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RESEARCH ARTICLE

Implementation of DSSS System using Chaotic Sequence using MATLAB and VHDL

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Abstract— ***In spread spectrum systems, pseudo-random (PN) sequences are used to spread the data bits. There are various type of PN sequences are available with good correlation properties, most of which are generated by Linear Feedback Shift Register (LFSR). In this paper we describe the generation pseudo chaotic sequences (PCS) and conventional PN sequences and its correlation properties. Here, pseudo-chaotic sequences are generated with different initial values and its autocorrelation, cross correlation properties evaluated. The BER performance of PCS sequence is compared with the conventional PN sequences. DSSS system is implemented both in MATLAB and VHDL language.***

Keywords— ***"Chaos", "Chaotic system", "Spread spectrum", "Correlation", "BER"***

I. Introduction

In telecommunications and radio communication spread-spectrum (SS) techniques are the methods by which a signal generated with a particular bandwidth is deliberately spread in the frequency domain, resulting in a signal with a wider bandwidth. The band spread is accomplished by utilizing a "code" called binary pseudo noise (PN) sequence which is independent of the data and a synchronized reception with the code at the receiver is used for de-spreading and data recovery.Spread spectrum techniques provides high security and susceptibility to interference from other parties. Now a day spread spectrum techniques are being used in variety of commercial applications such as mobile and wireless communication. Performance of direct sequence spread spectrum (DSSS) system depends on the spreading sequence used [1]. Spreading sequences used should have minimum cross correlation and very good auto correlation properties. Most commonly used PN sequences are m-sequence and gold sequence.The ability to predict future sequence is nevertheless possible though difficult. Therefore transmission is not completely secured. The number of sequences generated by linear feedback shift registers (LFSR) may be insufficient for wideband ds-ss with a very large number of users. In addition, LFSR techniques provide limited flexibility in incorporating security into multiple user systems. The use of chaotic sequences as spreading sequence is because of its sensitivity to initial conditions and has characteristics similar to random noise.

Section II explains chaotic sequence. Section III describes the proposed system. Section IV explains results obtained and section V gives the conclusion.

II. CHAOTIC SEQUENCE

A chaotic sequence is non-converging and non-periodic noise like sequence. A large number of uncorrelated, random-like, yet deterministic and reproducible signals can be generated by changing initial value. These sequences so generated by chaotic systems are called chaotic sequences [2]. Since the spreading sequence in a Chaotic Spread Spectrum (SS) is no longer binary. Chaos is a deterministic, random-like process found in non-linear, dynamical system, which is non-period, non-converging and bounded. Moreover, it has a very sensitive

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dependence upon its initial condition and parameter. Chaotic signals can be used in communication. Chaotic sequences have been adopted instead of random ones and very interestingly used in many applications such as secure transmission, natural phenomena modeling, neural networks, and nonlinear circuits. Also in, chaotic time series were used in DNA computing procedures. The choice of chaotic sequences is justified theoretically by their unpredictability, i.e., by their spread-spectrum characteristic.

III.PROPOSED SYSTEM

Chaotic system or chaos is behaviour between rigid regularity and randomness based on pure chance. Chaotic systems provide a rich mechanism for signal design and generation, with potential applications to communications and signal processing [3]. Because chaotic signals are typically broadband, noise-like, and difficult to predict, because of long periodicity, it provides very high security and is capable of handling many users .The highlight of this paper is the PCS Generator, which generates a pseudo-chaotic PN sequence with good cross-correlation and auto-correlation properties that is well suited for DS-SS system [3].

A. *DSSS System*

The most common type of spread spectrum that is used nowadays is Direct Sequence Spread Spectrum (DSSS) because of its simplicity and ease of implementation. The major spread spectrums differ in a way they encode with PN sequence. In DSSS, information that has to be transmitted is divided into small pieces; each of this is allocated to a frequency channel across the spectrum.

In DSSS system the message bits are multiplied by spreading codes to obtain spreaded signal. Spreading the message provides security for transmitting signal making it difficult to demodulate for the unknown user who is unknown of spreading code. This spreaded signal is modulated and transmitted. The transmitted signal is demodulated and despreaded using spreading sequence to recover original sequence. The functional blocks of a DSSS communication system are illustrated in fig 1. The information bits are divided into small pieces and each of them is allocated a frequency channel across the spectrum. These information bits are then multiplied by pseudo-Chaotic sequences to obtain spreaded sequence. The spreaded sequence occupies wide bandwidth. The spreaded sequence is BPSK modulated and transmitted via channel. The channel is modeled as an AWGN channel. The demodulator performs the reverse operation and extracts the information bits from the received modulated signal which is corrupted by the noise. The demodulator produces the sequences that are the estimates of the information bits.

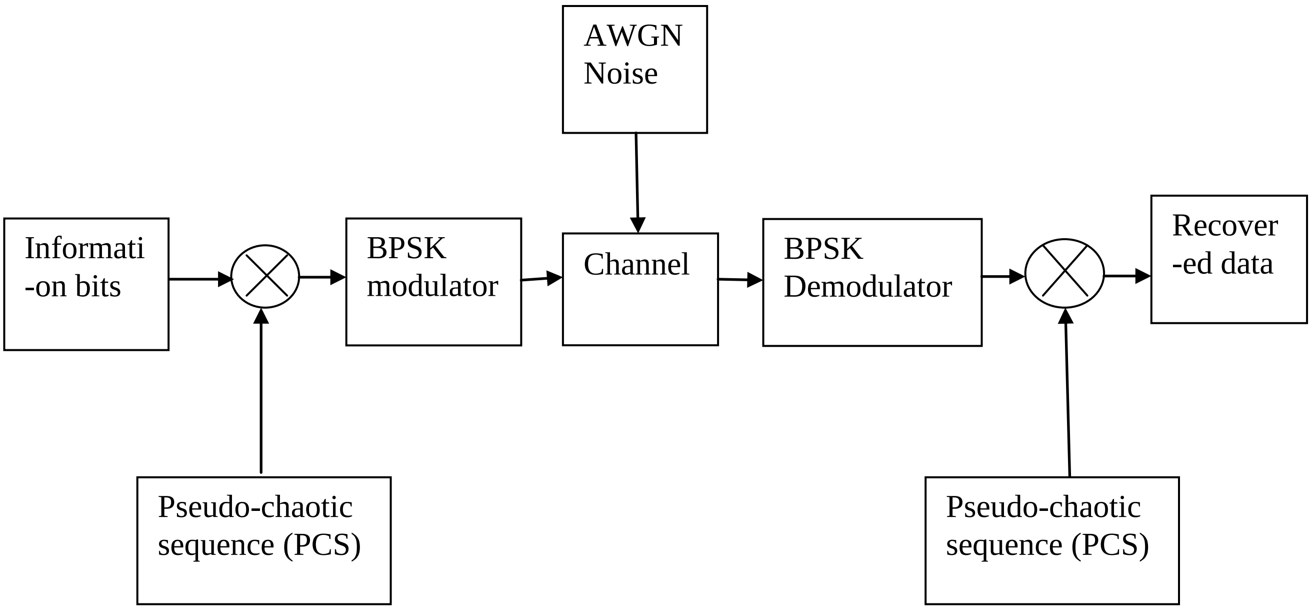

Fig 1 Block diagram of DSSS system using PCS

B. *BPSK modulation and demodulation*

BPSK modulation is widely used in DSSS system because of its simplicity and it is most robust of all PSK techniques. It uses two phases 0^0 and 180^0. In order to generate BPSK signal binary sequence must be represented in polar form. The BPSK modulation and demodulation is illustrated in fig 2 and 3 respectively. The BPSK modulator circuit is very simple. The binary sequence is multiplied sinusoidal signal to obtain BPSK signal.

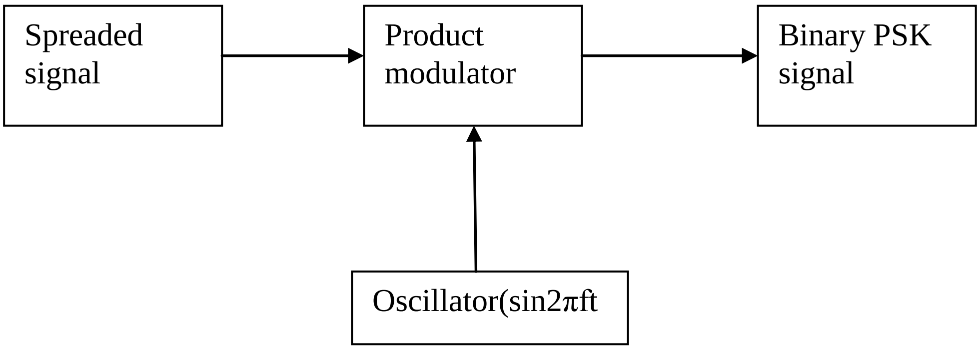

Fig 2 BPSK modulator

In the receiver part, the BPSK modulated signal is multiplied by sinusoidal signal and then it is passed through integrator and decision circuit to obtain message signal.

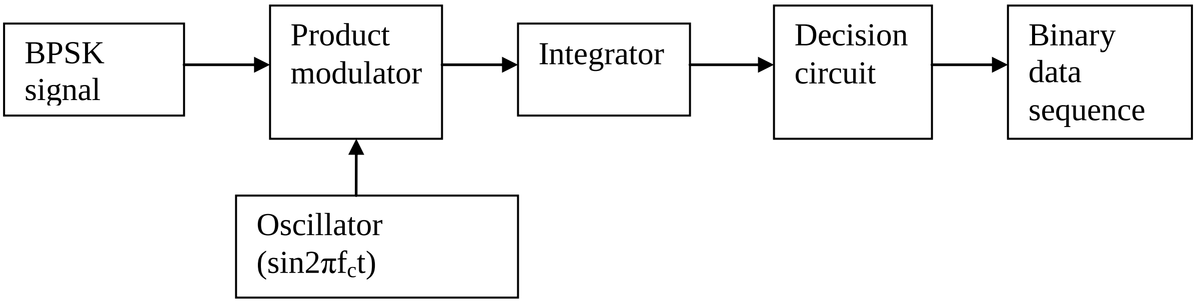

Fig 3 BPSK demodulator

C. *PCS Generation*

Basic NLFSR cell consist of two 8 bit programmable register and a xor gate. The contents of registers are xored to obtain cell out.

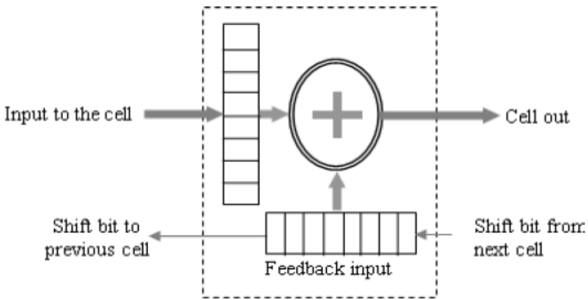

Fig 4 Basic NLFSR cell

PCS generator consists of a cascade of four basic cells with two 8-bit programmable registers each. Each of the register is loaded with initial contents. Contents of R7 and R8, R5 and R6, R4 and R3, R1 and R2 are xored. If the xor of R1 and R2 have even number of 1's then PCS is 1 else it is 0. The generated PCS is fed to feedback register. For each iteration the feedback register are shifted one place to the left. Any length of sequence can be obtained using this architecture.

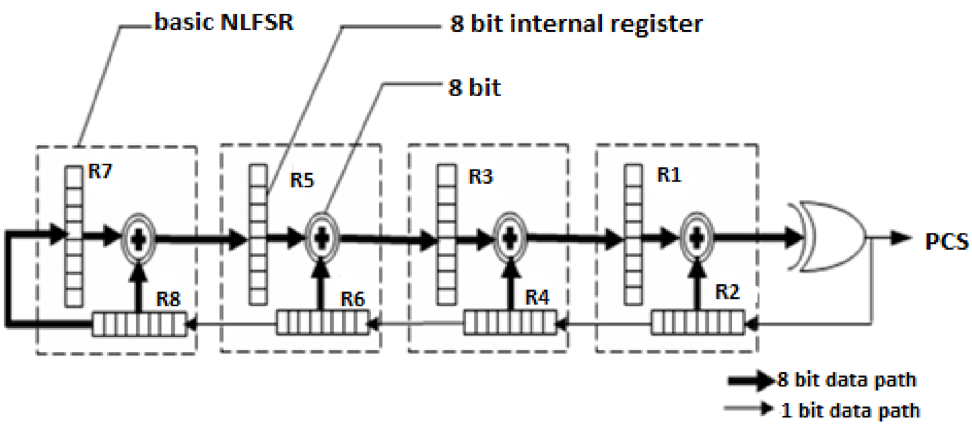

Fig 5 PCS generator

IV. RESULTS

The following results are obtained with given below initial conditions:

First initial conditions
R1=1 1 1 1 1 1 1 0
R2=1 1 1 1 1 1 0 1
R3=1 1 1 1 1 1 0 0
R4=1 1 1 1 1 0 1 1
R5=1 1 1 1 1 0 1 0
R6=1 1 1 1 1 0 0 1
R7=1 1 1 1 1 0 0 0
R8=1 1 1 1 0 1 1 1

Second initial conditions
R1=1 1 1 1 1 1 1 0
R2=1 1 1 1 1 1 0 1
R3=1 1 1 1 1 1 0 0
R4=1 1 0 0 1 0 1 1
R5=1 1 1 1 1 0 1 0
R6=1 1 1 1 1 0 0 1
R7=1 1 1 1 1 0 0 0
R8=1 1 1 1 0 1 1 0

A. MATLAB simulation results

PCS is sensitive to initial condition as a result any number of sequences can be generated just by changing initial conditions. Fig 6 shows two different sequences obtained by changing initial conditions.

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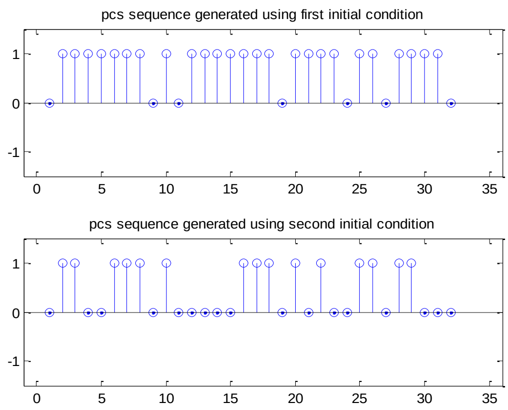

Fig 6 PCS generated by taking two diferent initial conditions

Autocorrelation is obtained by taking product of a sequence and its shifted version. Fig 7 shows the autocorrelation plot obtained by PCS. It can be seen that the correlation has maximum value at the origin and its minimum at all other places. Hence the autocorrelation is good.

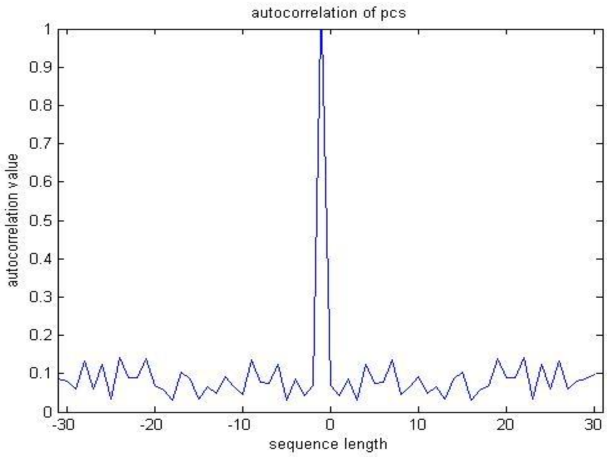

Fig 7 Autocorrelation of PCS

Maximum length (M) sequence and Gold sequences are mostly used PN sequences. They have properties similar to that of white noise. They lack security due to the fact that they are available in limited number. PCS overcome this advantage of PN sequences because of its sensitive nature to initial condition. Fig 8 shows the different sequences obtained by MATLAB simulation.

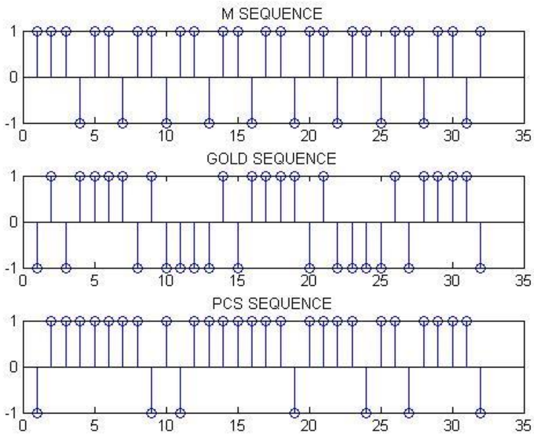

Fig 8 MATLAB simulation showing generation of different sequences.

Fig 9 shows the comparison of autocorrelation of PCS, m-sequence and gold sequence. It can be seen that all the sequences have maximum value at 0. But PCS have minimum value at all other places compared to other PN sequences. Hence PCS has best autocorrelation property.

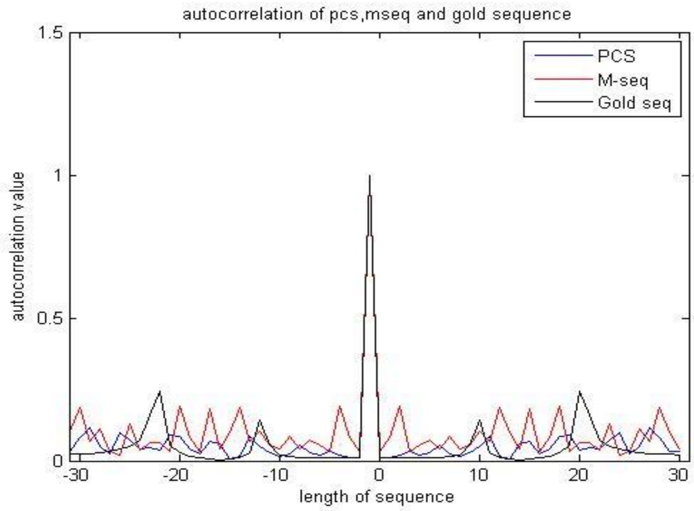

Fig 9 MATLAB simulation showing autocorrelation plots of different sequences

Fig 10 shows the comparison of the cross correlation of different sequences. It can be seen from the graph that PCS have minimum cross correlation compared to conventional PN sequences.

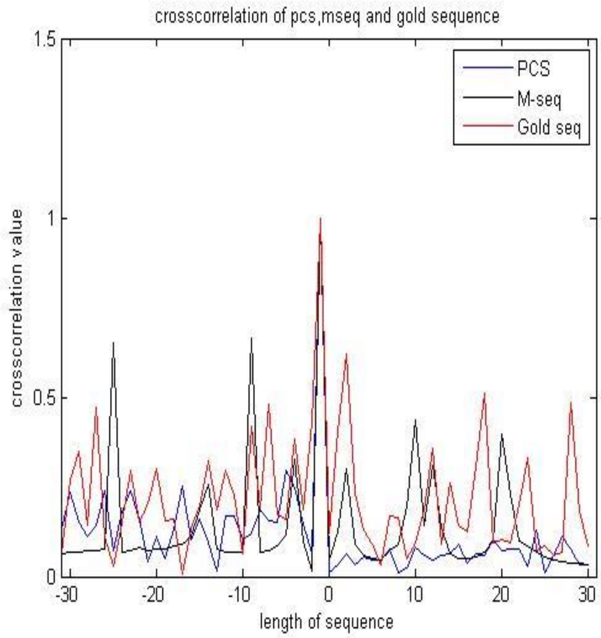

Fig 10 MATLAB simulation showing cross correlation plots of different sequences

Fig 11 and 12 shows the simulation results of BPSK modulation and demodulation. Information bits are multiplied by PCS to obtain spreaded signal. It is then BPSK modulated and transmitted via channel. At receiver reverse operation is performed to get original signal. It can be seen that original data and despreaded data are identical.

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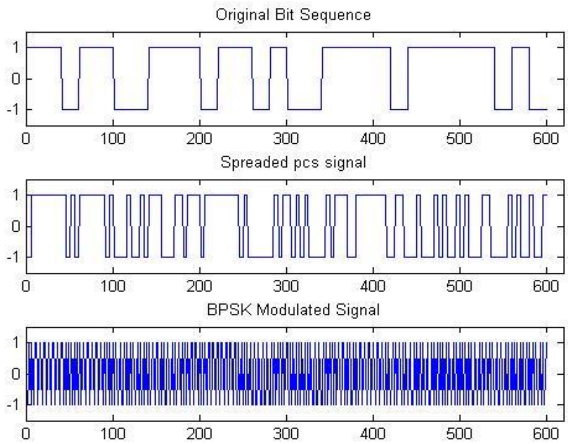

Fig 11 BPSK modulation

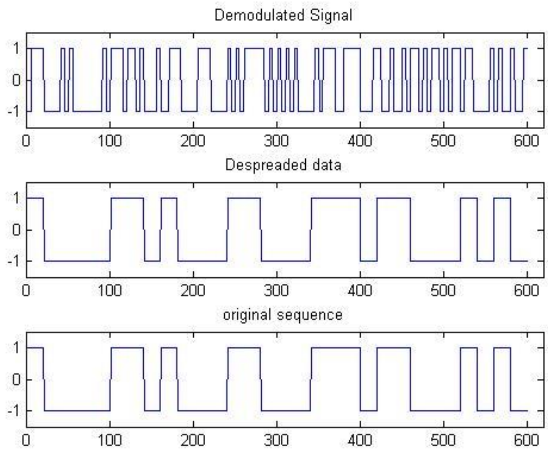

Fig 12 BPSK demodulation

Fig 13 shows the BER simulation results of various sequences. PCS have improved BER than other sequences.

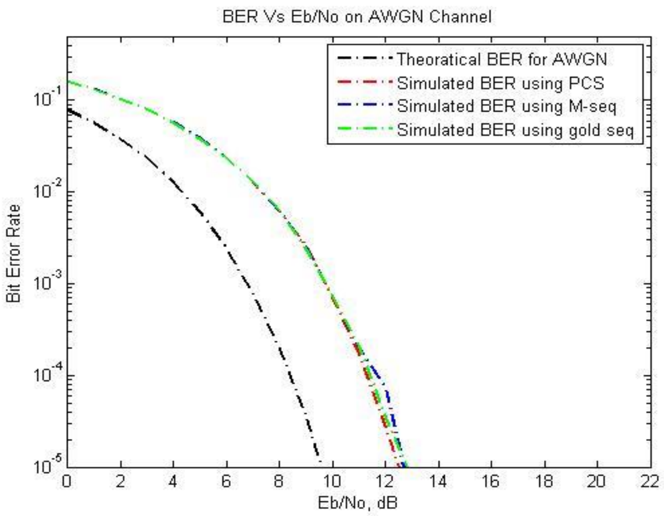

Fig 13 simulation results of BER analysis

B. *VHDL Simulation Results*

The results obtained by implementing DSSS system using VHDL are shown in this section. Fig 14 and 15 shows PCS generated by different initial condition and fig 16 shows the spreaded signal.

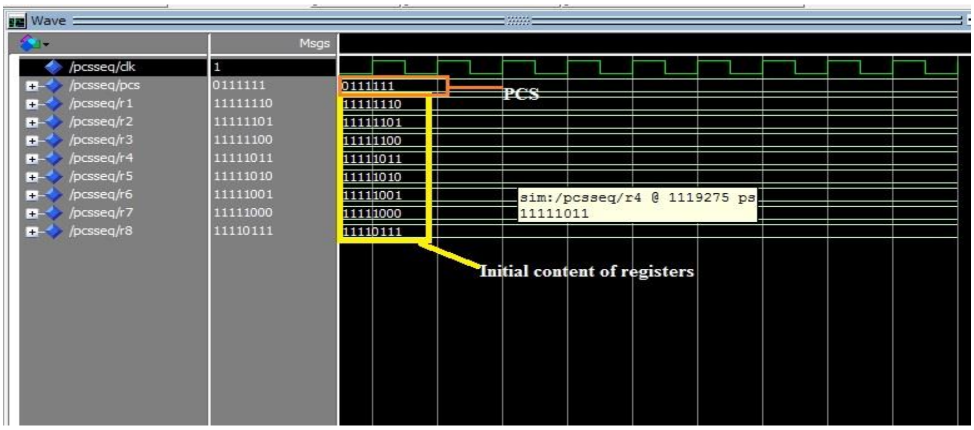

Fig 14 PCS obtained using first initial condition

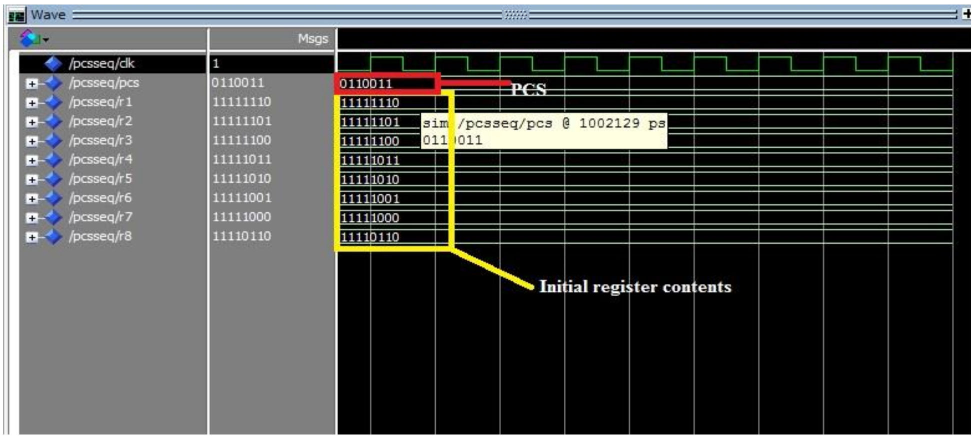

Fig 15 PCS obtained using second initial condition

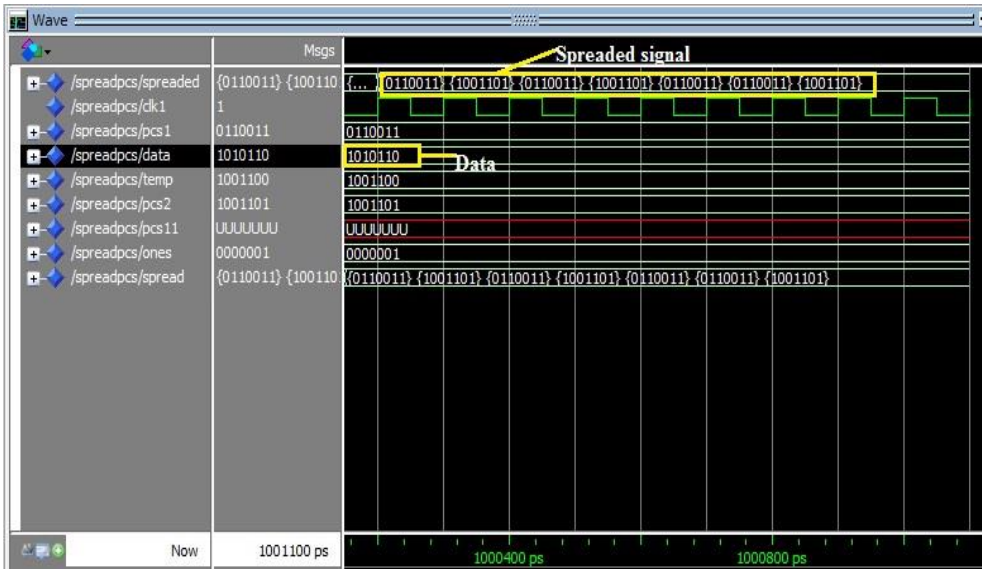

Fig 16 spreading of signal in DSSS system

Fig 17 shows the BPSK modulated and demodulated signal.

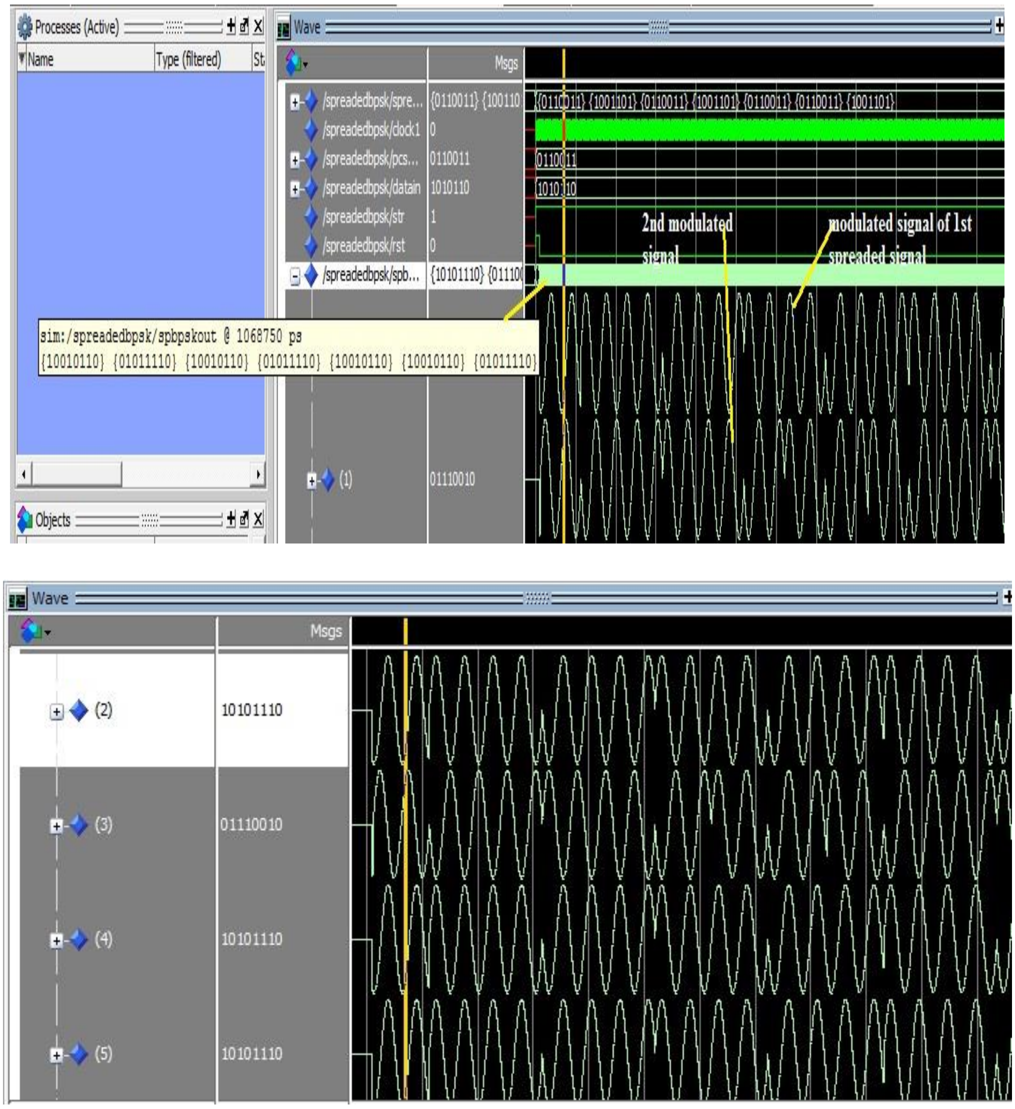

Fig 17 BPSK modulated and demodulated signal

V. CONCLUSION

The PCS generator in this paper is sensitive to initial conditions and can be randomly selected to produce pseudo-chaotic sequence with good correlation properties. Large number of PCS can be generated using same amount of memory when compared to conventional PN sequences. Pseudo-chaotic PN sequences proved better correlation properties than conventional m-sequences and hence can be used for DS-SS. They provide an high level of security and low-probability of interception. BER of PCS have improved performance than the gold and M-sequence. DSSS system is easily implemented using both MATLAB and VHDL language.

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