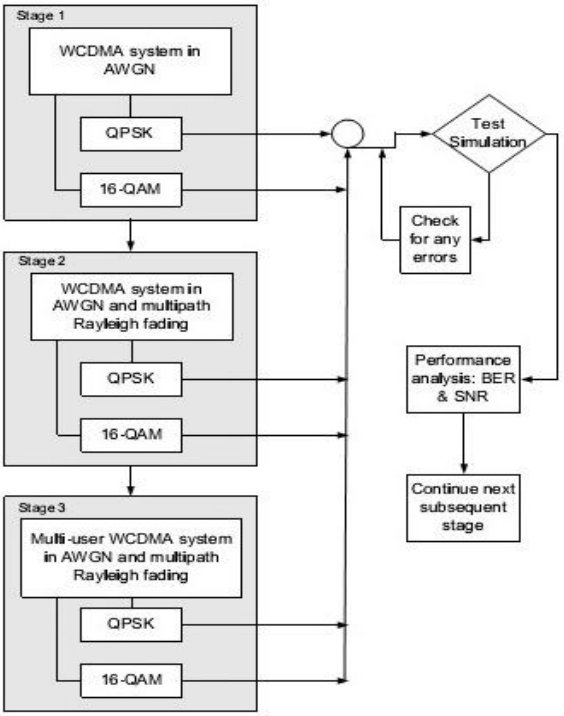

Figure 1: Simulation flow chart for W-CDMA system models used in Simulink and M files.

III. CODE GENERATION BY LSFR (LINEAR FEEDBACK SHIFT REGISTER)

In this task Linear feedback shift register will be used to generate code sequences in WCDMA. A shift register contains a number of cells identified by numbers 1 to r, and each cell is a storage unit that, under the control of a clock pulse, moves the contents to its output while reading its new contents from the input. In a standard configuration of a feedback register, the input of cell *m* will be a function of the output of cell *m*-1 and the output of cell r (the last cell of the shift register) forms the desired code sequence.

In linear feedback shift registers (LFSRs), the function combining the outputs of cell m-1 and cell r with the input of cell m is linear. Figure 2 shows a single linear binary shift register, which can generate a sequence from generation polynomial h(x) = x5 + x2 + 1. In general, the configuration of a linear binary shift register of *n* sections is described by a generator polynomial, which is a binary polynomial of degree *n*. *n*, in this case, is the number of register of the shift register.

$h(x)=h_n x^n + h_{n-1}x^{n-1}+\ldots..h_1x^1+1$ (h_i€{0,1})

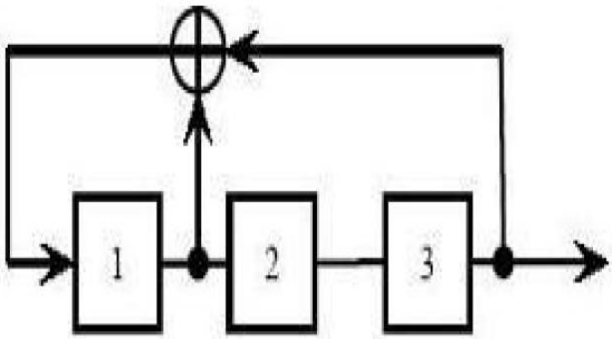

Figure 2: Three-stage M-sequence

IV. PERFORMANCE ANALYSIS OF QPSK MODULATION TECHNIQUE OF WCDMA IN AWGN

Simulation result for evaluation on BER vs. SNR for ray tracing (also called 2-ray,one is LOS and other is reflected or NLOS) AWGN channel for 1 user when the number of data is 200,000.

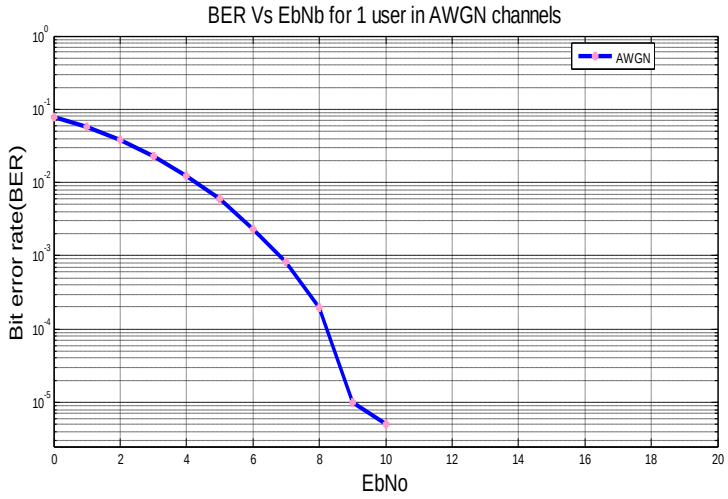

Figure 3: Performance of W-CDMA in ray tracing model AWGN Channels for 1 user.

In this simulation, the BERs are obtained by varying the values of Eb/No in the range of 0 to 20. The iteration is done 1000 times where the total number of data transmitted is 200,000.

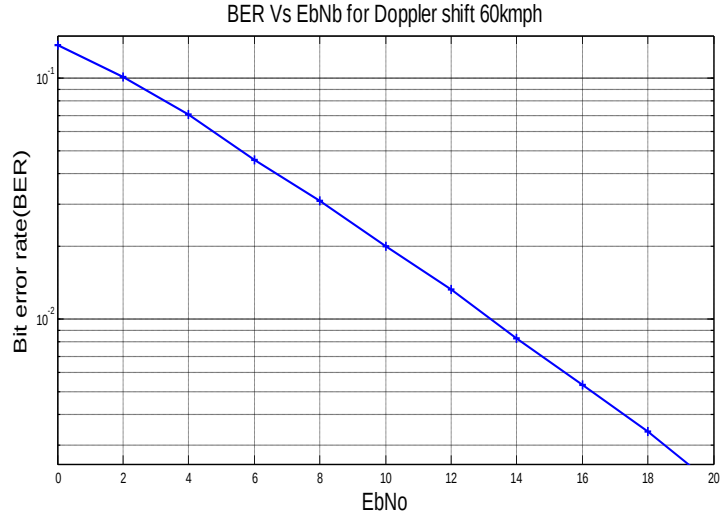

Figure 4: Performance of W-CDMA in 2-Rays Multipath Rayleigh Fading Channels for 1 user when the number of data is 200000 at 60 kmph.

The simulation of BER is done in the range of 0 to 20 of Eb/No. Simulation results for evaluation on BER vs. SNR for 2-ray Multipath Rayleigh Fading channel for 1 user when the of data is 200,000 at 60 kmph.

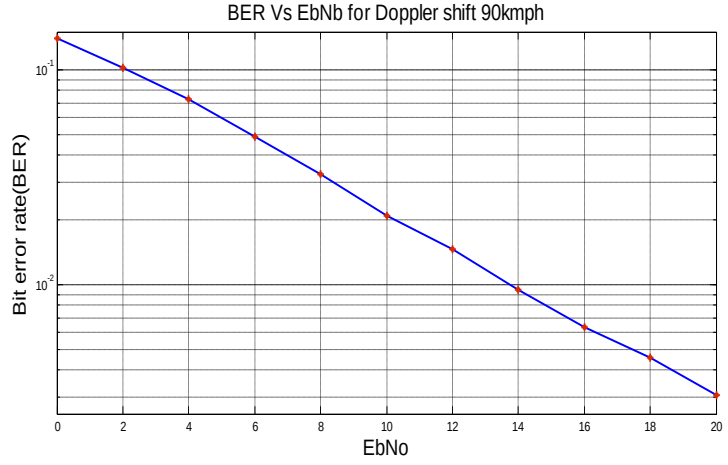

Figure 5: Performance of W-CDMA in 2-Rays Multipath Rayleigh Fading Channels for 1 user when the number of data is 200000 at 90 kmph.

The simulation of BER is done in the range of 0 to 20 of Eb/No. Simulation results for evaluation on BER vs. SNR for 2-ray Multipath Rayleigh Fading channel for 1 user when the number of data is 200,000 at 90 kmph.

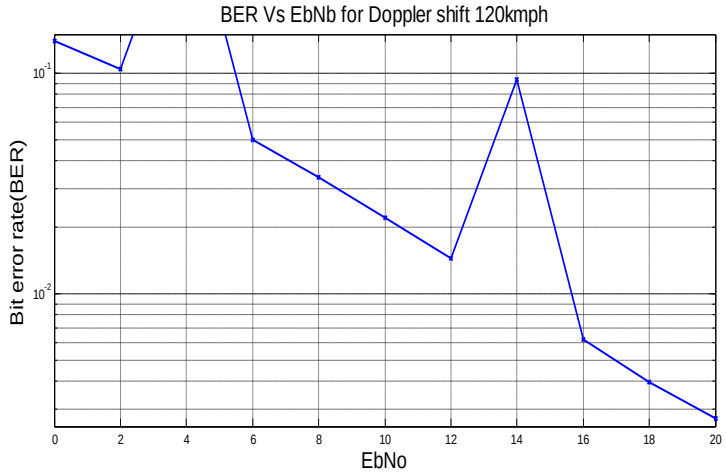

Figure 6 : Performance of W-CDMA in 2-Rays Multipath Rayleigh Fading Channels for 1 user when the number of data is 200000 at 120 kmph.

The simulation of BER is done in the range of 0 to 20 of Eb/No. Simulation results for evaluation on BER vs. SNR for 2-ray Multipath Rayleigh Fading channel for 1 user when the number of data is 200,000 at 120 kmph.

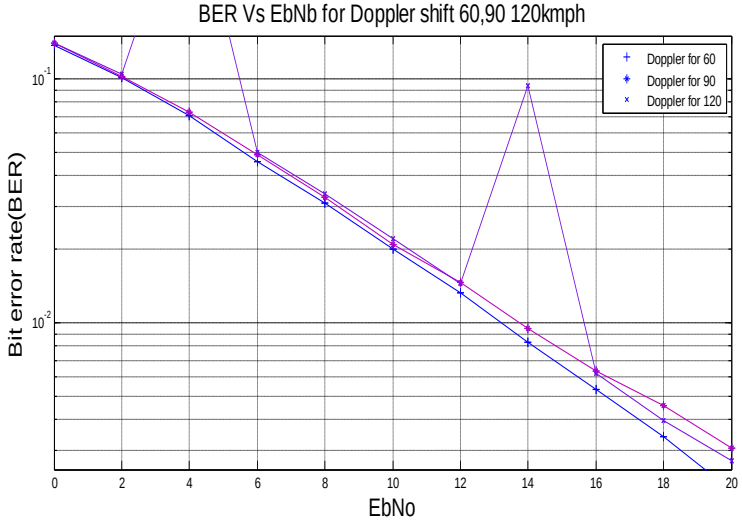

Figure 7: Performance of W-CDMA in 2-Rays Multipath Rayleigh Fading Channels for 1 user when the number of data is 200000 at 60,90,120 kmph.

V.PERFORMANCE ANALYSIS OF QPSK MODULATION TECHNIQUE OF WCDMA BETWEEN AWGN AND RAYLEIGH FADING CHANNEL

Simulation result for evaluation on BER vs. SNR for 2-ray Rayleigh Fading channel for 1 user when the number of data is 200,000.

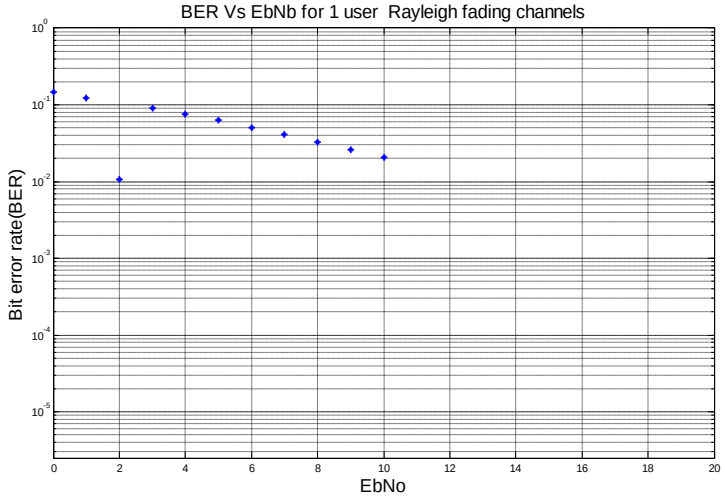

Figure 8: Performance of W-CDMA in 2-Rays Multipath Rayleigh Fading Channels for 1 user.

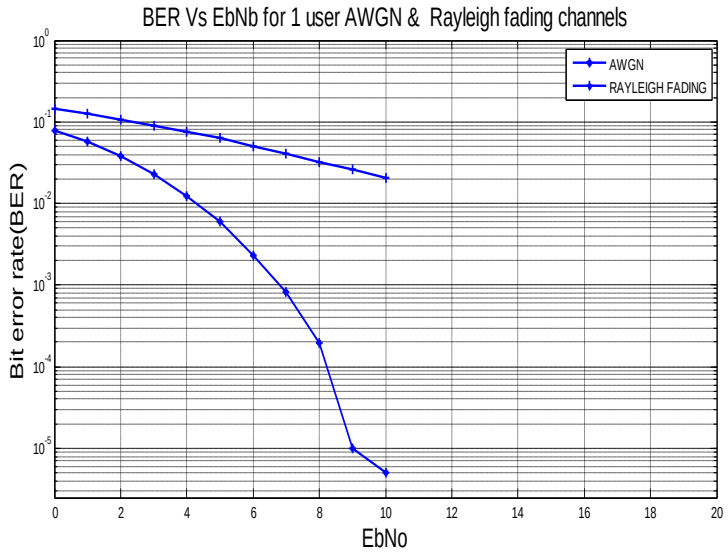

Figure 9: Performance Comparison of W-CDMA in 2-Rays between AWGN and Multipath Rayleigh Fading Channels for 1 user

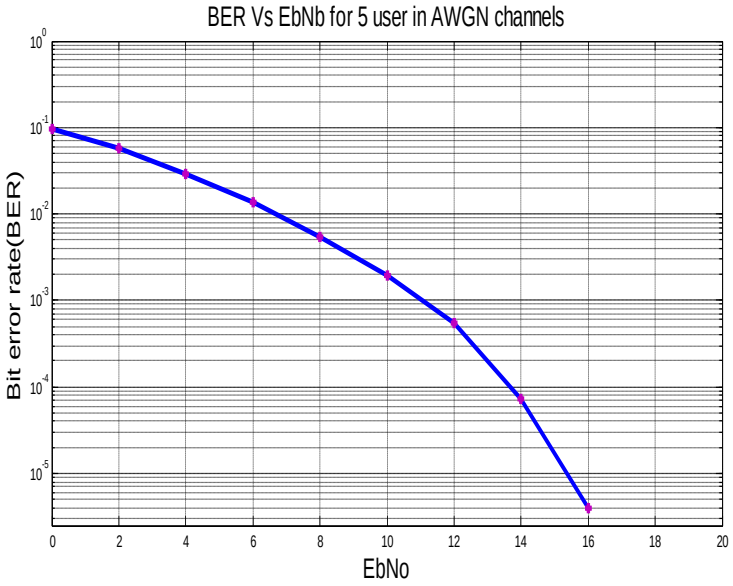

Figure10: Performance Comparison of W- CDMA in 2-Rays for AWGN Channels for 5 user

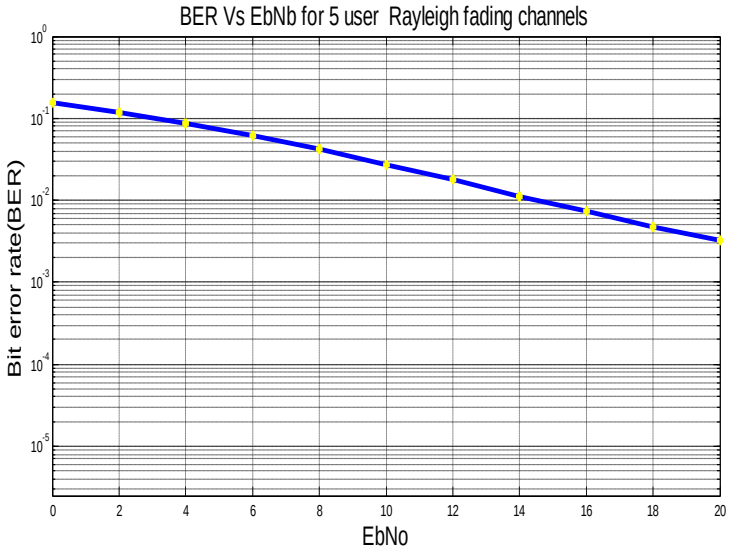

Figure 11: Performance Comparison of W-CDMA in 2-Rays for Rayleigh Fading Channel for 5 user .

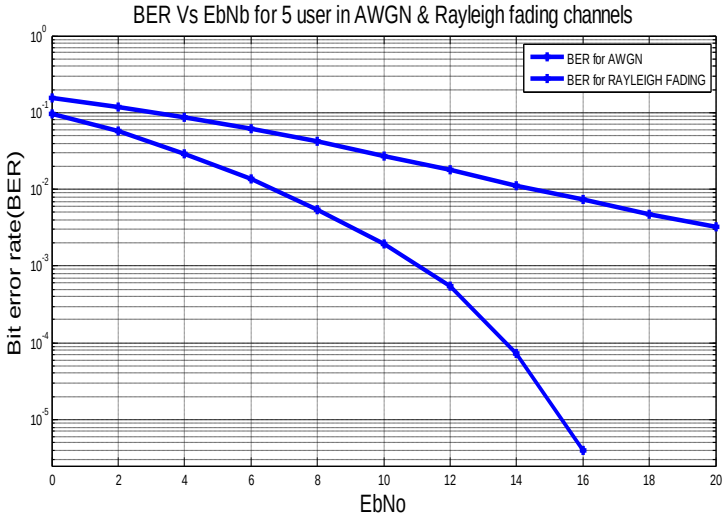

Figure 12: Performance Comparison of W-CDMA in 2-Rays between AWGN and Multipath Rayleigh Fading Channels for 5 users

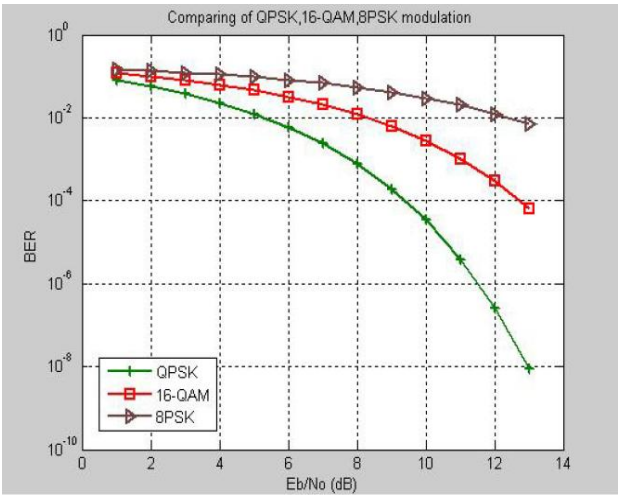

Figure 13 : Comparison of performance analysis of QPSK,16-QAM & 8PSK modulation techniques.

VII. ANALYSIS & DISCUSSION

Simulation using m files shows that each QPSK and 16-QAM modulation techniques in AWGN channel has good performance when it is compared to that of Multipath Rayleigh channel. Also, the performance of QPSK and 16-QAM degrades when the channel is subjected to Multipath fading with increasing value of Doppler shift (Hz). In other words, it performs poorly as the speed of mobile terminal is increased. Moreover, the system performs badly as the number of users is increased. Comparison between QPSK and 16-QAM modulation schemes shows that 16-QAM performs very poorly in both AWGN (LOS channel) and AWGN with Multipath fading channel. The simulation of 16-QAM modulation technique using m files cannot be done because it is suspected that the variation of amplitude with phase causes errors in the constellation of 16-QAM signal.

The reason behind this poor performance of 16-QAM of W-CDMA system in multipath fading channel is basically due to the interference between adjacent carriers phase in the constellation of 16-ary QAM. A sound approach is needed to be used in 16-QAM of WCDMA system to ensure zero or minimal interference between adjacent carriers phase in the constellation of 16-QAM. It is suggested that error correction coding such as convolution coding or turbo coding is used in this system to ensure better performance of 16-QAM modulation technique of W-CDMA system. Also, it is possible to consider the use of a RAKE receiver or a smart antenna (MIMO) in this system to exploit the delayed signals generated in multipath fading channel. It is discovered, as well, that the performance of multi-user in the m file is limited to a maximum of 7 users. Thus, this system needs to be improved to simulate more number of users so that the performance of multiple accesses in W-CDMA can be studied more dynamically.

VII. CONCLUSION

In telecommunication field the major challenges is to convey the information as efficiently as possible through limited bandwidth, though the some of information bits are lost in most of the cases and signal which is sent originally will face fading. To reduce the bit error rate the loss of information and signal fading should be
Minimized.

In this paper two modulation techniques is analyzed, QPSK and 16-QAM to reduce the error performance of the signal and compare which technique is better through Rayleigh Fading Channel in the presence of AWGN.

The performance of W-CDMA system in AWGN channel shows that QPSK modulation technique has a better performance compared to that of 16-QAM.

Furthermore, similar trend is found when the channel is subjected to multipath Rayleigh fading with Doppler shift. The performance of QPSK and 16-QAM modulation technique in W-CDMA system degrades as the mobility is increased from 60kmph to 120kmph for both QPSK and 16-QAM. However, QPSK shows better performance compared to that of 16-QAM in LOS channel and multipath Rayleigh fading channel. In other words, 16-QAM suffers signal degradation and error prone when the simulations are done in these channels.

As the number of users is increased, the QPSK

Modulation technique performs poorly in W-CDMA system. Unfortunately, the simulation for 16-QAM has failed to show the expected results in both Simulink and m files. This is because the 16-QAM modulation scheme experiences adjacent carrier interference when the simulation is carried out. Therefore, it results in inconsistence of data or signal throughput causing abnormal values of BER and eventually affecting the performance of WCDMA system. It is expected that 16- QAM will show performance degradation similar like QPSK as the number of users is increased but with lower performance compared to that of QPSK. In general, the reason behind the poor performance of W-CDMA system when the number of users in increased is because the value of cross correlation between the codes is not 0 and thus it causes interference. Many studies and researches have showed that 16-QAM modulation technique is a primary candidate for high speed data transmission in 3G mobile communication [5]. High Speed Downlink Packet Access (HSDPA) is considered as a 3.5G where it has the capability to boost up the data rates of up to 10.7 Mbps using 16-QAM in a static environment. However, higher data rate modulation scheme (e.g.16-QAM) suffers significant degradation in noise and Multipath Rayleigh fading channel compared to lower data rate modulation technique (e.g. QPSK). The errors are resulted from interference between adjacent carriers phase in constellation of M-ary QAM. Larger value of M of M-ary QAM suffers more signal degradation. Thus, it is suggested that high data rate modulation technique such as 16-QAM needs an error correction coding such as convolution coding or turbo coding so that the interference from the adjacent carrier phase in the constellation of 16-QAM can be eliminated if not minimized.

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