Performance Study of BPSK and 8-PSK Using Cyclic Codes in CDMA Environment

Suzi Seroja Sarnin, *IEEE*, Fazri Abdul Latif, Norfishah Ab. Wahab, *IEEE*, Wan Norsyafizan W. Muhamad, *IEEE*, Noor Hafizah Abdul Aziz, *IEEE*, Nani Fadzlina Naim, *IEEE*, Muhamad Adib Haron, *IEEE*,

Abstract— **This paper highlight the performance of BPSK and 8-PSK in Code Division Multiple Access (CDMA) environment by using Cyclic Codes as the Forward Error Correction (FEC). This model consists of transmission medium, transmitter and receiver. Cyclic codes is use to encode and decode the digital signal of the two channels before modulation and after demodulation process. The main objective is to compare and identify which modulation is better by analyzing the performance of both channels in CDMA environment. The performance of the modulation is analyzed in term of bit error rate (BER) and energy bit to noise density (Eb/No). This paper provides analysis, evaluation and computer simulations in MATLAB**

Index Terms— Bit Error Rate, Cyclic Code, Code Divison Multiple Access, Additive White Ghaussian Noise, Forward Error Correction.

I. INTRODUCTION

Allowing several transmitters to send information simultaneously over a single communication channel is one of the basic concepts in data communication [1]. This means, it allows several users to share a bandwidth of frequencies. This concept is called multiplexing technique. Code Division Multiple Access (CDMA) employs spread-spectrum technology and a special coding scheme (where each transmitter is assigned a code) to allow multiple users to be multiplexed over the same physical channel. In CDMA, they would speak dissimilar languages. People speaking the same language can recognize each other, but not other people. Similarly, in radio CDMA, each group of users is given a shared code. Many codes occupy the same channel, but only users related with a particular. In CDMA it allows multiple users to use a channel in same time and same frequency. A correlation to the problem of multiple access is a room (channel) in which people wish to communicate with each other. To evade misunderstanding, people could take turns speaking (time division), speak at different pitches (frequency division), or speak in different directions (spatial division) [2].

Binary phase shift-keying (BPSK) is the simplest type of PSK. It uses two phases which are separated by 180° and so it can also be known as 2-PSK. BPSK, where N = 1 and M = 2. Therefore, with BPSK, two phases ($2^1 = 2$) are possible for the carrier. One phase represents the logic 1, and the other phases represent the logic 0. It does not particularly matter exactly where the constellation points are positioned, and in this figure below shown on the real axis, at 0° and 180°. This modulation is the most robust of all the PSKs since it takes serious distortion to make the demodulator reach an incorrect decision. It is, however, only able to modulate at 1 bit/symbol, so is unsuitable for high data-rate applications when bandwidth is limited [3].

8-PSK is usually the highest order PSK constellation deployed. With more than 8 phases, the error-rate becomes too high and there are better, though more complex, modulations available such as BPSK and quadrature amplitude modulation (QAM). Although any number of phases may be used, the fact that the constellation must usually deal with binary data means that the number of symbols is usually a power of 2 — this allows an equal number of bits-per-symbol [4].

In a bandpass modulator using 8-PSK, there are eight possible phases (usually equally spaced).The incoming bits are mapped to eight possible symbols (phases) by subdividing the bit stream into groups containing three bits each. The bits enter a serial-to-parallel (S/P) converter where they are passed to three parallel channels labeled I, Q, and C. The bit rate in each of the three channels is fb/3, where fb is the input bit rate. The bits in the I- and Q-channels enter two separate 2-to-4 level converters. When these are combined with the C and −C channels, the 2-to-4 level converters yield two 4-ary PAM signals which are processed by a quadrature modulator for transmission across the channel [5].

With 8-PSK, because the data are divided into three channels, the bit rate in the I, Q, or C bits is equal to one-third of the binary input data rate ($f_b/3$). Because I, Q, and C bits are outputted simultaneously and in parallel, the 2-to-4-level converters also see a change in their inputs (and consequently their input) at a rate equal to $f_b/3$. There is one change in phase at the output for every three data input bits [6].

Manuscript received October 31, 2009. Suzi Seroja Sarnin is with the Universiti Teknologi MARA, 40450 Shah Alam, MALAYSIA. (phone: 603-5543 6011; fax: 603-5543 5077; e-mail: seroja045@salam.uitm.edu).
Norfishah Ab Wahab is with Universiti Teknologi MARA, 40450 Shah Alam, MALAYSIA. (e-mail: fishahahu@salam.uitm.edu.my).

II. CODE DIVISION MULTIPLE ACCESS

The synchronous CDMA model is constructed for simulation where, a CDMA channel with K users sharing the same bandwidth is shown in figure 1. Code 1 is for channel-1 (BPSK) and Code 2 is for channel-2 (8-PSK).

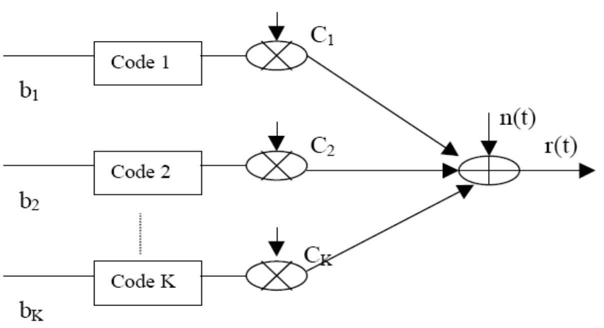

Fig. 1 The CDMA channel model

From Fig. 1 the channels will generate a spread spectrum at Code 1 and Code 2. Then, it will be composed at the summing point before being modulated. The process will continue after demodulation by decomposing the signal into its own channel. Each user in CDMA system uses a different code to modulate their signal. Choosing the codes use to modulate the signal is very essential in the performance of CDMA technique. The best performance will occur when there is good separation between the signal of a desired user and the signals of other users. The separation of the signals is made by correlating the received signal with the locally generated code of the desired user. If the signal matches the desire user's code then the correlation function will be high and the system can extract that signal. If the desired user's code has nothing in regular with the signal the correlation should be as close to zero as possible thus eliminating the signal; this is referred to as correlation. If the code is correlated with the signal at any time offset other than zero, the correlation should be as close to zero as possible.

Basically, modulation techniques used are BPSK and 8-PSK for channel 1 and channel 2 respectively. BPSK is able to modulate at 1 bit/symbol and so unsuitable for high data rate application when bandwidth is limited. BPSK output is given by,

$$\text{BPSK output} = [\sin(2\pi f_a t)] \times [\sin(2\pi f_c t)] \tag{1}$$

In which,

f_a = maximum fundamental frequency of binary

f_c = reference carrier frequency (hertz)

Solving for trig identity for the product of two sine functions,

$$\frac{1}{2}\cos[2\pi(f_c - f_a)t] - \frac{1}{2}\cos[2\pi(f_c + f_a)t] \tag{2}$$

Thus, the minimum double-sided Nyquist bandwidth (B) is,

$$B = \frac{2 f_b}{2} = f_b \tag{3}$$

Where, B is the minimum double-sided Nyquist bandwidth.

For 8-PSK, the baud is equal $f_b/3$. Mathematically, the output of the balance modulator,

$$\theta = (X \sin \omega_a t)(\sin \omega_c t) \tag{4}$$

Where,

$$\omega_a t = 2\pi \frac{f_b}{6} t$$
$$\omega_a t = 2\pi f_c t$$

And

X = ±1.307 or ±0.541

Thus from equation (6), the current before fault, $I\cos(\theta-\alpha)_{bf}$ from E_1 to the monitoring point X is given as,

$$\begin{aligned}\theta &= \left(X \sin 2\pi \frac{f_b}{6} t\right)(\sin 2\pi f_c t) \\ &= \frac{X}{2}\cos 2\pi\left(f_c - \frac{f_b}{6}\right)t - \frac{X}{2}\cos 2\pi\left(f_c + \frac{f_b}{6}\right)t\end{aligned} \tag{5}$$

III. RESULTS AND ANALYSIS

The project consisted of transmitting and receiving element. All the results are obtained from the simulation from the Matlab 7.5. At the transmitter, two input signals (Channel 1 and Channel 2) are generated randomly, and the encoding process for generated signal and modulation process also take part. At the air interface, only AWGN is added and other fading or power density function (PDF) are neglected.

By referring Fig. 4 until Fig. 6(b), all processes of each stage are transformed into its graphical form. It is easier to make an observation and analysis of each stage via graphical. Each figure will describe the process of the signal from the transmitter to the receiver. The spread spectrum transmits many signals in the same radio band at the same time as shown in Fig. 4(a) and Fig. 4(b).

At this stage, the analogy is by considering a few dozen people in a small room all talking in pairs. Each listener knows his or her speaker's voice and can tune out the other voices that interfere with his or her own conversation. This tuning out ability can reduce the noise and the interference between them. The signals assigned to each digital stream have its own distinct voice in the form of digital code, and all of these streams coexist on the same radio channel all at the same time. The effect of spread spectrum signaling is that the modulated coded signal has a much higher bandwidth than the data being communicated. So, it will provide a high capacity data or message in the channel.

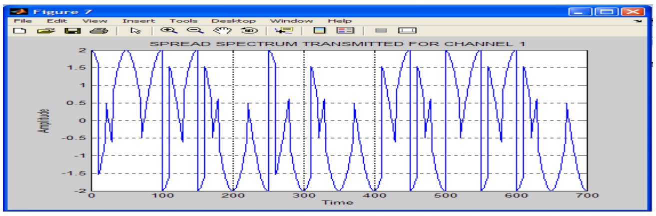

Fig. 4(a) Spread Spectrum for Channel 1

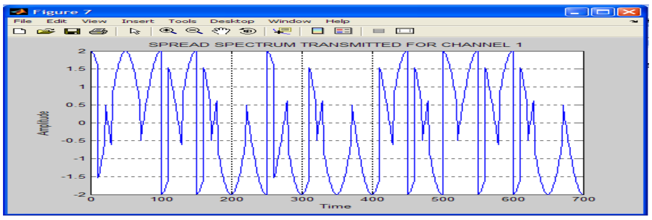

Fig. 4(b) Spread Spectrum for Channel 2

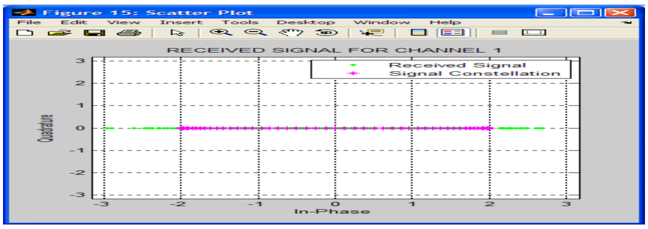

Fig. 5(a) Constellation Diagram for Channel 1

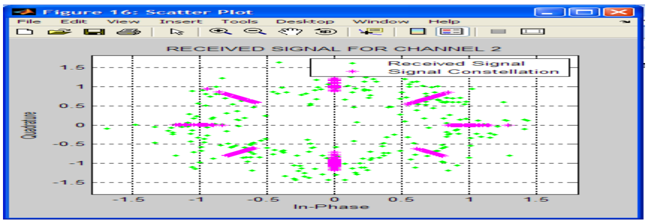

Fig. 5(b) Constellation diagram for Channel 2

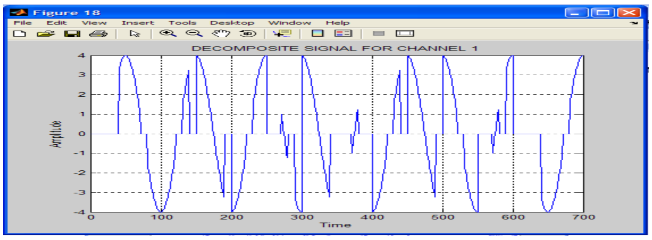

Fig. 6(a) Decomposed Signal for Channel 1

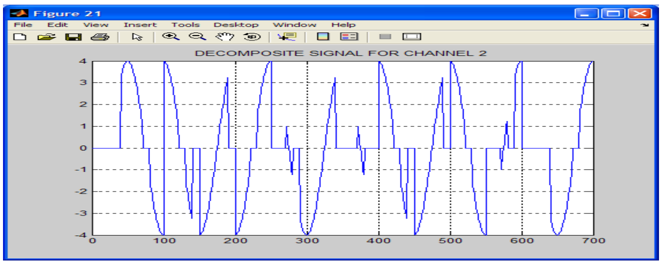

Fig. 6(b) Decomposed Signal for Channel 2

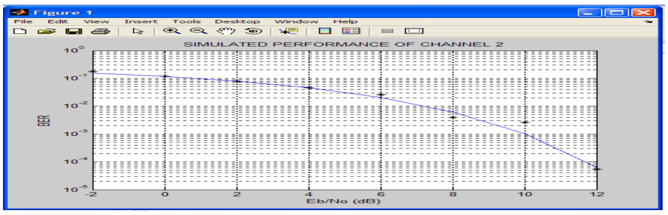

Fig. 7(a) Simulated Performance of Channel 1

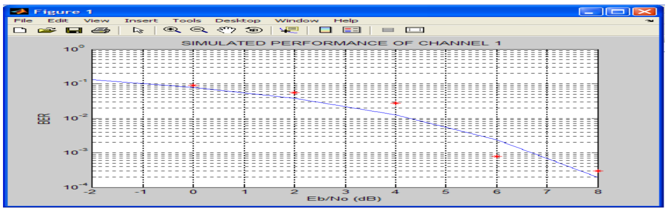

Fig. 7(b) Simulated Performance of Channel 2

A. *Performance Evaluation*

Fig. 7 shows the simulated performance of both channels. The red dot is for 8-PSK and the black dot is for 8-PSK. By make a comparison and observation, 8-PSK will give a better performance compare to BPSK. It proves by theoretical result. Fig. 7(a) shows the plot of BER of BPSK and Fig. 7(b) shows the plot of BER for 8-PSK. By comparing BER, we can see that during Eb/No equal to 4 BER for 8-PSK is $10^{-1.7}$ while BPSK is $10^{-1.4}$. When Eb/No is increase the BER for 8-PSK is decrease rather than BER for BPSK. Results performances can be observed in term of BER for BPSK and 8-PSK are tabulated in Table I.

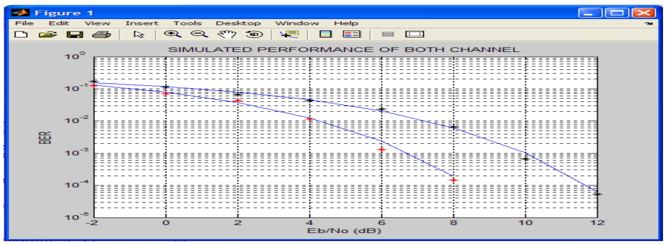

Fig. 8 Simulated performances of both channels

TABLE I
TABULATED PERFORMANCE TABLE

Type of modulation	BPSK	8-PSK	BPSK	8-PSK	BPSK	8-PSK
BER	$10^{-0.9}$	$10^{-0.95}$	$10^{-1.4}$	$10^{-1.7}$	10^{-2}	$10^{-2.5}$
E_b/N_o	-2	-2	4	4	8	8

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IV. CONCLUSION

The objectives of this project are accomplished. All simulation process is done effectively by using Matlab. The simulated, performance and tabulated result is similar to the theoretical result. The result shows that the 8-PSK is more powerful compared to BPSK. CDMA, which uses multiple access for BPSK and 8-PSK, is likely to overcome some issues regarding noise and interference in the channel by introducing the spread spectrum signal. From the results, it has been proven that the 8-PSK satisfy 100% of the better performance comparing BPSK. By using CDMA, more capacity and bandwidth can be achieved and it is very effective for applications in modern communication such as The method also can be used for another system which will be published in our next paper.

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BIOGRAPHIES

Suzi Seroja Sarnin received her B.Eng. (Hon), from Universiti Teknologi Malaysia (UTM), Malaysia in 1999 and M.Sc. (Microelectronic), from Universiti Kebangsaan Malaysia (UKM), Malaysia in 2006 respectively. She is head of programme at the faculty of Electrical Engineering, University Teknologi MARA, Malaysia. Her research interests include Coding Algorithm for CDMA and WCDMA, Mobile Telecommunication, Synchronization Algorithm in OFDMA for the Wimax Technology Application and Wimax Technology Application.

Norfishah Ab. Wahabd received her B.Sc.Eng. from University Teknologi Malaysia, Malaysia in and M.S.c (Telecommunication), from Universiti Teknologi MARA, Malaysia in 2007, respectively. She is currently a lecturer at Universiti Teknologi MARA (UiTM), Malaysia. Her current research interests are Synchronization Algorithm in OFDMA for the Wimax Technology Application and Wimax Technology Application.