PROJECT OF INTRODUCTION TO COMMUNICATION SYSTEMS LECTURE

Project Subject : COMPARISON THE ANALOG MODULATION TECHNIQUES via MATLAB CODES

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Group : C-5

Deadline : May 29, 2016

DEFINITIONS of AM, DSB-SC, SSB-SC and FM for INTRODUCTION

Amplitude Modulation

AM was the first widespread technique used in commercial radio broadcasting. An AM signal has the mathematical form

$$s(t) = A_c[1 + k_a m(t)] \cos \omega_c t$$

where
- m(t) is the baseband message.
- c(t) = Ac cos(wct) is called the carrier wave.
- The carrier frequency, fc, should be larger than the highest spectral component in m(t).
- The parameter ka is a positive constant called the amplitude sensitivity of the modulator.

Double Side Band Suppressed Carrier Modulation

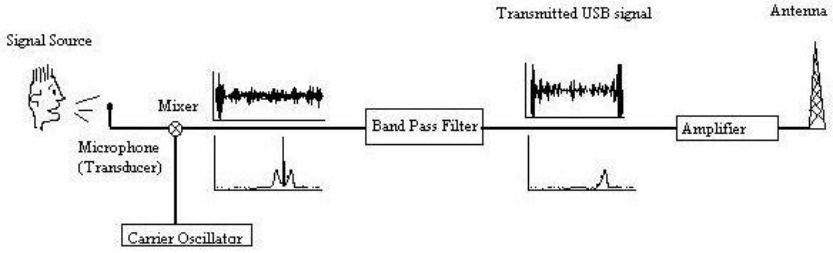
Let m(t) be a bandlimited baseband message signal with cutoff frequency W. The DSBSC-AM signal corresponding to m(t) is

$$s(t) = A_c m(t) \cos \omega_c t$$

This is the same as AM except with the sinusoidal carrier component eliminated.

Single Side Band Suppressed Carrier Modulation

The concept of single side-band (SSB) is very simple: if we don't need two side-bands, we must eliminate one. To make that happen, we merely add a component to your system that removes the extra side-band. That component is called a band pass filter.



Frequency Modulation

In the FM modulation technique, the frequency of the carrier signal is modulated in proportion to the baseband signal. In other words, the frequency of a modulating signal is used to directly vary the frequency of a carrier signal. Bearing in mind that an angle modulated signal;

$$S(t) = A_c \cos(\theta i(t))$$

then for FM signal, θi(t) is given by;

$$\theta i(t) = 2\pi fc\, t + \beta \int (m(t)dt)$$

Then a Frequency modulated (FM) signal is given by:

$$S(t) = A_c \cos(2\pi fct + \beta \int m(t)dt)$$

where m(t) is the modulating signal, Ac and fc are the carrier amplitude and frequency respectively, and β is a frequency modulation index. Depending on the value of β, FM can be either narrowband or wideband.

AMPLITUDE MODULATION

```
% AMPLITUDE MODULATION
% MUSTAFA GÜÇLÜ - 05110000994
% İBRAHİM BATUHAN ÖZTÜRK - 05150000711

clc;
clear all;
close all;
date = datetime('now') %for homework date details
fs=1000; %Sampling frequency
t=0:1/fs:1; %Time vector
Am=input('Amplitude of Message Signal='); %Amplitude of signal
fm=input('Message frequency='); %Accepting input value
Ac=input('Amplitude of Carrier Signal='); %Amplitude of signal
fc=input('Carrier frequency='); %Accepting input value (fc>fm)
mi=input('Modulation Index='); %Modulation Index
Sm=Am*sin(2*pi*fm*t); %Message Signal
subplot(3,1,1); %Plotting frame divided in to 3 rows and this fig appear at
1st
plot(t,Sm);
xlabel('Time');
ylabel('Amplitude');
title('Message Signal');
grid on;
Sc=Ac*cos(2*pi*fc*t); %Carrier Signal
subplot(3,1,2);
plot(t,Sc);
xlabel('Time');
ylabel('Amplitude');
title('Carrier Signal');
grid on;
S=(1+mi*Sm).*Ac.*cos(2*pi*fc*t); %AM Signal
subplot(3,1,3);
plot(t,S);
xlabel('Time');
ylabel('Amplitude');
title('AM in Time Domain');
grid on;

figure;
L=length(S); %Length of AM signal
f=linspace(-fs/2,fs/2,L); %Frequency vector
plot(f,abs(fftshift(fft(S,L)/L)));
xlabel('Frequency (Hz)');
ylabel('Magnitude');
title('AM in Frequency Domain');
grid on;
```

Editor - C:\Users\Asus X550\Desktop\data lab proje\matlab\AM.m

AM.m | DSB_SC.m | SSB_SC.m | FM.m | +

```
1      % AMPLITUDE MODULATION
2      % MUSTAFA GÜÇLÜ - 05110000994
3      % İBRAHİM BATUHAN ÖZTÜRK - 05150000711
4
5  -   clc;
6  -   clear all;
7  -   close all;
8  -   date = datetime('now') %for homework date details
9  -   fs=1000; %Sampling frequency
10 -   t=0:1/fs:1; %Time vector
11 -   Am=input('Amplitude of Message Signal='); %Amplitude of signal
12 -   fm=input('Message frequency='); %Accepting input value
13 -   Ac=input('Amplitude of Carrier Signal='); %Amplitude of signal
14 -   fc=input('Carrier frequency='); %Accepting input value (fc>fm)
15 -   mi=input('Modulation Index='); %Modulation Index
16 -   Sm=Am*sin(2*pi*fm*t); %Message Signal
```

Command Window

```
date =

   01-Jun-2016 22:36:14

Amplitude of Message Signal=1
Message frequency=2
Amplitude of Carrier Signal=1
Carrier frequency=20
Modulation Index=1
fx >>
```

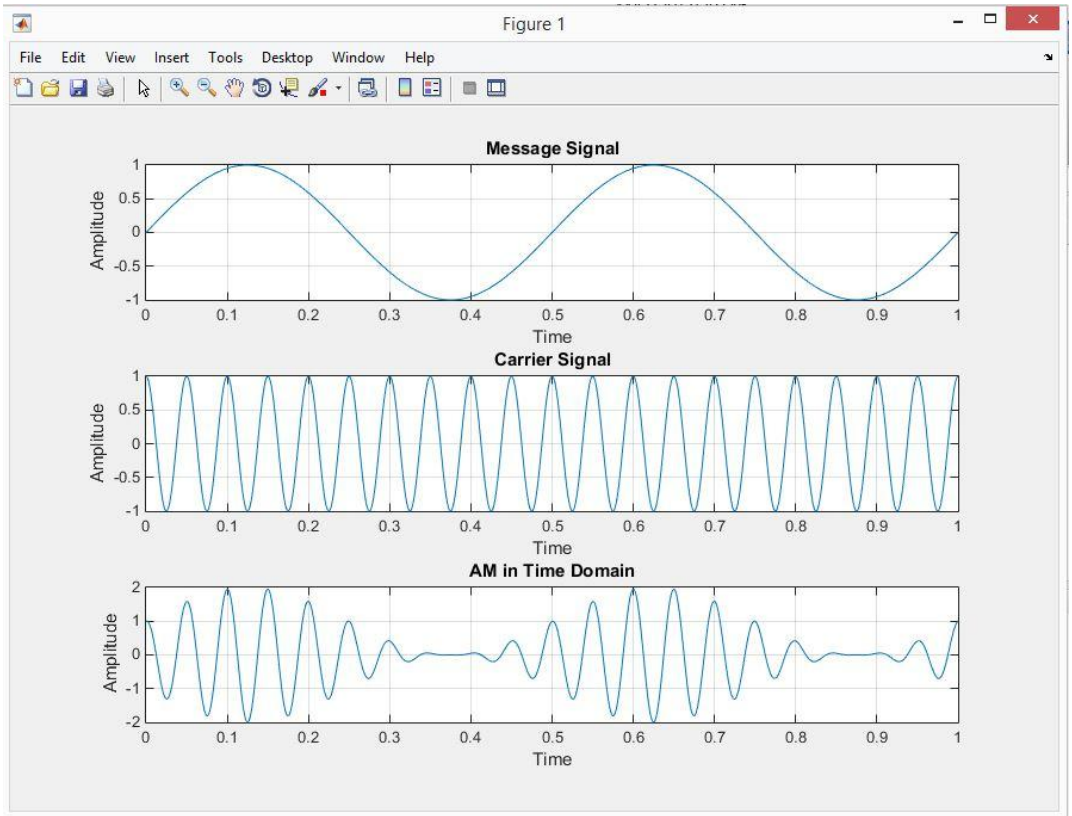


Figure 1
File Edit View Insert Tools Desktop Window Help
Message Signal
Amplitude
Time
Carrier Signal
Amplitude
Time
AM in Time Domain
Amplitude
Time

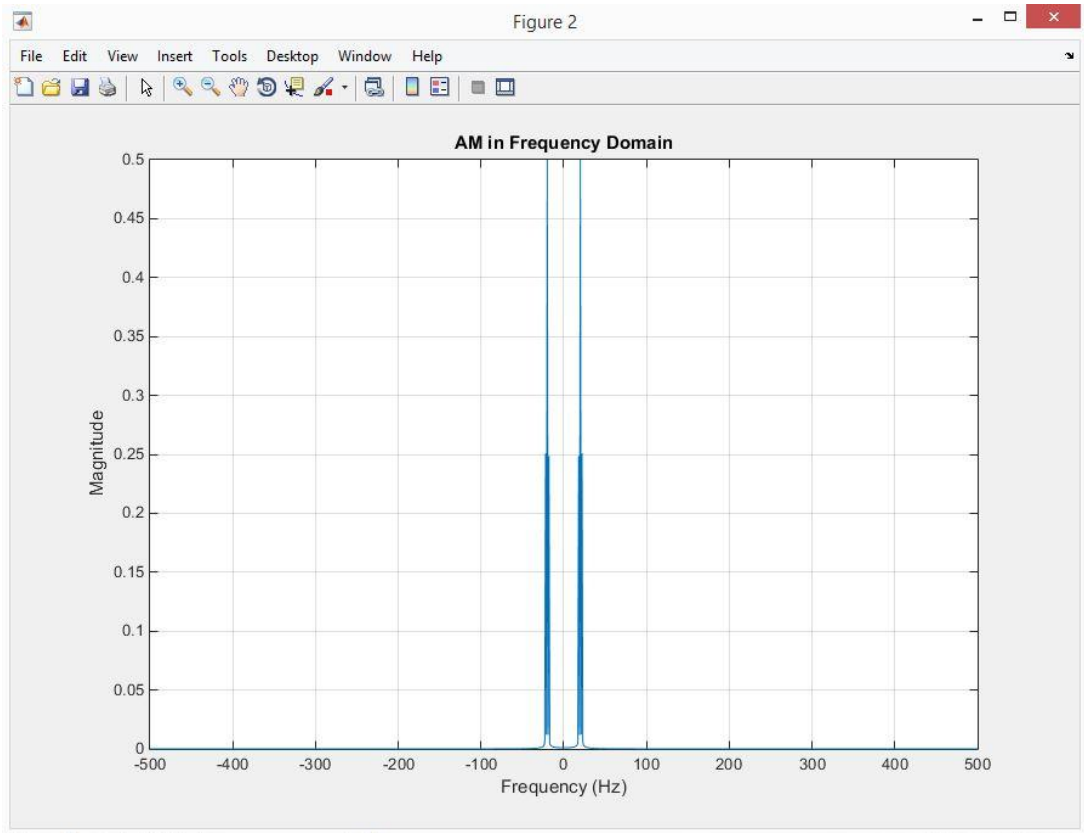


Figure 2
File Edit View Insert Tools Desktop Window Help
AM in Frequency Domain
Magnitude
Frequency (Hz)

DOUBLE SIDE BAND - SUPPRESSED CARRIER MODULATION

```
% DOUBLE SIDE BAND SUPPRESSED CARRIER MODULATION
% MUSTAFA GÜÇLÜ - 05110000994
% İBRAHİM BATUHAN ÖZTÜRK - 05150000711

clc;
clear all;
close all;
date = datetime('now') %for homework date details
fs=1000; %Sampling frequency
t=0:1/fs:1; %Time vector
Am=input('Amplitude of Message Signal='); %Amplitude of signal
fm=input('Message frequency='); %Accepting input value
Ac=input('Amplitude of Carrier Signal='); %Amplitude of signal
fc=input('Carrier frequency='); %Accepting input value (fc>fm)
Sm=Am*sin(2*pi*fm*t); %Message Signal
subplot(3,1,1); %Plotting frame divided in to 3 rows and this fig appear at
1st
plot(t,Sm);
xlabel('Time');
ylabel('Amplitude');
title('Message Signal');
grid on;
Sc=Ac*cos(2*pi*fc*t); %Carrier Signal
subplot(3,1,2);
plot(t,Sc);
xlabel('Time');
ylabel('Amplitude');
title('Carrier Signal');
grid on;
S=Sm.*Sc; %DSB-SC Signal
subplot(3,1,3);
plot(t,S);
xlabel('Time');
ylabel('Amplitude');
title('DSB-SC in Time Domain');
grid on;

figure;
L=length(S); %Length of DSB-SC signal
f=linspace(-fs/2,fs/2,L); %Frequency vector
plot(f,abs(fftshift(fft(S,L)/L)));
xlabel('Frequency (Hz)');
ylabel('Magnitude');
title('DSB-SC in Frequency Domain');
grid on;
```

Editor - C:\Users\Asus X550\Desktop\data lab proje\matlab\DSB_SC.m

AM.m | DSB_SC.m | SSB_SC.m | FM.m | +

```
1      % DOUBLE SIDE BAND SUPPRESSED CARRIER MODULATION
2      % MUSTAFA GÜÇLÜ - 05110000994
3      % İBRAHİM BATUHAN ÖZTÜRK - 05150000711
4
5 -    clc;
6 -    clear all;
7 -    close all;
8 -    date = datetime('now') %for homework date details
9 -    fs=1000; %Sampling frequency
10 -   t=0:1/fs:1; %Time vector
11 -   Am=input('Amplitude of Message Signal='); %Amplitude of signal
12 -   fm=input('Message frequency='); %Accepting input value
13 -   Ac=input('Amplitude of Carrier Signal='); %Amplitude of signal
14 -   fc=input('Carrier frequency='); %Accepting input value (fc>fm)
15 -   Sm=Am*sin(2*pi*fm*t); %Message Signal
16 -   subplot(3,1,1); %Plotting frame divided in to 3 rows and this fig appear at 1st
```

Command Window

```
date =

   01-Jun-2016 22:43:12

Amplitude of Message Signal=1
Message frequency=2
Amplitude of Carrier Signal=1
Carrier frequency=20
fx >>
```

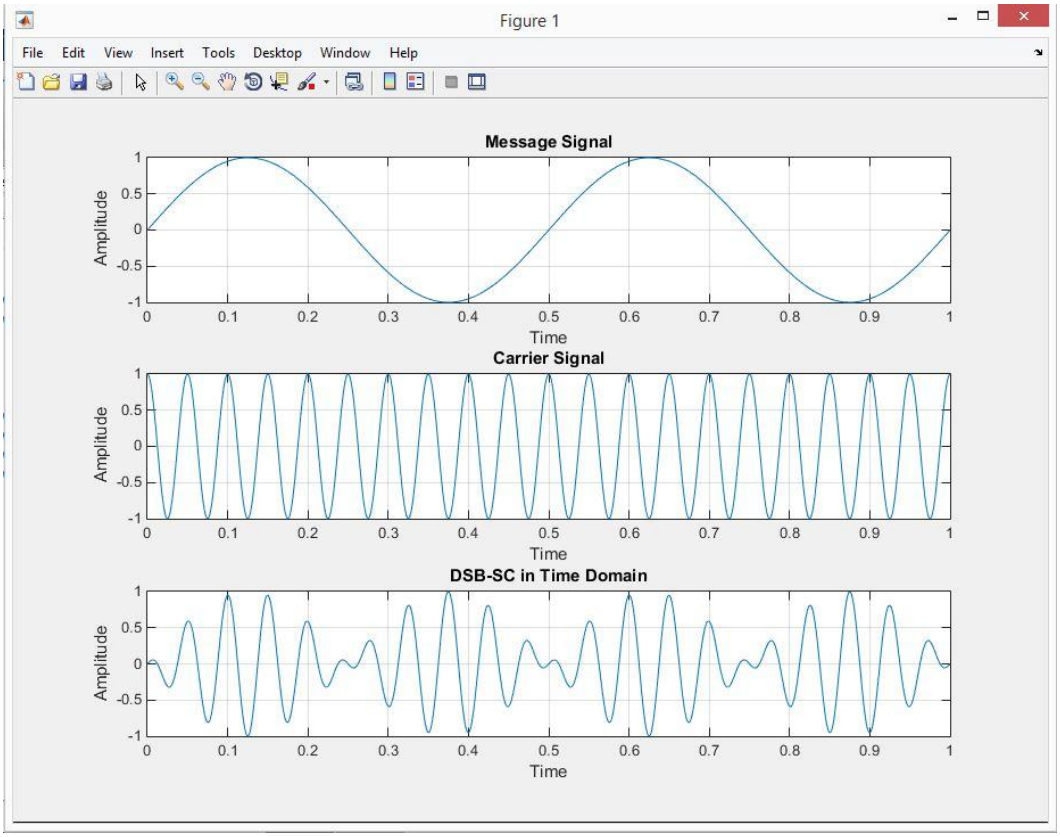


Figure 1
File Edit View Insert Tools Desktop Window Help
Message Signal
Amplitude
Time
Carrier Signal
Amplitude
Time
DSB-SC in Time Domain
Amplitude
Time

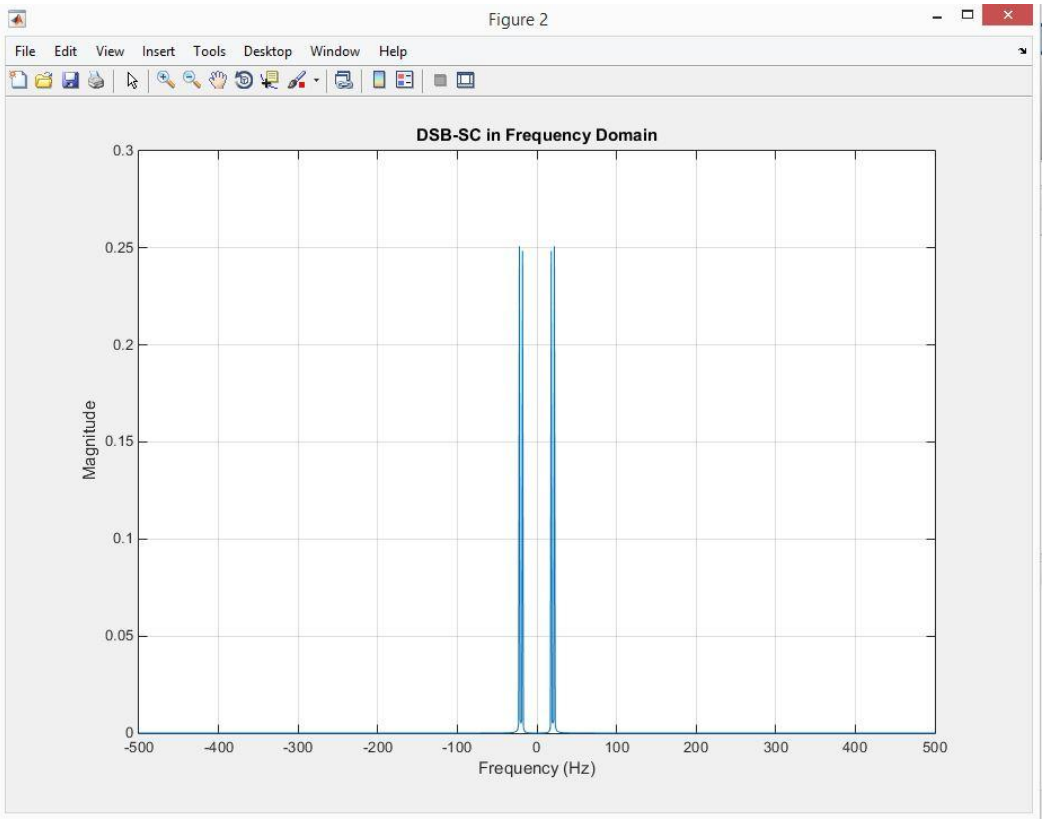


Figure 2
File Edit View Insert Tools Desktop Window Help
DSB-SC in Frequency Domain
Magnitude
Frequency (Hz)

SINGLE SIDE BAND - SUPPRESSED CARRIER MODULATION

```
% SINGLE SIDE BAND SUPPRESSED CARRIER MODULATION
% MUSTAFA GÜÇLÜ - 05110000994
% İBRAHİM BATUHAN ÖZTÜRK - 05150000711

clc;
clear all;
close all;
date = datetime('now') %for homework date details
fs=1000; %Sampling frequency
t=0:1/fs:1; %Time vector
Am=input('Amplitude of Message Signal='); %Amplitude of signal
fm=input('Message frequency='); %Accepting input value
Ac=input('Amplitude of Carrier Signal='); %Amplitude of signal
fc=input('Carrier frequency='); %Accepting input value (fc>fm)
Sm=Am*sin(2*pi*fm*t); %Message Signal
Sm_H=Am*sin(2*pi*fm*t-pi/2); %Hilbert Transform of Message Signal
figure(1);
subplot(3,1,1); %Plotting frame divided in to 3 rows and this fig appear at
1st
plot(t,Sm);
xlabel('Time');
ylabel('Amplitude');
title('Message Signal');
grid on;
Sc=Ac*cos(2*pi*fc*t); %Carrier Signal
subplot(3,1,2);
plot(t,Sc);
xlabel('Time');
ylabel('Amplitude');
title('Carrier Signal');
grid on;
USB=2.*Sm.*Sc+2.*Sm_H.*Sc; %USB-SSB-SC Signal
LSB=2.*Sm.*Sc-2.*Sm_H.*Sc; %LSB-SSB-SC Signal
subplot(3,1,3);
plot(t,LSB);
xlabel('Time');
ylabel('Amplitude');
title('LSB-SSB-SC in Time Domain');
grid on;

figure(2);
L=length(LSB); %Length of AM signal
f=linspace(-fs/2,fs/2,L); %Frequency vector
plot(f,abs(fftshift(fft(LSB,L)/L)));
xlabel('Frequency (Hz)');
ylabel('Magnitude');
title('LSB-SSB-SC in Frequency Domain');
grid on;
```

Editor - C:\Users\Asus X550\Desktop\data lab proje\matlab\SSB_SC.m

AM.m | DSB_SC.m | SSB_SC.m | FM.m | +

```
1      % SINGLE SIDE BAND SUPPRESSED CARRIER MODULATION
2      % MUSTAFA GÜÇLÜ - 05110000994
3      % İBRAHİM BATUHAN ÖZTÜRK - 05150000711
4
5 -    clc;
6 -    clear all;
7 -    close all;
8 -    date = datetime('now') %for homework date details
9 -    fs=1000; %Sampling frequency
10 -   t=0:1/fs:1; %Time vector
11 -   Am=input('Amplitude of Message Signal='); %Amplitude of signal
12 -   fm=input('Message frequency='); %Accepting input value
13 -   Ac=input('Amplitude of Carrier Signal='); %Amplitude of signal
14 -   fc=input('Carrier frequency='); %Accepting input value (fc>fm)
15 -   Sm=Am*sin(2*pi*fm*t); %Message Signal
16 -   Sm_H=Am*sin(2*pi*fm*t-pi/2); %Hilbert Transform of Message Signal
```

Command Window

```
date =

   01-Jun-2016 22:45:15

Amplitude of Message Signal=1
Message frequency=2
Amplitude of Carrier Signal=1
Carrier frequency=20
>>
```

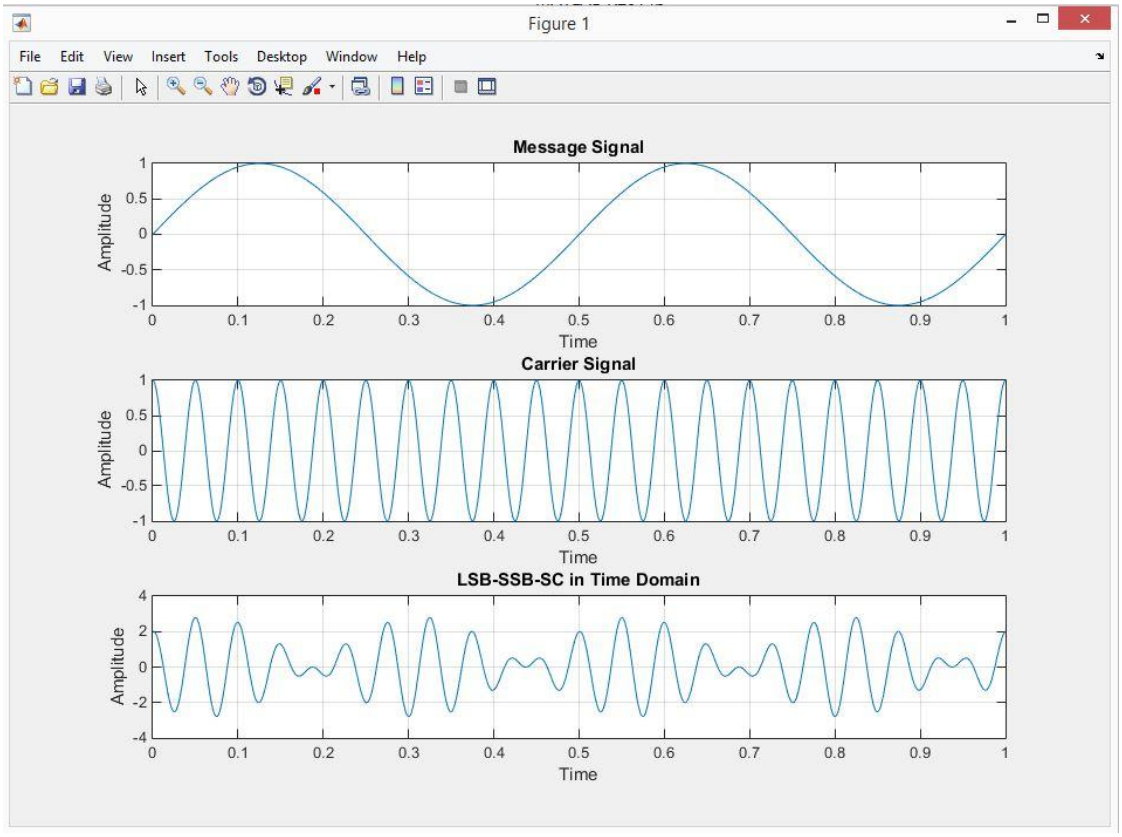


Figure 1
File Edit View Insert Tools Desktop Window Help
Message Signal
Amplitude
Time
Carrier Signal
Amplitude
Time
LSB-SSB-SC in Time Domain
Amplitude
Time

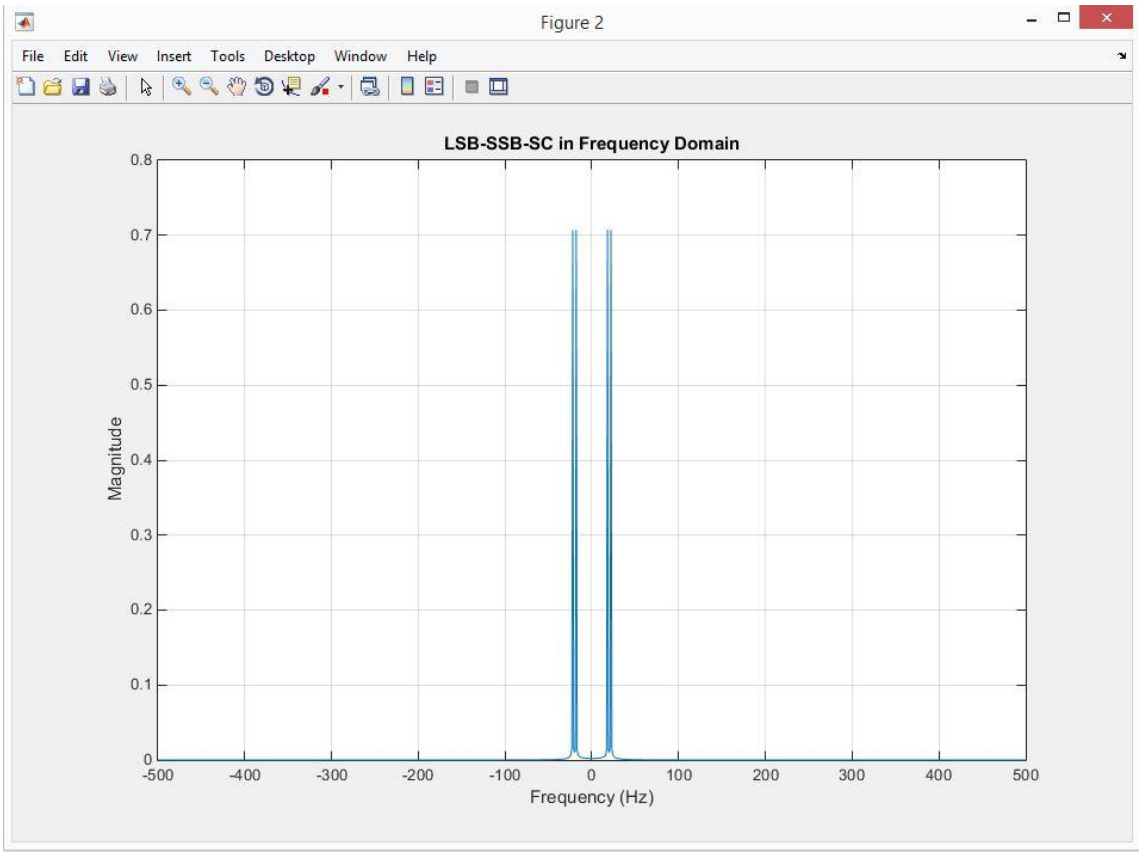


Figure 2
File Edit View Insert Tools Desktop Window Help
LSB-SSB-SC in Frequency Domain
Magnitude
Frequency (Hz)

FREQUENCY MODULATION

```
% FREQUENCY MODULATION
% MUSTAFA GÜÇLÜ - 05110000994
% İBRAHİM BATUHAN ÖZTÜRK - 05150000711

clc;
clear all;
close all;
date = datetime('now') %for homework date details
fs=1000; %Sampling frequency
t=0:1/fs:1; %Time vector
Am=input('Amplitude of Message Signal='); %Amplitude of signal
fm=input('Message frequency='); %Accepting input value
Ac=input('Amplitude of Carrier Signal='); %Amplitude of signal
fc=input('Carrier frequency='); %Accepting input value (fc>fm)
kf=input('Modulation Index='); %Frequency Deviation Sensitivity
Sm=Am*sin(2*pi*fm*t); %Message Signal
subplot(2,1,1); %Plotting frame divided in to 2 rows and this fig appear at
1st
plot(t,Sm);
xlabel('Time');
ylabel('Amplitude');
title('Message Signal');
grid on;
wc=2*pi*fc;
S=cos(wc*t+(kf*2*pi.*Sm.*t)); %FM Signal
subplot(2,1,2);
plot(t,S);
xlabel('Time');
ylabel('Amplitude');
title('FM in Time Domain');
grid on;

figure;
L=length(S); %Length of FM signal
f=linspace(-fs/2,fs/2,L); %Frequency vector
plot(f,abs(fftshift(fft(S,L)/L)));
xlabel('Frequency (Hz)');
ylabel('Magnitude');
title('FM in Frequency Domain');
grid on;
```

Editor - C:\Users\Asus X550\Desktop\data lab proje\matlab\FM.m

AM.m | DSB_SC.m | SSB_SC.m | FM.m | +

```
1      % FREQUENCY MODULATION
2      % MUSTAFA GÜÇLÜ - 05110000994
3      % İBRAHİM BATUHAN ÖZTÜRK - 05150000711
4
5  -   clc;
6  -   clear all;
7  -   close all;
8  -   date = datetime('now') %for homework date details
9  -   fs=1000; %Sampling frequency
10 -   t=0:1/fs:1; %Time vector
11 -   Am=input('Amplitude of Message Signal='); %Amplitude of signal
12 -   fm=input('Message frequency='); %Accepting input value
13 -   Ac=input('Amplitude of Carrier Signal='); %Amplitude of signal
14 -   fc=input('Carrier frequency='); %Accepting input value (fc>fm)
15 -   kf=input('Modulation Index='); %Frequency Deviation Sensitivity
16 -   Sm=Am*sin(2*pi*fm*t); %Message Signal
```

Command Window

```
date =

   01-Jun-2016 22:47:27

Amplitude of Message Signal=1
Message frequency=2
Amplitude of Carrier Signal=1
Carrier frequency=20
Modulation Index=2
fx >>
```

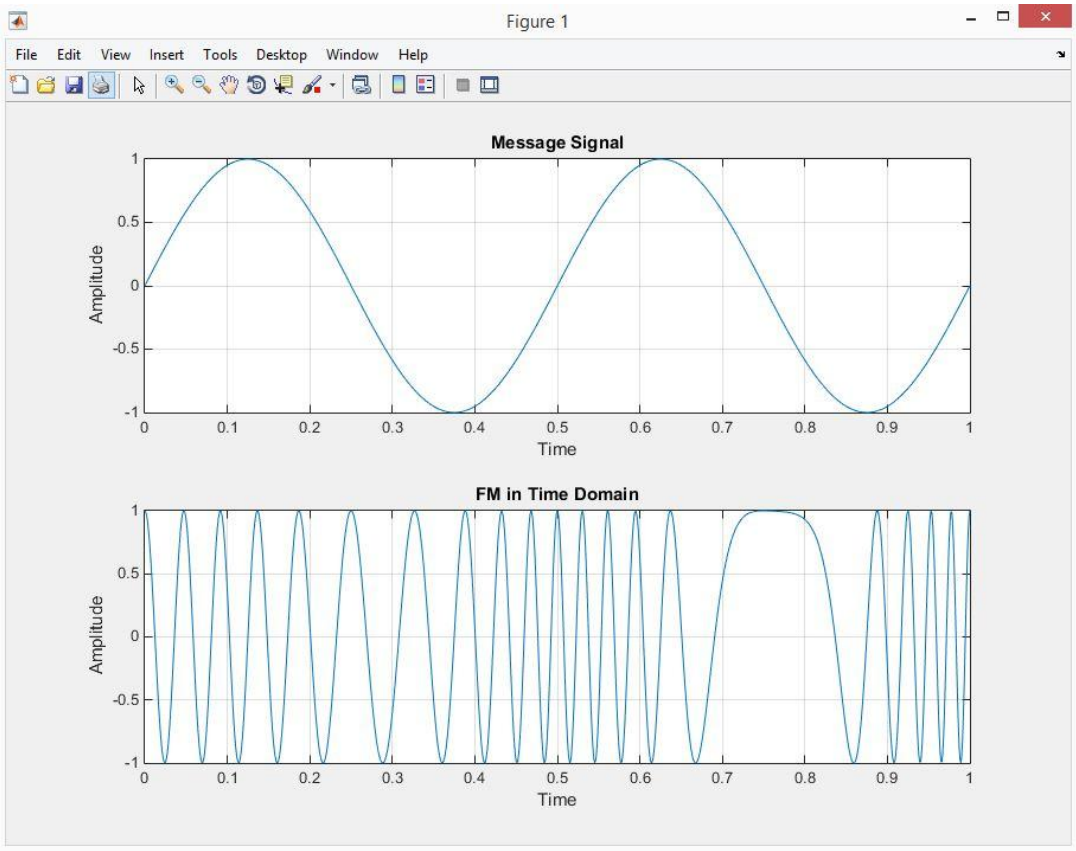


Figure 1
File Edit View Insert Tools Desktop Window Help
Message Signal
Amplitude
Time
FM in Time Domain
Amplitude
Time

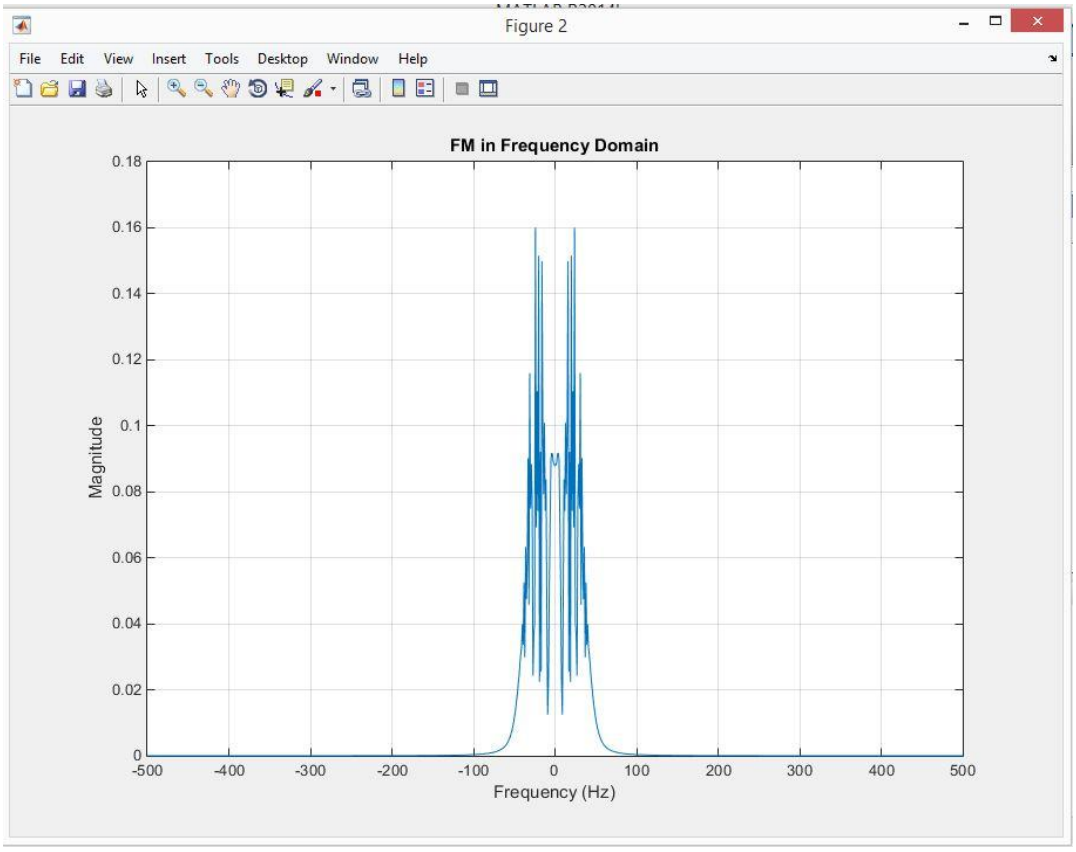


Figure 2
File Edit View Insert Tools Desktop Window Help
FM in Frequency Domain
Magnitude
Frequency (Hz)

CONCLUSION

In amplitude modulation, the amplitude of the carrier wave is modified in order to transmit information. In DSB-SC modulation, output signal is equal to product of message and carrier signals. In SSB-SC modulation, we get LSB or USB according to filter type (Low Pass Filter or High Pass Filter) after product of message and carrier signals. In frequency modulation, the instantaneous frequency of the carrier wave is modified in order to transmit information.