Date 21/10/2020

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Experiment No: 09

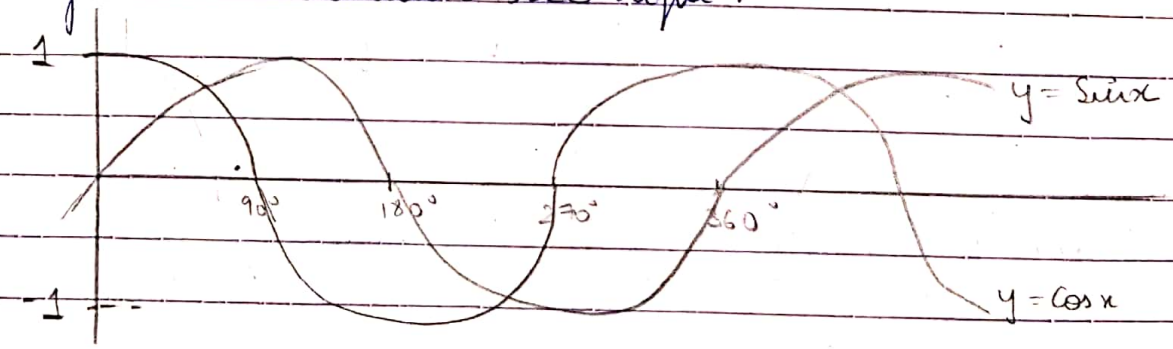
16-QUADRATURE AMPLITUDE MODULATION AND DEMODULATION

Objective: To examine the 16-Quadrature Amplitude Modulation and Demodulation scheme. Draw the 16--QAM m-ary mapped signal and modulated waveforms. Evaluate the BER values for it. Show the input/output waveforms using Matlab code/simulink in virtual mode.

Software: 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 communi--cations. QAM is a signal in which two carriers shifted in phase by 90° are modulated and the resultant output consists of both amplitude and phase variations. Hence it may be considered as a mixture of amplitude and phase modulation. QAM is both an analog and digital modulation technique.



Quadrature = Sine Wave + Cosine Wave

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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:

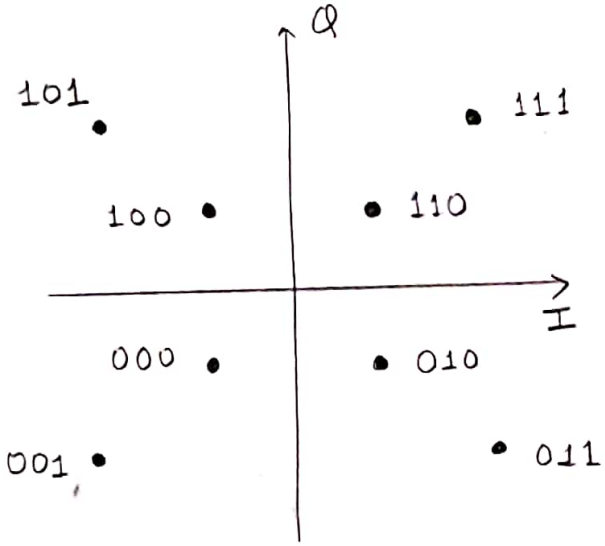
→ 16 QAM
→ 32 QAM
→ 64 QAM
→ 128 QAM
→ 256 QAM

- Quadrature amplitude Theory: It states that both amplitude and phase changes within a QAM signal. The basic way in which QAM signal can be generated is to generate two signals that are 90° out of phase with each other and then sum them.

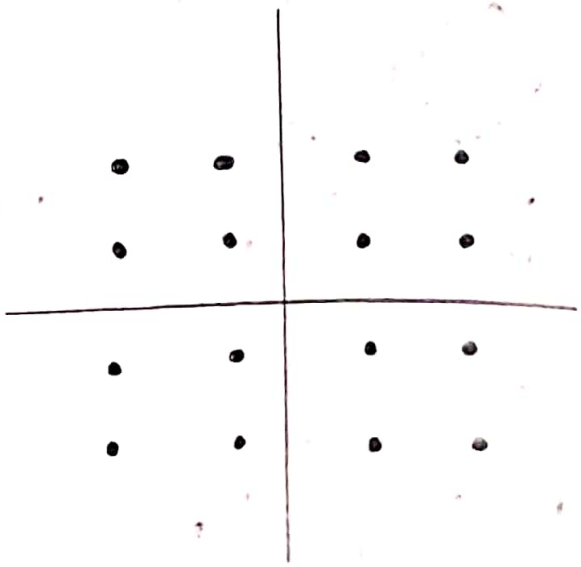
The I and Q signals can be represented by the equations below:

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

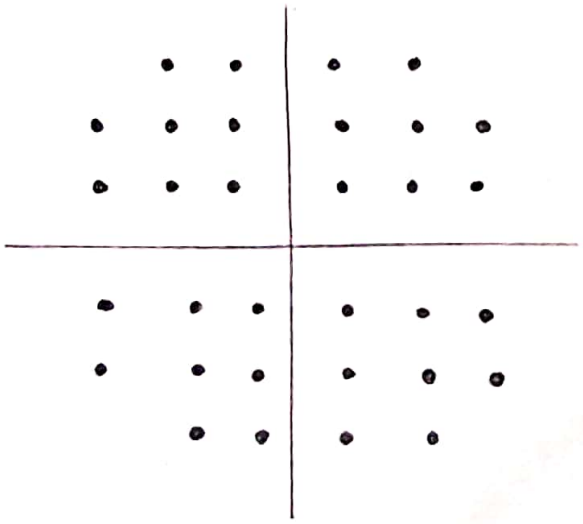
TYPES OF QAM - CONSTELLATION DIAGRAMS



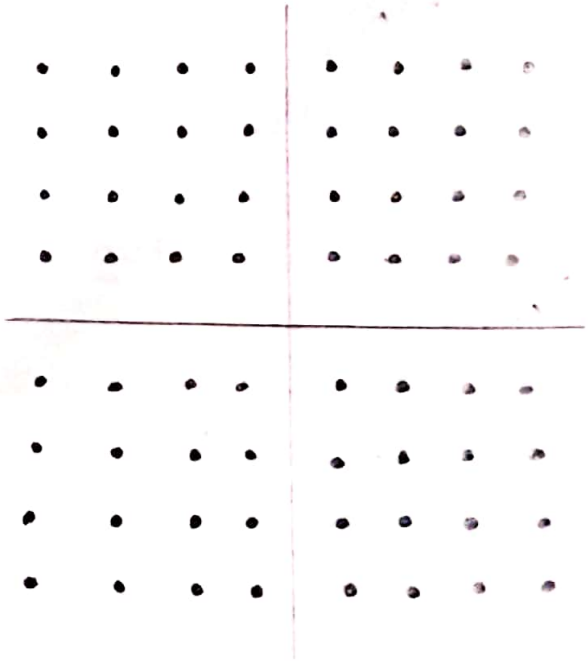
(8 QAM)



(16 QAM)



(32 QAM)



(64 QAM)

These signal will not overlap each other because they are orthogonal. It is possible to transmit two DSB-SC signals with a bandwidth of 2fm

→ Provide bandwidth efficiency
→ Gives better performance
→ Improves data rate.

QAM Demodulation:

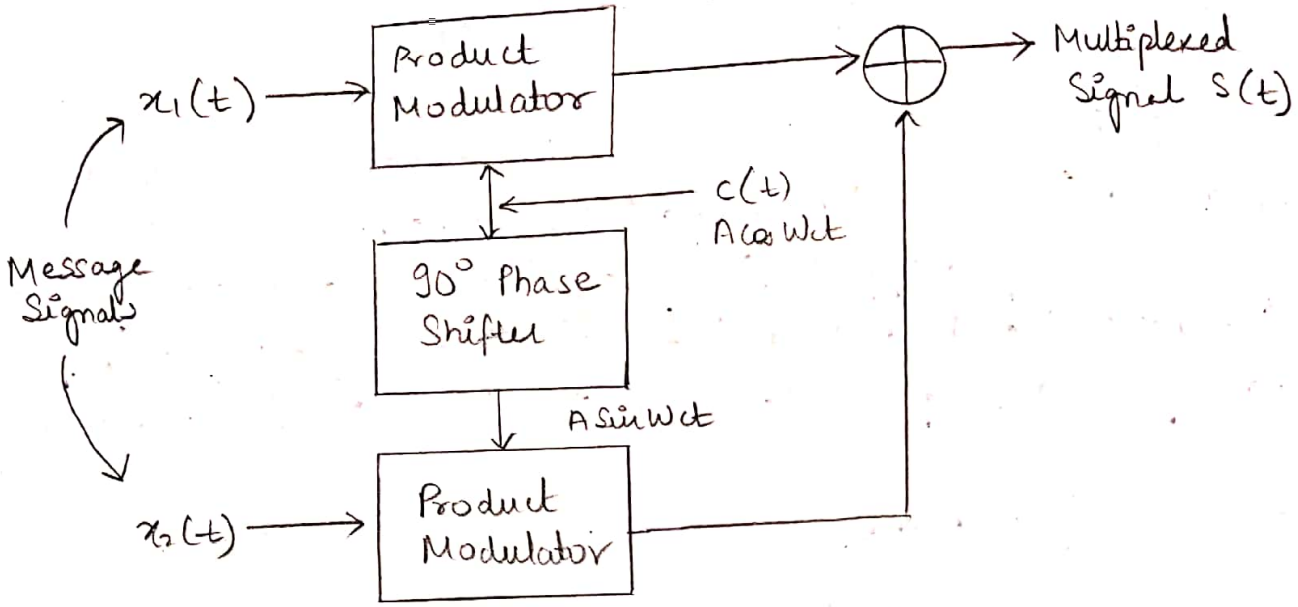
→ The QAM demodulator is very much the reverse of the QAM modulator
→ The signals enter the system, they are split and each side is applied to a mixer.

Bit Error Rate (Received Bits)

- 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 interferences.
- 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 rate for the given conditions
- M-QAM technique provide better bit error rate performance than M-PSK modulation techniques.

BLOCK DIAGRAMS

1) QAM Modulation:



$$\int s(t) = x_1(t) A\cos Wct + x_2(t) A\sin Wct$$

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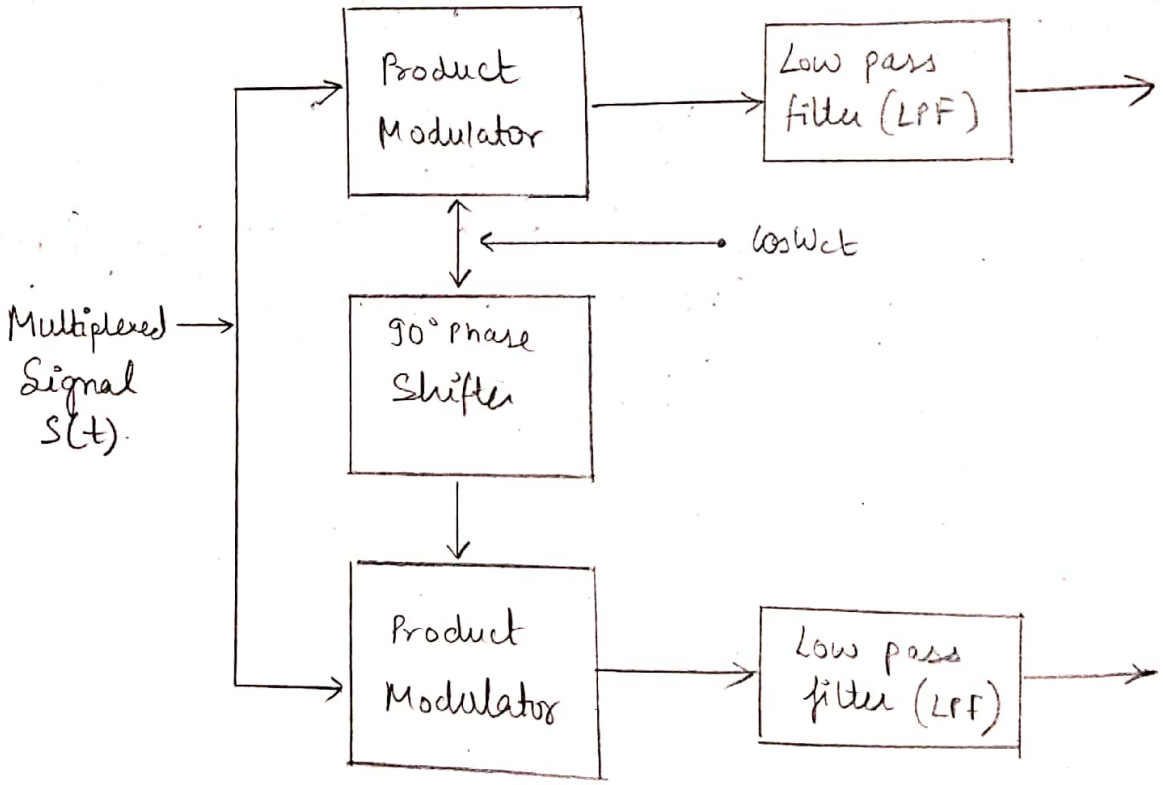
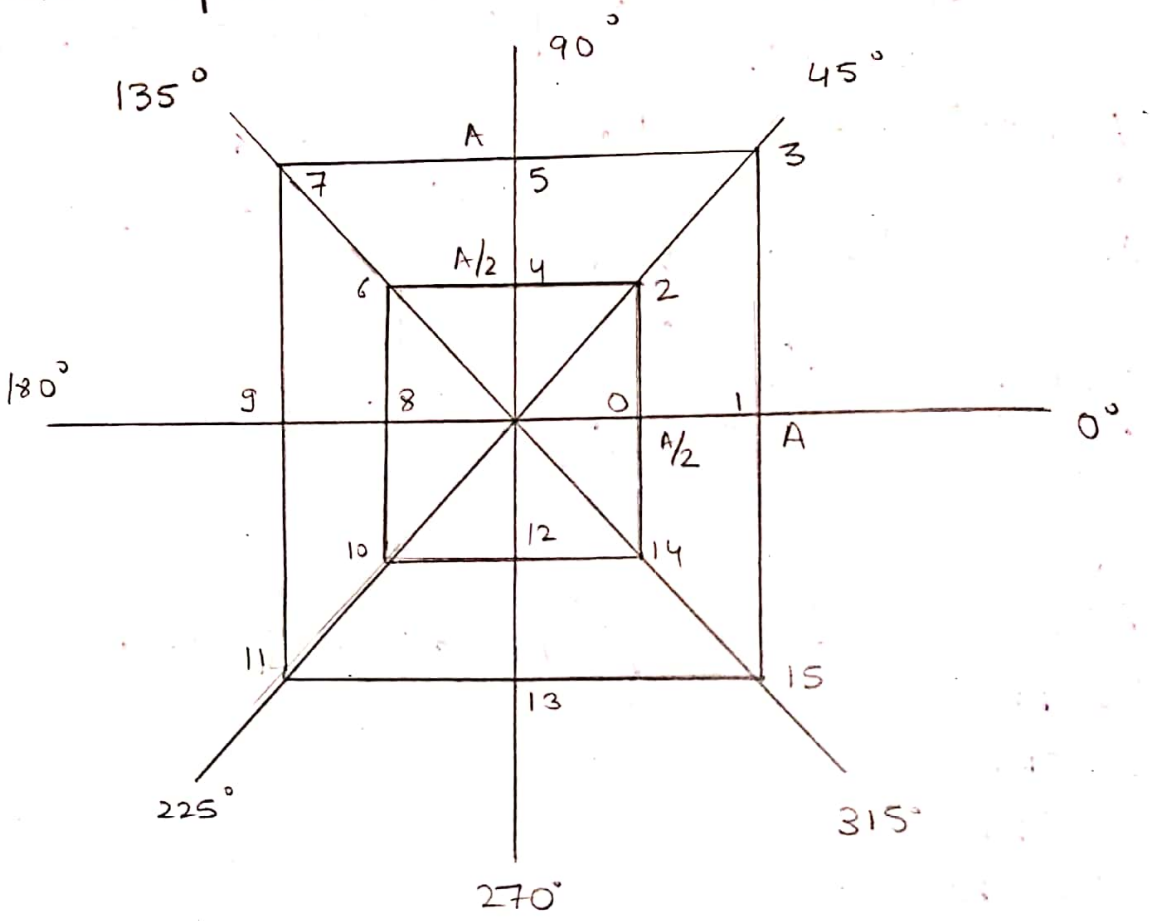
2) QAM Demodulation:

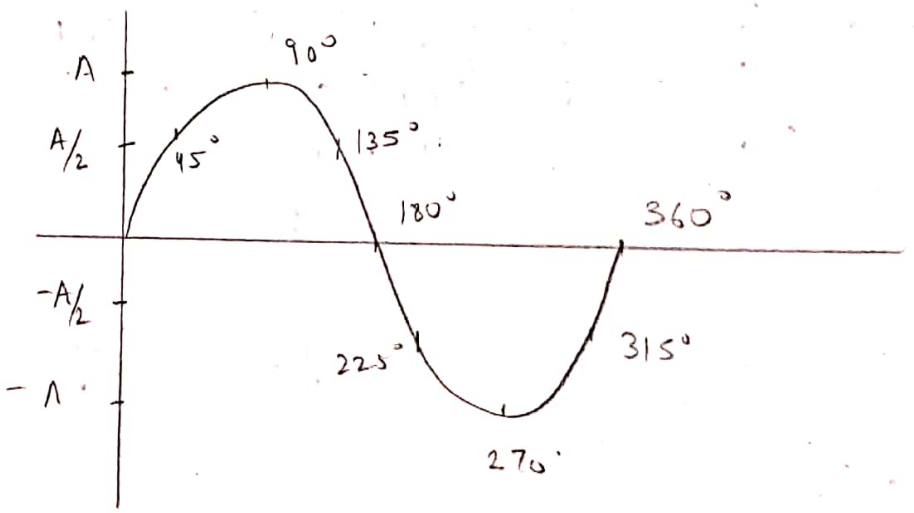


16 QAM Waveforms

2 Amplitude x 8 phase $(16 = 2^4 = 4 \text{ bits})$



Phasor Diagram:



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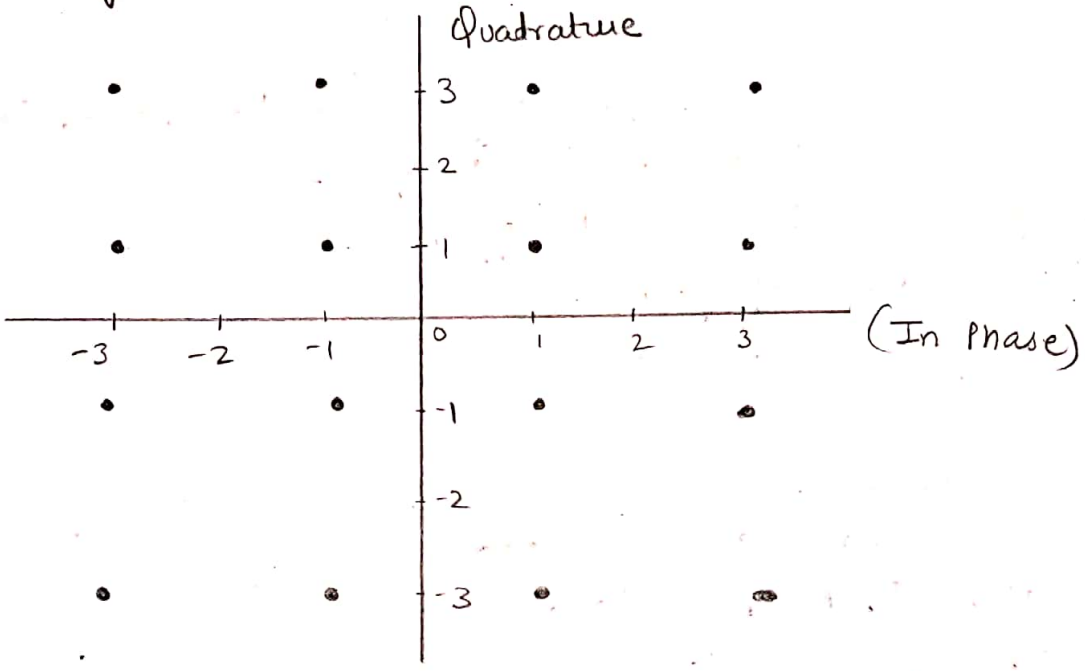
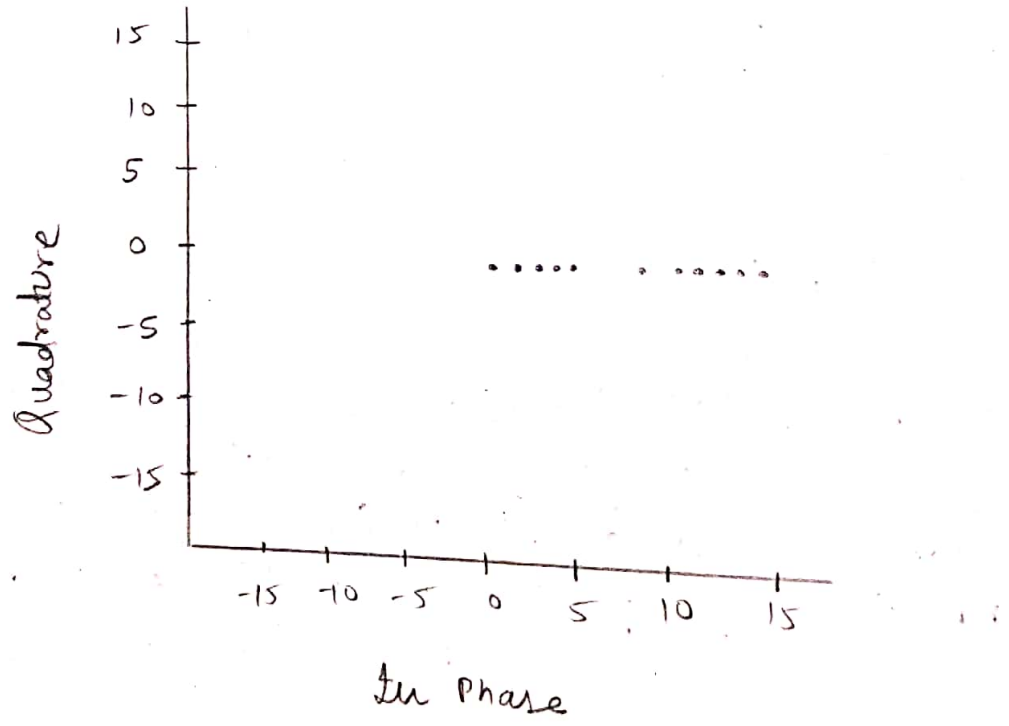
Matlab Code:

```
clc;
clear all;
close all;
M = 16;
 x = (0:M-1);
 y = scatterplot(y);
% z = qamdemod (y, M, pi/4)
% scatterplot(z)
ber_1 = []
for EbNOdB = 0:20;
        EbNO = 10^(EbNOdB/10);
        ber = (1/log2(M))*(2*(1-sqrt(1/M))*erfc(sqrt((3*log2(M)
                                    * EbNO)/2*(M-1))))
end
EbNOdB = 0:20;
figure
semilogy(EbNOdB, ber_1(1,:), 'ro-');
xlabel('Eb/NO (dB)');
ylabel('BER');
title('BER of 16-QAM');
axis([0 16 10^-6 10^0]);
grid on;
```

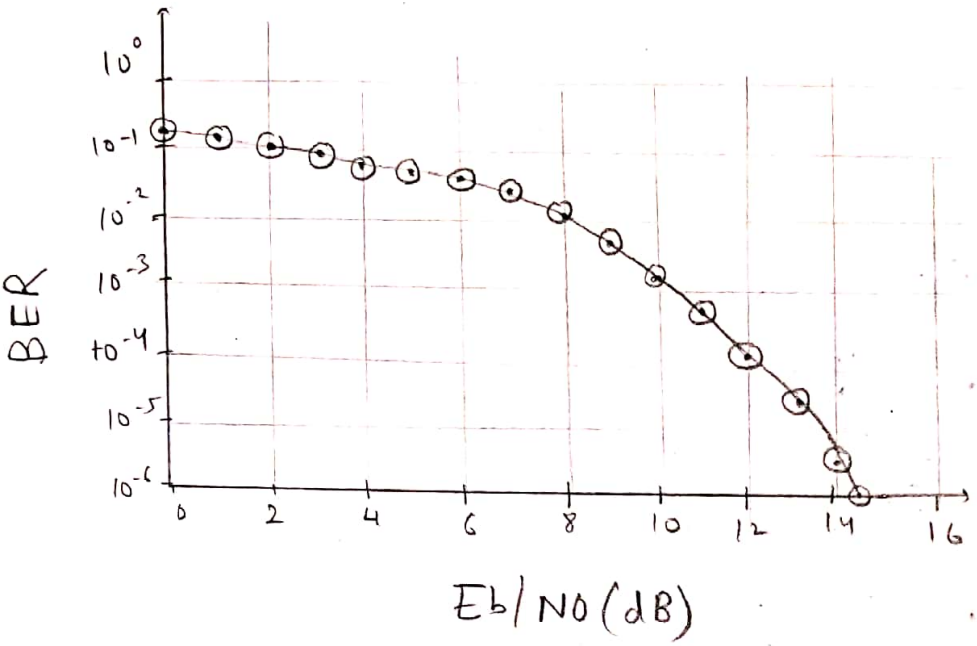
Scatter plot of 16-QAM Modulation:



Scatter plot for 16-QAM Demodulation:



BER of 16-QAM:



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Advantages:

- The advantage of using QAM is that it is 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.

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 for telephone lines for data transmission.
- Ultra high capacity Microwave Backhaul Systems also use 1024-QAM.

MODULATION	BITS PER SYMBOL	SYMBOL RATE
BPSK	1	1 x bitrate
QPSK	2	½ bitrate
8PSK	3	⅓ bitrate
16QAM	4	¼ bitrate
32QAM	5	⅕ bitrate
64QAM	6	⅙ bitrate

Conclusion: Successfully examined 16-QAM modulation and demodulation scheme and illustrated the input/output waveforms using Matlab.