Programme : **B.Tech - ICT (4th semester)**

Course: Analog and Digital Communication

SEAS, Ahmedabad University

Group No: 10

Topic: communication by QPSK signaling

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Synopsis:

Today is the time when everyone has mobiles and at a time lots and lots of data is being transmitted and received on the other hand. So, this whole thing became possible without tons of wires, because of “Wireless Communication”.

In wireless communication data is modulated on a suitable signal and on the other hand it is demodulated. Here, Modulation means putting our data signal on some kind of proper carrier signal(like loading our luggage on a vehicle). Demodulation means differentiating data from carrier signals (like unloading the vehicle on the destination).

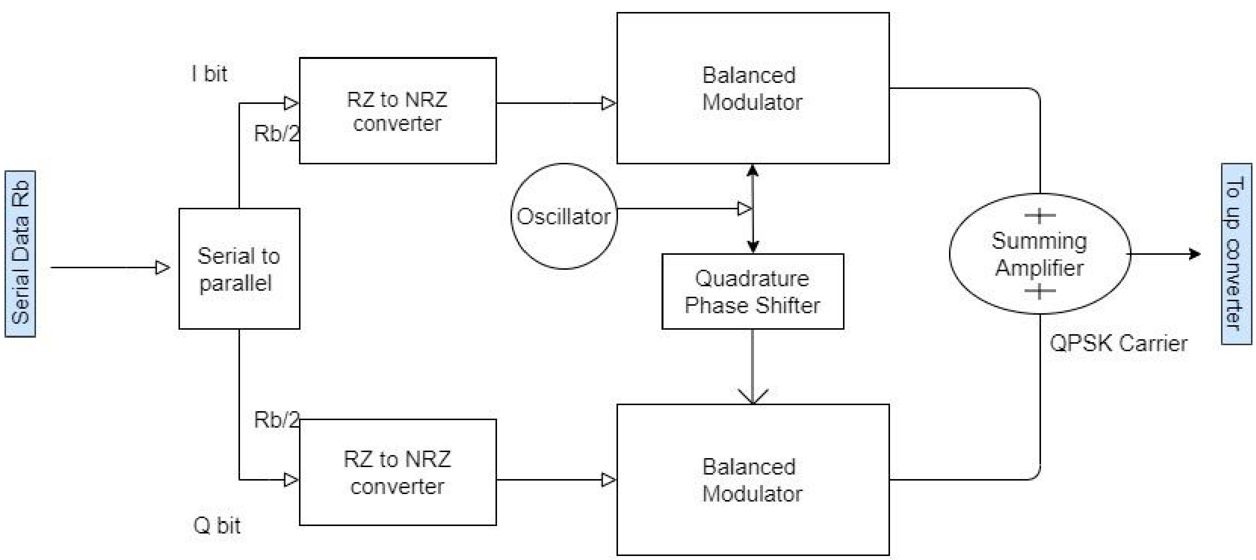
We must choose the carrier signal and modulation process efficiently so that the amount of data lost and the amount of noise added must be minimum.

So here we are doing this whole modulation and demodulation process by using QPSK(Quadrature Phase Shift Keying) because it provides high performance of bandwidth efficiency and very good noise immunity which leads to low error probability.

<u>Block Diagram</u>:

QPSK modulator:

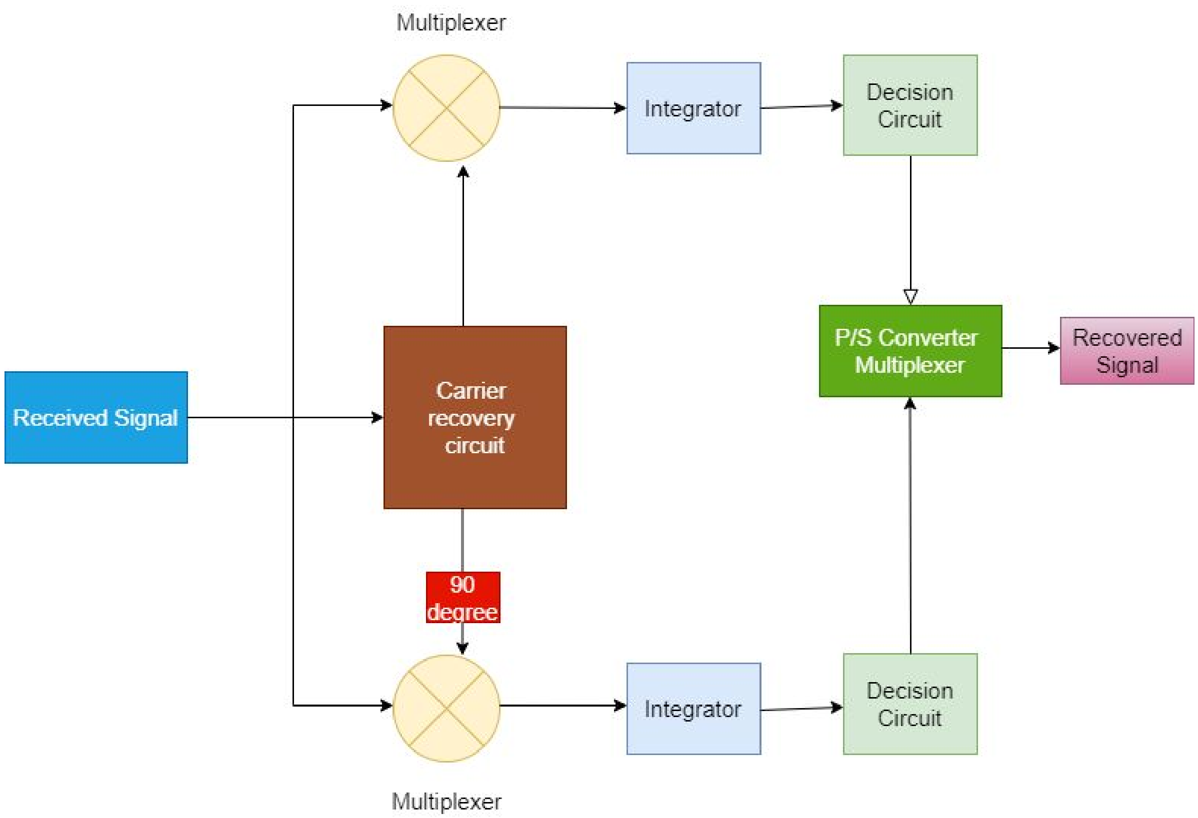
- QPSK modulator consists of two binary phase-shift keyings (BPSK) modulators, serial to a parallel converter shift register, oscillator, and 900 phase shifter. The binary serial bit sequence with bit rate Rb applied to the modulator is converted into two-bit parallel sequence I-bit and Q-bit each of having bit rate Rb/2. These I and Q bits are applied to BPSK modulators, whose carrier frequency is orthogonal to each other. This orthogonal signal is achieved through phase shifter; which shifts the applied signal to 90 degrees. The output from both BPSK modulators is added by the summing amplifier; which results in QPSK modulated signal.



Block diagram of QPSK Modulator

QPSK Demodulator:

- The design of the coherent carrier recovery circuit for the demodulation of suppressed carrier PSK signals is very critical and involves several performance considerations and tradeoffs. The digitally modulated signal (QPSK) is fed to the demodulator. And it is applied to the I mixer, which is driven with 00 carrier phase, and to the Q mixer with the 900 carrier phase. The carrier recovery circuit regenerates the coherent reference for the demodulation and is routed to the balanced modulators (multipliers). The multipliers extract the in-phase (I) and quadrature-phase (Q) data streams, which are low pass filtered and fed to the corresponding plug-in of the bit synchronizer and signal conditioner NRZ converter unit



Specifications:

- ➔ QPSK is a method to transmit digital data across an analog channel.
- ➔ In order to achieve that Data bits are grouped into pairs, and each pair is represented by a particular waveform, called a symbol, which is to be sent across the channel after modulating the carrier.
- ➔ The QPSK signals are mathematically defined as,

$$S_i(t) = A\, cos(2\,\pi f_c\, t + \theta_i) \qquad 0 \le 1 \le T$$

Where,

$$\theta_i = (2i - 1)/4$$

Now we decompose it,

$$s_t(t) = A\,[(cos\,\theta_i) * (cos\,2f_c t)] - A[(\,sin\,\theta_i) * (\,sin\,2f_c t)$$

$$s_t = s_{i1}\varnothing_1(t) + s_{i2}\varnothing_2(t)$$

Where,

$$\varnothing_1 = \sqrt{}(2/T)\; cos2f_c t, \qquad 0 \le t \le T$$

$$\varnothing_2 = -\sqrt{}(2/T)\; cos2f_c t, \qquad 0 \le t \le T$$

$$s_{i1} = \sqrt{}E\; cos\;\theta_i$$

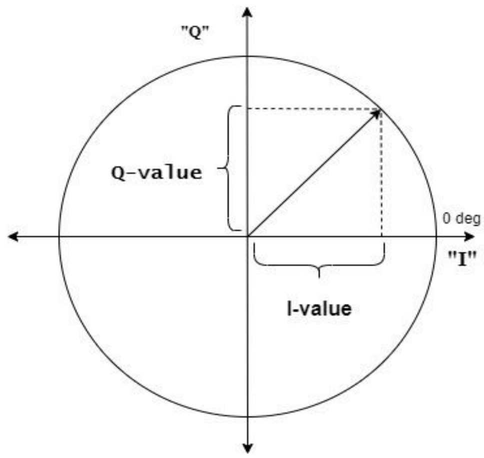
$$s_{i2} = \sqrt{}E\; sin\;\theta_i$$

$$\theta_i = tan^{-1}(s_{i2}/s_{i1})$$

The final equation of qpsk can be written as :

$$S(t) = A/\sqrt{}2\;[I(t)cos(2f_c t) - Q(t)\;sin(2f_c t)\,] \quad where \;\; -\infty < t < \infty$$

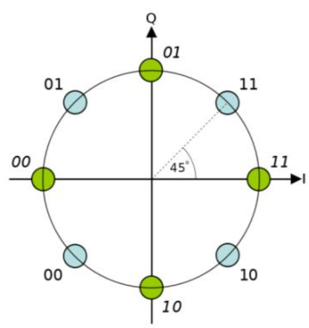
The Constellation diagram of QPSK modulation looks like:



Polar to rectangular conversion

Here Q-value means Quadrature component and I-value means in-phase component.

Quadrature phase-shift keying (QPSK)



Phase of QPSK	2bits Inputs
π/4	10
3π/4	00
5π/4	01
7π/4	11

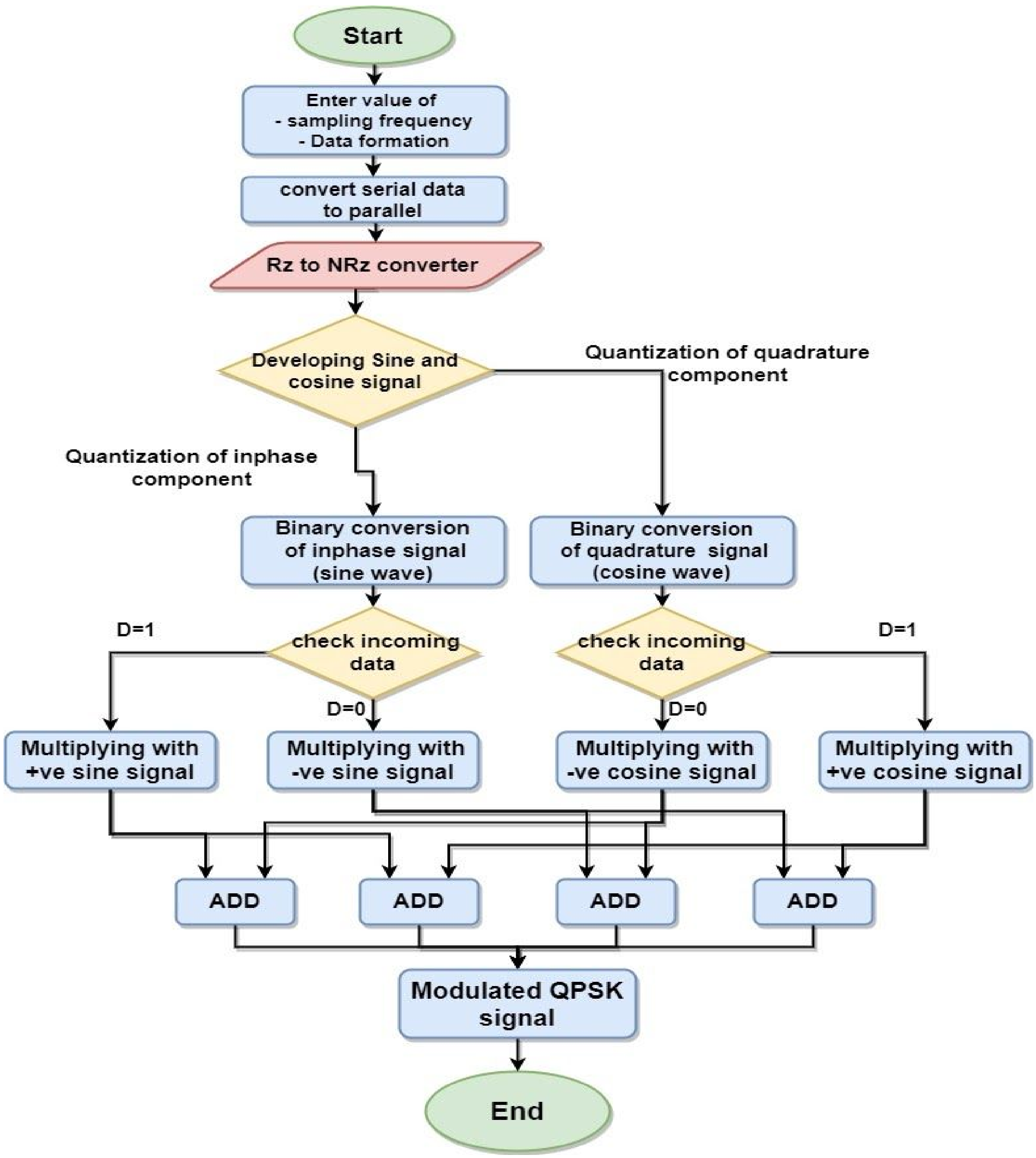
Figure : Constellation diagram for QPSK with Gray coding. Each adjacent symbol only differs by one bit.

Here is Specification of Matlab CODE:

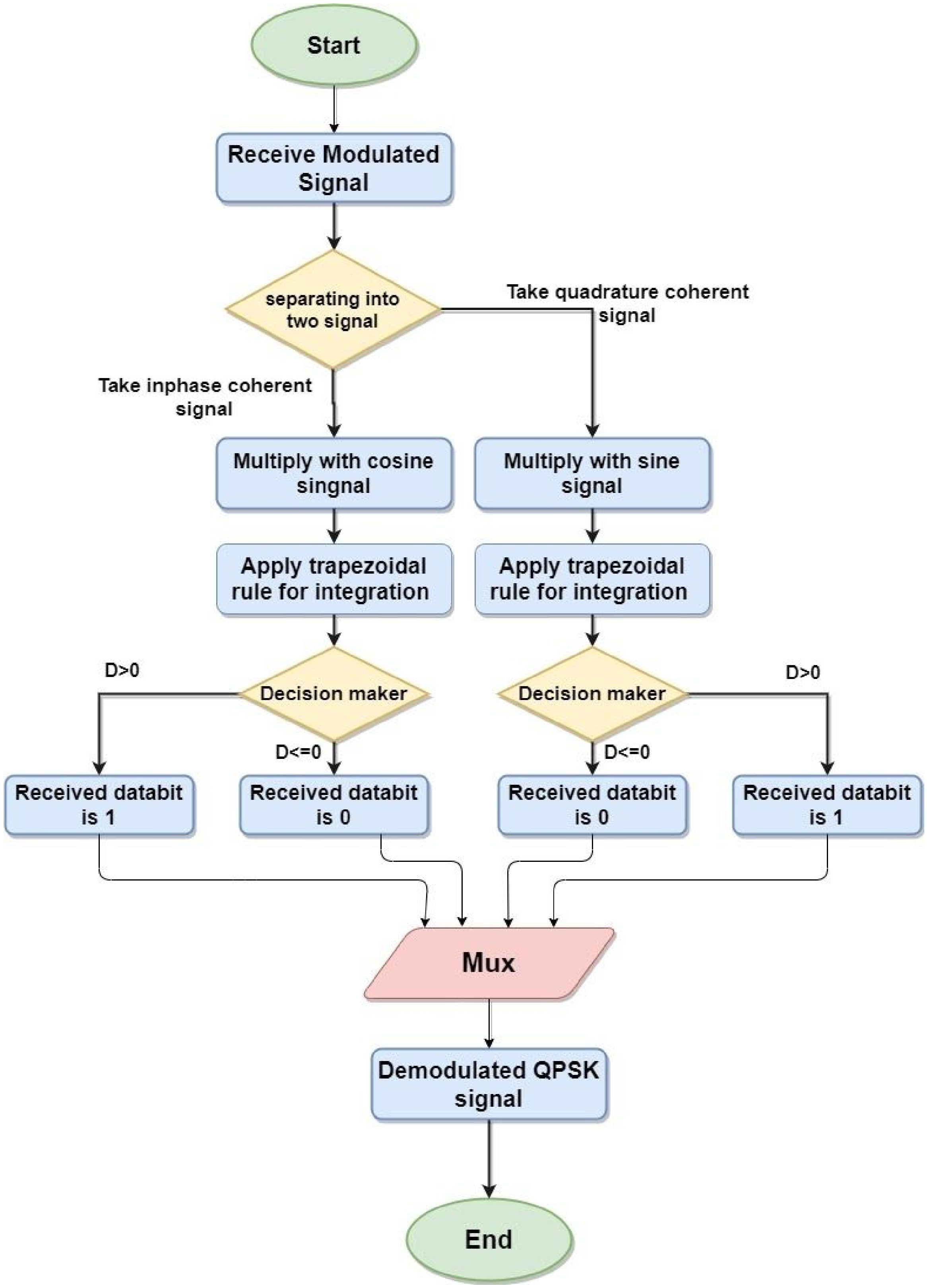
1> Modulation: QPSK
2> Carrier Frequency : 10 MHz
3> Data Rate: 1024bps
4> Noise type: AWGN(white Gaussian noise)
5> SNR ratio(signal to noise ratio) : 10
6> Integration Method: Trapezoidal rul

Flowchart:

Modulation:



Demodulator :



Code:

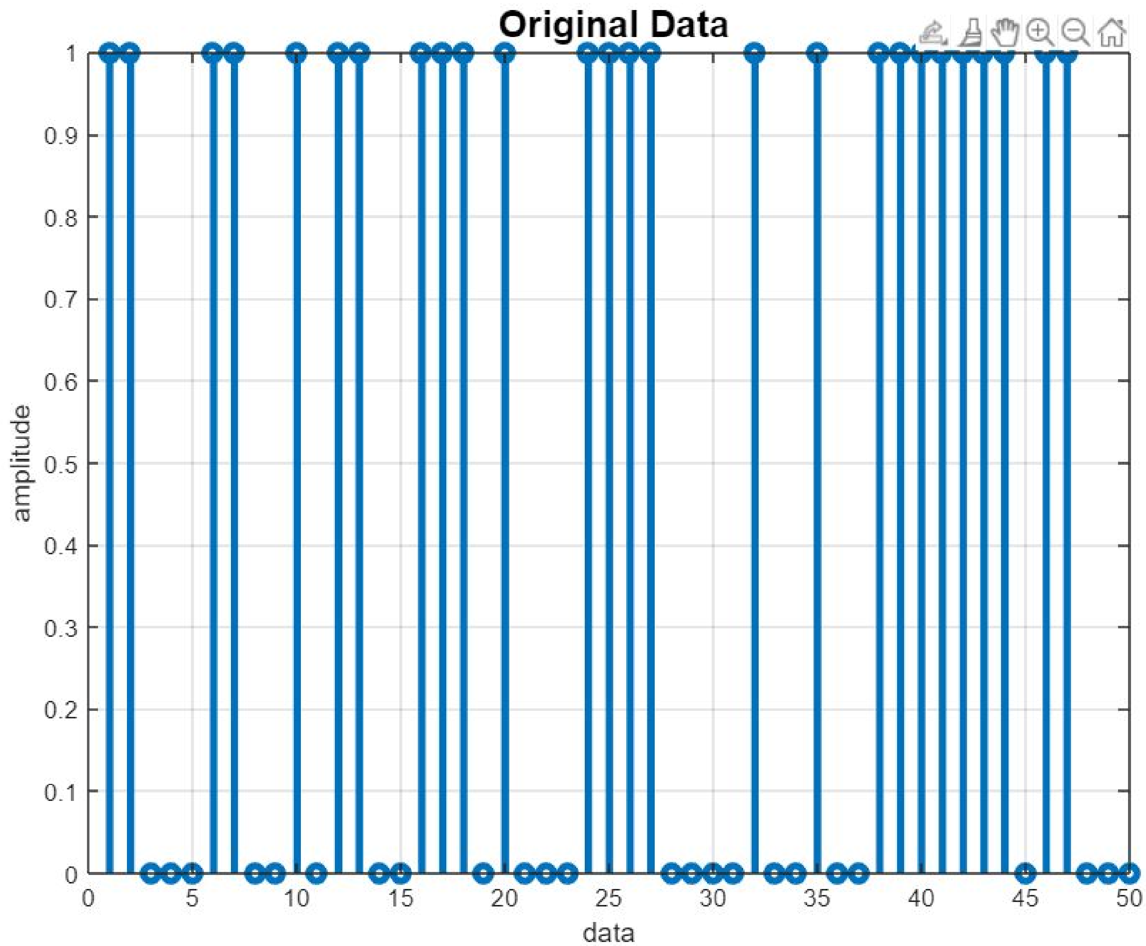
```
clc;
close all;

cnt=0;

data = randn(50,1);
for i=1:length(data)
if data(i)<=0
   data(i)=0;
elseif data(i)>0
   data(i)=1;
end
end

figure(1)
stem(data, 'linewidth',3), grid on; %plotting the data which is gonna send.
title(' Original Data ',"FontSize",15);
xlabel("data");
ylabel("amplitude");
axis([ 0 length(data) 0 1]);
data_NZR = 2*data-1; % Data Represented at NZR form for QPSK modulation
s_p_data = reshape(data_NZR,2,length(data)/2); % S/P conversion of data
br = 10.^6; %Let us transmission bit rate 1000000
f = br; % minimum carrier frequency
T = 1/br; % bit duration
t = T/99:T/99:T; % Time vector for one bit information

%%%% QPSK modulation %%%%%

y=[];
y_in=[];
y_qd=[];
y_noise =  [];

for i=1:length(data)/2
y1=s_p_data(1,i)*cos(2*pi*f*t); % inphase component
%disp("size of y1: "+size(t));
Y2 = s_p_data(2,i)*sin(2*pi*f*t) ;% Quadrature component
Y_in = [y_in y1]; % inphase signal vector
Y_qd = [y_qd y2]; %quadrature signal vector
noise = awgn(i,10,'measured'); %noise component
```

```
%noise= s_p_data(1,i)*(sin(2*pi*f*t)+randn(1,99));
%noise = ((sqrt(0.1)*(randn(1,99)+randn(1,99)))); %noise component
y_noise = [y_noise noise]; % noise vector
y=[y y1+y2+noise]; % modulated signal vector
%disp(y);
end

%disp("size of the noise"+size(y_noise));
Tx_sig=y; % transmitting signal after modulation
tt=T/99:T/99:(T*length(data))/2;
figure(2)
%disp("size of tt: "+size(tt));

subplot(4,1,1);
plot(tt,y_in,'linewidth',3), grid on;
title(' wave form for inphase component in QPSK modulation ',"FontSize",12);
xlabel('time(sec)');
ylabel(' amplitude(volt0)');

subplot(4,1,2);
plot(tt,y_qd,'linewidth',3), grid on;
title(' wave form for Quadrature component in QPSK modulation ',"FontSize",12);
xlabel('time(sec)');
ylabel(' amplitude(volt0');

subplot(4,1,3);
plot(y_noise,'linewidth',3), grid on;
title(' wave form for noise component in QPSK modulation ',"FontSize",12);
xlabel('time(sec)');
ylabel(' amplitude(volt0');

subplot(4,1,4);
plot(tt,Tx_sig,'r','linewidth',3), grid on;
title('QPSK modulated signal (sum of inphase and Quadrature phase signal and
noise)',"FontSize",12);
xlabel('time(sec)');
ylabel(' amplitude(volt0');

%%%%% QPSK demodulation %%%%

Rx_data=[];
Rx_sig=Tx_sig; % Received signal

for(i=1:1:length(data)/2)
   %%%     inphase coherent dictator %%%
   Z_in=Rx_sig((i-1)*length(t)+1:i*length(t)).*cos(2*pi*f*t);
```

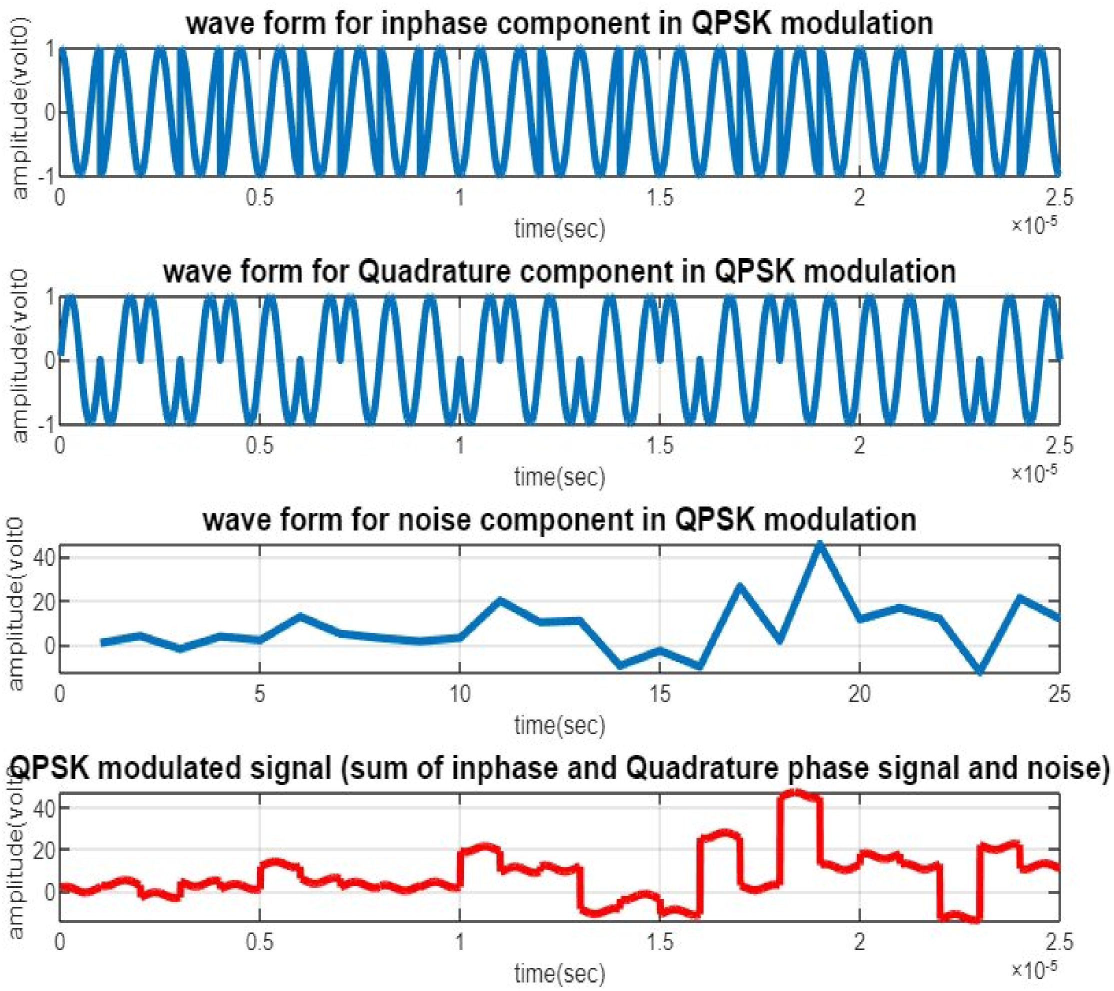
```
   % above line indicates multiplication of received & inphase carred signal
   Z_in_intg=(trapz(t,Z_in))*(2/T);% integration using trapezoidal rule
   if(Z_in_intg>0) % Decision Maker
       Rx_in_data=1;
   else
      Rx_in_data=0;
   end

   %%% Quadrature coherent dictator %%%

 Z_qd=Rx_sig((i-1)*length(t)+1:i*length(t)).*sin(2*pi*f*t);
   %above line indicate multiplication of received & Quad Phase carried signal
   Z_qd_intg=(trapz(t,Z_qd))*(2/T);%integration using trapezoidal rule
       if (Z_qd_intg>0)% Decision Maker
            Rx_qd_data=1;
       else
           Rx_qd_data=0;
       end
   Rx_data=[Rx_data  Rx_in_data  Rx_qd_data]; % Received Data vector

end
%disp(Rx_data);
%disp(length(Rx_data));
for i=1:length(Rx_data)
  if(data(i)~=Rx_data(i))
       cnt = cnt+1;
   end
   %disp("data is: "+data(i));
   %disp("Received data is: "+Rx_data(i));
end

figure(3)
stem(Rx_data,'linewidth',2)
title('Received Data ',"FontSize",15);
axis([ 0 length(data) 0 1]), grid on;

%disp("cnt is: "+cnt);
%disp("len of rx: "+length(Rx_data));
bit_error_probability = (cnt/length(Rx_data));
disp("bit error probability is:  "+bit_error_probability);
cnt=0;
```

Results: you can find a simulation of this link

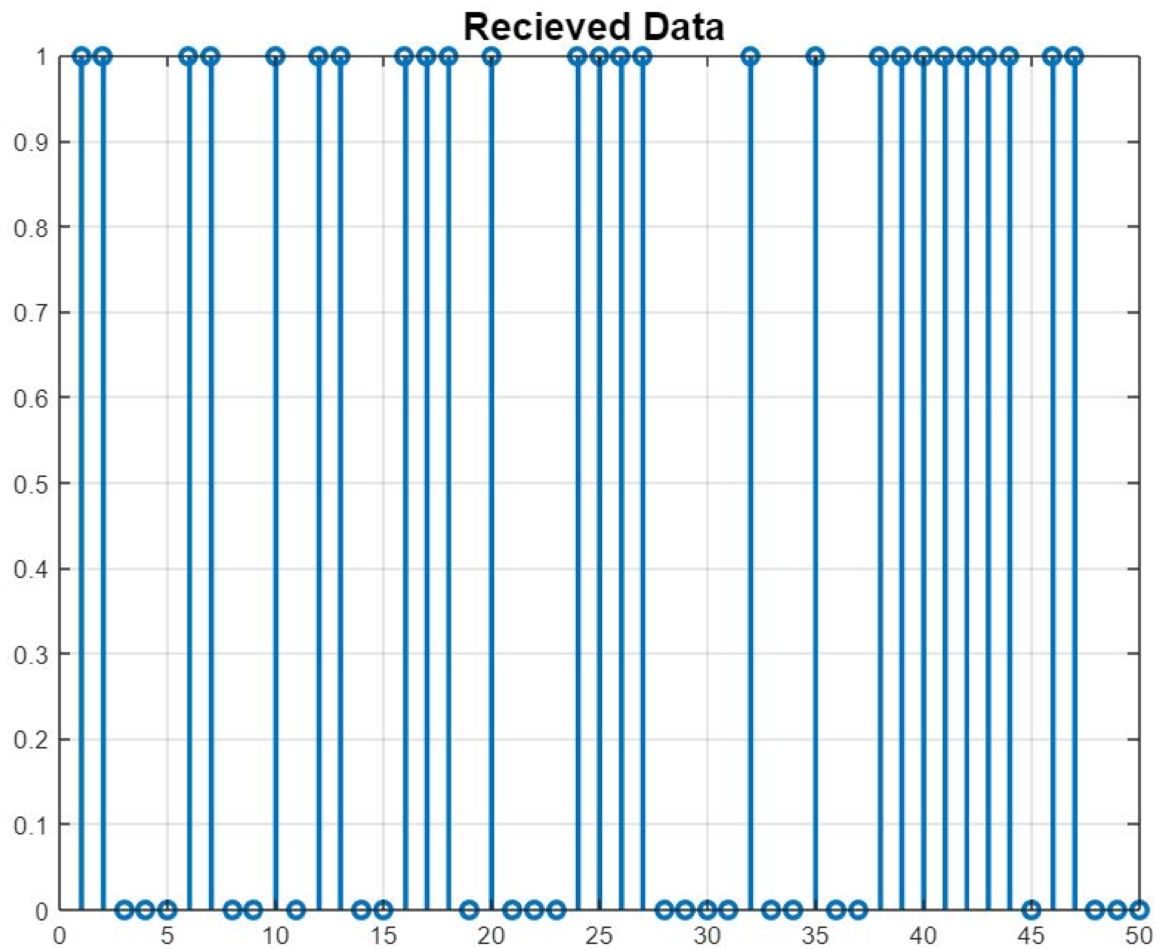
- **The first figure shows the input data.**



- **The second figure shows the two carrier signal and noise signal and the modulated signal.**



- **The third figure shows the demodulated data.**



- **The value of bit error probability for different ranges(for AWGN):**

0-500	0-0.01
500-2000	0.01-0.2
2000-500000	0.2-0.3

REFERENCES

1> T. D. Memon, W. Ghangro, B. S. Chowdhry and A. A. shaikh, "Quadrature Phase Shift Keying modulator & demodulator for Wireless Modem," 2009 2nd International Conference on Computer, Control and Communication, Karachi, 2009, pp. 1-6, DOI: 10.1109/IC4.2009.4909180.
link

2> notes on QPSK

3> QPSK modulation and Demodulation (with Matlab and Python implementation)

4> Quadrature Phase Shift Keying

5> Quadrature phase shift keying - File Exchange - MATLAB Central

6> Design and implementation of qpsk modulator using digital subcarrier Gongadi Nagaraju