DAYANANDA SAGAR UNIVERSITY

SCHOOL OF ENGINEERING

Hosur Main Road, Kudlu Gate, Bangalore-560068

Report on SIMULINK MODELLING performed as part of

SPECIAL INITIATIVES LAB (19EC3505) 5th SEMESTER

For the topic

"Air Traffic Control using Direct Sequence Spread Spectrum"

Submitted in partial fulfillment of the requirement for the degree of

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In

Electronics and Communication Engineering

By

Harshitha Divakar ENG19EC0040

MV Lavanya ENG19EC0055

Department of Electronics and Communication Engineering

DAYANANDA SAGAR UNIVERSITY, BENGALURU -560068.

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INTRODUCTION

The chosen application 'Air traffic control' is one of the most important applications of RADAR systems. An air traffic control system is a ground-based control system that is an integration of various communication blocks which together help in preventing mid-air collision, ensuring safe takeoff and landing of the aircraft.

The system monitors the location of the aircraft using RADAR. Based on this location, the control system will guide the aircraft through a safe, collision-free route.

Air traffic control itself is a very broad domain. In this project, we will be covering the air control systems for take-off and landing of the craft.

For taking off the following conditions must be met:

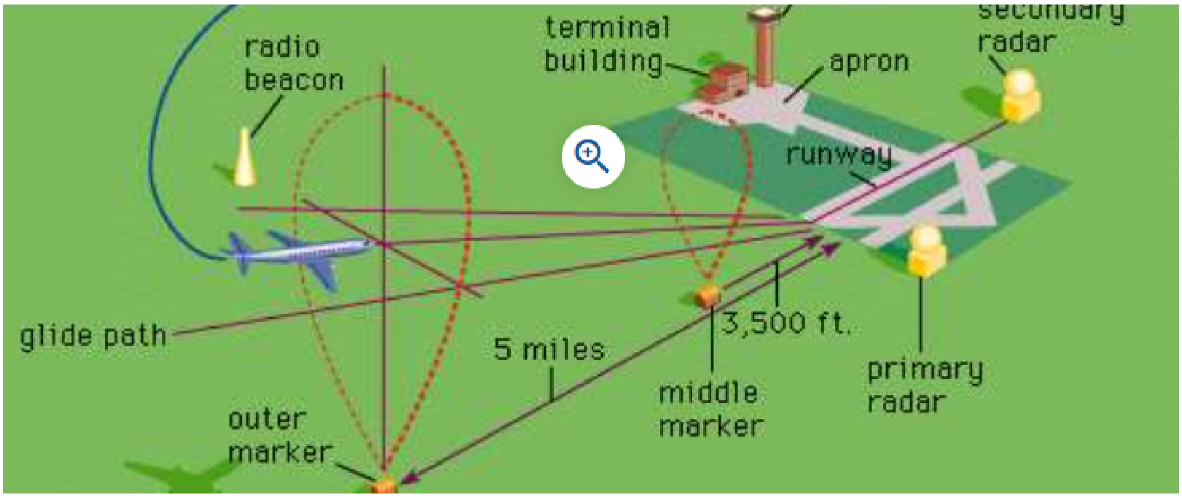
1) No other airplane must be in the vicinity of the landing runway.
2) There should be no other plane in the line of take-off

For landing:

1) The airplane must be at the correct altitude for decent.
2) In case of emergency landings, the airplane must be delayed or must be re-routed to a different landing site

Many more conditions have to be met. Many of these conditions have to be monitored and communicated to airplanes continuously or in real-time. This project is an implementation of such a communication system

This will be done using a direct sequence spread spectrum. A figure depicting the decent of the craft is shown below



OPERATING PRINCIPLE

Direct sequence spread spectrum (DSSS) is a transmission technology used in local area wireless network transmissions. In this technology, a data signal at the sending station is combined with a high data rate bit sequence, which divides user data based on a spreading ratio.

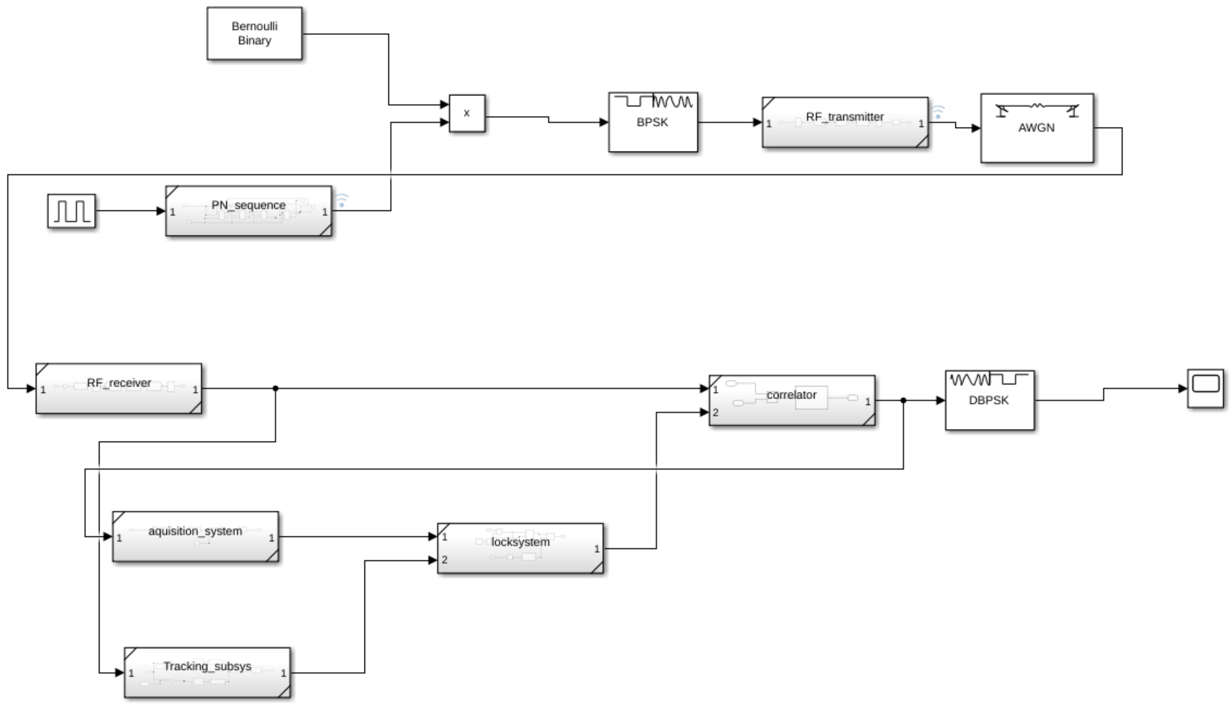
DSSS is a spread spectrum modulation technique used for digital signal transmission over airwaves.

Why is this technique used?

1) Resistance to jamming effects.
2) Spectrum is unique for every plane.
3) Very effective for short-distance communication
4) Performance of DSSS system in presence of noise is better

The complete implementation of the concept will be explained in the following sections.

SIMULATION MODEL

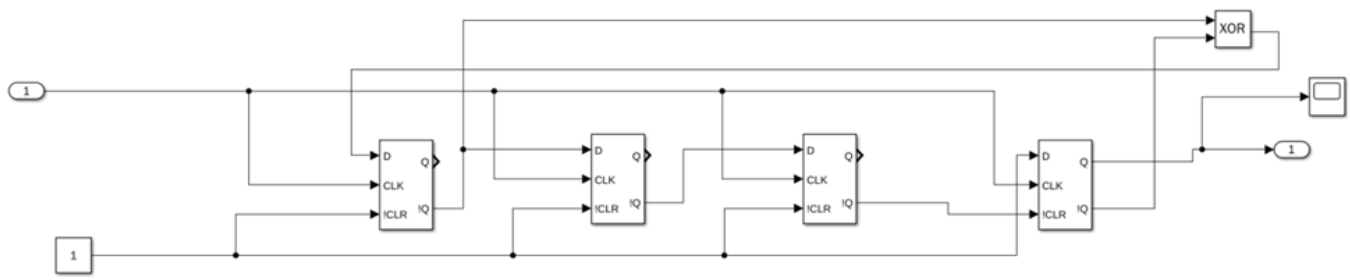


The above simulation model consists of both the transmitter and the receiver connected by an AWGN channel.

Block Specifications: Transmitter

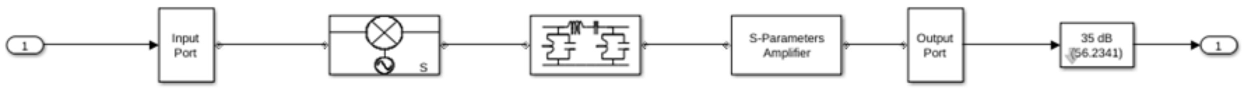
Bernoulli Binary Generator: This generates a message signal which is a random sequence of ones and zeroes. In real cases, this message signal will contain the necessary information for control. Here the probability of One is set to 0.5 and the sample period is given as 1/250.

PN Sequence Generator: This is a Pseudo noise generator that comprises of a 4 stage D-FlipFlop controlled by a digital clock whose period is set to 1/(4 x 10^3) which gives the bit rate as 4Kbps.



RF Transmitter:

The RF transmitter of the system consists of a mixer, band pass-pi filter, and s parameter amplifier. Mixer converts the BPSK baseband modulated signal to IF frequency. Then, the RF signal is band-limited using a band pass-pi filter. The band-limited signal is then amplified by using an s-amplifier. The output of the RF transmitter is then transmitted through the AWGN channel.



BPSK Modulator baseband:

BPSK stands for Binary Phase Shift Keying which is a digital modulation technique that uses a carrier wave that represents both symbols ‘1’ and ‘0’ but with a different phase(180 deg).

AWGN Channel: It represents the transmission channel for the modulated signal which adds Additive Wite Gaussian Noise to the transmitted signal.

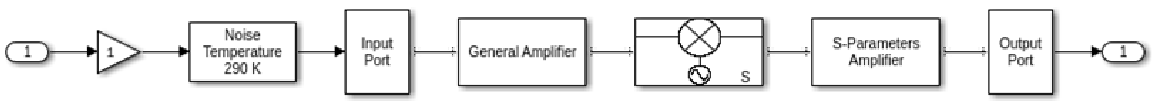
<u>**Working:**</u>

- The message signal is multiplied by the PN sequence(of a much higher frequency). This process is called spreading.

- The output of the multiplier is given to the BPSK modulator which modulates the signal accordingly.
- The modulated signal is then passed through the RF transmitter where the mixer converts the BPSK baseband modulated signal to RF frequency.
- The RF signal is band-limited using a band pass-pi filter.
- The band-limited signal is then amplified by using an s-amplifier.
- The output of the RF transmitter is then transmitted through the AWGN channel.

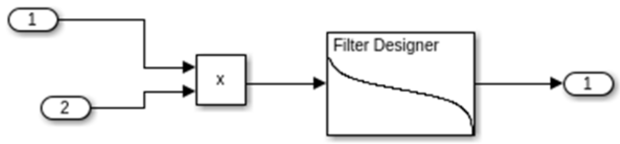
Block Specifications: Receiver

RF receiver: Received signal from the AWGN channel is amplified by the general amplifier and proceeds to the mixer for conversion of RF signal to IF signal and once again amplifier by S-parameter amplifier.



Correlator:

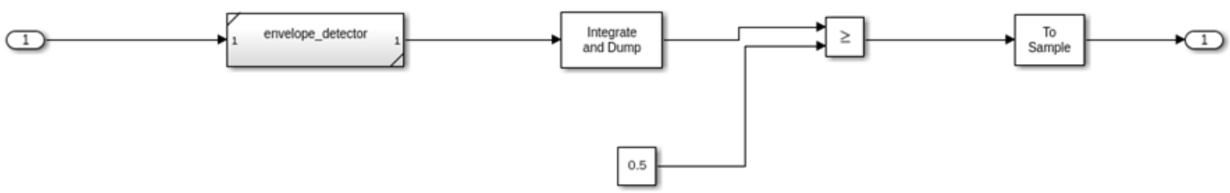
The correlator contains a mixer and a digital filter. In the correlator, the received signal is despreaded only when received PN code and locally PN generated to have the same phase and the cutoff frequency of digital LPF same as the data rate(250bps).



Acquisition Block:

It uses a serial search of an acquisition method . It contains envelope detector and integrator and dump to detect the correlated signal energy at constant test intervals.

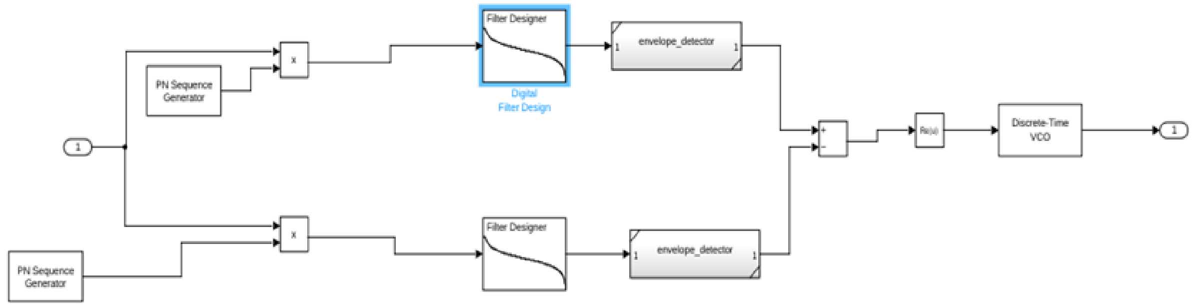
The output of the integrator and dump is compared with a preset threshold voltage. If the threshold is exceeded, then the phase of local PN code is corrected and tracking is initiated, otherwise a phase update signal is generated by SLCU for the next phase test operation



Tracking Block:

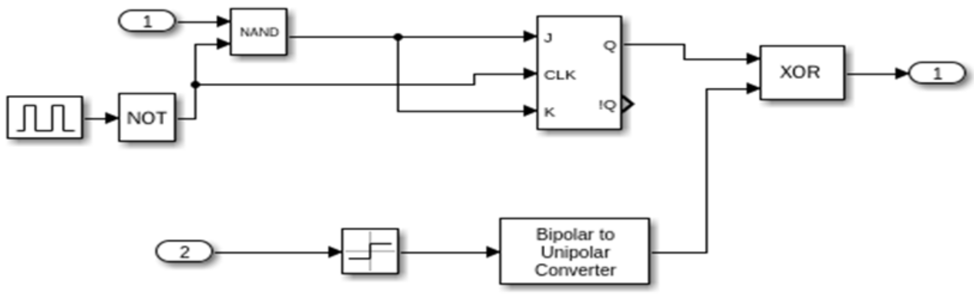
It uses a delay-locked loop method. The tracking subsystem consists of two branches; the common input to the branches is the received signal , the second input to the upper branch is the output of the local PN code generator (Early), while the second input to the lower branch is the output of the local PN code generator (Late).

Each branch consists of a mixer (multiplier), digital LPF, and square law (envelope detector). The cutoff frequency of the low pass filter is the same as the data rate and the passband and stop band attenuation was varied until the correct demodulated output was attained . The detected energy from both branches is subtracted to generate an error signal to excite the voltage control oscillator to correct the local clock frequency (4MHz).



Search and Lock:

The pulse generator generates a pulse width equal to half the chip period, after inversion this pulse is NANDed with the output of the acquisition subsystem to check the acquisition status. The VCO output is polar, it must be converted to unipolar format to satisfy the requirement of the XOR gate which produces the final local PN clock. However, the local PN code is faster than the received PN code.



Working:

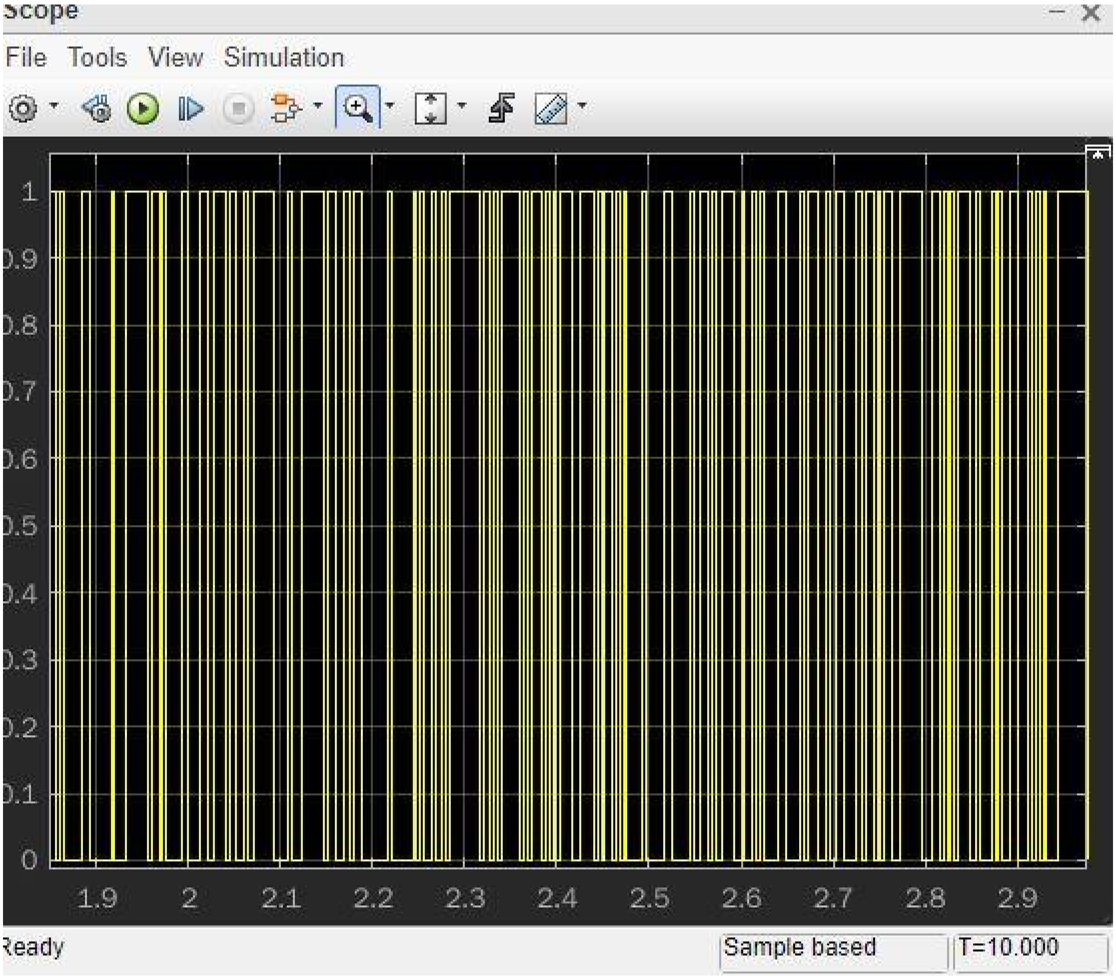
1) The output of the AWGN Channel is fed into the RF receiver of the receiver block. The received signal was amplified using a general amplifier of central frequency 2.1Mhz. This was then passed to a S-Parameter mixer that converts RF to IF this is then amplified by the S-parameter amplifier.
2) The output of the receiver was fed into the correlator and the acquisition system.
3) Let us consider the correlator. In the correlator the output of the receiver is multiplied with the PN sequence only when the received PN code and the locally generated PN code have the same phase. This process is called despreading.The LPF used is a FIR Low Pass Filter with cutoff frequency as 250bps. The passband and stopband was varied accordingly to get a maximally flat response.
4) Now let us consider the acquisition block. Here the output of the correlator is fed into an envelope detector(detects the amplitude of the waveform to give an 'outline' of the input signal) and the integrate and dump block which detect the energy of the correlator signal at constant time intervals. the output of this is compared to a threshold(0.5). If the threshold is exceeded the phase of the PN sequence is corrected and traction is initiated otherwise the output moves to the next stage.
5) The tracking system consists of two branches. Both the upper and lower branches are fed with the output of the receiver. as it can be observed, the top block will be fed with the Early PN Sequence and the branch below is fed with the late PN sequence. The pn sequence is multiplied with the receiver output and then passes through Low pass filter where the low pass filter(cutoff frequency = 250bps) and the

envelope detector. The detected energy is subtracted from each other to get the error signal which activates the voltage controlled oscillator.

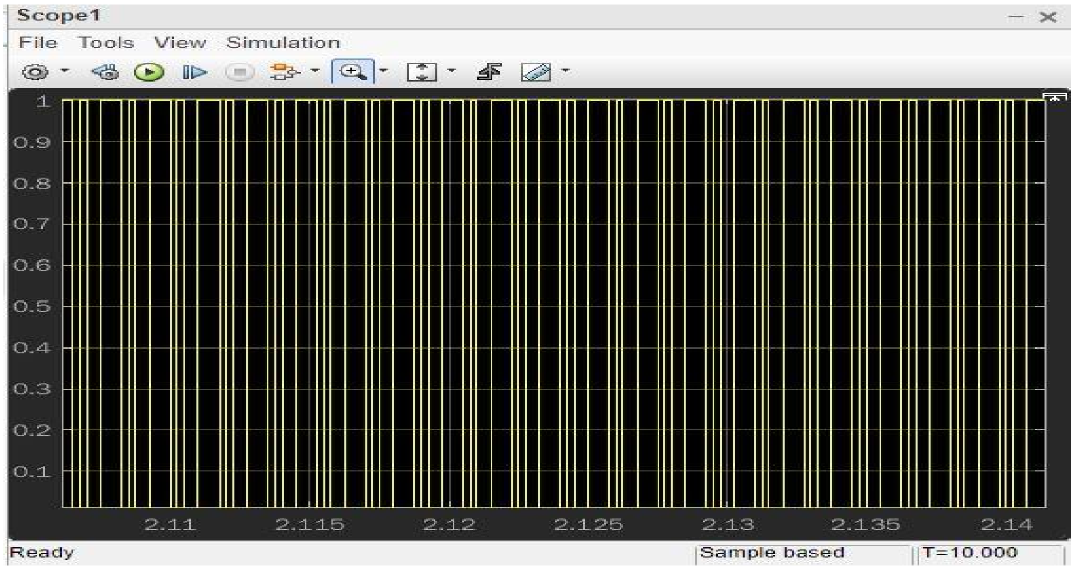
6) Search/lock control system: The pulse generator in this block generates a pulse with 50%on period which is inverted and then NANDed with the acquisition output.The tracking output will be polar that has e to be converted to unipolar format which is accepted by the Xor gate which along with the JK flip flop will generate a final clock signal that will be fed into the correlator.
7) The output of the correlator will be passed through the BPSK demodulator Baseband block to retrieve the original message signal.(although in our implementation we have received an extra delay in demodulated signal when compared to the message signal)

WAVEFORMS: Transmitter

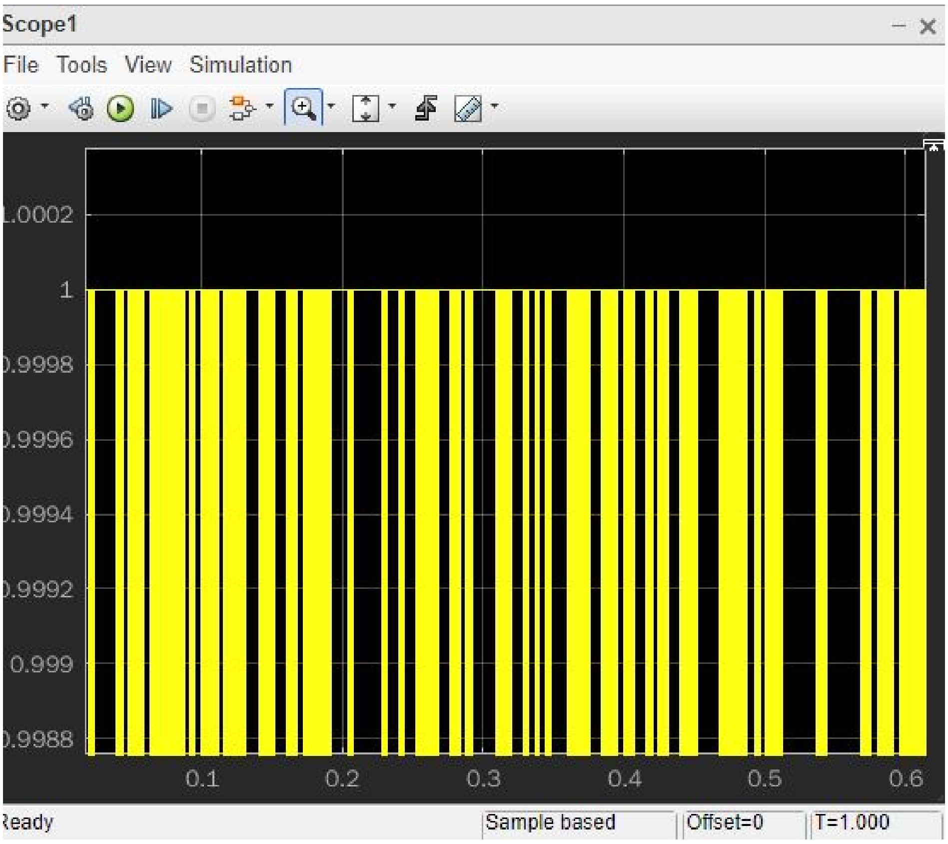
Message signal:



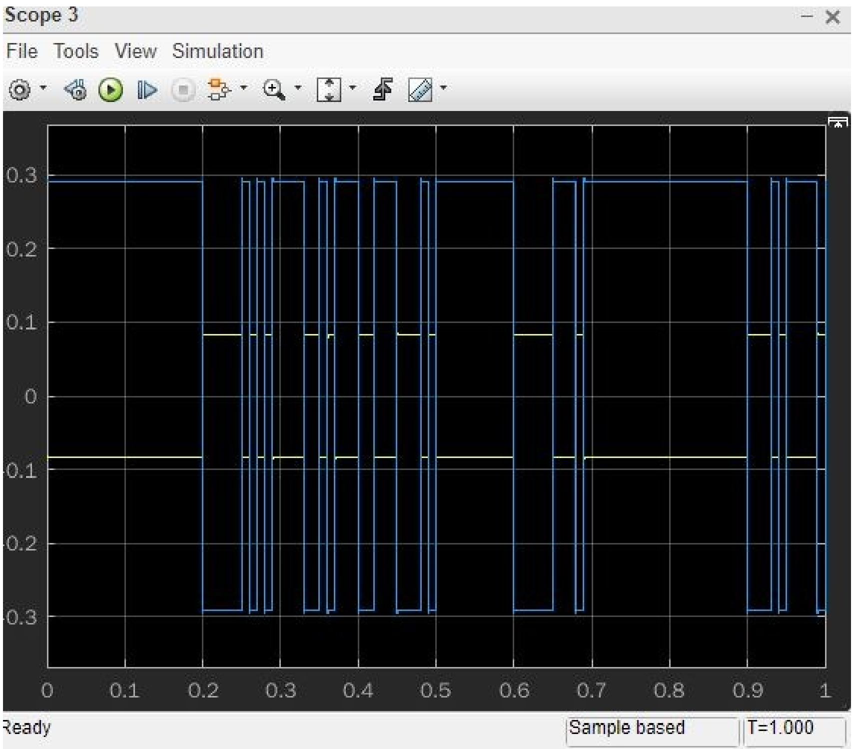
PN Sequence:



BPSK Modulated:

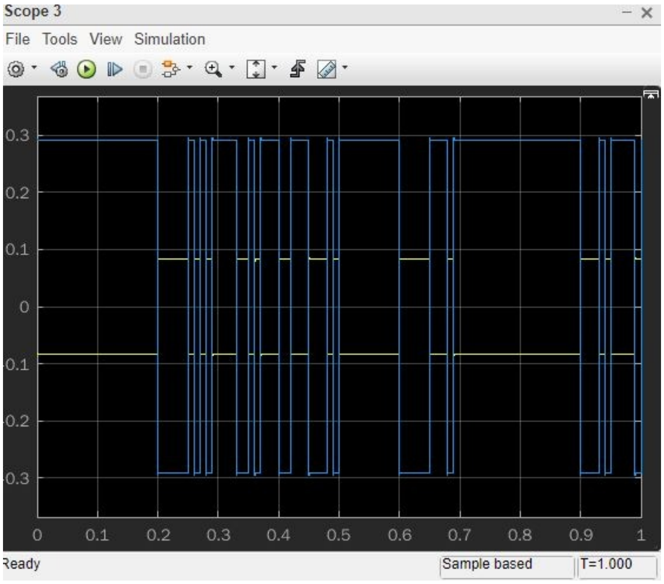


Transmitter output:

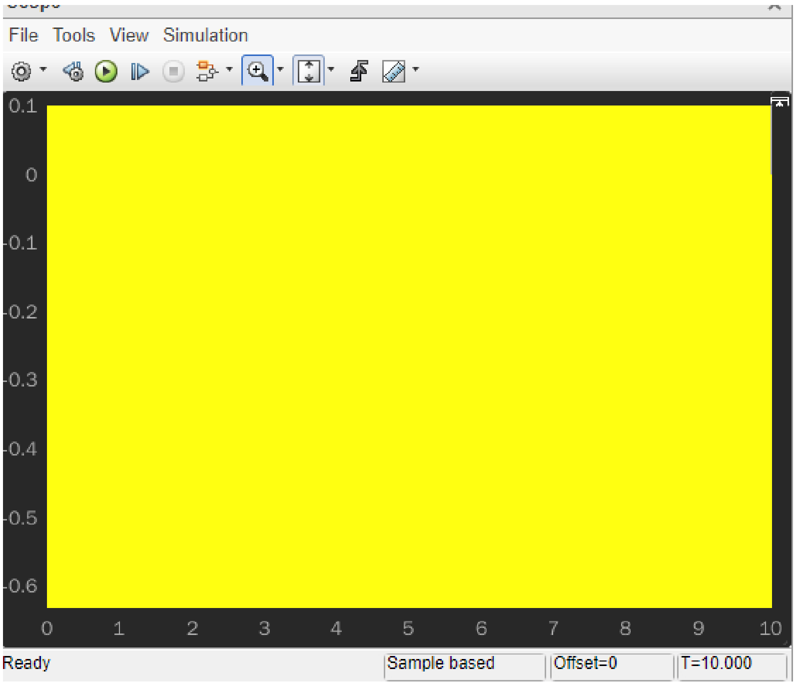


WAVEFORMS: Receiver

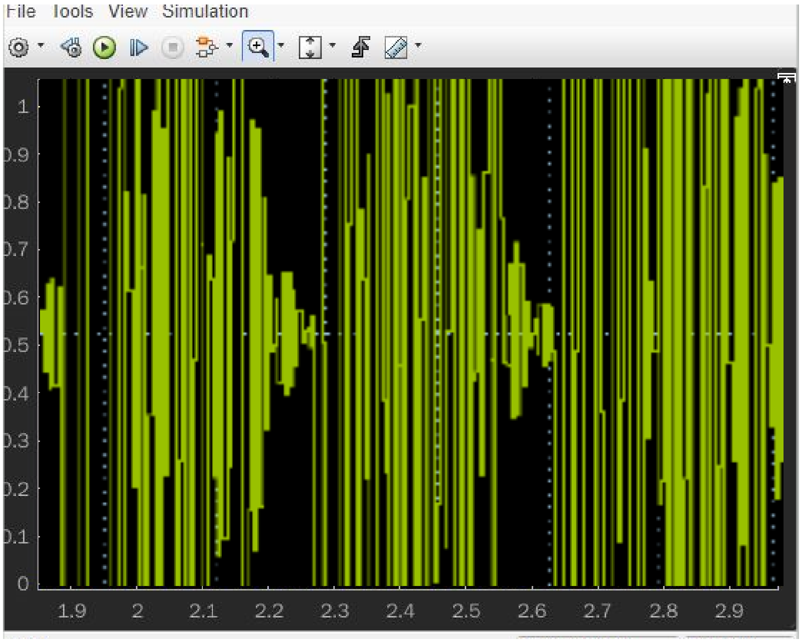
Receiver output:



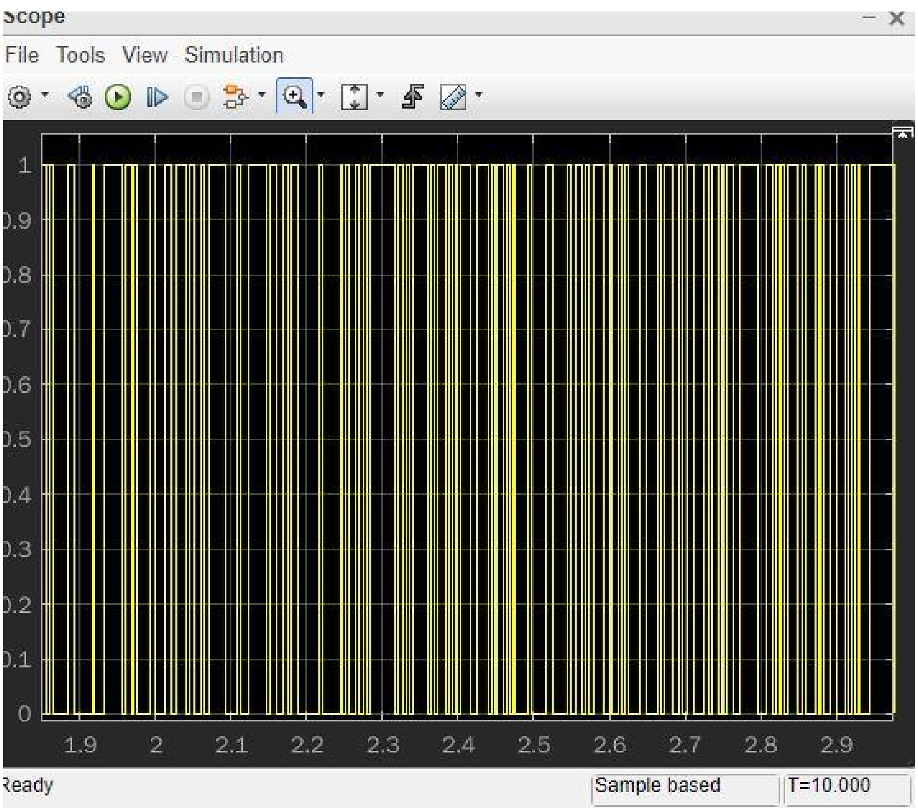
Tracking system output:



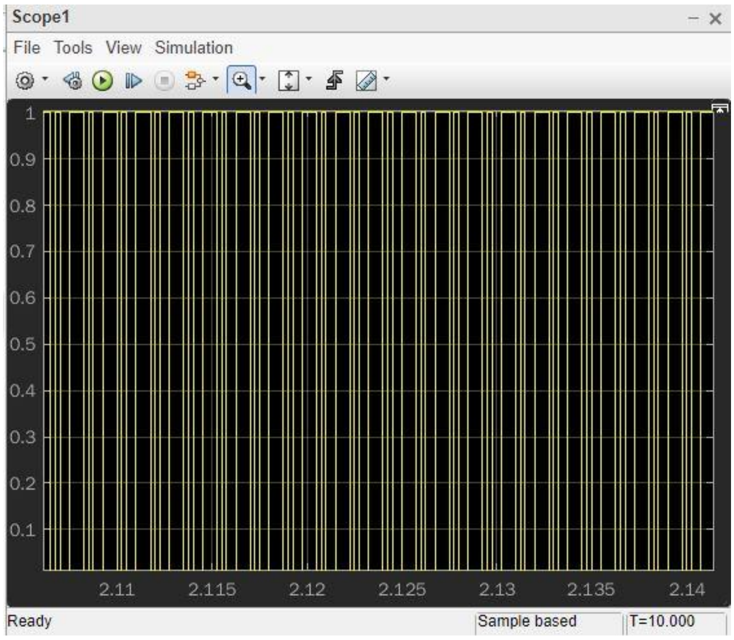
Correlator output:



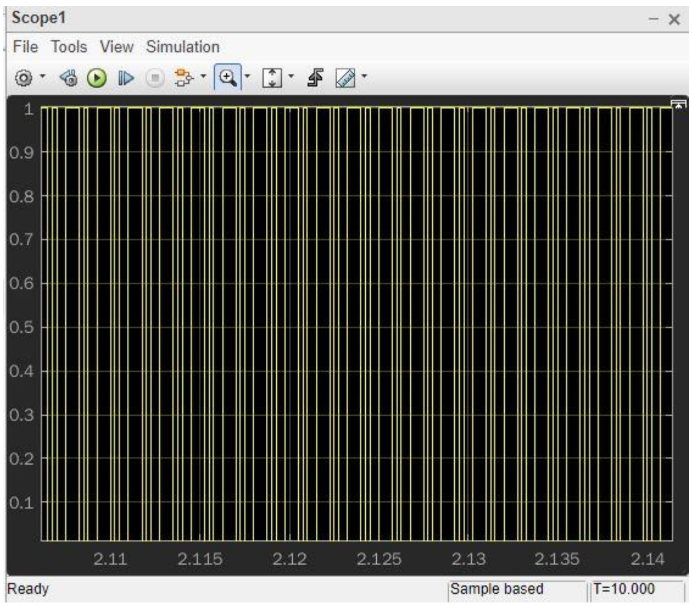
Final demodulated signal:



Early PN Sequence:



Late PN Sequence:



INFERENCE

- The concept of RADAR systems are largely used nowadays in variety of applications like air traffic control, astronomy, air defense systems, ocean surveillance, ground penetrating radars for geological observations, flight control systems and automotive RADAR for Intelligent Transport Systems (ITS) etc. and spread spectrum systems have some good properties which make them an excellent candidate for RADAR applications.
- The DSSS system is widely used in wireless and military applications because it is very effective at suppressing interference..
- Spread spectrum systems have some good properties which make them an excellent candidate for radar applications. Some primary motivations for implementing spread spectrum in radar are accuracy of ranging, sensitivity, and target-separation, accuracy of power estimation and interference separation.
- It is observed that the system is more accurate in computing the distance of the target towards the maximum range and also calculates bit error rate.
- Therefore as the signal to noise ratio increases, the bit error rate decreases.
- The system developed has virtues such as high accuracy, good efficiency, interference suppression and low power consumption etc.

  Considering the above mentioned benefits we cannot overlook the following drawbacks of using this concept. Some of which are mentioned below.

- ❖ DSSS has a longer acquisition time
- ❖ It requires wideband channel with small phase distortion.
- ❖ The pseudo noise generator must generate sequence at high rates

- ❖ Near-far problems
- ❖ Fast code generator needed
- ❖ The system is prone to error at lower than frequency hoping spread spectrum

- While running the simulation in MATLAB, it took a very long time before giving output and also indicated memory overload at several instances.

REFERENCES

Shirude, Nilesh & Gofane, Manoj & Panse, M.S.. (2014). Design and Simulation of RADAR Transmitter and Receiver using Direct Sequence Spread Spectrum. IOSR Journal of Electronics and Communication Engineering. 9. 56-65. 10.9790/2834-09365665.