University of Malta
Department of Communications and Computer Engineering

Laboratory session 2: Modulation

Name: ______________________
Date: ______________________

Objective: In this experiment you will learn how to use Matlab to simulate modulation schemes.

Experiment 1: Double Sideband Full Carrier Modulation

Copy the program below in the editor and save it as an .m file.

```
N = 1024;   %N point FFT N>fc to avoid freq domain aliasing
fs = 4096; % sample frequency
t = (0:N-1)/fs;

fc  = 600;  %Carrier Frequency
fm1 = 20;   %Three message signal frequencies
fm2 = 80;
fm3 = 40;

Ec  = 20;    %Carrier Amplitude
Em1 = 5;    %Three message signal amplitudes
Em2 = 5;
Em3 = 5;


A  =  Ec + Em1*sin(2*pi*fm1*t) + Em2*sin(2*pi*fm2*t) +
Em3*sin(2*pi*fm3*t); %Envelope/eliminate the carrier amplitude
m  = A.*[sin(2*pi*fc*t)];
%to convert DSB-AM to DSB-SC
Mf = 2/N*abs(fft(m,N));
f = fs * (0 : N/2) / N;    %Since the fft result is symmetrical, only
the positive half is sufficient for spectral representation

close all;

figure('Name','Time/Fequency domain representations of DSB-AM
signals');
subplot(2,1,1); %Time domain plot
plot(t(1:N/2),m(1:N/2),t(1:N/2),A(1:N/2),'r',t(1:N/2),-A(1:N/2),'r');
title('Time Domain');
xlabel('Time'); ylabel('Modulated signal');
```

```
subplot(2,1,2); %Frequency Domain Plot
plot(f(1:256),Mf(1:256));
title('Frequency Domain');
xlabel('Frequency (Hz)'); ylabel('Spectral Magnitude');
```

1. Run the program.
2. Save a copy of the result.
3. Change the values of the signal amplitudes and carrier amplitude and observe the difference at the output.
4. Save a copy of the results.

Experiment 2: Double Sideband Suppressed Carrier Modulation

Copy the program below in the editor and save it as an .m file.

```
N = 1024;   %N point FFT N>fc to avoid freq domain aliasing
fs = 4096; % sample frequency
t = (0:N-1)/fs;

fc  = 600;  %Carrier Frequency
fm1 = 20;   %Three message signal frequencies
fm2 = 80;
fm3 = 40;

Ec  = 20;    %Carrier Amplitude
Em1 = 5;    %Three message signal amplitudes
Em2 = 5;
Em3 = 5;

A  =   Em1*sin(2*pi*fm1*t) + Em2*sin(2*pi*fm2*t) + Em3*sin(2*pi*fm3*t);
%Envelope/eliminate the carrier amplitude
m  = A.*[sin(2*pi*fc*t)];
%to convert DSB-AM to DSB-SC
Mf = 2/N*abs(fft(m,N));

figure('Name','Time/Fequency domain representations of DSB-SC
signals');
subplot(2,1,1); %Time domain plot
plot(t(1:N/2),m(1:N/2),t(1:N/2),A(1:N/2),'r',t(1:N/2),-A(1:N/2),'r');
title('Time Domain');
xlabel('Time'); ylabel('Modulated signal');

subplot(2,1,2); %Frequency Domain Plot
plot(f(1:256),Mf(1:256));
title('Frequency Domain');
xlabel('Frequency (Hz)'); ylabel('Spectral Magnitude');
text(15,60,'Carrier');
```

1. Run the program.
2. Save a copy of the result.

3. Change the values of the signal amplitudes and carrier amplitude and observe the difference at the output.
4. Save a copy of the results.

Experiment 3: Single Sideband Modulation

Copy the program below in the editor and save it as an .m file.

```
N = 1024;
fs = 2048;
t = (0:N-1)/fs;
fc = 600; %Carrier frequency !! Limit fc<800 to avoid freqdomain
aliasing
fm1 = 200;
fm2 = 100;
Em1 = 2;
Em2 = 2;

m = Em1*cos(2*pi*fm1*t)+Em2*cos(2*pi*fm2*t); %Message
mh = imag(hilbert(m)); %Hilbert transform of the message signal

sbu = m.*2.*cos(2*pi*fc*t) - mh.*2.*sin(2*pi*fc*t);  %Expression for
USB SSB
sbl = m.*2.*cos(2*pi*fc*t) + mh.*2.*sin(2*pi*fc*t);  %Expression for
LSB SSB
SBU = 2/N*abs(fft(sbu));
SBL = 2/N*abs(fft(sbl));

freq = fs * (0 : N/2) / N;
clc;
display('Single SideBand Modulation');
sprintf('Carrier frequency: %d Hz',fc)
sprintf('Message frequency: %d Hz and %d Hz',fm1,fm2)
sprintf('USB spectra at: %d Hz and %d Hz',fc+fm1,fc+fm2)
sprintf('LSB spectra at: %d Hz and %d Hz',fc-fm1,fc-fm2)

close all;
subplot(211);
plot(10*t(1:200),sbu(1:200),'b'); %Time Domain Plot
title('Time Domain Representation');
xlabel('Time'); ylabel('Modulated Signal');

subplot(212);
plot(freq,SBU(1:N/2+1),freq,SBL(1:N/2+1)); %Frequency domain plot
title('Frequency Domain Representation');
xlabel('Frequency(Hz)'); ylabel('Spectral Magnitude');
legend('USB','LSB')
```

1. Run the program.
2. Save a copy of the result.
3. Change the values of the signal amplitudes and carrier amplitude and observe the difference at the output.
4. Save a copy of the results.

Comments:

Matlab scripts above by Saurav R Tuladhar available at http://www.mathworks.com/matlabcentral/fileexchange/loadFile.do?objectId=8732&objectType=file