Simulation and Analysis Performance of 4-QAM, 8-PSK and 1024-QAM by Using Reed Solomon Codes in WCDMA Environment

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Abstract— **This project illustrates the simulation and performance of 4-QAM, 8-PSK and 1024-QAM in WCDMA environment. This model consists of transmitter, transmission channel and receiver. This simulation is dealing with three channels. Channel 1 is using 4-QAM meanwhile channel two is using 8-PSK and channel three is using 1024-QAM. Reed Solomon codes is use to encode and decode the signal of this three channels before modulation and after demodulation process. The main objective of this project is to identify and compare which channel is better by analyzing the performance of the channels in term of bit error rate (BER). This project simulated by using Matlab Version 7.6.**

Keywords – Additive White Gaussian Noise (AWGN), Rayleigh Fading, 4 Quadrature Amplitude Modulation (4-QAM), 8 Phase Shift Keying (8-PSK) and 1024 Quadrature Amplitude Modulation (1024-QAM)

I. INTRODUCTION

A. *Digital Communication System*

Digital communication is the system where high frequency analog carriers are modulated by a low frequency of digital information signal. Digital communication systems consist three primary sections, which is a source, transmission medium and destination [1]. Compared to analog, digital communication system is more robust. Digital system is immune to noise. It is less susceptible to interference compared to analog and has better suited for processing and combination of signal in term of multiplexing technique. Besides, it is more resistance due to signal regeneration [2]. Digital communication system has higher data rate transmission, more power and better quality and coverage.

B. *Modulation Technique*

Modulation is the process of varying a periodic waveform in order to use that signal to convey a message. Normally a high frequency sinusoid waveform is used as carrier signal. The three key parameters of a sine wave are its amplitude, its phase and its frequency, all of which can be modified in accordance with a low frequency information signal to obtain the modulated signal [3]. There are several types of digital modulation techniques which are Phase-Shift Keying (PSK), Frequency-Shift Keying (FSK), Amplitude-Shift Keying (ASK) and Quadrature Amplitude Modulation (QAM). For this project, 4-QAM, 8-PSK and 1024-QAM is used to modulate a signal.

C. *Wideband Code Division Multiple Access (WCDMA)*

WCDMA is a wideband spread-spectrum channel access method that utilizes the direct-sequence spread spectrum method of asynchronous code division multiple access to achieve higher speeds and support more users compared to most time division multiple access (TDMA) schemes used today. WCDMA is an enhancement of CDMA, which will produce much more benefits. It is a direct spread technology to satisfy ever-increasing demands for higher data rates [4]. It will spread its transmissions over a wide, 5MHz carrier. Using WCDMA, user's information bits are spread over wider bandwidth compared to CDMA [5]. In reality, WCDMA networks are true multiservice network whose capabilities are unmatched by any other technology. It will permit very high-speed multimedia services such as full-motion video, Internet access and video-conferencing [6]. The project is going to be done to determine whether 4-QAM, 8-PSK or 1024-QAM modulation type can perform well in WCDMA. WCDMA is used as a multiple access for all the modulation types.

D. Reed Solomon Codes

Reed-Solomon codes are *nonbinary cyclic* codes with symbols made up of *m*-bit sequences, where *m* is any positive integer having a value greater than 2. R-S (*n*, *k*) codes on *m*-bit symbols exist for all *n* and *k* for which

$$0 < k < n < 2m + 2 \qquad (1)$$

where *k* is the number of data symbols being encoded, and *n* is the total number of code symbols in the encoded block. For the most conventional R-S (*n*, *k*) code,

$$(n, k) = (2m - 1, 2m - 1 - 2t) \qquad (2)$$

where *t* is the symbol-error correcting capability of the code, and $n - k = 2t$ is the number of parity symbols. An extended R-S code can be made up with $n = 2m$ or $n = 2m + 1$, but not any further [7]. In this project, all the parameters are assigned with a considered value. Where m=3, n=7, k=3.

E. Matlab Simulation

Matlab are very powerful mathematical computation tools and provide extensive capabilities for generating graph [8].It is a high-performance language for technical computing. It is a software package of simulation, analyzing and modeled in continuous time, sampled time or hybrid [9].By using Matlab, a comprehensive communication model via WCDMA with Reed Solomon Codes can be built up to evaluate the performance of 4-QAM, 8-PSK and 1024-QAM by comparing the Bit Error Rate (BER) for all channels.

F. Rayleigh Fading and Additive White Gaussian Noise (AWGN)

AWGN channel model is one in which the information is given a single impairment: a linear addition of wideband or white noise with constant spectral density and a Gaussian distribution of noise samples. Meanwhile Rayleigh fading is a reasonable model when there are many objects in the environment that scatter the radio signal before it arrives at the receiver. It assume that the magnitude of a signal that has passed through such a transmission medium will vary randomly or fade . In this project, both AWGN and Rayleigh fading are combined to be the additive noise at air interface.

II. SCOPE OF WORK

This project focused on the study of identifying the performance and development of 4-QAM, 8-PSK and 1024-QAM in WCDMA environment. Before the implementation this project, several important works must be completed to make sure it is functioning. Theory of communication must be well acknowledged by doing some literature review on digital communication especially for 4-QAM, 8-PSK and 1024-QAM modulation technique using Reed Solomon codes. The success of this project can be determined by comparing the theoretical and simulated results. It is important to be knowledgeable in Matlab programming. The main objective of this project is to make observation and analyzing the performance of 4-QAM, 8-PSK and 1024-QAM in WCDMA by using Reed Solomon codes in AWGN and Rayleigh fading channel. By comparing these three channels, a better modulation and evaluation of performance in term of Bit Error Rate (BER) through simulation in Matlab can be determined.

III. METHODOOGY

A. Block Diagram and Flow Chart

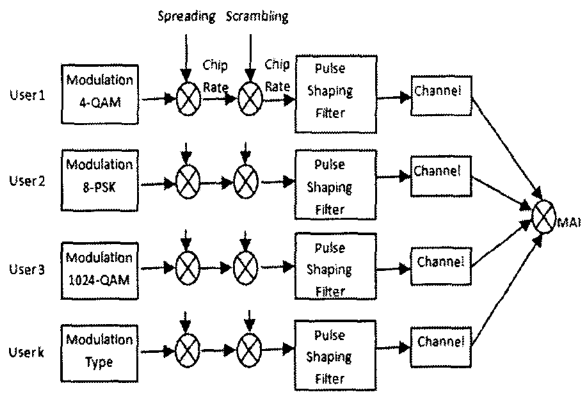

Figure 1: Transmitter of WCDMA Channel Model

In this project, WCDMA model is constructed for simulation using Matlab 7.6. Transmitter of WCDMA channel with k users is shown in Figure 1. User 1 (Channel 1) is for 4-QAM modulation technique, User 2 (Channel 2) is for 8-PSK modulation techniques and User 3 (Channel 3) is for 1024-QAM modulation techniques. In WCDMA, more messages can be transmitted at the same time. Each message is differ by each scrambling code. Both channels will generate spread spectrum by multiplying each modulated signals with scrambling code to provide randomization so that interference would be uniform before it is going to be transmitted. In this project, Pseudorandom codes (PN) is used as scrambling code [10]. Then, signals will be composed at the summing point (MAI) and ready to be transmitted. At the receiver side, the process is vice versa. Hence, the results of the process will be analyzed.

	Channel	Input message (k)	Code word (n)
4-QAM	1	3	7
8-PSK	2	3	7
1024-QAM	3	3	7

Table 1: Parameters for Reed Solomon coding system in 4-QAM, 8-PSK and 1024-QAM modulation scheme

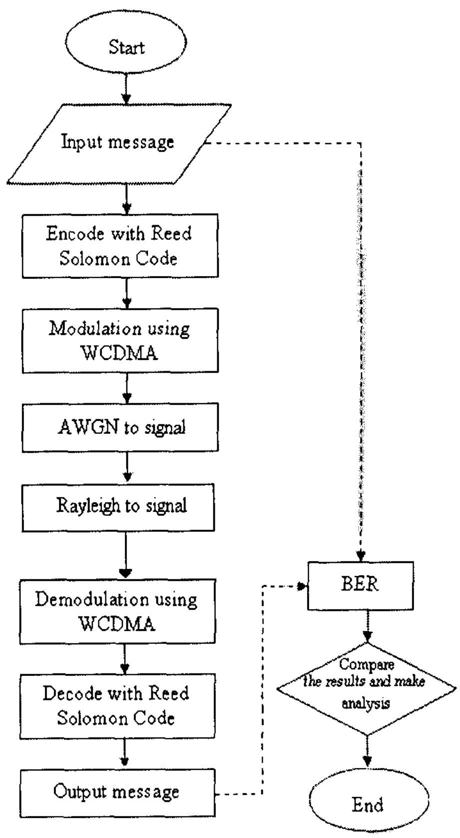

Figure 2: Program flow chart for simulation

Figure 2 shows the program flow for simulation. Simulation is started by generating input random signal for channel 1, 2 and 3 with input message k=3 and codeword n=7. The input signal is set to be random for the reason to generate more messages to compare the performance between all modulation techniques. Reed Solomon code is used to perform encoding and decoding process. Input message length will change from 3 bits to 7 bits after encoded. Then, both signals will be modulated in WCDMA. WCDMA will take part to convert digital signal to analog signal before transmitting. At the air interface, signals will be added with AWGN and Rayleigh fading. At receiver end, demodulation process will convert back the analog signal to digital signal by interpreting it into codeword. Forward error correction (FEC) will be conducted to check the codeword. The corrected codeword will be decoded to get the output. Hence, to get BER, output message will be compared to the original message.

IV. Result and Analysis

A. Simulation Results

Results from simulation were attached in APPENDIX (Figure 7 – Figure 24).

B. Analysis of Result

After completing the simulation, the plotted graph can be observed in appendix. Figure 6,7 and 8 shows that the three bits input signal in Figure 3, 4 and 5 were encoded to a corresponding codeword with vector length of 7 respectively. Referring to Figure 12,13 and 14, it shows that spread spectrum can transmit a lot of signals at the same time. To realize the simulation as in real world, additive noise (AWGN) and Rayleigh fading were added during simulation where the effect can be seen in Figure 16 and 17. By comparing Figure 15 and 16, it can be observed that while AWGN is added in the simulation (Figure 16), the amplitude of the plotted signal is slightly higher compared to signal without additive noise (Figure 11). While injecting Rayleigh fading (Figure 17), the plotted graph shows that there was a significant decrease in amplitude of signal. It clearly shows the effect of Rayleigh fading.

C. Performance Result

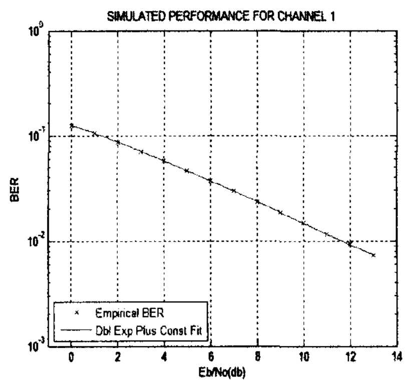

Figure 3 : Simulated performance for channel 1

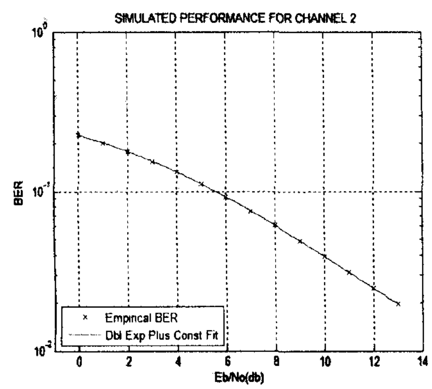

Figure 4 : Simulated performance for channel 2

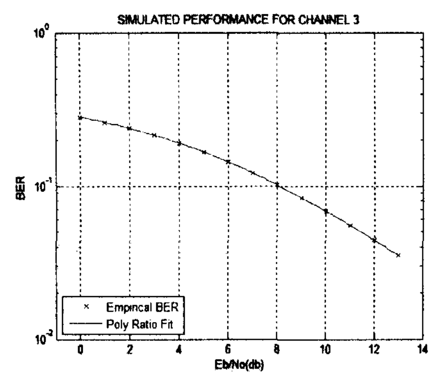

Figure 5 : Simulated performance for channel 3

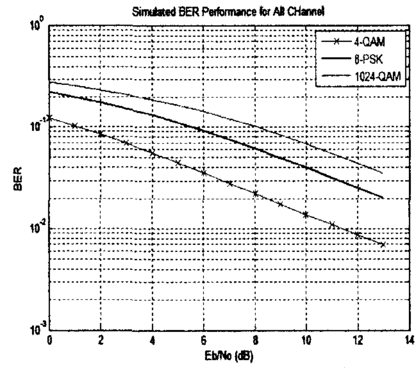

Figure 6 : Combination of Channel 1, Channel 2 and Channel 3

Modulation Technique / EbNo(dB)	4-QAM	8-PSK	1024-QAM
3	0.0865	0.1769	0.2372
5	0.0571	0.1312	0.1898
13	0.0093	0.0248	0.0440

Table 2 : The performance Comparison of 4-QAM, 8-PSK and 1024-QAM in terms of BER

Figure above shows that the simulated performance of 4-QAM in Channel 1, 8-PSK in Channel 2 and 1024-QAM in Channel 3.Performance between 4-QAM, 8-PSK and 1024-QAM can be observed by analyzing plotted BER in Figure 3, Figure 4 and Figure 5. By referring at BER equal to 10^{-1} in all figure, 4-QAM shows 1dB for the value of En/No while 8-PSK shows 5dB and 8dB for 1024-QAM. Thus, the performance of 1024-QAM in the WCDMA is better than other modulation technique.

V. DISCUSSION

From the observation and analysis of this project, this objective of this project is achieved. This project manage to compare which channels have better performance. Comparison by theory also state that 1024-QAM gives better performance compared to other channel. 4-QAM which referred as QPSK or 4-PSK transmits two bits on each carrier rather than 8-PSK, which transmit three bits on each carrier and 1024-QAM transmit 10 bits[12]. Using 8-PSK, more output phases are possible and it can undergo almost $\pm 22.5^{\circ}$ phase shift during transmission and can retain its integrity.

VI. CONCLUSION

The objective of this project is achieved. The performance for both modulation schemes had been analyzed. Using Matlab all the simulation process was conducted effectively. From the simulation and performance result, it shows which channel have better performance in term of BER and EbNo, but in theoretical we know that that 8-PSK is more robust compared to 4-QAM/QPSK or 1024-QAM.. For example in satellite broadcast application. In PSK, the carrier amplitude is not modulated with information signal, hence the amplitude distortion in satellite channel is not a problem for both scheme. However, 8-PSK give better performance since the spectral efficiency for QPSK is low [13]. The purpose of spread spectrum in WCDMA is to overcome issue regarding noise and interference in the channel. It is used as a multiple access for both 4-QAM, 8-PSK and 1024-QAM. Using WCDMA, more data can be transmitted at the same time since the bandwidth offered is larger (5MHz) compared to CDMA which offer 1.25MHz. In modern communication, WCDMA is very affective to fulfill the needs of higher data transfer rate. It offers 7.2Mbps for downlink access and 3.5Mbps for uplink access.

	QAM	PSK
Advantage	High bit rates, proven technology, chosen by 802.16.1 and ETSI BRAN Hyper access Efficient, dynamic capacity allocation for burst sources [13].	Constant amplitude Data information is hidden in the phase component Robustness to noise and interference because noise in general affects the amplitude and not the phase component [12].
Disadvantage	Susceptible to multipath interference (needs an equalizer) Susceptible to interference (needs interference avoidance technique) [13].	8-PSK has higher incidence of symbol errors compared to QPSK for the same SNR [14].

Table 3: Advantage and disadvantage of QPSK/QAM and PSK

VII. FUTURE WORK

This project is applied the fundamental concepts of digital communication system. This project can be further explored by using higher M-ary QAM since it is more robust compared to 8-PSK. For example, *-QAM has higher peak-to-peak power ratio than 8-PSK and it is more immune to the effect of phase noise. This project also can be improved in terms of performance of higher order QAM when using Reed Solomon Codes as forward error correction.

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