ELP311

Communication Engineering Laboratory

Experiment 2

Modelling of DSB-SC Signal using MATLAB

Ishvik Kumar Singh

2018EE10616

Objective

The experiment aims to achieve the following goals:

[1] Generation and visualization of DSB-SC signal
[2] Spectrum analysis of message, carrier, and DSB-SC signal
[3] Demodulation of DSB-SC signal using product modulator followed by lowpass filter

Theory

Modulation
Consider a message signal, $m(t) = E_m cos\mu t$ and carrier signal $c(t) = E_c cofs\omega t$. A double sideband suppressed carrier (DSB-SC) signal represented by $x(t)$ is defined as their product:

$$x(t) = c(t).m(t) = E_c cos\omega t. E_m cos\mu t$$

where carrier frequency is much larger than message frequency $\omega \gg \mu$

$$x(t) = \frac{E_c E_m}{2}\cos{(\omega + \mu)t} + \frac{E_c E_m}{2}\cos{(\omega - \mu)t}$$
$$x(t) = \frac{E}{2}\cos{(\omega + \mu)t} + \frac{E}{2}\cos{(\omega - \mu)t}$$

here, $E = E_c E_m$

Demodulation
Demodulation is done using coherent demodulation, where the modulated signal is multiplied by the carrier signal (with the same phase and frequency), and the resulting signal is passed through a lowpass filter.

MATLAB code

Following are the parameters used for the experiment:

i. Message signal frequency, $f_m = 10\ Hz$
ii. Carrier frequency, $f_c = 1000000\ Hz$
iii. Message signal amplitude, $E_m = 1$
iv. Sampling frequency, $f_s = 4 * 1e6\ Hz$

We perform the experiment using $m = 0.5$, 1 and 1.5, and plot the modulated signal, the original message signal, the demodulated signal, as well as the frequency domain representation of these signals.

```
%% DSB-SC
fc=1e6;    % Carrier frequency
fm=10;    % Message frequency
```

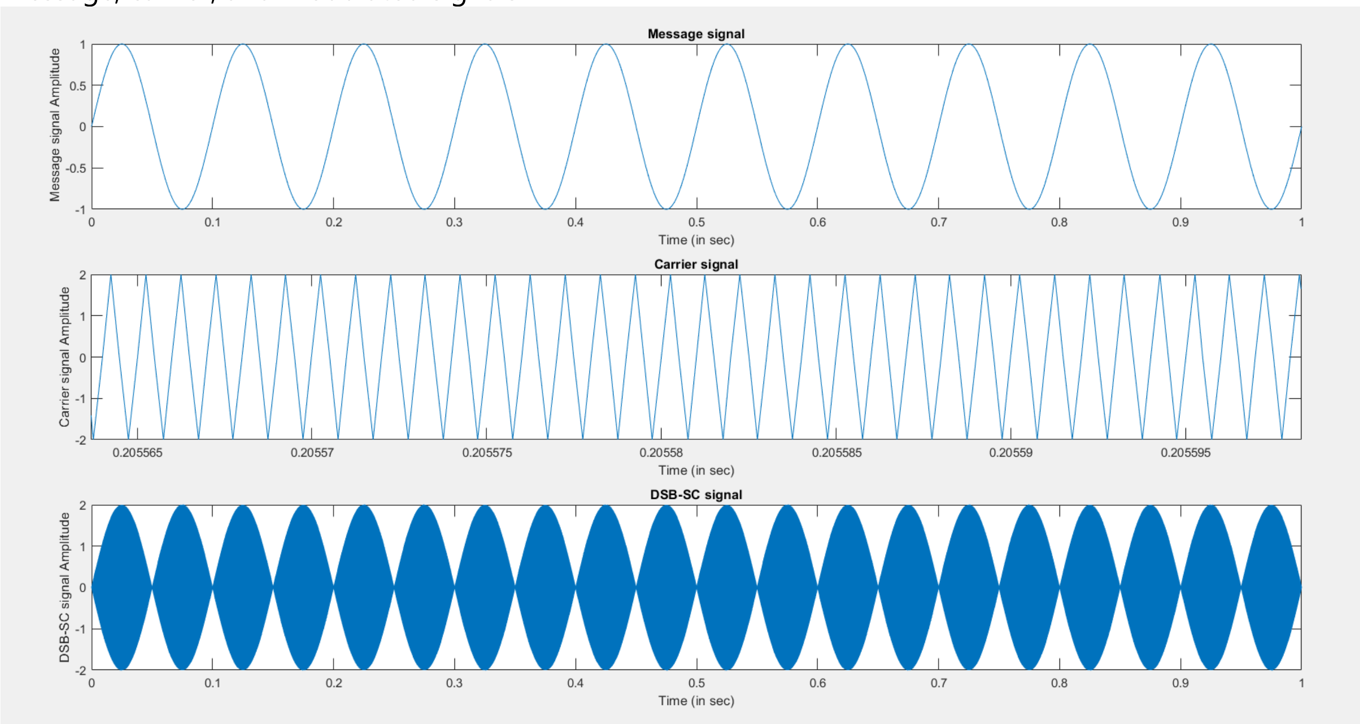
```
fs=4 * 1e6;
t=0:1/fs:1;

m=input("Enter m: ");
Am=1;   % Amplitude of message signal
Ac=Am/m;   % Amplitude of carrier signal

message=Am.*sin(2*pi*fm*t);
carrier=Ac.*sin(2*pi*fc*t);
DSB_SC=carrier.*message;

%% plotting signals
figure(1)
subplot(311)
plot(t, message)
xlabel('Time (in sec)')
ylabel(' Message signal Amplitude')
title('Message signal')
subplot(312)
plot(t, carrier)
xlabel('Time (in sec)')
ylabel('Carrier signal Amplitude')
title('Carrier signal')
subplot(313)
plot(t, DSB_SC)
xlabel('Time (in sec)')
ylabel('DSB-SC signal Amplitude')
title('DSB-SC signal')

%% FFT of carrier
lc=length(carrier);
f=linspace(-fs/2,fs/2,lc);
carrierf=fft(carrier,lc);
carrierF=fftshift(carrierf);
carrierM=abs(carrierF)/lc;
figure(2)
subplot(311);
plot(f,carrierM);
xlabel('frequency(Hz)');
ylabel('Carrier Magnitude');
xlim([-1.5e6,1.5e6]);

%% FFT of message signal
lm=length(message);
f=linspace(-fs/2,fs/2,lm);
messagef=fft(message,lm);
messageF=fftshift(messagef);
messageM=abs(messageF)/lm;
subplot(312);
plot(f,messageM);
xlabel('frequency(Hz)');
ylabel('Message Magnitude');

%% FFT of DSB-SC signal
ld=length(DSB_SC);
f=linspace(-fs/2,fs/2,ld);
DSB_SCf=fft(DSB_SC,ld);
DSB_SCF=fftshift(DSB_SCf);
DSB_SCM=abs(DSB_SCF)/ld;
subplot(313);
plot(f,DSB_SCM);
xlabel('frequency(Hz)');
ylabel('DSB-SC Magnitude');
```

```
xlim([-1.5e6,1.5e6]);

%% Demodulation
Dem_signal=DSB_SC.*carrier;
figure(3)
plot(t,Dem_signal)
xlabel('Time (in sec)')
ylabel('Demodulated signal Amplitude')
title('Demodulated signal')

Wp = 15/500;
Ws = 150/500;
[n,Wn] = buttord(Wp,Ws,0.1,5);
[a,b] = butter(n,Wn);

Rec_signal=filter(a,b,Dem_signal);
figure(4)
plot(t,Rec_signal);
xlabel('Time (in sec)')
ylabel('Recieved signal Amplitude')
title('Recieved signal from LPF');
```

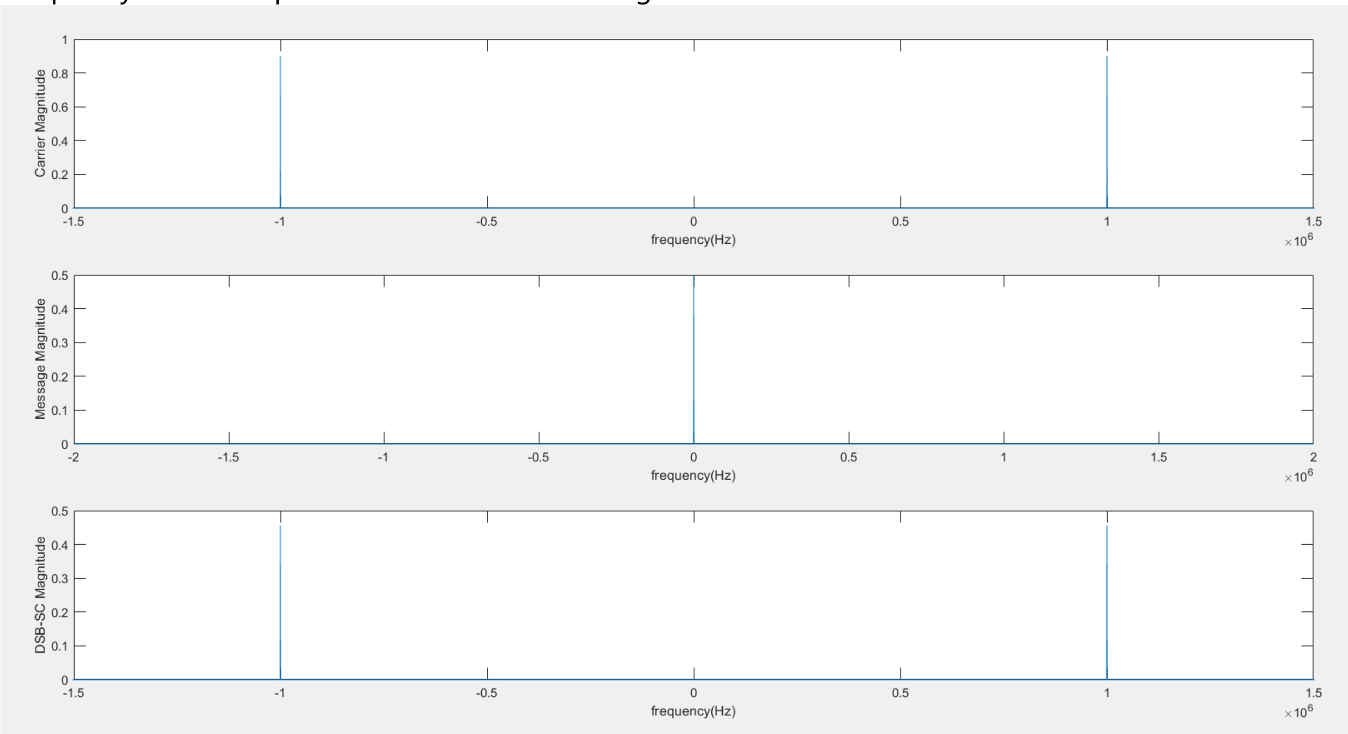
Plots

1. $m = 0.5$

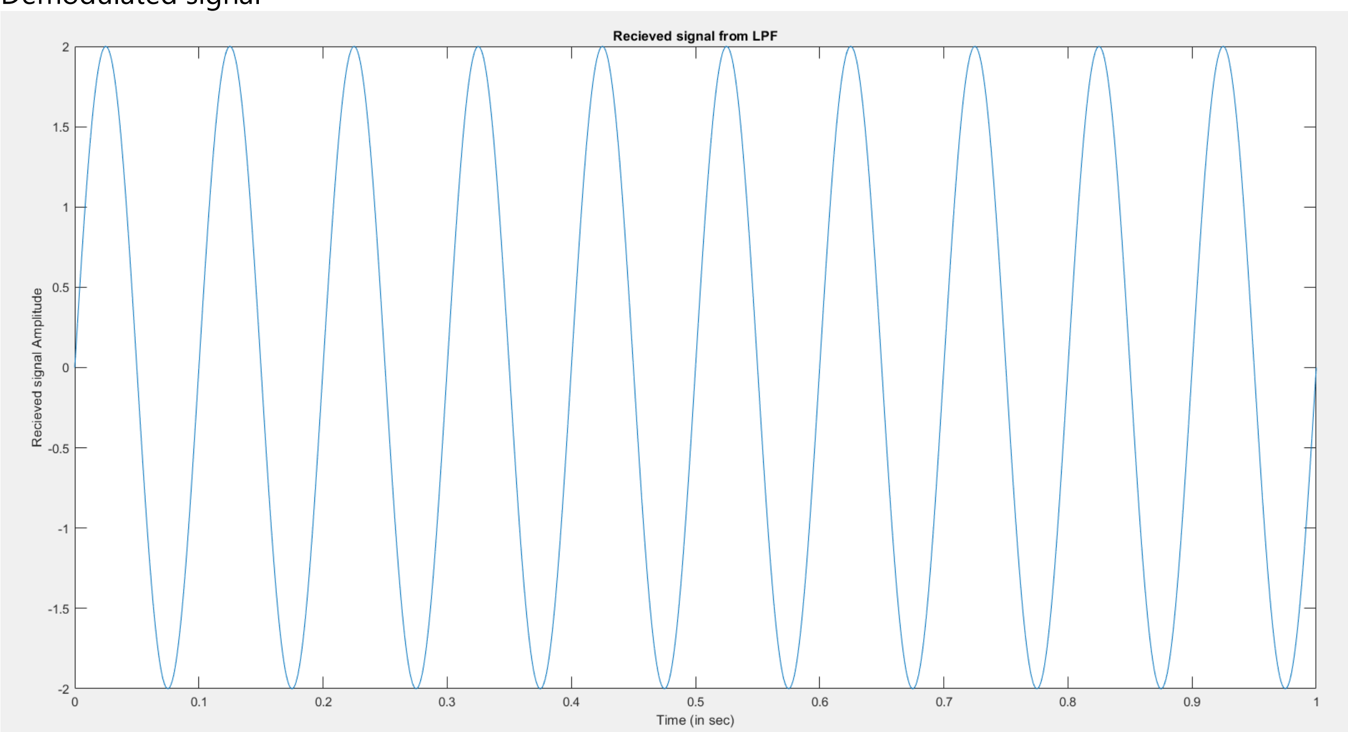
Message, carrier, and modulated signals



Frequency domain representation of the above signals

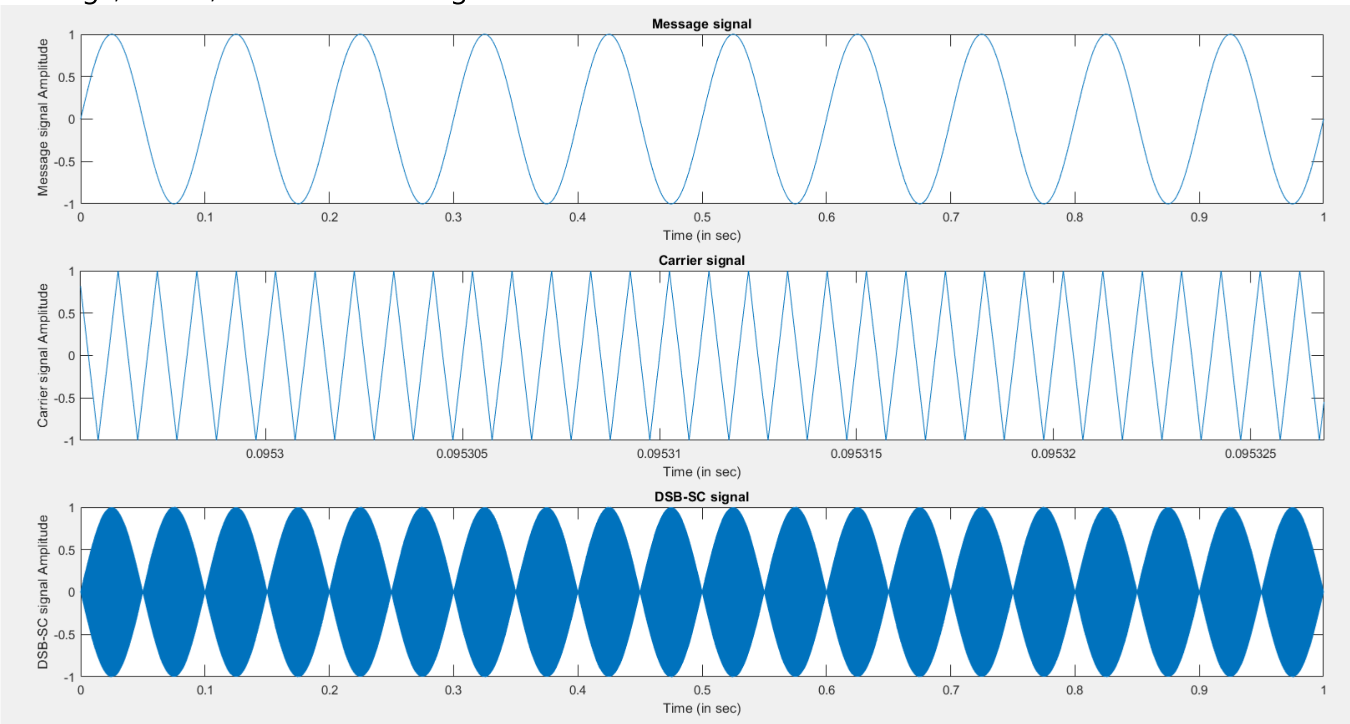


Demodulated signal

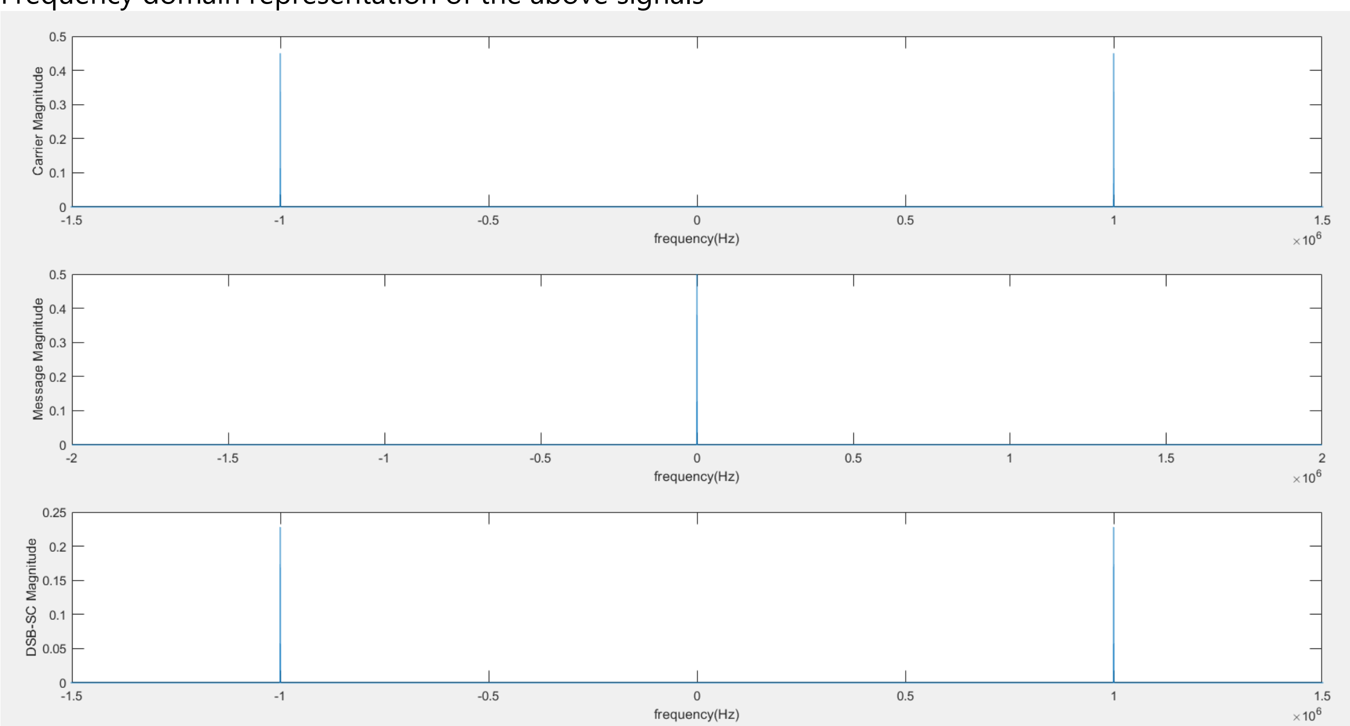


2. $m = 1$

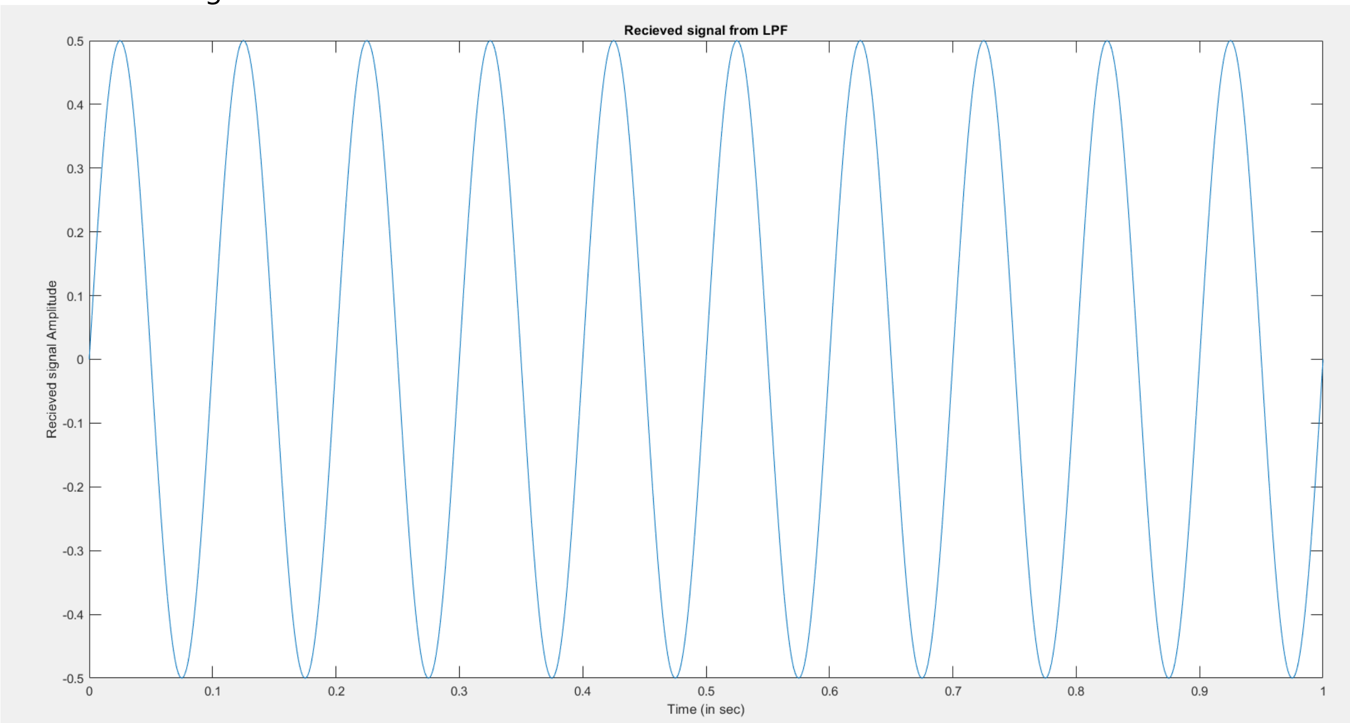
Message, carrier, and modulated signals



Frequency domain representation of the above signals

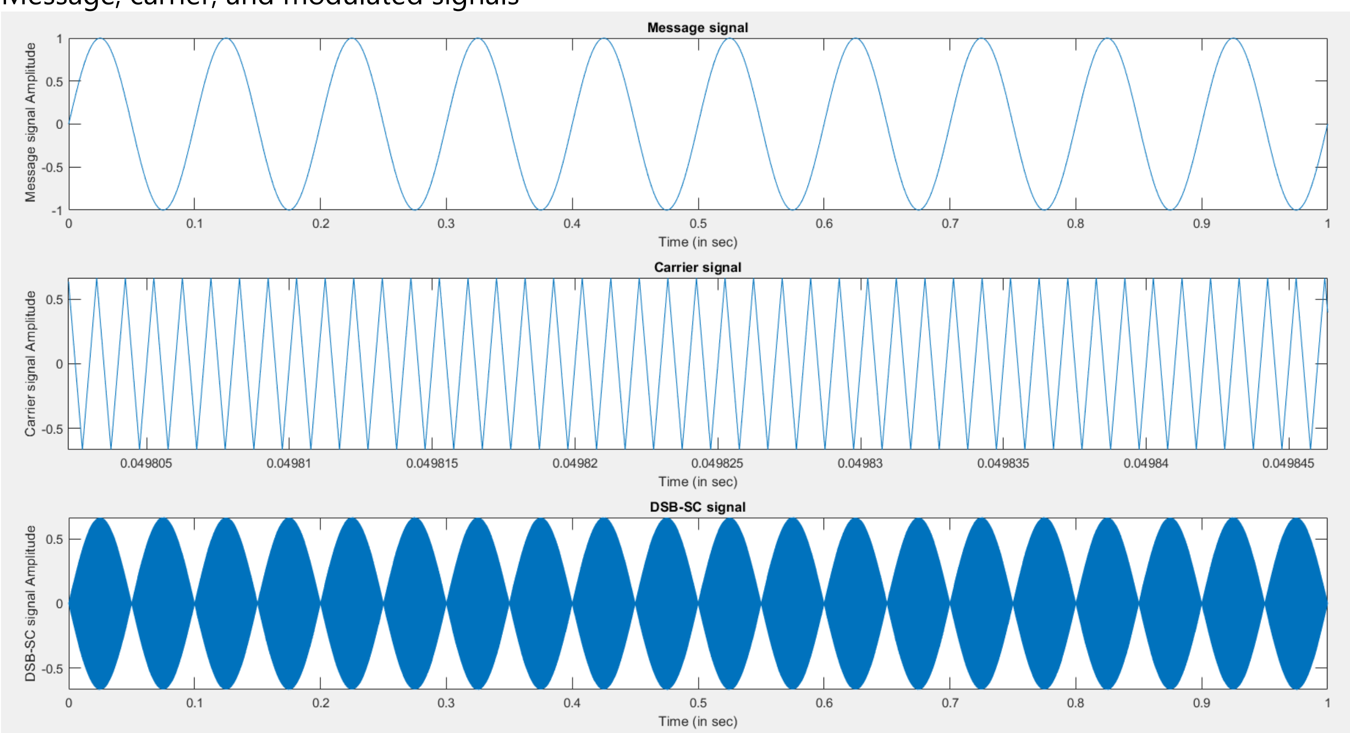


Demodulated signal

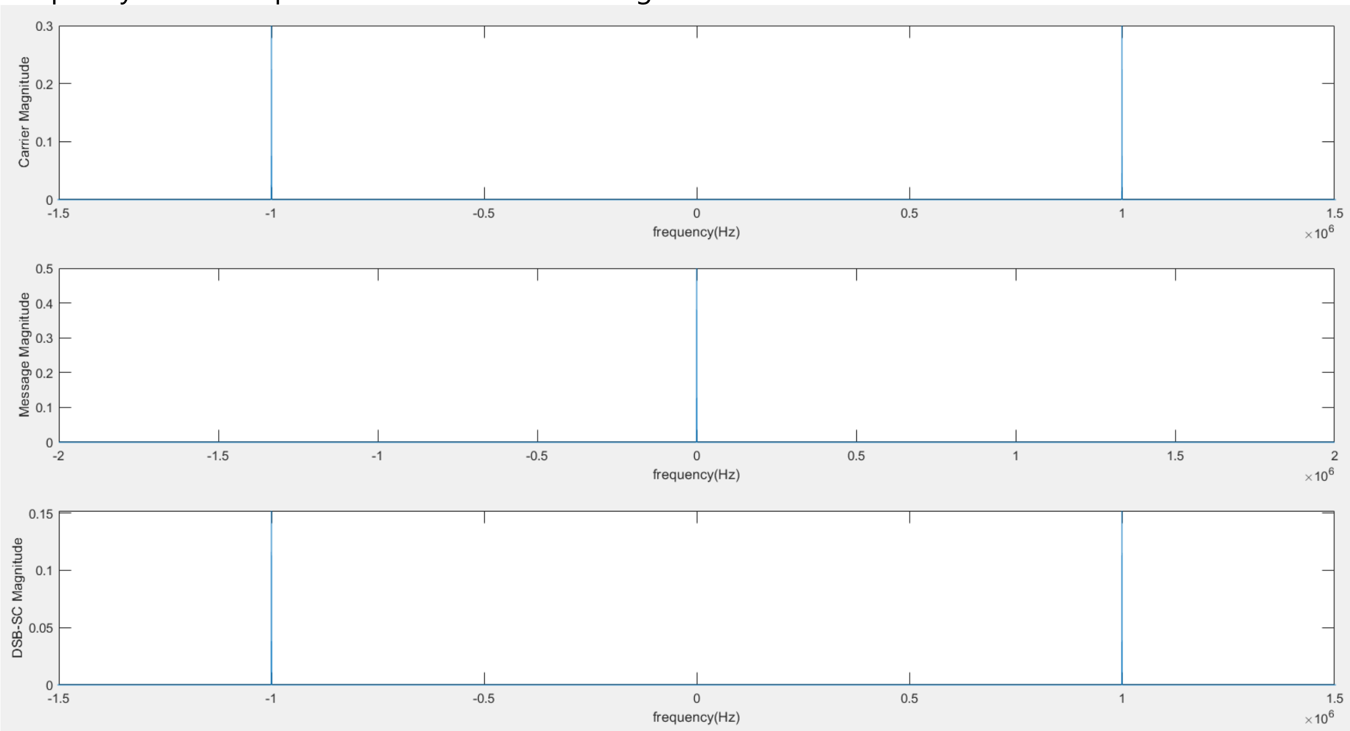


3. $m = 1.5$

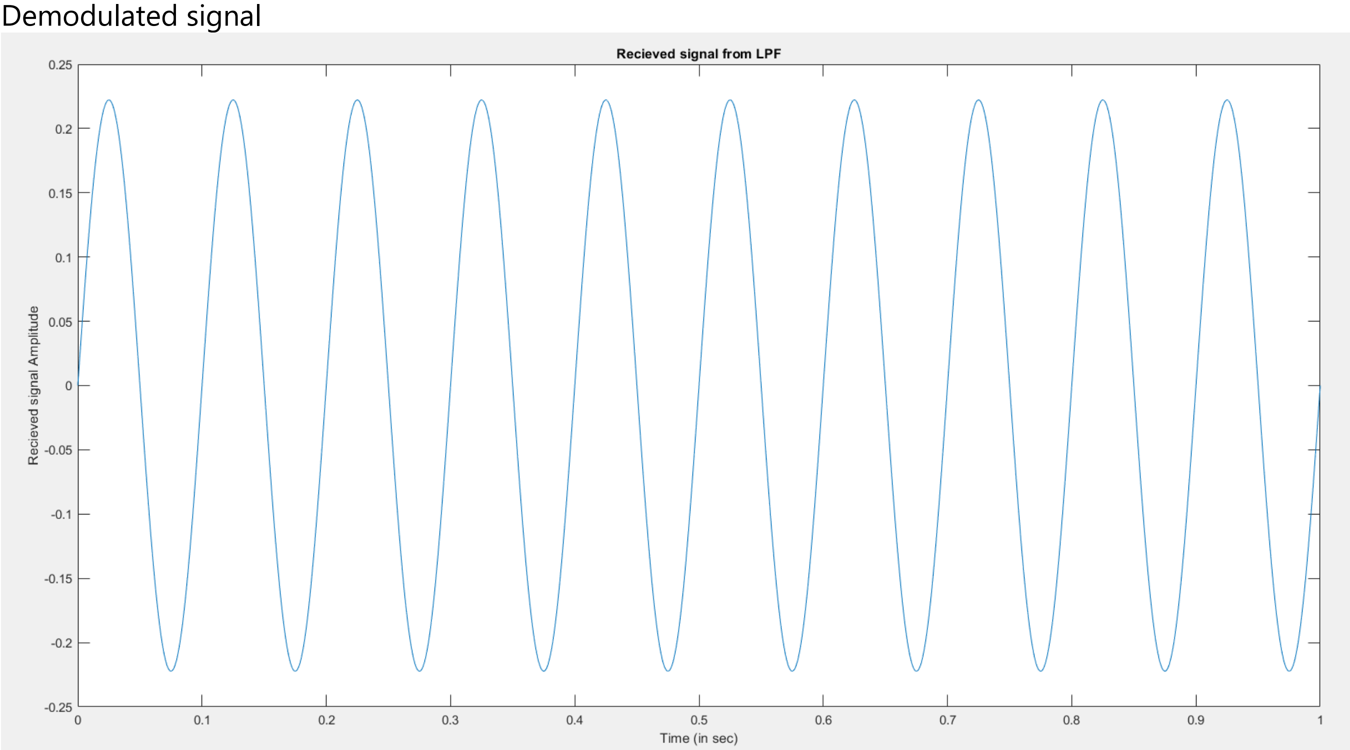
Message, carrier, and modulated signals



Frequency domain representation of the above signals



Demodulated signal



Inferences

We can observe that the waveforms after modulation and demodulation match theoretical expectations. Further, DSB-SC modulation and coherent demodulation are not affected by the value of modulation index, m.