3rd Year Computer Engineering

Communication Engineering

Lab 1

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Sec: 1

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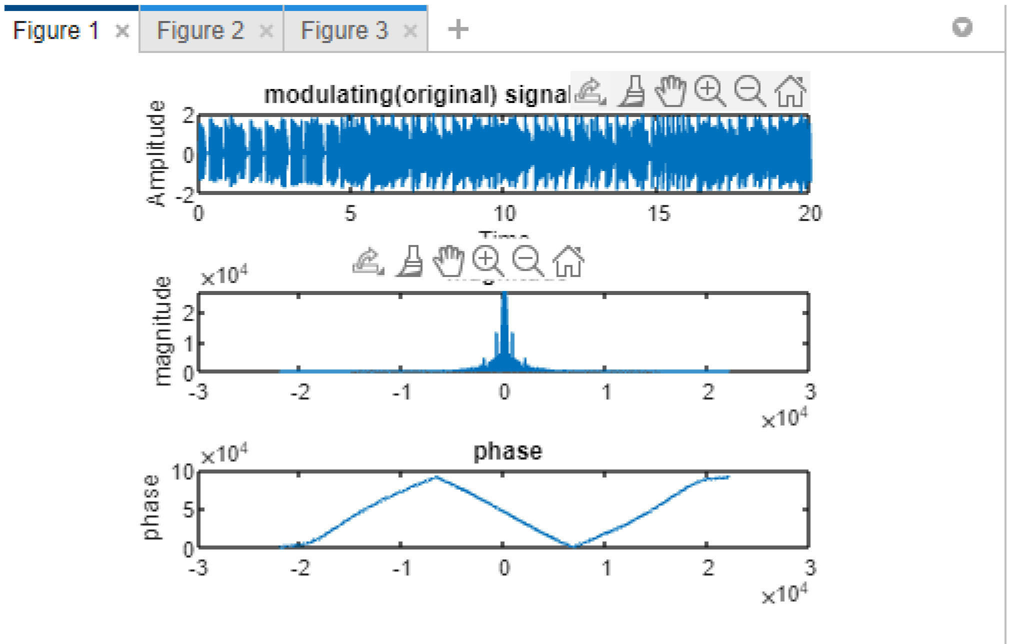
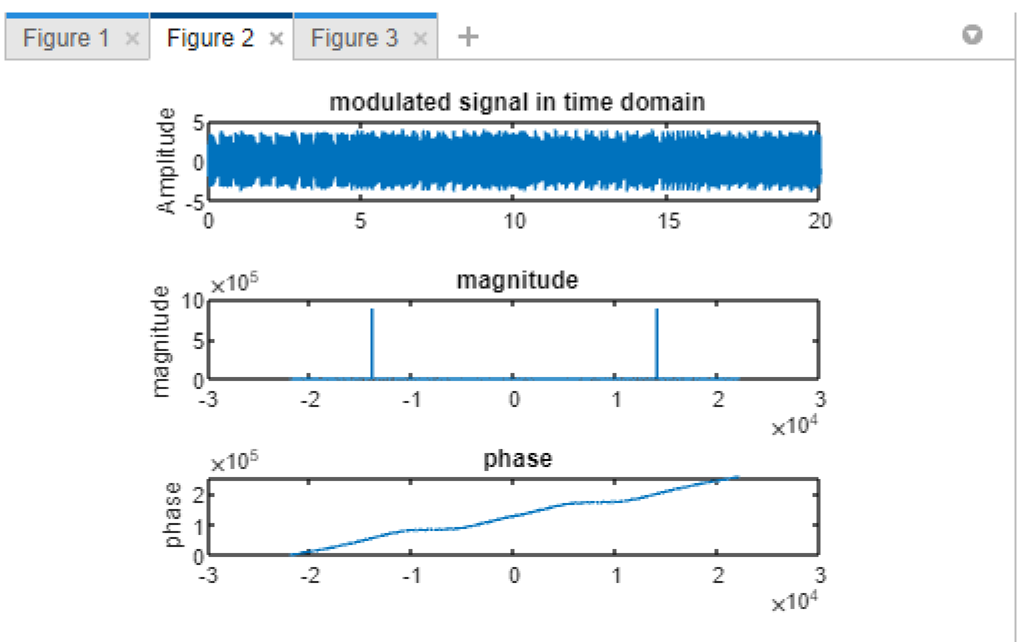
Simulating result screenshots:

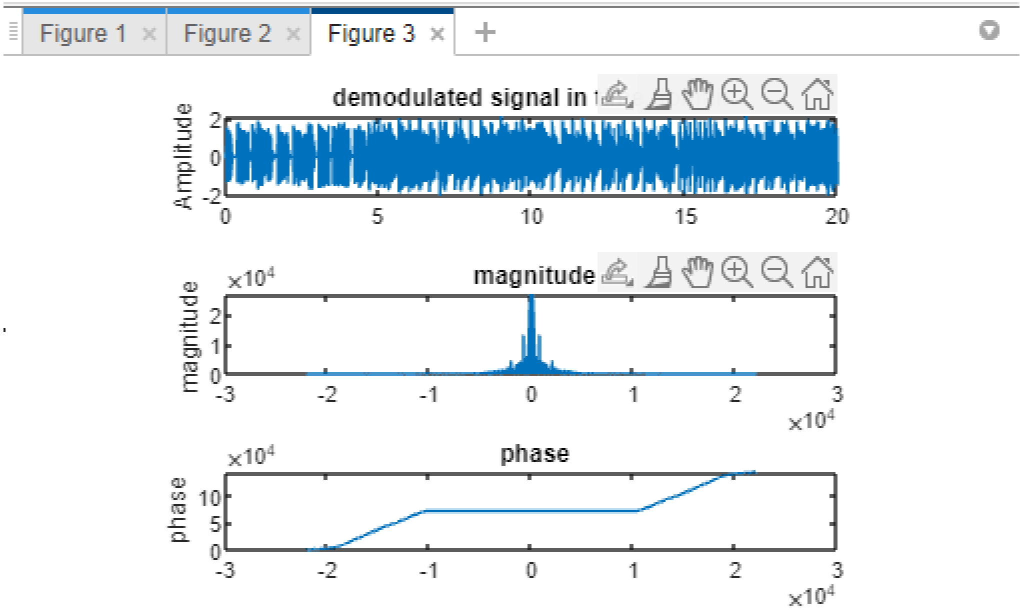
- **Modulating signal result:**



- **Modulated signal result:**



- **demodulated signal result:**



Questions:

Choose any audio signal with 20sec length:

1. Read the audio signal in MATLAB and then plot the signal waveform in time domain, the signal amplitude, and phase in the frequency domain.
   Answer: Done in the code.

Perform DSB-LC modulation:

2. Choose reasonable values for A and ω to achieve DSB-LC modulation with your previous audio signal and explain how you choose them?
   Answer: A >= 1.991, because that the absolute negative peak amplitude = |-1.991| to avoid any over lapping.

   Wc = 2*pi*Fc, Ts = 1/Fs, Fc <= Fs/2, minimum value for W is Wc (band width of the signal).

3. Plot the modulated signal waveform in time domain and the modulated signal amplitude and phase in frequency domain.
   Answer: Done in the code.
4. What do you think is a carrier's minimum Amplitude (A) to avoid over modulation? What is the problem with the AM signal when it is over-modulated?
   Answer: minimum (A) is approximately 1.991 to avoid any over lapping, The problem with the AM signal when it is over-modulated, then when demodulated the modulated signal will not be like the modulating signal.
5. Compare between the bandwidth of the audio signal and the modulated one by

plotting both signal in the frequency domain.
Answer: Done in the code.

Perform DSB-LC modulation:

6. Do synchronous demodulation to obtain x(t), then plot the final signal in time and frequency domain as previous.
   Answer: Done in the code.
7. Hear the demodulated signal and compare it with the original one.
   Are the two signals the same? Explain why?
   Answer: the demodulated signal and the original one is almost the same.
   Efficiency η = (Ps)/ (Pc + Ps) = (Pm)/ (Ac^2 + Pm) = (μ^2)/(2 + μ^2)

$$\text{Efficiency } \eta = \frac{\text{useful power}}{\text{total power}} = \frac{P_S}{P_C+P_S}$$

$$= \frac{\mu^2}{2+\mu^2} 100\%$$

   μ = |-1.991|/2 = 0.9955, then η = (0.9955^2)/ (2 + (0.9955) ^2) = 0.33
   then η = 33%, and the efficiency is value between [0, 33%], so the demodulated signal almost the same as the original one.

My code:

```
filename = 'sample3.wav';
[sig,fs] = audioread(filename);
samples = [1,20*fs];
clear sig fs
[sig,fs] = audioread(filename,samples);
sig = sig(:,1) + sig(:,2);
N = size(sig,1);
sound(sig,fs);
%=======================================================================%
%time domain
time = (0:length(sig) - 1)*20/length(sig);
figure(1);
subplot(3,1,1);
plot(time,sig);
title(" modulating(original) signal in time domain");
xlabel('Time');
ylabel('Amplitude');
%=======================================================================%
%  Frequency domain
freq_y= fft(sig);
dfs=fs/length(sig);
fre_range=-fs/2:dfs:fs/2-dfs;
```

```
magnitude_1=abs(fftshift(freq_y));
phase_1=unwrap(angle(freq_y));
subplot(3,1,2);
plot(fre_range,magnitude_1);
title(" magnitude");
ylabel('magnitude');
subplot(3,1,3);
plot(fre_range,phase_1);
title(" phase");
ylabel('phase');
%===========================================================================%
%carrier and modulation
bw=bandwidth(sig)./(2.*pi);
fc=(fs/2)-bw;
wc=fc*2*pi;
%A ==> minimum value
Ac = abs(min(sig));
carrier= cos(wc*time).';
%===========================================================================%
%time
modulated_signal = (sig+Ac).*carrier;
figure(2);
subplot(3,1,1);
plot(time,modulated_signal);
title(" modulated signal in time domain");
ylabel('Amplitude');
%===========================================================================%
%  Frequency domain
freq_y_2=fft(modulated_signal);
magnitude_2=abs(fftshift(freq_y_2));
phase_2=unwrap(angle(freq_y_2));
subplot(3,1,2);
plot(fre_range,magnitude_2);
title(" magnitude");
ylabel('magnitude ');
subplot(3,1,3);
plot(fre_range,phase_2);
title(" phase");
ylabel('phase');
%===========================================================================%
%demodulation
demodulated_signal =  modulated_signal.*carrier;
LPF = lowpass(demodulated_signal,10000,fs);
LPF=LPF*2;
```

```
LPF = LPF -Ac;
%=====================================================================================%
%time
figure(3);
subplot(3,1,1);
plot(time,LPF);
title(" demodulated signal in time domain");
ylabel('Amplitude');
%=====================================================================================%
%  Frequency domain
freq_y_3=fft(LPF);
magnitude_3=abs(fftshift(freq_y_3));
phase_3=unwrap(angle(freq_y_3));
subplot(3,1,2);
plot(fre_range,magnitude_3);
title(" magnitude");
ylabel('magnitude ');
subplot(3,1,3);
plot(fre_range,phase_3);
title(" phase");
ylabel('phase');
sound(LPF,fs);
```

Code screenshots:

ex.m

```
filename = 'sample3.wav';
[sig,fs] = audioread(filename);
samples = [1,20*fs];
clear sig fs
[sig,fs] = audioread(filename,samples);
sig = sig(:,1) + sig(:,2);
N = size(sig,1);
%sound(sig,fs);
%========================================================================%
%time domain
time = (0:length(sig) - 1)*20/length(sig);
figure(1);
subplot(3,1,1);
plot(time,sig);
title(" modulating(original) signal in time domain");
xlabel('Time');
ylabel('Amplitude');
```

ex.m

```
ylabel('Amplitude');
%========================================================================%
%  Frequency domain
freq_y= fft(sig);
dfs=fs/length(sig);
fre_range=-fs/2:dfs:fs/2-dfs;
magnitude_1=abs(fftshift(freq_y));
phase_1=unwrap(angle(freq_y));
subplot(3,1,2);
plot(fre_range,magnitude_1);
title(" magnitude");
ylabel('magnitude');
subplot(3,1,3);
plot(fre_range,phase_1);
title(" phase");
ylabel('phase');
%========================================================================%
```

ex.m

```
%========================================================================%
%carrier and modulation
bw=bandwidth(sig)./(2.*pi);
fc=(fs/2)-bw;
wc=fc*2*pi;
%A ==> minimum value
Ac = abs(min(sig));
carrier= cos(wc*time).';
%========================================================================%
%time
modulated_signal = (sig+Ac).*carrier;
figure(2);
subplot(3,1,1);
plot(time,modulated_signal);
title(" modulated signal in time domain");
ylabel('Amplitude');
%========================================================================%
```

ex.m

```
%=========================================================================%
%  Frequency domain
freq_y_2=fft(modulated_signal);
magnitude_2=abs(fftshift(freq_y_2));
phase_2=unwrap(angle(freq_y_2));
subplot(3,1,2);
plot(fre_range,magnitude_2);
title(" magnitude");
ylabel('magnitude ');
subplot(3,1,3);
plot(fre_range,phase_2);
title(" phase");
ylabel('phase');
%=========================================================================%
%demodulation
demodulated_signal =  modulated_signal.*carrier;
LPF = lowpass(demodulated_signal,10000,fs);
```

ex.m

```
LPF = lowpass(demodulated_signal,10000,fs);
LPF=LPF*2;
LPF = LPF -Ac;
%=========================================================================%
%time
figure(3);
subplot(3,1,1);
plot(time,LPF);
title(" demodulated signal in time domain");
ylabel('Amplitude');
%=========================================================================%
%  Frequency domain
freq_y_3=fft(LPF);
magnitude_3=abs(fftshift(freq_y_3));
phase_3=unwrap(angle(freq_y_3));
subplot(3,1,2);
plot(fre_range,magnitude_3);
```