# INSTITUTE OF ENGINEERING
# CENTRAL CAMPUS,PULCHOWK

COMMUNICATION SYSTEM II

LAB #3

# Digital Modulation

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Digital Modulation

# 2   Objective

To observe Different digital Modulation.

- Amplitude Shift Keying(ASK)

- Frequency Shift Keying (FSK)

- Binary Phase-shift keying (BPSK)

- Quadrature Amplitude Modulation (QAM)

# 3   Theory

## 3.1   Digital Modulation

Digital modulation means the encoding of a digital information signal into the transmitted signal's amplitude, phase, or frequency. Digital modulation offers more capacity for information, better data security, rapid system accessibility and good communications.

Some major Digital modulation schemes are:

### 3.1.1   Amplitude Shift Keying(ASK)

Amplitude Shift Keying is a type of amplitude modulation where Binary data is encoded into the amplitude of the transmitted signal. If $A$ is the amplitude of the modulated signal and $f_c$ is the carrier frequency.then modulated signal is :

$$s(t) = \begin{cases} A \cos\left(2\pi f_c t\right), & \text{for binary input 1} \\ 0, & \text{for binary input 0} \end{cases}$$

### 3.1.2   Frequency Shift Keying (FSK)

Frequency Shift Keying is a type of frequency modulation where Binary data is encoded into the frequency of the transmitted signal. If $f_1$ and $f_2$ are two distinct transmit frequencies then modulated signal is.

$$s(t) = \begin{cases} \sqrt{\frac{2E_b}{T_b}} \cos\left(2\pi f_1 t\right), \text{for bit 1} \\ \sqrt{\frac{2E_b}{T_b}} \cos\left(2\pi f_2 t\right), \text{for bit 0} \end{cases}$$

### 3.1.3   Binary Phase-shift keying (BPSK)

Binary Phase-shift keying is a type of phase modulation where Binary data is encoded into the phase of the transmitted signal. It is also called 2-phase PSK or Phase Reversal Keying. If $P = E_b/T_b$ is power of the transmitted signal and $f_c$ is the carrier frequency. then modulated signal is:

$$s(t) = \begin{cases} \sqrt{2P} \cos\left(2\pi f_c t\right), \text{for bit 1} \\ -\sqrt{2P} \cos\left(2\pi f_c t\right), \text{for bit 0} \end{cases}$$

### 3.1.4   Quadrature Amplitude Modulation (QAM)

Quadrature Amplitude Modulation is a type of amplitude modulation where Binary data is encoded into the both amplitude and phase of the transmitted signal. QAM p provide high levels of spectrum usage efficiency.QAM is a signal in which two 90-degree phase-shifted carriers (sine and cosine) are modulated and concatenated to form a single complex signal.

Quadrature amplitude modulation (QAM) is a technique used to transmit two digital bit streams or two analog signals by modulating or changing the amplitudes of two carrier waves so that they differ in phase by 90 degrees, a quarter of a cycle, hence the name quadrature.If $a_i$ and $b_j$ are signal amplitudes that are dependent on the message signal, then the quadrature amplitude modulation (QAM) signal is given by:

$$s(t) = \sqrt{\frac{2E_b}{T_b}} a_i \cos\left(2\pi f_c t\right) + \sqrt{\frac{2E_b}{T_b}} b_j \sin\left(2\pi f_c t\right)$$

# 4    Problems

## 4.1    Amplitude Shift Keying(ASK)

```matlab
clc;
clear all;
close all;
n=8;
x=randi([0,1],1,n); %random bit generator
bp=.000001; % bit period
%disp(' Binary information at Transmitter :');
disp(x);

N = length(x);
Tb = bp % 0.0001; %Data rate = 1MHz i.e., bit period (second)

% ************* Represent input information as digital signal *************

nb = 100; % Digital signal per bit
digit = [];
for n = 1:1:N
if x(n) == 1;
sig = ones(1,nb);
else x(n) == 0;
sig = zeros(1,nb);
end
digit = [digit sig];
end
t1 = Tb/nb:Tb/nb:nb*N*(Tb/nb); % Time period

%figure('Name','ASK Modulation','NumberTitle','off');
subplot(2,1,1);
plot(t1,digit,'LineWidth',2.5);
grid on;
axis([0 Tb*N -0.5 1.5]);
xlabel('Time(Sec)');
ylabel('Amplitude(Volts)');
title('Digital Input Signal');

% *************************** ASK Modulation ****************************
Ac1 = 12; % Carrier amplitude for binary input '1'
Ac2 = 0; % Carrier amplitude for binary input '0'
br = 1/Tb; % Bit rate
Fc = br*10; % Carrier frequency
t2 = Tb/nb:Tb/nb:Tb; % Signal time
mod = [];
for (i = 1:1:N)
if (x(i) == 1)
y = Ac1*cos(2*pi*Fc*t2); % Modulation signal with carrier signal 1
else
y = Ac2*cos(2*pi*Fc*t2); % Modulation signal with carrier signal 2
end
mod = [mod y];
end
t3 = Tb/nb:Tb/nb:Tb*N; % Time period
subplot(2,1,2);
plot(t3,mod);
xlabel('Time(Sec)');
ylabel('Amplitude(Volts)');
title('ASK Modulated Signal');
sgtitle('(PUL074BEX004)');
% ******************** Transmitted signal x ***************************
```

Code 1: MATLAB code Amplitude Shift Keying

# (PUL074BEX004)

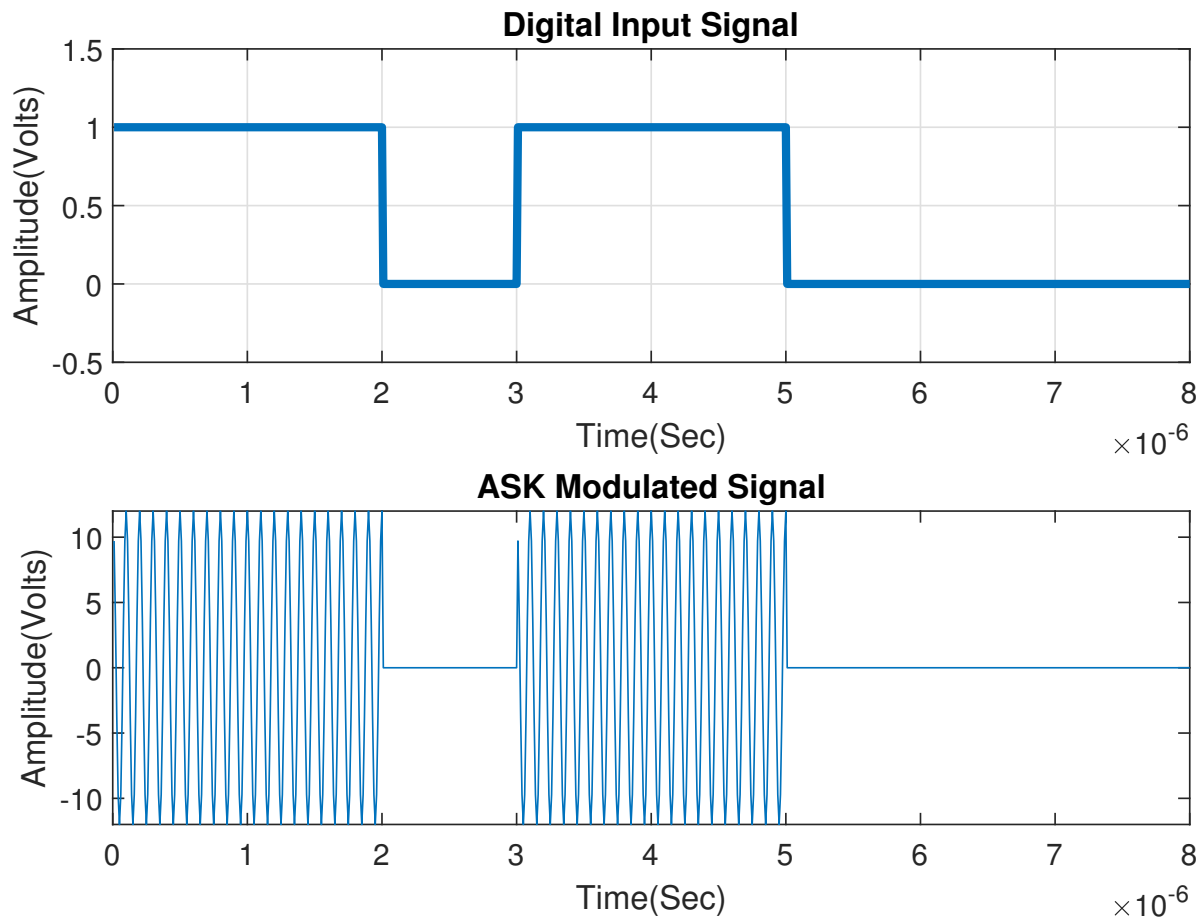## Digital Input Signal



Figure 1: Simulation of Amplitude Shift Keying

## 4.2 Frequency Shift Keying (FSK)

```
1   clc %for clearing the command window
2   close all %for closing all the window except command window
3   clear all %for deleting all the variables from the memory
4   fc1=10 %input('Enter the freq of 1st Sine Wave carrier:');
5   fc2=30 %input('Enter the freq of 2nd Sine Wave carrier:');
6   fp=5 %input('Enter the freq of Periodic Binary pulse (Message):');
7   amp=1 %input('Enter the amplitude (For Both Carrier & Binary Pulse Message):');
8   %amp=amp/2;
9   t=0:0.001:1; % For setting the sampling interval
10  c1=amp.*sin(2*pi*fc1*t);% For Generating 1st Carrier Sine wave
11  c2=amp.*sin(2*pi*fc2*t);% For Generating 2nd Carrier Sine wave
12  subplot(4,1,1); %For Plotting The Carrier wave
13  plot(t,c1)
14  xlabel('Time')
15  ylabel('Amplitude')
16  title('Carrier 1 Wave')
17  ylim([-1.2 1.2])
18  subplot(4,1,2) %For Plotting The Carrier wave
19  plot(t,c2)
20  xlabel('Time')
21  ylabel('Amplitude')
22  title('Carrier 2 Wave')
```

```
23   ylim([-1.2 1.2])
24   m=amp.*square(2*pi*fp*t)+amp;%For Generating Square wave message
25   subplot(4,1,3) %For Plotting The Square Binary Pulse (Message)
26   plot(t,m)
27   xlabel('Time')
28   ylabel('Amplitude')
29   ylim([0 2.5])
30   title('Binary Message Pulses')
31   for i=0:1000 %here we are generating the modulated wave
32   if m(i+1)==0
33   mm(i+1)=c1(i+1);
34   else
35   mm(i+1)=c2(i+1);
36   end
37   end
38   subplot(4,1,4) %For Plotting The Modulated wave
39   plot(t,mm)
40   ylim([-1.2 1.2])
41   xlabel('Time')
42   ylabel('Amplitude')
43   title('Modulated Wave')
44   sgtitle('(PUL074BEX004)');
```

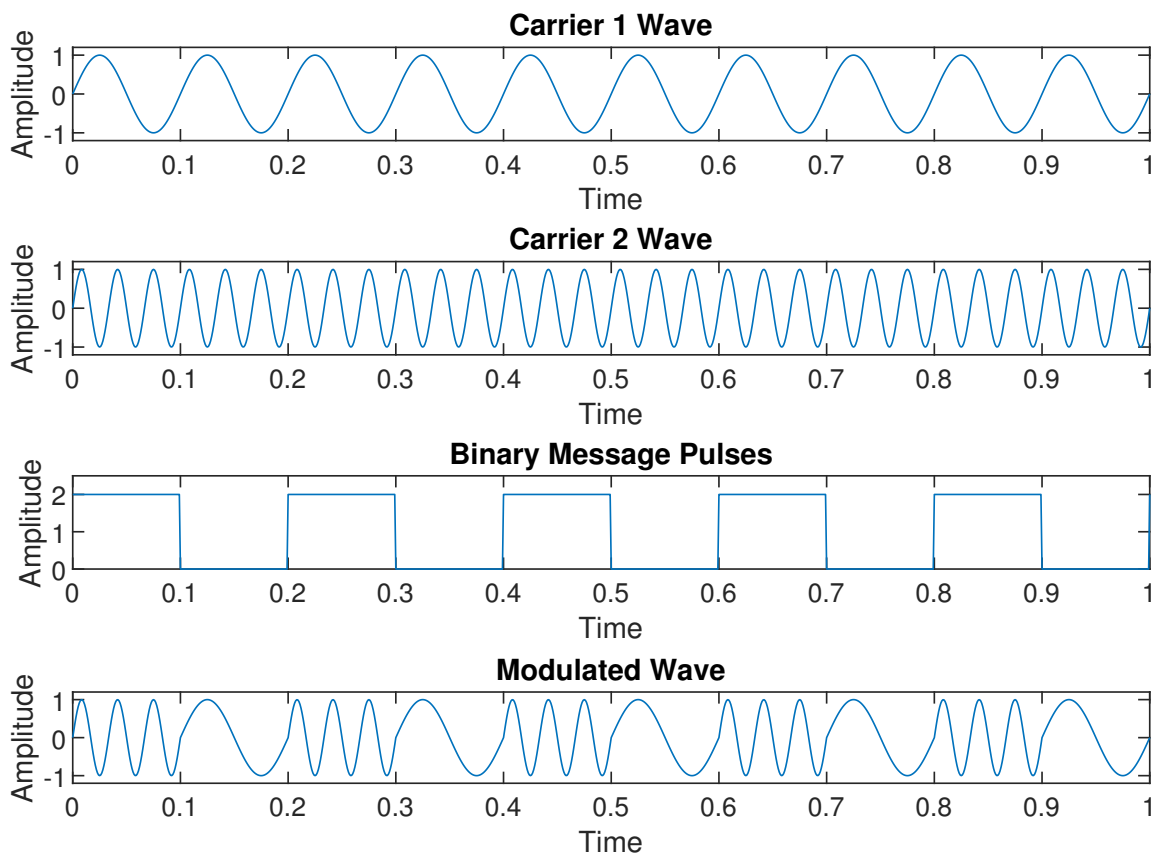Code 2: MATLAB code Frequency Shift Keying

# (PUL074BEX004)



Figure 2: Simulation of Frequency Shift Keying

## 4.3 Binary Phase-shift keying (BPSK)

```matlab
clc;
clear all;
close all;
n=8;
x=randi([0,1],1,n); %random bit generator
bp=.000001; % bit period
disp(' Binary information at Trans mitter :');
disp(x);
% representation of transmitting binary information as digital signal
bit=[];
for n=1:1:length(x)
if x(n)==1;
se=ones(1,100);
else
se=zeros(1,100);
end
bit=[bit se];
end
t1=bp/100:bp/100:100*length(x)*(bp/100);
subplot(3,1,1);
plot(t1,bit,'lineWidth',2.5);grid on;
axis([ 0 bp*length(x) -.5 1.5]);
ylabel('amplitude(volts)');
xlabel(' time(sec)');
title('Binary data in the form of a digital signal');
%XXXXXXXXXXXXXXXXXXXXXX Binary-PSK modulation XXXXXXXXXXXXXXXXXXXXXXXXXXXX
A=5; % Amplitude of carrier signal
br=1/bp; % bit rate
f=br*2; % carrier frequency
t2=bp/99:bp/99:bp;
ss=length(t2);
m=[];
kl=[];
for i=1:1:length(x)
wave=A*sin(2*pi*f*t2);
kl=[kl wave];
end
for i=1:1:length(x)
if (x(i)==1)
y=A*sin(2*pi*3*f*t2);
else
y=A*sin(2*pi*3*f*t2+pi); %-A*sin(2*pi*f*t)
end
m=[m y];
end
t3=bp/99:bp/99:bp*length(x);
subplot(3,1,2);
plot(t3,kl);grid on;
xlabel('time(sec)');
ylabel('amplitude(volt)');
title('Carrier Signal');
subplot(3,1,3);
plot(t3,m);grid on;
xlabel('time(sec)');
ylabel('amplitude(volt)');
title('PSK modulated wave coresponding to binary information at the transmitter')
;
sgtitle('(PUL074BEX004)');
```

Code 3: MATLAB code Binary Phase-shift keying

# (PUL074BEX004)

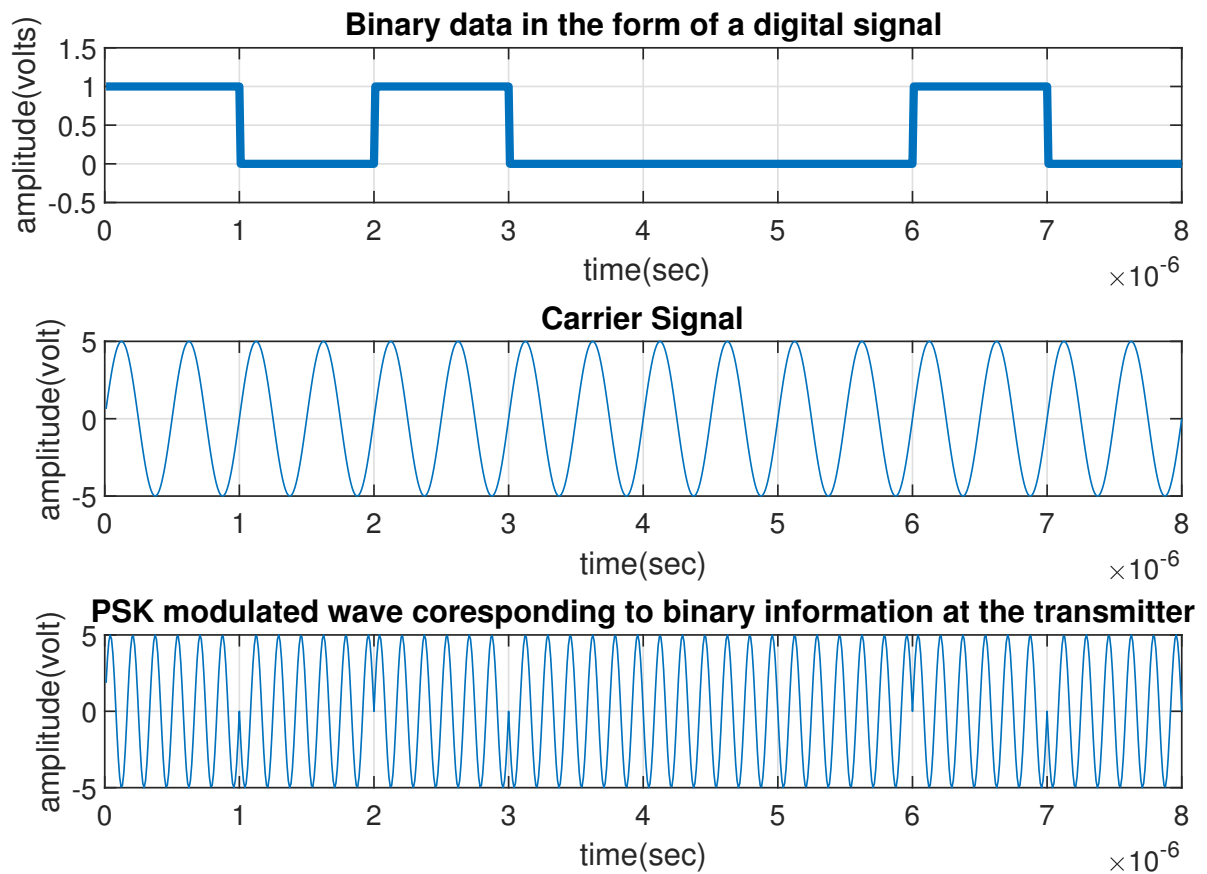**Binary data in the form of a digital signal**

**Carrier Signal**

**PSK modulated wave coresponding to binary information at the transmitter**

Figure 3: Simulation of Binary Phase-shift keying

## 4.4   Quadrature Amplitude Modulation (QAM)

```matlab
M = 4;      % M number of symbols
N = 10;     % No. sybmols to generate
x = randi( M, N, 1 )-1;  % Generate random combination of symbols as the message
    signal
s = qammod( x, M);       % Produce I and Q compnents of the QAM modulated message
    signal

Tb = 0.2;    % Bit time of 0.2 seconds
duration = Tb * length(s);
sampling_period = 0.001;
Tvec = [];
modulated_signal = [];
message_signal = [];
time = 0.0;
fc = 10;
for i = 1:length(s)
  t = time + (0:sampling_period:Tb);
  msig  = real(s(i))*cos(2*pi*fc*t) - imag(s(i))*sin(2*pi*fc*t);
  modulated_signal = [modulated_signal msig];

  m = ones(1,length(t)) .* x(i);
  message_signal = [message_signal m];
```

```matlab
21
22    Tvec = [Tvec t];
23    time = time + Tb;
24  end
25
26  % Generate base carrier wave
27  carrier = cos( 2 * pi *fc * Tvec);
28
29  subplot(3,1,1)
30  plot(Tvec,message_signal)
31  xlim([0 duration])
32  ylim([0 M])
33  xlabel('Time (seconds)')
34  ylabel('Symbol')
35  title('Digial message signal')
36  subplot(3,1,2)
37  plot(Tvec,carrier)
38  xlim([0 duration])
39  ylim([-1.2 1.2])
40  xlabel('Time (seconds)')
41  ylabel('Amplitude')
42  title('Carrier signal')
43  subplot(3,1,3)
44  plot(Tvec,modulated_signal)
45  xlim([0 duration])
46  ylim([-1.5 1.5])
47  xlabel('Time (seconds)')
48  ylabel('Amplitude')
49  title('Modulated signal')
50  sgtitle('(PUL074BEX004)');
```

Code 4: MATLAB code Quadrature Amplitude Modulation
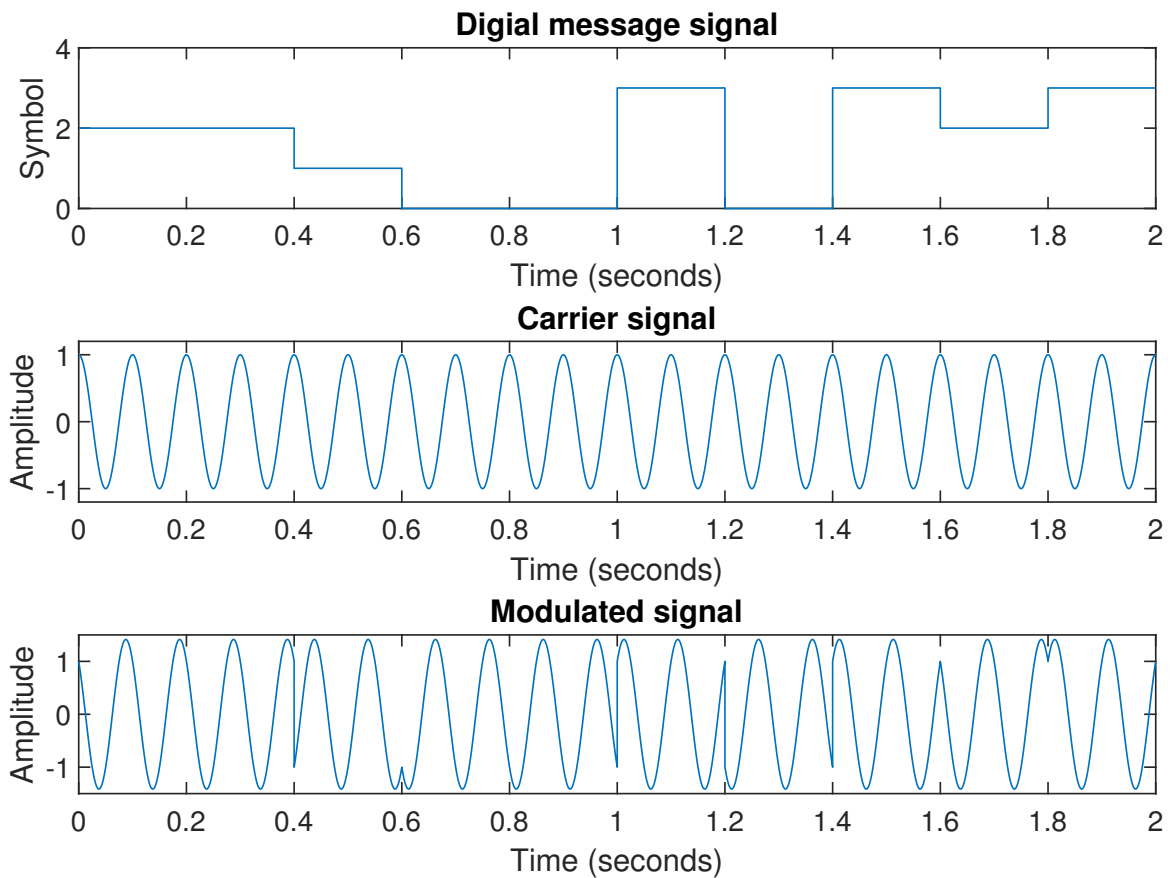
# (PUL074BEX004)



Figure 4: Simulation of Quadrature Amplitude Modulation

## 5   Discussion and Conclusion

In this Lab we performed the major types of Digital modulation.  Amplitude Shift Keying(ASK) ,
Frequency Shift Keying(FSK) , Binary Phase-shift keying(BPSK) and Quadrature Amplitude Modu-
lation(QAM) are the most used Digital modulation schemes. **ASK** is the most used scheme for voice
transmission and binary data is encoded into amplitude of the transmitted signal. Similarly in **FSK**
binary data is encoded into frequency of the transmitted signal. In **BPSK** binary data is encoded into
phase where as in **QAM** binary data is encoded into both amplitude and phase of the transmitted
signal.We used MATLAB, its modules and functions to perform the above tasks and fulfill our Lab
objectives.