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Matlab and Simulink Based Simulation of Wideband Code Division Multiple Access [WCDMA]

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Abstract— **MATLAB and Simulink based simulation of wideband code division multiple access presents a way of demonstrating the performance of WCDMA in a Wireless Communication Network. In this paper 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 scheme like QAM and QPSK where studied and simulated with a view to measuring their efficiency, power spectrum, time scope and scattered plot where developed to analyse the system, The simulation of BER was done in the range of 0 to 20 of Eb/No and the behavior in a Doppler shift environment was realised.**

Index Terms— **UMST,CDMA,GMSK,MULTIPATH**

I. INTRODUCTION

W-CDMA is being used by Universal Mobile Telecommunication System (UMTS) as platform of the 3rd generation cellular communication system. W-CDMA uses noise-like broadband frequency spectrum where it has high resistance to multipath fading whereas this was not present in conventional narrowband signal of 2nd generation (2G) communication system. High data rate signal transmission can be transmitted over the air by using W-CDMA system, thus enabling of multimedia pictures to end users. Thus, we need suitable modulation rich applications such as video streams and high resolution technique and error correction Mechanism to be used in W-CDMA system.

In 2G networks, GMSK modulation scheme is widely used in GSM (Global System for Mobile Communication). This modulation 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, there is a need to study the performance of new modulation technique that could deliver higher data rate effectively in a multipath fading channel.[1]

II. OBJECTIVE AND SCOPE.

The work 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 16-ary QAM (Quadrature Amplitude Modulation) and QPSK (Quadrature Phase Shift Keying).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 was used in this work. 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.

There are some parameters for multiple rays using QPSK and QAM in W-CDMA system models that will be obtained using MatLab. They are

1. Bit Error Rate (BER) versus Signal-to-Noise ratio (SNR) in AWGN channel for QPSK modulation technique.[2]
2. BER versus SNR in AWGN channel for 16-QAM modulation scheme.
3. BER versus SNR in AWGN and multipath Rayleigh fading channel with Doppler shift (60kmph, 120kmph) for 16-QAM modulation scheme.
4. BER versus SNR in AWGN and multipath Rayleigh fading channel with Doppler shift (10kmph,120kmph) for 16-QAM modulation scheme.
5. BER versus SNR to compare between AWGN channel and Rayleigh fading channel for different number of user for 16-ary QAM modulation technique.
6. BER versus SNR to compare between AWGN channel and Rayleigh fading channel for different number of user for QPSK modulation technique.[3]

III. RESEARCH METHODOLOGY

The research work first review the high speed data rate modulation schemes, DSSS W-CDMA and fading effects on the channels. Then, we develop a generic model of DSSS W-CDMA as it is shown in figure 1 and is being simulated by MatLab modulation schemes 16-QAM and QPSK. [4]

When noise power has a uniform spectral density, it is referred as white noise. The adjective "white" is used in the same sense as it is with white light, which contains equal amounts of all frequencies within the visible band of electromagnetic (EM) radiation.

Since thermal noise is present in all communication systems and is a prominent noise source for most system, the thermal noise characteristics that are additive, white and Gaussian are

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most often used to model the noise in communication systems.[6]

IV. RAYLEIGH FADING.

Since signal propagation takes place in the atmosphere and near the ground, apart from the effect of free path loss, Ls, the most notable effect of signal degradation is multipath propagation. The effect can cause fluctuations in the received signal's amplitude, phase and angle of arrival, giving rise to terminology multipath fading.
Generally, there are two fading effects in mobile communications: large-scale and small-scale fading. Large-scale fading represents the average signal power attenuation or path loss due to shadowing effects when moving over large areas. On the other hand, small-scale fading refers to the dramatic changes in signal amplitude and phase that can be experienced as a result of small changes (as small as a half-wavelength) in the spatial separation between a receiver and transmitter. Small-scale fading is also called Rice fading because the envelope of received signal can be represented by a Rician pdf.[7]
The received signal consists of large number of multiple reflective paths and there is no line-of-sight signal component. When there is a dominant non-fading signal component present, such as a line-of-sight propagation, the small-scale fading envelope is described by a Rician pdf.

V. DIRECT SEQUENCE SPREAD SPECTRUM (DSSS).

DSSS is normally used in Code Division Multiple Access (CDMA) scheme. The received DSSS signal for a single user can be represented as
$S_n(t) = \sqrt{2}Es/Tsm(t)p(t)(Cos(2\pi f_C+\theta))$.. (1)
Where *m* (t) is the data sequence, *p* (t) is the PN spreading sequence, *fc* is the carrier frequency and θ is the carrier phase angle at *t* = 0.

VI. DSSS CDMA BIT ERROR PROBABILITY CALCULATIONS.

There are two approaches to calculate BER for DSSS-CDMA operating under AWGN channel. The first approach uses accurate BER approximations because it is presumed that BER evaluation is numerically cumbersome. There are many researches on this approach and most widely used approximation is the so called Standard Gaussian Approximation (SGA). In the SGA, a central limit theorem (CLT) is employed to approximate the sum of the multiple-access interference (MAI) signals as an AWGN process additional to the background Gaussian noise process. SGA is widely used because it is easy to apply. However, it is known based on performance analysis that SGA often over estimate system performance especially for small number of users. Thus, Improved Gaussian Approximation (IGA) is created to overcome the limitations in SGA. IGA is more accurate that SGA especially for small number of users, but with exploiting numerical integration and multiple numerical convolutions. **[8]**

VII. CONFIGURATION OF TRANSMITTER AND RECEIVER.

The system is configured based on synchronous W-CDMA system. Each user employs their own sequence to spread the information data. In the downlink transmission, the information data are modulated by the modulation scheme. After, the modulated data are spread by code that is M-sequence. The "spreaded" data of all users in the system are transmitted to the mobile users at the same time. The mobile user detects the information data of each user by correlating the received signal with a code sequence allocated to each user.[7,8,9]
The performance of the W-CDMA system is studied based on QPSK and 16-QAM modulation techniques that will be used in this simulation.

VIII. SIMULATION USING SIMULINK.

Fig.1. is a WCDMA is a Simulink representation of physical layer , the WCDMA air interface is a direct spread technology. This means that it spreads encoded user data at a relatively low rate over a much wider bandwidth (5MHz), using a sequence of pseudo-random units called chips at a much higher rate (3.84 Mbps). By assigning a unique code to each user, the receiver, which has knowledge of the code of the intended user, can successfully separate the desired.

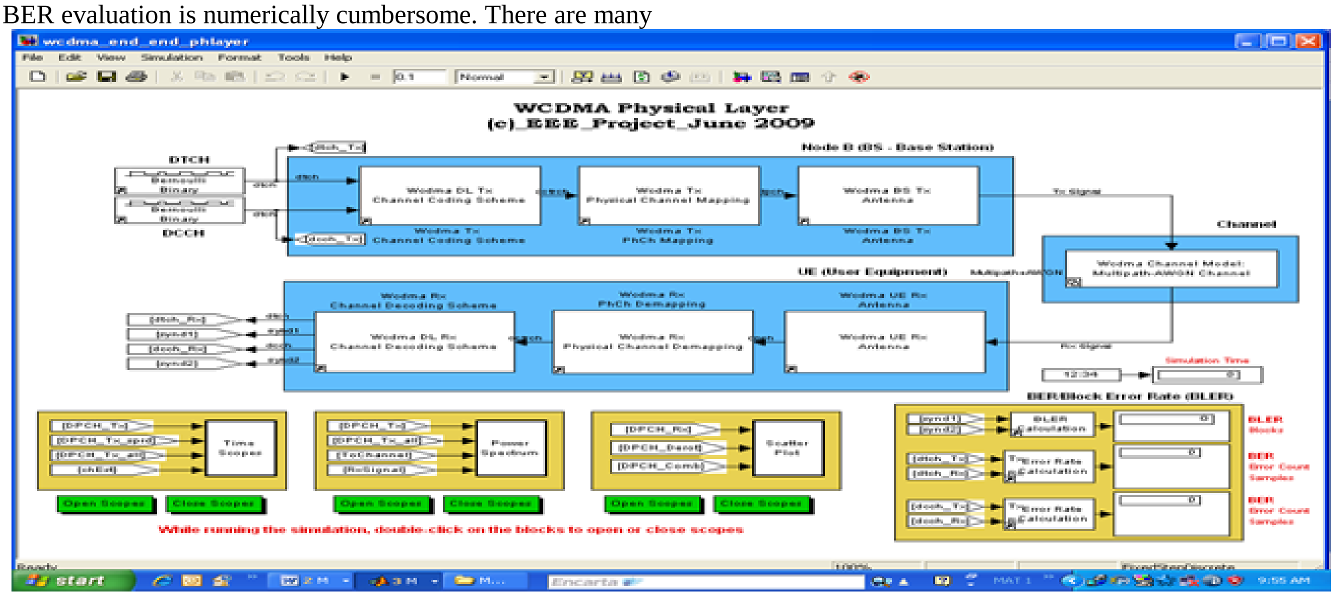

Fig. 1: WCDMA physical layer

signal from the received waveform. WCDMA DL Tx Channel Coding Scheme: This is used for Transport channel encoding and multiplexing.[6]

IX. SUBSYSTEM FUNCTION.

WCDMA Tx Physical Channel Mapping and WCDMA BS Tx Antenna are used for Modulation and spreading WCDMA Channel.

X. WCDMA BS TX ANTENNA SPREADING AND MODULATION.

The WCDMA BS Tx Antenna Spreading and Modulation subsystem performs the following functions:

a. Modulation
b. Spreading by a real-valued orthogonal variable spreading factor (OVSF) code.
c. Scrambling by a complex-valued Gold code sequence
d. Power weighting
e. Pulse shaping

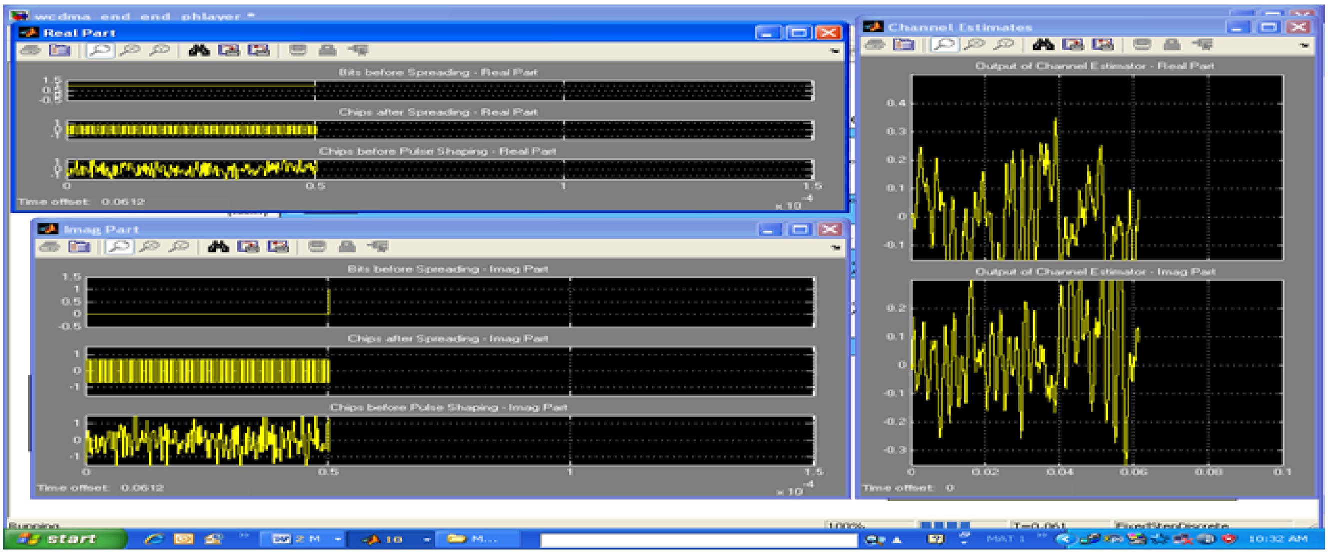

Fig. 2 Plot of Time scopes.

XI. WCDMA CHANNEL MODEL.

The WCDMA Channel Model subsystem simulates a wireless link channel containing additive white Gaussian noise (AWGN) and, if selected, a set of multipath propagation conditions. You can modify the multipath profile with the Propagation conditions environment parameter, as described under Parameters in the model.[10]

XII. WCDMA RX ANTENNA.

The received signal at the WCDMA Rx Antenna subsystem is the sum of attenuated and delayed versions of the transmitted signals due to the so-called multipath propagation introduced by the channel. At the receiver side, a Rake receiver is implemented to resolve and compensate for such effect. A Rake receiver consists of several rake fingers, each associated with a different received component. Each rake finger is made of chip correlates to perform the dispreading, channel estimation to gauge the channel, and a derogator that, using the knowledge provided by the channel estimator, corrects the phase of the data symbol. The subsystem coherently combines the output of the different rake fingers to recover the energy across the different delays.[11,12,13]

XIII. WCDMA RX PHYSICAL CHANNEL DEMAPPING AND CHANNEL DECODING SCHEME.

The WCDMA RX Physical Channel Demapping and the WCDMA DL Rx Channel Decoding Scheme subsystem

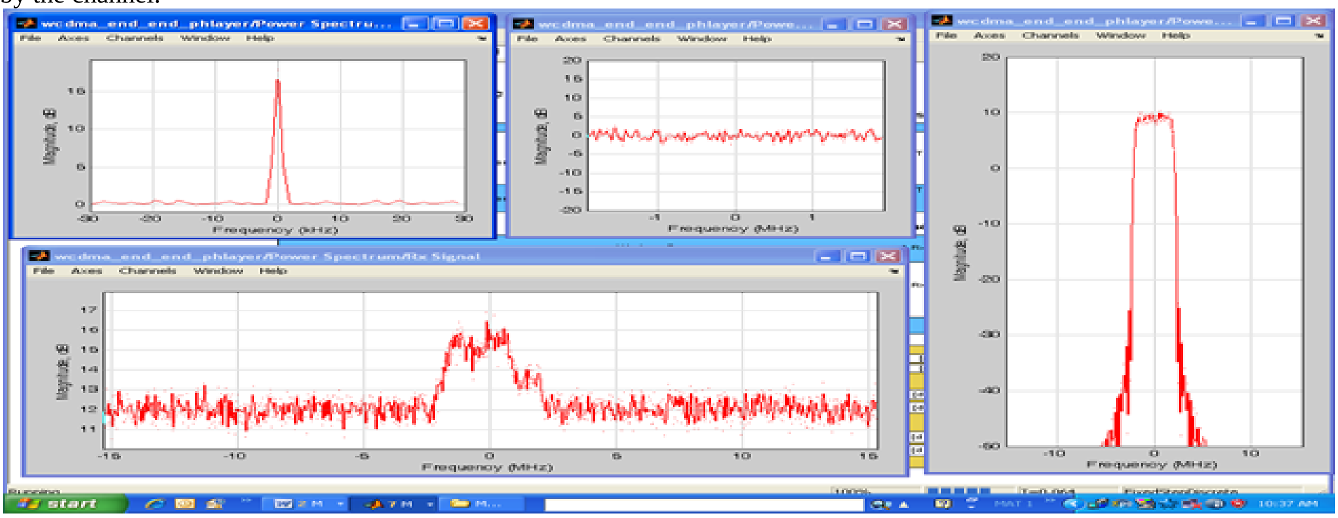

Fig. 4: POWER SPECTRUM PLOTS.

Signal The following scopes in fig 4 display the signal in various ways. To view the scopes in real life, one can double-click the icons when the simulation is running.

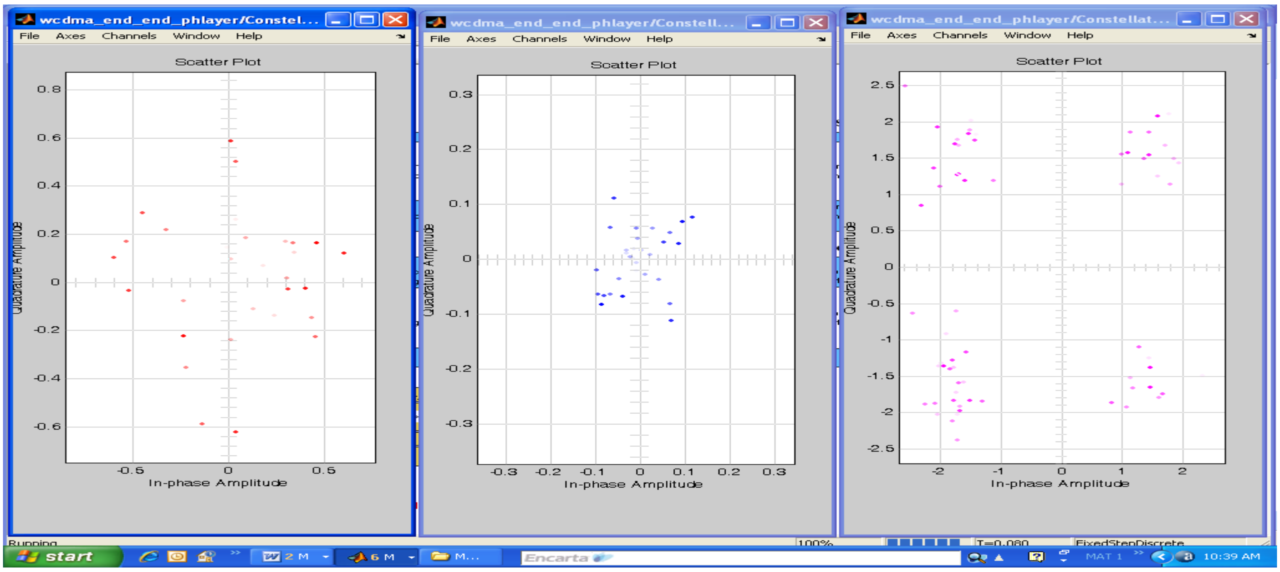

Figure 5: SCATTER PLOTS

Signal can be decoded by performing the inverse of the functions of the WCDMA DL TX Channel Coding Scheme Subsystem, as described above.

Figure 3 shows the results of the BER computation block associated with each transport channel separately.

Figure 4 shows the bit stream before spreading, after spreading, and after combining the different weighted physical channels. It shows both the real and the imaginary part separately. It also displays both the real and the imaginary part of the output of the channel estimator for the first rake finger.[12]

XIV. Power Spectrum Plots.

Fig 3 Shows the power spectrum of the signal before spreading, after spreading, after pulse shaping, and at the input of the receiver antenna.

XV. Time Scopes.

Time scope in figure 2 shows the bit stream before spreading, after spreading, and after combining the different weighted physical channels. It shows both the real and the imaginary part separately. It also displays both the real and the imaginary part of the output of the channel estimator for the first rake finger.

XVI. Scatter Plots.

Fig 5 Shows the constellation at signal at the output of the data correlator, after phase derotation, and after amplitude correction.

XVII. SIMULATION USING M FILES.

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

Based on data generated by computer simulation of W-CDMA models, relationship for ray tracing model using QPSK and QAM modulation techniques between BER as a function of the following parameters are obtained for NLOS.

Performance Analysis of QPSK modulation technique of WCDMA in AWGN

Fig 5 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.

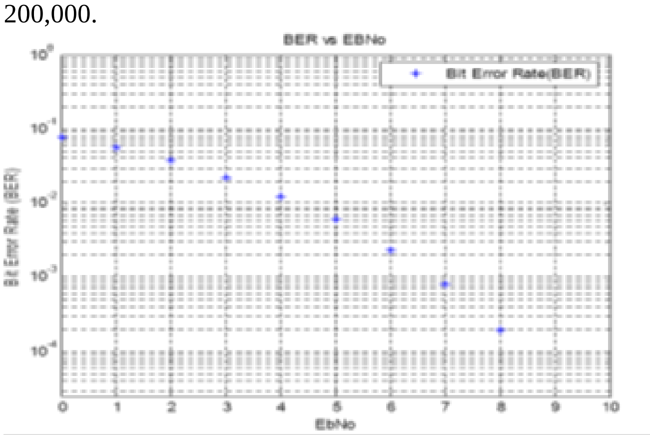

Fig. 6: Performance of W-CDMA in ray-tracing model AWGN Channels for 1 user.

XVIII. Performance Analysis of QPSK modulation technique of WCDMA in AWGN and Multipath Fading Channel.

The simulation of BER is done in the range of 0 to 20 of Eb/No. The BER graphs of various Doppler shifts are simulated on the same graph as it is shown in figure 6.

The y axis of BER is blown up to depict the behavior in Doppler shift environment. 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 is shown in fig 6.

XIX. Performance Analysis Comparison of QPSK Modulation Technique of WCDMA between AWGN and Rayleigh Fading Channel.

Rays between AWGN and Multipath Rayleigh Fading Channels for 1 user is shown in figure 7.

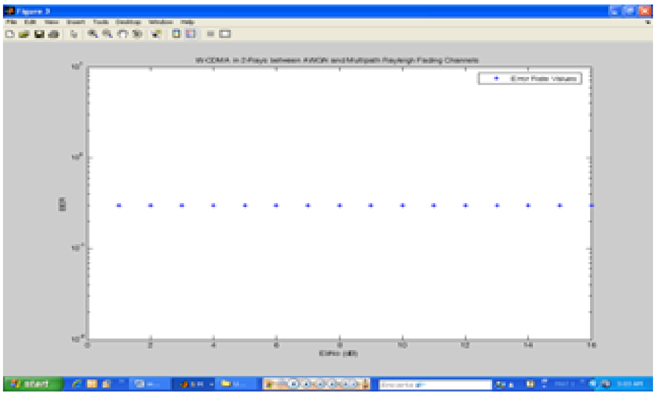

Fig. 7: Performance of W-CDMA in 2-Rays Multipath Rayleigh Fading Channels for 1 user.

Simulation result represent evaluation on BER vs. SNR for 2-ray Multipath Rayleigh channel for 5 users when the number of data is 100,000 in fig 8.

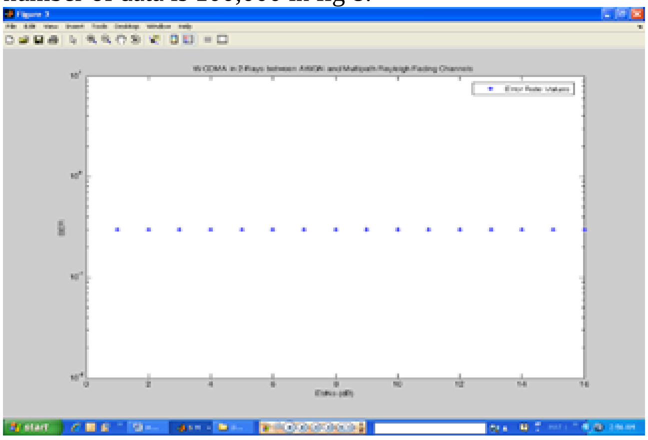

Figure 8: Performance Comparison of W-CDMA in 2-Rays between AWGN and Multipath Rayleigh Fading Channels for 5 users.

We cannot obtain any results in this scenario as the results are inconsistent and uncertain. Therefore, we cannot investigate the performance of W-CDMA for this scenario.[13]

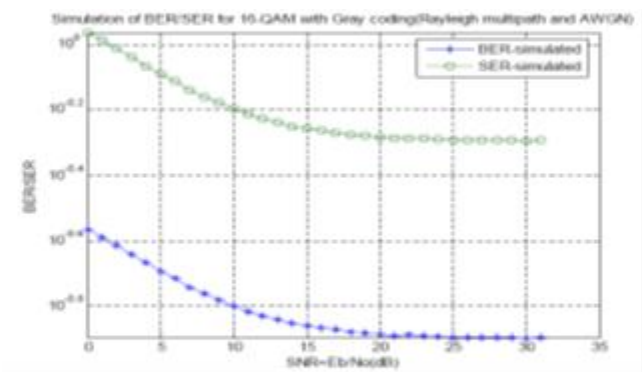

Fig. 9: Performance Comparison of 16-QAM in

XX. W-CDMA System in AWGN Channel XVII Analysis and 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 access in W-CDMA can be studied more dynamically.[14,15]

XXI. CONCLUSION

In telecommunication field the major challenges is to convey the information as efficiently as possible through limited bandwidth, though some of the 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 our thesis we analyze two modulation techniques, 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 proned 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.

In general, the reason for the poor performance of W-CDMA system when the number of users increases is because the value of cross correlation between the codes is not 0 which thus cause interference. Many studies and researches have showed that 16-QAM and higher version of QAM modulation technique is a primary candidate for high speed data transmission in 3G mobile communication. 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.

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