Performance Analysis on High Data Rates Modulation Techniques of Wideband Code Division Multiple Access (W-CDMA) in Multipath Rayleigh Fading Channel

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Abstract— **This paper presents the study of the performance quality of high data rate modulation schemes of WCDMA system. 16QAM and QPSK modulation technique are considered. This system is assign to Additive White Gaussian Noise, AWGN and multipath Rayleigh fading channel. This simulation and evaluation of Bit Error Rate (BER) and Signal to Noise Ratio (SNR) are using MATLAB 6.5. This project will analysis of Quadrature phase shift keying and 16 Quadrature Amplitude modulations which are being used in Wideband Code Division Multiple Access system, so that the system can go more suitable modulation technique to suit the channel quality and can deliver the optimum and efficient data rate to mobile terminal. For this paper, the suitable high data rate modulation scheme in the AWGN and multipath Rayleigh fading channel of WCDMA is QPSK modulation techniques. When the channel is subjected to multipath Rayleigh fading with Doppler shift, the performance of QPSK and 16QAM in WCDMA system are degrades when the mobility is increased from 60km/hr to 120km/hr. From the simulation result, it can be concluded QPSK is suitable modulation techniques compared to 16QAM in multipath Rayleigh fading with Doppler shift.**

Keywords-component; Multipath Rayleigh fading, Additive White Gaussian Noise (AWGN), Wideband Code Division Multiple Access (W-CDMA), Signal to Noise Ratio (SNR), Bit Error Rate (BER), Quadrature Phase Shift Keying (QPSK), and Mary Quadrature Amplitude Modulation (16QAM).

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 such as like broadband frequency spectrum where it has high resistance to multipath fading where, this was not present in straight narrowband signal of 2nd generation (2G) communication system [1].

High data rate signal transmission can be transmitted over the air by using W-CDMA system, and enabling of multimedia rich applications such as video streams and high resolution pictures to users. Other than that we need suitable modulation 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 and 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. 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 [5].

From the previous research about the WCDMA and the multipath fading channel is to investigate the bit error rate (BER) of a WCDMA system at both uplink and downlink for different channel conditions at a multiuser environment. Simple rake diversity combining is employed at the receiver. Performance improvement due to error correction coding scheme is also shown [1].

This project is focus on the study of the performance quality of high data rate modulation schemes in Additive White Gaussian Noise (AWGN) and Multipath Rayleigh Fading. Modulation schemes that will be studied are 16QAM (Quadrature Amplitude Modulation) and QPSK (Quadrature Phase Shift Keying). The objectives of this project are determined which the modulation technique has good performance in Additive White Gaussian Noise (AWGN) with Multipath Rayleigh Fading. The second one is analysis performance of WCDMA system in AWGN and multipath

Rayleigh fading channel with Doppler shift (60km/hr, 90km/hr and 120km/hr) for QPSK and 16QAM modulation scheme.

Then, it compares the two modulation schemes that have good performance in multipath Rayleigh Fading channel with Doppler shift.

II. METHODOLOGY

For this project, the WCDMA wireless cellular system models will be used. The models are WCDMA systems in AWGN and Multipath Rayleigh Fading. This model is using two modulation techniques. There are M-ary Quadrature Amplitude modulation (QAM) and Quadrature phase shift keying (QPSK). The MATLAB 6.5 has been identified to simulate W-CDMA model based on related theories, formulae and parameters. Two approaches are adopted in this project. Firstly, the simulation is simulated using Simulink and it follows with simulation using m files. The Simulink using to build the block diagram for each models and for generate the BER versus SNR graph are using m files. Figure 1 show the flowchart for overall simulation process.

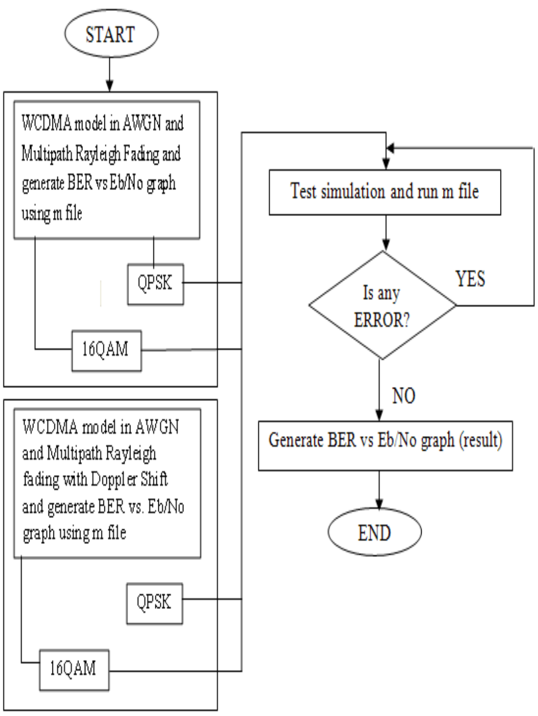

Figure 1 : The flowchart for overall simulation process

First, a graphical model of the system is simulated, using the Simulink model editor. The models show the time-dependent mathematical relationships among the system's inputs, states, and outputs. Then, Simulink is used to simulate the behavior of the system over a specified time span. Simulink uses information entered into the model to perform the simulation.

A. WCDMA model in AWGN channel and Multipath Rayleigh Fading channel

In this model, both transmitter and receiver part are built based on the system model as shown in Figure 2 and Figure 3 (refer to the next page), multipath Raleigh fading channel block is used. This model is divided transmitter part, channel part and receiver part. The assumptions made for this model of simulation are stated as follows:

1] Evaluation of the performance is made on one user in the multi-user environment. It considers the rest of the users contribute the multi user interference to the reference user in the system.

2 In this simulation, only downlink (base station to mobile station) transmission is considered.

The transmitter parts for this model are User Data Sequence Generator, Spreading Sequence Generator, and Spreader. The signal is produced by Bernoulli Data Generator. The Bernoulli Binary Generator block generates random binary numbers using a Bernoulli distribution.

The PN Sequence Generator block generates a sequence of pseudorandom binary numbers [4]. A pseudo-noise sequence can be used in a pseudorandom scrambler and descrambler. It can also be used in a direct-sequence spread-spectrum system. The PN Sequence Generator block uses a shift register to generate sequences. The XOR block has been used to operate like a spreader.

In this simulation, the Quadrature Phase Shift Keying (QPSK) Baseband modulator and 16QAM modulator baseband have been used. The M-PSK Modulator Baseband block modulates using the M-ary phase shift keying method. The output is a baseband representation of the modulated signal. The M-ary number parameter, M, is the number of points in the signal constellation. This block uses the baseband equivalent block, M-PSK Modulator Baseband, for internal computations and converts the resulting baseband signal to a baseband representation. The parameters in this block are the same as those of the baseband equivalent block M-ary number, Input type and Constellation ordering. This block uses a baseband representation of the modulated signal as an intermediate result during internal computations.

For channel part, this model used the AWGN block and multipath Rayleigh fading block. The last part for this model is the receiver part**.** This part is divided into QPSK Demodulator, 16-QAM Demodulator, Despreader, Error Rate Calculation, and Display. The M-PSK Demodulator Baseband block demodulates a signal that was modulated using the M-ary phase shift keying method and this block same with the M-

PSK Demodulator Baseband block but it has the reverse function.

As in QPSK demodulator, similar design procedure will be employed for 16QAM. In order to recover the data symbols from the spreading signal, the process of dispreading is applied. When this right code is chosen with right synchronization, in this case delay is one output period the output from the 'XOR' block will be exactly the same as the source signal.

The Error Rate Calculation block compares input data from a transmitter with input data from a receiver. It calculates the error rate as a running statistic, by dividing the total number of unequal pairs of data elements by the total number of input data elements from one source. The Display block shows the value of its input, the amount of data displayed and the time steps at which the data is displayed

B. WCDMA model in AWGN channel and Multipath Rayleigh Fading with Doppler Shift (60km/hr,90km/hr and 120km/hr)

This model is simulated in the baseband simulation environment. The input of multipath Raleigh fading block requires complex signal which can be obtained through baseband simulation only. The value of Maximum Doppler shift (Hz) is setting through the multipath Rayleigh Fading block. The equation below [2] to determine the Maximum Doppler shift (Hz) as below :

$$Fd = (vf/c)\cos\theta \quad (1)$$

where f is the transmission carrier frequency and c is the speed of light. The Doppler frequency is the maximum Doppler shift arising from motion of the mobile. Fd is the Maximum Doppler shift (Hz). For third generation systems, assume that the transmission carrier frequency, f = 2GHz. Assume mobile moves at three different speed, v = 60 km/hr, v = 90 km/hr and v = 120 km/hr. Angle θ set to 60 degree. The calculations for each speed is :

(a) v = 60km/hr

$$Fd = \frac{60\ \text{km/hr} \times 2\text{GHz}}{3\times10^{8}\ \text{ms}^{-1}}\cos 60° \quad (1(a))$$

$$= 55.56\text{Hz}$$

(b) v = 90km/hr

$$Fd = \frac{90\ \text{km/hr} \times 2\text{GHz}}{3\times10^{8}\ \text{ms}^{-1}}\cos 60° \quad (1(b))$$

$$= 83.33\text{Hz}$$

(c) v = 120km/hr

$$Fd = \frac{120\ \text{km/hr} \times 2\text{GHz}}{3\times10^{8}\ \text{ms}^{-1}}\cos 60° \quad (1(c))$$

$$= 111.111\text{Hz}$$

The BER versus Eb/No graph is generated from the program language in m files, this program language is already have in library browser in MATLAB. This m file declares the parameters defined in the simulink's block diagram check box.

III. RESULTS AND DISCUSSIONS

As a result, suitable modulations techniques will be determined and concluded based on BER that will be plotted as a function of Eb/No.

A. WCDMA system using QPSK and 16 QAM modulation technique in AWGN and Multipath Rayleigh Fading channel

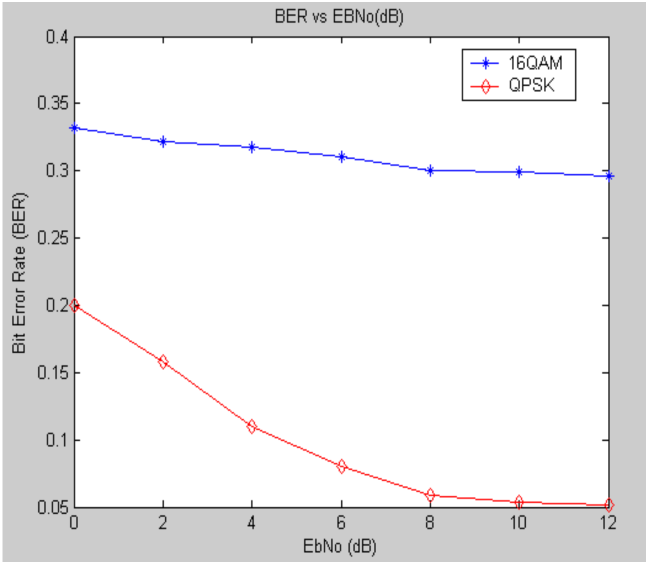

Figure 4 : Performance of WCDMA system using QPSK and 16QAM in Multipath Rayleigh Fading channel

B. WCDMA system using QPSK modulation technique in AWGN channel and Multipath Rayleigh Fading with Doppler Shift (60km/hr,90km/hr and 120km/hr)

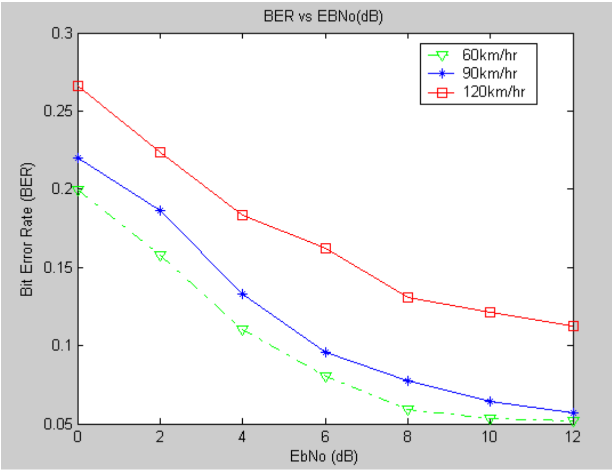

Figure 5 : Performance of WCDMA system using QPSK in AWGN channel and Multipath Rayleigh Fading with Doppler Shift (60km/hr,90km/hr and 120km/hr)

C. WCDMA system using 16QAM modulation technique in AWGN channel and Multipath Rayleigh Fading with Doppler Shift (60km/hr,90km/hr and 120km/hr)

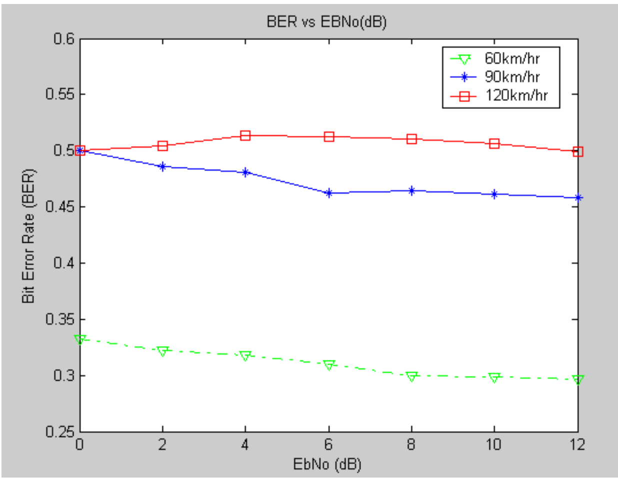

Figure 6 : Performance of WCDMA system using 16QAM in AWGN channel and Multipath Rayleigh Fading with Doppler Shift (60km/hr,90km/hr and 120km/hr)

D. Comparison between QPSK and 16QAM modulation techniques of WCDMA system using 16QAM modulation technique in AWGN channel and Multipath Rayleigh Fading with Doppler Shift (60km/hr,90km/hr and 120km/hr)

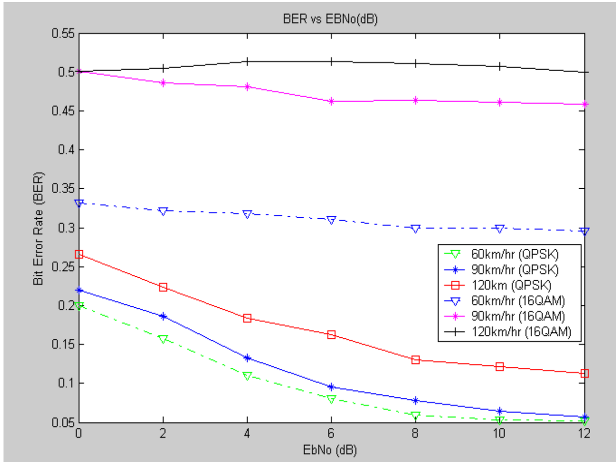

Figure 7 : Performance of WCDMA system using 16QAM in AWGN channel and Multipath Rayleigh Fading with Doppler Shift (60km/hr,90km/hr and 120km/hr)

For each figure is similar to the theory because of the value of the BER will decrease when the value of Eb/No is increase. Refer to figure 4, it compare between QPSK and 16-QAM modulation schemes shows that 16QAM performs very poorly in multipath Rayleigh fading channel. It is because the value of BER for 16QAM modulation technique is bigger than QPSK modulation technique when the value of Eb/No is increase . The 16QAM performs poorly because it is supposed that the variation of amplitude with phase causes errors in the constellation of 16QAM signal. The reason poor performance of 16QAM of WCDMA system in multipath Rayleigh fading channel is basically due to the interference between adjacent carriers phase in the constellation of 16QAM.

The performance of WCDMA system using QPSK modulation techniques in AWGN and multipath Rayleigh fading channel with Doppler Shift (60km/hr, 90km/hr and 120km/hr) is shown in figure 5. Then, the figure 6 shows that the performance of WCDMA system using 16QAM modulation techniques in AWGN and multipath Rayleigh fading channel with Doppler Shift (60km/hr, 90km/hr and 120km/hr). The speed is increased from 60km/hr to 120km/hr, the performance of QPSK and 16QAM in WCDMA system is performs poorly.

For figure 7, it compared performance between QPSK and 16QAM in multipath Rayleigh fading with Doppler Shift (60km/hr, 90km/hr and 120km/hr). It shows that the QPSK is suitable modulation technique in multipath Rayleigh fading with Doppler shift (60km/hr, 90km/hr and 120km/hr). A sound approach is needed to be used in 16QAM of WCDMA system to ensure zero or minimal interference between adjacent 91 carriers phase in the constellation of 16-QAM. It is suggested that error correction coding such as convolutional coding or turbo coding is used in this system to ensure better performance of 16QAM modulation technique of WCDMA system. But for this project, the there will be no error correction coding or channel coding in use for this simulation model.

III. CONCLUSION

From this project, the performance of WCDMA system in multipath Rayleigh fading channel shows that QPSK modulation technique has a better performance compared to the 16QAM. When the channel is subjected to multipath Rayleigh fading with Doppler shift (60km/hr, 90km/hr and 120km/hr, the performance of QPSK in WCDMA system are degrades when the mobility is increased from 60km/hr to 120km/hr. So that the QPSK is suitable modulation technique compared to 16QAM in multipath Rayleigh fading with Doppler shift.

For future recommendations, it is suggested that error correction scheme such as convolutional coding and turbo coding particularly with 16QAM are implemented in WCDMA system. Besides that, A rake receiver or a smart antenna (Multiple Input and Multiple Output) is recommended to be used in this system to utilize the delayed signals arrived at the antenna caused by multipath Rayleigh fading.

REFERENCES

[1] Fakhrul Alam, Brian D. Woerner and W.H. Tranter, BER Simulation for WCDMA System in Multipath Fading Channel, Mobile and Portable Radio Research Group Virginia Polytechnic Institute and State University Blacksburg, VA-24061-0350, USA, 2001.

[2] William CY Lee, Mobile Communications Engineering Theory and Applications, Second Edition, John Wiley,1998.

[3] Wayne Tomasi, Electronic Communications Systems Fifth Edition, DeVry University, Phoenix, Arizona, 2004.

[4] The MathWorks , MATLAB 6.5, Library Browser, The MathWorks, Inc. Mail 3 Apple Hill Drive, Natick, 2002.

[5] http://www.absoluteastronomy.com/topics/Additive_white_Gaussian_noise