EXPERIMENT 9 [U19CS012]

QAM MODULATION AND DEMODULATION

> **AIM:** Study of 16 QAM Modulation and Demodulation technique with ~~dig~~ constellation diagram and waveforms.

> **APPARATUS:** MATLAB

> **THEORY:** ① QAM: 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.

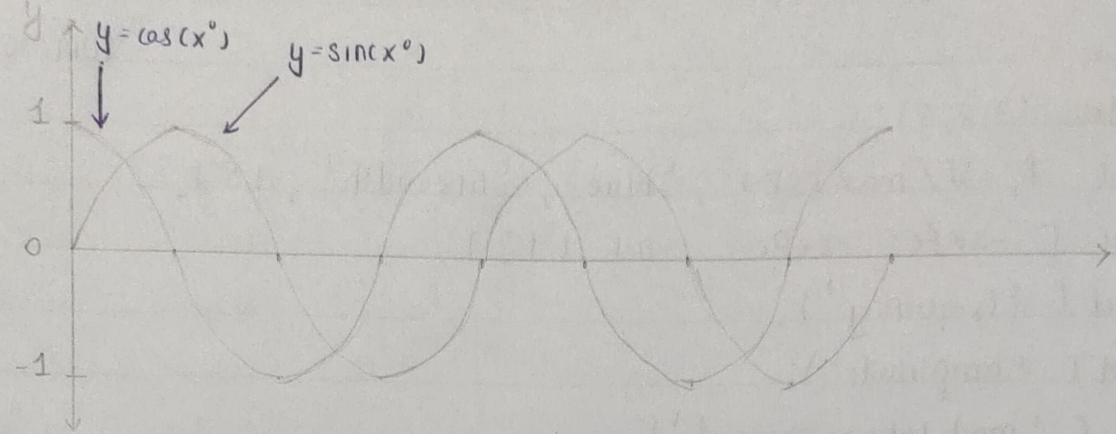
- QAM is a signal in which two carriers shifted in phase by 90° are modulated & the resultant output consists of both Amplitude and phase variations.

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

② Main parameters to be considered while designing any communication system
- Transmission Power
- Transmission Bandwidth

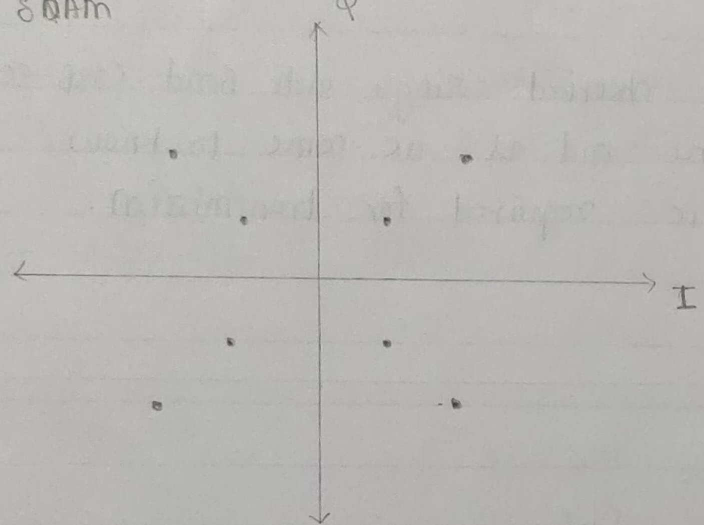
- Although the SSB-SC systems are most power and bandwidth efficient but still their performance lags in the noisy environment.

Quadrature = Sine wave + Cosine wave

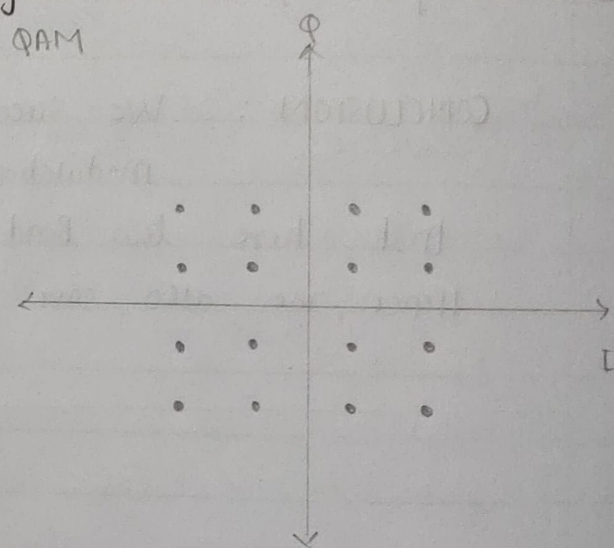


Types of QAM - constellation Diagram

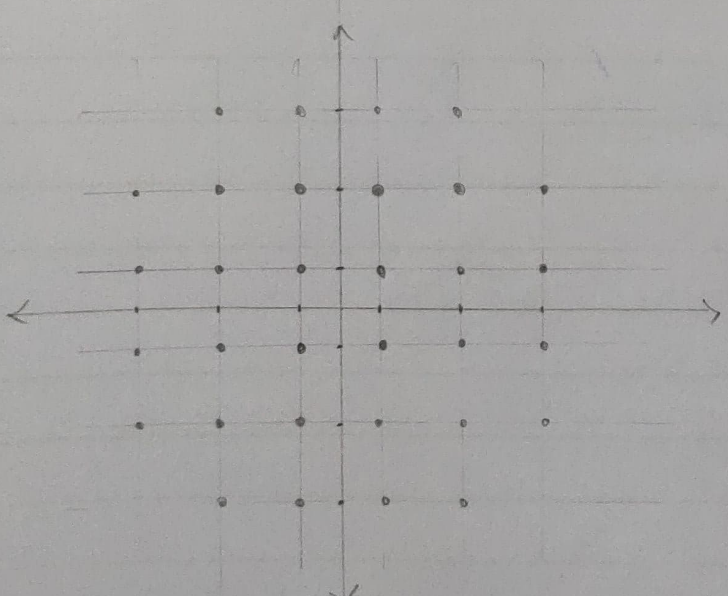
8 QAM



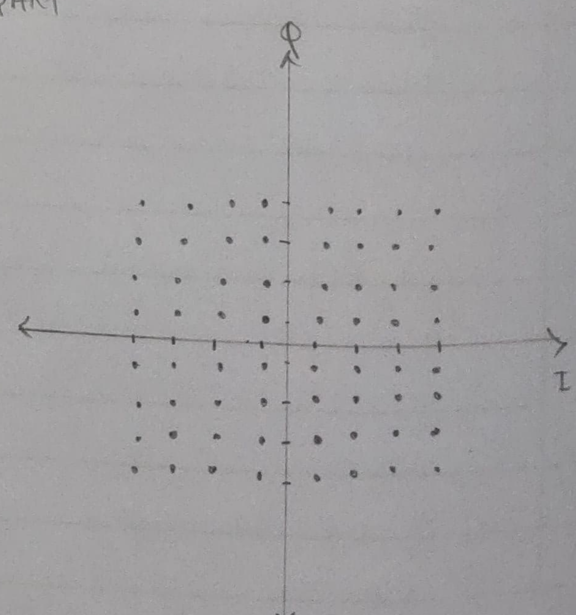
16 QAM



32 QAM



64 QAM



3.) Why QAM?

- The main aim 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.

4.) Types of QAM

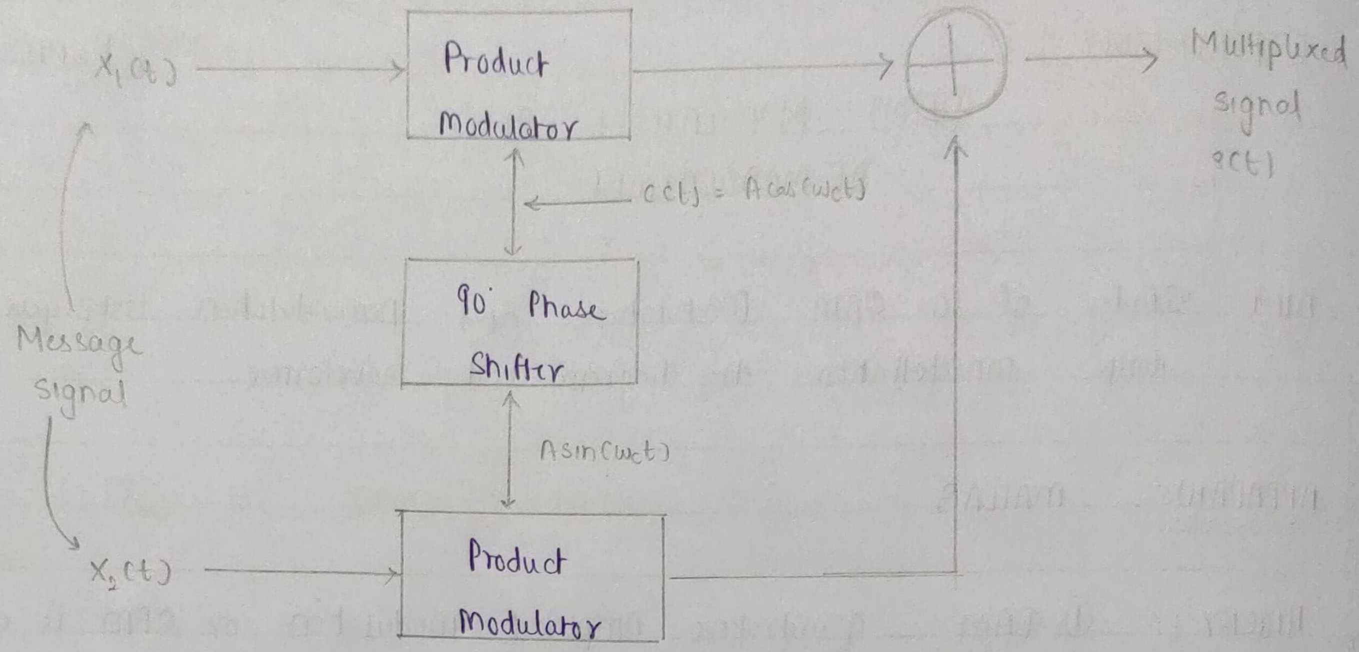
- A variety of forms of QAM are available which include:

  - 16 QAM
  - 32 QAM
  - 64 QAM
  - 128 QAM
  - 256 QAM

5.) QAM Modulation

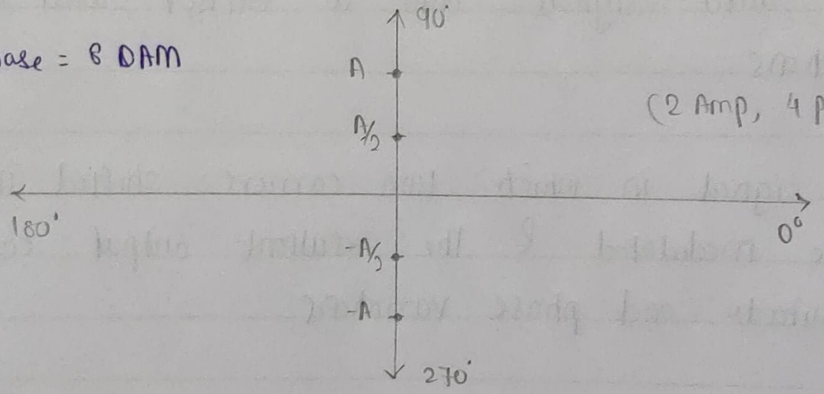
- QAM theory states that both Amplitude and phase changes within a QAM signal.
- The basic way in which a QAM signal can be generated is to generate two signals that are 90° out of phase with each other and them sum them.

QAM Modulation

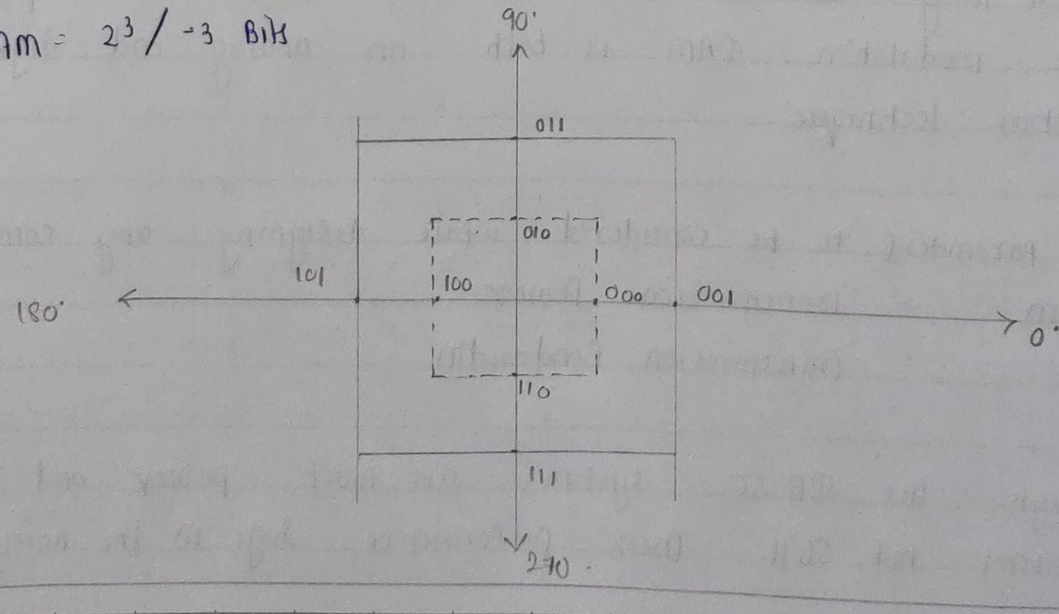


$$s(t) = x_1(t)\, A\cos(w_c t) + x_2(t)\, A\sin(w_c t)$$

2 Amp × 4 phase = 8 QAM



8 QAM = 2^3 / → 3 Bits



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

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

- This signals will not overlap with each other because they are orthogonal.

- It is possible to transmit two DSB-SC signal with in bandwidth of "$2f_m$"

- It provides bandwidth effeciency.

- Gives better performance than SSB and also improves data rate.

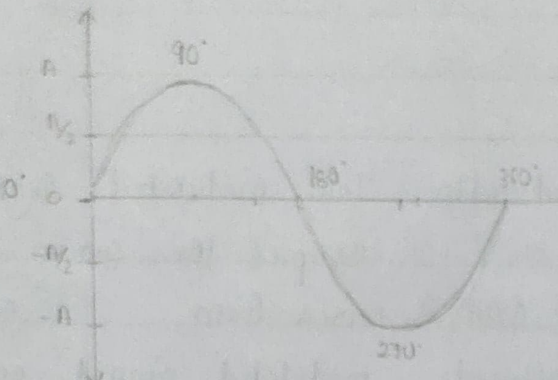
6.) QAM Demodulation

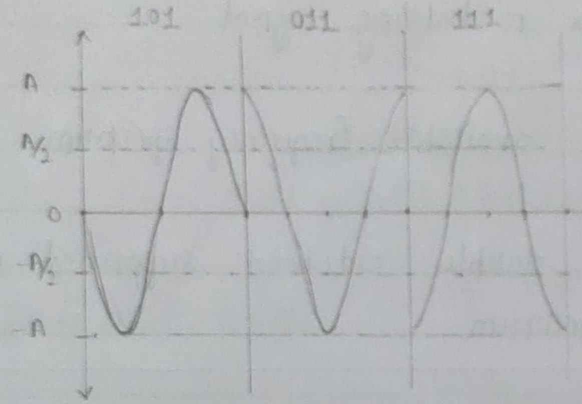
- The QAM demodulator is very much the reverse of the QAM modulator
- The signals enter the systems, they are split and each side is applied to a mixer.

7.) Bit error Rate (Received Bits)

- While higher order modulation rates are able to offer much faster data rates and higher levels of spectral effeciency for the radio communication system, this comes at a price.
- The higher order modulation schemes are considerable less relient to noise and interference.

Phasor Diagram

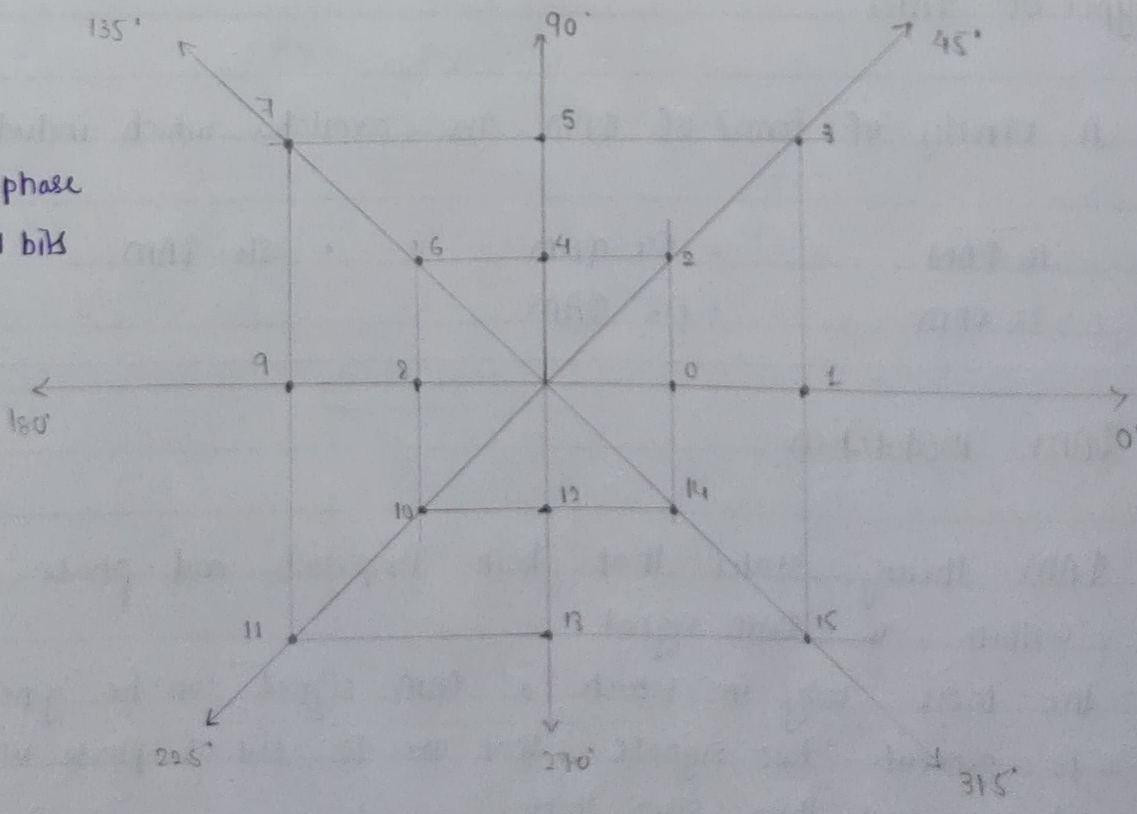




16 QAM

2 Amp * 8 phase

$= 2^4$ / 4 bits



- 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 provides better bit error rate performance than M-PSK modulation techniques.

8.) 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

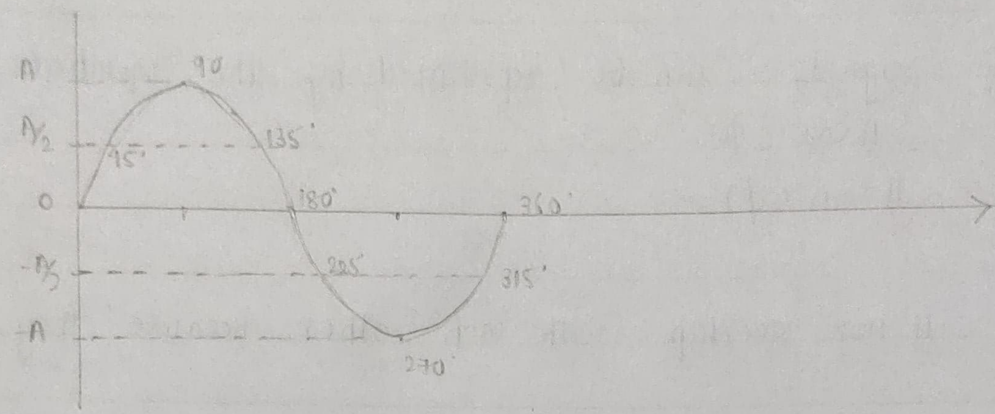
- By selecting a higher order format of QAM, the data rate of a link can be increased.

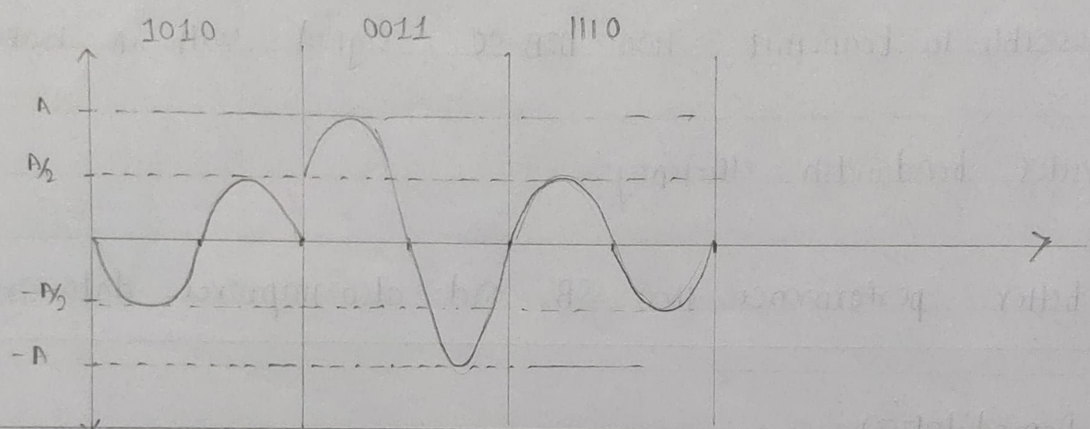
- Bit rate ~~of~~ is increased without increasing the Bandwidth.

9.) Applications

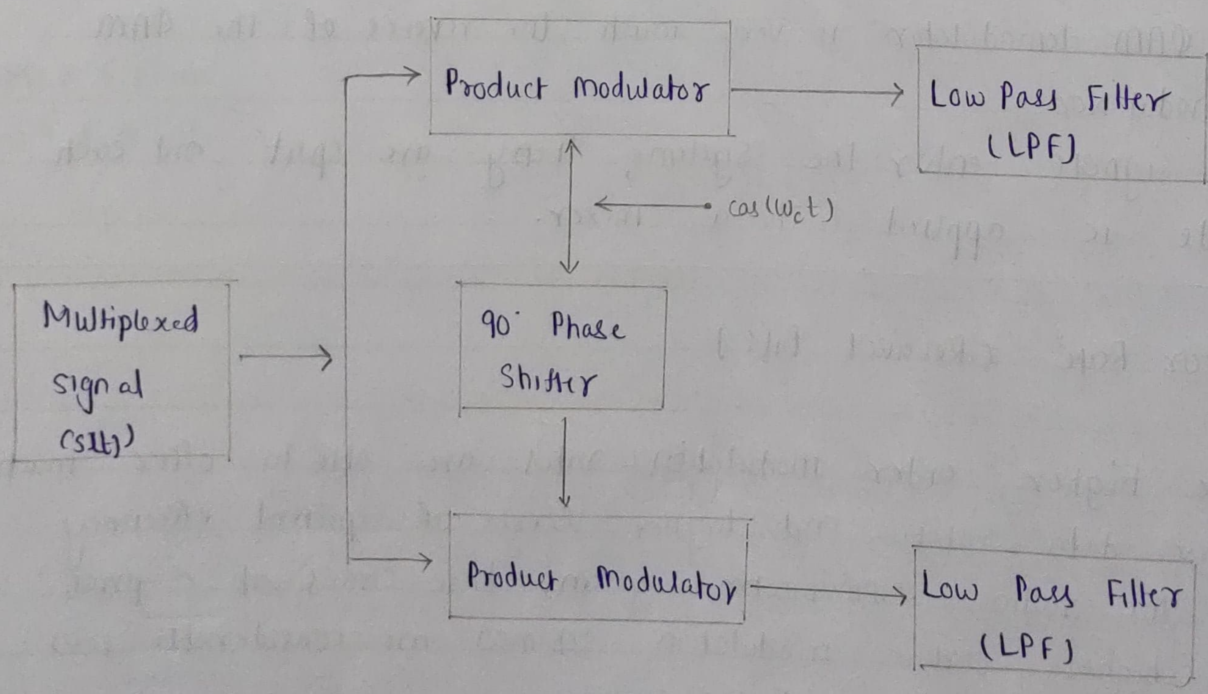
- Quadrature multiplexing is used in color television to multiplex the so-called chrominance signals which carry the information about colors.
- QAM scheme is used on telephone lines for data transmission
- Ultra high capacity Microwave Backhaul systems also use 1024-QAM.

Phasor Diagram





QAM Demodulation

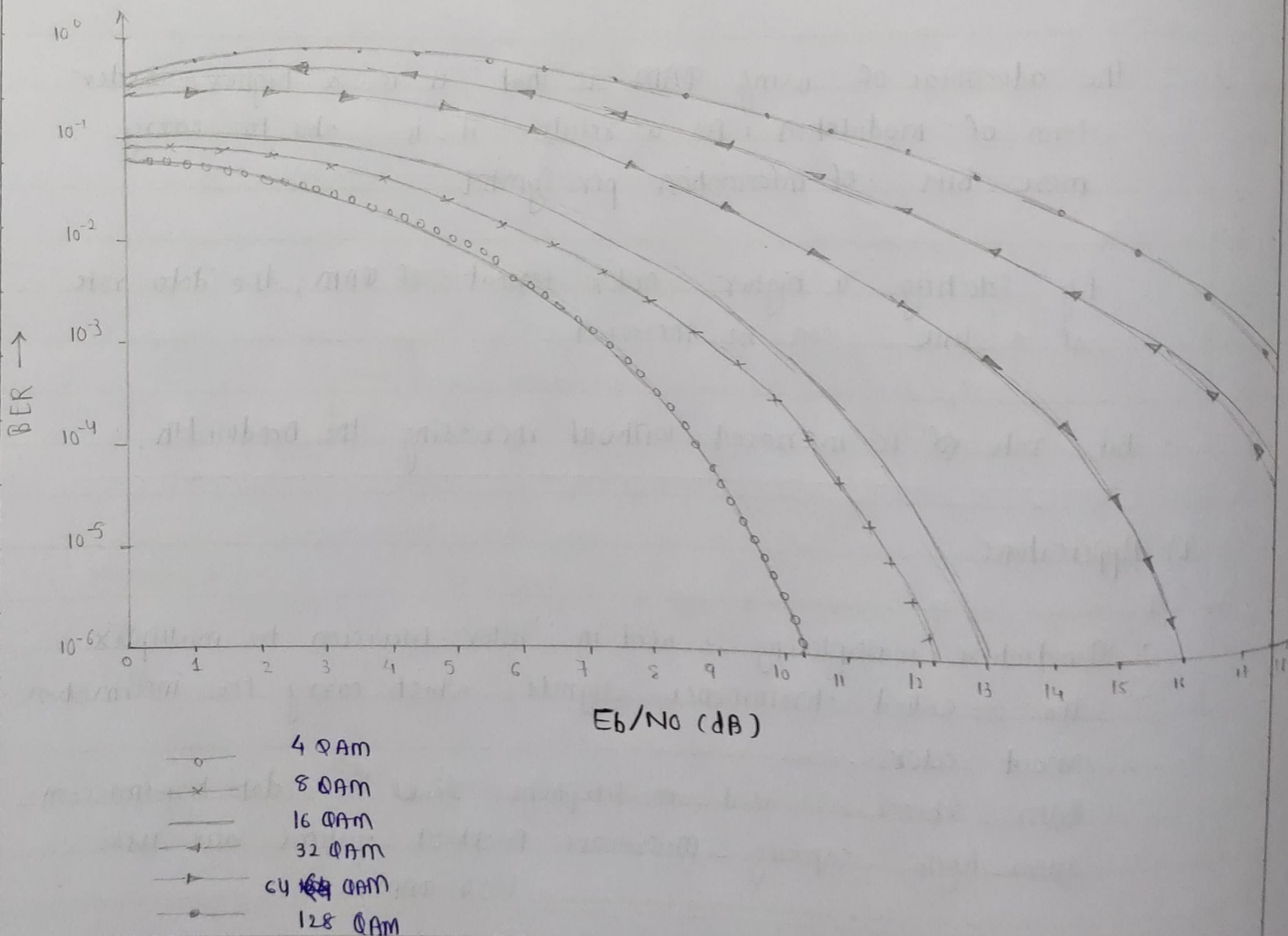


MATLAB Code:

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

Modulation	Bit Per Symbol	Symbol Rate
BPSK	1	1 Bit Rate
QPSK	2	1/2 Bit Rate
8PSK	3	1/3 Bit Rate
16PSK	4	1/4 bit Rate
32 PSK	5	1/5 bit Rate
64 PSK	6	1/6 bit Rate

"BER Values" using MATLAB



[U19CS012]

```
% BER comparision of various M-QAM
clc; clear; close all;
M = [4 8 16 64 128 256]
for i=1: length (M)
        ber_th1 = [];
for EbNodB = 0:20
            EbNO = 10.^(EbNodB/10);
            ber = (1/log2 (M(i))) * (2* (1-sqrt(1/m(i)))) *
                  erfc (sqrt ((3* log2(M(i)) * EbNO) / 2*(m(i)-1))))
            ber_thi = [ ber_th1  ber];
end
        berth = [ber_th; ber_thi];
end
EbNodB = 0:20;
semilogy (EbNodB, ber_th(1,:), 'ro-'); hold on
semilogy (EbNodB, ber_th(2,:), 'g+-'); hold on
semilogy (EbNodB, ber_th(3,:), 'y.-'); hold on
semilogy (EbNodB, ber_th(4,:), 'k>-'); hold on
semilogy (EbNodB, ber_th(5,:), 'c<-'); hold on
semilogy (ebNodB, ber_th(6,:), 'mx-'); hold on

xlabel ('Eb/NO(dB)'); ylabel ('BER'); axis ([0 20 10^-6 10^0]);
```

>> CONCLUSION: We successfully examined the 16-Quadrature Amplitude Modulation (16-QAM) and Demodulation scheme.

We also evaluated 16 BER values for different QAM using MATLAB.