ELP 725 Wireless Communication Laboratory

Experiment 5

"Interference mitigation with Spread Spectrum techniques using SDR"

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1. INTRODUCTION.

DSSS

(a) DSSS is a spread spectrum technique used for digital data transmission over the channel. This technique was originally developed for military use and was employed to resist jamming.

(b) In DSSS, information stream is divided into small pieces and each associated with frequency channel across spectrum. Data signals are combined with a higher data rate bit sequence which divides data on basis of spreading ratio.

(c) The chipping code used in DSSS is a redundant bit pattern which is associated with each bit transmitted. This increases signals resistance to interference.

(d) If any bits are damaged during transmission, the data can still be recovered due to redundancy of transmission.

(e) Above mentioned entire process is performed by multiplying a carrier and PN (pseudo-noise) digital signal. This PN code can be modulated onto information signal using any modulation scheme.

(f) Benefits of using DSSS:

- (i) Resistance to jamming.
- (ii) Sharing of single channel among multiple users.

FHSS

(g) In FHSS, the frequency of the carrier signal used for transmitting data is rapidly changed, or "hopped," over a wide range of frequencies according to a predefined pattern.

(h) This hopping pattern is known to both the transmitter and the receiver, allowing them to stay synchronized and hop to the same frequencies at the same time.

(j) This technique helps to mitigate interference and improve resistance to jamming or eavesdropping, making it suitable for applications where secure and robust communication is desired.

2. OBJECTIVES.

(a) Design transmitter and receiver module for different spread spectrum techniques.

(b) Use one SDR as jammer and use spread spectrum techniques as the transmitter & the receiver to overcome interference created by the jammer.

3. EQUIPMENT USED.

(a) Two SDRs, Antennas.

(b) Laptop for programming the SDR

4. EXPERIMENTAL SETUP.

(a) Open the GNU radio(**gnuradio-companion)**.

(b) Design a transmitter & receiver module for spread spectrum techniques (Direct sequence spread spectrum- DSSS & Frequency Hopping Spread Spectrum- FHSS).

(c) Test the constructed block for DSSS & FHSS through simulation on GNU Radio and ascertain whether the transmitted and received signals are same or not.

(d) Install the transmitter and receiver module on separate laptops connected with two SDRs and verify:

(i) **DSSS** – By jamming the channel by transmitting high power signal by a third SDR on the same frequency.

(ii) **FHSS** – Interfering the channel by transmitting a signal on one of the frequencies used by Tx and Rx SDRs.

5. REQUIREMENTS.

DSSS SIMULATION:

(a) Designing a DSSS transmitter (by using a Signal source as transmitter, followed by its modulation and multiplication with pseudo random sequence) and receiver.

(b) Synchronization of received signal with the transmitted signal

(c) Multiplication of received signal with the same pseudo random sequence and followed by coherent detection to retrieve the original signal

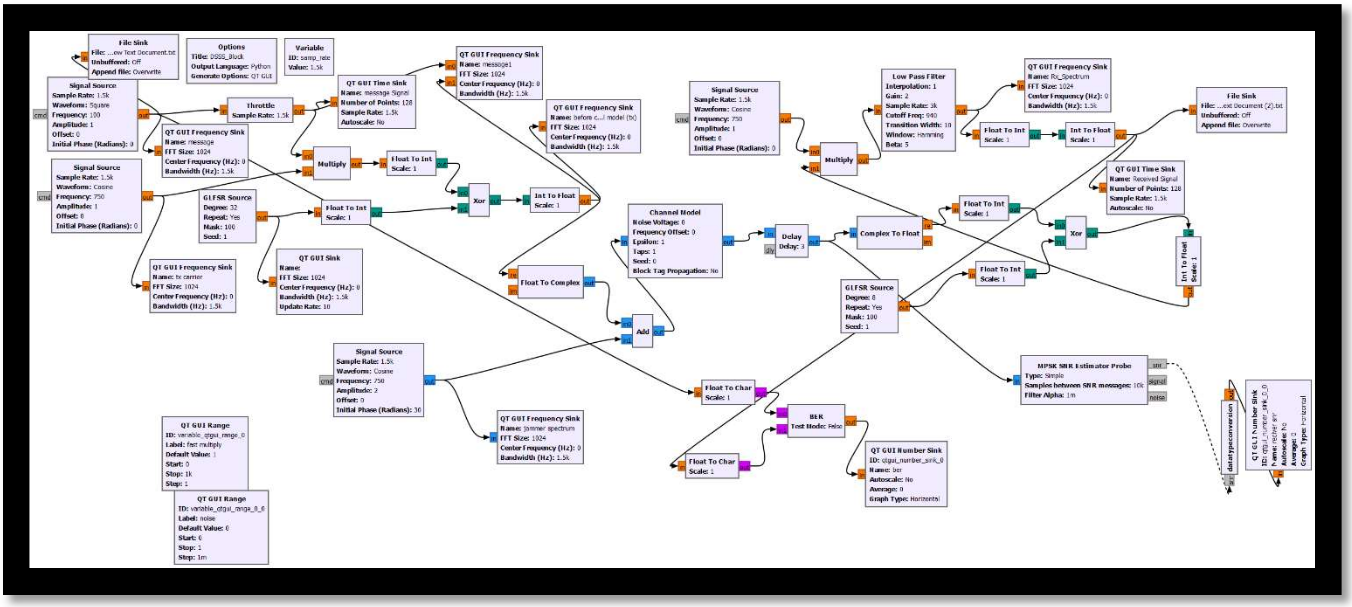

Figure 1-Block diagram of DSSS technique with Jamming

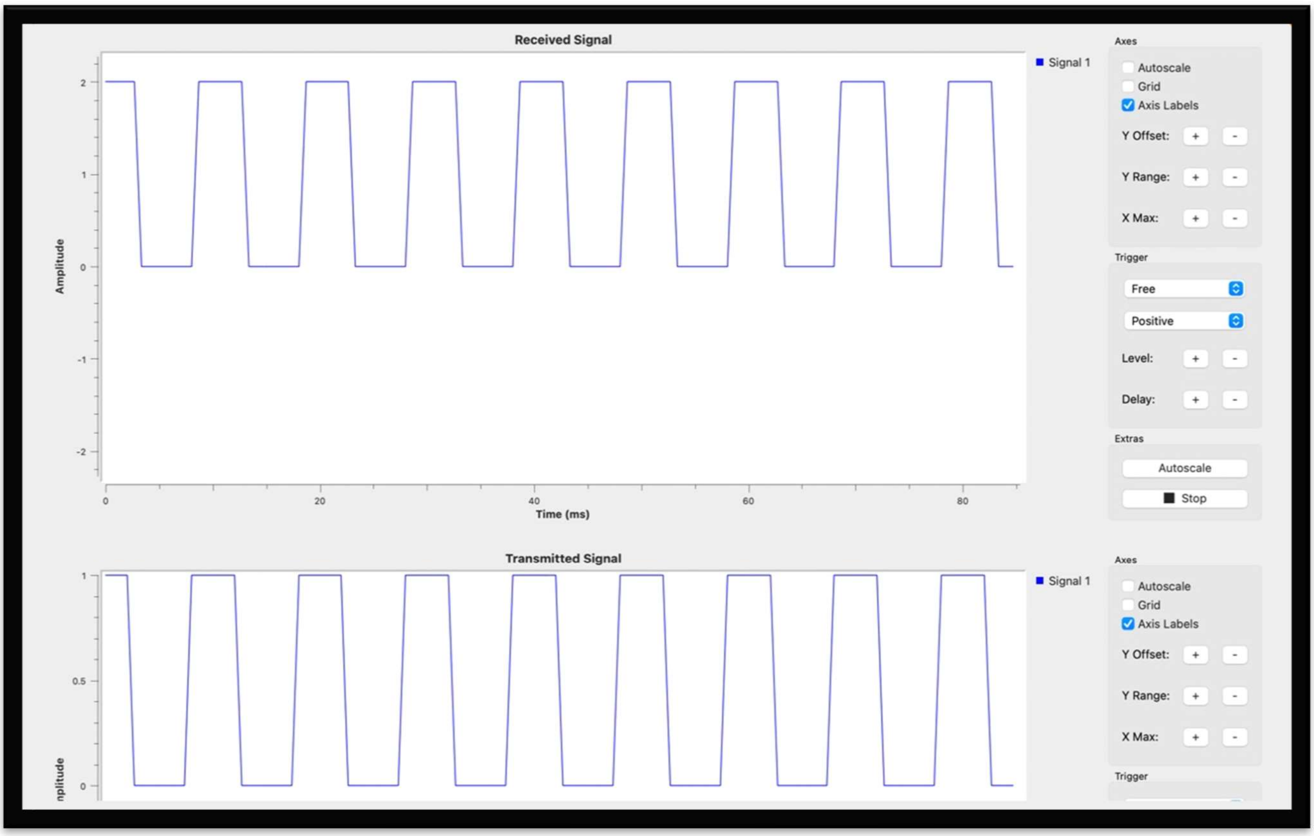

Figure 2-Tx and Rx signal Spectrum with jamming

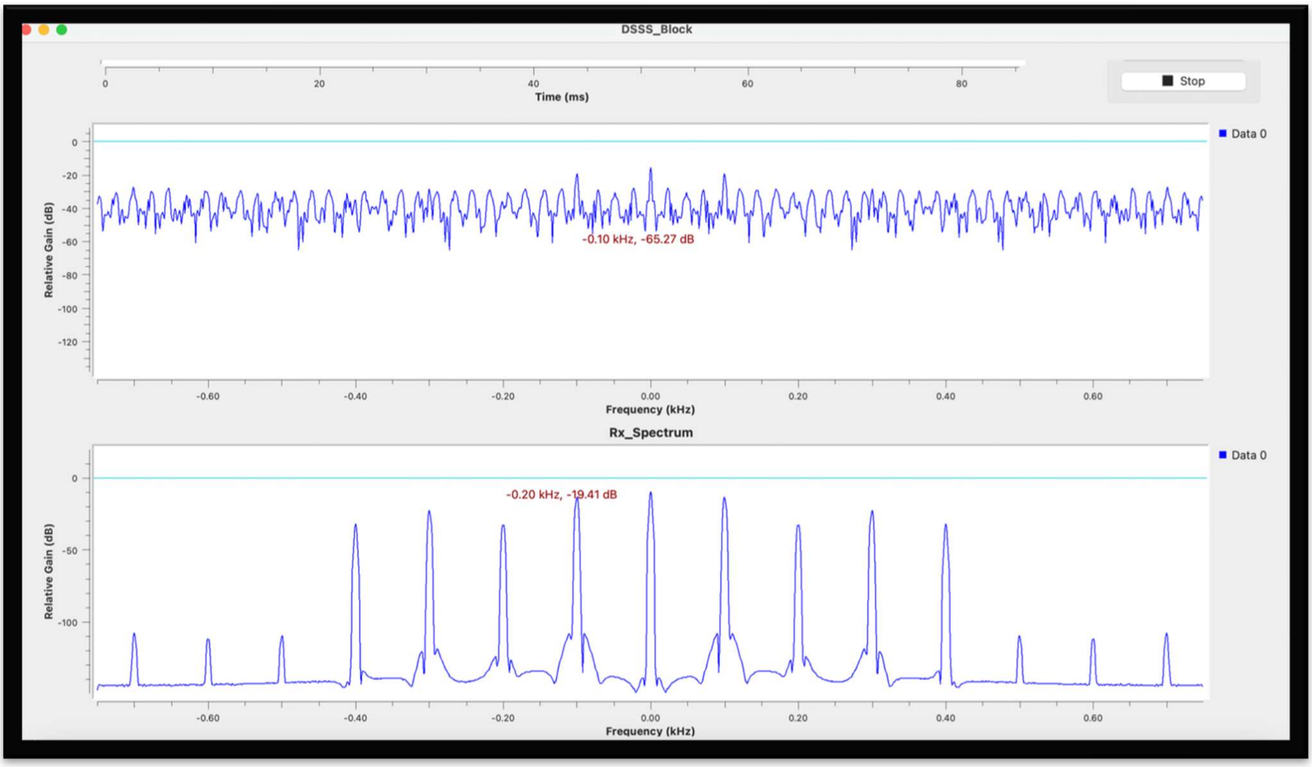

Figure 3-Transmitted spread spectrum sequence and Rx spectrum

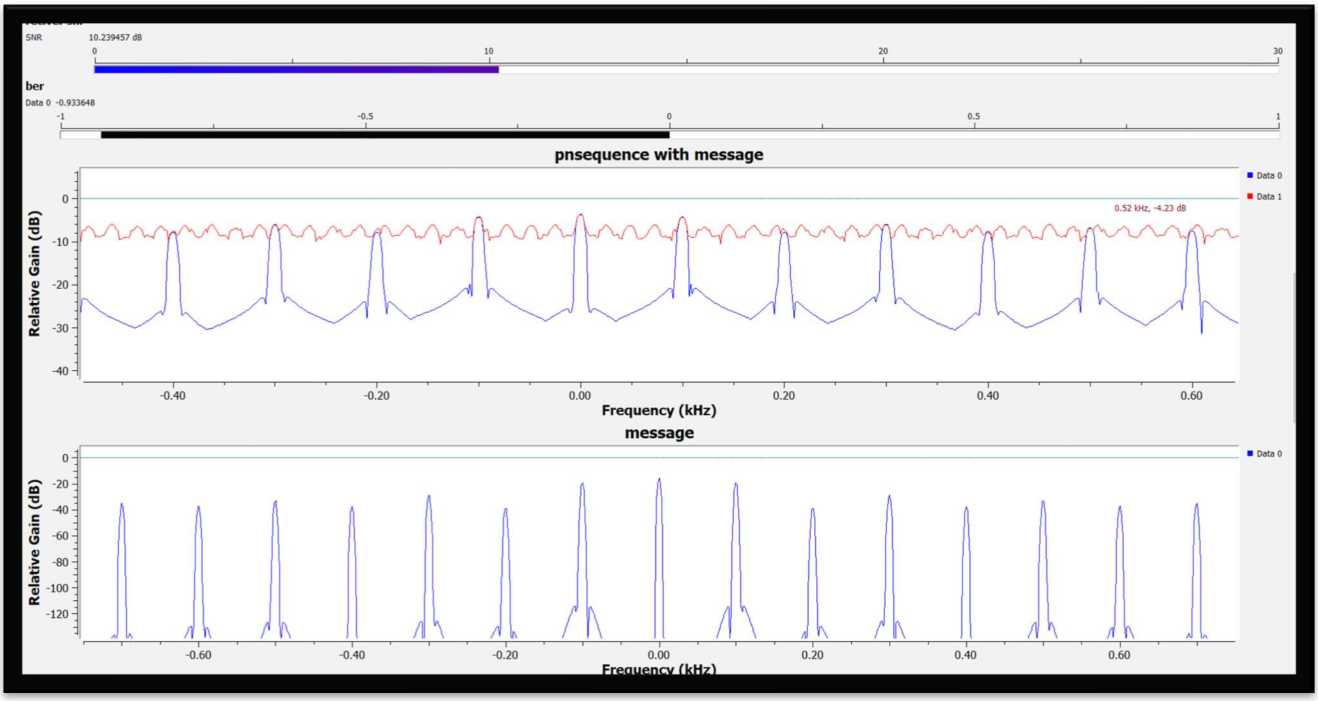

Figure 4-Transmitted DSSS Signal, BER, SNR .

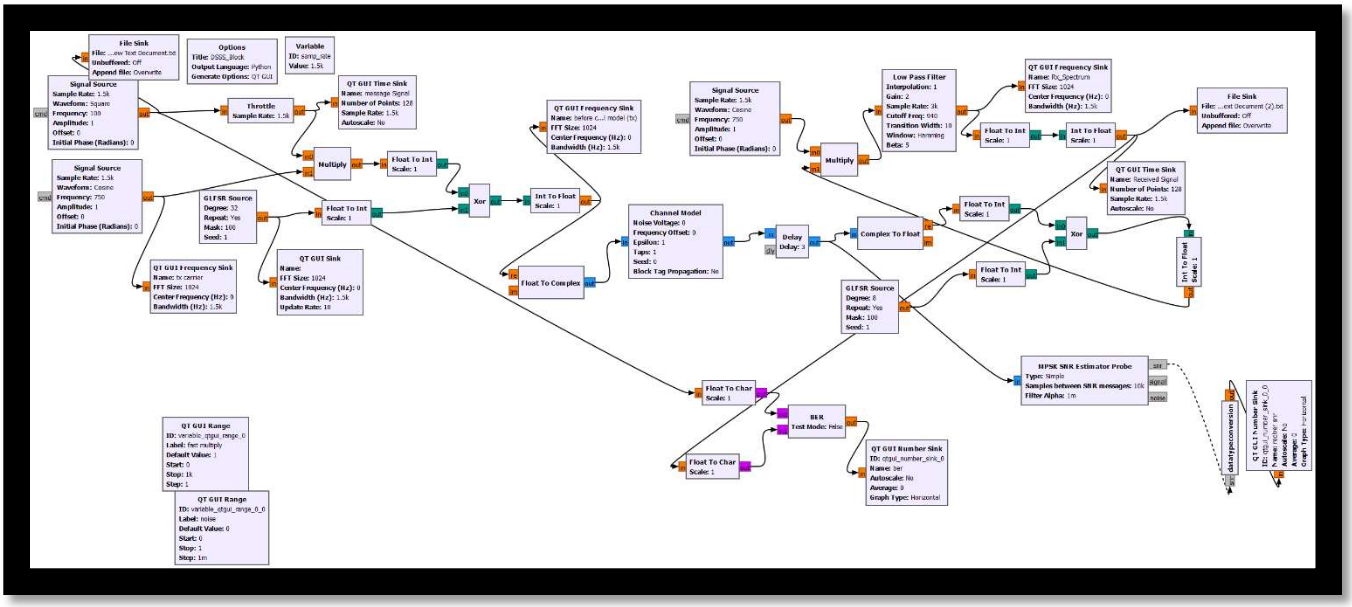

Figure 5-Block diagram of DSSS technique without Jamming

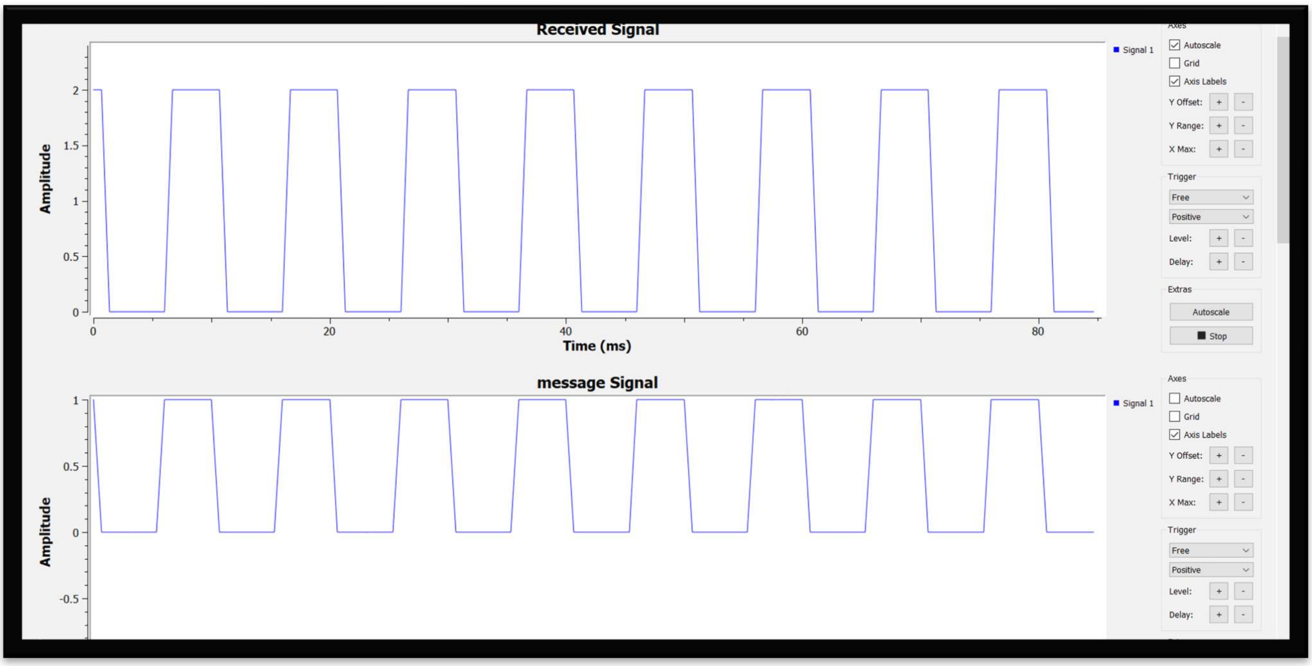

Figure 6-Tx and Rx signal Spectrum without jamming

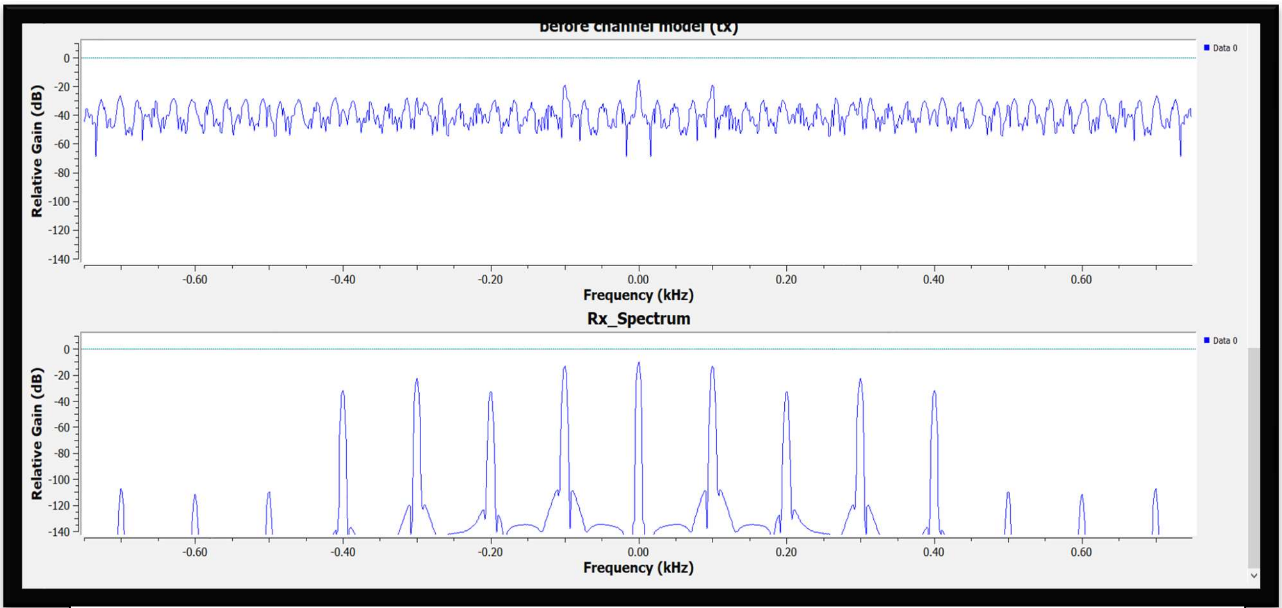

Figure 7-Transmitted DSSS Signal without jamming

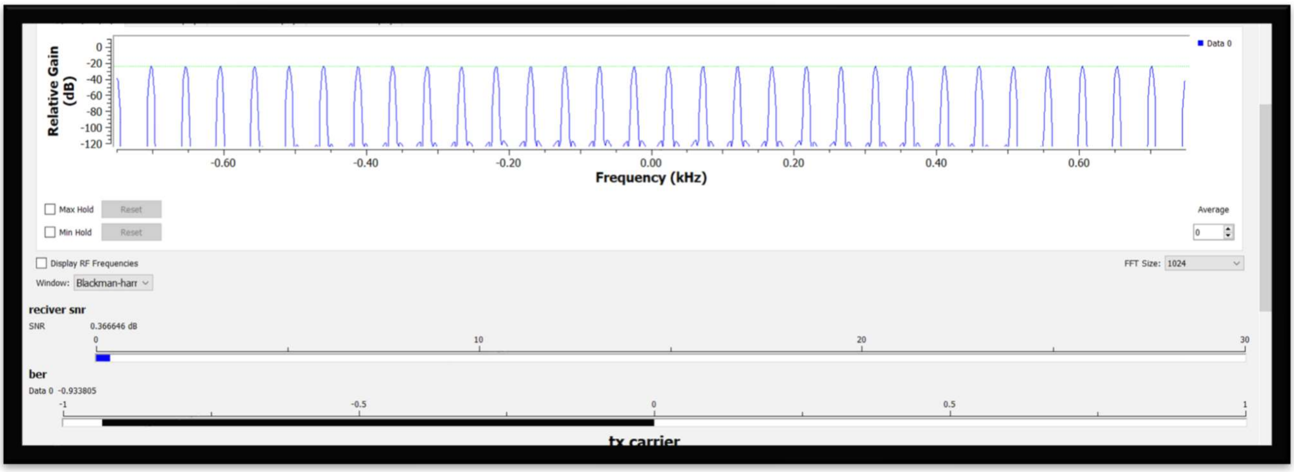

Figure 8-Transmitted PN Sequence, BER,SNR without jamming

Hardware Implementation of DSSS

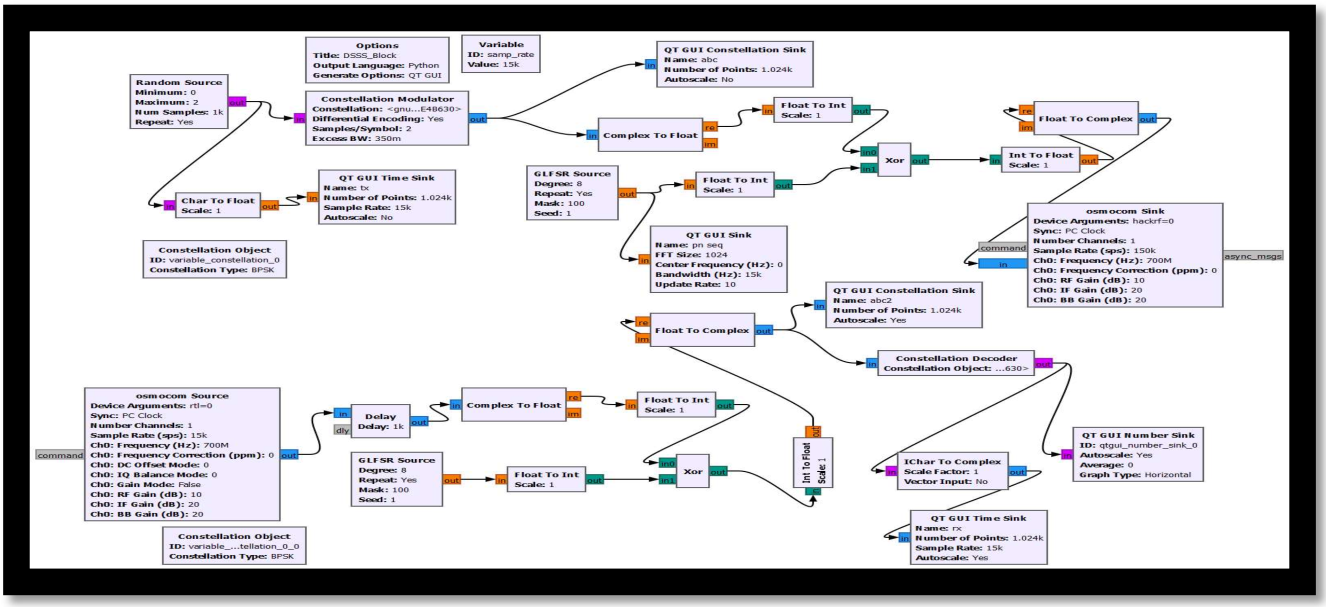

Figure 9-Block diagram of DSSS technique

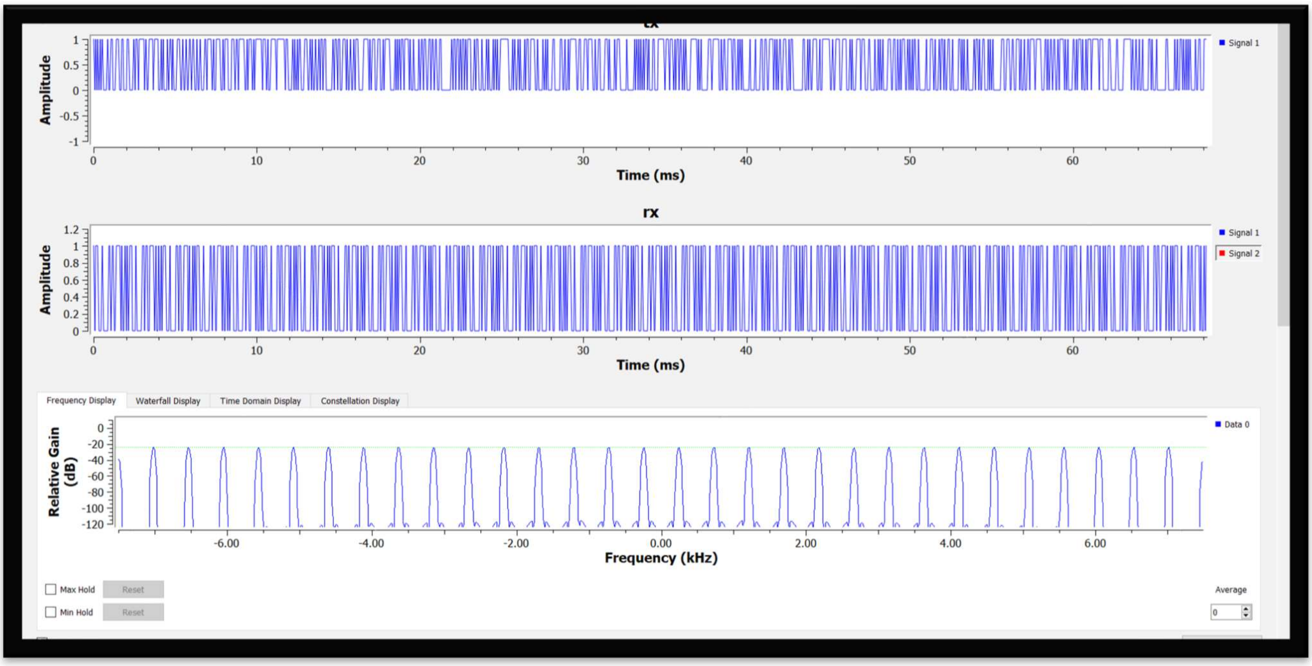

Figure 10-Tx and Rx signal Spectrum

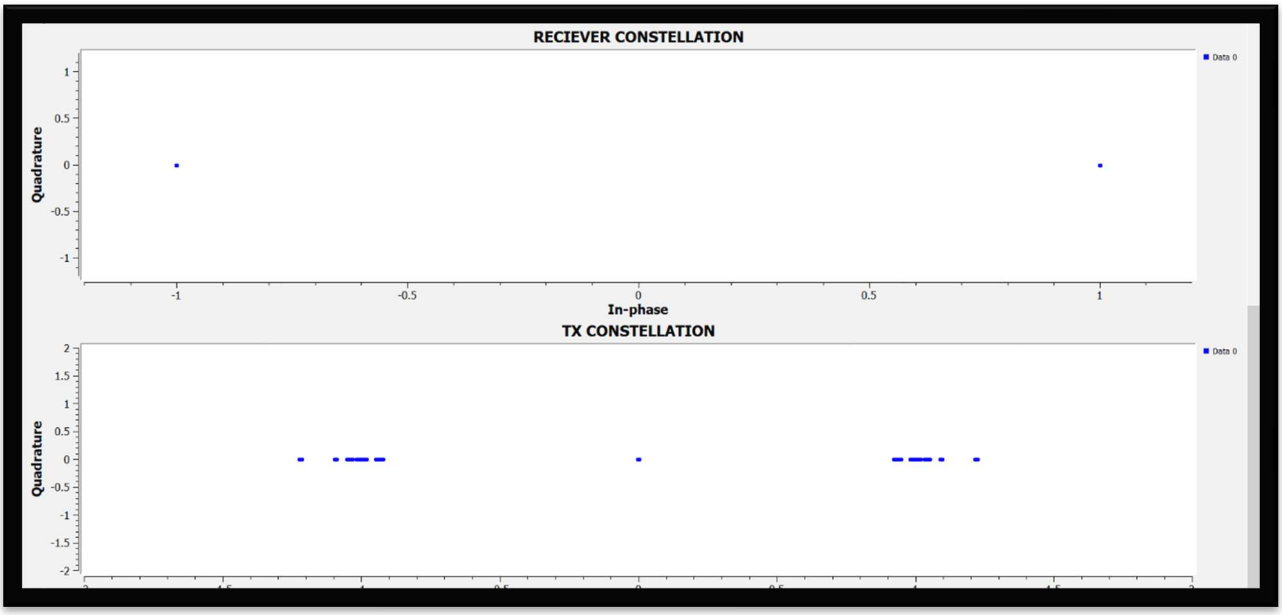

Figure 11-Constellation Diagram

FHSS:

(a) **Frequency Hopping Pattern Design**:

(i) The first step in implementing FHSS is to design a frequency hopping pattern.

(ii) This pattern determines the sequence of frequencies that the transmitter and receiver will hop between during data transmission.

(iii)The hopping pattern should be pre-defined and known to both the transmitter and receiver.

(iv)Python block has been designed for the predefined pattern generation for FHSS.

(b) **Frequency Hopping Receiver:**

(i)The receiver needs to be designed to synchronize with the hopping pattern of the transmitter and correctly demodulate the received signal.

(ii)This typically involves a frequency synthesizer that can track and synchronize with the hopping pattern, as well as demodulation and decoding circuits to extract the original data from the received signal.

FHSS Simulation with jamming

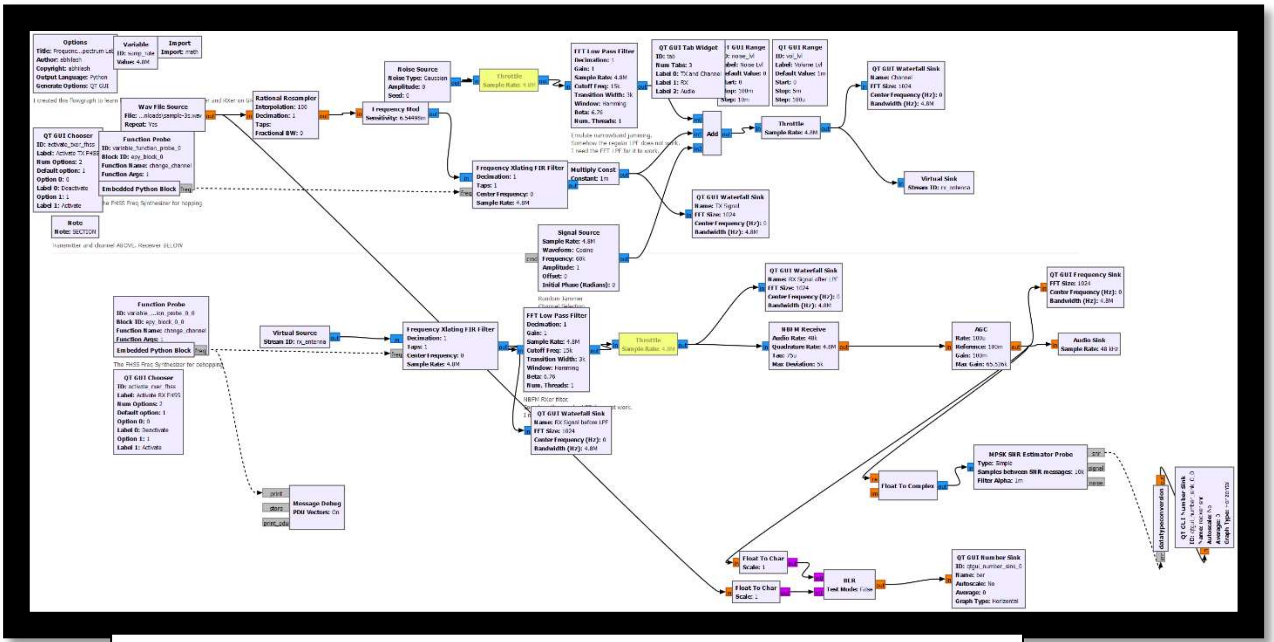

Figure 15-FHSS GNURADIO Block

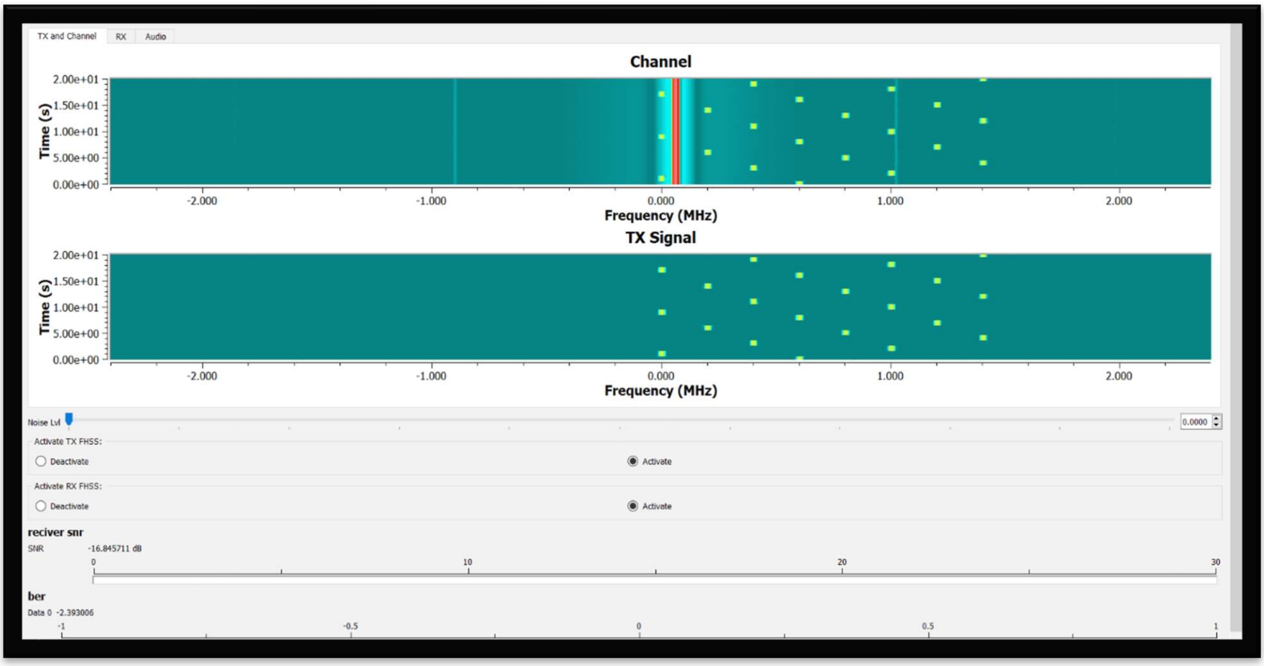

Figure 16-FHSS TX SIDE

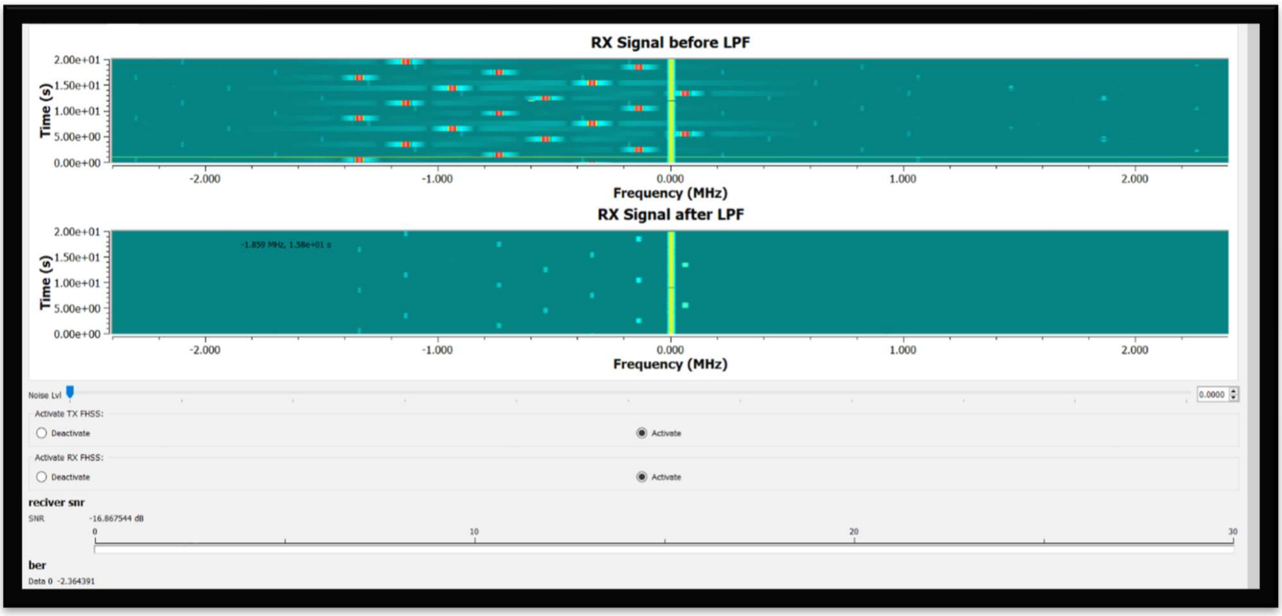

Figure 17-FHSS RX SIDE

FHSS Simulation without Jamming

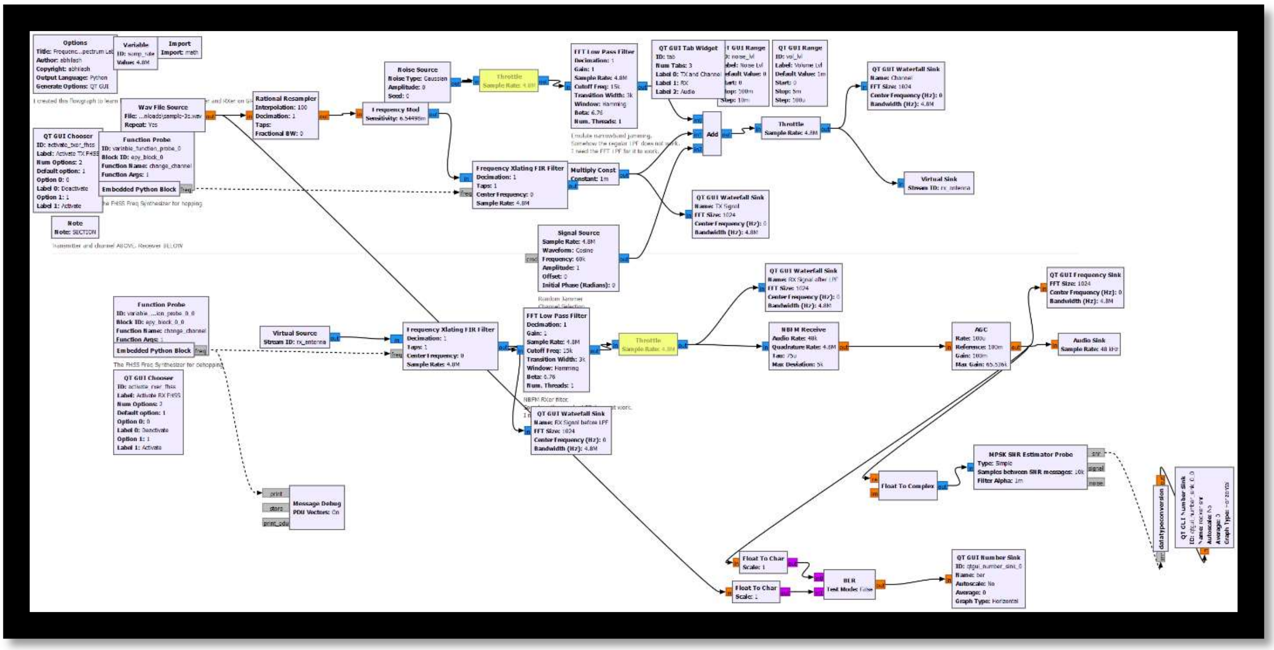

Figure 18-FHSS GNURADIO Block

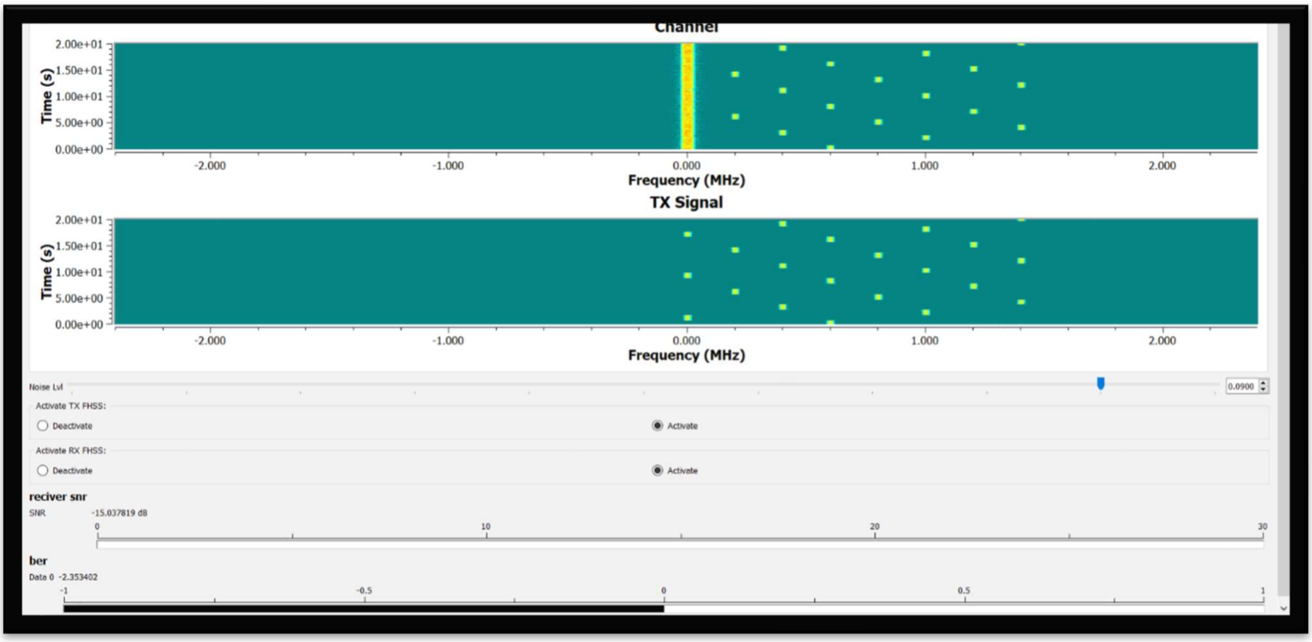

Figure 19-FHSS TX SIDE

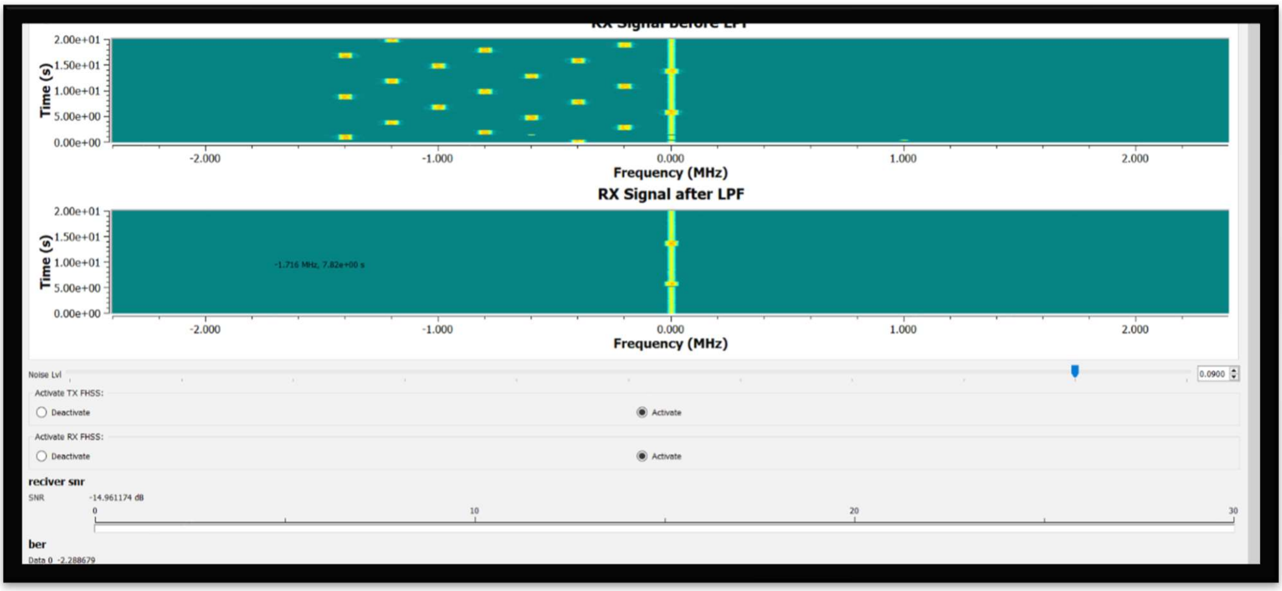

Figure 20-FHSS RX SIDE

FHSS Hardware Implementation

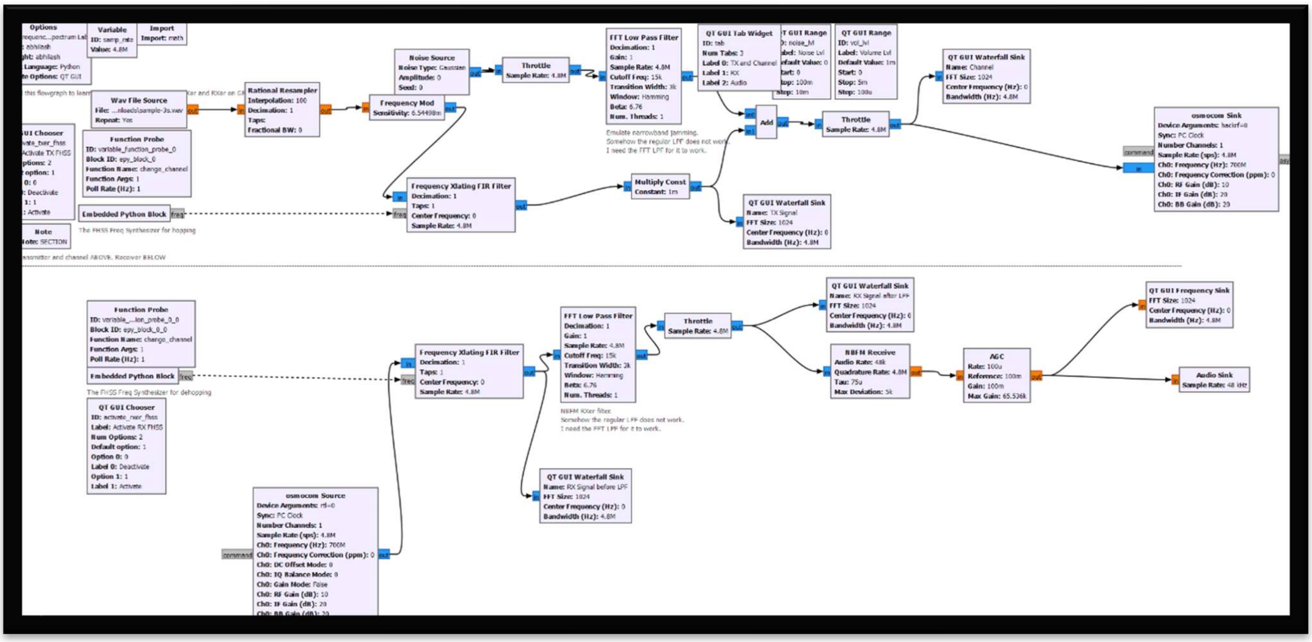

Figure 21-FHSS GNURADIO BLOCK

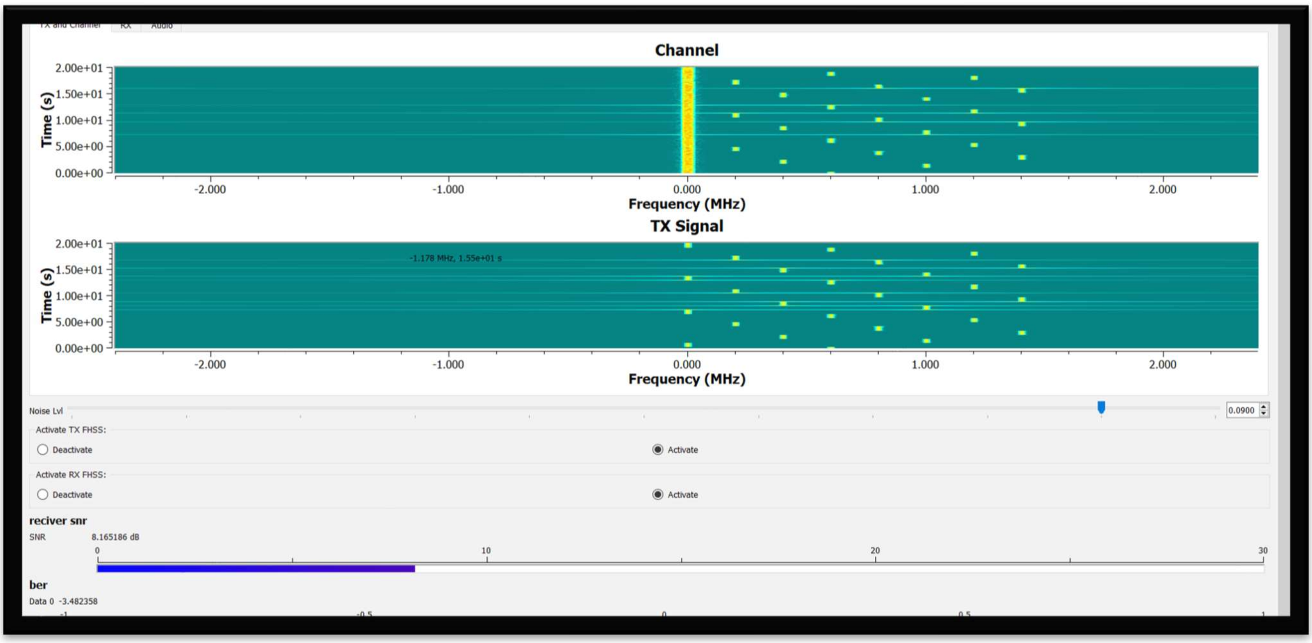

Figure 22-FHSS TX SIDE

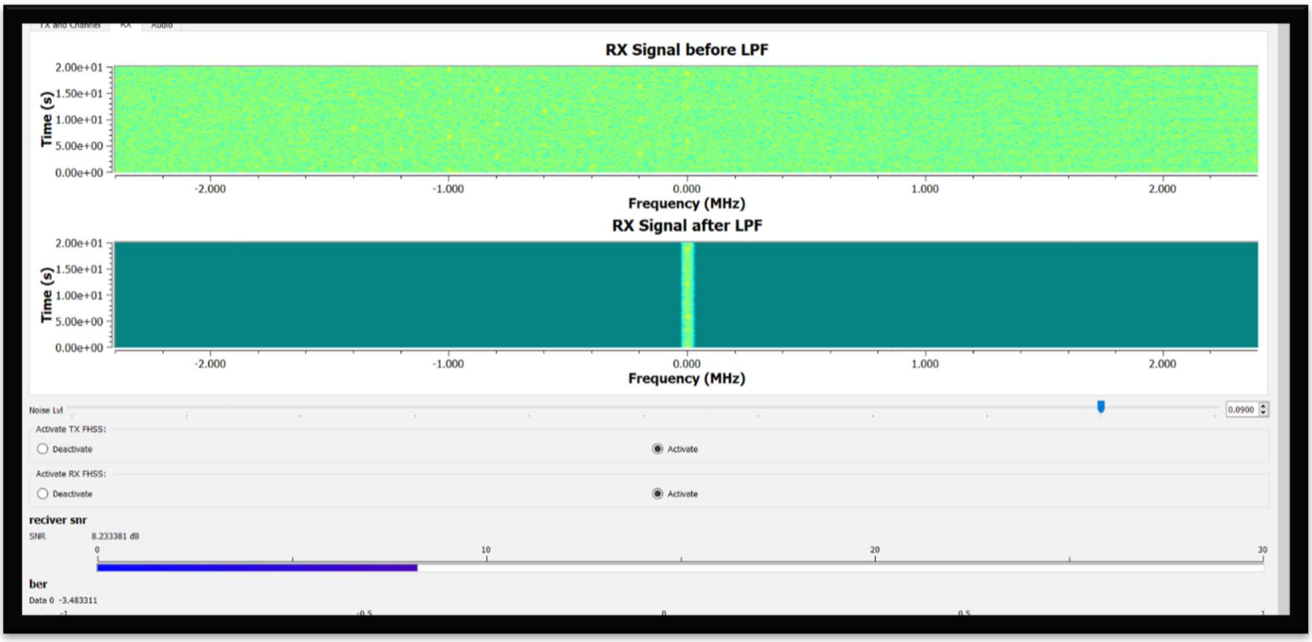

Figure 22-FHSS RX SIDE

6. RESULT

DSSS WITH JAMMING

BER	SNR(db)	TAPS
0.1071	10.22	1
0.268	0.0051	2
0.387	1.06	3
0.462	-3.559	4
0.469	-2.61	5
0.453	-3.48	6

DSSS WITHOUT JAMMING

BER	**SNR(db)**	**TAPS**
0.115	-0.3668	1
0.302	-0.057	2
0.293	-0.89	3
0.3423	-1.589	4
0.4149	-1.779	5
0.4083	-2.079	6

FHSS WITH JAMMING

BER	**SNR(db)**	**NOISE LEVEL** (UNITLESS)
0.00426	-16.93	0
0.00516	-16.61	0.01
0.00562	-16.30	0.02
0.00512	-16.24	0.05
0.0050	-16.21	0.07
0.0038	-16.19	0.10

FHSS WITHOUT JAMMING

BER	**SNR(db)**	**NOISE LEVEL** (UNITLESS)
0.0038	-15.97	0
0.0039	-15.83	0.01
0.0052	-14.87	0.03
0.0063	-14.47	0.06
0.0070	-14.34	0.08
0.0075	-14.25	0.1

7. Experimental Inferences.

(a) In DSSS multiplying the Tx signal with a pseudo random sequence of high frequency, spreads it over the entire frequency spectrum.

(b) This spreading of signal over the entire spectrum makes it difficult for the jammer to identify the actual signal to be jammed as the transmitted signal appears to be similar to White Noise.

(c) Interference from a separate signal source at same frequency was successfully mitigated using DSSS.

(d) In FHSS, the frequency of the carrier signal used for transmitting data is rapidly changed, or "hopped," over a wide range of frequencies according to a predefined pattern generated by python block.

(e) Interference was mitigated and improved resistance from jamming and noise was successfully demonstrated in the lab by using FHSS.

(f) It was also observed that DSSS is more prone to the selective fading as compared to FHSS.

8. References

(a) https://medium.com/@solomontan_68263/learning-frequency-hopping-spread-spectrum-fhss-with-gnu-radio-7b1ab34b1b10

(b) https://static.squarespace.com/static/543ae9afe4b0c3b808d72acd/543aee20e4b09162d086348c/543aee20e4b09162d08634a9/1411158960237/Sep18_07_David_DSSSFHSS.pdf

(c) https://en.wikipedia.org/wiki/Frequency-hopping_spread_spectrum#:~:text=Frequency%2Dhopping%20spread%20spectrum%20(FHSS,to%20both%20transmitter%20and%20receiver.

(d) https://en.wikipedia.org/wiki/Direct-sequence_spread_spectrum#:~:text=In%20telecommunications%2C%20direct%2Dsequence%20spread,bandwidth%20than%20the%20information%20bandwidth.