Performance Analysis of CDMA System using Direct Sequence Spread Spectrum and Frequency Hopping Spread Spectrum Techniques

Md. Imran Hossain[1], Md. Imran Hossain[2] and Md. Mojahidul Islam[3]

[1] Pabna science and technology university, Bangladesh

Received: 10 December 2012 Accepted: 31 December 2012 Published: 15 January 2013

Abstract

In digital communication system, selection of the most appropriate access method is a challenging task. To meet this challenge we have to be familiar with the technologies and system architectures on the CDMA digital cellular system. The demand for high speed mobile wireless communications is rapidly growing. DS-CDMA plays the best competitive role for achieving the high data capacity and spectral efficiency requirements for communication systems. This paper represents the performance analysis of CDMA using direct sequence and frequency hopping technique in a Fading AWGN Channel. It also concerned with how well DSCDMA performs when transmitted over an Additive White Gaussian Noise (AWGN) channel and/or both AWGN and the fading channels. In order to investigate this, a simulation model created and implemented using MATLAB. The Modulated signal transmitted over the fading, AWGN, and/or both channels for various signal-to-noise ratio (SNR) values. To evaluate the performance, for each SNR level, the received signal demodulated and the received data compared to the original information. The result of the simulation is shown in a plot of the bit error rate (BER)/error probability versus SNR, which provides the information about the systems performance.

Index terms— AWGN, CDMA, DS-CDMA, BER, ISI, FFT, OFDM, SNR.

1 Introduction

ODE-DIVISION multiple-access communication (CDMA) is an important emerging technology for underwater acoustic networks for both civilian and military purposes. CDMA permits random, overlapping access to a shared communication channel as required in an autonomous ocean-sampling network (AOSN) scenario. In combination with code-division multiple-access (CDMA) techniques, multicarrier modulation has attracted a lot of attention in the past decade for the future-generation wireless communications on account of countering channel frequency selectivity and removing inter-symbol interference (ISI) while supporting high-rate applications, providing frequency diversity, collecting the entire energy spread in the frequency domain, and simple Author ? ? ? ? : Pabna Science and Technology University, Bangladesh. E-mail : md.k.noman@gmail.com implementation through Fast-Fourier-Transformation (FFT) techniques [1].

On the one hand, different configurations of multicarrier CDMA (MC-CDMA) schemes as combinations of direct-sequence CDMA (DS-CDMA) and orthogonal frequency-division multiplexing (OFDM) were developed after 1993 [1] [2]. The performance and design of such systems have been investigated extensively in different non-fading and fading channels since then [2][3][4][5][6][7][8].

On the other hand, frequency-hopping spreadspectrum (FH-SS) techniques in combination with OFDM or MC-CDMA received considerable attention recently, and as a result, various multicarrier frequencyhopping (MC-FH) systems were proposed ??9-11][13]. MC-FH schemes, on account of fewer subcarriers transmitted in each symbol interval, have smaller peakto-average-power ratio (PAPR) than MC-CDMA systems, making the implementation of MC-FH systems less complex than MC-CDMA schemes especially in the uplink, where linear amplification with a large dynamic range at the transmitter side is not viable. The MC-FH system studied in this paper is the one described in [13] [14], wherein the frequency spacing between diversity hopping sub-carriers in distinct frequency subbands is implemented in a way to diminish the correlation of fading gains on different sub-carriers, while keeping the region of hopping for a single subcarrier so small that phase-shift keying (PSK) modulation and coherent detection are practically feasible [13]. This scheme was developed from a frequency-diversity spread-spectrum system, called FD-SS [12], for countering band-limited jamming interference [13]. It has been examined in a single-user fading channel [14], as well as in multi-user non-fading and fading channels with and without coding [15].

The purpose of this paper is to simulate and analysis the performance of CDMA system for that we will present: Signal to noise ratio on the BER performance using QPSK modulation techniques, Effect of number of multi-user on the BER performance and bit error performance(BER) for various estimation rates with a maximum Spread Spectrum. The third multiple access technology which was designed to increase both the system capacity and the service quality is called CDMA. CDMA is a form of spread spectrum technology a family of digital communication techniques that have been used in military applications for many tears. It spreads the information contained in a particular signal of interest over a much greater bandwidth than the original signal at the same data rate, the capabilities of the spread spectrum technique for both anti-jam and low probability of undesired interception; make this technology suitable for multi-user applications. Fig. ?? shows a general scheme of a CDMA system. Figure ?? : General Scheme of a CDMA system When CDMA is implemented in cellular systems, all users share a common channel in time and frequency. The separation is done using a code. Each user transmits with unique code, the spreading sequence, and since the receiver knows the user's code it can demodulate and extract the information. Usually, within a network there are two channels, one for the uplink (mobile to base station) and one for the downlink (base station to mobile). All users share both channels at the same time. The number of users which can communicate simultaneously is dependent, among other factors, such as, the length of the spreading sequence (code, a series of binary data), channel quality, receiver type, etc. b) Spread Spectrum Concept DS-CDMA systems are based on spread spectrum communications principles that provide a flexible and efficient framework for coverage and capacity sharing. The spread spectrum schemes are increase the radio links robustness against fading and interference.

1. Direct Sequence Spread Spectrum (DSSS) and 2. Frequency Hopping Spread Spectrum.

2 c) Direct Sequence Spread Spectrum (DSSS)

A pseudo-noise sequence pnt generated at the modulator, is used in conjunction with an M-ary PSK modulation to shift the phase of the PSK signal pseudo randomly, at the chipping rate Rc (=1/Tc) a rate that is an integer multiple of the symbol rate Rs (=1/Ts).The transmitted bandwidth is determined by the chip rate and by the base band filtering. The implementation limits the maximum chip rate Rc (clock rate) and thus the maximum spreading. The PSK modulation scheme requires a coherent demodulation. A short-code system uses a PN code length equal a data symbol. A long-code system uses a PN code length that is much longer than a data symbol, so that a different chip pattern is associated with each symbol.

3 d) Frequency Hopping Spread Spectrum

A pseudo-noise sequence pni generated at the modulator is used in conjunction with all M-ary FSK modulation to shift the carrier frequency of the FSK signal pseudo randomly, at the hopping rate Rh .The transmitted signal occupies a number of frequencies in time, each for a period of time Th (=1/Rh), referred to as dwell time . FHSS divides the available bandwidth into N channels and hops between these channels according to the PN sequence. The PN generator feeds the frequency synthesizer a frequency word FW (a sequence of n chips) which dictates one of 2n frequency positions fhi transmitter and receiver follow the same frequency hop pattern. The transmitted bandwidth is determined by the lowest and highest hop positions and by the bandwidth per hop position (fch). For a given hop, the instantaneous occupied bandwidth is identical to bandwidth of the conventional M-FSK, which is typically much smaller than Wss. So the FSSS signal is a narrowband signal, all transmission power is concentrated on one channel. In the transmitter, the binary data dt is 'directly' multiplied with the PN sequence.

4 e) Pseudo Random (PN)

The pseudo random (PN) sequence is a bit stream of '1's and '0's occurring randomly, or almost randomly, with some unique properties. The pseudo random (PN) is widely used in direct sequence spread spectrum wireless communication systems, for example, synchronous CDMA or asynchronous CDMA. Due to the periodic nature of the PN sequence the frequency spectrum has spectral lines which become closer to each other with increasing sequence length Nc. Each line is further smeared by data scrambling, which spreads each spectral line and further fills in between the lines to make the spectrum more nearly continuous. The DC component is determined by the zero-one balance of the PN sequence. Here, the number of user=12, the desired user=12, the chips length=7, using coding technique with and without Hamming code. The signal passed away through the AWGN channel with Hamming coding

5 Conclusion

CDMA, which has been very attractive for future high rate wireless communication is providing high transmission data rate with high spectral efficiency. One drawback of WCDMA is its multipath fading and AWGN noise. This noise destroys the original signal, leading to the significant performance degradation. The transmitted signal is corrupted by multipath and multiple access interference. The signal is further corrupted by AWGN at the front end of the receiver. Several simulations were carried out for estimation of the performance of CDMA with spreading and scrambling, error correct and detection coding technique. The error detects and correct coding technique leads to significant increase performance of CDMA. In this paper, the Additive White Gaussian Noise (AWGN) corrupted the transmitted signal and this resulted in a different received constellation than the original constellation. For small SNR values the calculated error rate was quite large and Multipath fading was produce due the relative high power of noise. As SNR was increased the error rate was decreasing, as expected. In fact, for SNR value greater than 10 dB for QPSK, the error was zero. From Fig- 6 show that the signal-noise ratio (SNR) increase then BER non-linearly decrease. From fig- 7 show that the signal-noise ratio (SNR) increase then BER linearly decrease. AWGN channel with Hamming coding is better than AWGN channel without Hamming coding [1] [2] [3]

Figure 1:

[1] E?

2

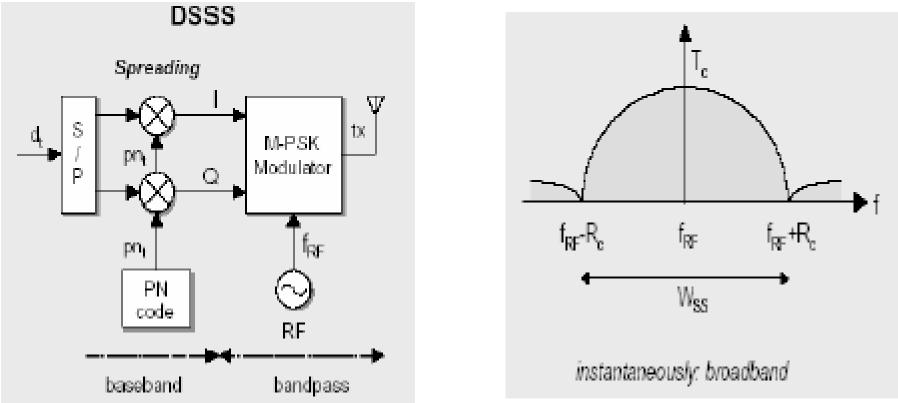


Figure 2: Figure 2 :

3

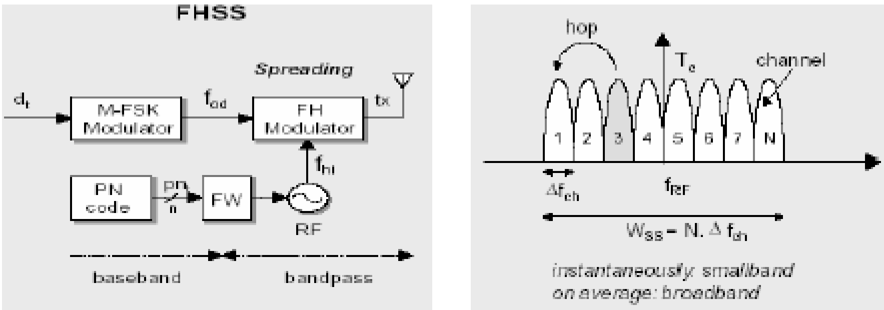


Figure 3: Figure 3 :

3524

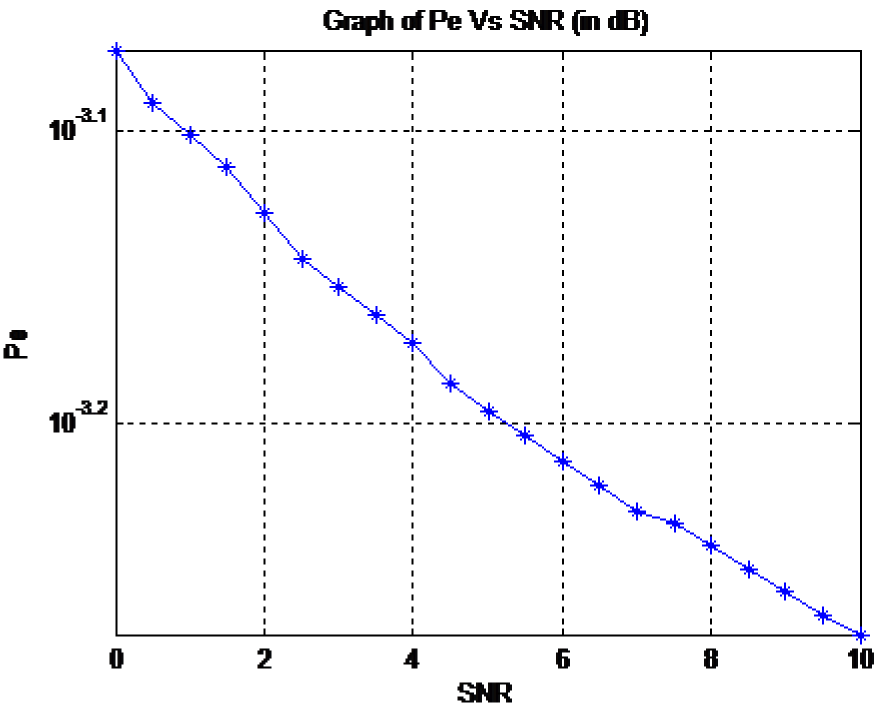
$$H_N=\begin{bmatrix} H_{N/2} & H_{N/2} \\ H_{N/2} & -H_{N/2} \end{bmatrix} \quad \text{with } H_0=[1]$$

Figure 4: 3 . 5 2 Figure 4 :

52

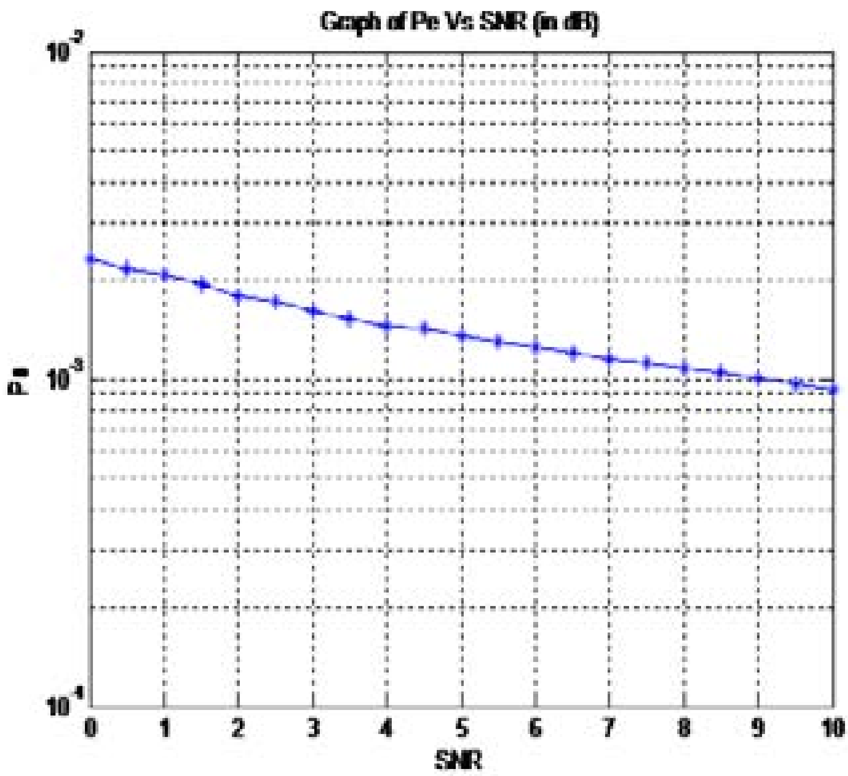
$$H_2=\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \quad H_4=\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \quad \mathbf{H}_8=\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{bmatrix}$$

Figure 5: Figure 5 : 2 E



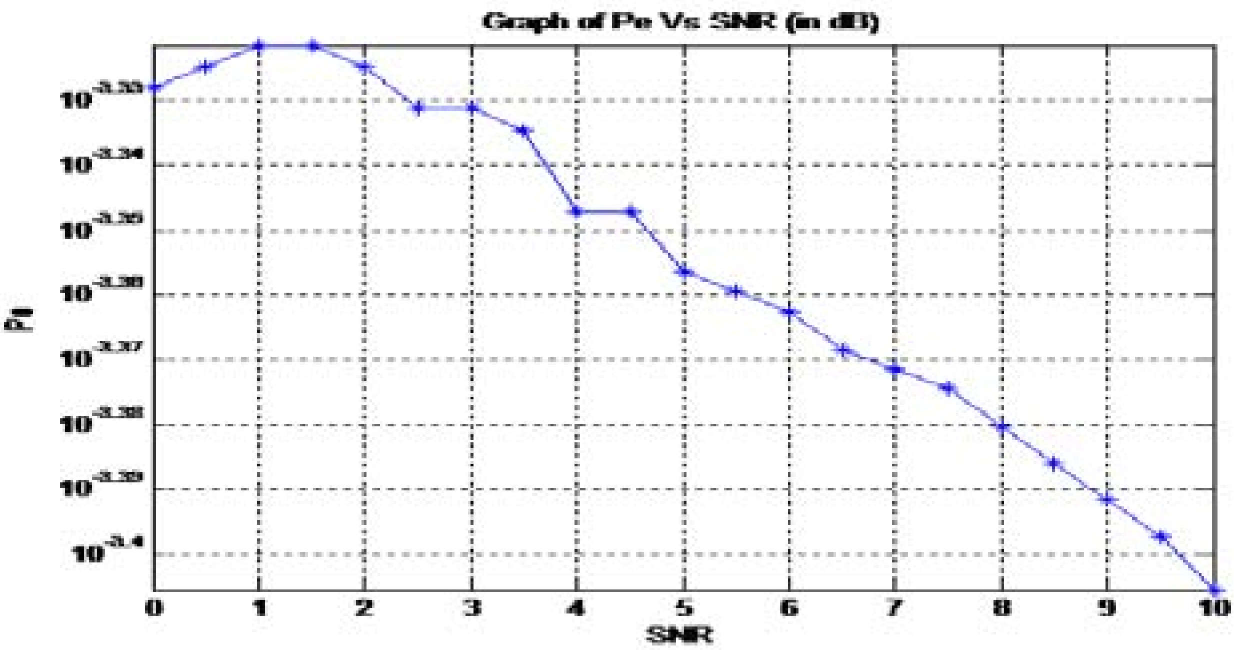
6

Figure 6: Figure 6 (



6

Figure 7: Figure 6 :



7

Figure 8: Figure 7 :

[Lance and Kaleh (1997)] 'A Diversity Scheme for a Phase-Coherent Frequency-Hopping Spread-Spectrum System'. E Lance , G K Kaleh . *IEEE Trans. Commun* Sep. 1997. 45 (9) p. .

[Ong and Leung (1995)] 'Code Diversity Transmission in a Slow-Frequency-Hopped Spread Spectrum Multiple-Access Communication System'. C T Ong , C Leung . *IEEE Trans. Commun* Dec. 1995. 43 (12) p. .

[Hara and Prasad (1999)] 'Design and Performance of Multicarrier CDMA System in Frequency-Selective Rayleigh Fading Channels'. S Hara , R Prasad . *IEEE Trans. on Vehicular Tech* Sep. 1999. 48 (5) p. .

[Tsumura and Hara ()] 'Design and Performance of Quasi-Synchronous Multi-Carrier CDMA system'. S Tsumura , S Hara . *IEEE VTC* 2001. (2) p. .

[Kaleh (1996)] 'Frequency-Diversity Spread-Spectrum Communication System to Counter Bandlimited Gaussian Interference'. G K Kaleh . *IEEE Trans. Commun* Jul. 1996. 44 (7) .

[Smida et al. (2001)] 'MC-CDMA Performance Evaluation Over a Multipath Fading Channel Using the Characteristic Function Method'. B Smida , C L Despins , G Y Delisle . *IEEE Trans. Commun* Aug. 2001. 49 (8) p. .

[Yee et al. (1993)] 'Multi-carrier CDMA in Indoor Wireless Radio Networks'. N Yee , J-P Linnartz , G Fettweis . *Proc. of IEEE PIMRC 1993*, (of IEEE PIMRC 1993Yokohama, Japan) Sep. 1993. p. .

[Ohkawa et al. (1994)] 'Orthogonal Multi-Carrier FH-CDMA Scheme for Frequency Selective Fading'. M Ohkawa , R Kohno , H Imai . *Proc. ICCS Conf*, (ICCS ConfSingapore) 18 Nov., 1994. 2 p. .

[Hara and Prasad (1997)] 'Overview of Multicarrier CDMA'. S Hara , R Prasad . *IEEE Commun. Mag* Dec. 1997. p. .

[Ebrahimi and Nasiri-Kenari ()] 'Performance Analysis of Multicarrier Frequency-Hopping (MC-FH) Code Division Multiple-Access Systems: Uncoded and Coded Schemes'. M Ebrahimi , M Nasiri-Kenari . *IEEE Trans. on Vehicular Technology* 2002. 55 p. . (IEEE)

[Shin and Bok (2001)] 'Performance Comparison of FFH and MCFH Spread-Spectrum Systems with Optimum Diversity Combining in Frequency-Selective Rayleigh Fading Channels'. O-S Shin , K Bok . *IEEE Trans. Commun* Mar. 2001. 49 (3) p. .

[Gui and Ng (1999)] 'Performance of Asynchronous Orthogonal Multicarrier CDMA System in Frequency Selective Fading Channel'. X Gui , T-S Ng . *IEEE Trans. Commun* Jul. 1999. 47 (7) p. .

[Elkashlan and Leung (2002)] 'Performance of Frequency-Hopping Multicarrier CDMA in Rayleigh Fading'. M Elkashlan , C Leung . *IEEE 56th VTC*, (Vancouver) Sep. 2002. 1 p. .

[Schulze ()] 'The Performance of Multicarrier CDMA for the Correlated Rayleigh Fading Channel'. H Schulze . *AE? Int. J. Electron. Commun* 2000. (X) p. .

[Yip and Ng (1998)] 'Tight Error Bounds for Asynchronous Multicarrier CDMA and Their Application'. K-W Yip , T-S Ng . *IEEE Communications Letters* Nov. 1998. 2 (11) p. .