22AIE211 Introduction to Communications and IoT

Lab sheet-2

Signal Modulation and Demodulation Techniques

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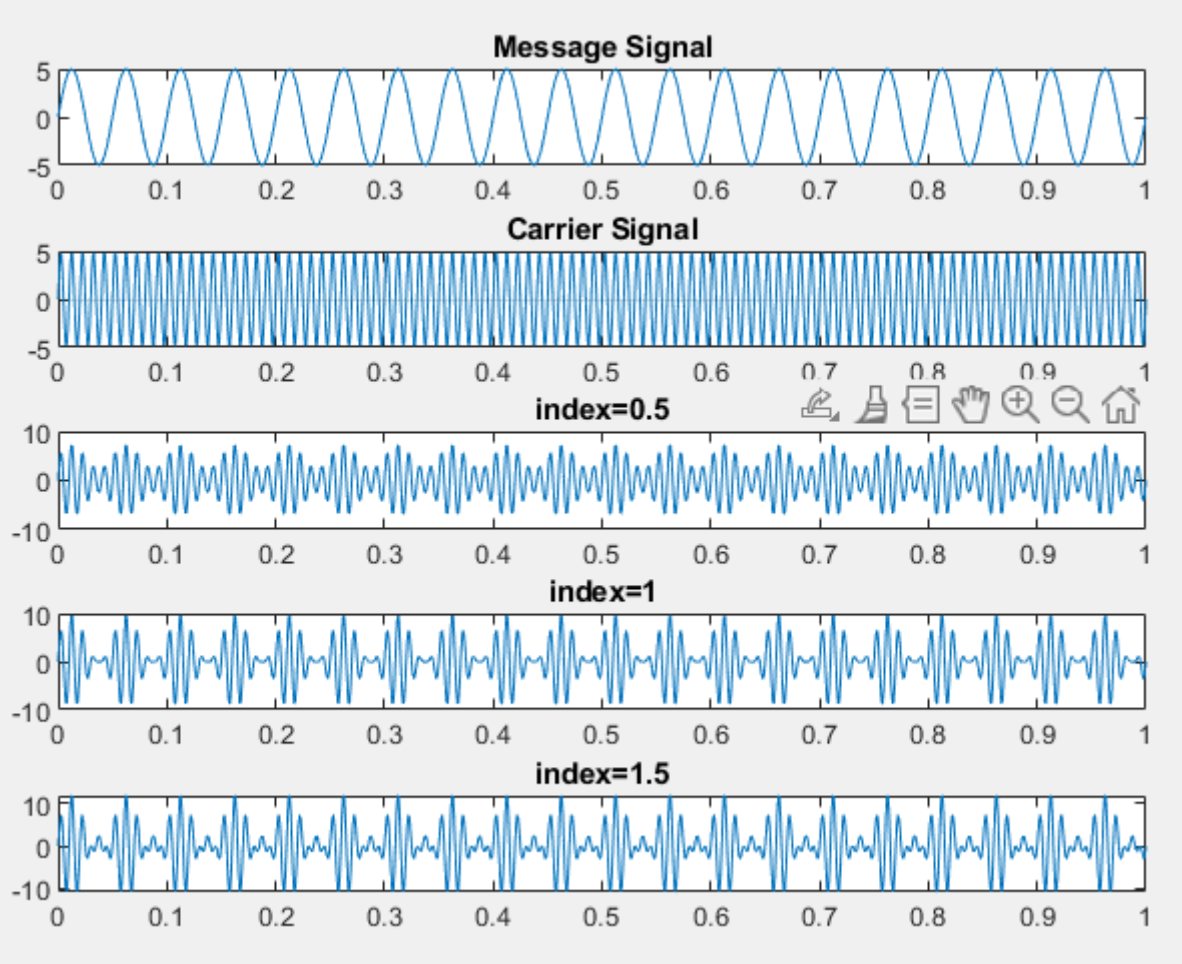
Submission Date: 3/5/24

1. Generate AM wave for different modulation indices(m=1, 0.5 and 1.5). Plot all the waveforms(in a single figure).(Am=Ac=5V, fs=1000Hz, fm=20Hz, fc=200Hz)

```
clc;
close all;
clear all;

m = [0.5 1 1.5];

Am = 5; %Amp. of modulating signal
fm = 20; %frequency of modulating signal
Tm = 1/fm;
t = 0:0.001:1;
ym = Am*sin(2*pi*fm*t);

subplot(5,1,1);
plot(t,ym)
title('Message Signal');

%Carrier signal

Ac = Am;
fc = 100;
Tc = 1/fc;
yc = Ac*sin(2*pi*fc*t);
subplot(5,1,2);
plot(t,yc)
grid on;
title('Carrier Signal');

%AM Modulation
index = 0;
titles = {'index=0.5', 'index=1', 'index=1.5'};
for i = m
    subplot(5,1,3+index);
    index = index + 1;
    y = Ac * (1+i*sin(2*pi*fm*t)).*sin(2*pi*fc*t);
    plot(t,y)
    title(titles{index});
```

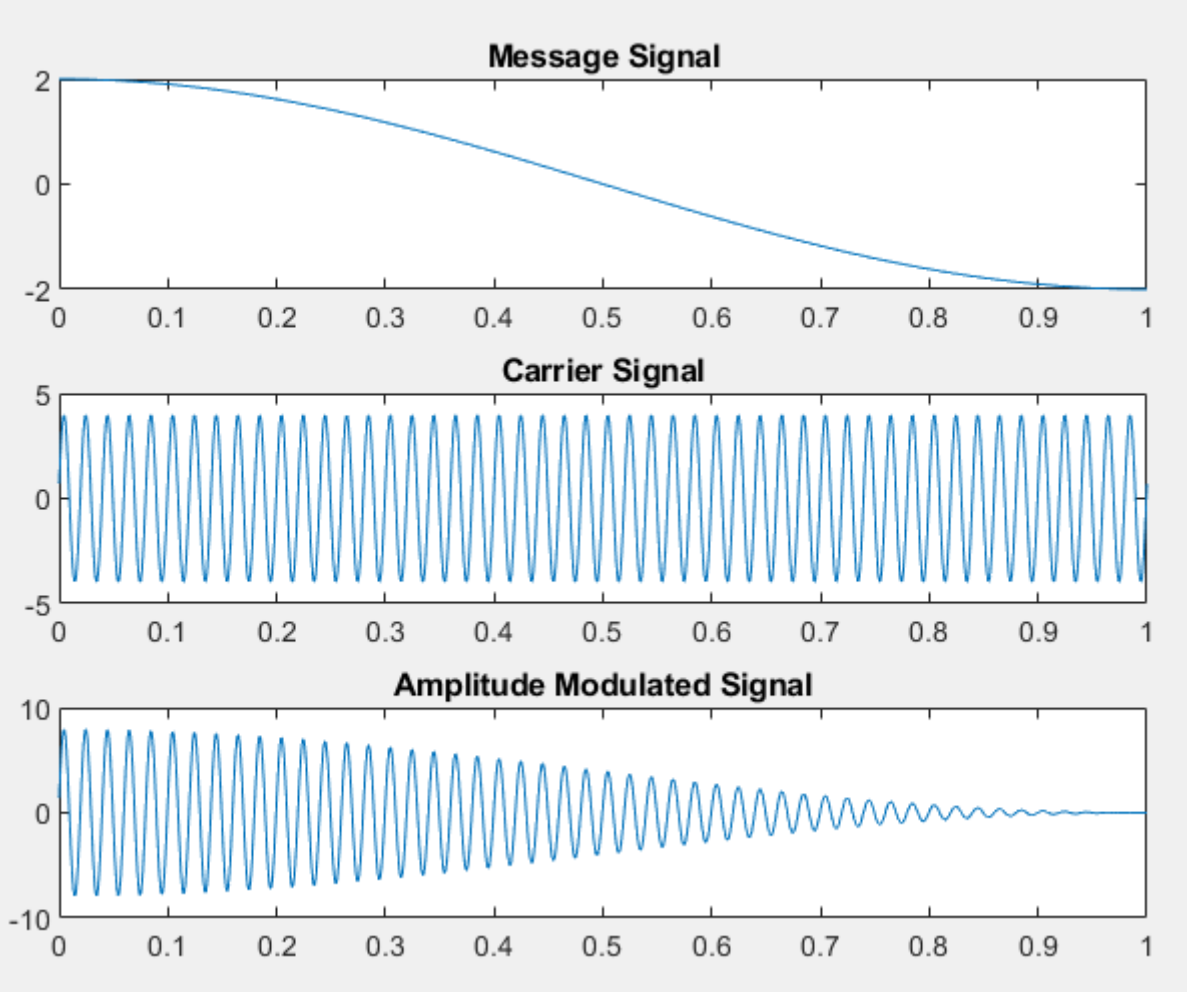
```
end
```



2. Generate an AM wave with message signal 2cos(πt) and carrier 4Sin(1000πt +10).

(Use deg2rad() function to convert phase from degrees to radians)

```
clc;
close all;
clear all;

t = 0:0.001:1;

ym = 2*cos(pi*t); % message signal
yc = 4*sin(100*pi*t + deg2rad(10)); % carrier signal
yam = 4*(1+cos(pi*t)).*sin(100*pi*t + deg2rad(10)); % Amplitude modulated Signal

subplot(3, 1, 1);
plot(t, ym);
title("Message Signal");

subplot(3, 1, 2);
plot(t, yc);
title("Carrier Signal");

subplot(3, 1, 3);
plot(t, yam);
title("Amplitude Modulated Signal");
```

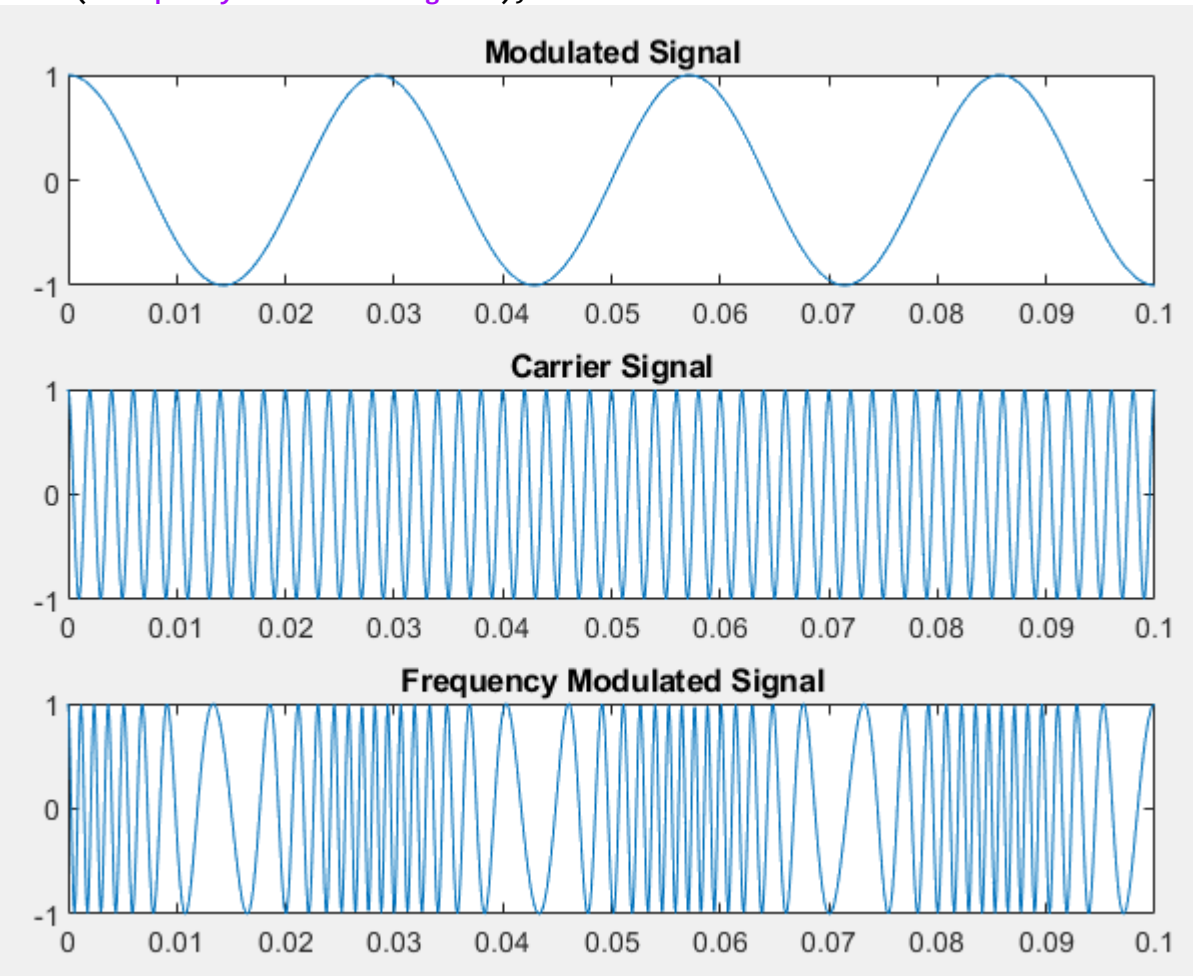


3. Generate an FM signal with m_f =10.

   (fs=10KHz, fm=35Hz, fc=500Hz, Am=Ac=1V, time vector, t=(0:.1*fs)/fs))

```
clc;
close all;
clear all;

mf = 10;
fs = 10000;
fm = 35;
fc = 500;
Am = 1;
Ac = 1;
t = 0:1/fs:0.1;

ym = Am*cos(2*pi*fm*t);
yc = Ac*cos(2*pi*fc*t);
yfm = Ac*cos(2*pi*fc*t + mf*sin(2*pi*fm*t));

subplot(3, 1, 1);
plot(t, ym);
title("Modulated Signal");

subplot(3, 1, 2);
plot(t, yc);
```

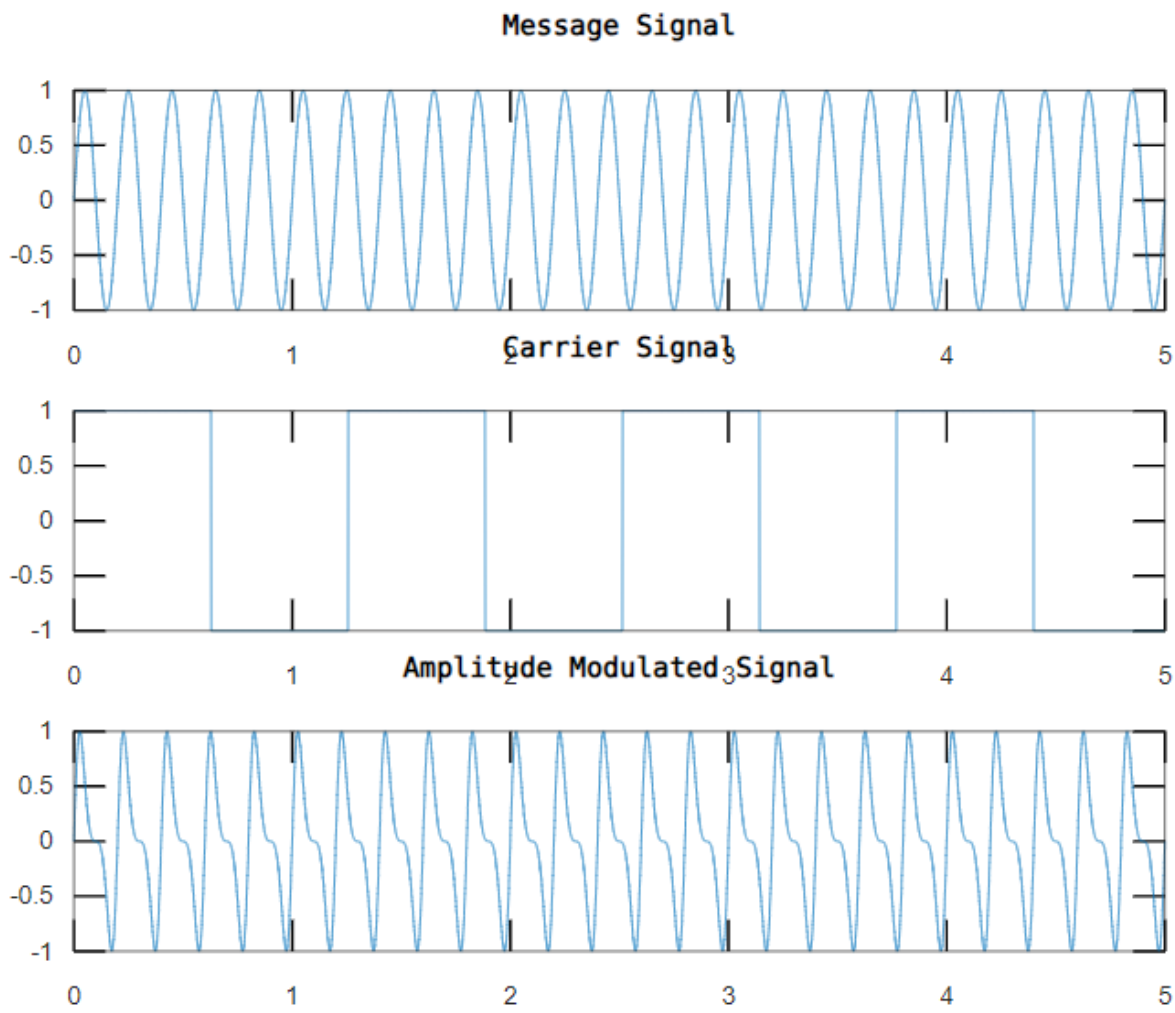
```
title("Carrier Signal");

subplot(3, 1, 3);
plot(t, yfm);
title("Frequency Modulated Signal");
```



4. Generate an FM signal when message input is a sinusoidal wave and carrier is a rectangular waveform. (use in-built function, fmmod())

```
clc;
close all;
clear all;

t = 0:0.001:5;

ym = sin(2*pi*5*t);
yc = square(5*t);
yam = sin(2*pi*5*t + ym);

subplot(3, 1, 1);
plot(t, ym);
title("Message Signal");

subplot(3, 1, 2);
plot(t, yc);
title("Carrier Signal");
```

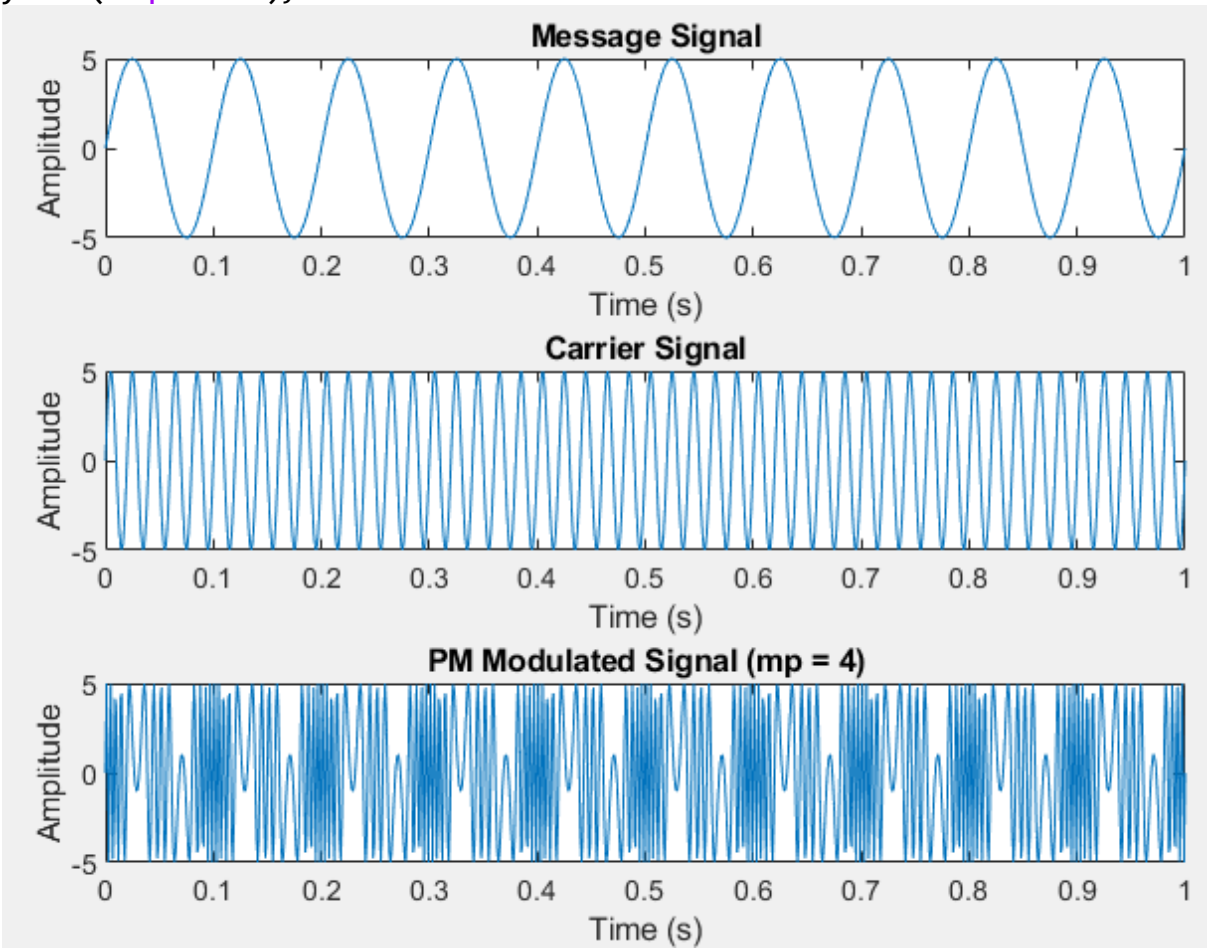
```
subplot(3, 1, 3);
plot(t, yam);
title("Amplitude Modulated Signal");
```



5. Generate a PM signal for modulation index, $m_p = 4$. (Am=Ac = 5V, fm = 10Hz, fc=50Hz, timevector, t = 0:0.001:1).

```
clc;
close all;
clear all;

t = 0:0.001:1;

ym = 5 * sin(2*pi*10*t);
yc = 5 * sin(2*pi*50*t);
ypm = 5 * sin(2*pi*50*t + 4*ym);

subplot(3,1,1);
plot(t, ym);
title('Message Signal');
xlabel('Time (s)');
ylabel('Amplitude');
```

```
subplot(3,1,2);
plot(t, yc);
title('Carrier Signal');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(3,1,3);
plot(t, ypm);
title('PM Modulated Signal (mp = 4)');
xlabel('Time (s)');
ylabel('Amplitude');
```

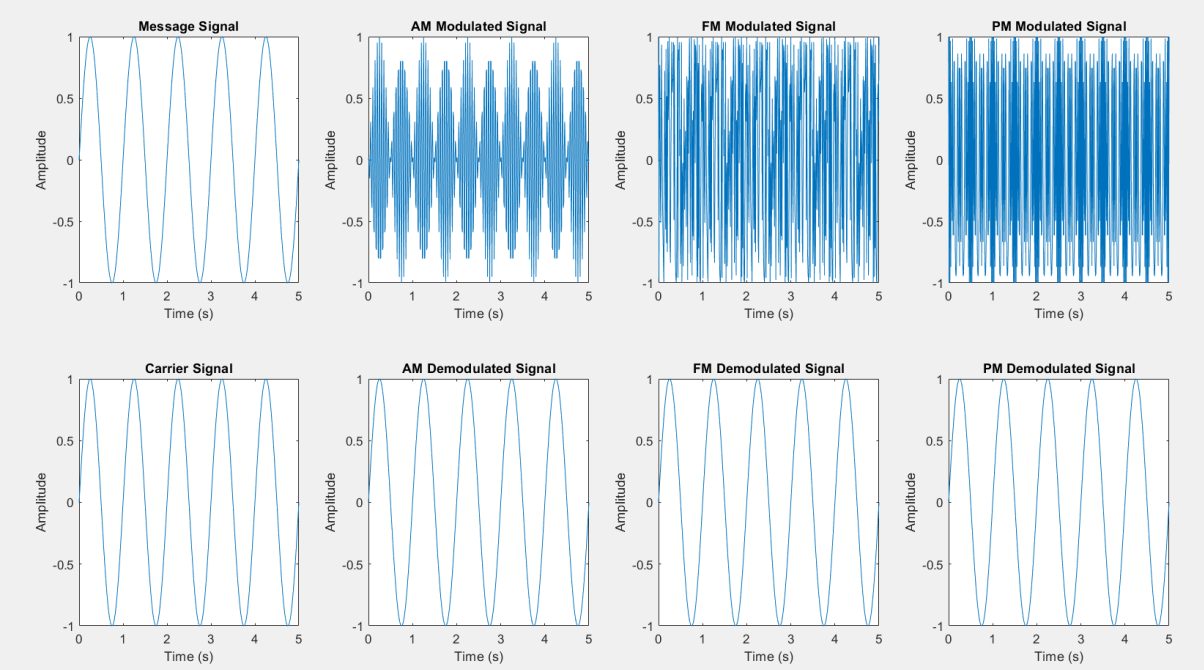


6. Generate the following signals using in-built functions in MATLAB. Perform both modulation and demodulation.
   a. AM signal (over modulation)
   b. FM signal
   c. PM signal

```
clc;
close all;
clear all;

cf = 1;
Fs = 100;
```

```
mi_am = 5;
mi_fm = 5;
mi_pm = 2;
t = 0:1/Fs:5;
ym = sin(2*pi*1*t);
yc = sin(2*pi*cf*t);

yam = ammod(ym, cf, cf*mi_am);
tam = amdemod(yam, cf, cf*mi_am);

yfm = fmmod(ym, cf, cf*mi_fm, Fs);
tfm = fmdemod(yfm, cf, Fs, cf*mi_fm);

ypm = pmmod(ym, cf, cf*mi_pm, Fs);
tpm = pmdemod(ypm, cf, Fs, cf*mi_pm);

subplot(2,4,1);
plot(t, ym);
title('Message Signal');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(2,4,5);
plot(t, yc);
title('Carrier Signal');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(2,4,2);
plot(t, yam);
title('AM Modulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(2,4,3);
plot(t, yfm);
title('FM Modulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(2,4,4);
plot(t, ypm);
title('PM Modulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(2,4,6);
plot(t, tam);
title('AM Demodulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(2,4,7);
plot(t, tfm);
title('FM Demodulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(2,4,8);
```

```
plot(t, tpm);
title('PM Demodulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');
```



7. Generate ASK, FSK, PSK signal.

```
clc;
close all;
clear all;

x = [1 0 0 1 1 0 1];
bp = 0.000001;

A1 = 10;
A2 = 0;

f1 = 10 / bp;
f0 = 5 / bp;

phi1 = 0;
phi0 = pi;

t_bit = bp / 100;

bit = [];
for n = 1:length(x)
    if x(n) == 1
        se = ones(1, 100);
    else
        se = zeros(1, 100);
    end
```

```
    bit = [bit se];
end
t1 = t_bit : t_bit : 100 * length(x) * t_bit;

% ASK modulation
f = 10 / bp;
m_ask = [];
for i = 1:length(x)
    if x(i) == 1
        y = A1 * cos(2 * pi * f * t_bit : 2 * pi * f * t_bit : 2 * pi * f * t_bit
* 100);
    else
        y = A2 * cos(2 * pi * f * t_bit : 2 * pi * f * t_bit : 2 * pi * f * t_bit
* 100);
    end
    m_ask = [m_ask y];
end
t2 = t_bit : t_bit : t_bit * length(x) * 100;

% FSK modulation
m_fsk = [];
for i = 1:length(x)
    if x(i) == 1
        y = cos(2 * pi * f1 * t_bit : 2 * pi * f1 * t_bit : 2 * pi * f1 * t_bit *
100);
    else
        y = cos(2 * pi * f0 * t_bit : 2 * pi * f0 * t_bit : 2 * pi * f0 * t_bit *
100);
    end
    m_fsk = [m_fsk y];
end
t3 = t_bit : t_bit : t_bit * length(x) * 100;

% PSK modulation
m_psk = [];
for i = 1:length(x)
    if x(i) == 1
        y = cos(2*pi*f1*t_bit + phi1:2*pi*f1*t_bit:2*pi*f1*t_bit*100 + phi1);
    else
        y = cos(2*pi*f1*t_bit + phi0:2*pi*f1*t_bit:2*pi*f1*t_bit*100 + phi0);
    end
    m_psk = [m_psk y];
end
t4 = t_bit : t_bit : t_bit * length(x) * 100;

% Plotting
subplot(4,1,1);
plot(t1, bit, 'r');
grid on;
axis([0 bp*length(x) -.5 1.5]);
title('Message Signal (Binary)');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(4,1,2);
plot(t2, m_ask, 'b');
title('ASK Modulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');
```

```
subplot(4,1,3);
plot(t3, m_fsk, 'g');
title('FSK Modulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(4,1,4);
plot(t4, m_psk, 'k');
title('PSK Modulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');
```