EEP3010

Communication System Lab

Analysis of the performance of the coherent demodulation in the presence of noise.

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By:

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Experiment #7

Abstract:

Coherent demodulation is a widely used technique in digital communications for detecting and demodulating binary phase shift keying (BPSK) signals. BPSK is a popular modulation scheme in which the phase of the carrier signal is modulated to represent binary data. In coherent
demodulation, the receiver makes a reference carrier signal that is in phase with the received signal. It then multiplies the received signal by the reference carrier signal to get the binary data. The coherent demodulation of BPSK is relatively simple and efficient, as it requires only a single bit of information per symbol. It is also less susceptible to noise and interference compared to other modulation schemes. But coherent demodulation requires the transmitter and receiver to be in syne, which can be hard to do in real life. Several methods, such as adding a pilot tone and phase-locked loops (PLLs), have been made to solve synchronization problems. These techniques help to maintain the correct phase and timing of the carrier signal, ensuring accurate demodulation of the BPSK signal. A phase-locked loop (PLL) is a common way to fix the difference in carrier phase and frequency between the signal being sent and the signal being received. The PLL is a feedback control system that adjusts the phase of a local oscillator based on the phase difference between the received signal and the local oscillator. The PLL can recover the transmitted data with high accuracy even in the presence of phase and frequency offset by tracking and minimizing this phase difference. The Costas loop is a type of PLL that is often used in coherent demodulation. It has a quadrature miser that makes both in-phase and out-of-phase parts of the received signal so that it can be demodulated. A power amplifier is an electronic circuit that increases the power of a signal, typically from a low-power source to a high-power load, such as a speaker or antenna. A power amplifier's job is to boost a signal while keeping its quality, so that the signal coming out is an exact copy of the
signal that went in. An upconverter is a type of frequency mixer that is used to increase the frequency of a signal The input signal is mixed with a local oscillator (LO) signal to produce an output signal at a higher frequency.

Objective:

Generate the BPSK signal, modulate it with carrier wave to give BPSK modulation and then demodulate it at receiver end with the same carrier wave frequency and study the performance like spectrum, eye diagram and find the error between the received and transmitted message.

Experimental Procedure:

The necessary equipment required for this part of experiment is :

- PC with MATLAB and VSA software
- LABVIEW software
- Arbitrary function generator
- Dream Catcher transmitter and receiver trainer kit
- Signal Analyser

- NI down convertor
- Local oscillator signal generator
- SMA(m)-to-SMA(m) coaxial cable
- SMA (M) to BNC connector
- Antenna

The experiment involved setting up the transmitter and the receiver side

Transmitter

The code for this part of the experiment

1. Reads the text file to be converted to binary.
2. Converts the text file to binary data.
3. Adds synchronization bits and a message length to the binary data.
4. Converts the entire bit sequence to a signal by upsampling.
5. Filters the signal with a root-raised cosine filter.
6. Saves the resulting signal in two CSV files: The first CSV file contains the synchronization bits, message length, and data bits. The second CSV file contains the resulting signal after filtering.

Receiver

The code for this part of the experiment

1. Generates a Pseudo-Noise sequence for synchronization.
2. Filters the received signal with a Root Raised Cosine filter.
3. Generates the Eye diagram and identifies the best sampling instant for downsampling the signal.
4. Downsamples the filtered signal by a factor of B.
5. Performs phase and frequency correction on the downsampled signal using a PLL/Costas loop.
6. Detects the start of the data packet using a correlation technique.

Procedure

Transmitter

1. Run the transmitter Matlab code and store the obtained data in a CSV file.
2. Load the CSV file into a function generator.
3. Connect the signal from the function generator to a BPSK modulator with a carrier frequency of 50MHz.
4. Send the obtained data to the Tx unit of Dream Catcher.

5. Visualize the data at every stage of the Tx unit.

Receiver

1. Configure the Rx unit of Dream Catcher.

2. Visualize the spectrum, constellation diagram, and eye diagram of the received signal.

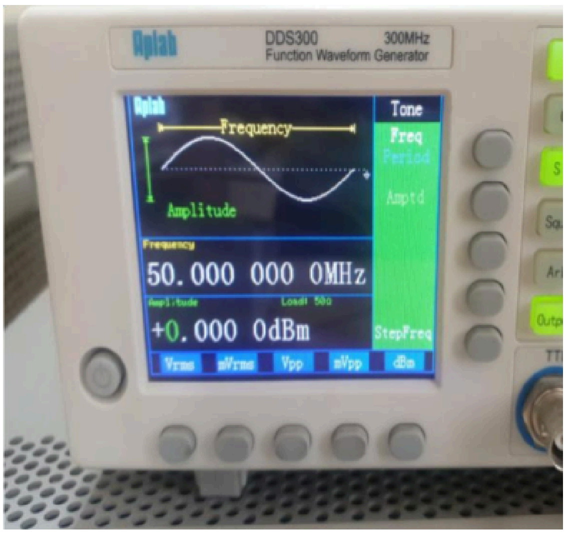
3. Store the output of the Rx unit in a CSV file.

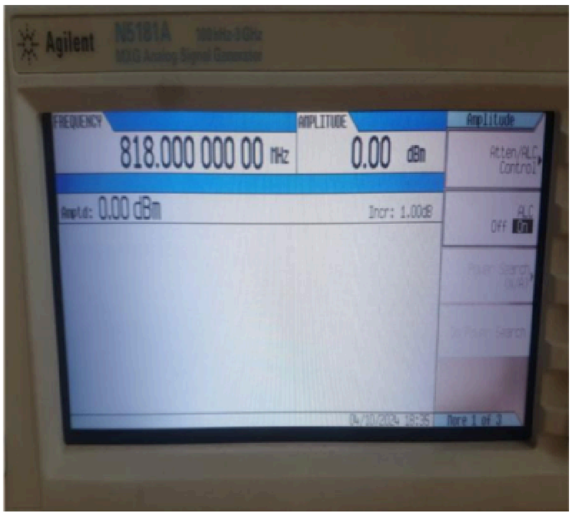
4. Run the receiver code and obtain the original message.

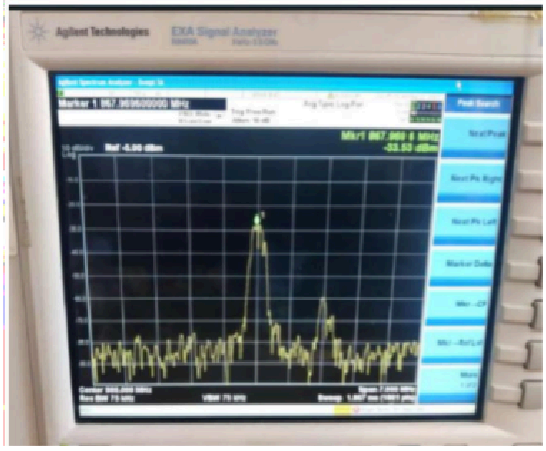
5. Find the BER for the obtained data.

Test Results:

The message signal we transmitted:





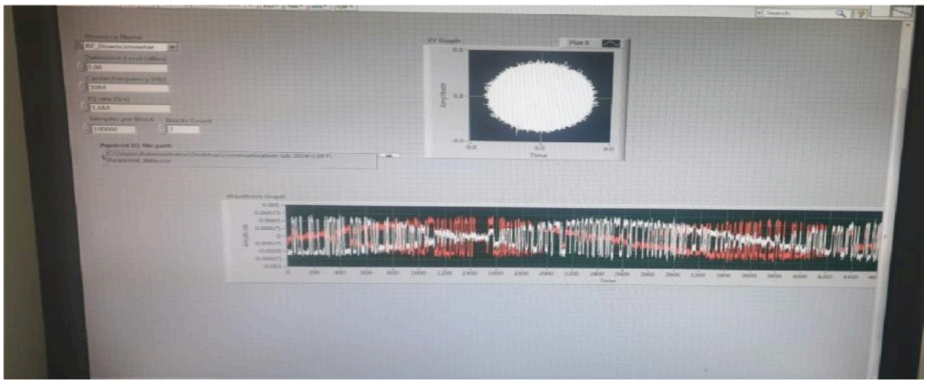


1 Transmitted signal spectrum 2 Received signal spectrum

1. A carrier wave at a frequency of 50MHz and -3dB is received by the LO port of the

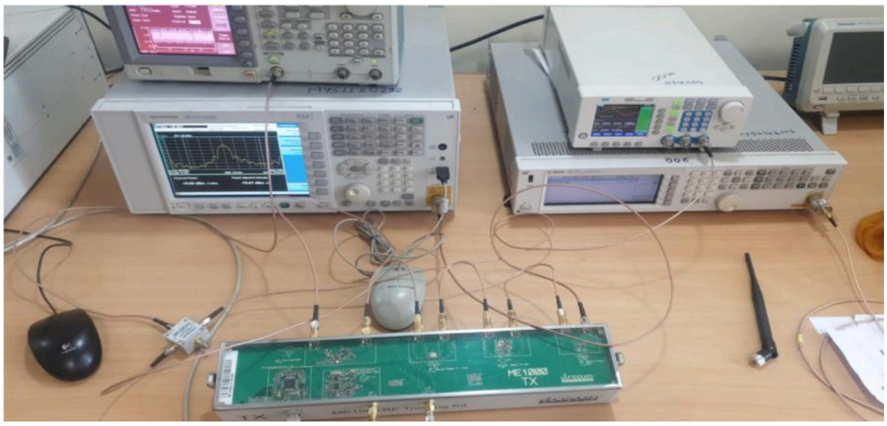
transmitter. The signal is upconverted by the kit to 868MHz as it is the allowed transmission band. The spectrum of this upconverted signal is shown in Figure 1.

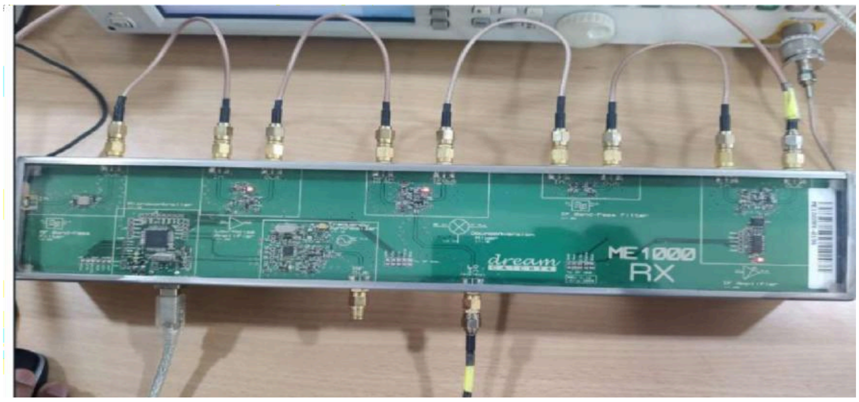
2. In the second figure the received signal is passed through a power amplifier and a downsampler. The signal after downsampling has a center frequency of 50Hz which tells us that the received signal is correct.



3 Received modulated signal

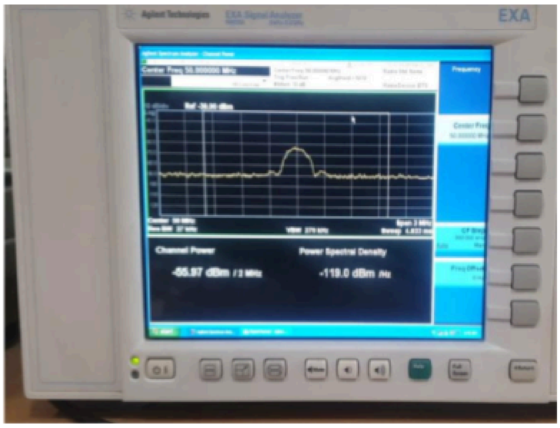
The white and red lines in the plot shows the I and Q components of the signal respectively. The entire experimental set up appeared as shown below.





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

The PSD of the signals are:



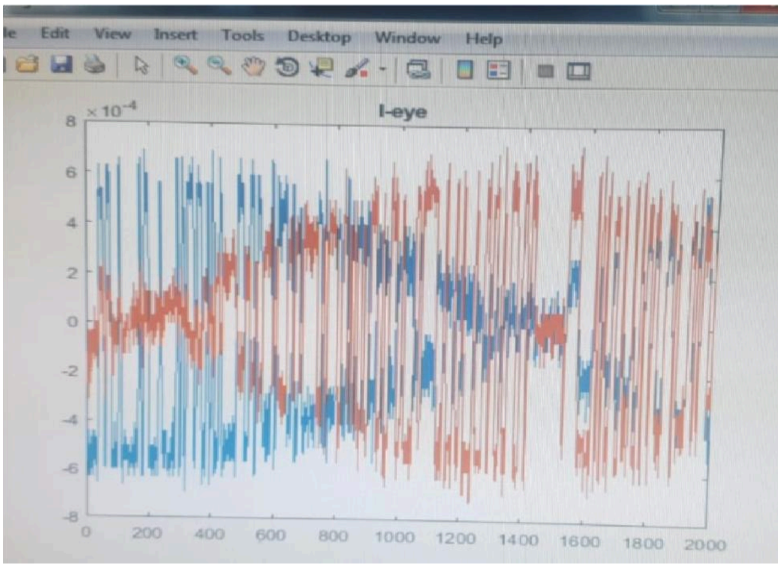
i)Transmitter end

ii)Receiver end

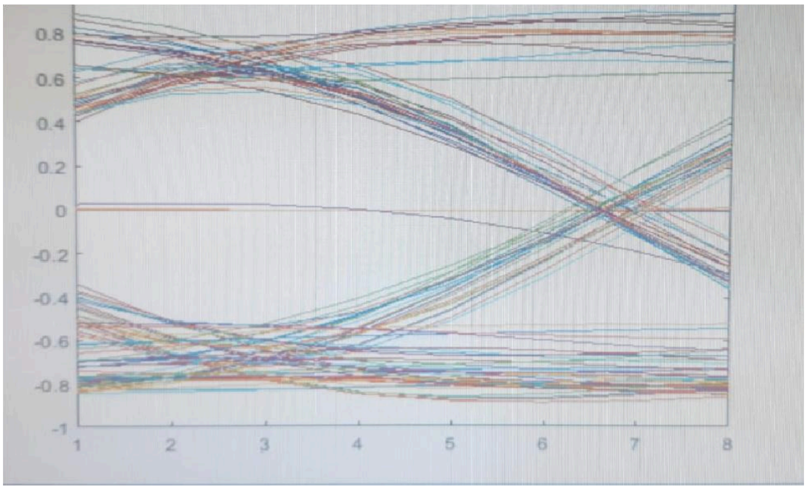
The eye diagram and the constellation plots obtained as

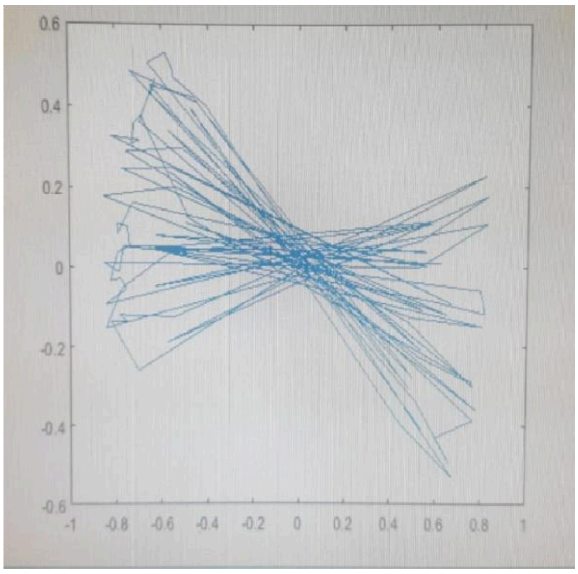
f

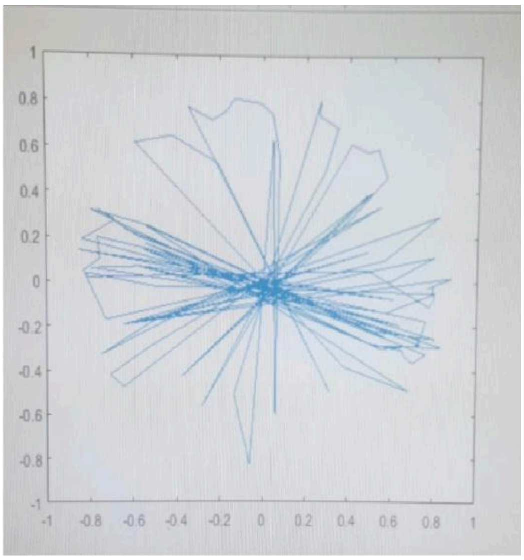
I-Eye:

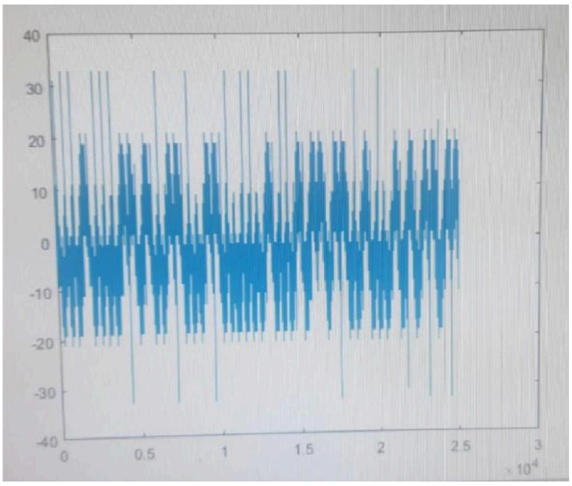


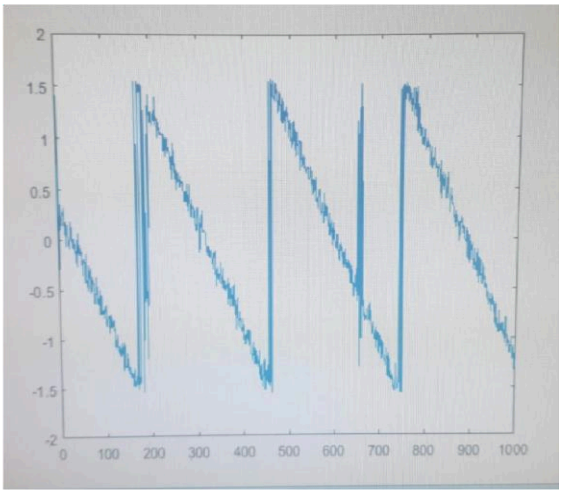
Eye -diagram:



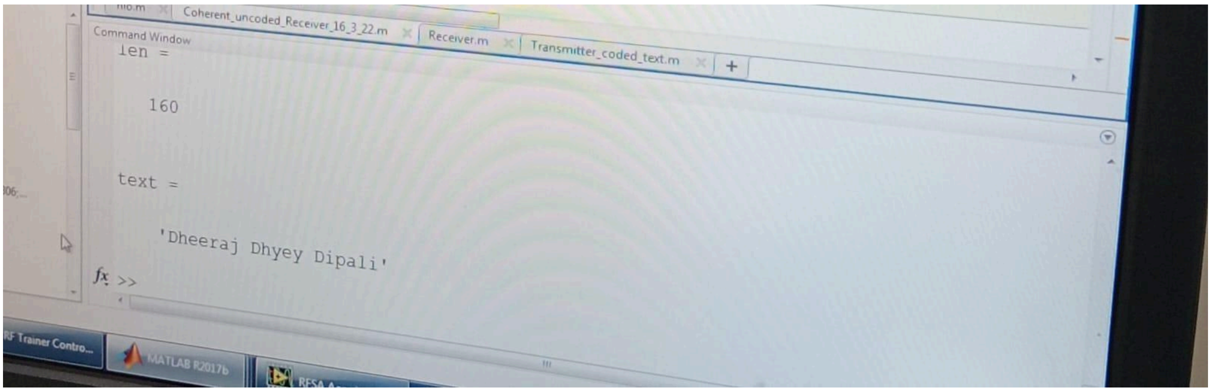








The received text message after demodulation:



Discussion:

Transmitter

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

2. When the signal is sampled the message signal gets carried to a frequency of 868 MHz. Here 868-818+50.

3. The signal is now having its center frequency at 868 MHz.

4. 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 minimizo distortions.

5. The bandpass filter maintains the signal to be concentrated in the frequency band assigned for educational purposes. This is a free frequency band.

Receiver

1. The receiver circuit contains the same circuitry as the transmitter but in reverse..
2. The circuitry contains a power amplifier and downsampler.
3. The obtained signal is having its spectrum situated at 50 MHz, which means that our obtained signal is correct.
4. The signal is then stored in the form of a CSV file for further computations.
5. The i-Q plot is made for the signal obtained, the yellow color lines show the transition of states.
6. The eye diagram is shown in blue lines in the figure. The constellation diagram is shown in red, it has 2 states which show that the signal is BPSK modulated which has 2 states.
7. The CSV file saved before is used to decode the signal to generate the bitstream and find the BER

Calculations

The Burst frequency and trigger intervals are calculated using the following formula :

$$Burst\ Frequency = \frac{Transmission\ rate\ of\ I/Q\ generator\ Function}{Transmission\ length\ of\ I/Q\ data}$$

$$Trigger\ Interval = \frac{1}{Burst\ Frequency}$$

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

The total length of data = 3712

The calculated Burst Frequency is 431.034483 Hz and the trigger interval is 2.32ms.

Conclusion

It was possible to broadcast and receive a BPSK coherent modulated signal using the dream catcher kit.

The result shows the robustness of the 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 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 #7.

Principles of communication systems – S.Haykin