Programming Assignment #3

Solution

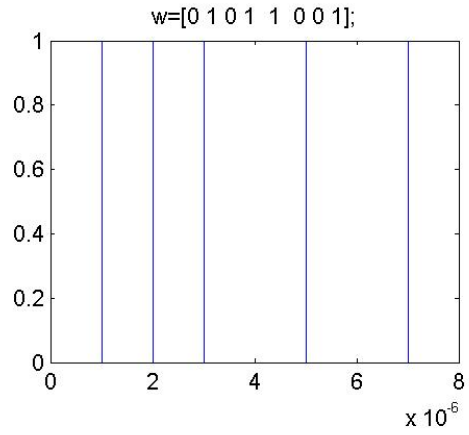
Q.1. Given the binary data [0 1 0 1 1 0 0 1] transmitted at a rate of 1 Mbps. It is required to transmit it using analog signals by modulating a carrier with a frequency of f_c=2 MHZ. The carrier signal used is $\cos(2\pi f_c)$. Plot the binary data, the modulated signal and its frequency spectrum for each of the following modulation techniques:

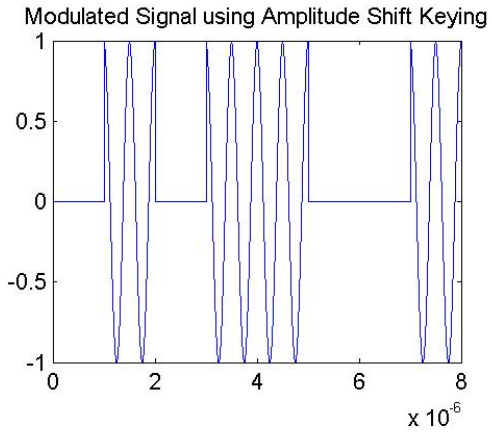
(i) Amplitude Shift Keying.

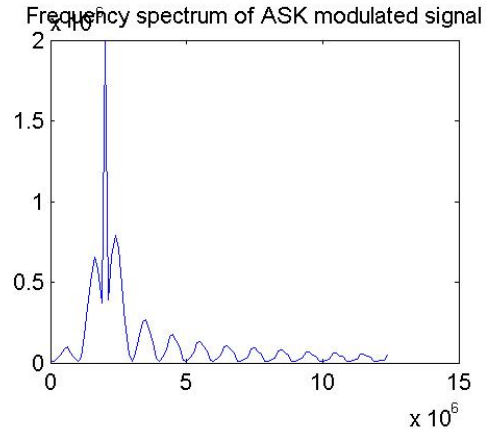
Matlab Code:

```
w=[0 1 0 1  1  0 0 1];
A=1;        %signal amplitude
p=1*10^-6;          % bit period
T=length(w)*p;
N=T*1/p*100;
n = 0:1:N-1;
dt = T/N;
t = n*dt;
x=[];
j=1;
for i=0:dt:dt*(N-1)
   if rem(i,p)==0
         x=[x w(j)*A];
         if  i>0
            j=j+1;
         end
   else
         x=[x w(j)*A];
   end
end
subplot(221);
plot (t,x);
title('w=[0 1 0 1  1  0 0 1];');
fc=2*10^6;
ask=x.*cos(2*pi*fc*t);
subplot(222);
plot (t,ask);
title('Modulated Signal using Amplitude Shift Keying');
W=dt*fft(ask);
```

```
f = n/T;
subplot(223);
plot(f(1:N/8),abs(W(1:N/8)));
title('Frequency spectrum of ASK modulated signal');
```





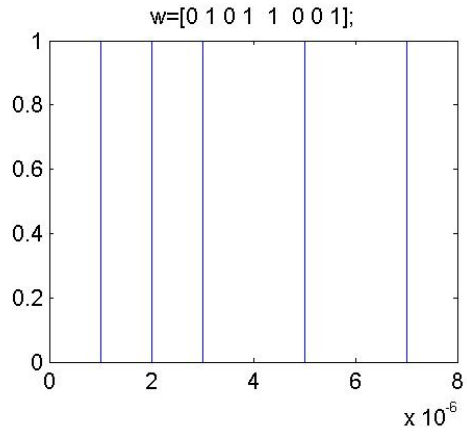


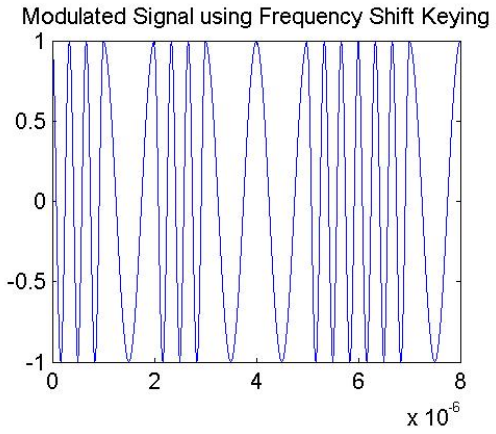
(ii) Frequency Shift Keying. Assume that binary 1 is transmitted using f1=1 MHZ and binary 0 is transmitted using f2=3 MHZ.

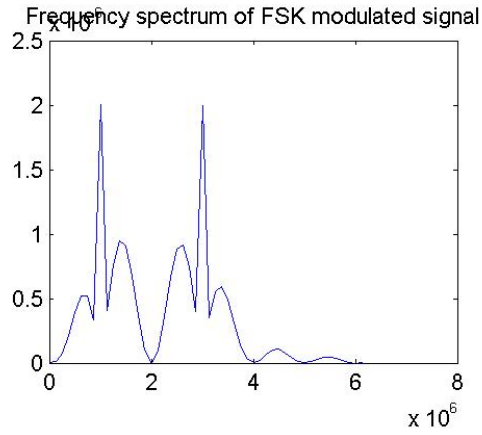
Matlab Code:

```
w=[0 1 0 1  1  0 0 1];
A=1;        %signal amplitude
p=1*10^-6;          % bit period
T=length(w)*p;
N=T*1/p*100;
n = 0:1:N-1;
dt = T/N;
t = n*dt;
x=[];
j=1;
for i=0:dt:dt*(N-1)
```

```
    if rem(i,p)==0
        x=[x w(j)*A];
        if  i>0
           j=j+1;
        end
    else
        x=[x w(j)*A];
    end
end
subplot(221);
plot (t,x);
title('w=[0 1 0 1  1  0 0 1];');
f1=1*10^6;
f2=3*10^6;
fsk=[];
j=1;
for i=0:dt:dt*(N-1)
    if x(j)==1
        fsk=[fsk cos(2*pi*f1*i)];
    else
        fsk=[fsk cos(2*pi*f2*i)];
    end
    j=j+1;
end

subplot(222);
plot (t,fsk);
title('Modulated Signal using Frequency Shift Keying');
W=dt*fft(fsk);
f = n/T;
subplot(223);
plot(f(1:N/16),abs(W(1:N/16)));
title('Frequency spectrum of FSK modulated signal');
```





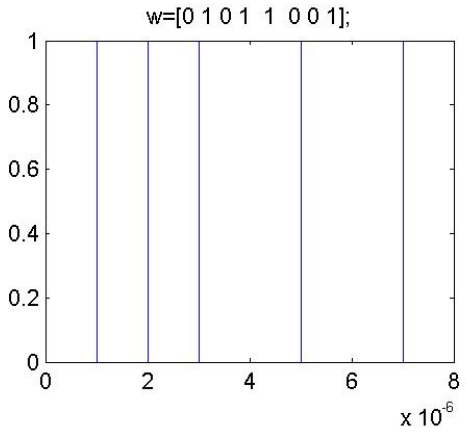


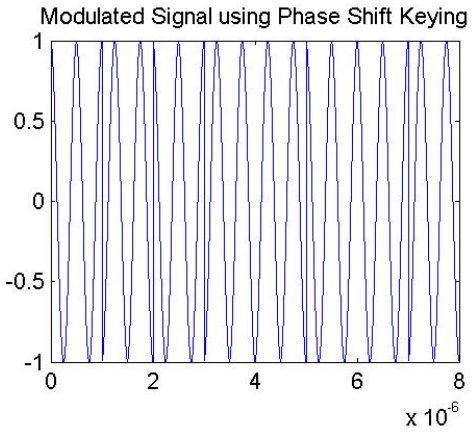
(iii) Phase Shift Keying. Assume that binary 1 is transmitted using a phase shift of π, and binary 0 is transmitted using a phase shift of 0.

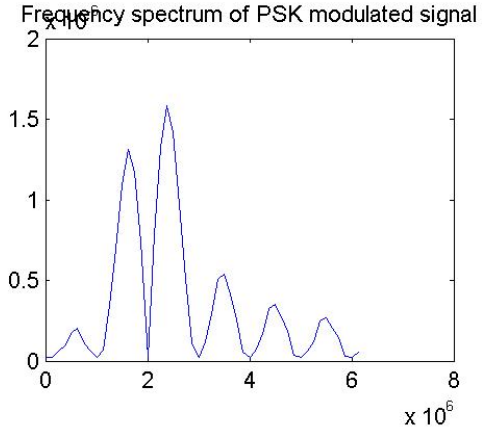
Matlab Code:

```
w=[0 1 0 1  1  0 0 1];
A=1;        %signal amplitude
p=1*10^-6;          % bit period
T=length(w)*p;
N=T*1/p*100;
n = 0:1:N-1;
dt = T/N;
t = n*dt;
x=[];
j=1;
for i=0:dt:dt*(N-1)
   if rem(i,p)==0
         x=[x w(j)*A];
         if  i>0
            j=j+1;
         end
```

```
   else
        x=[x w(j)*A];
   end
end
subplot(221);
plot (t,x);
title('w=[0 1 0 1  1  0 0 1];');
fc=2*10^6;
psk=[];
j=1;
for i=0:dt:dt*(N-1)
   if x(j)==1
        psk=[psk cos(2*pi*fc*i+pi)];
   else
        psk=[psk cos(2*pi*fc*i)];
   end
   j=j+1;
end

subplot(222);
plot (t,psk);
title('Modulated Signal using Phase Shift Keying');
W=dt*fft(psk);
f = n/T;
subplot(223);
plot(f(1:N/16),abs(W(1:N/16)));
title('Frequency spectrum of PSK modulated signal');
```







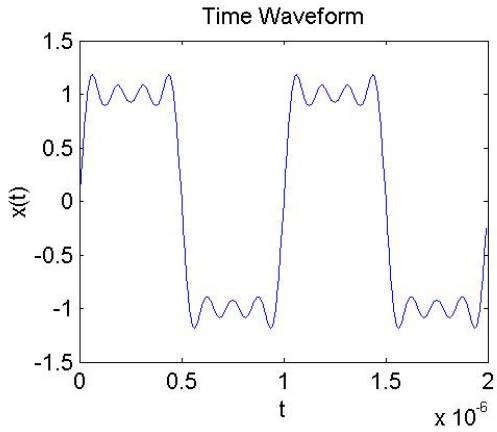
Q.2. Given the signal $x(t) = \frac{4}{\pi} \times [\sin(2\pi ft) + \frac{1}{3}\sin(2\pi 3\, ft) + \frac{1}{5}\sin(2\pi 5\, ft) + \frac{1}{7}\sin(2\pi 7\, ft)]$, with a frequency f =1 MHZ. It is required to transmit this signal using a carrier frequency f_c=20 MHZ. Assume that the carrier used is $\cos(2\pi f_c)$. Plot the signal, the modulated signal and its frequency spectrum for each of the modulation techniques given below. Show the signals for two periods.

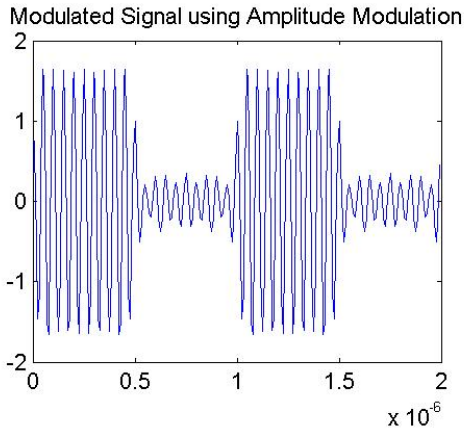
(i) Amplitude modulation using modulation index of 0.7, i.e. $AM(t) = [1 + 0.7x(t)]\cos(2\pi f_c t)$

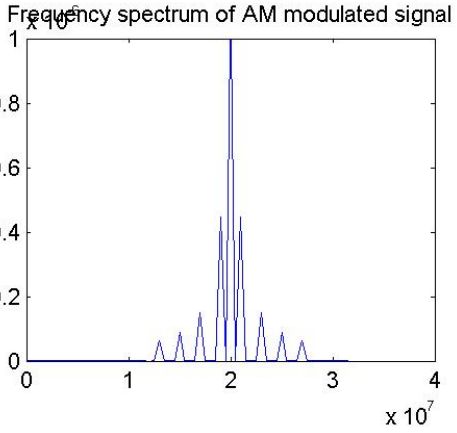
Matlab Code:

```
%setting parameters
M=8;
N=2^M;
n=0:1:N-1;
fo=1*10^6;
T=2/fo;
dt=T/N;
t=n*dt;

%defining the time waveform
A=0;
```

```
x=A;
h=7;
for i=1:2:h
x=x+4/pi*1/i*sin(2*pi*fo*i*t);
end

%ploting time waveform
subplot(221);
plot (t,x);
xlabel('t');
ylabel('x(t)');
title('Time Waveform');

fc=20*10^6;
am=(1+0.7*x).*cos(2*pi*fc*t);
subplot(222);
plot (t,am);
title('Modulated Signal using Amplitude Modulation');
W=dt*fft(am);
f = n/T;
subplot(223);
plot(f(1:N/4),abs(W(1:N/4)));
title('Frequency spectrum of AM modulated signal');
```





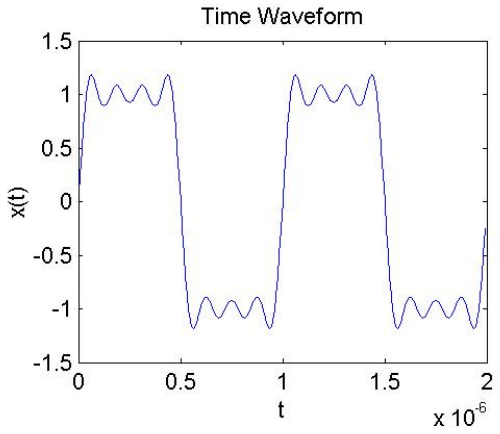


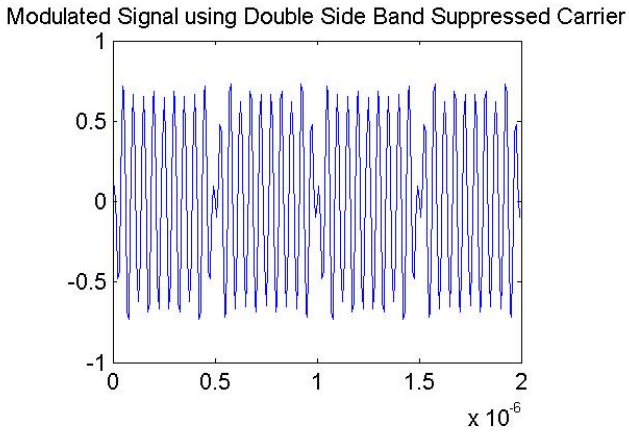
(ii) Double-Side Band Suppressed Carrier using modulation index of 0.7, i.e. $DSBSC(t) = [0.7x(t)]\cos(2\pi f_c t)$

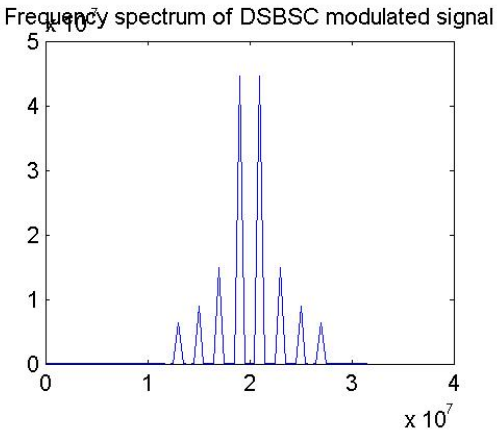
Matlab Code:

```
%setting parameters
M=8;
N=2^M;
n=0:1:N-1;
fo=1*10^6;
T=2/fo;
dt=T/N;
t=n*dt;

%defining the time waveform
A=0;
x=A;
h=7;
for i=1:2:h
x=x+4/pi*1/i*sin(2*pi*fo*i*t);
end
```

```
%ploting time waveform
subplot(221);
plot (t,x);
xlabel('t');
ylabel('x(t)');
title('Time Waveform');

fc=20*10^6;
dsbsc=0.7*x.*cos(2*pi*fc*t);
subplot(222);
plot (t,dsbsc);
title('Modulated Signal using Double Side Band Suppressed Carrier');
W=dt*fft(dsbsc);
f = n/T;
subplot(223);
plot(f(1:N/4),abs(W(1:N/4)));
title('Frequency spectrum of DSBSC modulated signal');
```



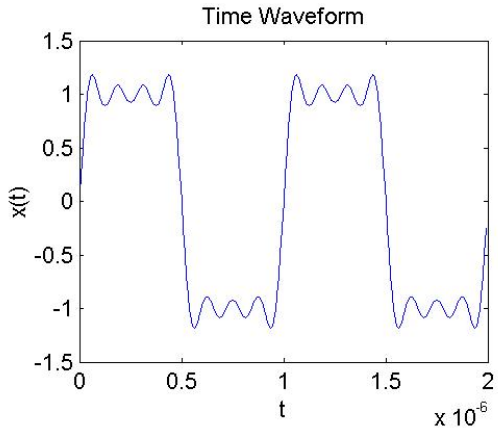


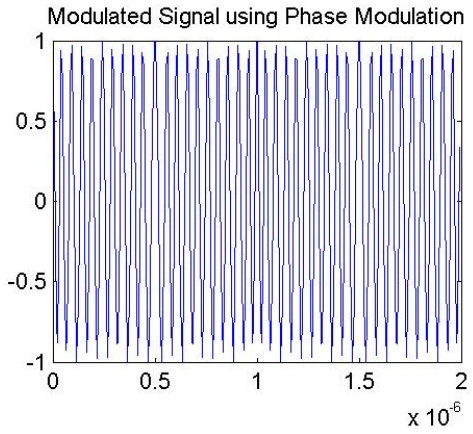


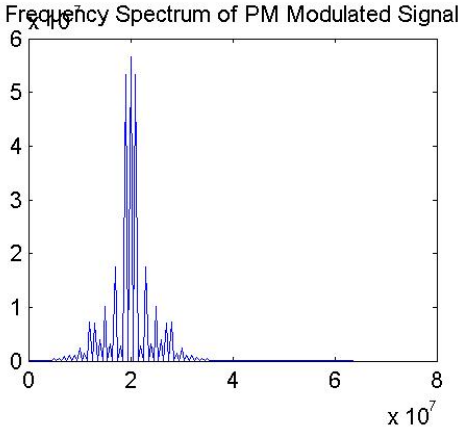
(iii) Phase Modulation using a phase modulation index of 1.

Matlab Code:

```
%setting parameters
M=8;
N=2^M;
n=0:1:N-1;
fo=1*10^6;
T=2/fo;
dt=T/N;
t=n*dt;

%defining the time waveform
A=0;
x=A;
h=7;
for i=1:2:h
x=x+4/pi*1/i*sin(2*pi*fo*i*t);
end

%ploting time waveform
subplot(221);
plot (t,x);
xlabel('t');
ylabel('x(t)');
title('Time Waveform');

fc=20*10^6;
pm=cos(2*pi*fc*t+x);
subplot(222);
plot (t,pm);
title('Modulated Signal using Phase Modulation');
W=dt*fft(pm);
f = n/T;
subplot(223);
plot(f(1:N/2),abs(W(1:N/2)));
title('Frequency Spectrum of PM Modulated Signal');
```





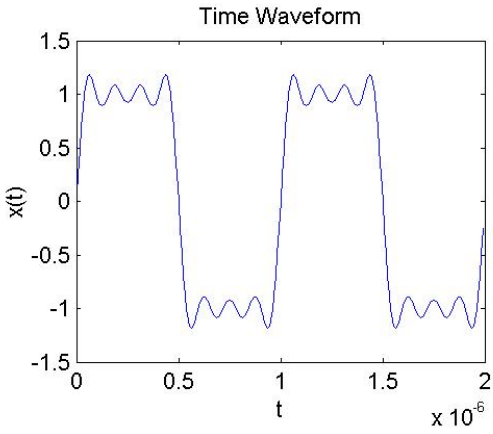


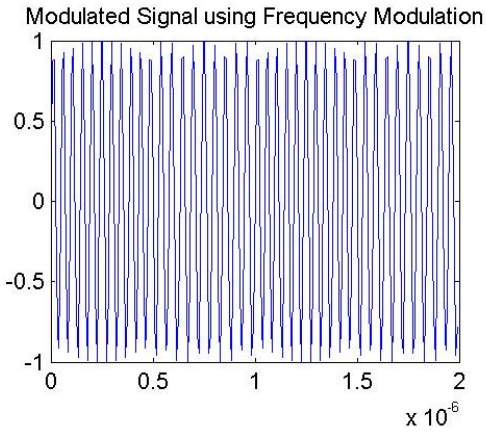
(iv) Frequency Modulation using a frequency modulation index of $2\pi f_o$.

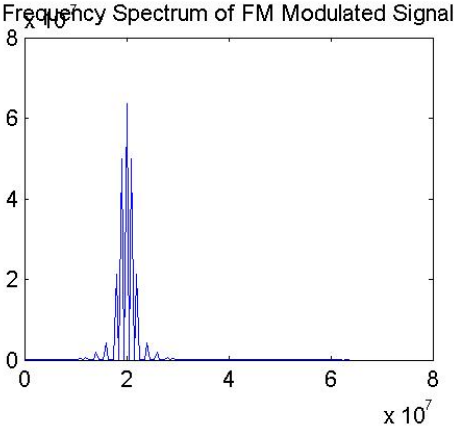
Matlab Code:

```
%setting parameters
M=8;
N=2^M;
n=0:1:N-1;
fo=1*10^6;
T=2/fo;
dt=T/N;
t=n*dt;

%defining the time waveform
A=0;
x=A;
h=7;
for i=1:2:h
x=x+4/pi*1/i*sin(2*pi*fo*i*t);
end
```

```
%ploting time waveform
subplot(221);
plot (t,x);
xlabel(‘t’);
ylabel(‘x(t)’);
title(‘Time Waveform’);

fc=20*10^6;
ix=0;
for i=1:2:h
ix=ix-4/(2*fo*pi^2)*[1/i^2*cos(2*pi*fo*i*t)];
end

fm=cos(2*pi*fc*t+(2*fo*pi)*ix);
subplot(222);
plot (t,fm);
title(‘Modulated Signal using Frequency Modulation’);
W=dt*fft(fm);
f = n/T;
subplot(223);
plot(f(1:N/2),abs(W(1:N/2)));
title(‘Frequency Spectrum of FM Modulated Signal’);
```


Time Waveform
x(t)
t
x 10^-6


Modulated Signal using Frequency Modulation
x 10^-6


Frequency Spectrum of FM Modulated Signal
x 10^7