# EEP3010

Communication System Lab

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**Analysis of non coherent BPSK demodulation in the presence of noise.**

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**By:**



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# Experiment #8

## Abstract:

Non-coherent demodulation is a way to demodulate a signal without a reference signal or phase synchronization between the receiver and the transmitter. This type of demodulation is often used in communication systems where a reference signal is not available or would be too expensive to set up. Unlike coherent demodulation, non-coherent demodulation does not require the use of expensive and complex carrier recovery circuits. In the following experiment a random text file is transmitted and then received on the receiver side following which we will analyse the performance of the BPSK non-coherent modulated signal using an eye diagram,constellation diagram and Bit Error Rate(BER). We compare the text sent from the transmitted side and the text received at the receiver side.

## Objective:

The main goal of the experiment is to see how well and reliably the communication system works in different noise environments. The goal of the experiment is to find out how noise affects the demodulation process and how accurate the information that is taken out is. A non-coherent demodulated system will be implemented and its Bit Error Rate(BER) will be evaluated in the presence of noise. The treasures of the experiment will give a full picture of how non-coherent demodulation works when there is noise, which can be used to design non-coherent demodulation systems for use in different kinds of communication.

## Experimental Procedure:

The necessary equipment required for this part of experiment is :

- N9010A Signal Analyzer/89601 Vector Signal Analysis Software with Oscilloscope (Digitizer).
- AFG3021B Function Generator (2 sets).
- Dream Catcher transmitter and receiver trainer kit.
- ME1100 dream-catcher training kit.
- A PC with MATLAB/LABVIEW.
- Coaxial cables and USB cables,
- Antenna
- Local oscillator signal generator.
- SMA(m)-to-SMA(m) coaxial cable

### Transmitter Code

1. In MATLAB, a pseudo-random binary sequence (PRBS) is generated. The PRBS signal is not a noise sequence but a code that resembles a noise sequence. The signal is generated using a linear feedback shift register. Using the command commsec, the PRBS signal is generated. The order of the polynomial and the initial states of the LFSR are given as parameters. The number of bits generated is 2^7.

2. The text file is then converted to binary. This is converted to characters in Matlab. To convert it into a double format, we subtract a "0" from it and then synchronize it using the PRBS sequence. The

synchronization tells us about the starting bit of the message. To find the end of the message, we use the length of the text file as the parameter itself.

3. Differential encoding is done next. The sequence is then upsampled to 8 bits, and then pulse shaping is done using a root-raised cosine filter. Convolution is then performed, followed by normalization. The waveforms are then converted to a CSV file and imported into a National Instruments machine.

**Receiver Code**

1. Set the number of samples per symbol to 8 and read the acquired data from a CSV file into the variable RX ss.

2. Load a set of filter coefficients (FIR_coeff75) and convolve them with the received signal RX ss to get a filtered signal XX_signal.

3. Normalize the filtered signal and store it in RX signal.

4. Generate an eye diagram of the received signal by dividing it into frames of length equal to the number of samples per symbol (eye_len) and plotting them.

5. Compute the variance of the in-phase component of the eye diagram for each sample position and find the offset of the sample with the highest variance (eye_offset).

6. Downsample the received signal by selecting samples with an offset of eye_offset and store them in the variable Symbols.

7. Compute the phase difference between consecutive symbols and threshold them to obtain the differential encoded bit sequence (bits_rec_bipolar).

8. Generate a pseudo-random bit sequence and perform correlation with the differential encoded bit sequence to detect the start of the message (start_bit_ind).

9. Determine the length of the message from the start of the message.

10. Extract the message bits from the differential encoded bit sequence.

11. Convert the message bits to

text. 

## Procedure and Calculations

**Transmitter**

- Since this is a BPSK experiment only I data is generated. The I data is fed into a function generator, In the function generator we load the user data and then set the Burst frequency.
  The Burst frequency and trigger intervals are calculated using the following formula:

Burst Frequency = (Transmission rate of 1/0 generator Function )/(Transmission length of 1/0 date)

Trigger Interval =1/ Burst Frequency

The transmission rate used = 200 x 10^3 x 8

The total length of data = 6976.

The calculated Burst Frequency is 229.375798 Hz and the trigger interval is 4.36ms.

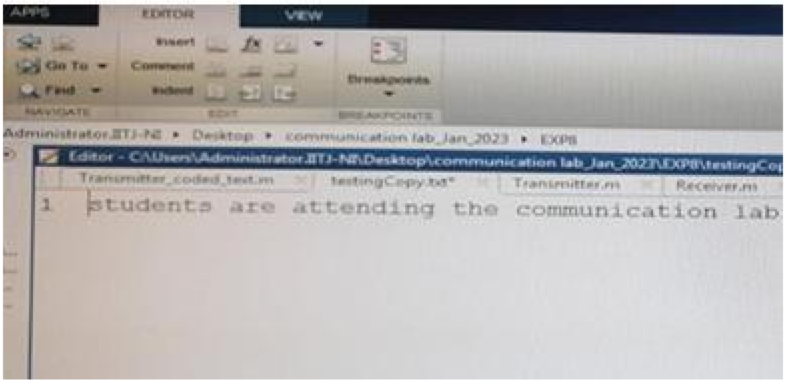
- The output of the function generator is fed to a modulator. The Q port is terminated using a terminator. In the LO port a carrier wave of frequency 50MHz and -3Db is fed. The RF port is then fed to a dream catcher kit In the dream catcher the signal is then upconverted to 866Mhz using a carrier frequency of 818Mhz. The signal is then amplified using a power amplifier.
- Up-conversion is required because as the frequency increases the length of the antenna. decreases as length of antenna is directly proportional to wavelength. Hence the wavelength for 868Mhz is much less compared to wavelength for 50Mhz. Hence the antenna size 868Mhz is much smaller compared to antenna size for 50Mhz.
  Antenna Size proportion to λ times wavelength.
- Power Amplification is done because in free space power dissipates according to the relation
  Power times the square of radius.
  Hence, to transmit over a distance, we need to make sure that our signal has sufficient power. Hence , Power Amplification is done.

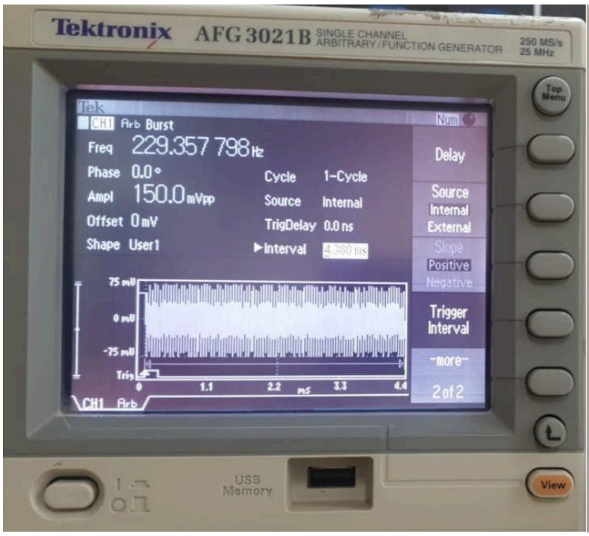
**Receiver**

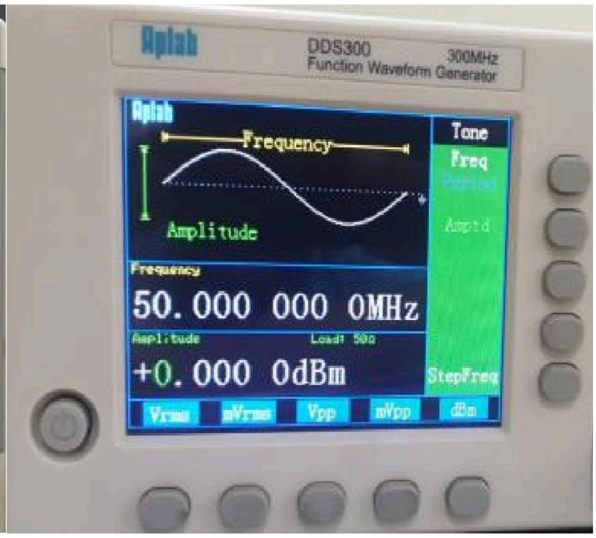
In the receiver side the reverse procedure is done. The signal is first passed through a low noise amplifier. Then it is down converted to 50 Mhz using a carrier wave of 818 Mhz. It is then passed through a low bandpass filter. The signal is then connected to the NI instrument to view its wave. In the NI instrument we study its properties, We see the IQ waveform that is generated. The signal is then fed into a signal analyser to analyse its properties.

## Test Results:

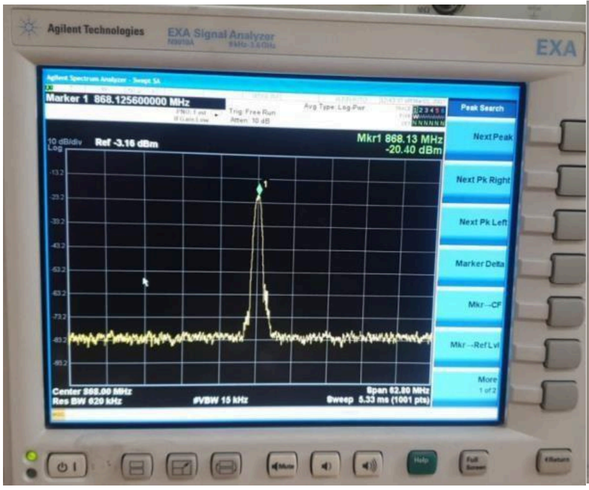
The text message we sent is:

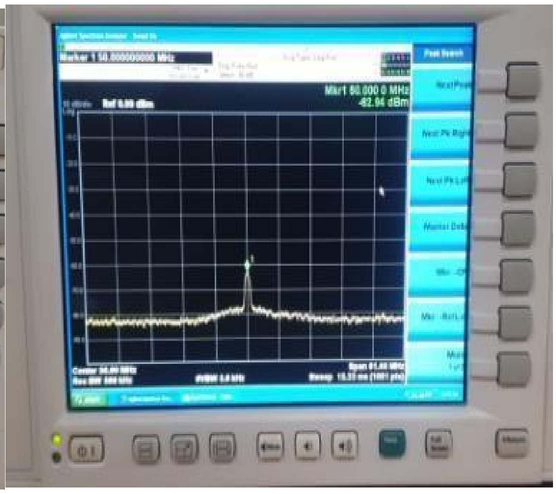







The I waveform sent to function generator:

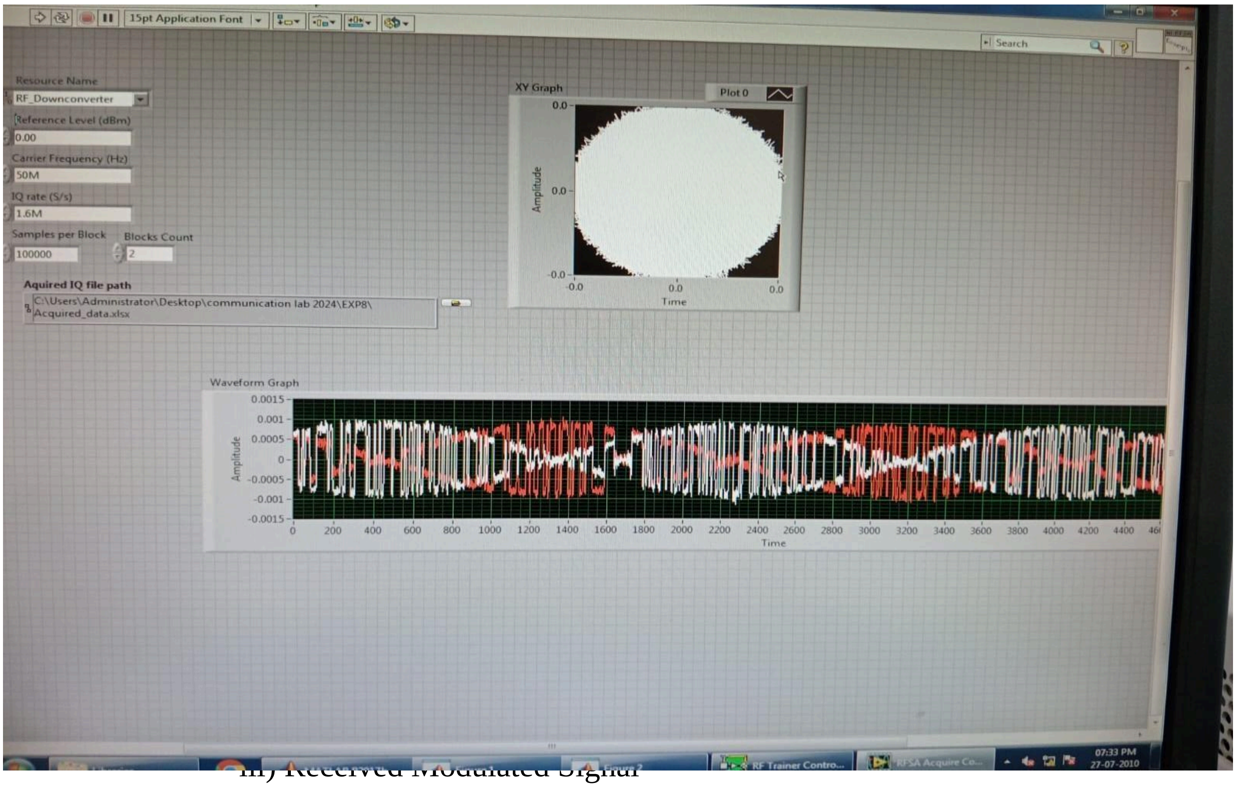






i)Transmitter Signal Spectrum ii) Received Signal Spectrum

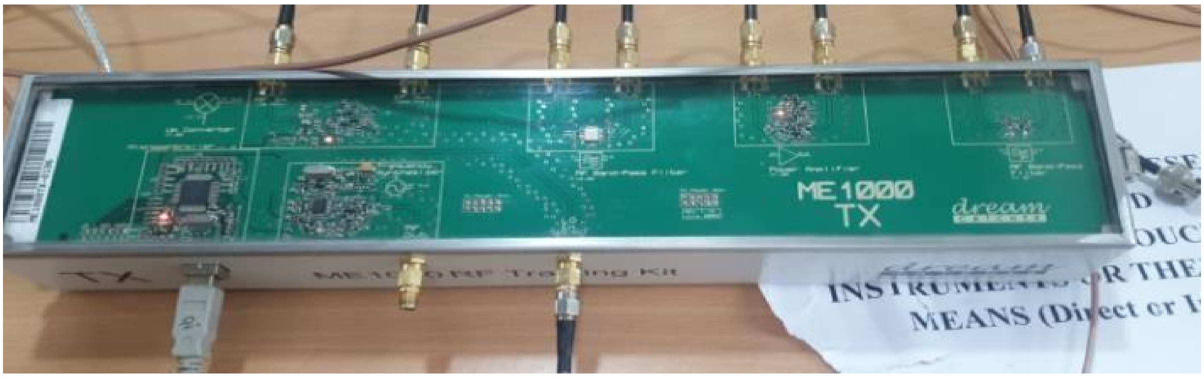
1. A carrier wave at a frequency of 50MHz and -3dB is received by the LO port of the transmitter. The signal is upconverted by the kit to 868MHz as it is the allowed transmission band. The spectrum of this upconverted signal is shown in Figure i.

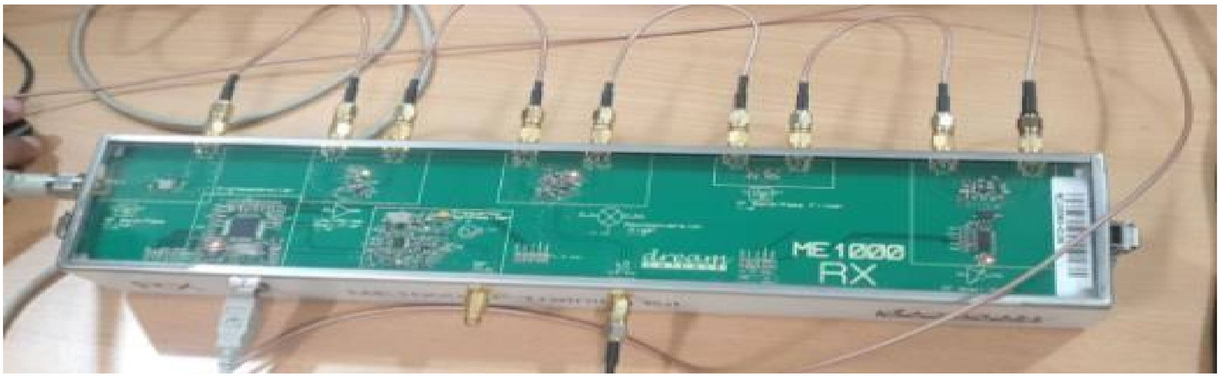
2. In the second figure the received signal is passed through a power amplifier and a downsampler. The signal after downsampling has a center frequency of 50Hz which tells us that the received signal is correct.




iii) Received Modulated Signal

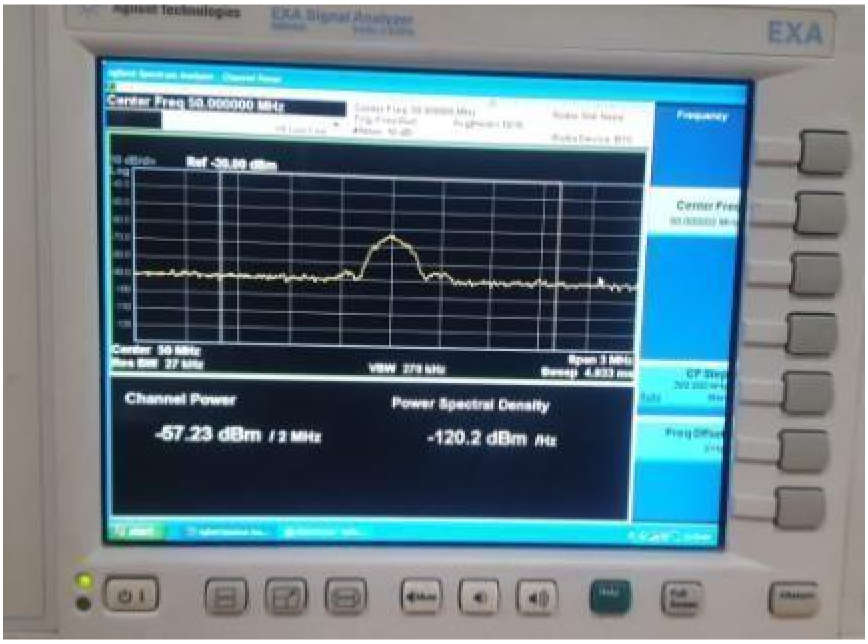
The white and red lines in the plot shows the I and Q components of the signal respectively.



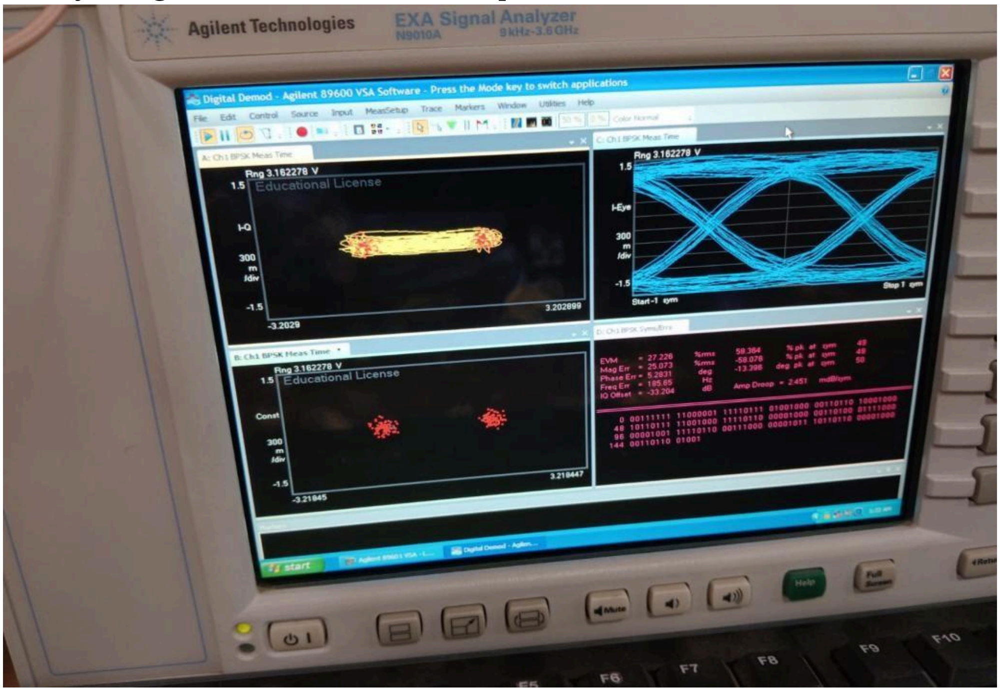




The correlated data plot obtained the signal receiver and transmitter end .

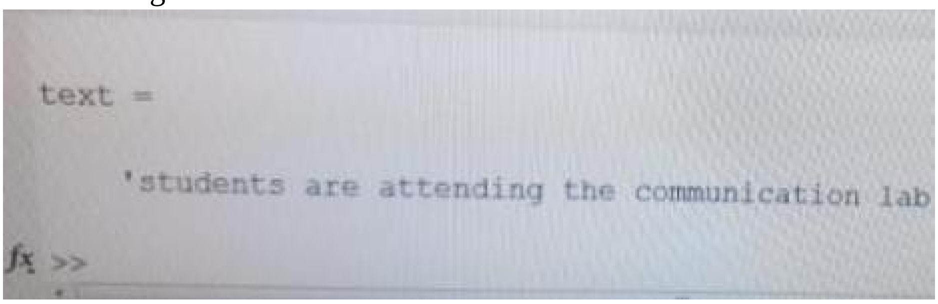
The PSD of the signals are:



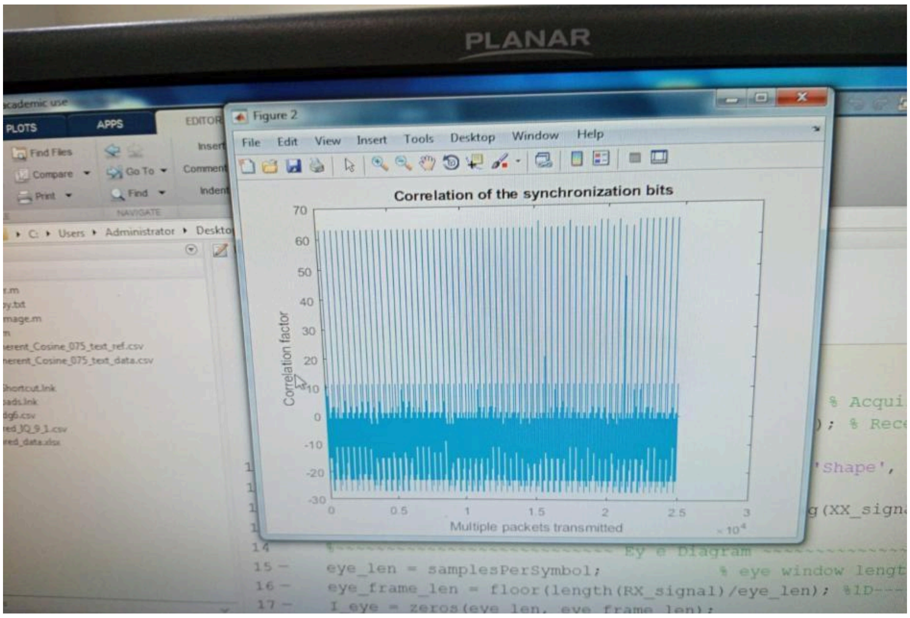

The eye diagram and the constellation plots obtained as follows:



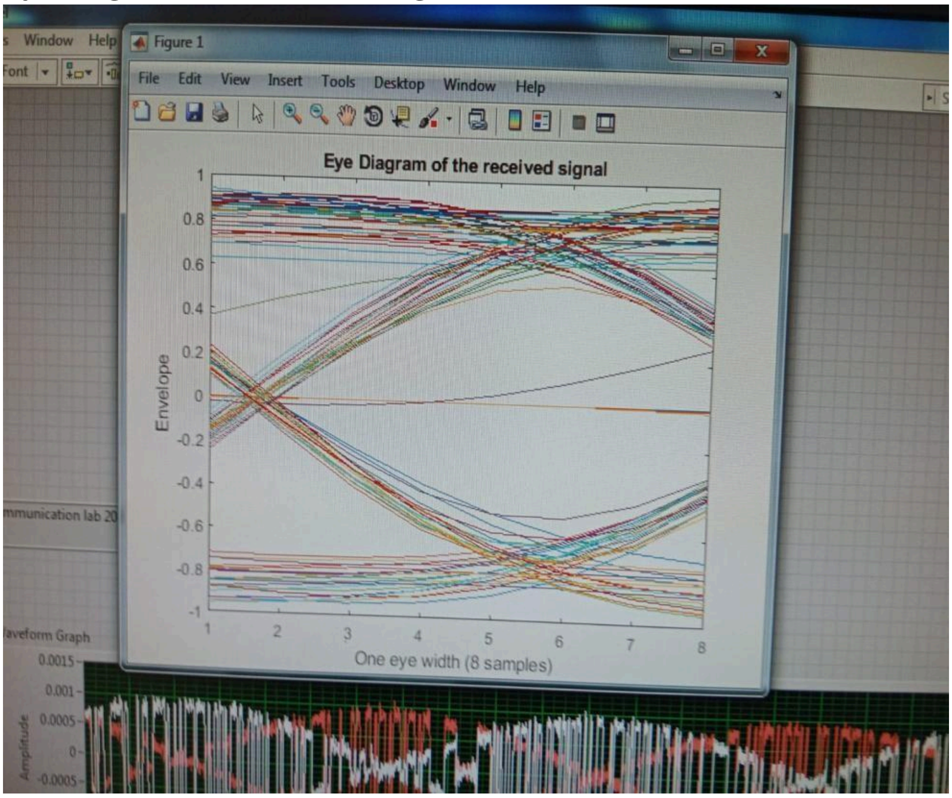

Text message received is:




Correlation Of Synchronization Bits:




Eye Diagram Of the received Signal:




## Discussion:

- The message signal is BPSK modulated with a carrier wave having a frequency of 50 MHz, thus the peak of the spectrum is at 50 MHz and the spectrum is centered at this frequency.

- When the signal is up-sampled the message signal gets carried to a frequency of 868 MHz. Here 868-818+50.
- The signal is now having its center frequency at 868 MHz.
- When this signal is passed through a power amplifier, the amplitude of the signal Increases, the output signal may have a broader spectrum, higher spectral density, and higher signal-to-noise ratio (SNR) due to increased power, but also more noise and intermodulation products due to nonlinearities in the amplifier. As a result, the signal needs to be filtered and equalized to restore its original spectrum and minimize distortions.
- The bandpass filter maintains the signal to be concentrated in the frequency band assigned for educational purposes. This is a free frequency band.
- Differential encoding is used here. In differential decoding, each symbol in the transmitted signal is encoded as the difference between the current symbol and the previous one. The receiver then decodes the signal by taking the difference between. consecutive symbols. Since similar phase noise gets added to both phases, when calculating the symbol by using subtraction this extra phase gets cancelled, Hence we don't have to do phase correction in this case.
- Differential coding has one significant drawback: it leads to error multiplication. That is, if one symbol was received incorrectly, two incorrect symbols would be at the differential decoder's output.
- Using this we observe that the Bit Error Rate(BER) for the text file is 0 from figure 1. This tells us that the received file is the same as the transmitted file. Further using the eye diagram we can analyse the signal better. The BER (Bit Error Rate) performance of a BPSK system can be improved by using error correction codes, such as forward error correction, and by increasing the signal-to-noise ratio.

## Conclusions:

- It was possible to broadcast and receive a DPSK, modulated signal using the dream catcher kit and using a method of non-coherent demodulation.
- The result shows the robustness of the non-coherent demodulation technique to the presence of noise and offers us a clear grasp of how it functions in communication systems.
- The performance analysis of non-coherent BPSK demodulation was observed in the presence of noise and we were able to successfully recover the input text after transmission.

## References:


- Lab Manual For Experiment #8.
- Principles of communication systems – S.Haykin.
- Communication system Notes.