INSTITUTE OF ENGINEERING
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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 :

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

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.

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

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:

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

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:

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

4 Problems

4.0.1 Amplitude Shift Keying(ASK)

```
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

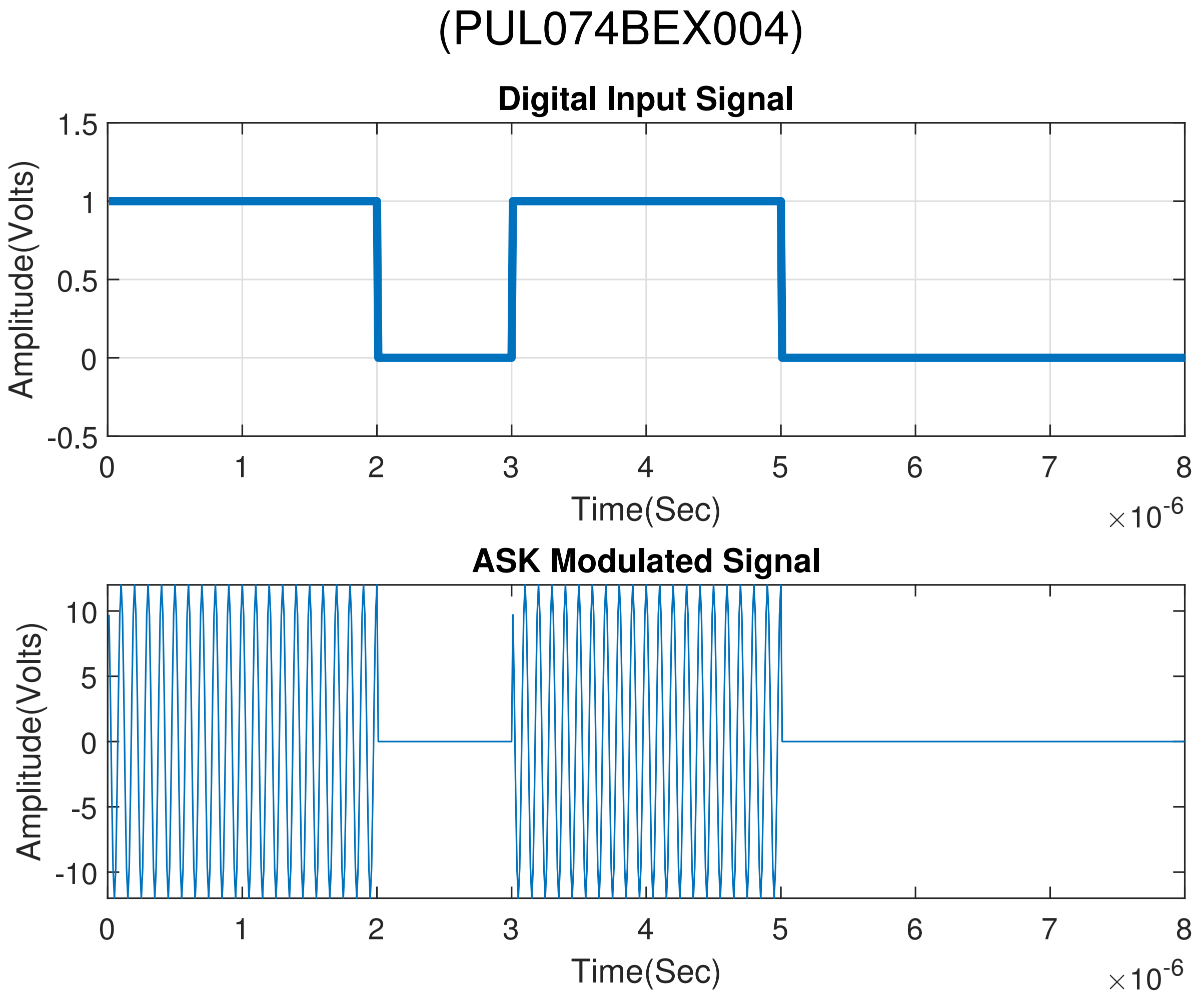

Figure 1: Simulation of Amplitude Shift Keying

4.0.2 Frequency Shift Keying (FSK)

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

```
ylim([-1.2 1.2])
m=amp.*square(2*pi*fp*t)+amp;%For Generating Square wave message
subplot(4,1,3) %For Plotting The Square Binary Pulse (Message)
plot(t,m)
xlabel('Time')
ylabel('Amplitude')
ylim([0 2.5])
title('Binary Message Pulses')
for i=0:1000 %here we are generating the modulated wave
if m(i+1)==0
mm(i+1)=c1(i+1);
else
mm(i+1)=c2(i+1);
end
end
subplot(4,1,4) %For Plotting The Modulated wave
plot(t,mm)
ylim([-1.2 1.2])
xlabel('Time')
ylabel('Amplitude')
title('Modulated Wave')
sgtitle('(PUL074BEX004)');
```

Code 2: MATLAB code Frequency Shift Keying

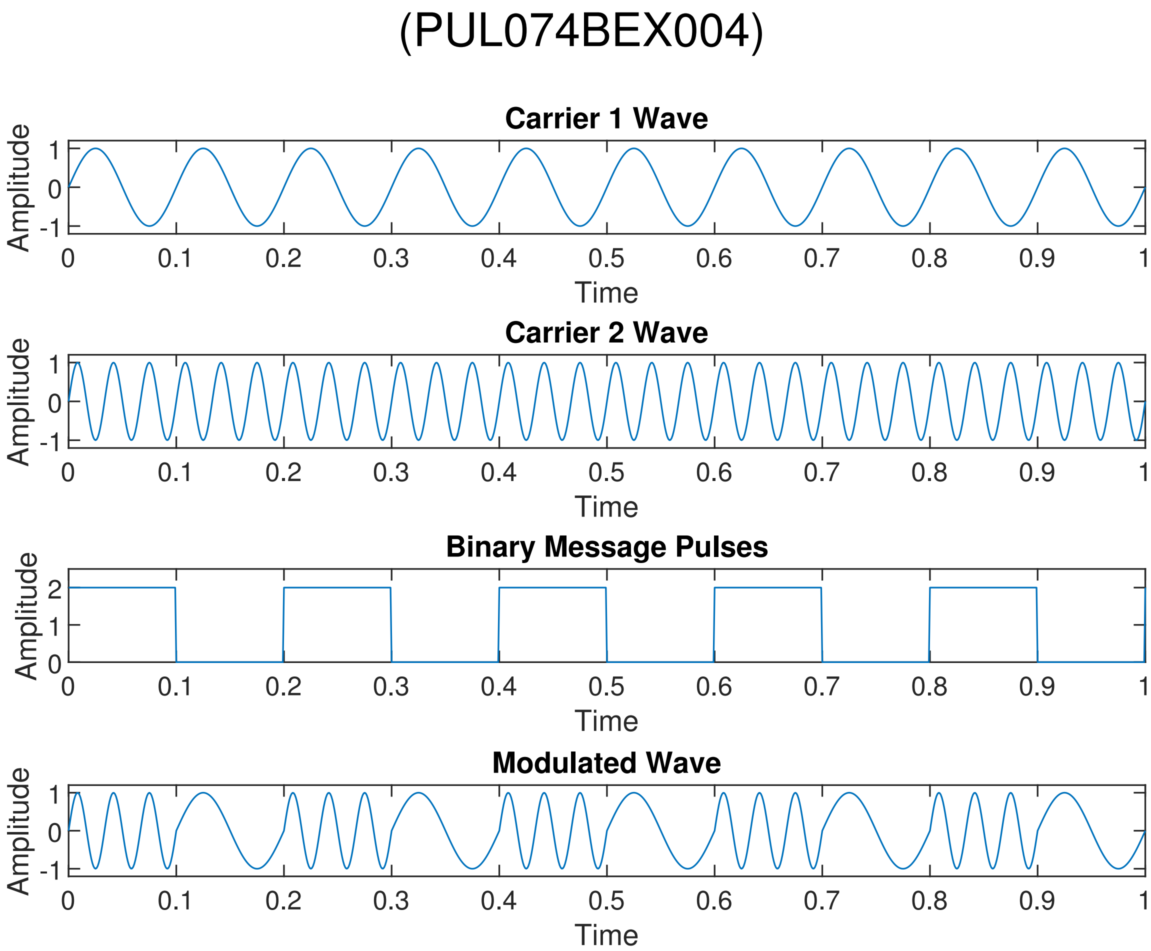

Figure 2: Simulation of Frequency Shift Keying

4.0.3 Binary Phase-shift keying (BPSK)

```
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');
%XXXXXXXXXXXXXXXXXXXXXXX Binary-PSK modulation XXXXXXXXXXXXXXXXXXXXXXXXXX
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

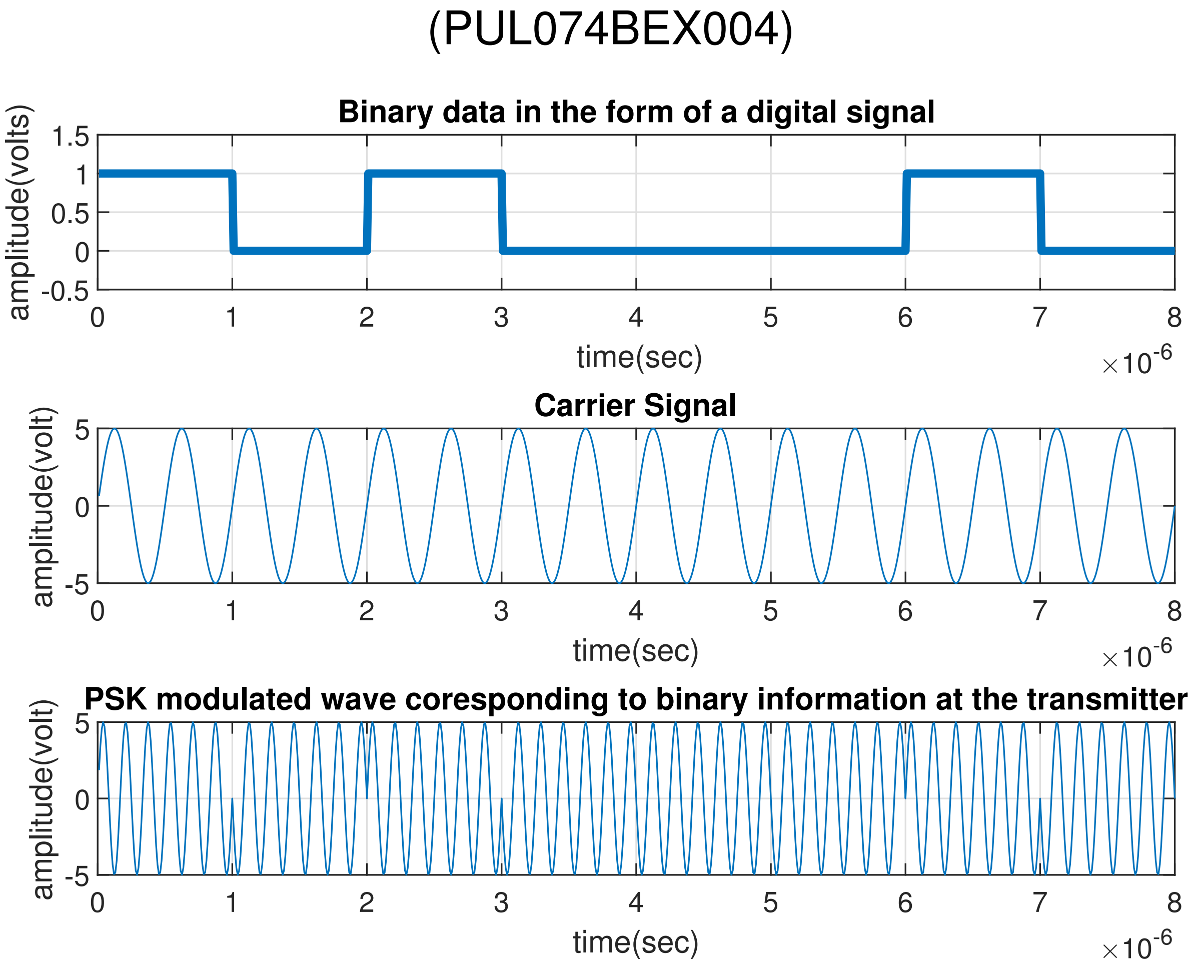

Figure 3: Simulation of Binary Phase-shift keying

4.0.4 Quadrature Amplitude Modulation (QAM)

```
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

    Tvec = [Tvec t];
    time = time + Tb;
  end

  % Generate base carrier wave
  carrier = cos( 2 * pi *fc * Tvec);

  subplot(3,1,1)
  plot(Tvec,message_signal)
  xlim([0 duration])
  ylim([0 M])
  xlabel('Time (seconds)')
  ylabel('Symbol')
  title('Digial message signal')
  subplot(3,1,2)
  plot(Tvec,carrier)
  xlim([0 duration])
  ylim([-1.2 1.2])
  xlabel('Time (seconds)')
  ylabel('Amplitude')
  title('Carrier signal')
  subplot(3,1,3)
  plot(Tvec,modulated_signal)
  xlim([0 duration])
  ylim([-1.5 1.5])
  xlabel('Time (seconds)')
  ylabel('Amplitude')
  title('Modulated signal')
  sgtitle('(PUL074BEX004)');
```

Code 4: MATLAB code Quadrature Amplitude Modulation

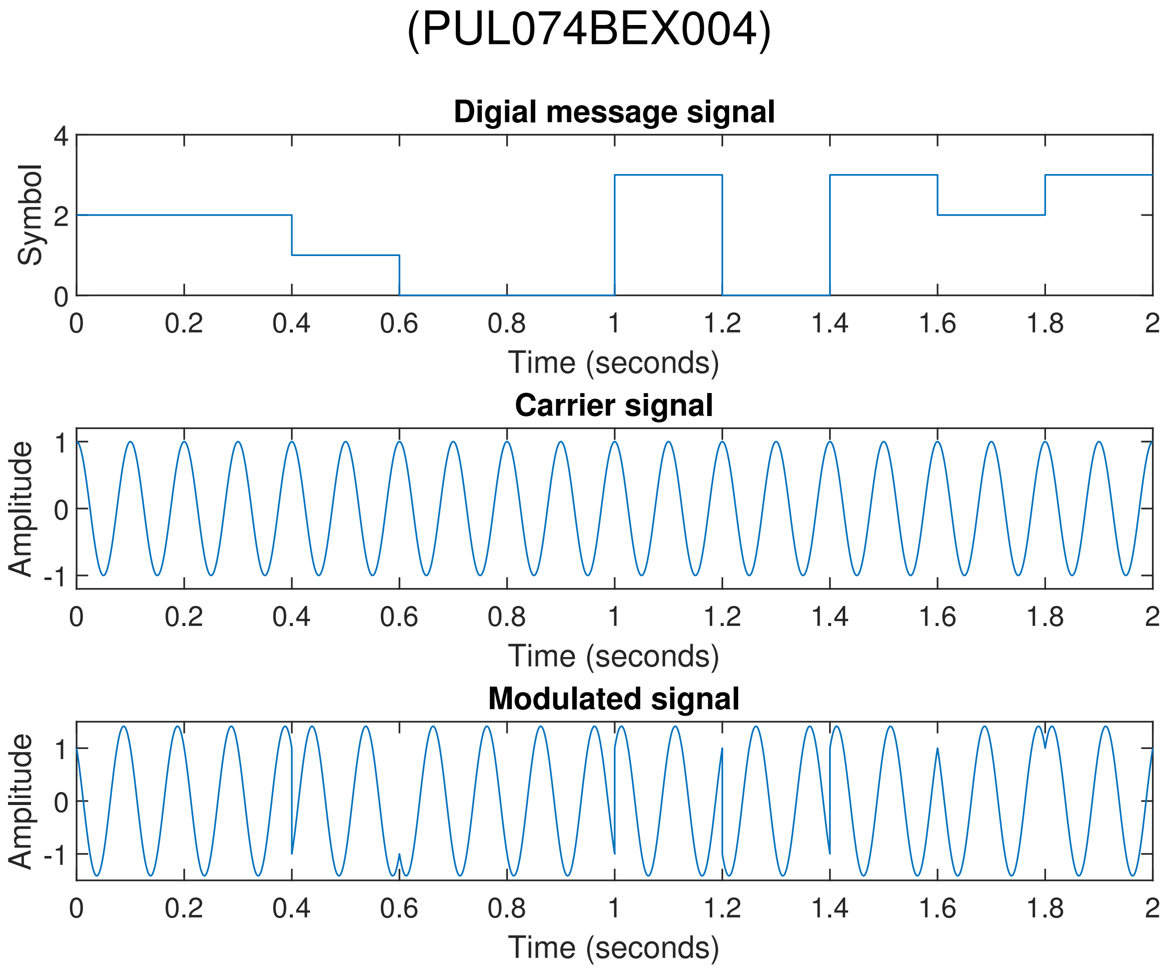

Figure 4: Simulation of Quadrature Amplitude Modulation

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 Modulation(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.