

Lab 1 : Digital Modulation

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1. BPSK

Figure 1: BER v/s Eb/No

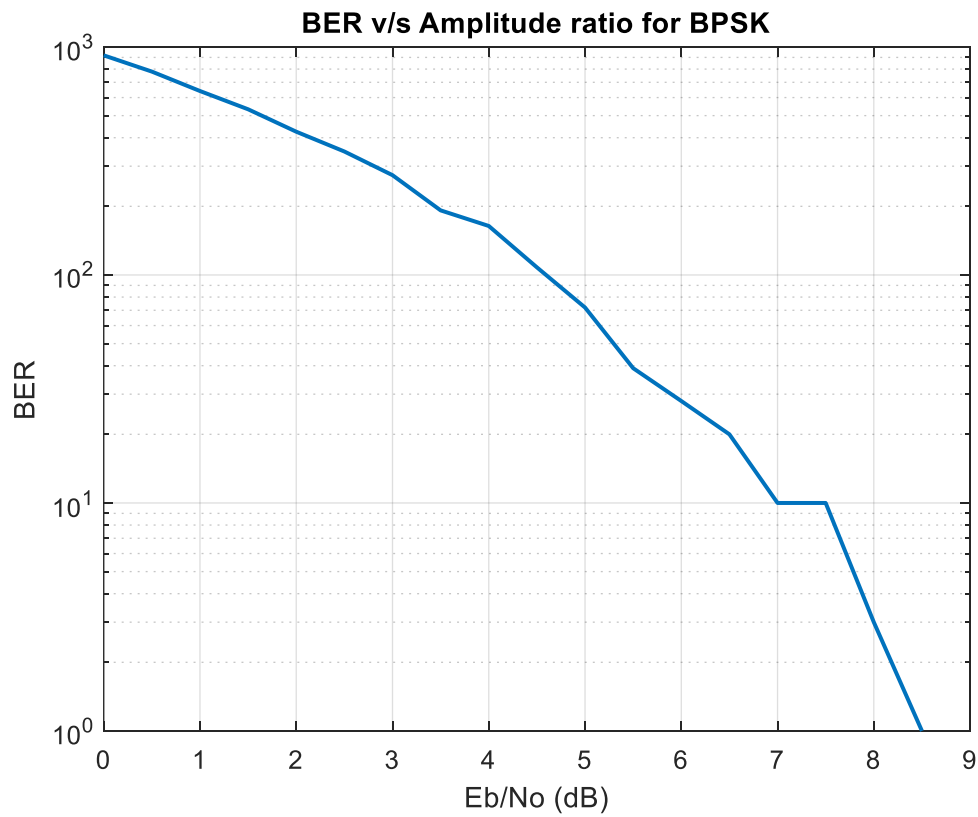


Figure 2: SER v/s Eb/No

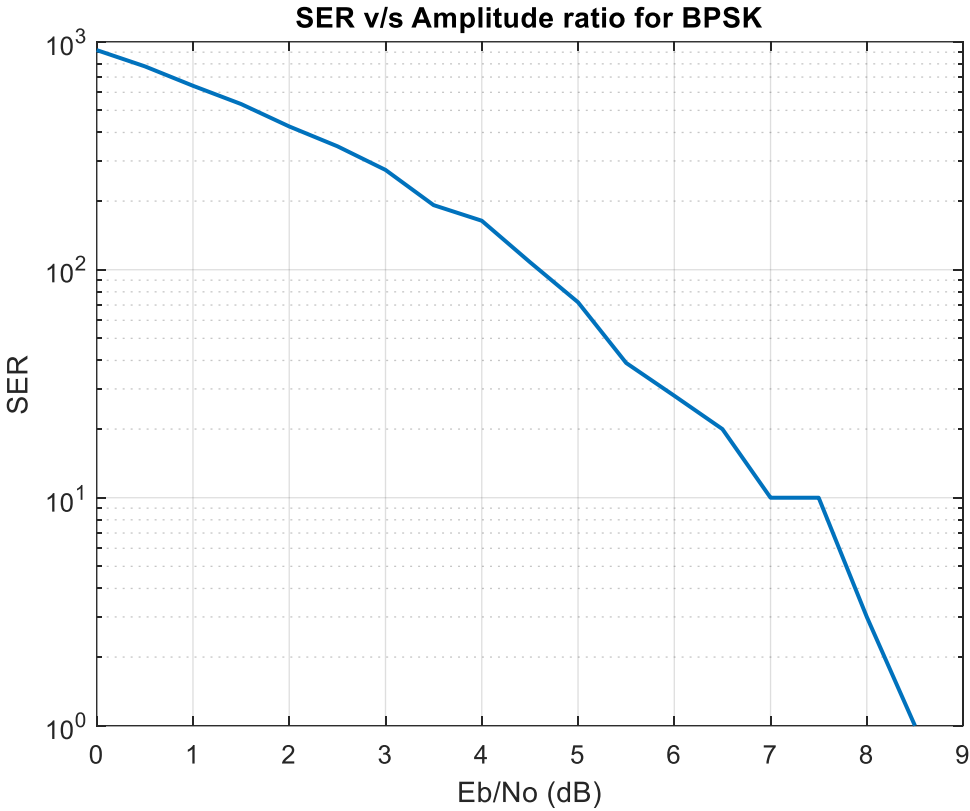


Figure 3: EVM v/s Eb/No

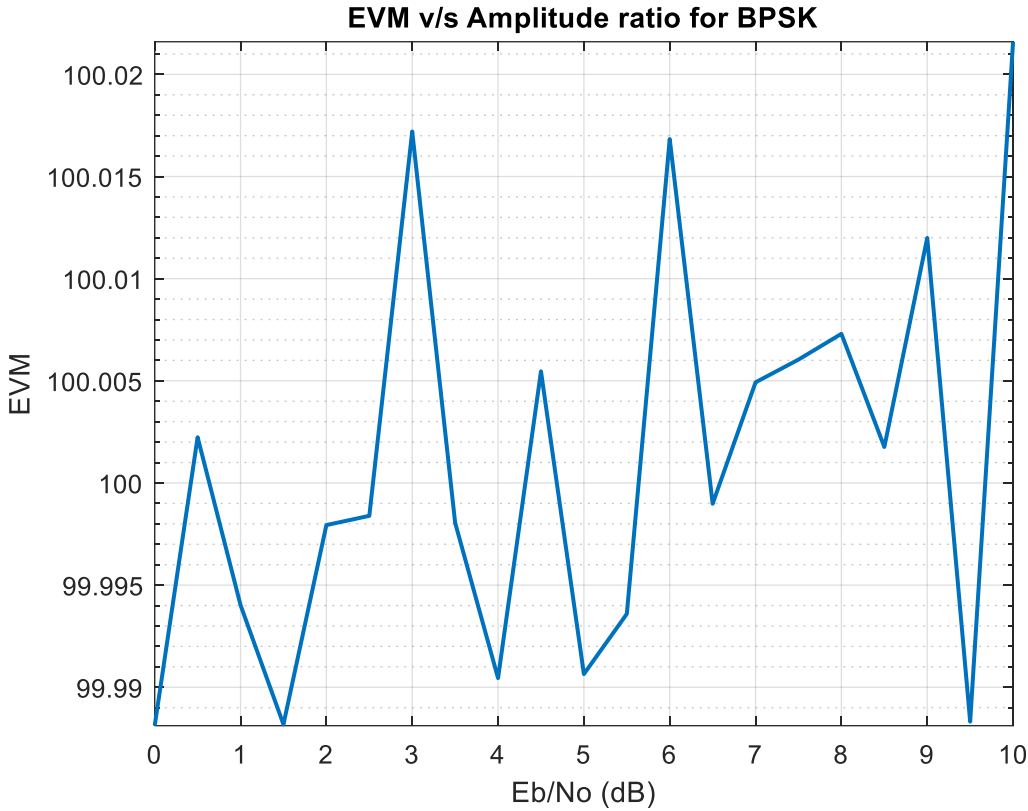
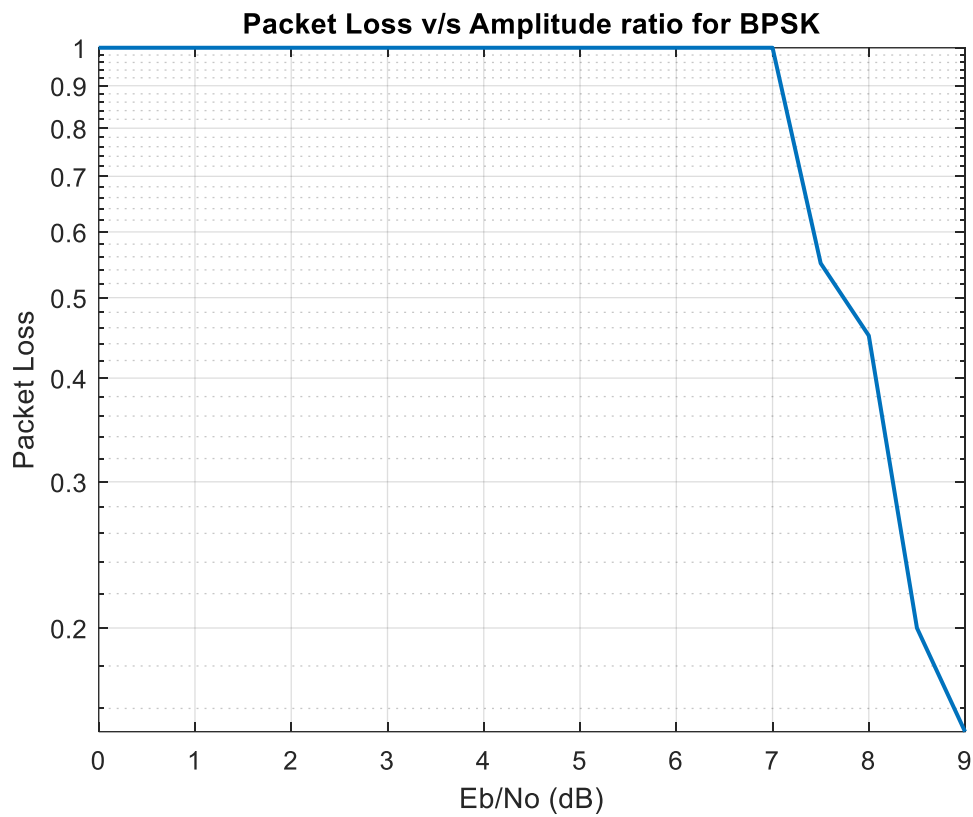


Figure 4: Packet Loss v/s Eb/No



Important notes:

1. The minimum threshold of SNR where BER goes zero is 10
2. The following plots and values of BER, SER, EVM, Packet loss are reported for SNR = 5
 - Bit Error rate = 0.005981
 - Symbol Error rate = 0.005981
 - EVM (%) = 100.033854
 - Packet Loss (%) = 100.000000

Figure 5: Received waveform

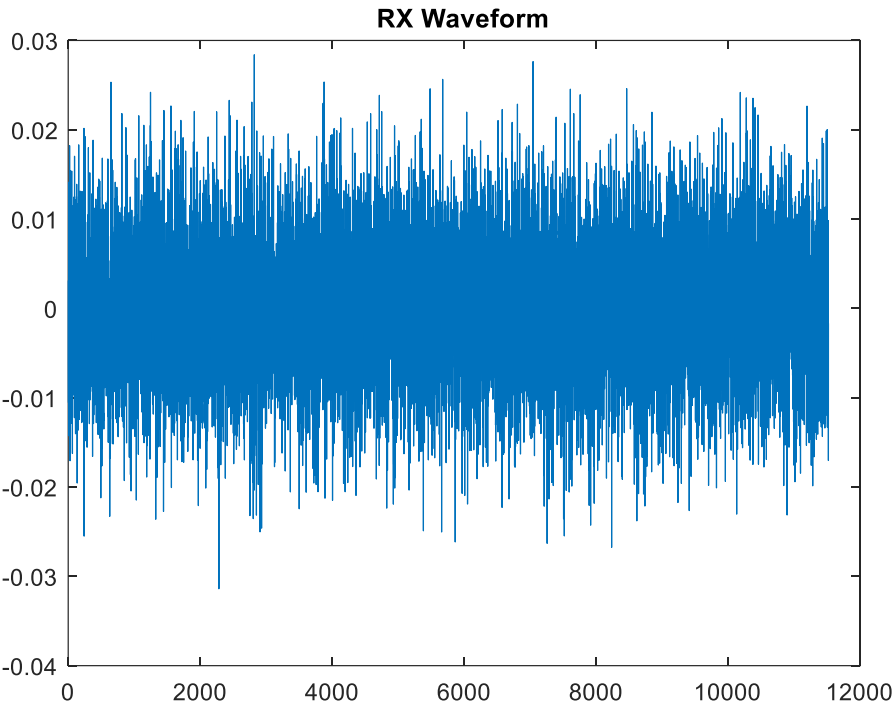


Figure 6: Transmitted waveform

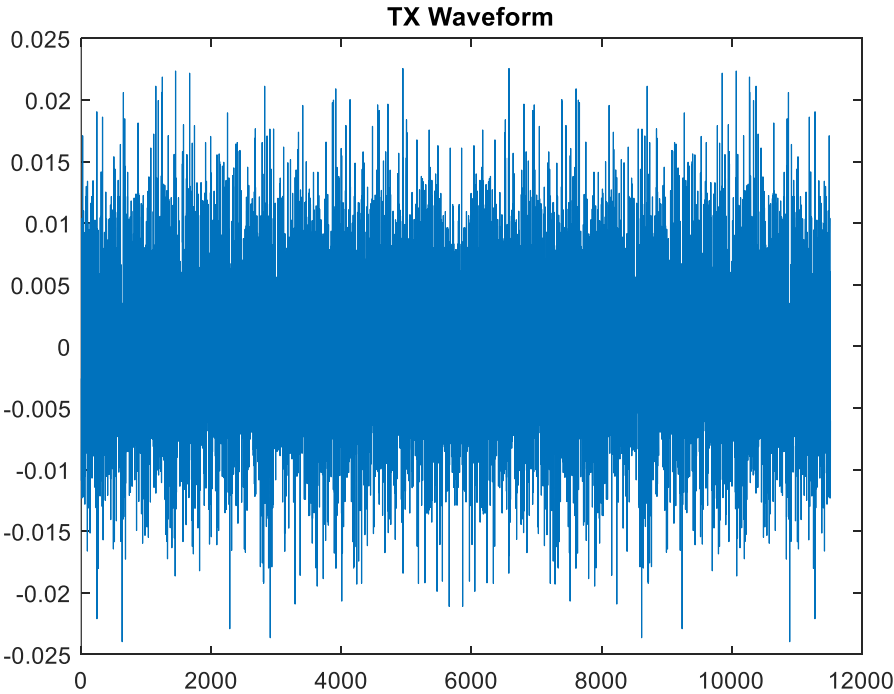
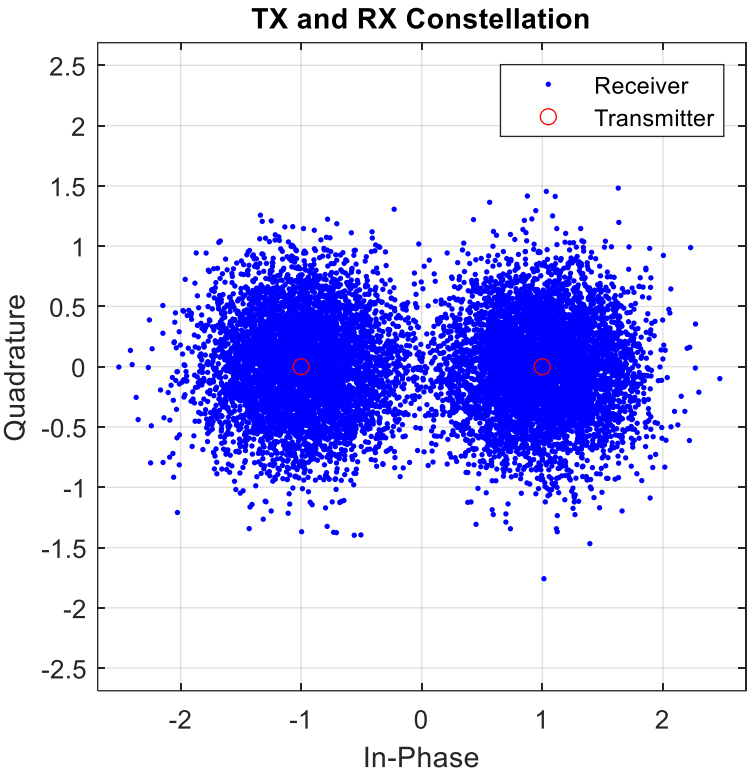


Figure 7: TX and RX Constellation



2. QPSK:

Important notes:

1. The minimum threshold of SNR where BER goes zero is 15
2. The following plots and values of BER, SER, EVM, Packet loss are reported for SNR = 12

Bit Error rate = 0.000052

Symbol Error rate = 0.000104

EVM (%) = 100.014138

Packet Loss (%) = 60.000000

Figure 1: Received waveform

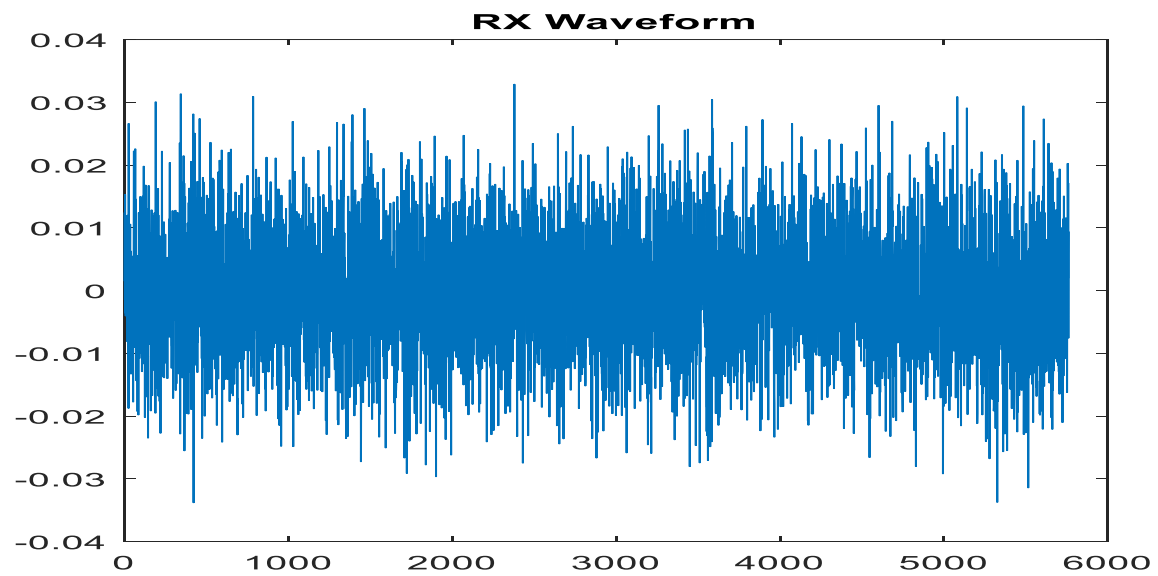


Figure 2: Transmitted waveform

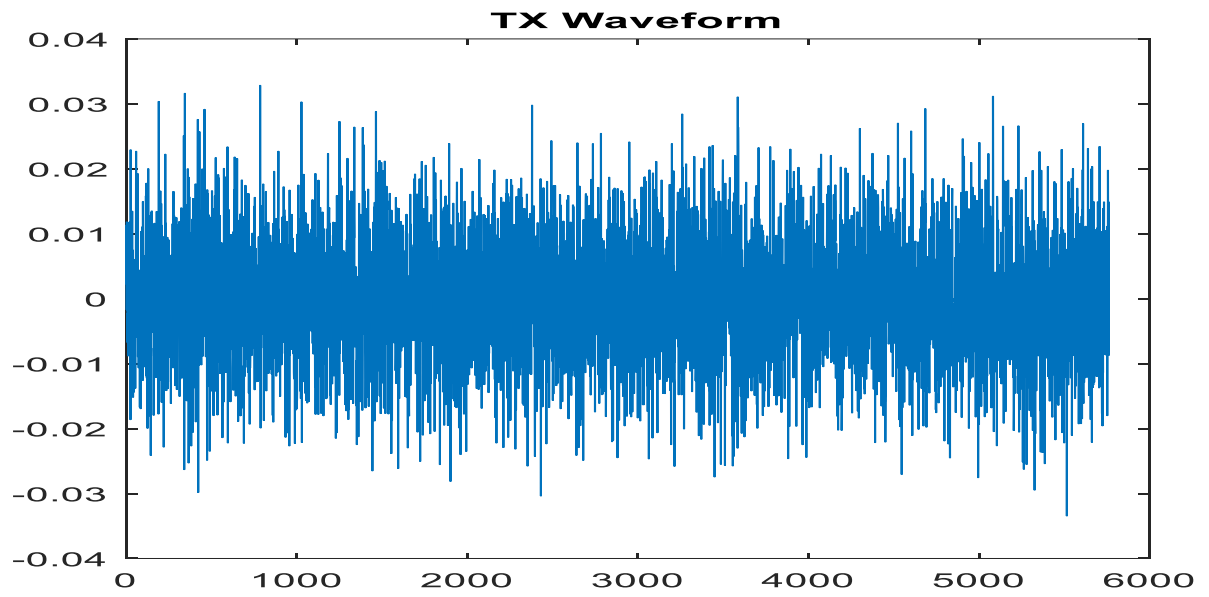


Figure 3: Tx and Rx Constellation

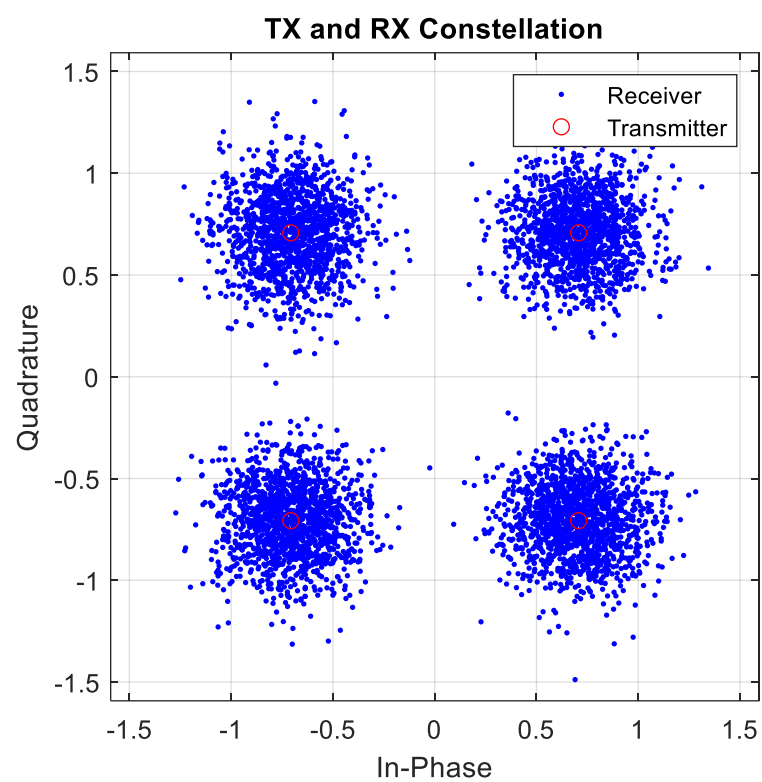


Figure 4: BER vs E_b/N_0

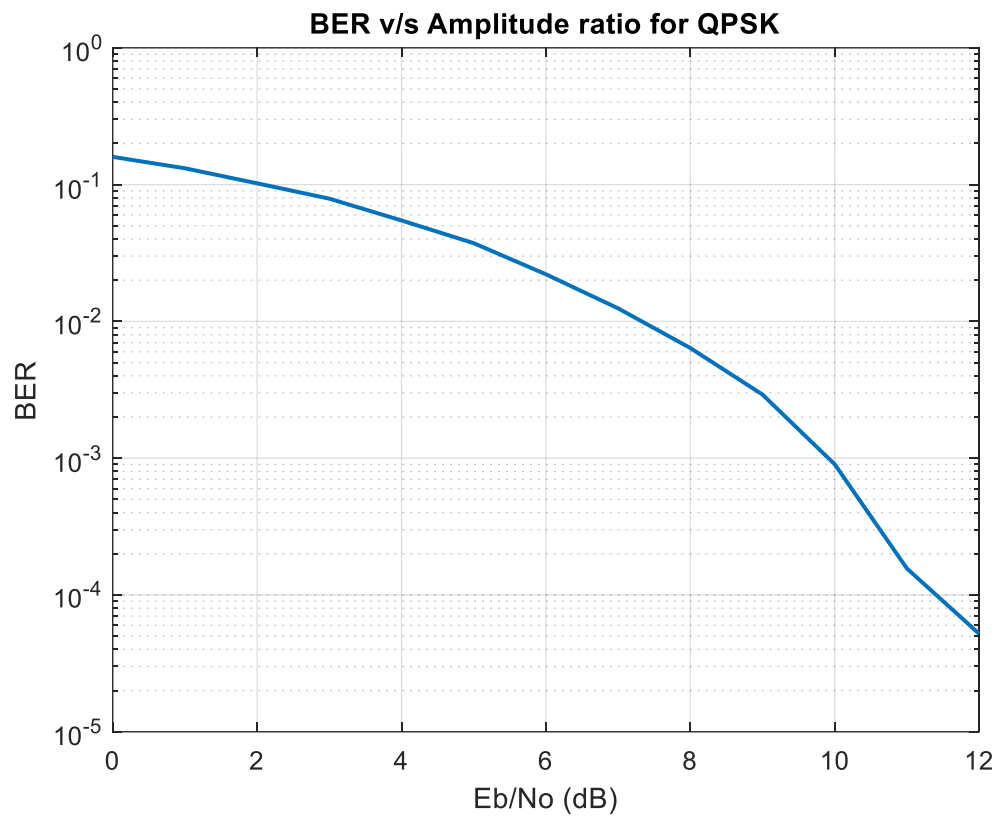


Figure 5: SER vs E_b/N_o

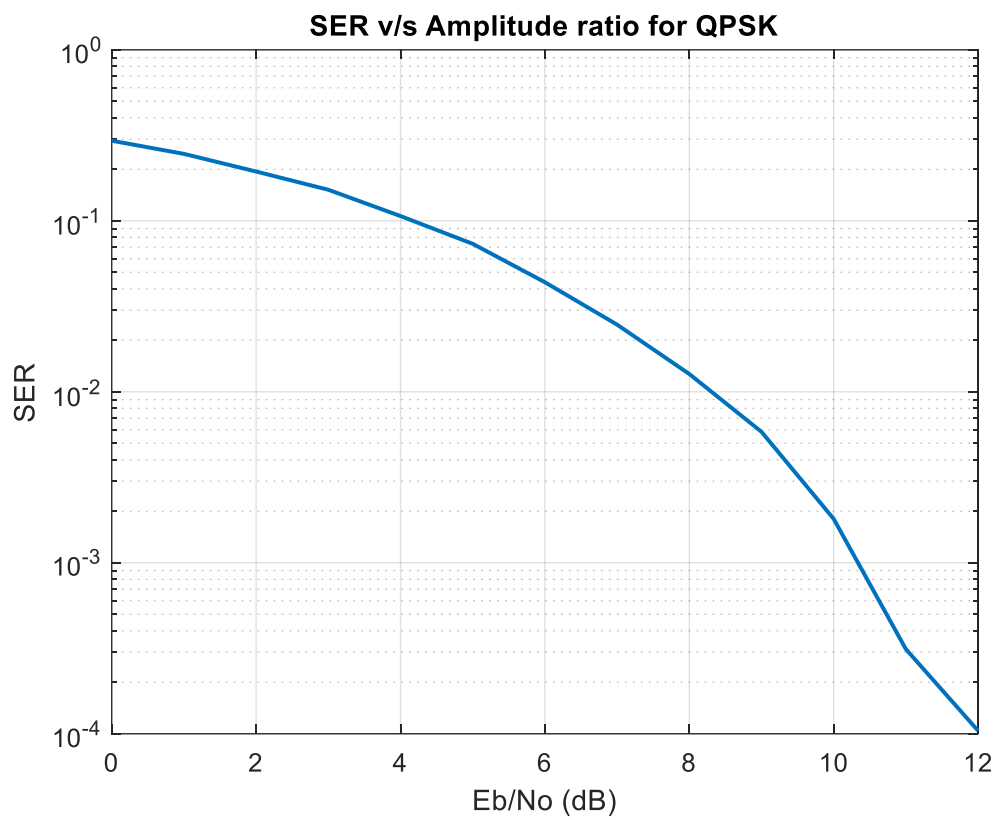


Figure 6: EVM vs E_b/N_0

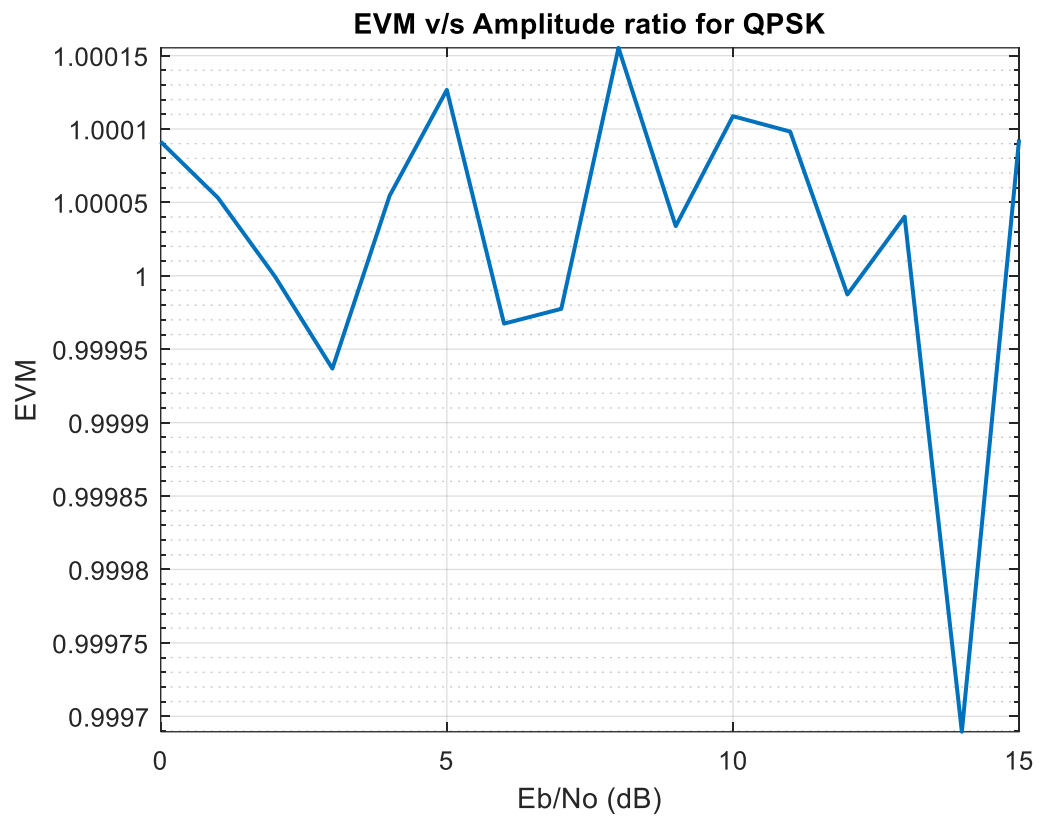
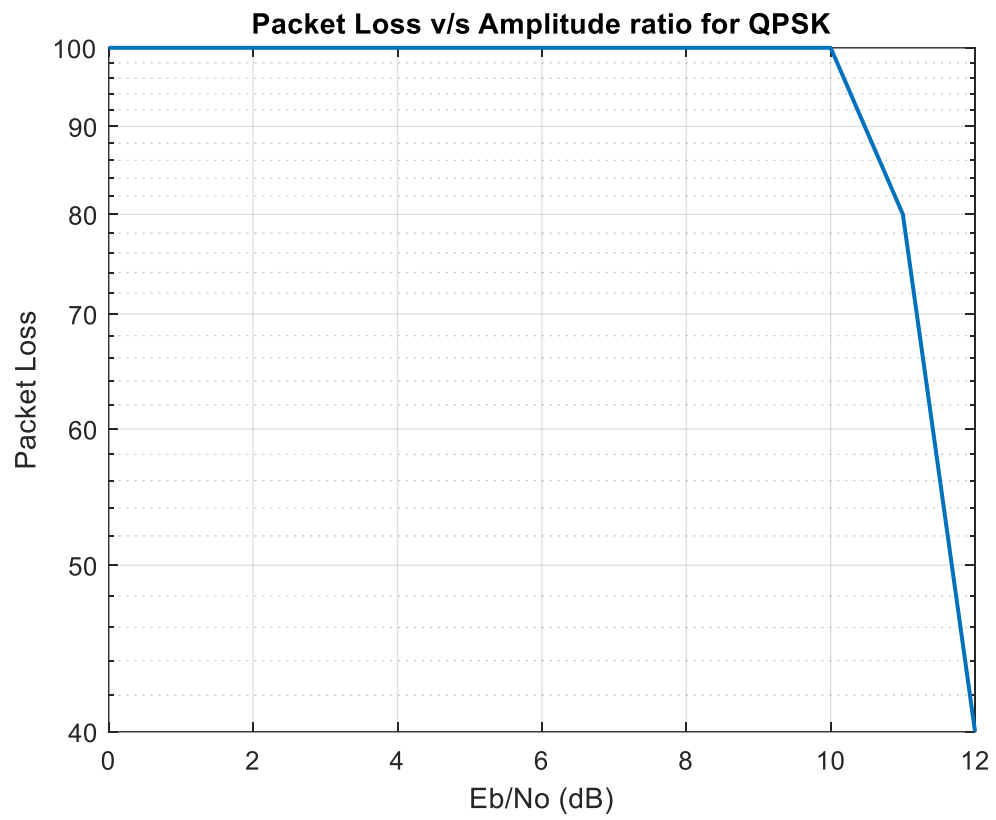


Figure 7: Packet Loss vs E_b/N_o



3. 16 QAM

Figure 1: BER v/s SNR for 16QAM

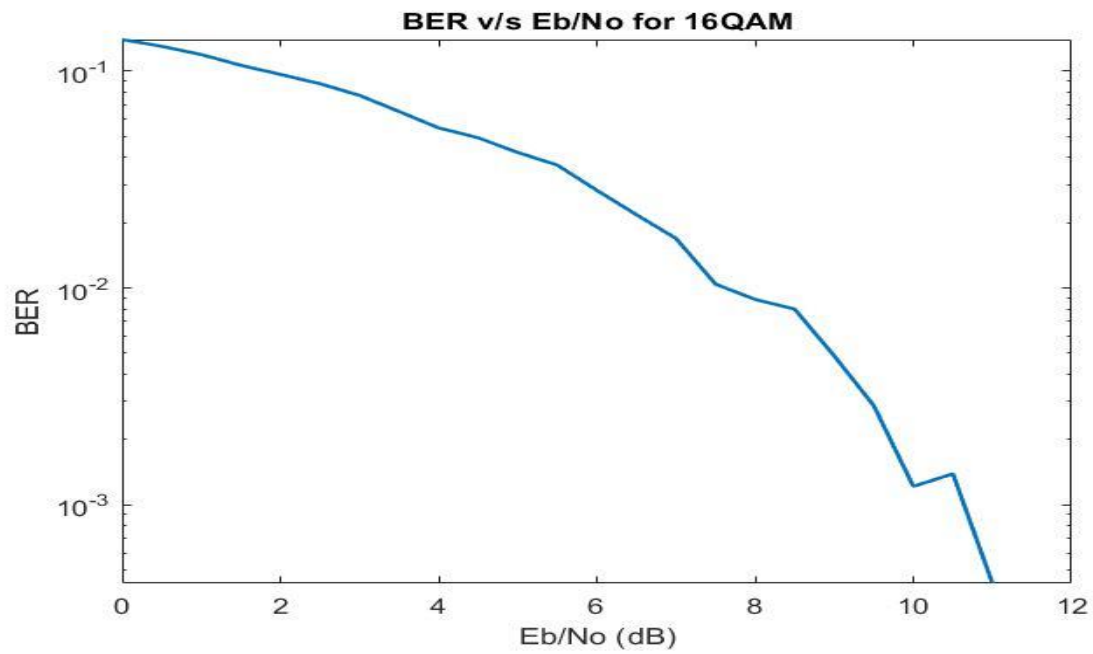


Figure 2: SER v/s SNR

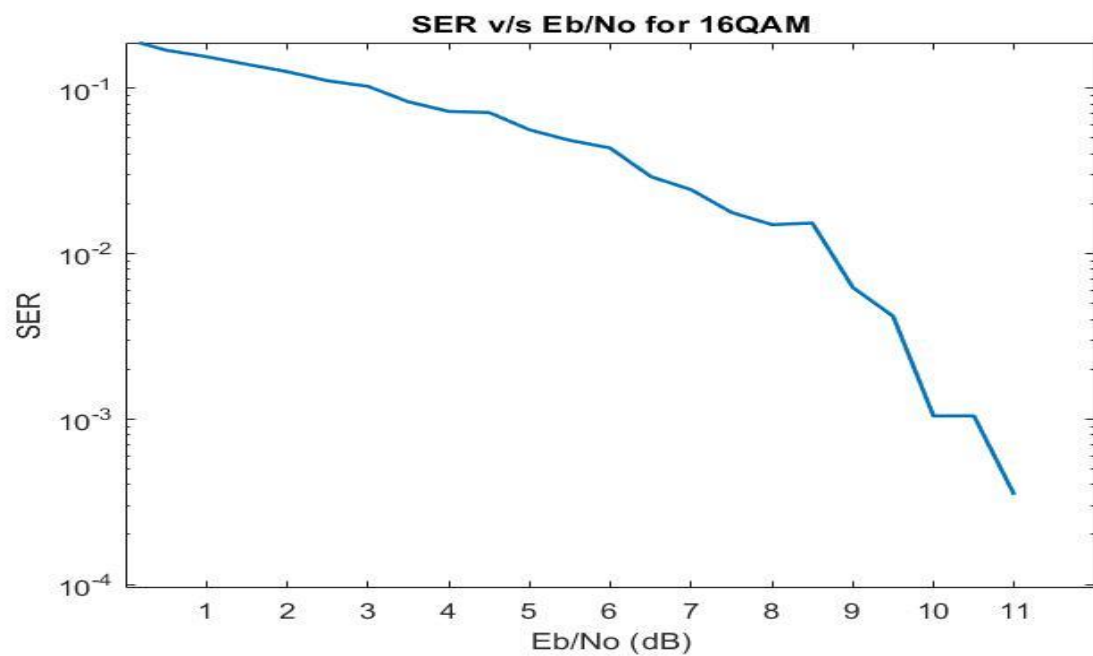


Figure 3: EVM v/s SNR

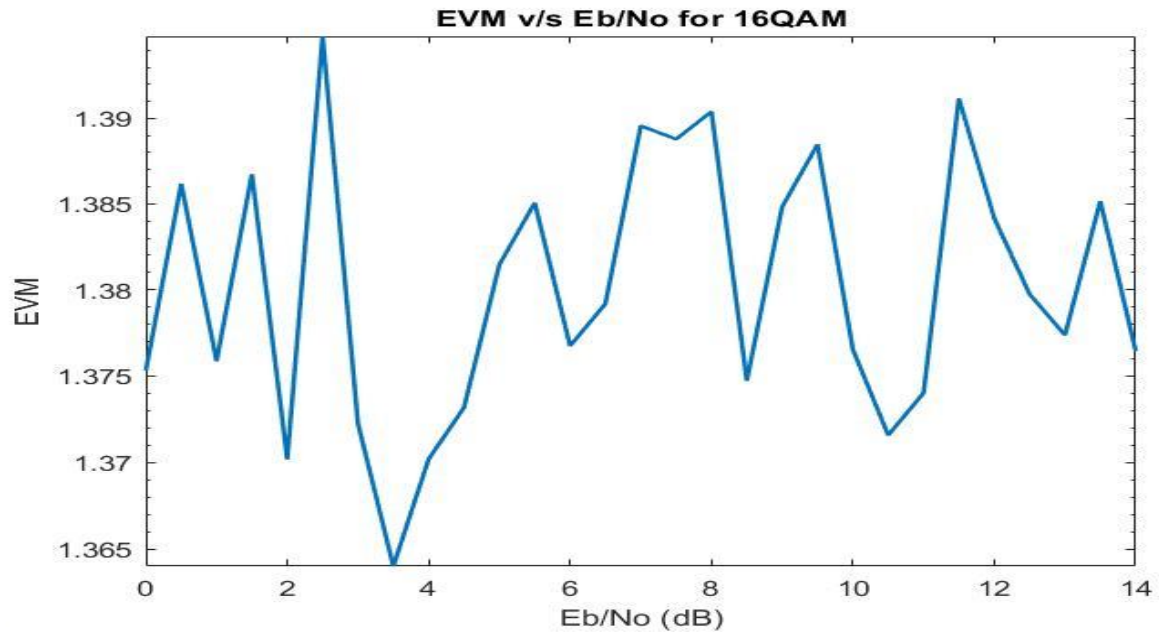


Figure 4: Packet loss v/s SNR

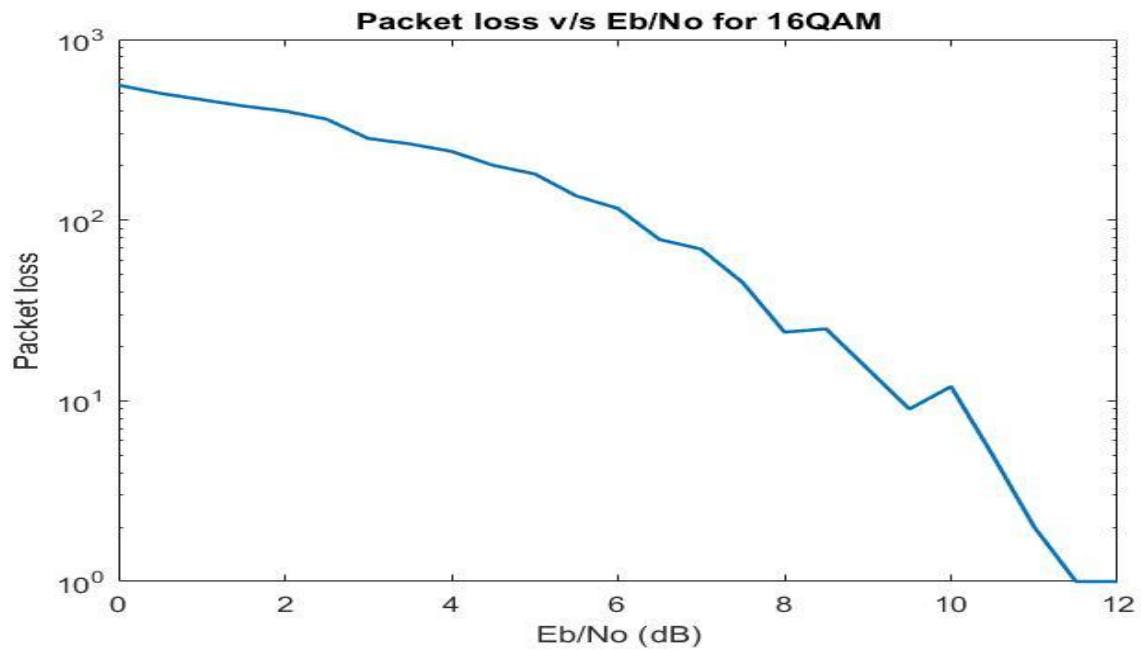


Figure 5: BER for both Gray and Sequential coding. As we can see, BER for Gray coding is lesser than sequential.

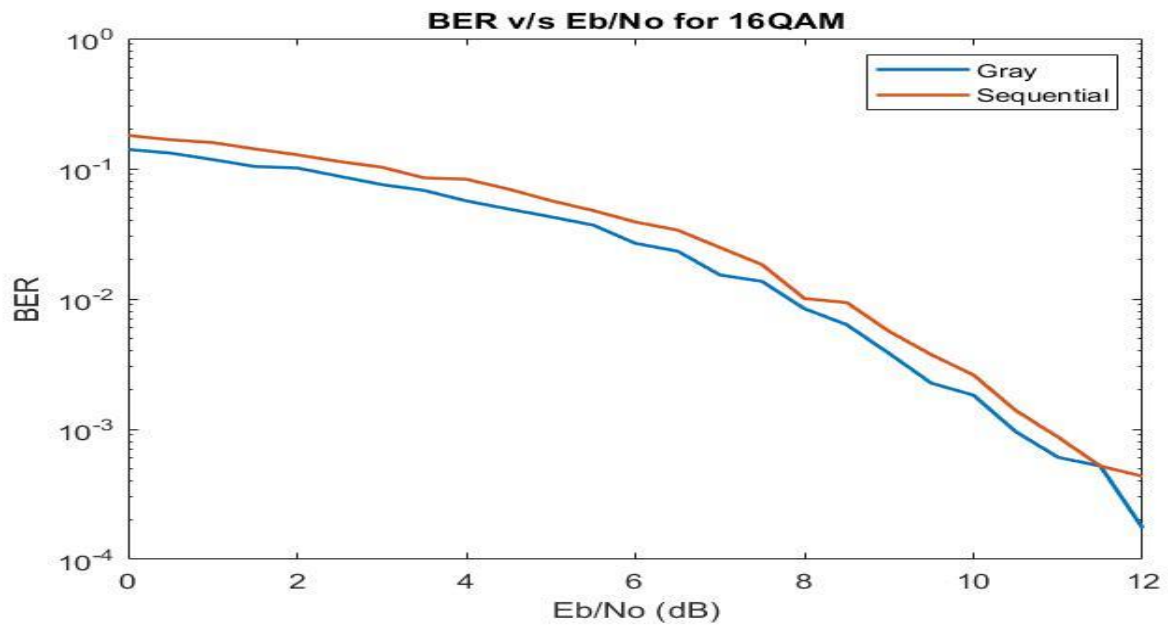


Figure 6: Constellation Diagram for SNR = 14dB, BER = 0.

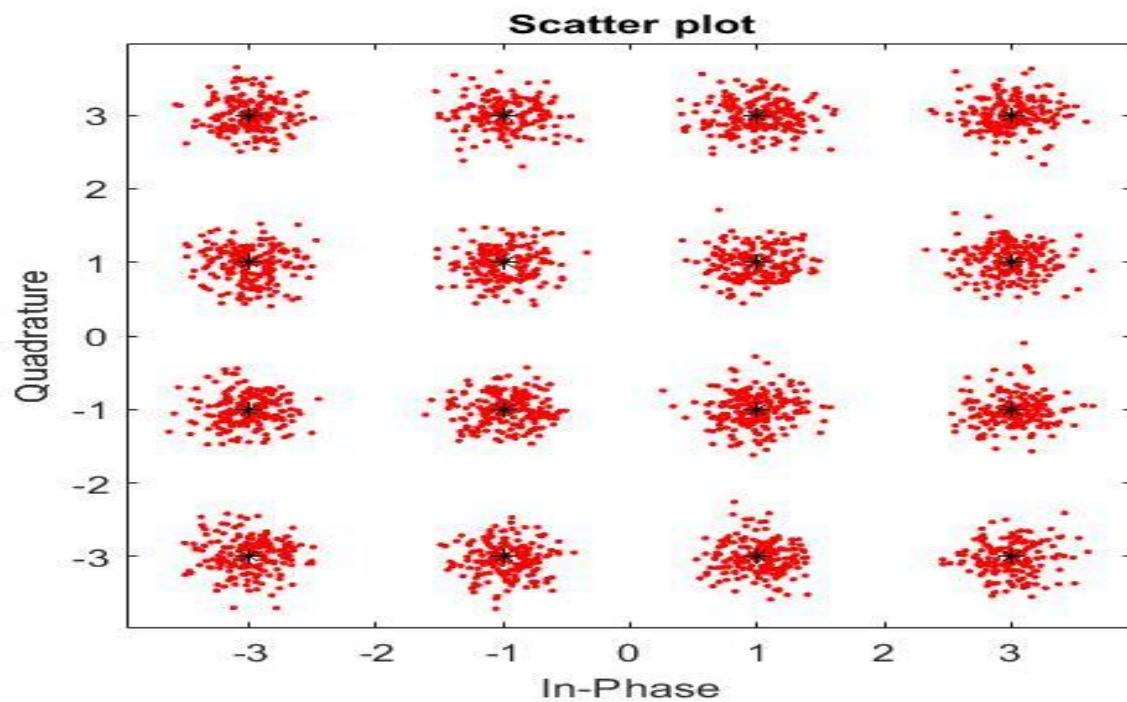


Figure 7: Transmission Waveform for SNR = 14dB

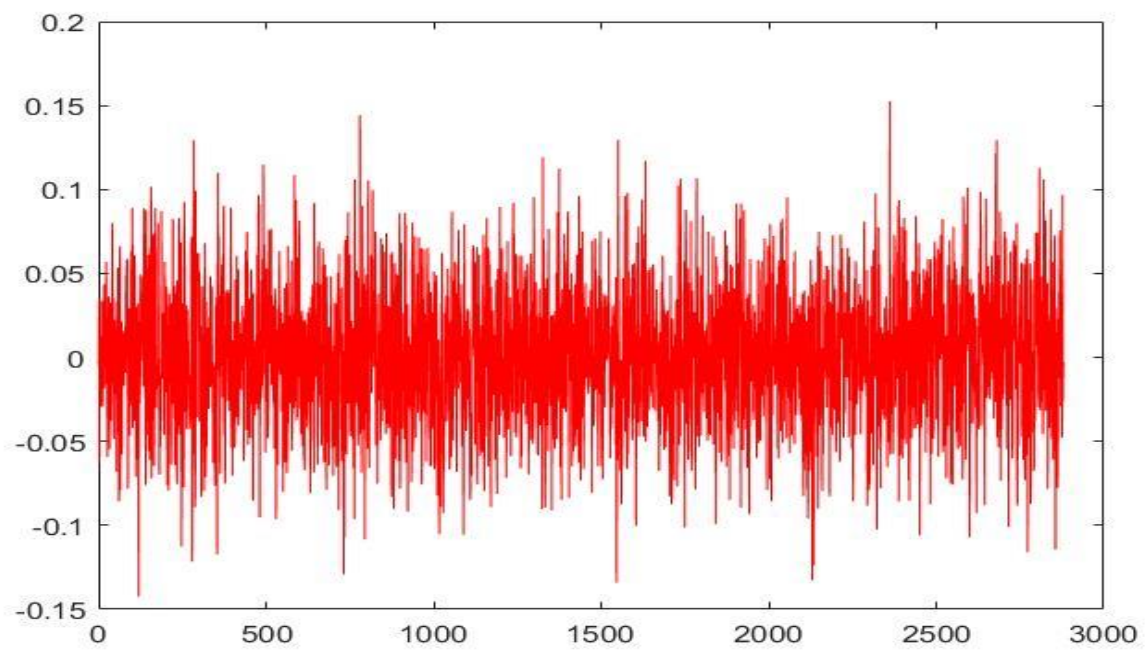


Figure 8: Receiver Waveform for SNR = 14dB

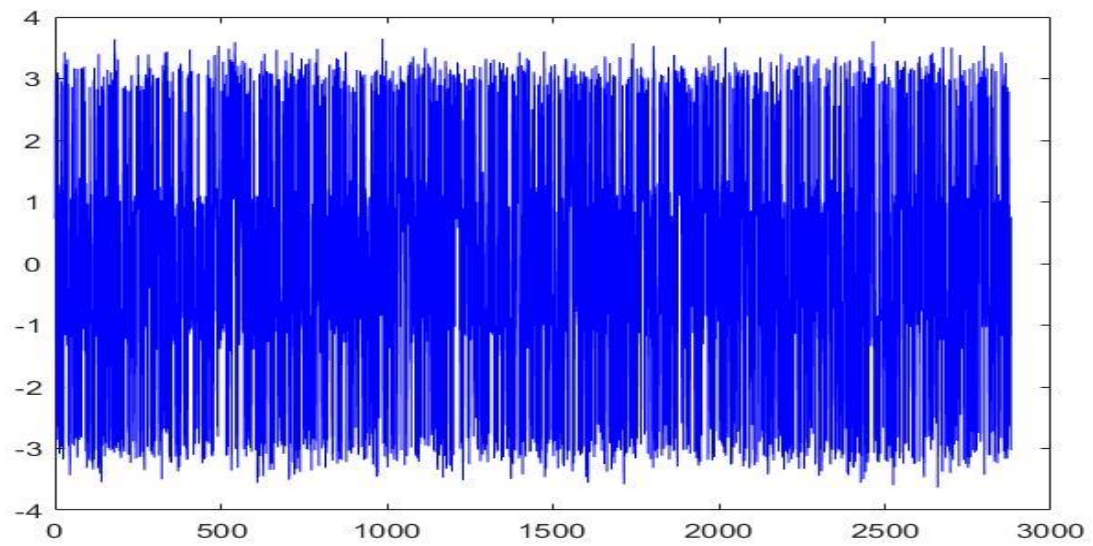


Figure 9: Constellation Diagram for SNR = 8dB

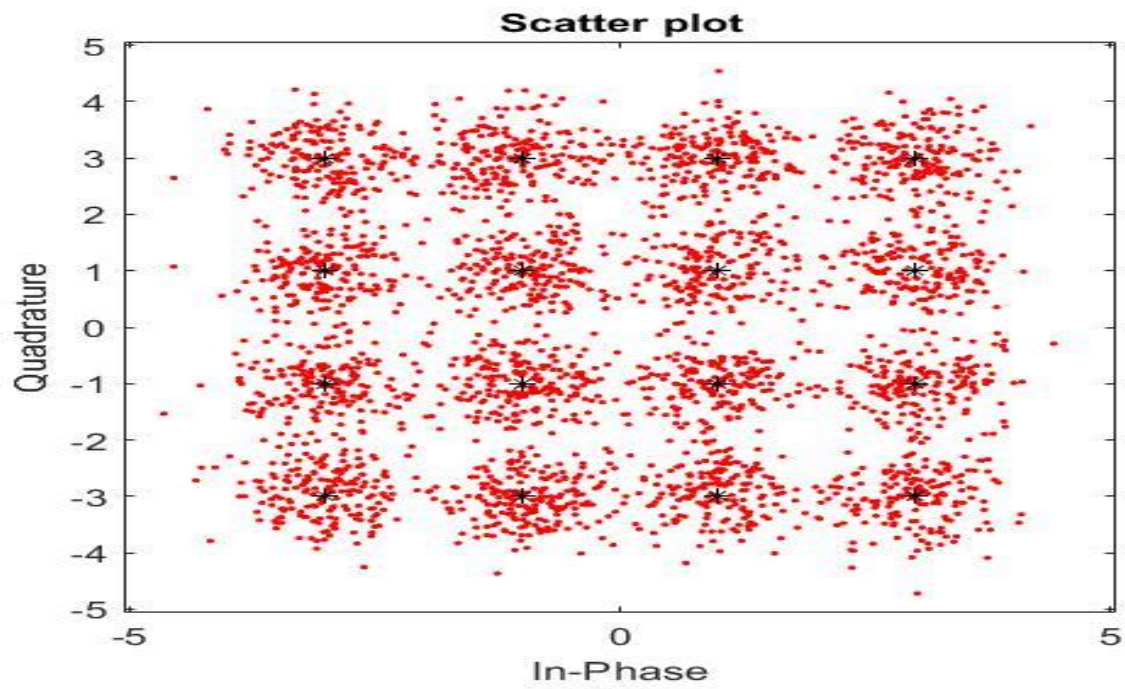


Figure 10: Transmission Waveform for SNR = 8dB

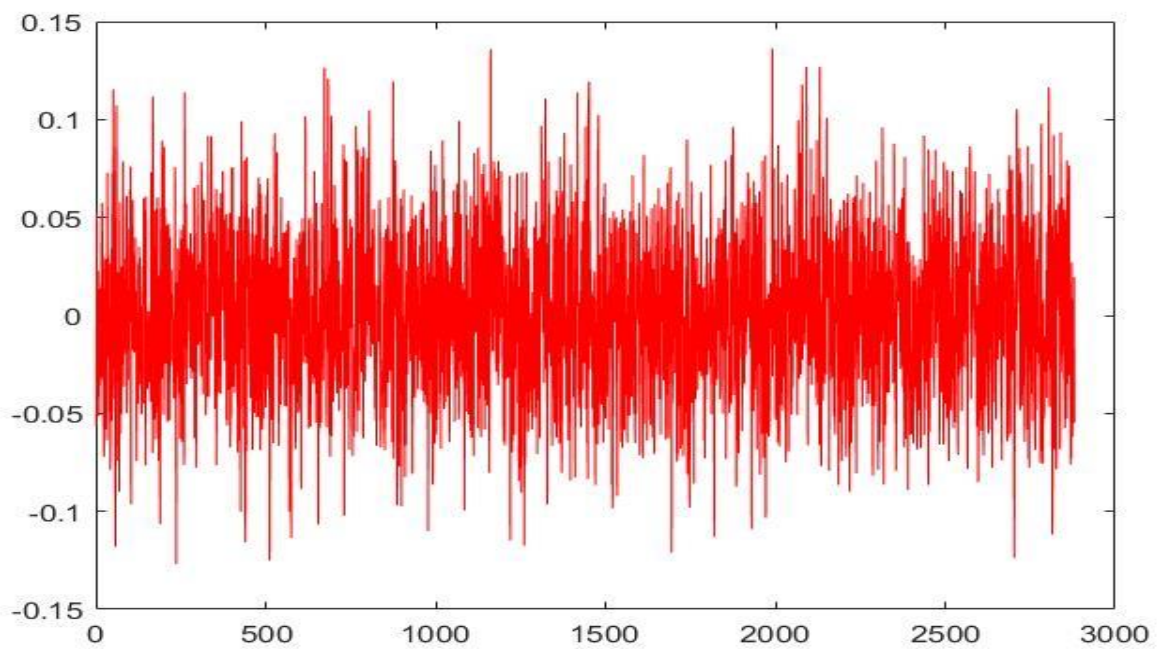
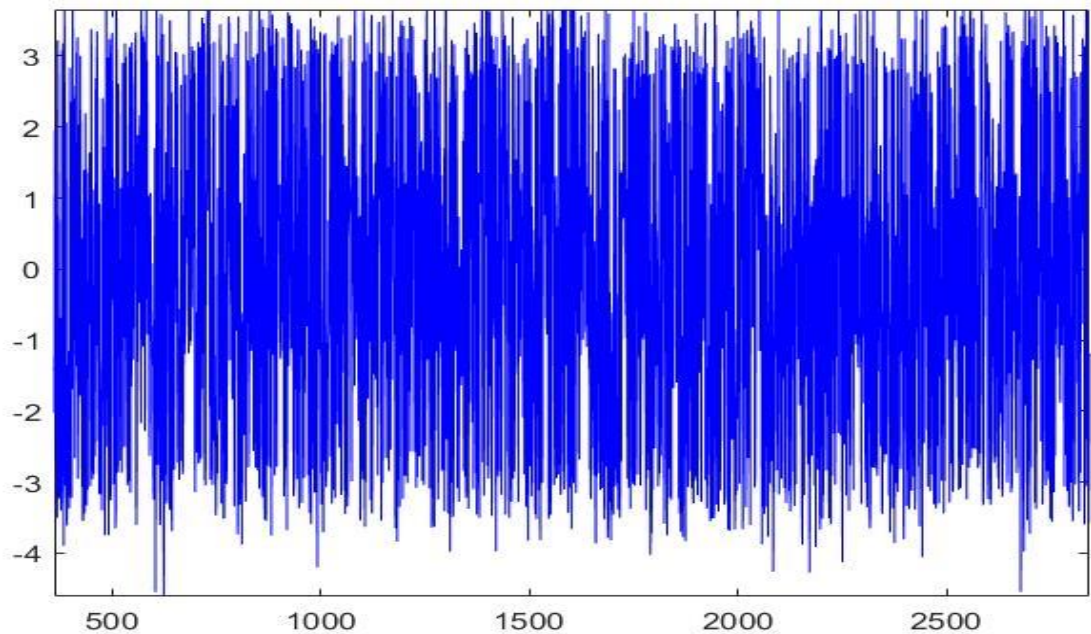


Figure 10: Receiver Waveform for SNR = 8dB



Few Points:

- SNR threshold for zero BER for 16QAM is 14dB.
- Modulation function used in `qammod()`.
- Noise function is `awgn()`.
- Zoom on function added to code files
- For SNR = 14dB, BER = 0, SER = 0, EVM = 1.3881, Packet loss = 0.
- For SNR = 8dB, BER = 0.0109, SER = 0.0160, EVM = 1.3725, Packet loss = 46.

To run the file:

- `[BER, SER, EVM, Packet_loss] = run(modulation_scheme, SNR, number_of_packets, packet_size)`

4. 64QAM

Figure 11: BER v/s SNR for 64QAM

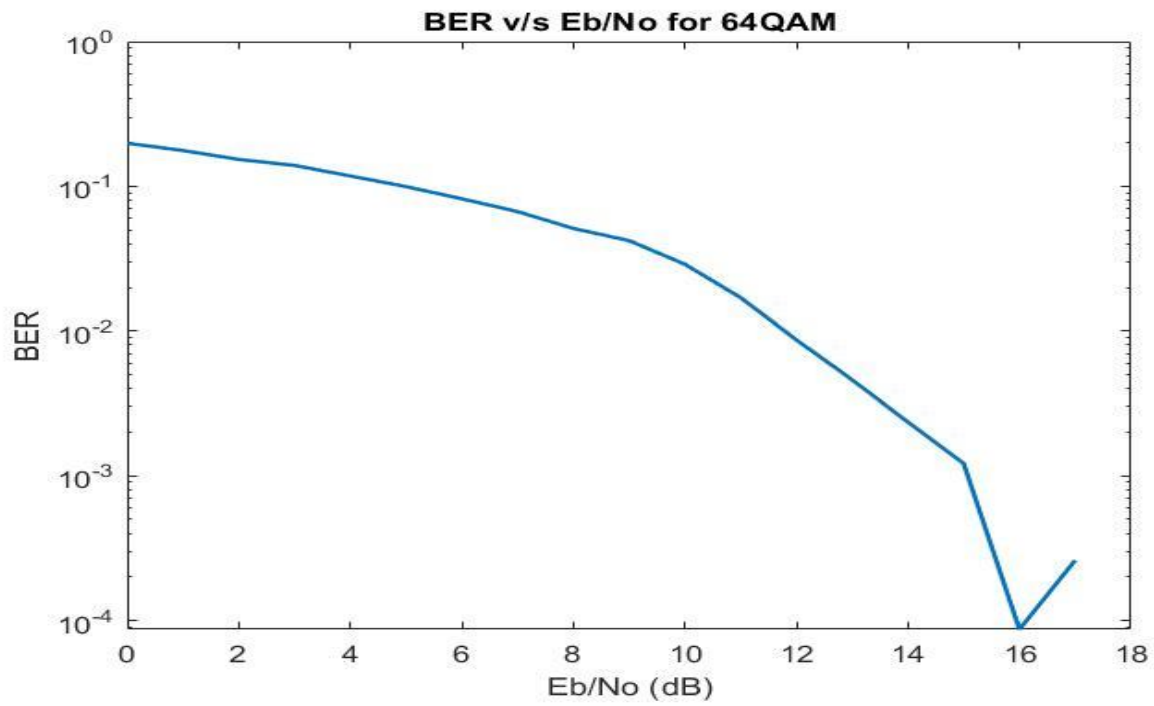


Figure 12: SER v/s SNR for 64QAM

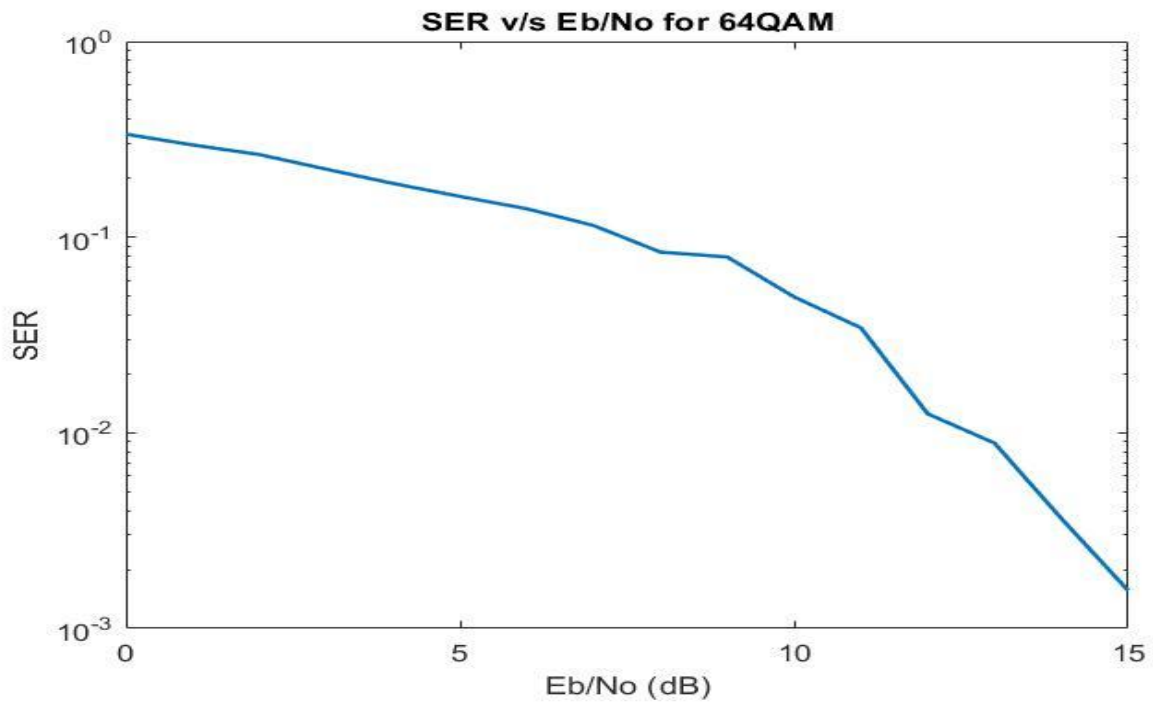


Figure 13: Packet Loss v/s SNR for 64QAM

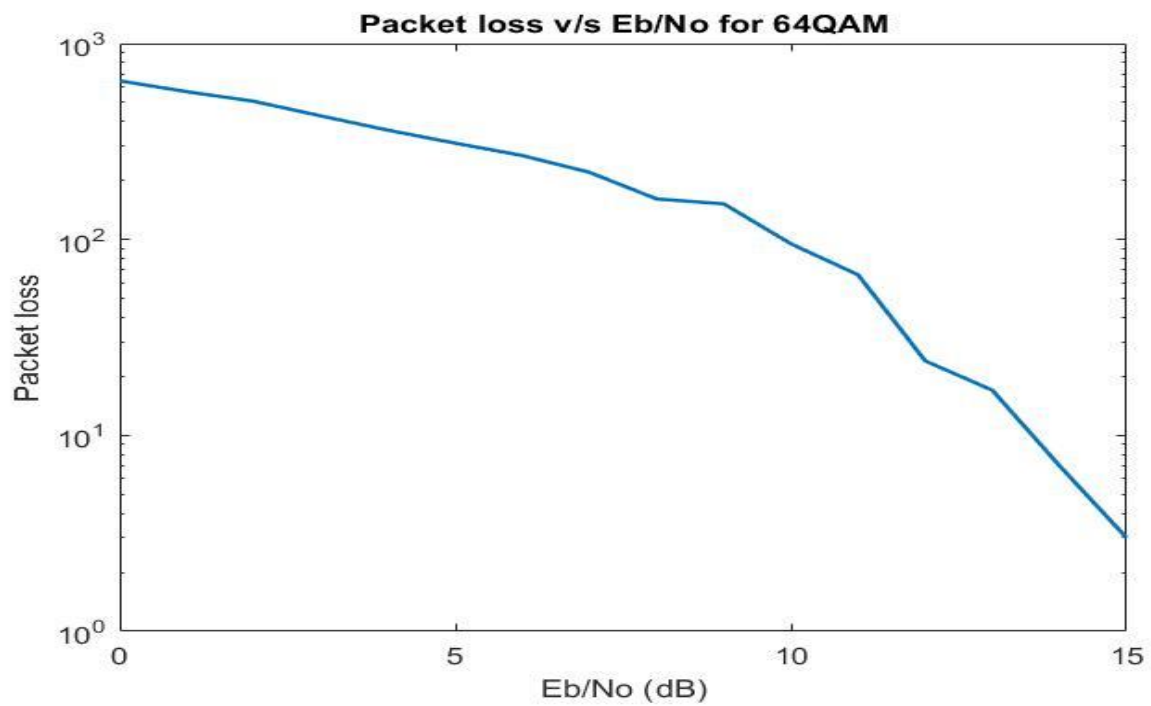


Figure 14: EVM v/s SNR for 64QAM

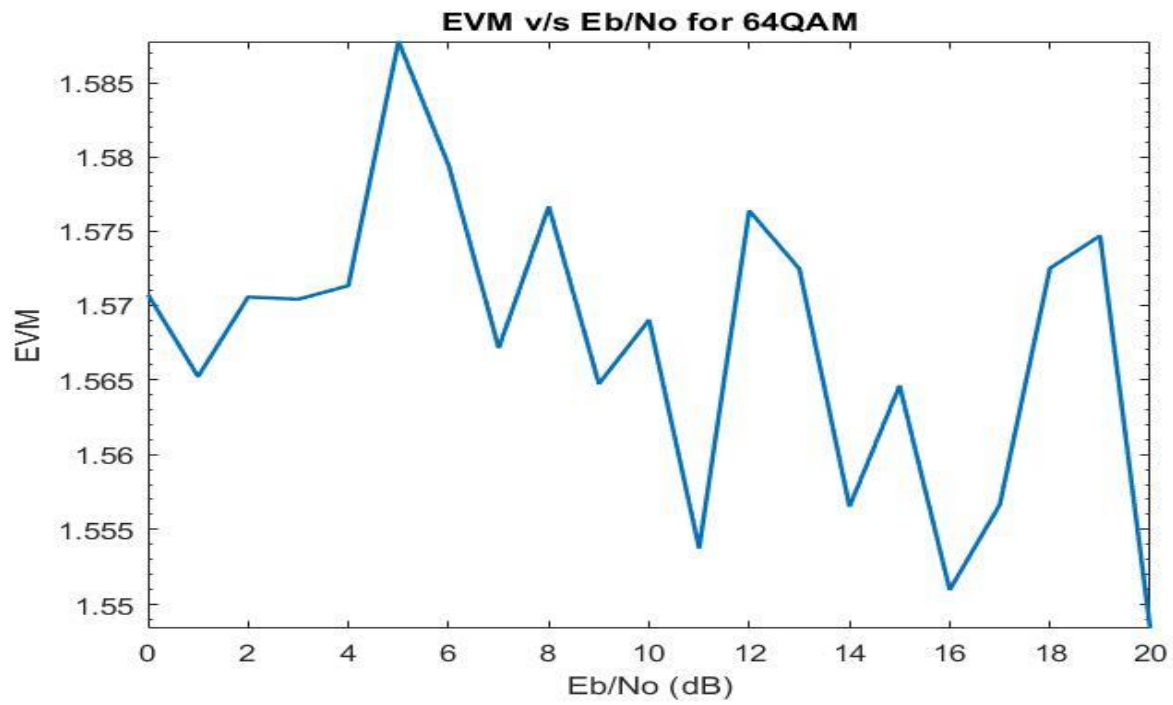


Figure 15: Constellation Diagram for SNR = 18dB, BER = 0.

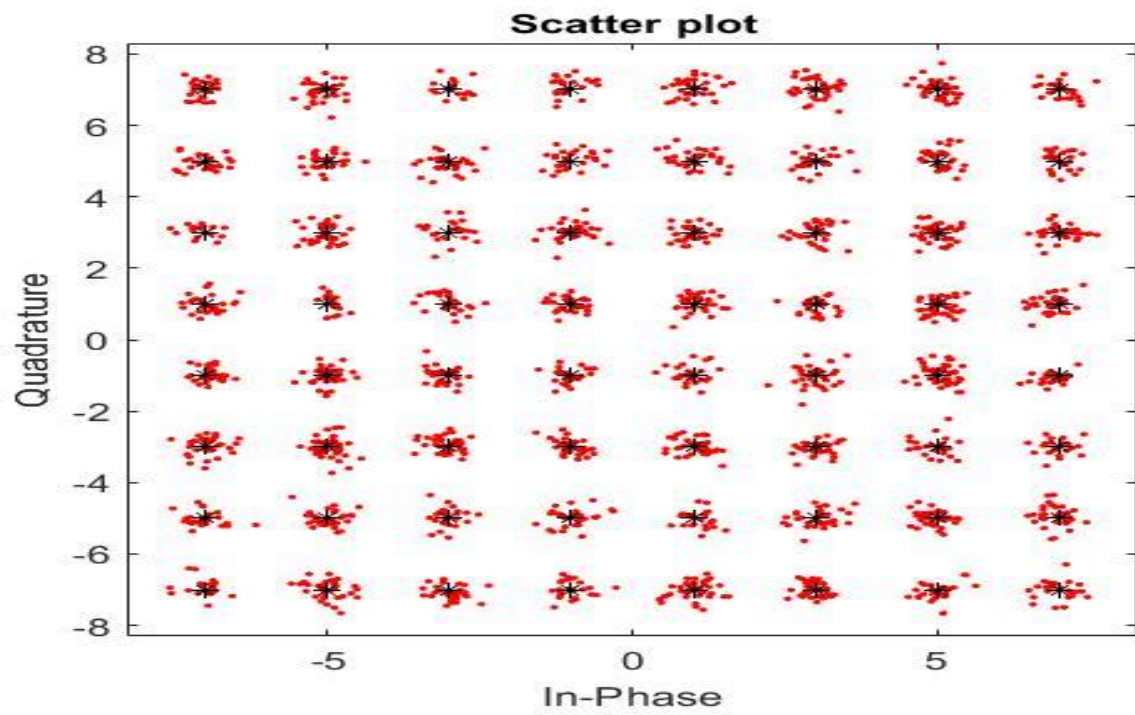


Figure 16: Transmission Waveform for SNR = 18dB

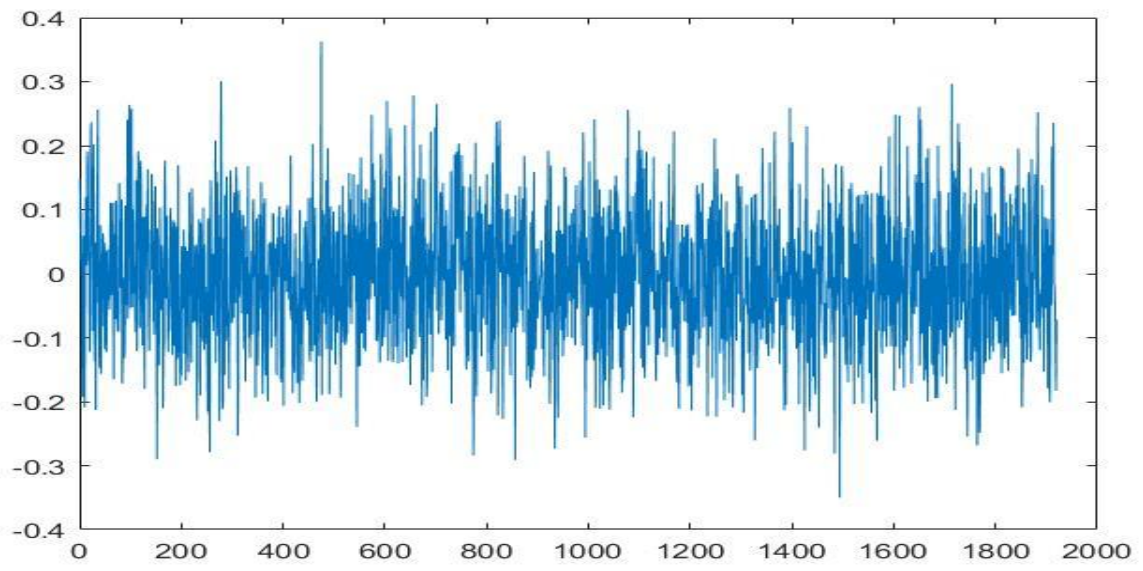


Figure 17: Receiver Waveform for SNR = 18dB

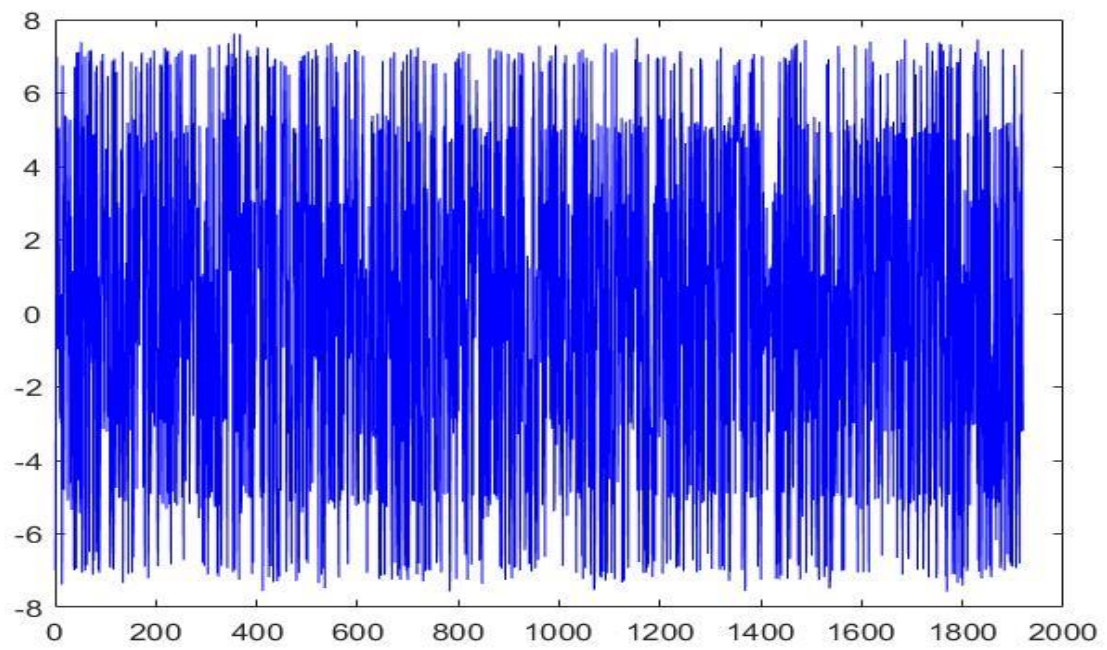


Figure 18: Constellation Diagram for SNR = 12dB

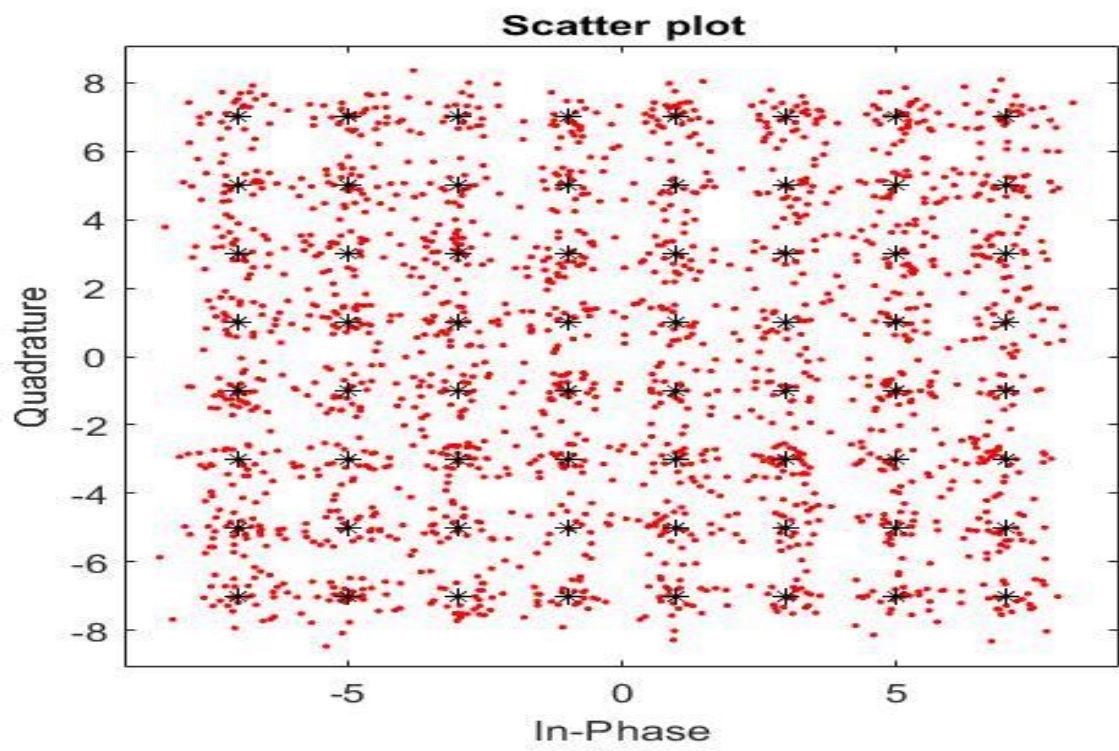


Figure 19: Transmission Waveform for SNR = 12dB

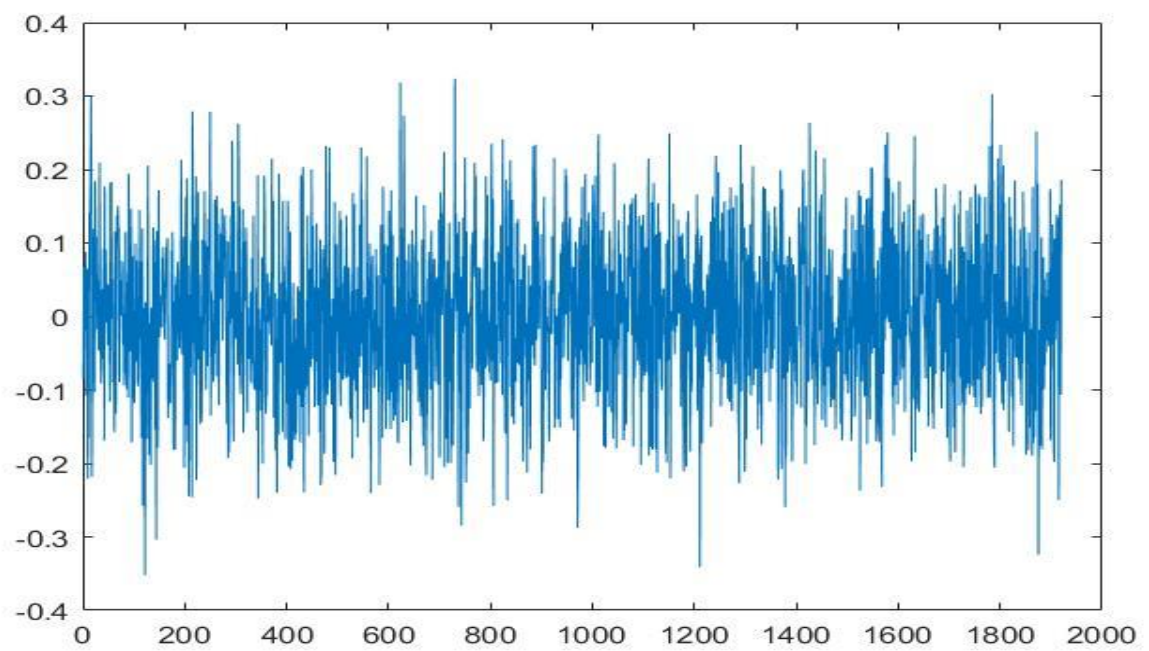
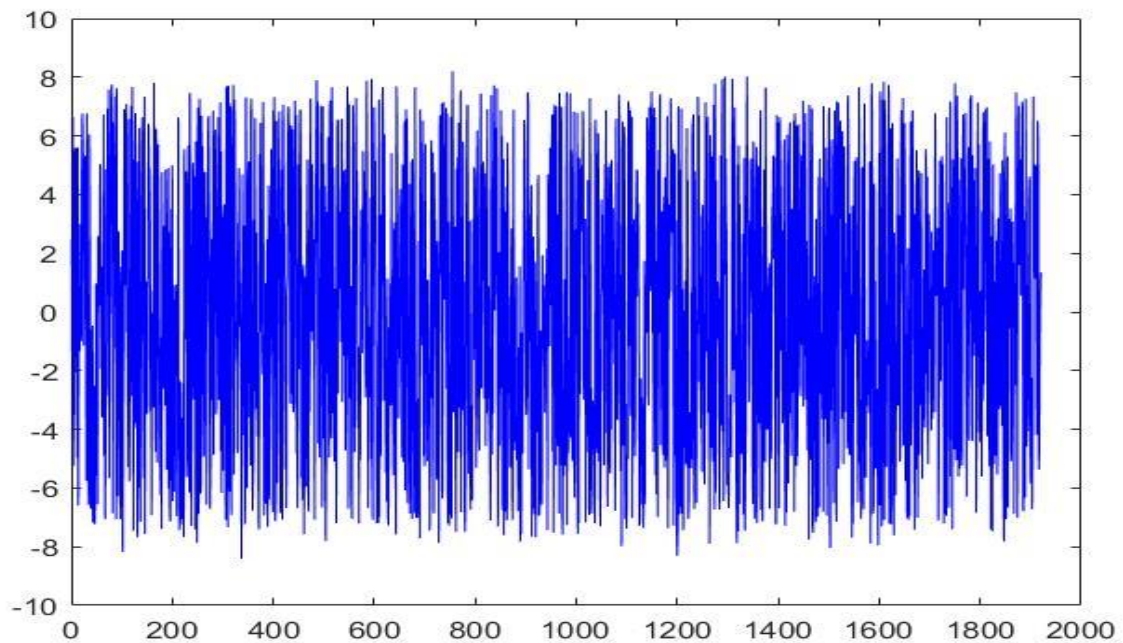


Figure 20: Receiver Waveform for SNR = 12dB



Few Points:

- SNR threshold for zero BER for 64QAM is 18dB.
- Modulation function used in `qammod()`.
- Noise function is `awgn()`.
- Zoom on function added to code files
- For SNR = 18dB, BER = 0, SER = 0, EVM = 1.5700, Packet loss = 0.
- For SNR = 12dB, BER = 0.0088, SER = 0.0161, EVM = 1.5591, Packet loss = 31.

To run the file:

- `[BER, SER, EVM, Packet_loss] = run(modulation_scheme, SNR, number_of_packets, packet_size)`

