



REVIEW ARTICLE

Review on Design and Implementation of DSSS-CDMA Transmitter using HDL with Raised Cosine Filter to Minimize ISI

Md. Sohrab Ansari¹, Mathew Oommen², Velmurugan.S³

¹M.Tech. Scholar, Dept. of ECE, Hindustan University, Chennai, India

²M.Tech. Scholar, Dept. of ECE, Hindustan University, Chennai, India

³M.Tech. Scholar, Dept. of ECE, Hindustan University, Chennai, India

¹ sohrab.ete@gmail.com; ² mathewoommen91@gmail.com; ³ velsrt@gmail.com

Abstract— Spread spectrum technology has blossomed from a military technology into one of the fundamental building blocks in current and next-generation wireless systems. The spread-spectrum technology provides antijam capabilities through a processing gain that results from using a wideband (large bandwidth) signal and it also provides capacity enhancement and robustness against noise. This paper presents the design and implementation of a direct sequence spread spectrum (DSSS-CDMA) system using HDL. The transmitter module mainly consist of symbol generator, PN sequence generator, spreader and BPSK modulator, IF carrier generator, Root cosine filter(RCF) and DAC (Digital to Analog Convertor) blocks. The Xilinx Synthesis Technology (XST) of Xilinx ISE (Integrated Software Environment) 14.7 version tool will be used for synthesis of transmitter on FPGA(Field Programmable Gate Array) and also MATLAB(R2012b) software will be used for simulation purpose. To minimize the inter-symbol interference (ISI) at transmitter side the Raised cosine filtering will be performed.

Keywords— DSSS-CDMA, VHDL, BPSK, Spread Spectrum, ISI, FPGA, RCF, DAC

1. INTRODUCTION

DSSS-CDMA is a popular multiple access technique because it provides- Multiple access capability, Protection against multipath interference, Privacy, interference rejection, Anti-jamming capability and Low probability of interception. The CDMA system provides the basic idea for the development of next generation technology for wireless and mobile communication like 3G, 4G. In recent years, there has been a significant amount of research performed in both industry and academia into the development of CDMA systems.

DS-CDMA is a type of spread-spectrum communication system in which multiple signal channels occupy the same frequency band, being distinguished by the use of different spreading codes. CDMA

communication is employed in, for example, digital cellular telephone systems and personal communication services.

Different Multiple access techniques:-

Multiple access is a signal transmission situation in which two or more users wish to simultaneously communicate with each other using the same propagation channel.

[1.1] FDMA(Frequency Division Multiple Access):- In FDMA, the total bandwidth is divided into non-overlapping frequency sub-bands. Each user is allocated a unique frequency sub-band (channels) for the duration of the connection, whether the connection is in active or idle state. The adjacent frequency bands in the FDMA are likely to interfere with each other therefore it is necessary to include the guard bands between the adjacent frequency bands.

[1.2] TDMA(Time Division Multiple Access):- In TDMA system, each user is allocated the spectral occupancy of the channel, but only for a short duration of time called a time slot. Buffer zones in the form of guard times are inserted between the assigned time slots to avoid interference.

[1.3] CDMA (Code Division Multiple Access):- CDMA is a "spread spectrum" technology, allowing many users to occupy the same time and frequency allocations in a given band/space. CDMA (Code Division Multiple Access) assigns unique codes to each communication to differentiate it from others in the same spectrum. In a world of finite spectrum resources, CDMA enables many more people to share the airwaves at the same time than do alternative technologies.

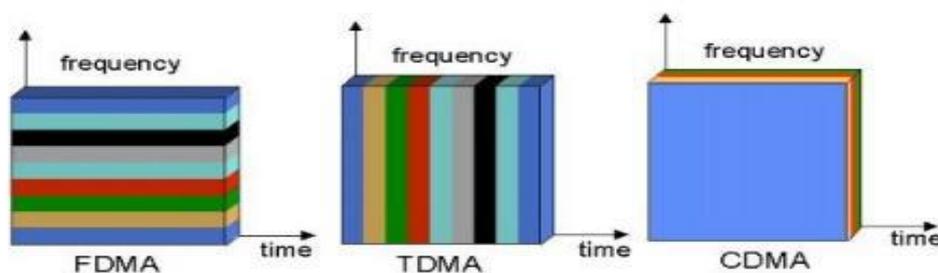


Figure-1:- Different multiple access schemes

[1.4] Spread- spectrum techniques:-

Spread-spectrum techniques involve the transmission of a signal in a radio frequency bandwidth substantially greater than the information bandwidth to achieve a particular operational advantage. Once only of interest to the military, spread-spectrum techniques have now been adapted for commercial applications, using nearly all the operational advantages that rendered the techniques important to the military.

Spread spectrum uses wideband, noise-like signals that are hard to detect, intercept, or demodulate. Additionally, spread-spectrum signals are harder to jam (interfere with) than narrow band signals. These low probability of intercept (LPI) and anti-jam (AJ) features are why the military has used spread spectrum for so many years. Spread-spectrum signals are intentionally made to be a much wider band than the information they are carrying to make them more noise-like ,Spread-spectrum transmitters use similar transmit power levels to narrowband transmitters.

The use of special pseudo noise (PN) codes in spread-spectrum communications makes signals appear wide band and noise-like. It is this very characteristic that makes spread-spectrum signals possess a low LPI. Spread-spectrum signals are hard to detect on narrow band equipment because the signal's energy is spread over a bandwidth of maybe 100 times the information bandwidth. **(Figure 1).**

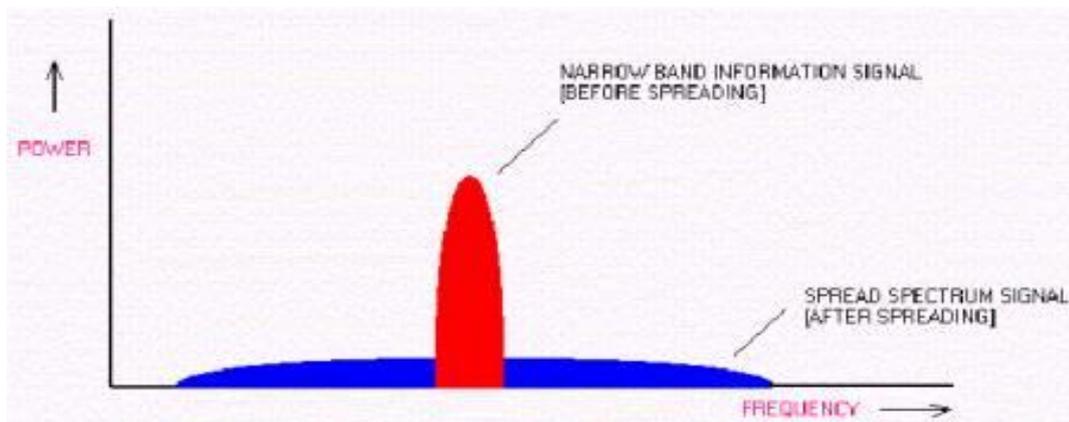


Figure- 2: In a spread-spectrum system, signals are spread across a wide bandwidth, making them difficult to intercept, demodulate, and intercept.

[1.5] Direct Sequence spread spectrum(DSSS):

Direct sequence is perhaps one of the most widely known and utilized spread spectrum systems and it is relatively simple to implement. A narrow band carrier is modulated by a code sequence. The carrier phase of the transmitted signal is abruptly changed in accordance with this code sequence. Direct Sequence is adopted by CDMA.

[1.6] CDMA Process Gain (Gp): One of the most important concepts required in order to understand spread spectrum techniques is the idea of process gain. The process gain of a system indicates the gain or signal to noise improvement exhibited by a spread spectrum system by the nature of the spreading and de-spreading process.

$$G_p = \frac{BW_{RF}}{BW_{info}}$$

2. BLOCK DIAGRAM

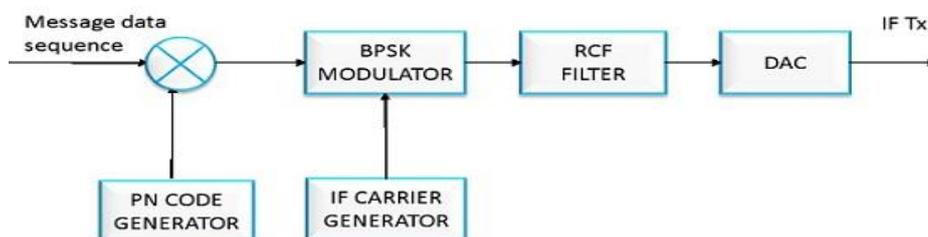


Figure:-3 DSSS-CDMA TRANSMITTER

The transmitter module mainly consist of symbol generator, PN sequence generator, spreader and BPSK modulator, IF carrier generator ,Root cosine filter(RCF) and DAC (Digital to Analog Convector) blocks.

[2.1] PN CODE GENERATOR:- Gold code generators are used extensively in CDMA systems to generate code sequences with good correlation properties. In this project we are using gold Code to generate PN

sequences .The Gold Sequence Generator block uses two PN Sequence Generator blocks to generate the preferred pair of sequences, and then XOR's these sequences to produce the output sequence, as shown below -

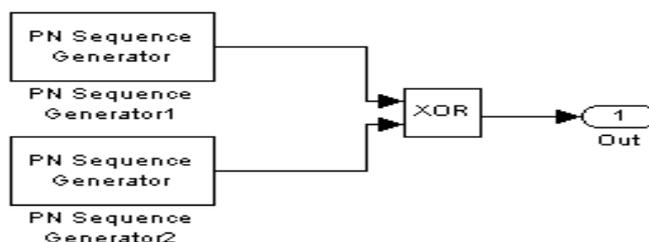


Figure-4:-Gold code generator

Joining the two original PN sequences, altogether $2^n + 1$ different sequences can be generated with one pair of primitive polynomials.

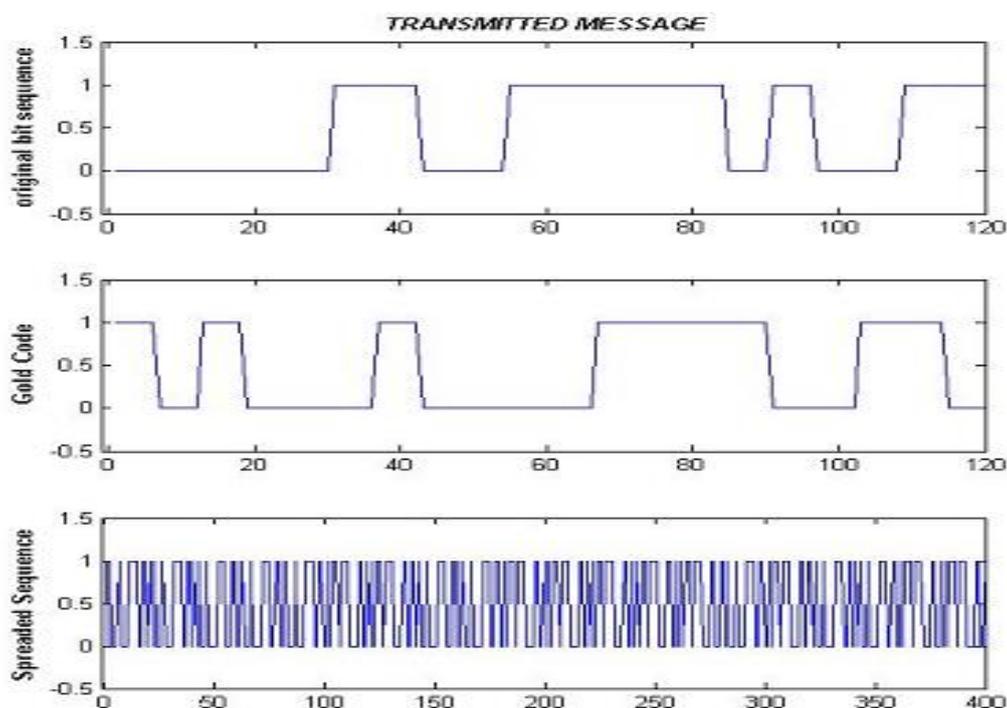


Figure-5 MATLAB simulation output Shows the process of spreading of message sequences

[2.2] .Raised Cosine Filtering and Inter-Symbol Interference (ISI):-

The raised cosine filter is one of the most common pulse-shaping filters in communications systems. In addition, it is used to minimize inter-symbol interference (ISI) by attenuating the starting and ending portions of the symbol period. Because these portions are most susceptible to creating interference from multi-path distortion, the shaping characteristics of the raised cosine filter helps reduce ISI. Inter-symbol interference (ISI) occurs when a pulse spreads out in such a way that it interferes with adjacent pulses at the sample instant. The amount of ISI can be seen on an oscilloscope using an Eye Diagram or Eye pattern.

A commonly used pulse shaping filter satisfying the Nyquist criterion while having a faster decay is called the raised cosine filters having the following equation,

$$g(t) = \left(\frac{\sin(\pi t/T)}{\pi t/T} \right) \left(\frac{\cos(\alpha \pi t/T)}{1 - (2\alpha t/T)^2} \right), \quad t = -\infty \text{ to } +\infty$$

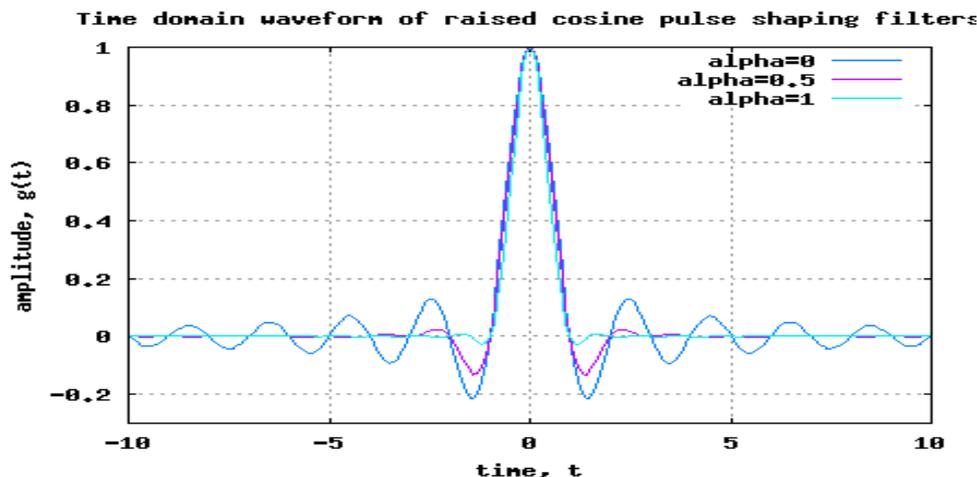


Figure- 6 The Response Of Filter For Different Value Of Alpha.

The alpha α is the roll-off factor, which determines the sharpness of the frequency response of the filter alpha and it takes values from 0 to 1.

From the time domain samples (Figure-6), can observe that filter tail of the raised cosine filter with greater than 0 dies down faster. This implies that practical implementations can ignore taps which are close to zero with negligible loss in performance.

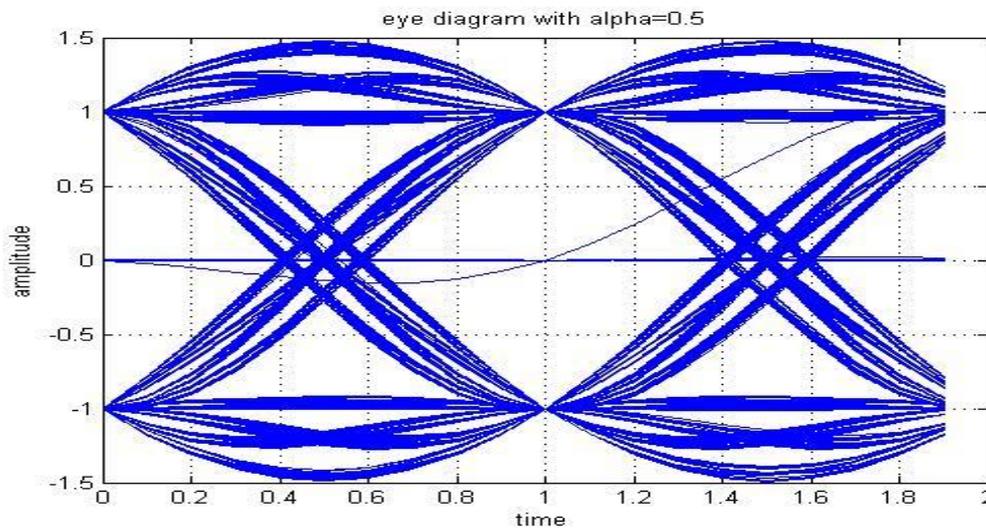


Figure -7 Eye diagram for raised cosine filter for alpha =0.5

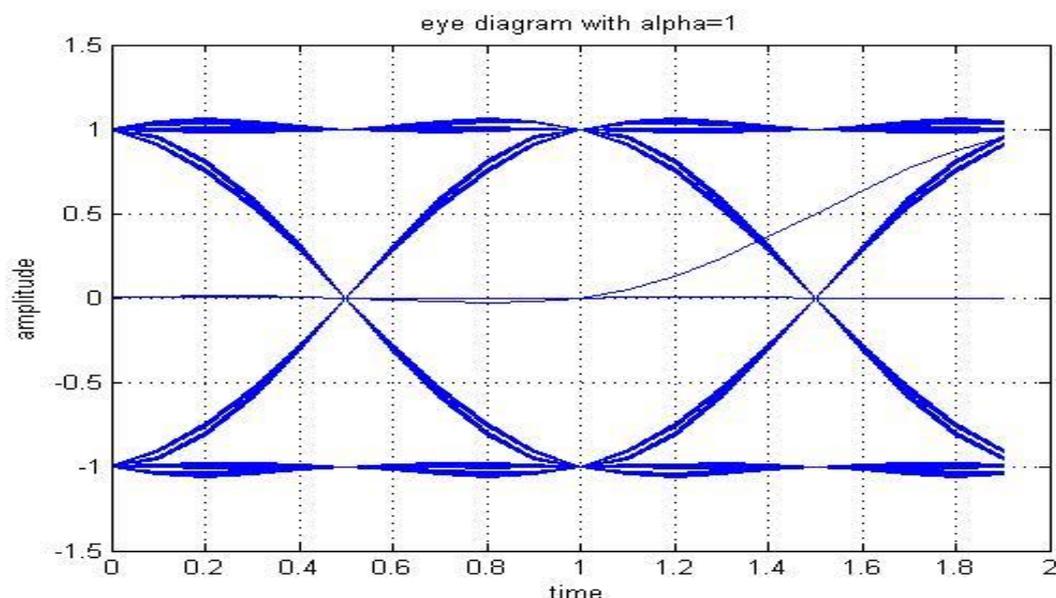


Figure -8 Eye diagram for raised cosine filter for alpha =1

Observations from eye diagram:-

[1] . For increasing the margin for error free transmission, the vertical opening of the eye should be more. In the presence of inter-symbol interference, the vertical opening of the eye reduces, thus increasing the probability of error. [2].The ideal sampling instant is the point where the vertical eye opening is maximum. [3]. Smaller horizontal eye opening means implies more sensitivity to timing errors.

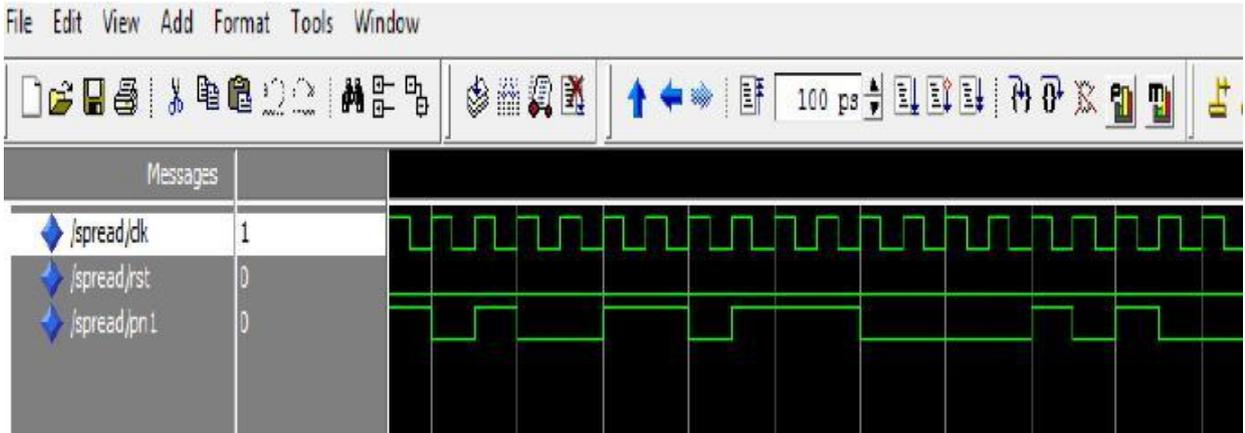
From the above figures, it can be observed that the horizontal eye opening with $\alpha=0.5$ is smaller than with $\alpha=1$; because the tails of the raised cosine filter with $\alpha=1$ dies away faster than the case where $\alpha=0.5$. Hence error in timing cause a bigger performance degradation for $\alpha=0.5$ than for $\alpha=1$ scenario. However, the flip side of using $\alpha=1$ is the increased bandwidth required for transmission.

[2.4] **BPSK modulator:-** In Binary Phase Shift Keying (BPSK) only one sinusoid is taken as basis function modulation. Modulation is achieved by varying the phase of the basis function depending on the message bits. In this project BPSK is chosen because the hardware implementation of BPSK modulation is easier in compare to other complex modulations techniques .

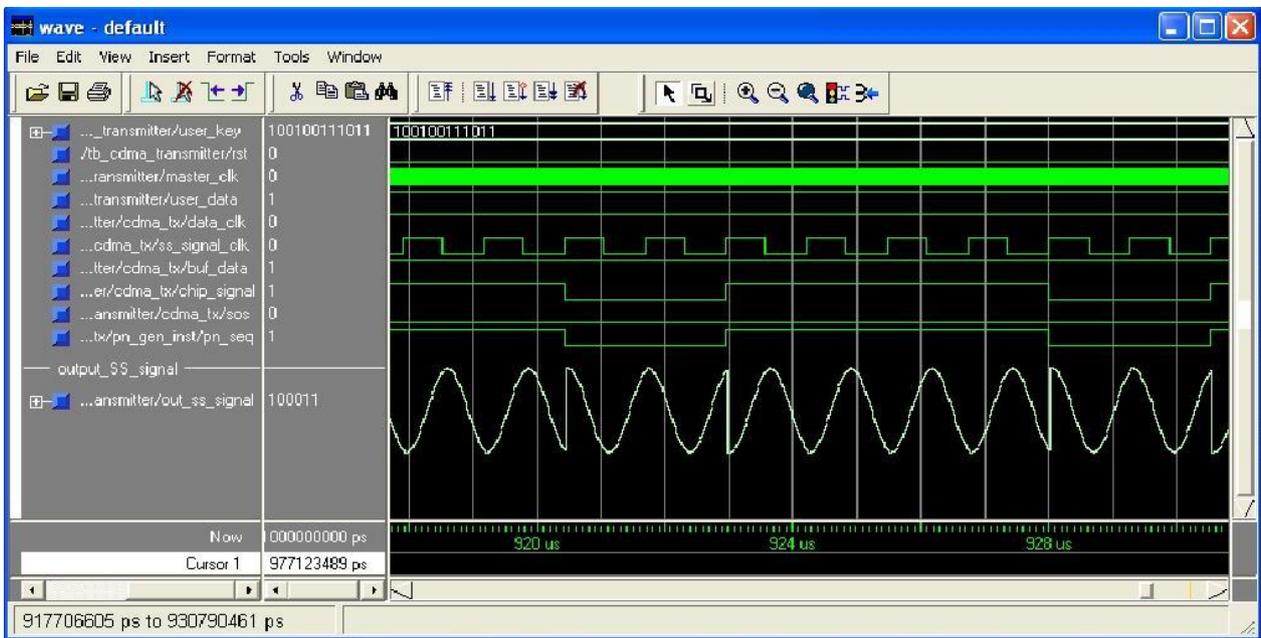
[2.3] **Local Oscillator Generator;-** The Direct Digital frequency synthesizer (DDS) will be used to produce the desired output with full digital control. So the local oscillator uses the DDS method to generate desired frequency.

3. XILINX SIMULATION RESULTS AND OBSERVATIONS

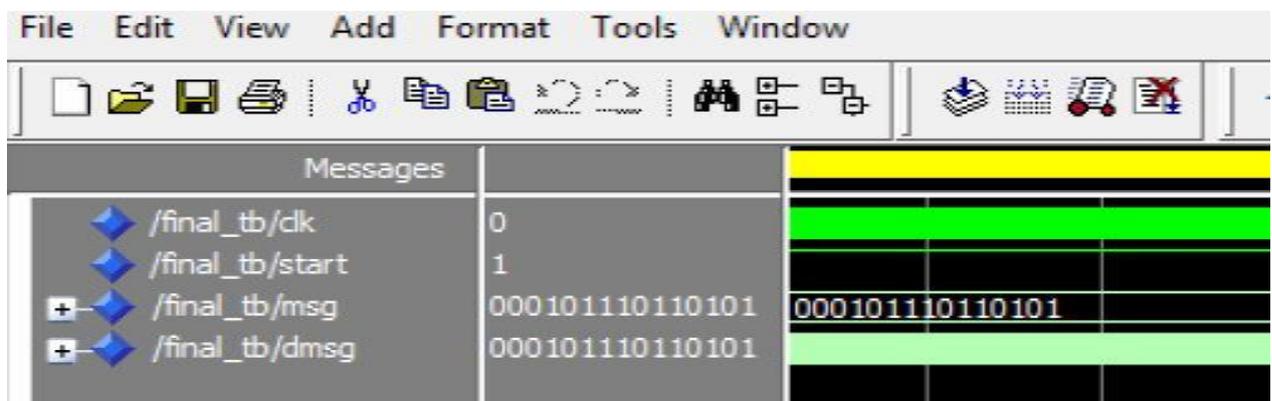
[3.1] **PN generator :-** PN Sequence is generated the by the preferred pair of sequences, and then XOR's these sequences to produce the output sequence. 101001101110000 is the generated PN code in the simulation shown below.



[3.2] BPSK Modulator



[3.3]. Transmitted and received data bit streams.



4. CONCLUSION

In this project a direct sequence spread spectrum (DSSS-CDMA) system using HDL has been proposed with the raised cosine filter to minimize the ISI and the output waveforms has been simulated by using MATLAB and XILINX software. Since nowadays we need higher data rate for communication devices so the chances of distortion increases with increase in data rate, so we have to find the efficient techniques to provide higher data rate with less error. From the eye diagram of the raised cosine filter we have seen the effect of ISI so we have to choose the value of alpha(Roll-off factor) around 0.5 for lesser distortion.

The simulation waveforms presented in this paper have proven the reliability of the HDL implementation to describe the characteristics and the architecture of the digital transmitter. The Implementation of a CDMA communication system with DSSS technique in HDL has the advantages like the design is fully reconfigurable, The number of bits and PN sequence can be changed very easily and it is useful for both FPGA and ASIC implementations.

5. FUTURE SCOPE

The proposed system can be further implemented using different modulation techniques. The different methods of PN sequence generation can also be used for generating the spreading codes. Also frequency hopping spread spectrum technique can be used instead of DSSS.

REFERENCES

- [1] Jung, P.; Baier, P.W.; Steil, A., "Advantages of CDMA and spread spectrum techniques over FDMA and TDMA in cellular mobile radio applications," Vehicular Technology, IEEE Transactions on, vol.42, no.3, pp.357,364, Aug 1993
- [2] Mohamed, K.E.; Ali, B.M., "Digital design of DS-CDMA transmitter using VHDL and FPGA," Networks, 2005. Jointly held with the 2005 IEEE 7th Malaysia International Conference on Communication., 2005 13th IEEE International Conference on, vol.2, no., pp.5 pp., 16-18 Nov. 2005
- [3.] Popescu, S. O.; Gontean, A.-S., "Performance comparison of the BPSK and QPSK modulation techniques on FPGA," Design and Technology in Electronic Packaging (SIITME), 2011 IEEE 17th International Symposium for, vol., no., pp.257,260, 20-23 Oct. 2011
- [4] Sarwate, D.V.; Pursley, M.B., "Cross-correlation properties of pseudorandom and related sequences," Proceedings of the IEEE, vol.68, no.5, pp.593,619, May 1980
- [5] Implementation of DS-CDMA Transmitter and Receiver in VHDL for FPGA, Vaibhav K Kakade, International Journal of Latest Trends in Engineering and Technology (IJLTET), Special Issue - IDEAS-2013.
- [6] F.Xiong, "Digital Modulation Techniques", Artech House, UK, 2000
- [7] John G. Proakis and Masoud Salehi. "Communications Systems Engineering" Prentice Hall pub. 1994
- [8] Rodger E. Ziemer and Roger L. Peterson. "Digital Communications and Spread Spectrum Systems" Macmillian Publishing Company, New York 1985.
- [9] Jhong S. Lee, Leonard E. Miller "Cdma System Engineering Handbook" (Artech House Mobile Communications), 1998.
- [10] Simon Haykin, "Communications Systems", 4th edition, Wiley pub.2001.
- [11] Digital Communications, 2nd E d. J. G. Proakis, McGraw-Hill Book Company, New York, 1989.
- [12] Spread Spectrum Communication Handbook, M. K. Simon, J. K. Omura, R. A. Schultz, and B. K. Levitt New York, McGraw-Hill, 1994
- [13] Theodore S. Rappaport, Wireless Communications: Principles and Practice.
- [14] The Designer's Guide to VHDL, Third Edition (Systems on Silicon), Peter J. Ashenden