Development of Hardware Testbed for CDMA Technology

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***Abstract*— Code division multiple access (CDMA) systems are being counted to provide the necessary infrastructure to implement future 3G systems. The CDMA is uniquely featured by its spread spectrum (a random) process employing a pseudo random noise (PN) sequence, thus it is called the spread spectrum multiple access (SSMA). The CDMA can eliminate the data transfer latency variations by sharing the data communication media among multiple users concurrently. In this proposed work, we simulate the functionality of CDMA system on Xilinx ISE platform. Here, we use Walsh encode/decode technique for encryption and decryption. The simulation results show the working of CDMA transmitter and receiver on Verilog platform. Implementation of proposed system is targeted on Virtex FPGAs.**

***Keywords*—pseudo random noise, multiple access, spread spectrum, data transfer latency, Walsh encode/decode.**

I INTRODUCTION

Cellular technology has grown tremendously both in terms of traffic and services[1-2].In 1989 Qualcomm corporation started developing a new digital technology known as CDMA for the next generation wireless mobile services. With the support of the Cellular Telecommunications Industry Association (CTIA) and the Telecommunications Industry Association (TIA) a standards group was set up. This group published the standard for the first CDMA system in the form of IS-95, resulting in the formal publication of IS-95-A in 1995[3].The IS-95 specified a dual mode of operation in the 800MHz cellular band for both AMPS and CDMA operation. The first CDMA system was launched in September 1995 by Hutchison Telephone Co. Ltd. in Hong Kong and SK Telecom in Korea soon followed along with networks in the USA [4].

CDMA offers wide ranges of advantages compared to GSM. Few important features of CDMA are wide bandwidth, higher security and Walsh encoding. Wide bandwidth provides immunity against jamming, interference etc.We need to have a prior knowledge of spreading code in order to decipher the signal thus ensuring higher security. Walsh encoding provides another dimension to the security by encrypting the signal. The first form of CDMA system to be implemented was IS-95.Additional features were added to CDMA standards in 1995 when IS-95A was published. The early forms of CDMA were grouped under one category called CdmaOne. This is a trade mark of CDMA development group.

The next generation which followed IS-95 is called CDMA2000.CDMA2000 (also known as IMT Multicarrier (IMT-MC)) belongs to 3G mobile technology standards, which use CDMA channel access, to send voice, data, and signalling data between mobile phones and cell sites. The set of standards includes: CDMA2000 1X, CDMA2000 EV-DO Rev. 0, CDMA2000 EV-DO Rev. A, and CDMA2000 EV-DO Rev. B. All are approved radio interfaces for the ITU's IMT-2000[5].

An upgrade into the evolution of CDMA is W-CDMA (Wideband Code Division Multiple Access.. It is sometimes used as a synonym for UMTS. It utilizes the DS-CDMA channel access method and the FDD duplexing method to achieve higher speeds and support more users compared to most time division multiple access (TDMA)[6].CDMA has undergone through a number of different generations since 1990’s.These in other words are also known as flavours of CDMA.The first CDMA systems were developed by Qualcomm, which was characterized by high capacity and small cell radius. B-CDMA and W-CDMA were during this generation. The next generation is called CdmaOne which is a narrowband CDMA (IS-95).At present we have Cdma2000 which is a wireless air interface standard.

II. DIRECT SEQUENCE SPREAD SPECTRUM

DSSS is one of the modulation techniques used in CDMA.In this technique each bit is represented by multiple bits using spread codes. Hence it consumes more bandwidth this reason why it is called as spread spectrum [7].

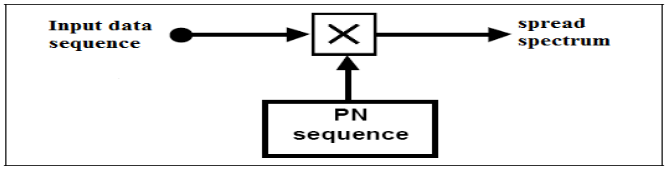

Figure 1.Direct Sequence Spread Spectrum

In CDMA there are many number of users, each one of them use different PN sequence to get there data stream modulated using BPSK.This gives the highest degree of security to the user. The spectrum of DSSS looks as follows

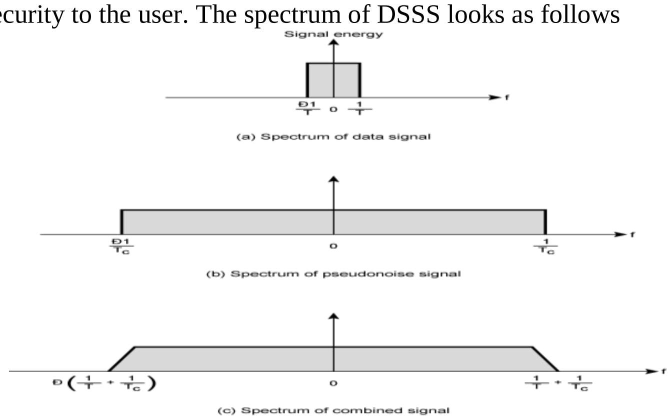

Figure 2.Spectrum of DSSS

III. THE BPSK MODULATION

This is the simplest form of phase modulation. With theoretical BPSK the carrier phase has only two states +/- pi/2. i.e. the transition from 1 to 0 and vice versa ,which will result in modulating signal. The hybrid versions of BPSK are used in real systems that combine constant amplitude modulation with phase modulation. In BPSK only one sinusoid is taken as a basis function. The equations of BPSK is shown below[8-9]

$S_0(t) = A\cos(\omega t)$ represents '0' (1)

$S_1(t) = A\cos(\omega \pm \pi/2)$ represents '1' (2)

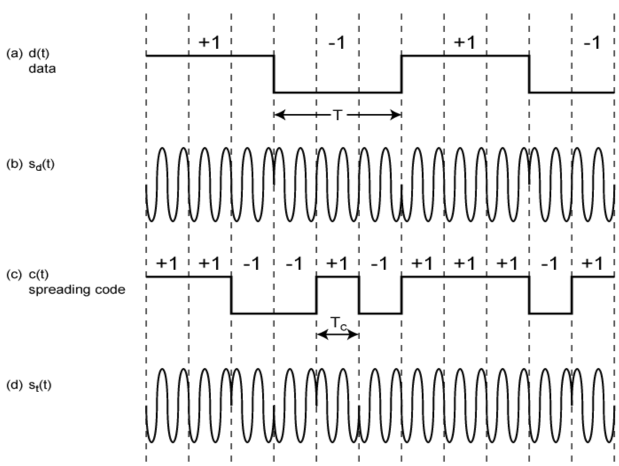

Figure 3. An example of BPSK

IV. THE WALSH ENCODING/DECODING

Walsh coding is the heart of the CDMA architecture. Walsh Code is a group of spreading codes having good autocorrelation properties and poor cross correlation properties. Walsh codes are the backbone of CDMA systems [10]. Walsh codes are created out of Hadamard matrices and Transform. Hadamard is the matrix type from which Walsh codes are created. In a family of Walsh codes, all codes are orthogonal to each other and are used to create channelization within the 1.25 MHz band. Walsh matrix is a specific square matrix, with dimensions a power of 2, the entries of which are +1 or −1 with the dot product of two entries is equal to zero. The Hadamard matrices of dimension 2^k for $k \in N$ is given by a recursive formula The lowest order of Hadamard matrix is 2 as shown in equations below

$$H(2^1) = \qquad (3)$$

$$H(2^2) = \qquad (4)$$

V. THE PROPOSED CDMA SYSTEM MODEL

The proposed CDMA model consists of a transmitter and a receiver. These are described below.

A. *The CDMA Transmitter Block*

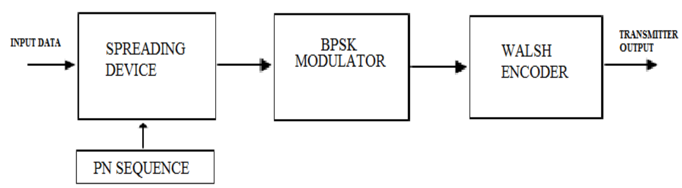

Figure 4. CDMA Transmitter Block

Figure 4. Shows transmitter block diagram. Here, a 8 bit input data stream of binary data is spreader at the spreading device using a PN sequence. The output of the spreading device is feed to the modulator where a noise like signal (a spreaded signal) is subjected to BPSK modulation. The modulated signal is encrypted using Walsh encoding technique. The output of which is given to the channel for transmission.

B. *The CDMA Receiver Block*

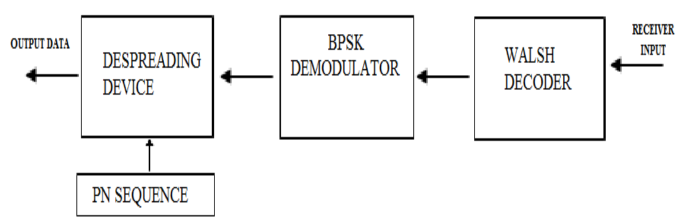

Figure 5. CDMA Receiver Block

Figure 5. Shows receiver block diagram. Here, a 64 bit encrypted signal is decrypted using Walsh decoding technique which is then forced to the BPSK demodulator, where the signal is demodulated. Further it is despreaded using dispreading technique.

VI. DESIGN METHODOLOGY

In the CDMA transmitter an 8 bit input data stream is spreaded using PN sequence. The spreaded signal which is 16 bit in width is modulated using BPSK technique >the width of the modulated signal now becomes 64 bit which is then encrypted using Walsh encoding. Figure 6 describes the flowchart.

A. CDMA transmitter flowchart

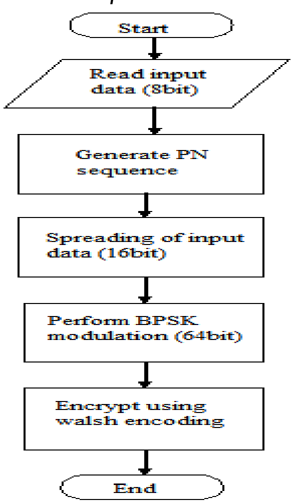

Figure 6. Flow chart of CDMA transmitter

In the receiver section the signal is decrypted using Walsh decoding technique which is then demodulated using BPSK demodulation technique which is 64 bit in length. This is then despreaded to obtain the original data stream. Figure 7 describes the complete methodology of CDMA receiver.

B. CDMA receiver flowchart

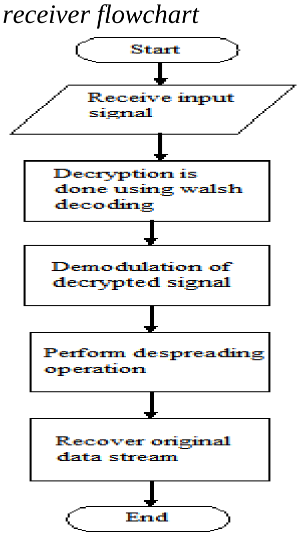

Figure 7. Flow chart of CDMA receiver

VII. RESULTS AND DISCUSSIONS

With respect to the procedures mentioned in the section VI, initially PN sequences are generated and input data test vector/stream is spreaded and the spreading sequence is shown in figure 8. Where 'in' is an 8 bit input signal and 'spr_outtt' (16 bit) is the spreaded output.

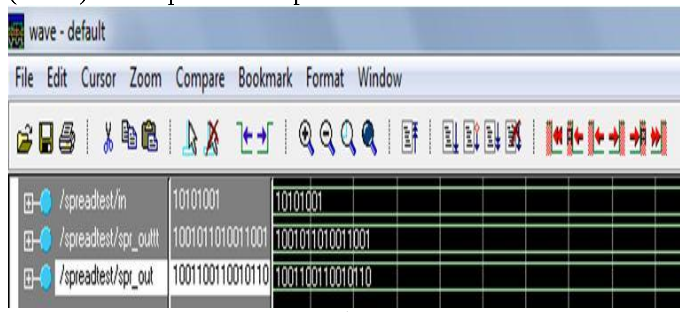

Figure 8. Spreading of the input data stream

Figure 9. shows the BPSK modulation waveform. In the BPSK modulation the output of the spreaded device i.e. 'Spr_outtt' is modulated to provide 'mod_out'(64 bit)

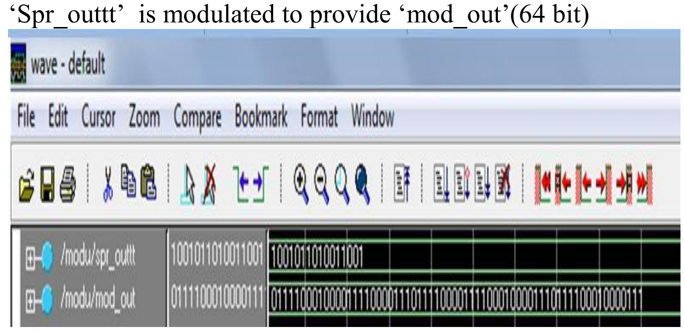

Figure 9. BPSK modulator waveform

Figure 10. shows the output of Walsh encoder.Here,'mod_out' is encrypted using Walsh encoding technique which provides an encrypted signal i.e. 'encr_out'(64 bit)

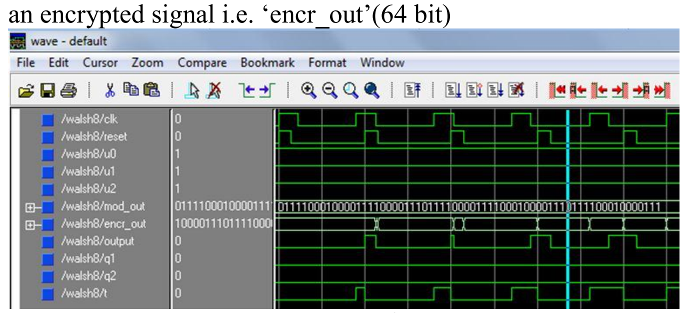

Figure 10. Walsh encoding of modulated signal

Figure 11. shows the decryption of received signal using Walsh decoding technique. Here, the encrypted signal is decrypted by reversing the operations performed in Walsh encoder.'decrypt_out' is the decrypted signal.

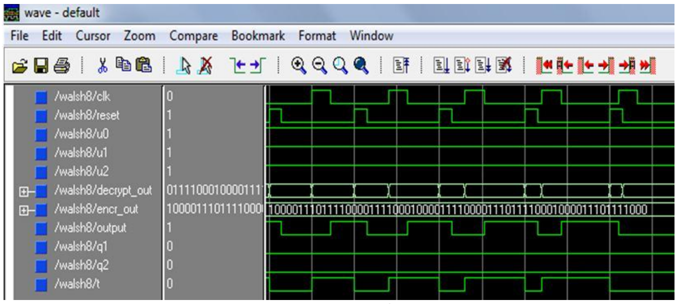

Figure 11 Walsh decoding of received signal.

Figure 12. depicts BPSK demodulation operation.Here,output of the Walsh decoder is demodulated to obtain 'demod_out' which is of 64 bit in length.

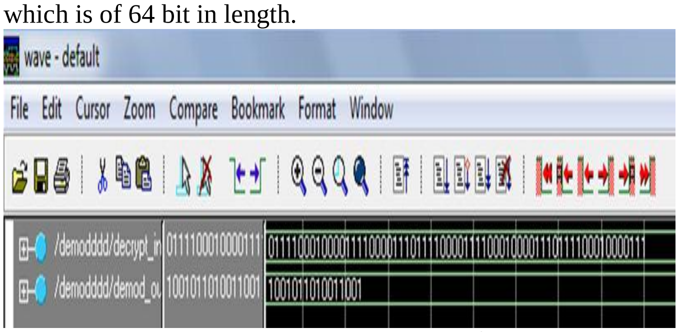

Figure 12. BPSK demodulation waveform.

The demodulated signal is despreaded to recover the original data stream i.e. 'dspr_out'which is 8 bit in length.

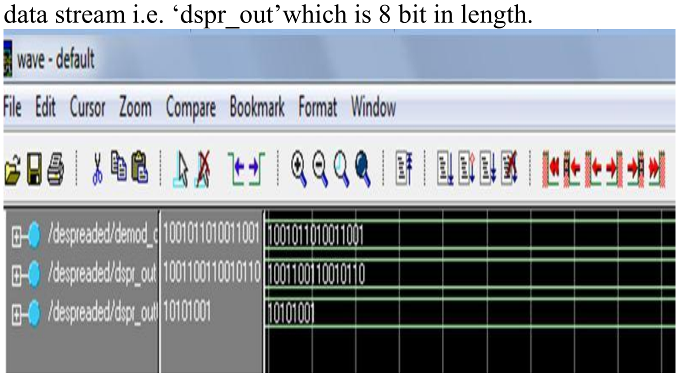

Figure 13. The despreaded signal waveform

From figure 13. We observed that the output of the despreaded signal is same as the input test vector which is initially applied to the spreading device.

VIII. SYNTHESIS REPORT

Table 1. depicts the synthesis report of CDMA transmitter.

Device – XC2V40

Package- CS144

Speed grade - -6

Peak memory usage- 258.6 MB

TABLE 1.DEVICE UTILIZATION OF TRANSMITTER

Modules	Target Devices	Speed Grades	Peak Memory Usage	No. Of Slices	No. of 4 input LUTS	No. Of Bonded IOBS	Global Max. Fanout
Spreading Devices	Xc2s15-6-cs144	-6	65052 KB	50/192(2%)	8/3 84(2%)	40/90(40%)	100
PN Sequence	Xc2s15-6-cs144	-6	65180 KB	9/192(4%)	16/384(1%)	2/90(2%)	100
BPSK Modulation	Xc2s15-6-cs144	-6	65948 KB	9/192(4%)	16/384(4%)	80/90(88%)	100
Walsh Encoding	Xc2s15-6-cs144	-6	68636 KB	41/192(21%)	70/384(18%)	133/90(147%)	100

Table 2. describes the synthesis report of CDMA receiver.

Device – XC2V80

Package- CS144

Speed grade - -6

Peak memory usage- 258.4 MB

TABLE 2. DEVICE UTILIZATION OF RECEIVER

Modules	Target Devices	Speed Grades	Peak Memory Usage	No. Of Slices	No. of 4 input LUTS	No. Of Bonded IOBS	Global Max. Fanout
Walsh Decoding	Xc2s15-6-cs144	-6	68636 KB	41/192(21%)	70/384(18%)	133/90(147%)	100
Demodulation	Xc2s15-6-cs144	-6	65884 KB	9/192(4%)	15/384(4%)	80/90(88%)	100
Despreading Device	Xc2s15-6-cs144	-6	64924 KB	9/192(4%)	16/384(4%)	40/90(44%)	100
PN Sequence	Xc2s15-6-cs144	-6	65180 KB	9/192(21%)	16/384(18%)	2/90(147%)	100

IX. CONCLUSIONS

In this proposed work the functionality of transmitter and receiver unit of CDMA has been simulated using Xilinx ISE 6 with the aid of Modelsim SE 5.5a.Here, we simulated each module of transmitter and receiver units by feeding arbitrary stream of data bits. The functionality of all the modules were found to be satisfactory.

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