SIMULATION OF DS-CDMA PERFORMANCE ESTIMATION USING VISSIM/COMM SOFTWARE

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Abstract:

The focus of this paper is to implement a simulator for the Direct Sequence - Code Division Multiple Access (DS-CDMA) communication system and test its performance against certain parameters using the VisSim/Comm Version 6.0.03 software. In this paper, the communication system is considered to consist of a number of users each of which generating binary data of specified rate and is assigned a unique code. There are many major system aspects that associated with the design of a spread spectrum system need to be considered. One of these very important concepts is how to evaluate the performance of the system. The main evaluation method in the simulator for system evaluation is the measurement of the Bit-Error-Rate (BER) for various conditions that are essential in the DS-CDMA design and implementation.

Keywords:

Spread Spectrum, Direct Sequence Spread Spectrum DSSS, DS-CDMA, BER estimation. Wideband CDMA, Wireless Communications, Communication System Simulation, VisSim.

1.Introduction

Spread spectrum is an increasingly important form of encoding for wireless communications that modulate the transmitted data with wideband PN code [1]. This will give the system the feature of anti-jamming and have better noise immunity together with random access. There are two types of SS, these are the direct sequence spread spectrum (DSSS) and the frequency hopping spread spectrum (FHSS). Both of these techniques are used in various wireless communications standards and products. A system is defined as a speared spectrum if it fulfills the following requirements [2],[3]:

i- The SS bandwidth is much greater than the bandwidth required to send the data.
ii- The spreading is Pseudo Noise N code and should be data independent.
iii-The same spreading PN must be used at the receiver to de-spread the SS signal and to recover the original transmitted data via the the correlation process between the received spread signal with a synchronized replica of the spreading code.

In DSSS technique, the data is multiplied directly with pseudo random noise PN before the carrier modulator [4],[5]. The next step is the RF modulation and the general form of modulation usually a PSK. This will make the bandwidth of the SS centered on the RF carrier frequency. The noise immunity together with anti-jamming usually reduces the bit error rate (BER) of any communication system employed DSSS[6]. This will in effect reduces the required Signal to Noise ratio to achieve the same BER. This assessment of any communication via employing or changing communication systems parameters or variable in the design. It is the likelihood that a single error bit will occur within received bits, independent of rate of transmission. Other methods to reduce BER include equalization, channel coding, diversity, and others.

The DSSS has many applications and usage and one of the main application in the modern data communication via providing the multiple channel access through the Code Division Multiple Access [8]. The CDMA system has many good features that made it favorable over other form of channelization such as FDMA and TDMA.
This paper presents how the DS-CDMA simulator is implemented using VisSim software. Results of simulation are presented. Finally the discussion and conclusion are analyzed.

2. Code Division Multiple Access (CDMA)

Multiple access refers to techniques that enable sharing a common communication channel between multiple users [9],[10],[11]. Spread spectrum methods can be used a multiple access technique. The technique, termed code division multiple access (CDMA), is commonly implemented using direct sequence spread spectrum (DSSS) technology. With CDMA each simultaneous user employs a unique spread spectrum signaling code. CDMA has the ability to provide communication privacy between users with different spreading signals. The most widely known applications of CDMA is for cell-phones.
One of the most good features that male CDMA applicable to cell-phone is a group of SS signals can be regenerated by using different pseudo-random code sequences. This is because each one of the SS signal have different signature. Thus the a code sequence assigned to each user can be used to separate and identify each user in an efficient way. This is basic concept that CDMA relay on the way that CDMA can be implemented. Furthermore, compared with other form of multiple accesssuch as FDMA and TDMA, it has been shown that CDMA

provides higher capacity. Specifically, the capacity of CDMA is more that 10 times that of AMPS and more than 5 times the capacity of GSM system. Other form of CDMA based on CDMA is Wideband CDMA that increase the bandwidth to achieve higher capacity.
Figure (1) shows an example of DS-CDMA system of n cell-phone users communicating with base-station sharing the same frequency and the same channel but each of them use different code (this is a specific form of BPSK modulation). In practical cases, the number of users would much larger and might be thousands.

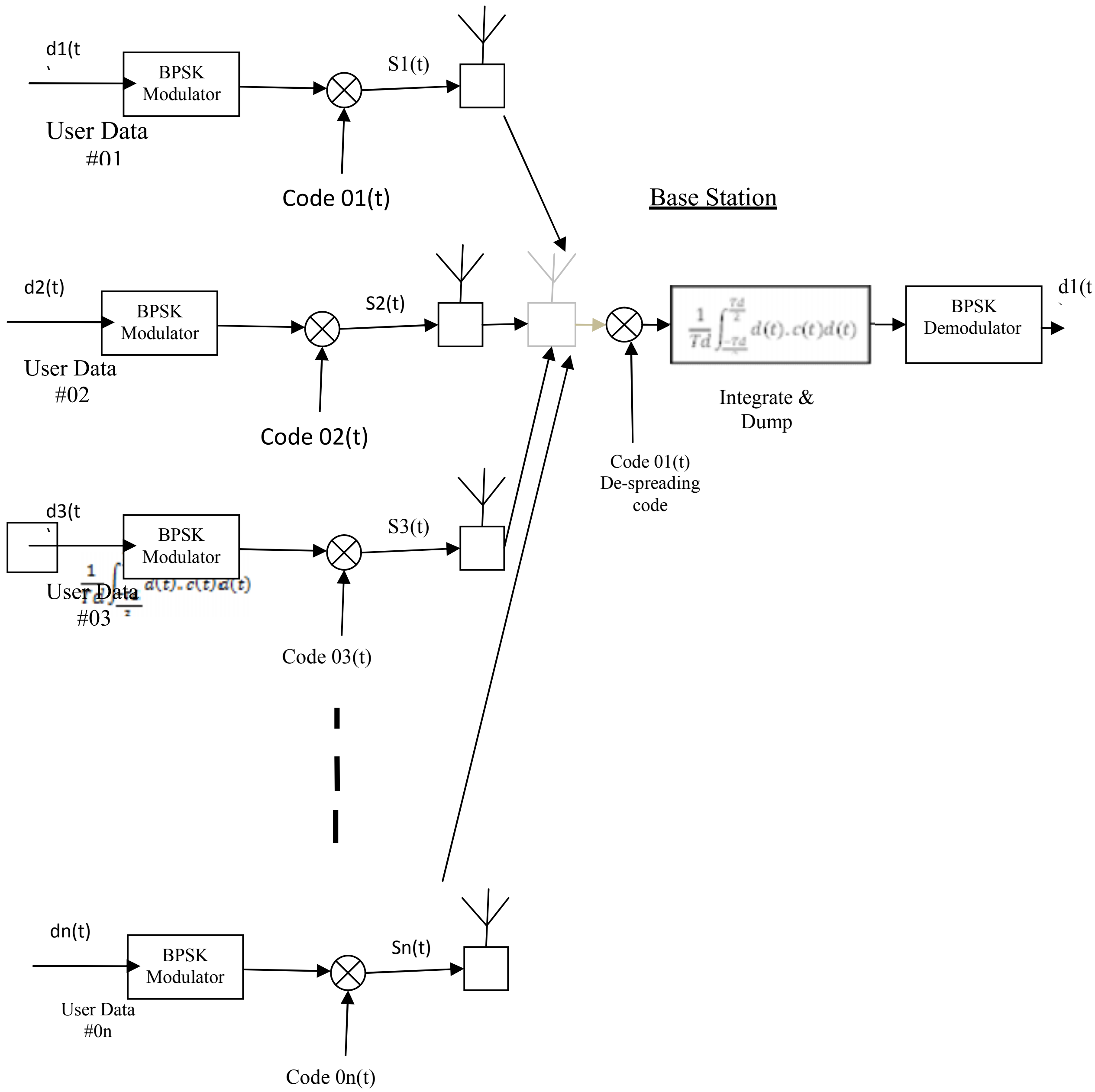


Figure (1) n-Users Implementing DS-CDMA System

3. Simulation of DS-CDMA System with VisSim Software

In this paper a simulation package VisSim/Comm version 6 is implemented using VisSim/Comm software. This software is used to model and simulate the physical layer level of an end-to-end communication system. This will help the communication system designer to produce their design in an accurate and fast way. The most important aspect in the VisSim/Comm software is the sampling rate of a given simulation. This rate depends on several parameters such as the input data rate, carrier frequency and accuracy of simulation. In the case of broadband, the sampling rate of eight samples per carrier cycle is satisfactory and completely depends on the carrier frequency. Furthermore, this sampling will specify the simulation step size. However, with baseband the step size will rely on the data rate. The sampling rate can be reduced via the use of complex envelop. The reduction in the sampling rate will defiantly degrade the accuracy of the simulation but will fasten the simulation

In the simulation of any communication system, the simulation must consider the simulation of each part, transmitter, link and the receiver part. Thus successful modeling is required for each part to fulfill the modeling and simulation of end-to-end modeling and simulation. Fig.(2) shows an example of cell-phone system using DS-CDMA. An uplink system is considered with nine independent users(of course this number is very low compared with practical applications) communicating with a base-station through a noisy channel.

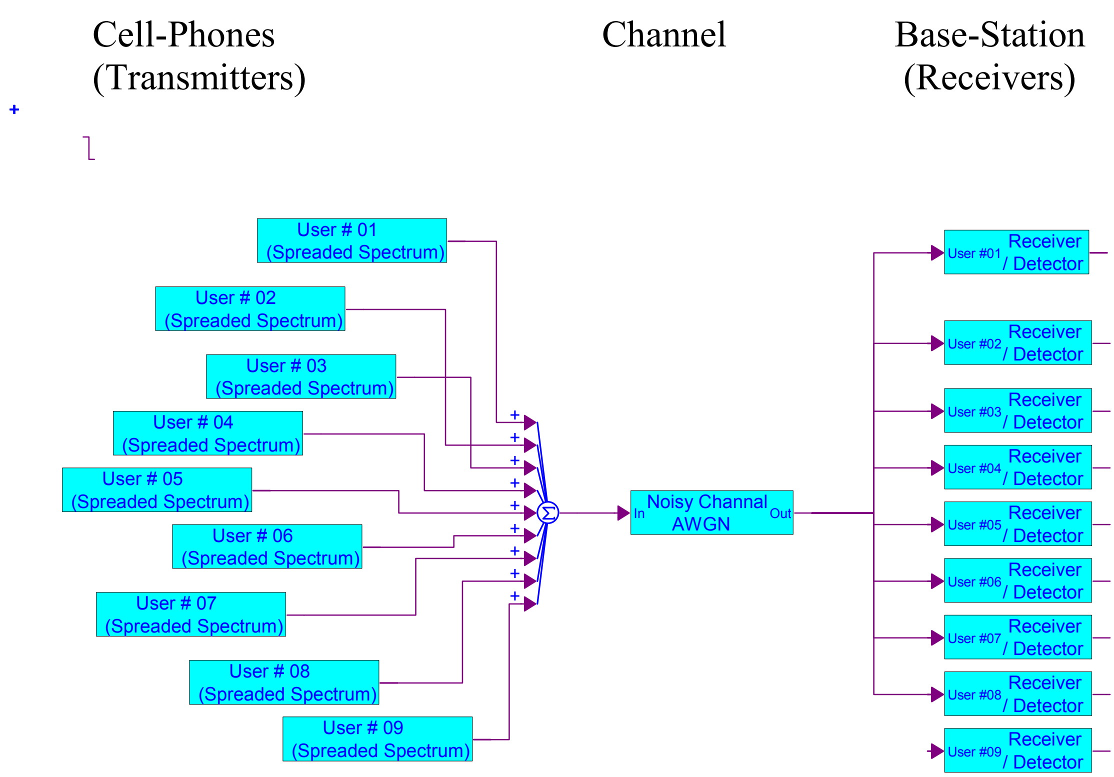


Figure (2) Simulation of SS-CDMA communication system of nine independent users.

The transmitter and receiver elements are in turn subdivided into further sub-systems. Figure (3) shows one of the nine users transmitting subsystem which includes:

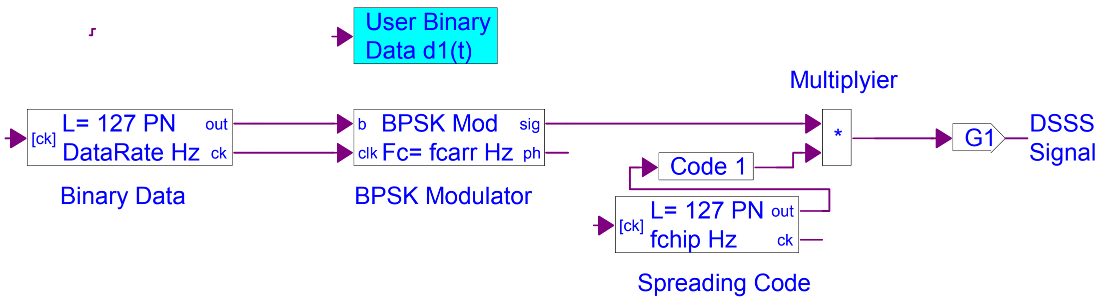


Figure (3) Simulation of transmitter subsystems of one of the nine users(#01)

(a) Data source:
Any form of required information analog or digital, speech, image, video or text can be generated by the data source. This signal can be then transferred to digital sequence. Thus, for simulation purposes usually this signal, baseband signal is taken as a Pseudo-Noise (PN) of voltage variation.

(b) BPSK Modulator:
The baseband signal generated by the data source is binary data and usually by the DS-CDMA is modulated by a BPSK modulator. However, with the simulator any other digital modulator can be taken depending on the application. It is also worth to mention here that the modulator is acting as an up frequency convertor that shift the baseband signal spectrum to the required frequency band centered around the carrier frequency..

(C) Spreading and Modulation:
A Pseudo-Noise (PN) generator is used as spreading code which should be random with data rate is selected to be much higher than the user data rates. For the DS-CDMA system usually, there are certain type of code always adopted such as Walsh code or Gold code. However, the simulator can generate any form of code that is required by the application.
The users signals (after spreading) are modulated using BPSK and summed in space. It also worth to mention here that there are other form of modulation with the simulator but the BPSK is selcted because of the DS-CDMA requirements.

(D) Transmission Link:
The transmission link between the transmitter and the intended receiver, usually known as the channel, may be wired or wireless. This channel distorts the transmitted signal. This form of distortion and its severity depend on the type of the link. Furthermore, the channel introduces noise in the transmitted signal which might be additive or multiplicative. Depending on the application and the environments, many forms of channel models have been developed. A commonly used channel model is the additive white Gaussian noise (AWGN) channel. The AWGN channel model is an essential form of model in the assessments of any communication systems

(E) Data Reception and Recovery
Figure (4) shows the simulated receiver block diagram with VisSim software. The received signal initially converted back to the baseband via the process of demodulation process as shown in Figure (4). This step should take into consideration the form of modulation process

adopted in the transmitter and the important attention is the carrier synchronization. The baseband signal next despreaded using the same code used in the spreading (synchronization also essential concept in the dispreading process). Figure (4) shows that the first step of detection is to decode the incoming signal using the same code of the specified user, otherwise reception of the signal will not be possible.

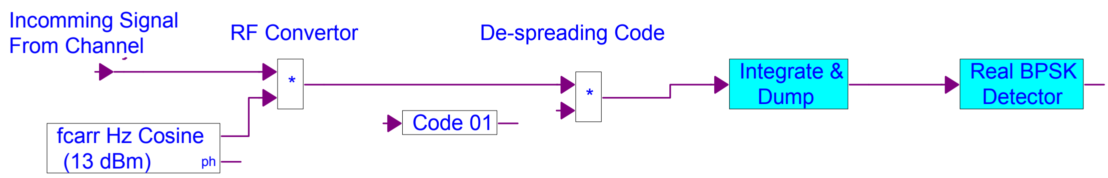


Figure (4): Simulation of receiving/detecting side (data decoder).

Input data to the simulator is as given in Fig. (5). The data shows relative values (per units) rather actual units. This makes simulation simpler and takes relatively much less execution times.

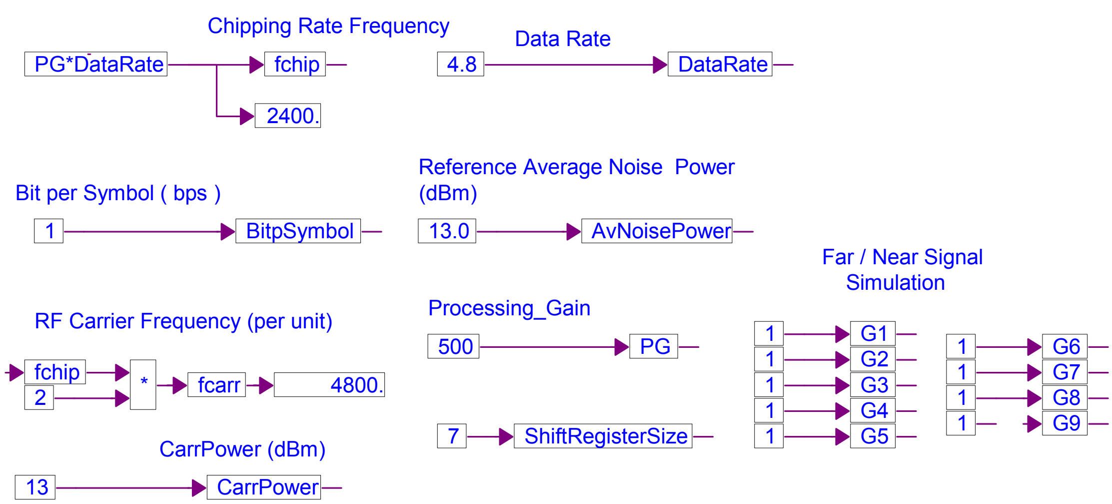


Figure (5): Input data to the DS-CDMA simulator system.

4. Simulation Results

This section presents the simulation results for the DS-CDMA system at different conditions. An estimate of the original signal is produced at the output of the receiver. As an example, Figure (6) shows a comparison between the original binary user signal of one of the nine users in DS-CDMA system and the detected signal of the same user. It is seen that the received signal shows no error at all, but this method of comparison is not practical since the testing should be taken at longer time.

In this paper, BER is adopted to evaluate the communication system under design as shown in Figures (7). It is worth to mention here that the BER assessment of any data communication is one of the most important metrics that can be used to evaluate and compare between data communication systems. However, there are other forms of assessment that can be provided by the simulator such as received signal to noise ratio (SNR), eye patterns, and phase scatter plots. Figure (7) shows the simulation results of the BER measurement for all nine users.

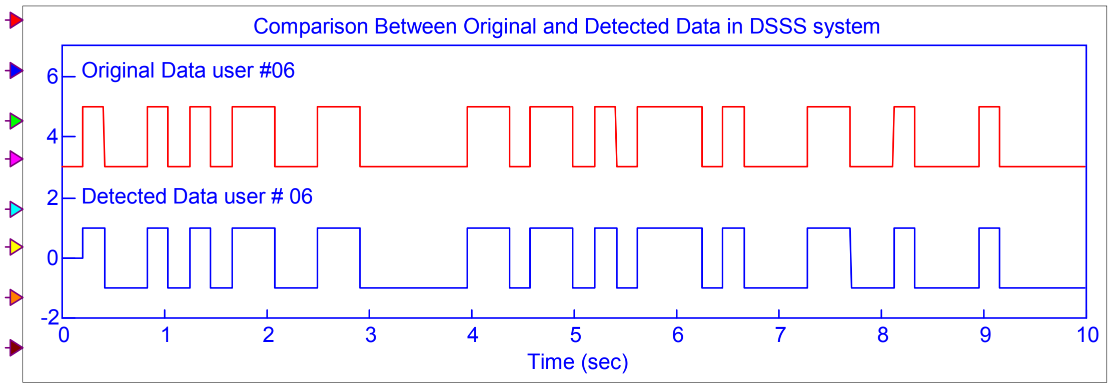
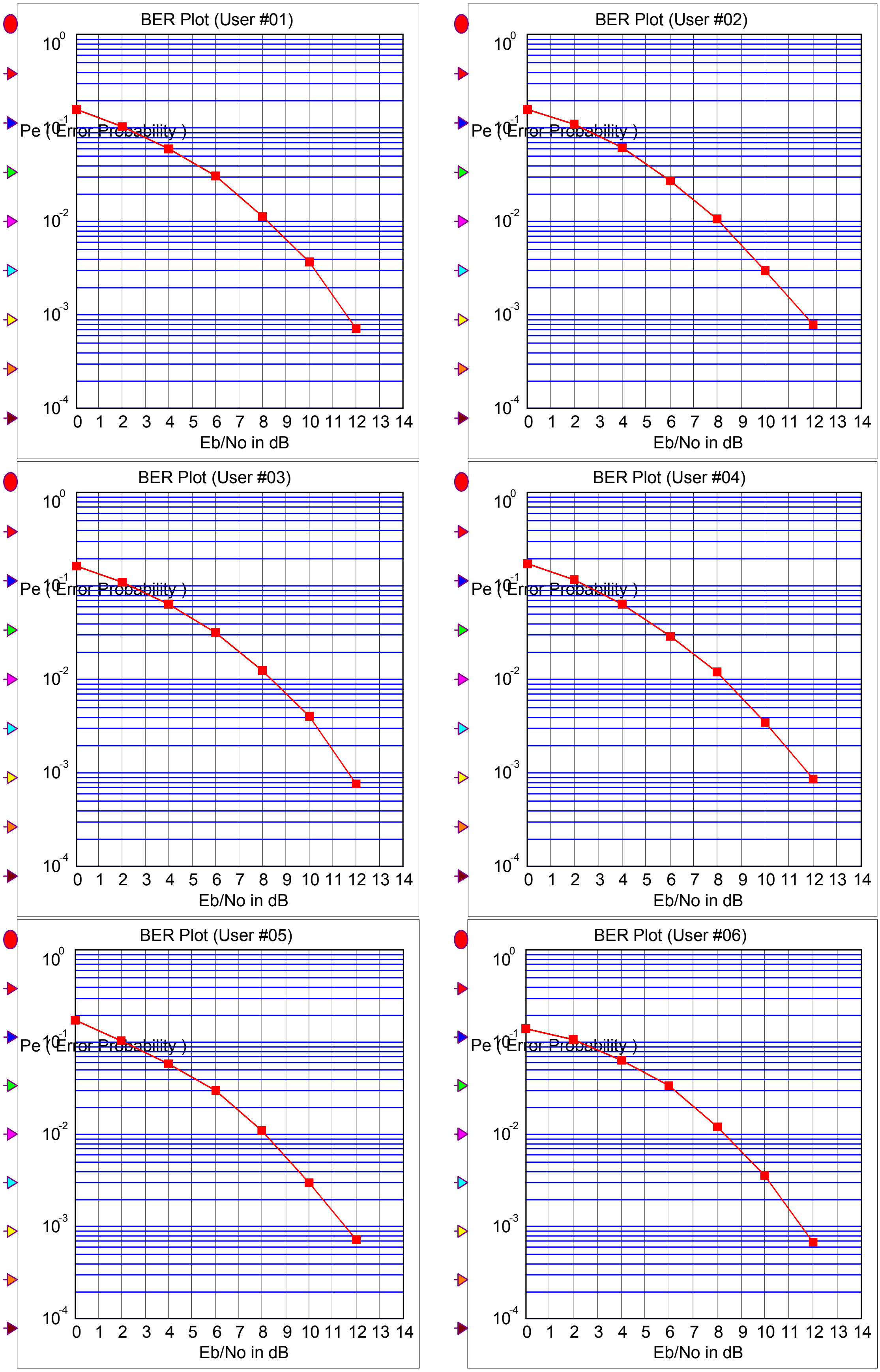


Figure (6) Comparison between original binary signal and received one of user #01

Simulation results of BER v's Eb/No (dB) for the nine users show that DS-CDMA system can be analyzed and evaluated using the simulator built in this paper with the aid of the VisSim6.0 software. Result shown in Figure (7) is for the case when the base-station receives equal power from the nine users (as simulated by G =1 for all users, as shown in Figure (8). In this case, the BER curves show almost the same level of error's probabilities. On the other hand, when the base-station receives unequal power levels from the users (as simulated by different values of G, as in fig.(12)) which shows that user #05 is nearest to the base-station (G =5), then user #01 (G = 4), then user #03 (G=3), then user #07 (G=2), and other users are at equal distances. The results of BER for this scenario is shown in Figure (9).

Simulation results of Figure (8) show that appreciable improvements are noticed for users nearer to the base station on the expense of other users which show a degraded BER performance.


BER Plot (User #01)
BER Plot (User #02)
BER Plot (User #03)
BER Plot (User #04)
BER Plot (User #05)
BER Plot (User #06)
Pe (Error Probability)
Eb/No in dB

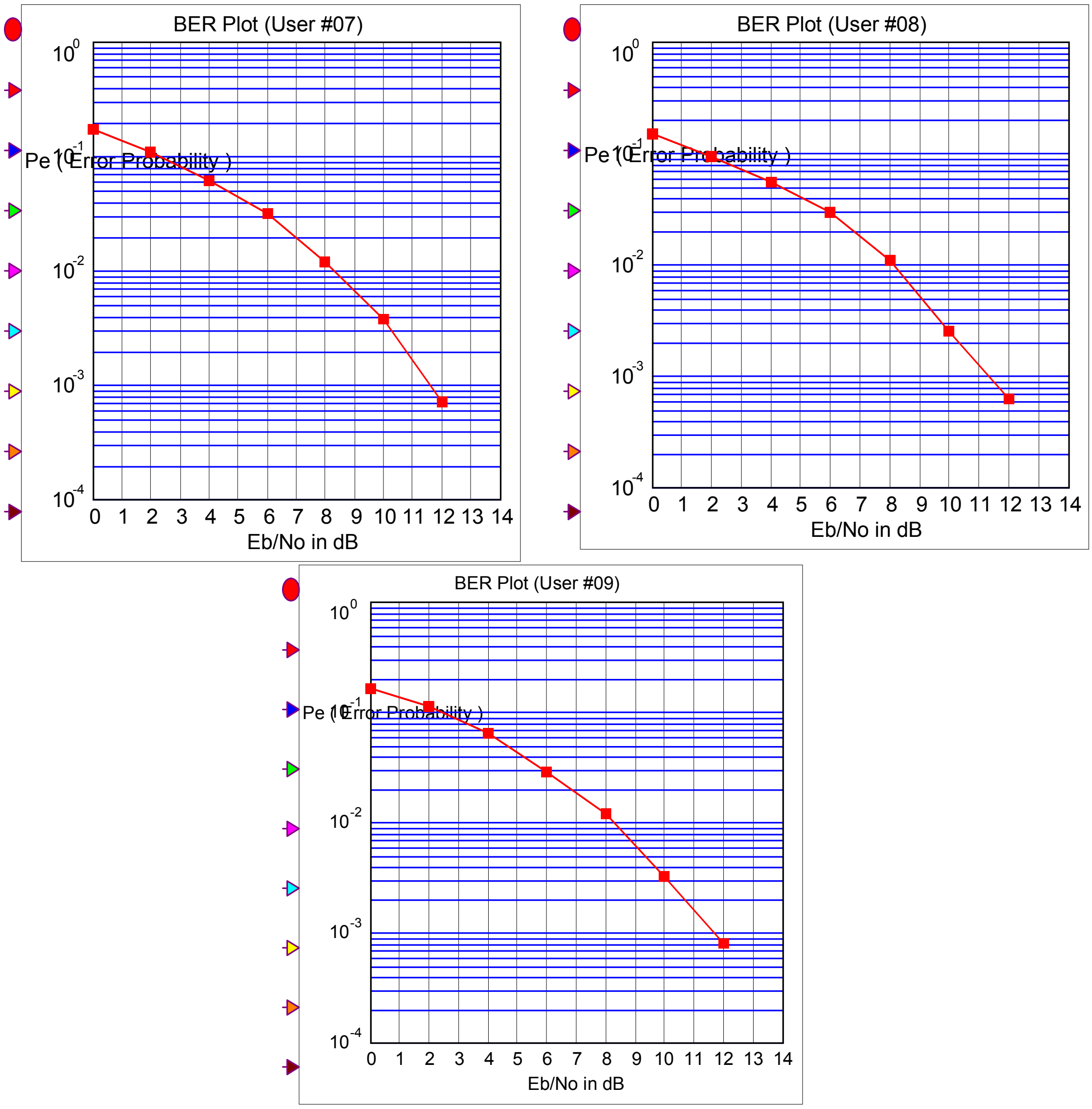


Figure (7) Results of Simulation of the bit-error-rate (BER) against Eb/No for all nine users (G = 1).

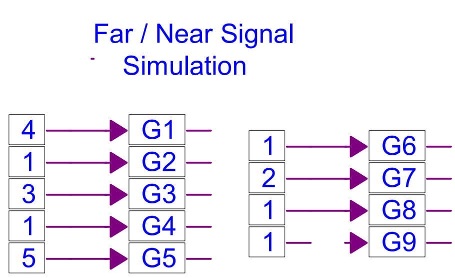
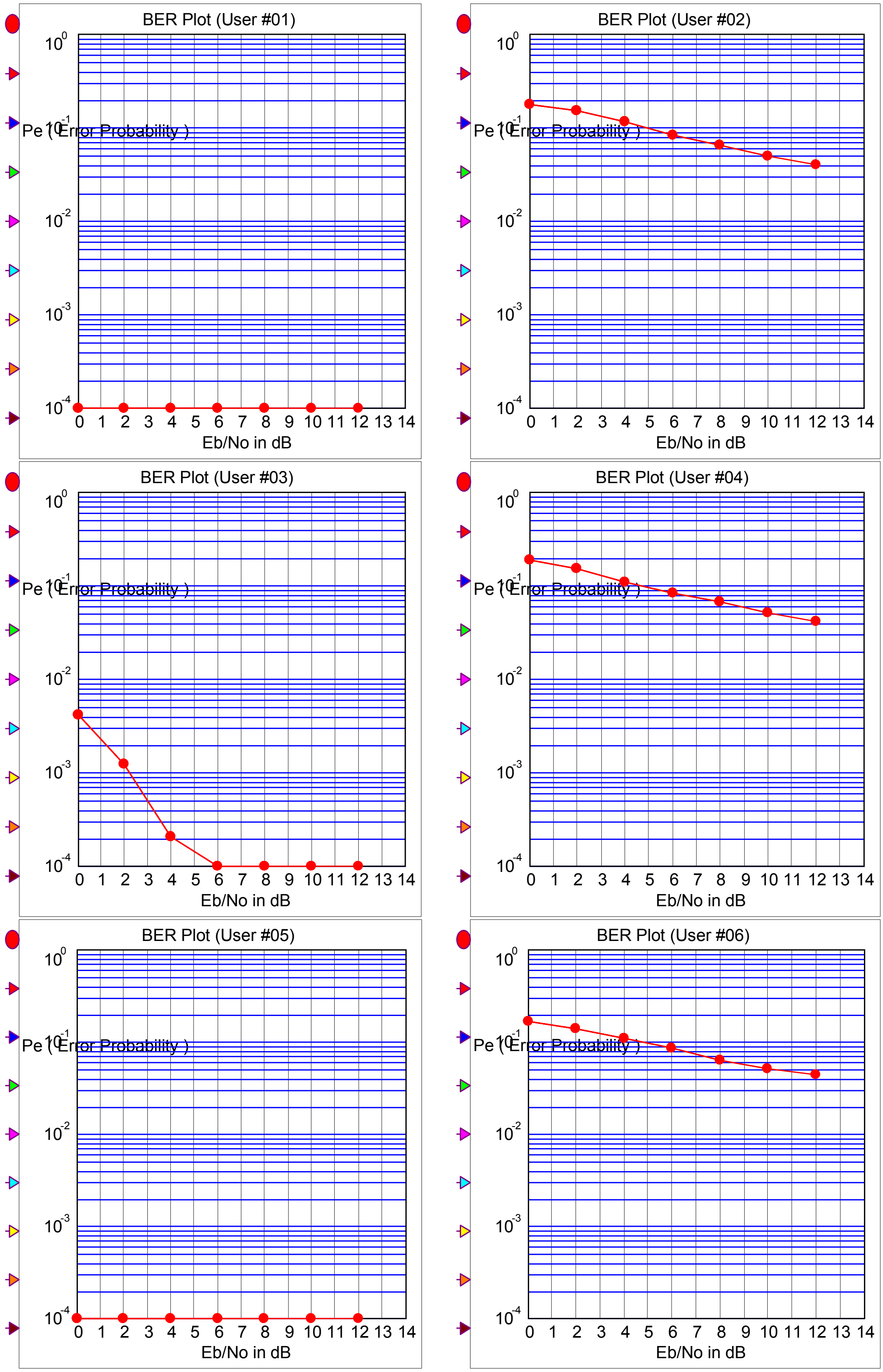


Figure (8) Relative values of different received user's output power used in simulation.


BER Plot (User #01)
BER Plot (User #02)
BER Plot (User #03)
BER Plot (User #04)
BER Plot (User #05)
BER Plot (User #06)
Pe (Error Probability)
Eb/No in dB
10^0
10^-1
10^-2
10^-3
10^-4
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

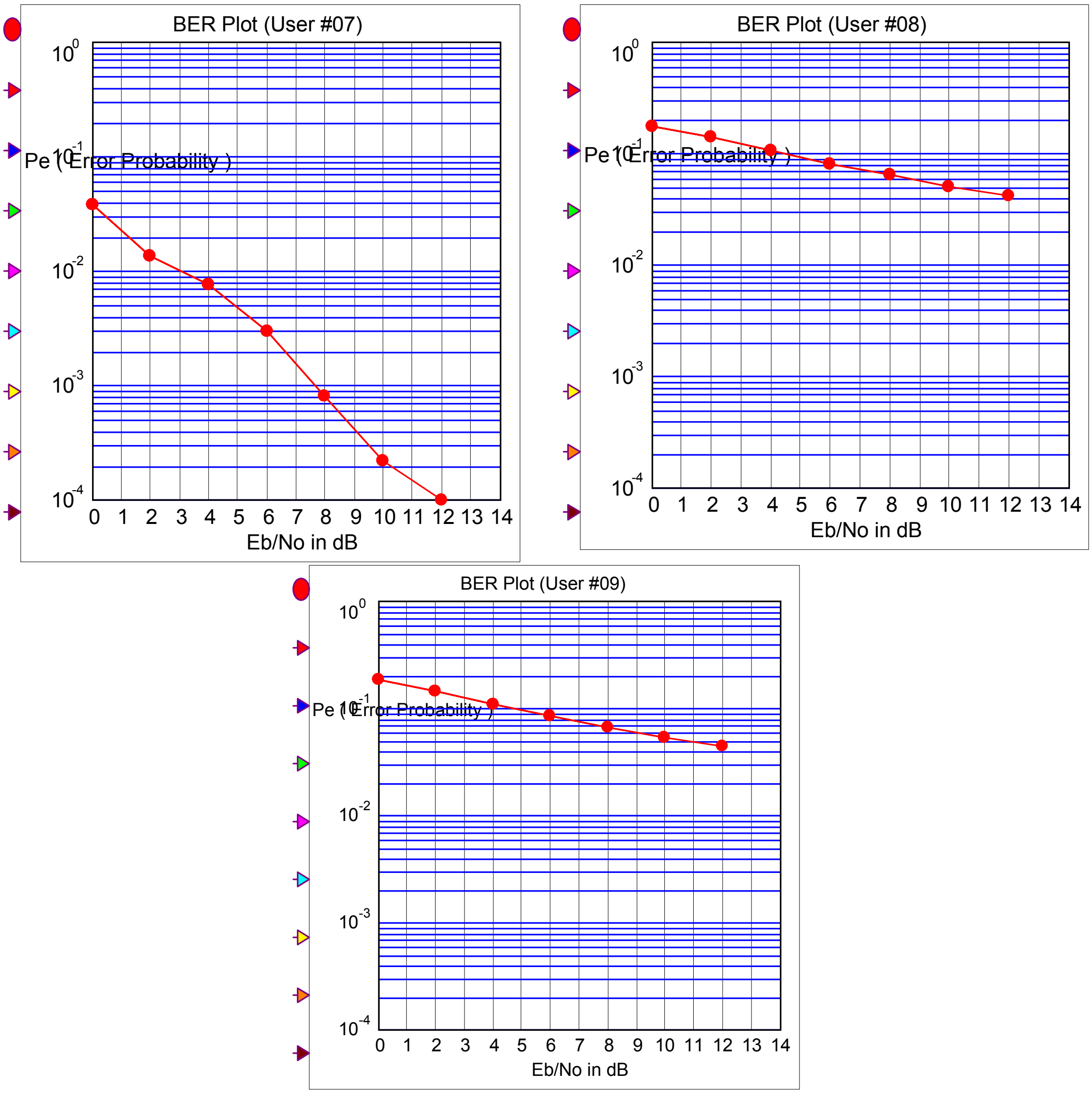


Figure (9) Results of Simulation of the bit-error-rate (BER) against Eb/No for all nine users (G values are shown in fig(8)).

5. Conclusion

In this paper a simulator for DS-CDMA using the VisSim/Comm Version 6.0.03 program is implemented. Simulation results of BER values are presented. Two cases were investigated in the analysis using the CDMA simulator, i.e. when the base-station receives equal power from all nine users and the other case when it receives different power levels. Receiving equal power from users is simulated by putting the gain G =1 for all nine users. The results of BER show acceptable performance as far as the BER values are concerned. In the second case, it is assumed that the base-station receives unequal power levels from the users. The results of BER curves for this case indicate that users nearest to the base-station exhibit better performance namely; user #01, #03, #03, #05 and #07, while the performance of other users are degraded or unacceptable. The simulation results give the answer to the question that why in CDMA systems, the output power of all users belonging to the same base station should their output power be controlled to arrive at base-station at equal levels (all having G =1 in the simulation).

The simulator implemented in this paper can be an invaluable tool for investigating the design and implementation of DS-CDMA and WCDMA systems. During design phases, engineers as well as students (undergraduates/graduates) might need such a simulator in their study/research work.

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