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CAD based implementation of RADAR using Direct Sequence Spread Spectrum technique

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Abstract:

DIRECT SEQUENCE SPREAD SPECTRUM (DSSS) is a spread spectrum technique and commonly used for military purposes. This paper consists of CAD based designing of RADIO WAVE DETECTION AND RANGING (RADAR)transmitter and receiver using DSSS techniques with better accuracy and ranging. The reason to use DSSS signal for spreading because it has its own inherent merits like accuracy of ranging, sensitivity of power estimation and interference suppression than other types of spread spectrum. The goal is to detect target at very short distance by sending and receiving RF signals with high resolution and calculate range of target with high accuracy and also to calculate the Bit Error Ratio (BER). Spread spectrum system techniques can be used to hide a signal by transmitting it at low power thus avoiding interference. BFSK modulation and demodulation technique is used in this project for the purpose of providing security to the proposed work. One of the main reasons behind using BFSK modulation and demodulation technique is the ease of detecting the information about the type of the target, while it was not possible with the previously employed techniques. MATLAB coding and simulation are used for the purpose of obtaining desired results

Keywords: BFSK, DSSS, PN SEQUENCE, RADAR TRANSMITTER AND RECIEVER, ERROR RATE CALCULATION

1. INTRODUCTION

RADAR is an object detection system that uses radio waves to determine range, angle or velocity of object. It is used in many applications like air traffic control, astronomy, air defense system, flight control system etc.

In this paper main emphasis is on direct sequence spread system technique for the implementation of radar because it has some inherent merits such as accuracy of ranging, sensitivity of power estimation and interference suppression better than any other types of spread spectrum . It is widely used in wireless and military applications because of its effectiveness in suppressing interference. Spread technique can be further used to hide a signal by transmitting it at low power [1].

In this work, focus is on analyzing a RADAR system based on DSSS technique on the basis of BER, security, accuracy and resolution. The aim is to detect a target at a very short distance with high resolution and calculate the range of target with high accuracy. Further the implications of BFSK technique on the RADAR's transreceiver are observed.

While implementing RADAR using FSK technique m-array FSK system is used for which m=2 is used and thus its functionality is equivalent to BFSK and hence obtaining the corresponding waveforms as a result of implementation.

Further the RADAR system consists of bursts of pulses whose frequencies are chosen by a random selection process with a probability density function based on the RADAR target's spectral contents and whose phase are a pseudo random-spreading signal. The capability of RADAR to match its illumination to a target could prove to be viral in tracking low observable targets. Additionally the spectral ability of a matched FSK system allows for spectrally adaptive signaling. Adaptive signaling could not only aid target tracking but also provide information about the target that could be used target identification purposes [1].

The work is developed using (Matrix laboratory) MATLAB which is a multi-paradigm numerical computing environment & 4thgeneration programming language.

Many authors worked in this area but the technique adopted in this paper is different from others.

Authors of [2] described that the system has the virtues such as high accuracy, good efficiency, interference suppression and low power consumption. BPSK modulator and demodulator are used for the generation of the signals. The overall system is accurate in computing the distance of the target for maximum range and also calculate the BER, It is noted that as BER increases signal to noise ratio reduces.

But there is a drawback that the designing of each block is complex which makes the overall system bulky and at a large extent it cannot be used for the security purpose just because of the presence of BPSK signal.

Authors of [3] described the designing of Ultra Wide Band (UWB) transmitter and receiver. UWB is having bandwidth which is greater than 500MHz or a fractional bandwidth larger than 20% at all times of transmission. This system is penetrating through walls, positioning and locating the target, but on the other side the overall system does not provide accuracy to the final result, which is not acceptable.

Authors of [4]worked on the development of remote radar data acquisition and control using CDMA RF link system. The use of spread spectrum technique which is present in SPZB260-Zigbee module is used in order to establish RF communication and it is controlled by ARM cortex M3 processor(LPC1768) which makes the designing of overall system costly and complex too.

Authors of [5] analyzed the performance of Ultra-Wide Band (UWB) technology using time hopping technique. The result from the simulation was very encouraging for the UWB receiver design presented in the paper. Better performance was obtained but the data rate is suffered.

The modulation technique used in the present work is BFSK modulation and demodulation which is different from all other techniques used in other papers. BFSK provides higher security to the message transmitted and received in comparison to other techniques.

2. METHODOLOGY

MATLAB simulation provides ease to design, Implement and test the desired system with clear imagination to the system parameter required to complete the design. MATLAB DSP tool box, communication tool box are used for the simulation [6].

Block diagram of RADARTRANSRECEIVER system is shown in figure1.

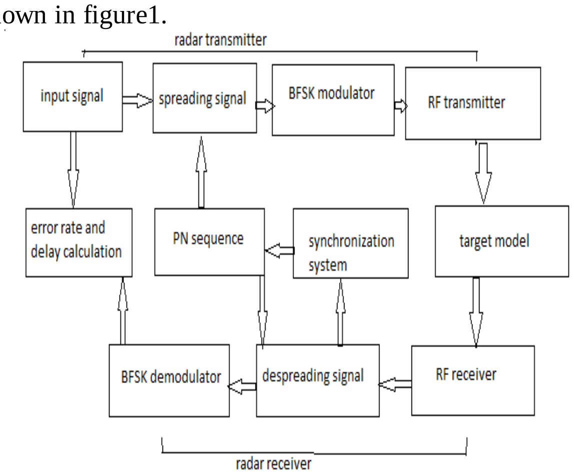

Figure 1 BLOCK DIAGRAM OF RADAR's TRANSRECIVER

Various steps are explained below.

1. Firstly at transmitter end binary message signal (Bernoulli signal) is spreaded using PN sequence and is further modulated using BFSK modulator.
2. Output of BFSK modulator is transmitted through RF transmitter to the target model and after striking it suffers reflection and is received by RF receiver at the receiver's side, which will convert received signal to IF frequency level.
3. RF receiver signal is passed to the synchronization unit which is further despreaded with local PN sequence generator which is to be generated by synchronization system.
4. It is further demodulated to obtain received signal.
5. Now using the received signal and the input message signal, the delay between the transmitter and receiver is calculated.
6. This is used to calculate Bit Error Rate (BER).

Simulated block diagram of overall RADAR system is shown in figure 2.

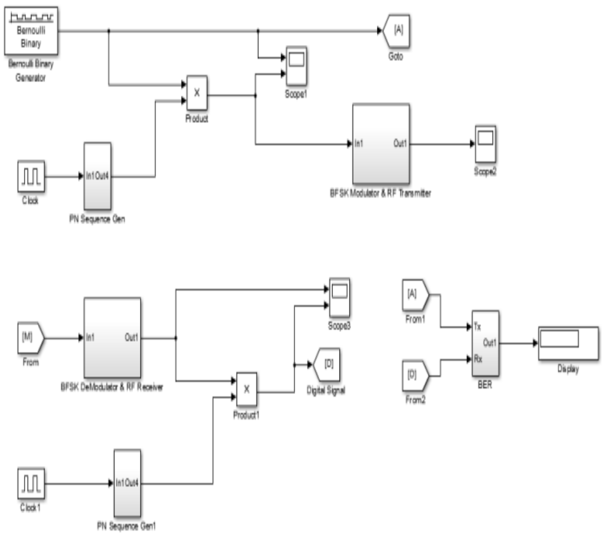

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Figure 2 SIMULATED BLOCK DIAGRAM OF OVERALL SYSTEM

3. IMPLEMENTATION

Generating binary data stream: Using Bernoulli generator binary message signal of 250 bps is generated from communication tool box with probability of 50% zeros and 50% ones.

PN code generator: PN sequence is generated as maximum linear code with polynomial 1+x+x^3 sequence is generated by using 4 stages d flip flop with 2 feedback taped (x^3,x), EX-OR to the input of 1^{st} stage d flip flop in order to get 15 bit sequence & clock is 4kbps.

BFSK modulator: Spreaded signal is modulated by BFSK
modulator.

RF transmitter: RF transmitter includes mixer, band pass pi filter and s parameter amplifier from simRF toolbox.

Target model: Target model depending on the target range, the transmitted signal is delayed & the signal power is attenuated & reflected towards the receiver.

RF receiver system: Received signal from antenna is amplifier by general amplifier and proceed to the mixer for conversion of RF to IF signal & again amplified by s parameter amplifier.

Correlator: It consists of acquisition, tracking, search/lock control unit & VCO. Operation starts from acquisition. 1^{st} output of correlator is compared to a present threshold level in acquisition subsystem. If threshold exceeds then there will be covered else load PN code clock is delayed by half chip & acquisition process is repeated after completion of acquisition.

4. RESULT

Various results are depicted below.

Figure 3 shows the input signal of radar transmitter generated with the help of Bernoulli generator.

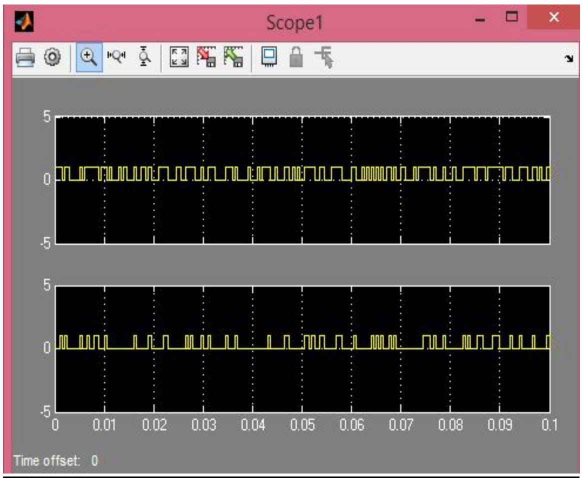

Figure 3 INPUT SIGNAL AND SPRESDED SIGNAL

The spreaded signal is modulated using BFSK modulator as shown in figure 4. It is a high frequency cosine wave.

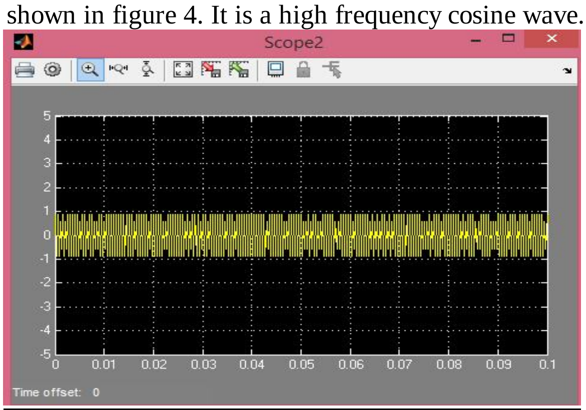

Figure 4 BFSK Modulated signal

Figure 5 shows the despreaded and demodulated signal. Signal is despreaded using synchronization system and then demodulated using BFSK demodulator.

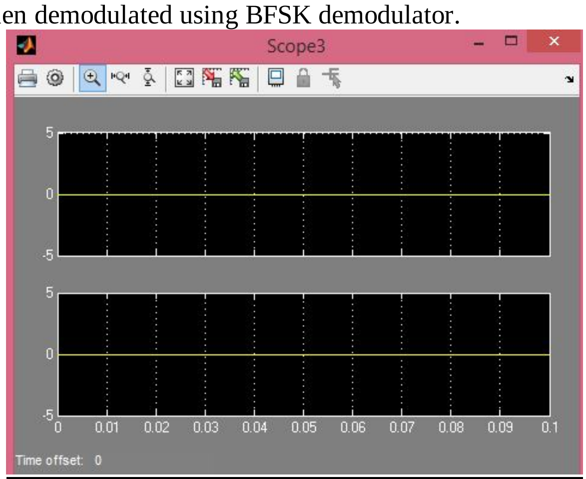

Figure 5 DESPREADED SIGNAL AND DEMODULAED SIGNAL

Now the result of coding part is shown below in figure 6 to figure 14.Figure 6 shows the m-sequence generated by generator polynomial. In coding part sequence is generated according to the equation $1+x+x^3$.

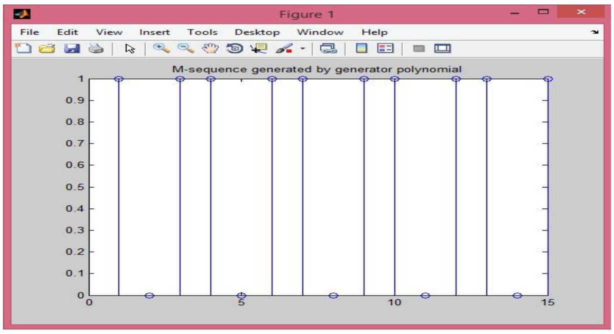

Figure 6 M-SEQUENCE GENERATED BY GENERATOR POLYNOMIAL

Figure 7 shows the transmitting information as digital signal. The signal is then transmitted in digital form.

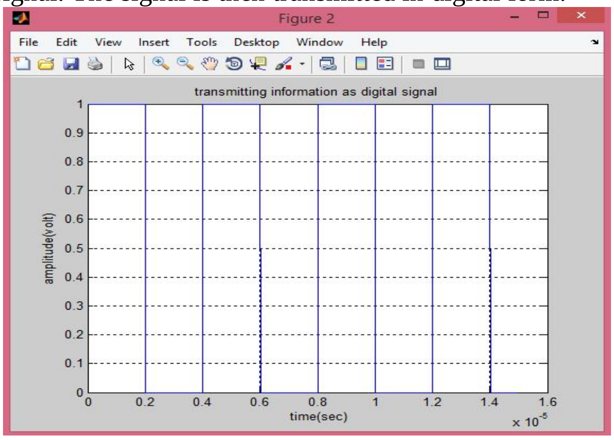

Figure 7 TRANSMITTING INFORMATION AS DIGITAL SIGNAL

Figure 8 shows the PN sequence of spreading sequence. The PN sequence is then multiplied by the spreading signal.

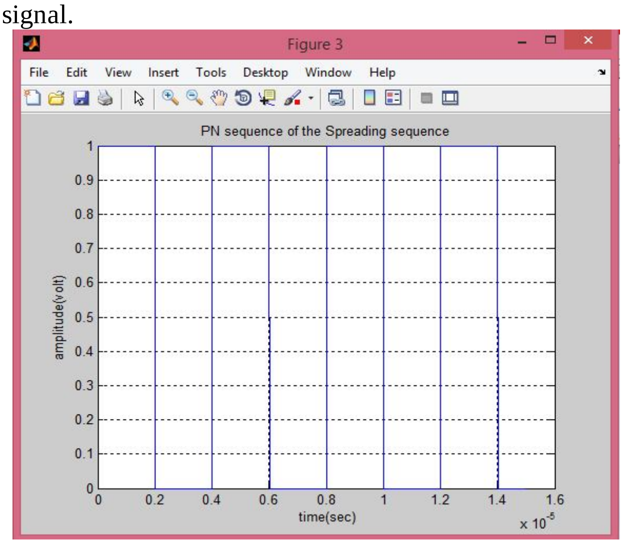

Figure 8 PN SEQUENCE OF SPREADING SEQUENCE

Figure 9 shows the spread signal. Spreaded signal is in the form of multiple samples to make it more secure for transmitting.

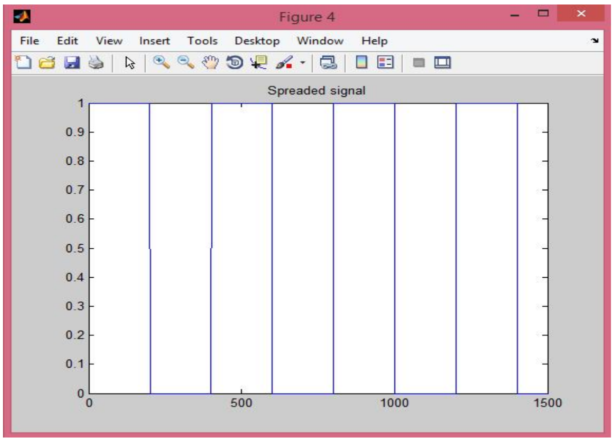

Figure 9 SPREADED SIGNAL

Figure 10 shows the modulated signal which is dense because it is in the form of multiple samples. It is made denser to make it more secure in comparison to other modulation techniques.

Figure 11 shows the PSD of the modulated signal. PSD is just to show the power spectrum density of the modulated signal.

Figure 12 shows the delayed signal with attenuation added into it. Here the delay and attenuation is added manually.

Figure 13 shows the despreaded signal which is done by synchronization.

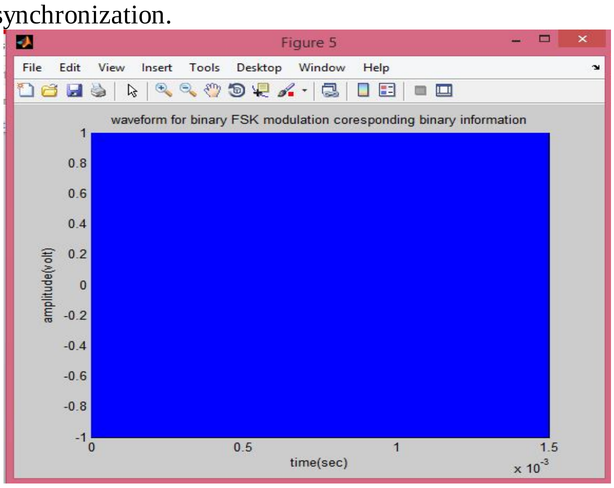

Figure 10 BINARY FSK MODULATION WAVEFORM CORRESPONDING TO BINARY INFORMATION

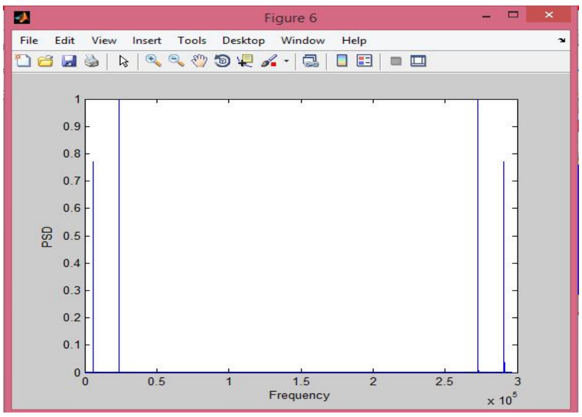

Figure 11 PSD OF MODULATED SIGNAL

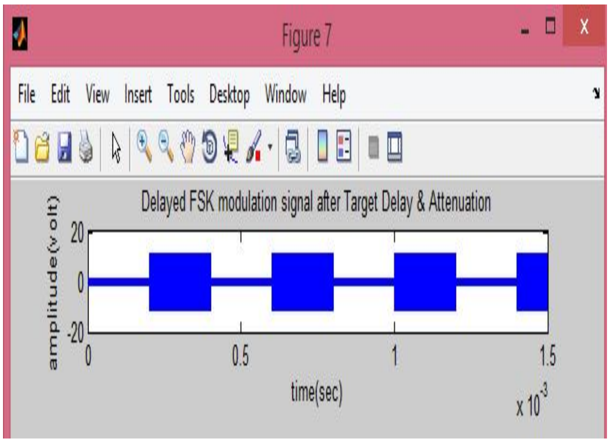

Figure 12 DELAYED FSK SIGNAL AFTER TARGET DELAY AND ATTENUATNION

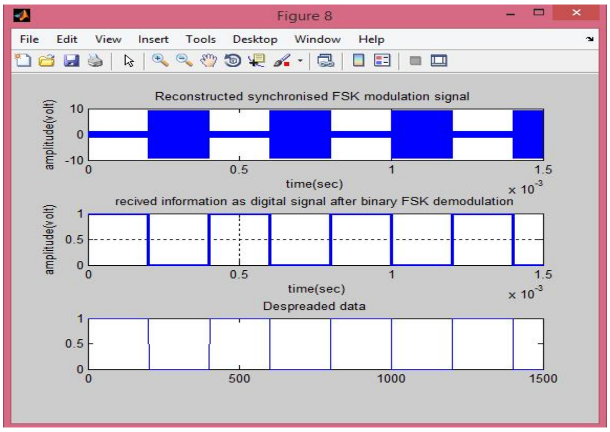

Figure 13 DESPREADED DATA

Figure 14 shows the power spectrum density of demodulated signal.

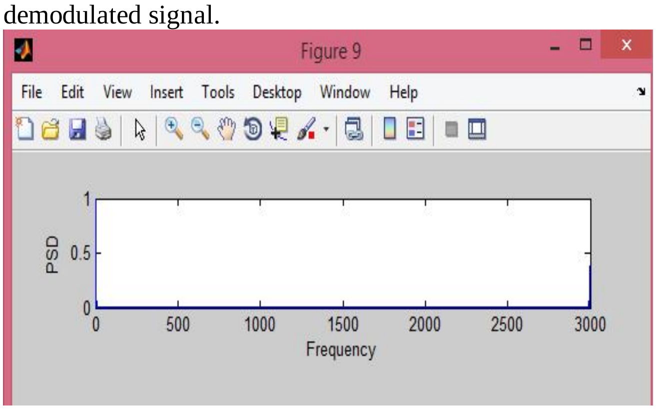

Figure 14 PSD OF DEMODULATED SIGNAL

Table 1 below shows comparison between various parameters of the presented paper and reference paper.

TABLE 1

S.NO	PARAMETERS	REFERENCE PAPER	PRESENTED PAPER
1.	Bit rate	250bps	250bps
2.	SNR	10db	10db
3.	Ranging	R F range	R F range
4.	Security	normal	Better
5.	BER/Accuracy	0.4615	0.5152

5. CONCLUSION

The work done in this paper consists of designing, coding and implementation of radar transreciever system with better accuracy, better security and simplicity on MATLAB simulink. The simulation and coding is done to transmit the data and get it compared with the received data. It is found that the system is more accurate and found better in security. The simplicity of designing is also achieved. Bit error rate (BER) is calculated and is noted that as the signal to noise ratio increases, the bit error rate decreases. Align signal block represents the target available and calculates delay represents target distance from the transmitter. BFSK modulation is used to provide better security. The system designed have different advantages like better accuracy, better security, simplicity and better interference suppression.

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