

İSTANBUL MEDİPOL UNIVERSITY



EECD1212913: DIGITAL COMMUNICATION LABORATORY

Lab report No. 7: Receiver Design

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Introduction

This lab aims to design a baseband receiver that will receive the signal and perform the required processing on the signal to obtain the transmitted message. Generally, the laboratory familiarized us with the following:

- a) Practical frame structures in wireless communication systems.
- b) Correlation characteristics of m sequences (synchronization sequence).
- c) Time offset estimation and compensation (i.e., time synchronization).
- d) Frequency offset estimation and compensation (i.e., frequency synchronization).
- e) Symbol synchronization/sample timing estimation.
- f) Effect of synchronization mismatch in the system.
- g) Channel estimation and compensation.

Procedure

The goal is to synchronize the received signal in time and phase to recover transmitted symbols. Follow TA's explanation of the methods below.

Frame Structure:

The frame has two parts.

1. Data part, where QAM symbols are loaded with this lab 512 16-QAM symbols are used
2. Preamble consisting of two cascaded, identical m-sequences each with (2^7-1) BPSK symbols.

Both data and preamble symbols are filtered using RRC filter. The frame parameters are as follows:

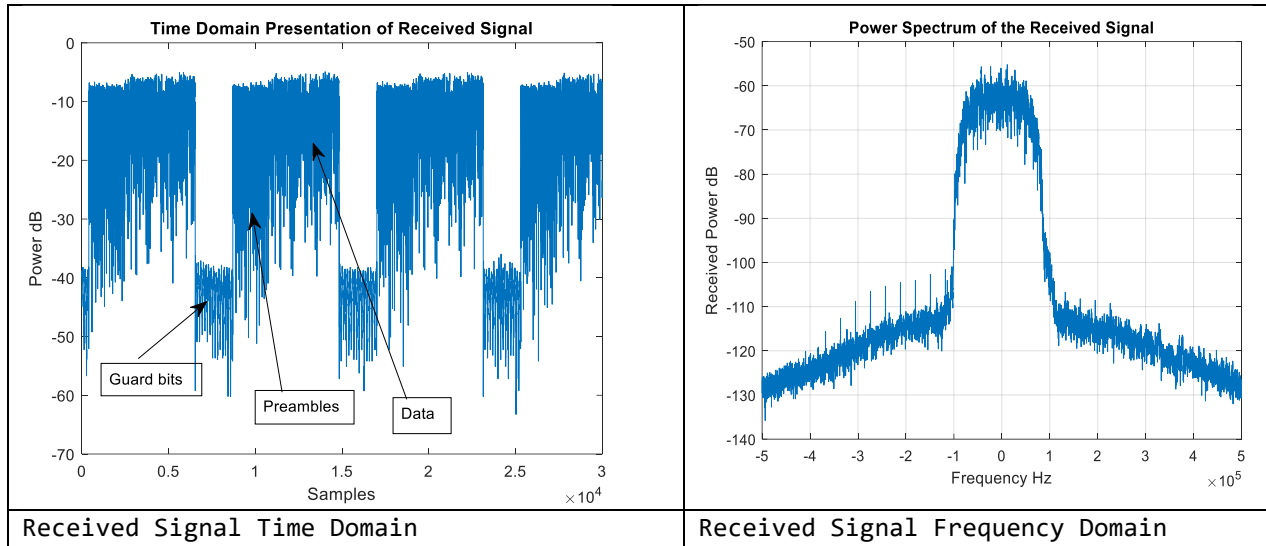
Preamble: two m-sequences

Filtering:

- RRC filter with 0.5 roll-off factor,
- The oversampling ratio of 8 samples per symbol and
- Span of 16 symbols.
- Sampling Rate: 10^6 samples/second.

After sending and receiving the generated samples, the following were performed:

Activity (a)



Observation:

The time domain plot shows the presence of guard bits and the rest of the frame which include preambles and the data of the transmitted signal as shown by the arrows, the preambles show higher energy variations dynamic range compared to data. The frequency domain presentation of the signal is as seen in the figure.

Activity (b)

Energy-based edge detection was carried out using the pre-ambles, and the figure below shows the obtained results.

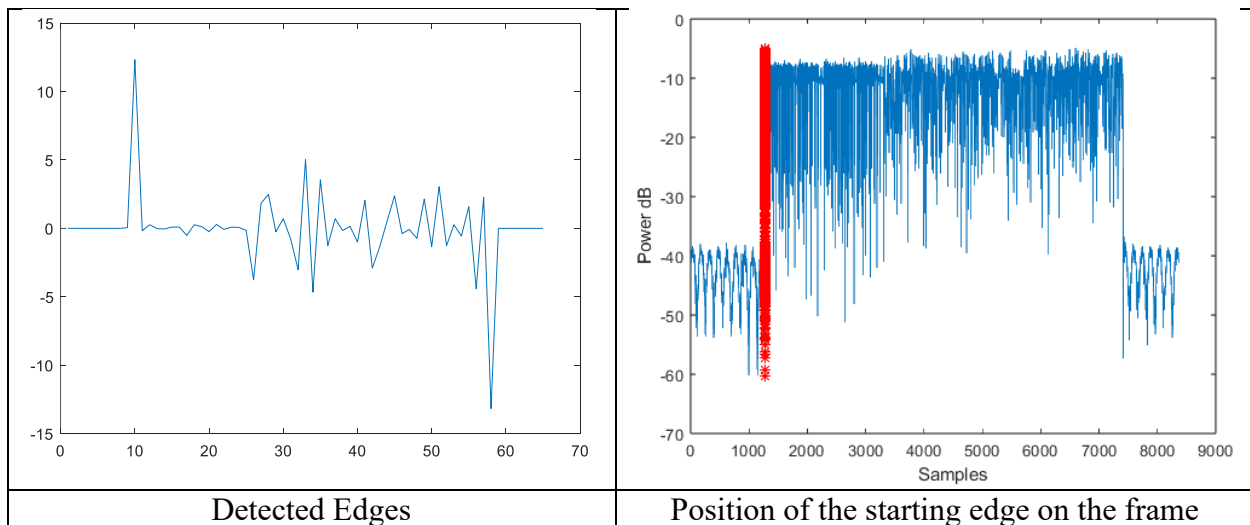


Figure 1 Selected Frame with Detected Edge

Observation:

Edge detection process reveals two edges, one at the rising side of the frame and the other at the falling edge of the frame. The detected edge which shows the start of the frame starts at an index of 1280 as depicted in the figure; it shows that energy-based edge detection can accurately obtain the edge of the frame.

Activity (c):

Match filtering was performed, and the following eye diagram was obtained

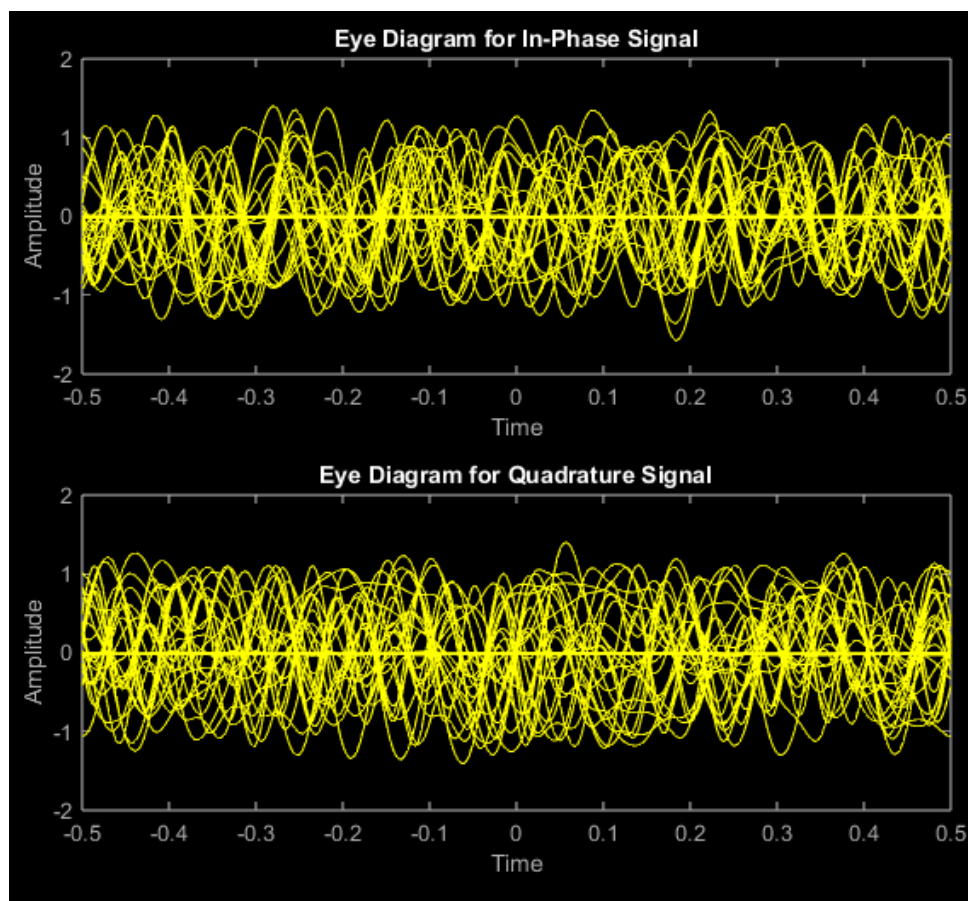


Figure 2 Eye Diagram of the Frame after Match Filtering

Activity (d)

- Frequency Offset was estimated using duplicated m-sequence, the estimated frequency offset was -6.727×10^3 Hz.

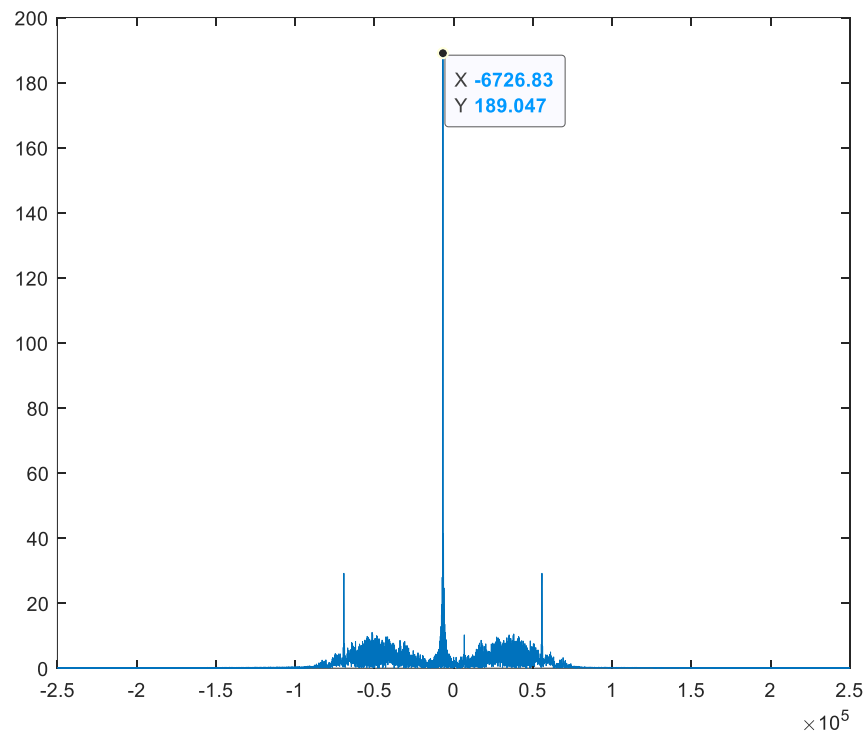


Figure 3 Frequency Offset Estimation

- Eye diagram was plotted and the following figure was obtained

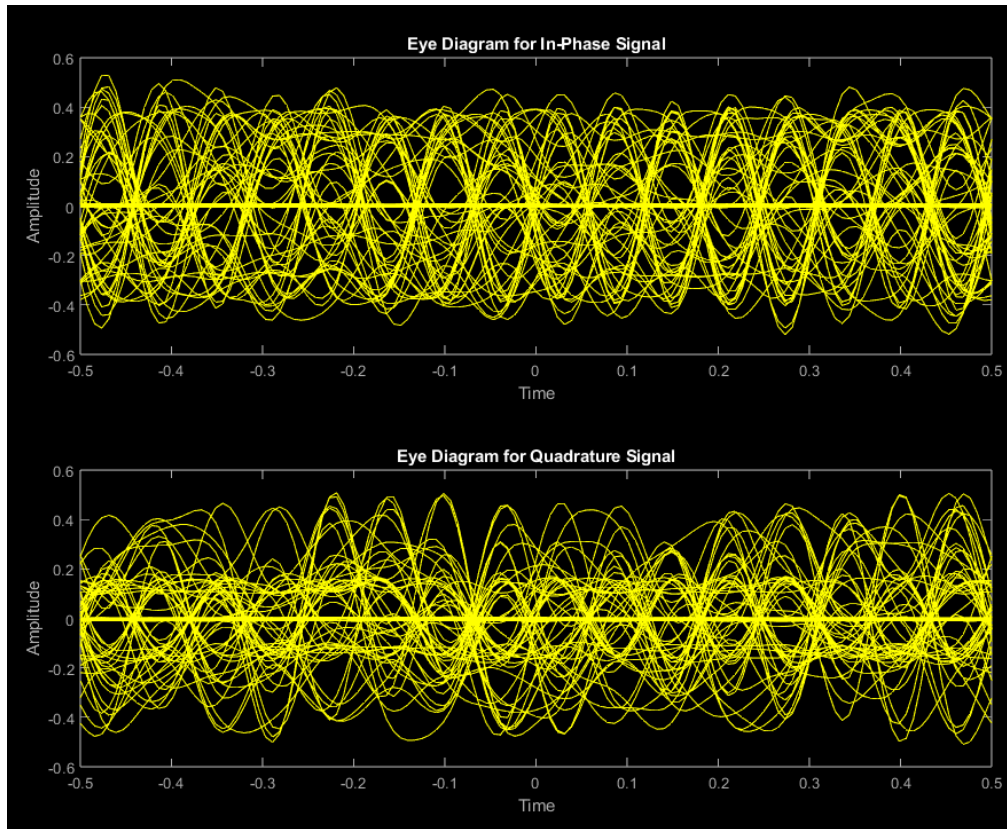


Figure 4 Eye Diagram for the Compensated Received Frame

After frequency offset compensation the eye diagram is wider, and jitter is somehow reduced compared with the one obtained at activity c, the presence of some guards, and pre-ambls and phase ambiguity in the samples make the eye still unclear for 16QM observations.

Activity (e)

- Correlation is performed between the received pre-ambls and the locally generated ones and the resulting correlation output is plotted as shown in the figure below.

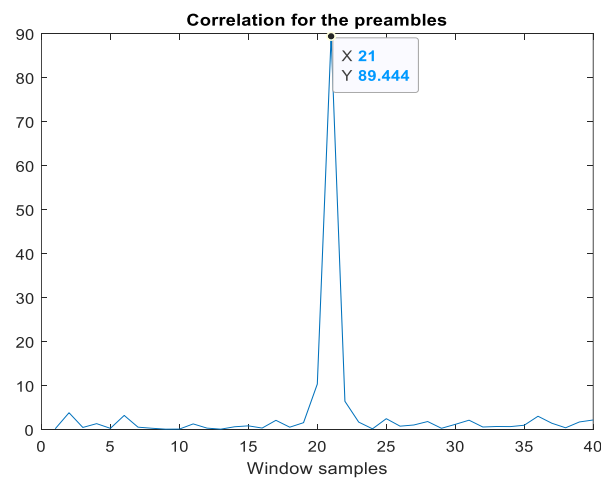


Figure 5 Correlation of the Pre-ambls.

- Data symbols were extracted from the frame and the following figure was obtained.

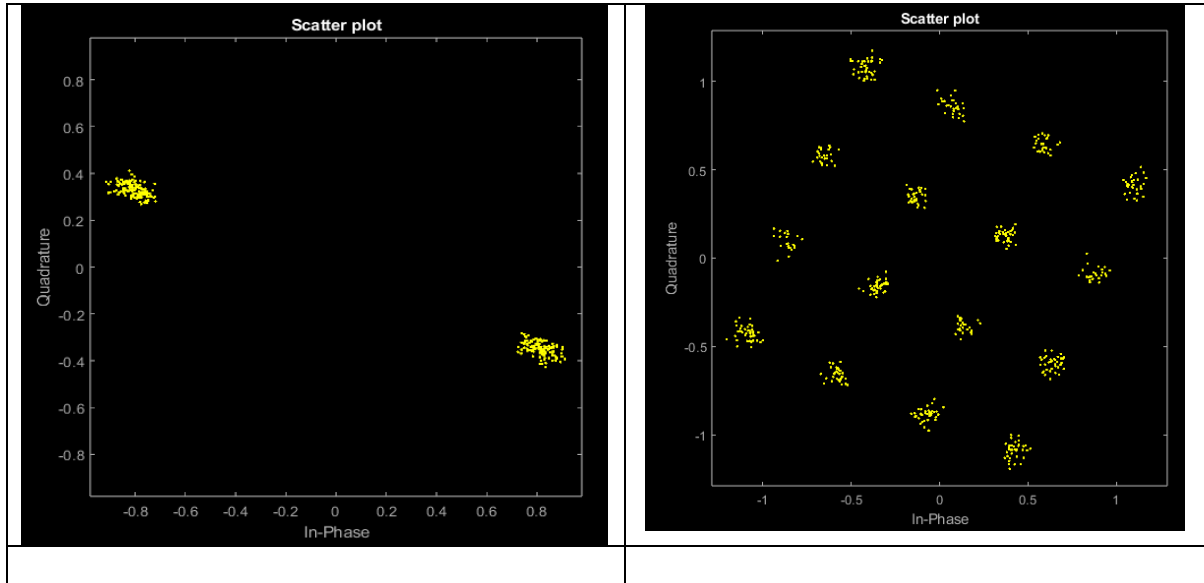
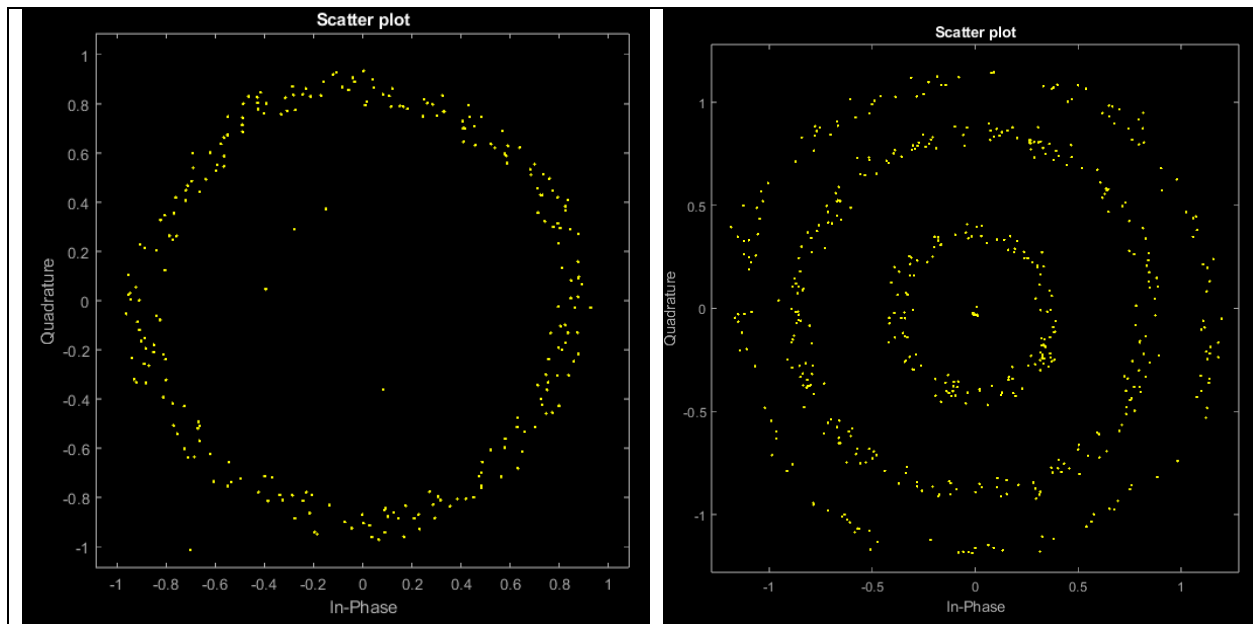
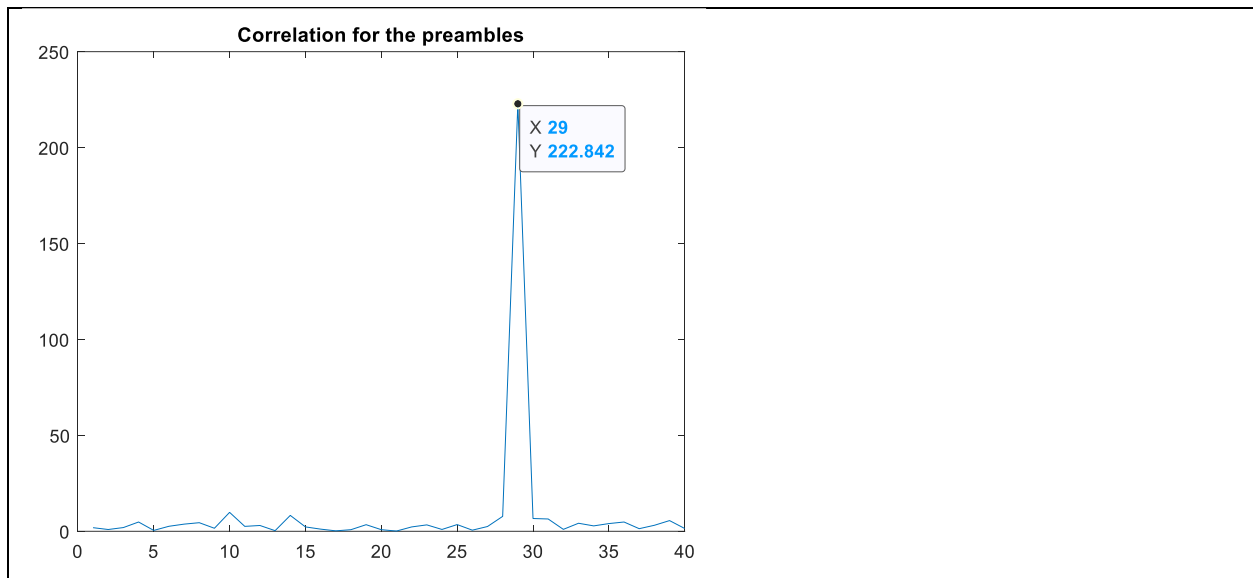


Figure 6 Extracted data Symbols.

Activity (f)

The obtained constellation diagram is shown in the figure below by repeating activity (e) without frequency offset compensation.



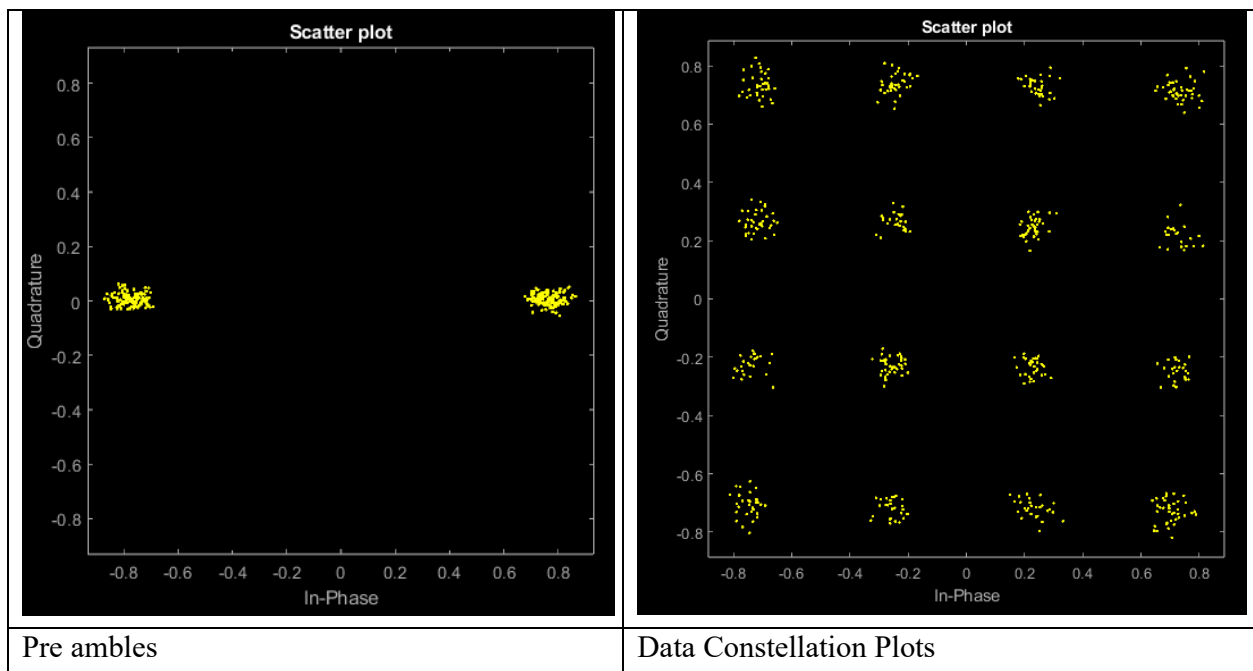


Observation

Without offset compensation, the effect of frequency offset can be seen, the constellation points appear circular which is a sign of them being rotated as a function of time with the frequency offset. There is also a slight change in the index of correlation part which moved to 29 instead of 21 as observed before.

Activity (g)

The estimated phase ambiguity is 0.8773 at an angle of 0.8735π , the calculated Bit Error Rate after comparing the detected preamble with the locally generated ones is 2.54×10^{-4} . The constellation diagram after the cancellation of the phase ambiguity is as shown in the figure.



Activity (h)

From the received data symbols, the EVM is calculated, and the obtained value is 2.9577% and by using the EVM we determine the Signal to Noise Ratio (SNR) which is 30.58.

Conclusion

With this laboratory, we learned a great deal of receiver design on how to receive an incoming signal transmission and process it so that we can extract the data contained in the signal. It gave us a great intuition on how you can capture frames, perform edge detection, frequency offset estimation and compensation, and finally estimation and cancellation of phase ambiguity for detecting the data so that the original message can be recovered.