Experiment - 9

Page No.:
Date:
YOUVA

Aim: 16 QAM Modulation and Demodulation technique with constellation diagram and waveforms.

Apparatus:

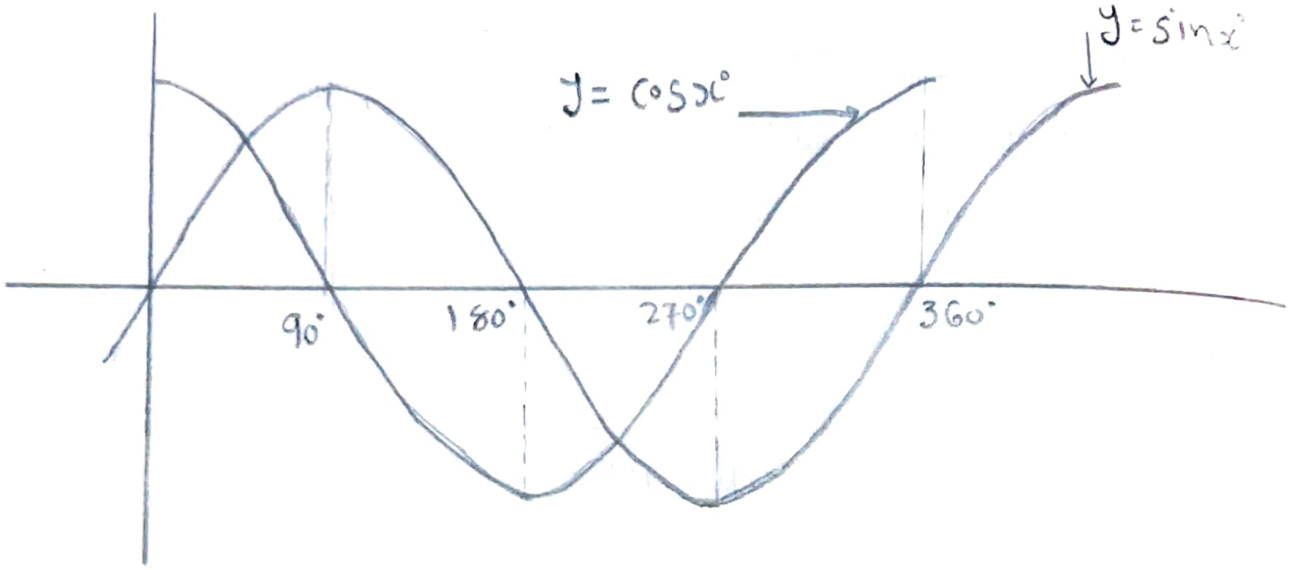
Software Required: MATLAB

Theory:

- Quadrature amplitude modulation or QAM is a form of modulation which is widely used for Modulating data signals onto a carrier used for radio communications.

- QAM is a signal in ~~with~~ which two carriers shifted in phase by 90° are modulated and the resultant output consist of both amplitude and phase variations.

- Hence it may also be considered as a mixture of amplitude and phase modulation. QAM is both an analog and digital Modulation technique.



Quadrature = sine wave + Cosine Wave

- The main aim of QAM is to save bandwidth. Two modulated signal occupies the same transmission channel.

- A motivation for the use of QAM comes from the fact that a straight amplitude modulated signal occupies twice the bandwidth of the modulating signal.

- This is very wasteful of the available frequency spectrum.

- QAM places two independent double sideband suppressed carrier signals in the same spectrum.

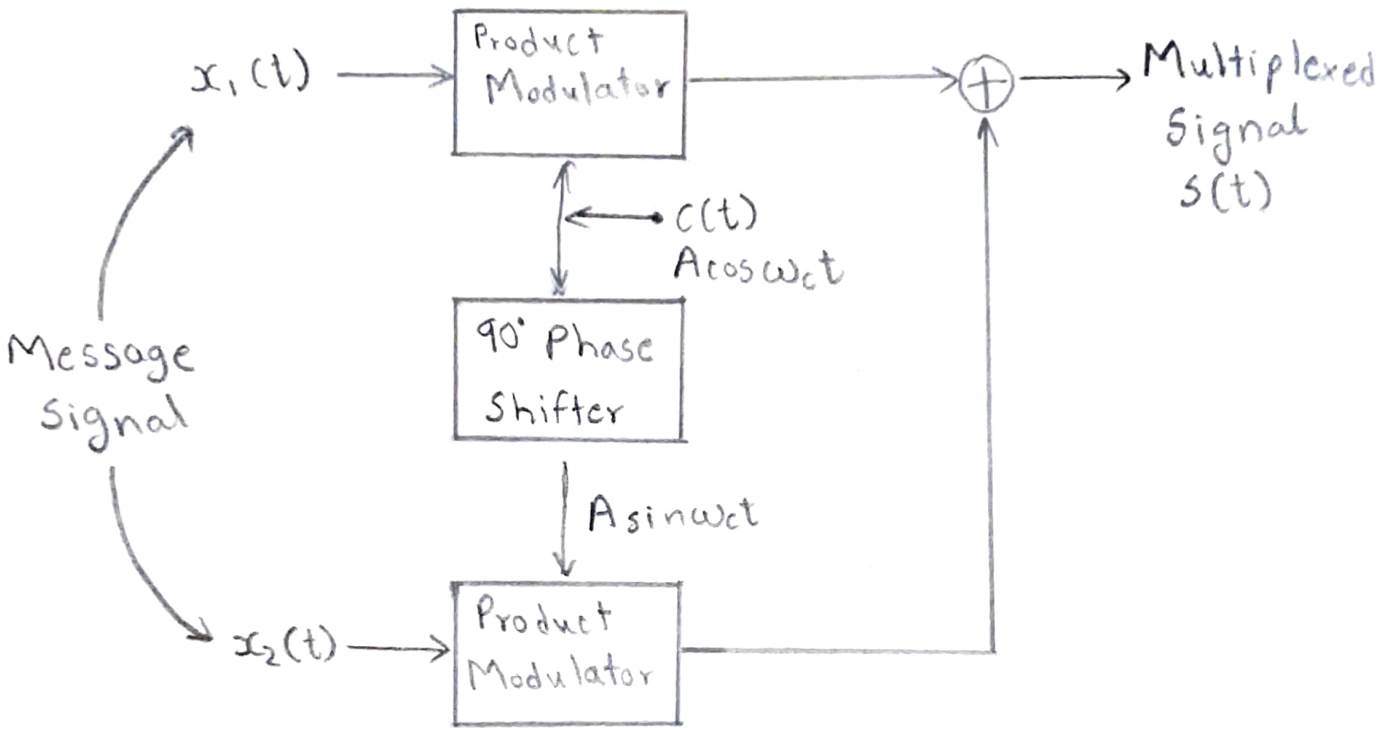
Types of QAM

- A variety of forms of QAM are available which include.
  16 QAM
  32 QAM
  64 QAM
  128 QAM
  256 QAM

- Quadrature amplitude theory states that both amplitude and phase change within a QAM signal.
- The basic way in which a QAM signal can be generated is to generate two signals that are 90° out of phase with each other and then sum them.
- The I and Q signals can be represented by the equations below:

$$I = A\cos(\Psi)$$
$$Q = A\sin(\Psi)$$

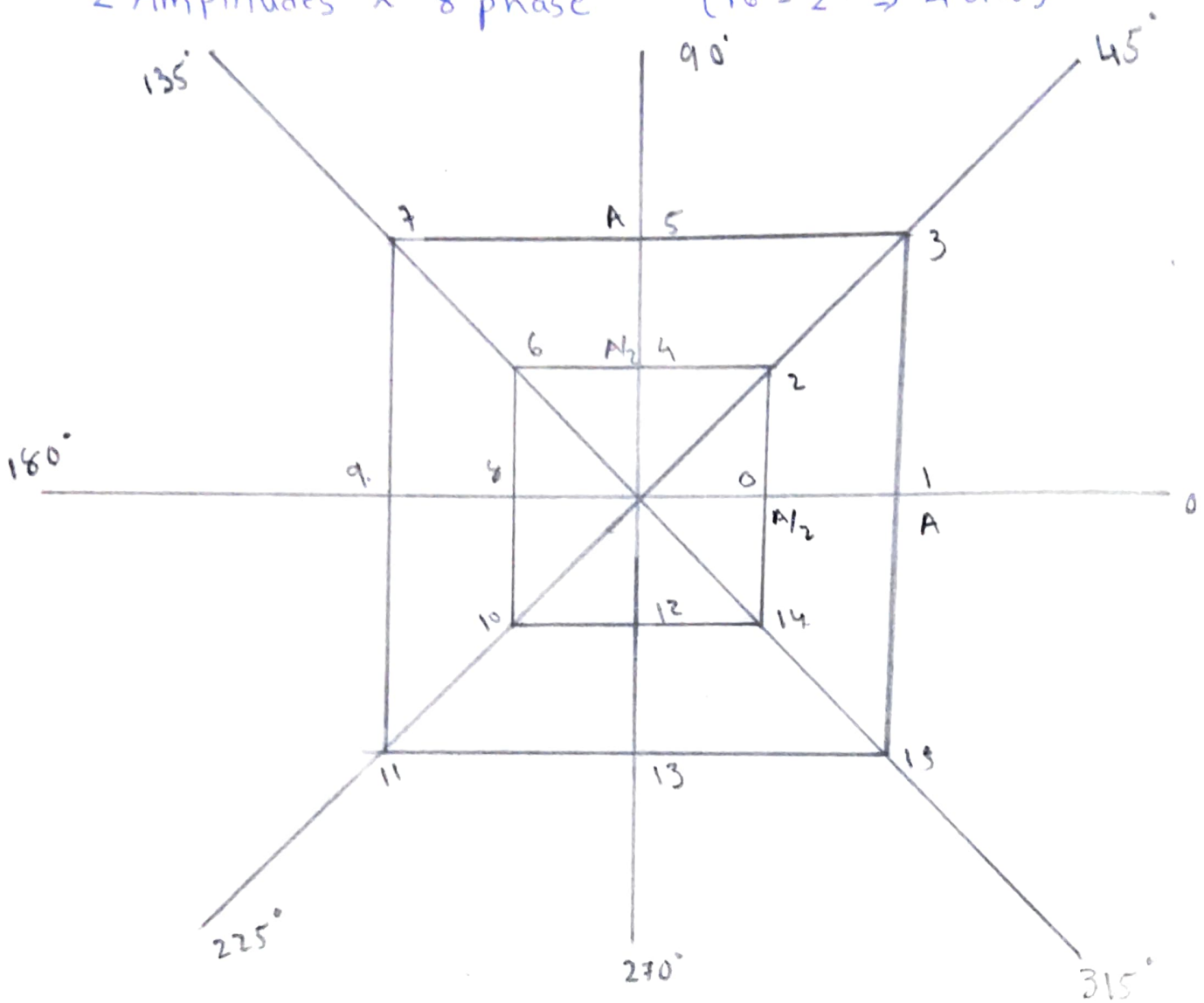
- These signal will not overlap with each other because they are orthogonal.
- It is possible to transmit two DSB-SC signals with in a bandwidth of 2fm.
- Provide bandwidth efficiency.
- Gives better performance than SSB.
- Improves data rate.



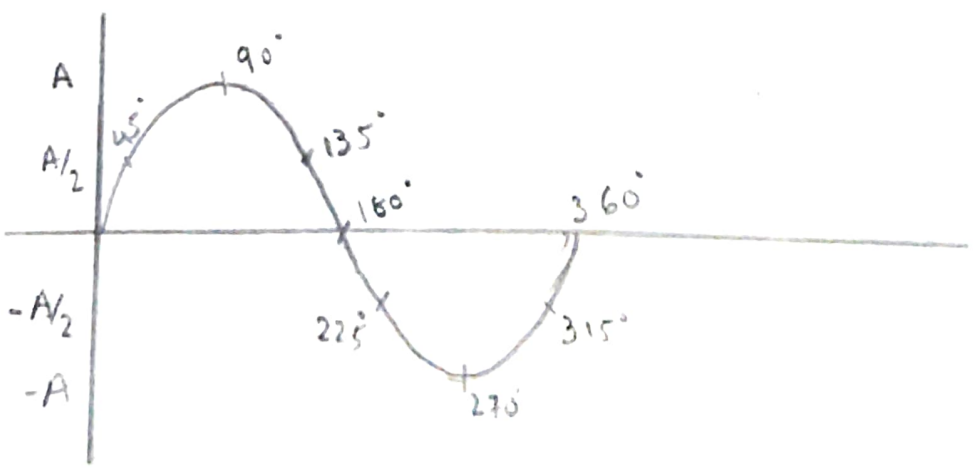
$$s(t) = x_1(t)\, A\cos\omega_c t + x_2(t)\, A\sin\omega_c t$$

16 QAM Waveforms

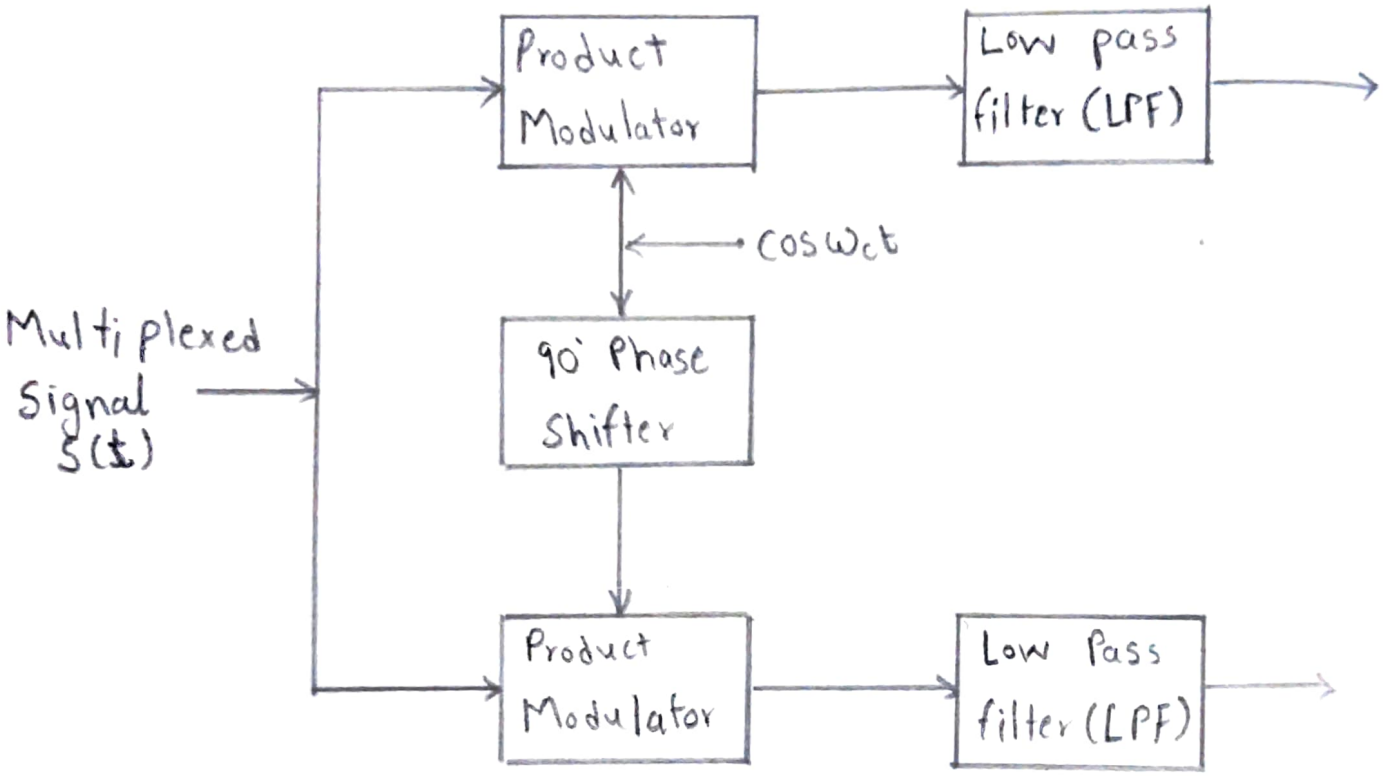
2 Amplitudes × 8 phase $(16 = 2^4 \Rightarrow 4 \text{ bits})$



Phasor Diagram



QAM Demodulation:



- The QAM demodulator is very much the reverse of the QAM modulator.

- The signals enter the system, they are split and each side is applied to a mixer.

Bit Error Rate

- While higher order modulation rates are able to offer much faster data rates and higher levels of spectral efficiency for the radio communications system, this comes at a price....

- The higher order modulation schemes are considerably less resilient to noise and interference.

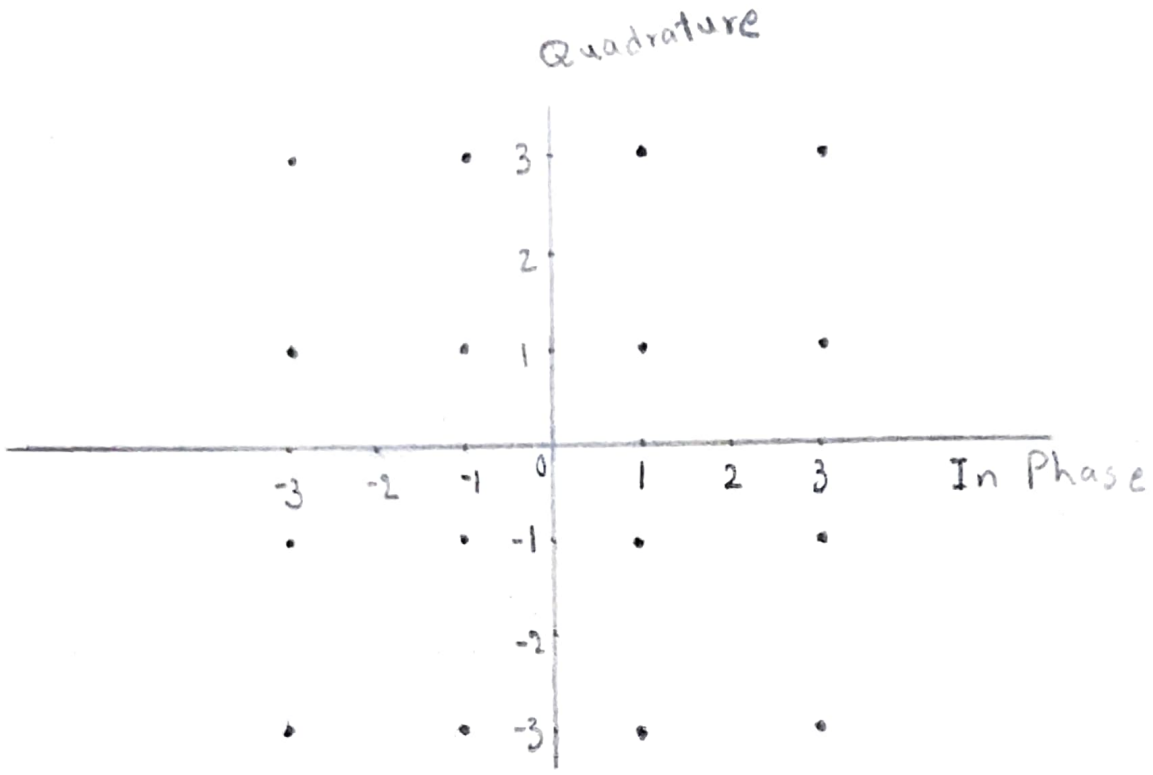
- Many radio communications systems now use dynamic adaptive modulation techniques. They sense the channel conditions and adapt the modulation scheme to obtain the highest data for the given conditions.

- M-QAM technique provide better bit error rate performance than M-PSK modulation techniques.

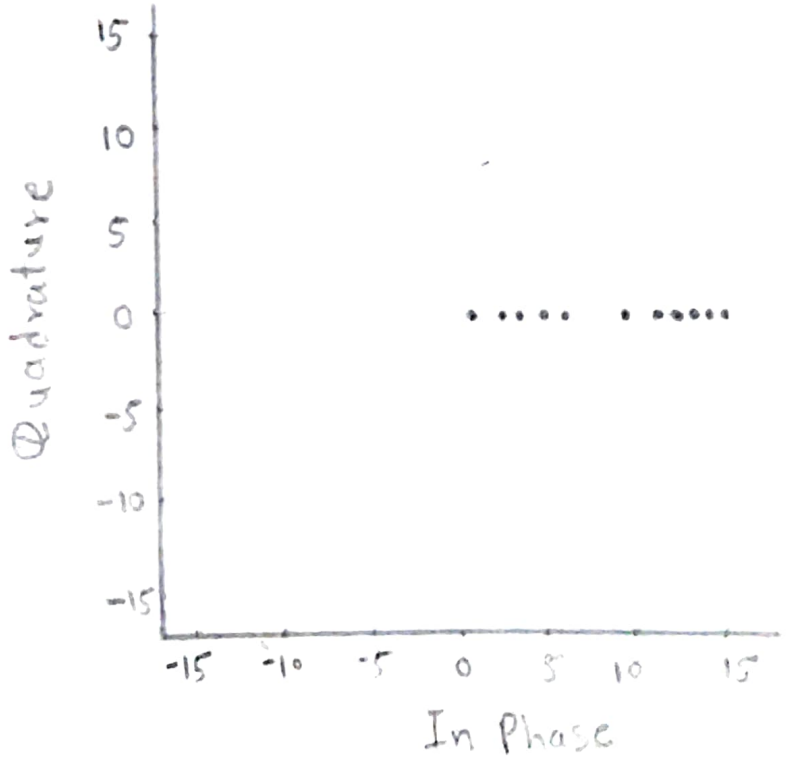
Page No.:
Date:

Matlab Code

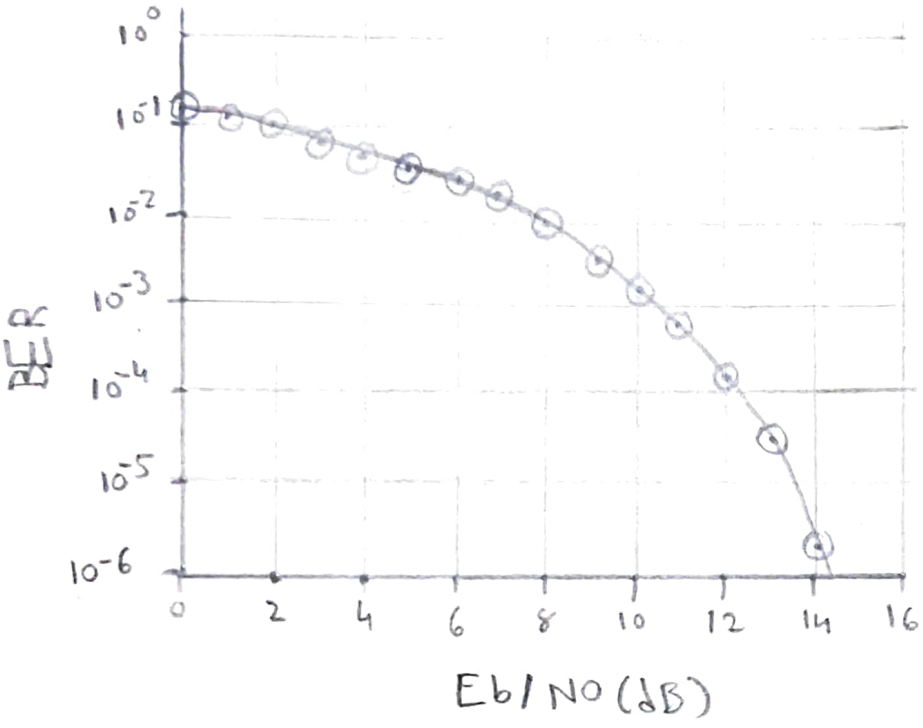
```
clc;
clear all;
close all;
M = 16;
x = (0: M-1);
y = qammod(x, M);
scatterplot (y);
z = qamdemod (y, M, pi/4);
scatter plot (z);
ber_1 = [];
for EbN0dB = 0:20;
    EbN0 = 10^(EbN0dB/10);
    ber = (1/log2(M))*(2*(1-sqrt(1/M))*erfc(sqrt((3*log2(M)
        * EbN0)/(2*(M-1)))));
    ber_1 = [ber_1 ber];
end
EbN0dB = 0:20;
figure
semilogy (EbN0dB, ber_1(1,:), 'ro-');
xlabel ('Eb/N0 (dB)');
ylabel ('BER');
title ('BER of 16-QAM');
axis ([0 16 10^-6 10^0]);
grid on;
```



Scatter Plot of 16-QAM Modulation



Scatter plot of 16-QAM demodulation



BER of 16-QAM

RESULTS:

Advantages :

- The advantage of using QAM is that it is a higher order form of Modulation. As a result it is able to carry more bits of information per symbol.

- By selecting a higher order format of QAM, the data rate of a link can be increased.

- Bit rate is increased without increasing the bandwidth.

Disadvantages :

- As states are more closer as shown in the figure, QAM modulation is more susceptible to the noise. Due to this QAM receiver is more complex compare to receivers of other Modulation types.

- As QAM uses amplitude component of signal to represent binary data, linearity need to be maintained and hence linear amplifier is needed which consumes more power.

Applications:

- Quadrature multiplexing is used in color television to multiplex the so called chrominance signals which carry the information about colors.
- QAM scheme is used on telephone lines for data transmission.
- Ultra-high capacity Microwave Backhaul systems also use 1024-QAM.