GEBZE TECHNICAL UNIVERSITY

ENGINEERING FACULTY

ELECTRONICS ENGINEERING

ELEC361

ANALOG COMMUNICATION SYSTEMS

MATLAB Project

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The message signal $m(t)=\sin(200\pi t)+5\cos(400\pi t)$ modulates the carrier signal $c(t)=10\cos(2\pi f c t)$, where $f c$=2kHz.

a) Plot the message signal for one period. Plot the magnitude spectrum of the message signal.

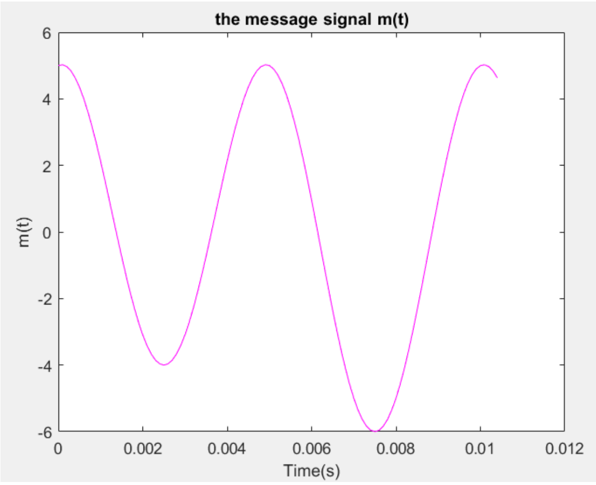


Figure 1. Matlab output for m(t)

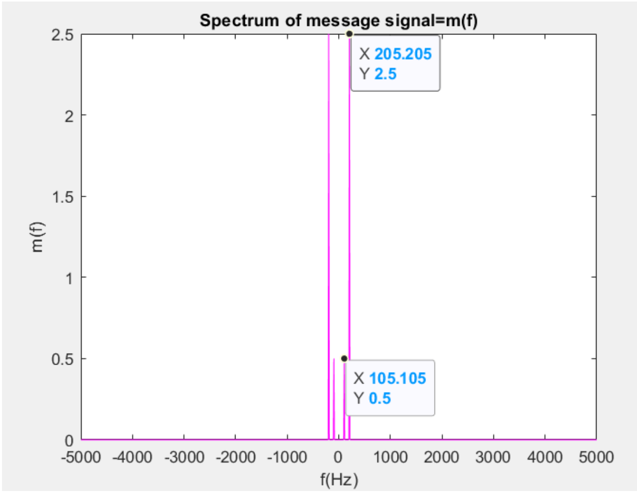
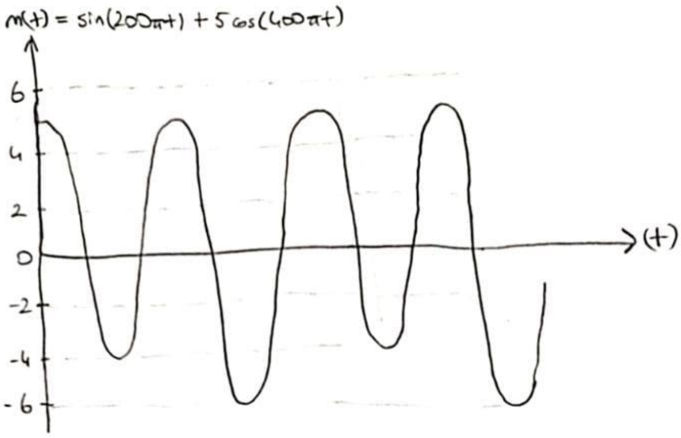
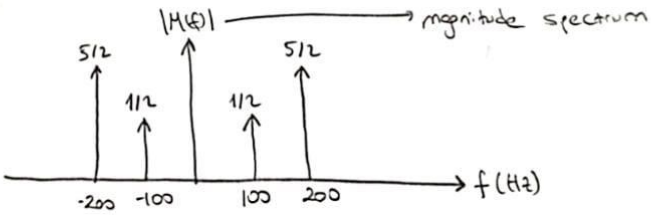


Figure 2. Matlab output for m(f)



M(f) = spectrum of the message signal

$$M(f)=\frac{1}{2j}\left[\delta(f+100)-\delta(f-100)\right]+\frac{5}{2}\left[\delta(f+200)+\delta(f-200)\right]$$



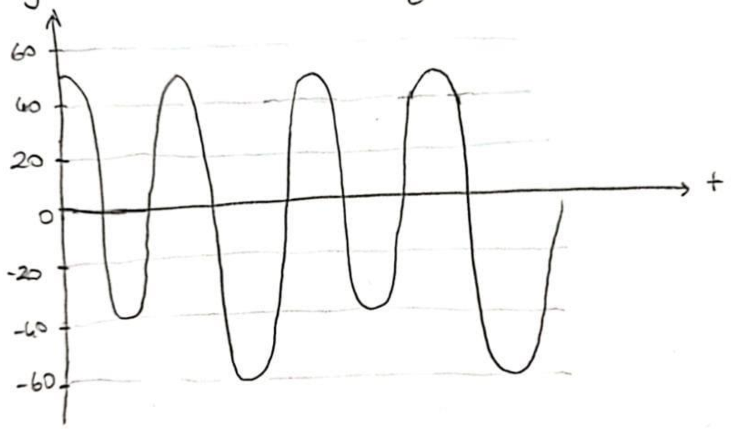
BW{m(t)}=200 Hz

It shows matlab compatibility with the analytically found graphic.

b) For Double Sideband Suppressed Carrier Amplitude Modulation (DSB-SC-AM),

i. Plot the modulated signal and its spectrum.

$y(t) = m(t) . c(t) = 10\cos(2\pi 2k t)[\sin(200\pi t) + 5\cos(400\pi t)]$

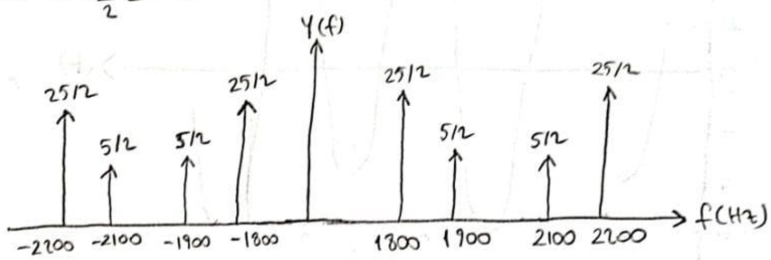


modulated signal = $y(t)$ $\longrightarrow$ its spectrum = $Y(f)$

$y(t) = 10 . m(t) . \cos(2\pi 2k t)$

$\Big\downarrow \mathcal{F}$

$Y(f) = 10 . \frac{1}{2} [M(f-2k) + M(f+2k)]$



The graph of y(t) is drawn analytically and by taking the Fourier transform, it is also drawn in Y(f). Compared to the following Matlab outputs.

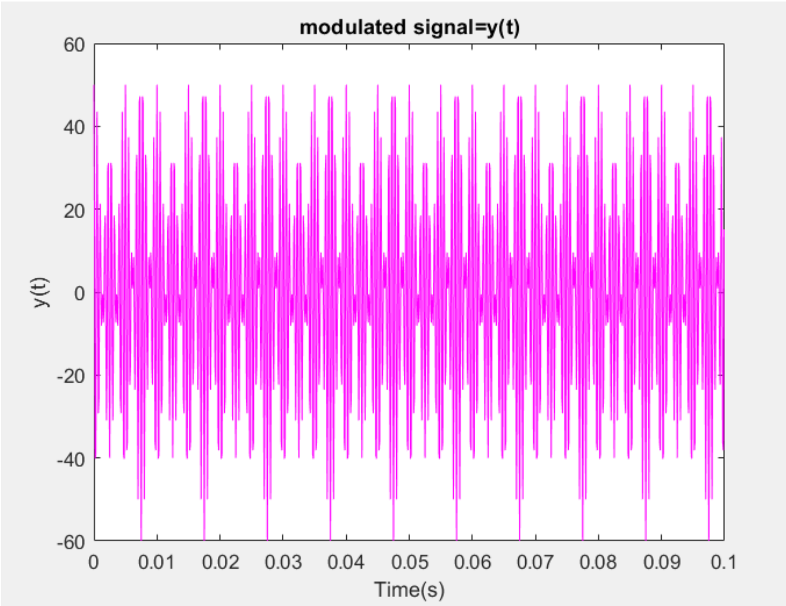


Figure 3. Matlab output for y(t)

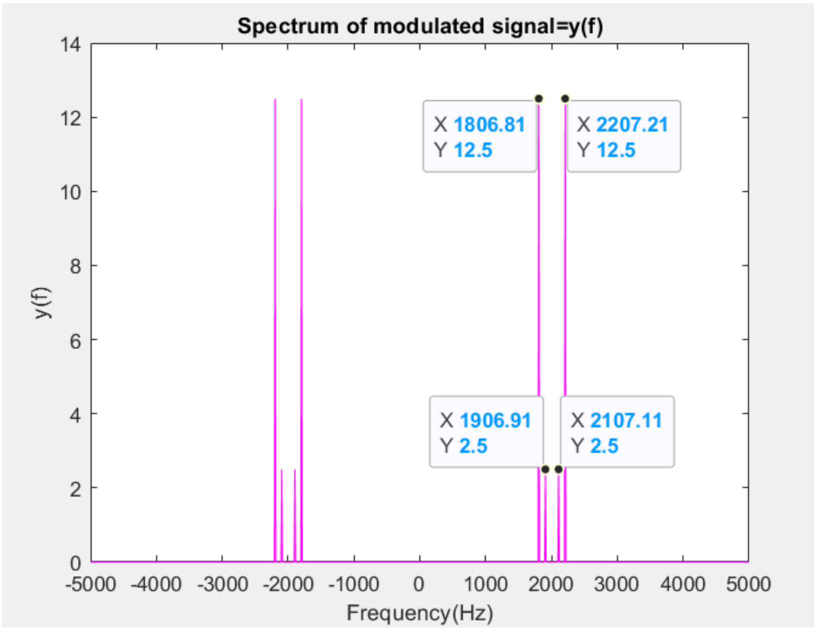
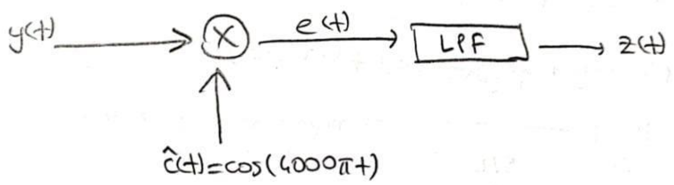


Figure 4. Matlab output for y(f)

ii. If the carrier signal generated at the demodulator is $\hat{c}(t)$=cos($4000\pi t$), plot the signal at the input of the LPF (with only simulation) and its spectrum.



signal at the input of the LPF=$e(t) = y(t).\ c\ (t)$

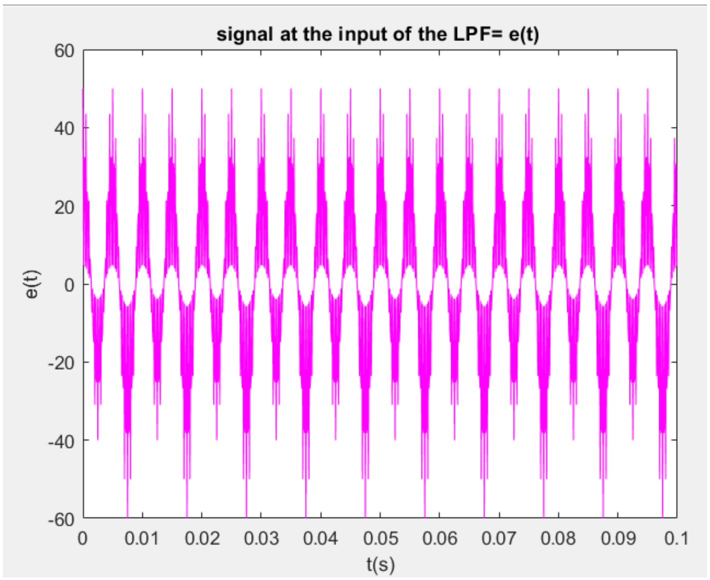


Figure 5. Matlab output for e(t)

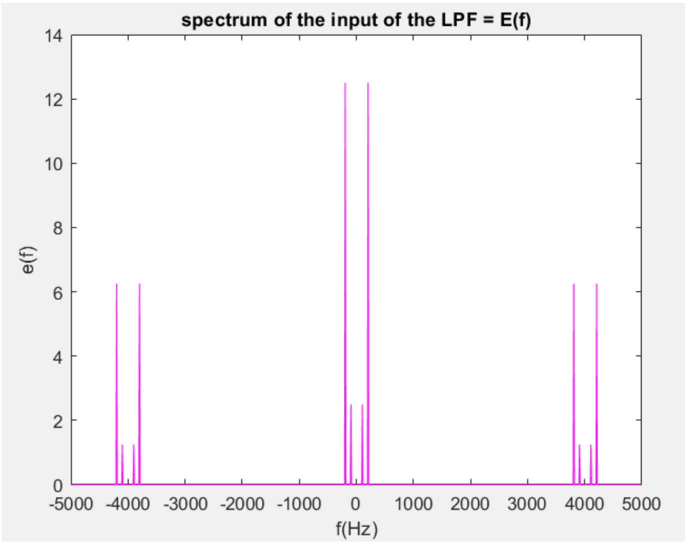
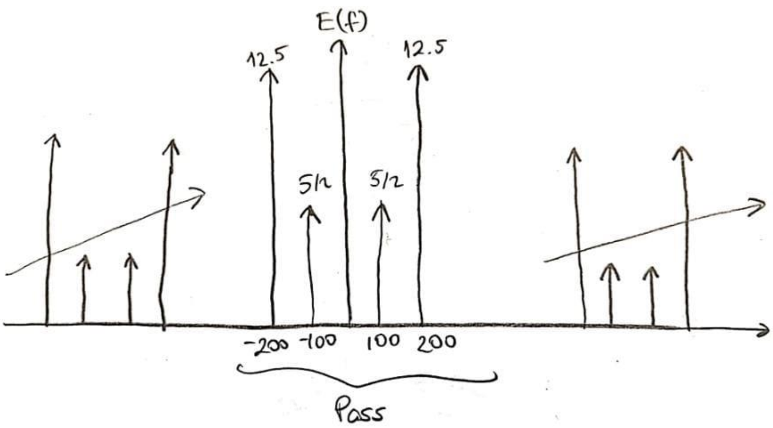


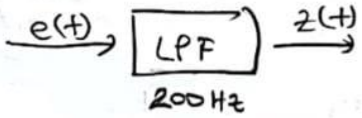
Figure 6. Matlab output for E(F)

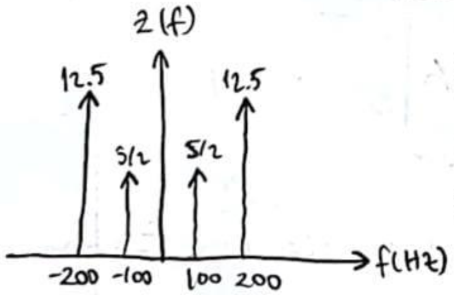
iii. Plot the signal at the output of the LPF and its spectrum.

Using 200 Hz Low pass filter;



Since the bodwith of the message signal is 200 Hz,
the bodwith of the low pass filter is determined as 200 Hz.
When we examine the E(f) output obtained in matlab,
if we pass this signal through the low-pass filter,
the signals at -100, -200, 100 and 200 Hz frequencies will
pass, and the other sidebands cannot pass through the filter.

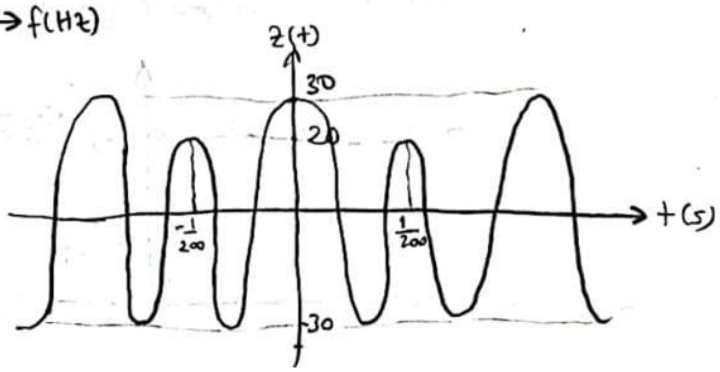




$$Z(f) = \frac{5}{2}\left[\delta(f-100)+\delta(f+100)\right] + \frac{25}{2}\left[\delta(f-200)+\delta(f+200)\right]$$

$$\Big\downarrow F^{-1}$$

$$z(t) = 5\cos(2\pi 100 t) + 25\cos(2\pi 200 t)$$



Matlab codes

```
%Merve TUTAR 1901022050
fs =10^4; % Sampling frequency
ts = 1/fs; % Sampling time
t = 0:ts:(5/50-ts); % Time axis

% the message signal m(t)
mt = sin(200*pi*t) + 5*cos(400*pi*t);
f_mt = fftshift(fft(mt)/length(mt)); %Fourier transform
f = linspace(-fs/2,fs/2,length(t)); % Frequency
figure(1);
plot(t(1:105),mt(1:105),'m');% Plotting message signal for only one
period
xlabel('Time(s)');
ylabel('m(t)');
title('the message signal m(t)');
```

```
figure(2);
plot(f,abs(f_mt),'m');
xlabel('f(Hz)');
ylabel('m(f)');
title('Spectrum of message signal=m(f)');

% the carrier signal c(t)
ct = 10*cos(2*pi*2000*t);
%modulated signal y(t)
yt = mt.*ct;
f_yt = fftshift(fft(yt)/length(mt));%Fourier transform
figure(3);
plot(t,yt,'m');
xlabel('Time(s)');
ylabel('y(t)');
title('modulated signal=y(t)');
figure(4);
plot(f,abs(f_yt),'m');
xlabel('Frequency(Hz)');
ylabel('y(f)');
title('Spectrum of modulated signal=y(f)');
%demodulator
c2 = cos(pi*4000*t);
%e(t)
et = yt.*c2; % the input of the LPF
f_et = fftshift(fft(et)/length(mt));%Fourier transform
figure(5);
plot(t,et,'m');
xlabel('t(s)');
ylabel('e(t)');
title('signal at the input of the LPF= e(t) ');
figure(6);
plot(f,abs(f_et),'m');
xlabel('f(Hz)');
ylabel('e(f)');
title('spectrum of the input of the LPF = E(f)');
```

In matlab codes, first the necessary frequency and period definitions were made and the message signal was drawn for one period. Then, the Fourier transform of the signal was taken using fftshift, fft commands. Then, the modulated signal y(t) is obtained by multiplying the message signal m(t) with the carrier signal c(t). The fourier transform of the modulated signal using the same commands was made and the M(f) sign was found.

For the demodulation process, the y(t) signal is multiplied by the carrier signal and the e(t) signal is obtained. That is, this is the input signal of the low-pass filter. Its Fourier transform is taken in the same way and passed through the low-pass filter to obtain z(f). Also, the Z(t) signal is found. In this way, the demodulation process was carried out.

c) For Double Sideband Large Carrier Amplitude Modulation (DSB-LC-AM),

i. Plot the modulated signal and its spectrum. The modulation index is μ=0.6

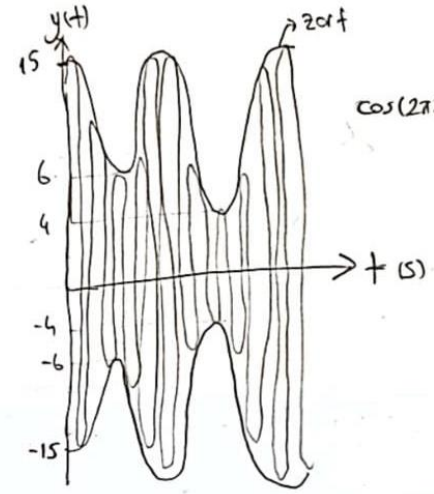
DSB-LC-AM

$$y(t) = A_c\,[1+\mu . m_n(t)] . \cos(2\pi f_c t) \qquad \mu = 0.6$$

$$m_n(t) = \frac{m(t)}{\max|m(t)|} \qquad m(t) = \sin(200\pi t) + 5\cos(400\pi t) \qquad \max|m(t)| = 6$$

$$y(t) = 10\left[1 + 0.6\,\frac{m(t)}{6}\right] . \cos(2\pi 2k t) = 10\,\underbrace{[1 + 0{,}1 . m(t)]} . \cos(2\pi . 2k t)$$

$t=0$ için 15



$\cos(2\pi 2k t)$ içeride salınacak.

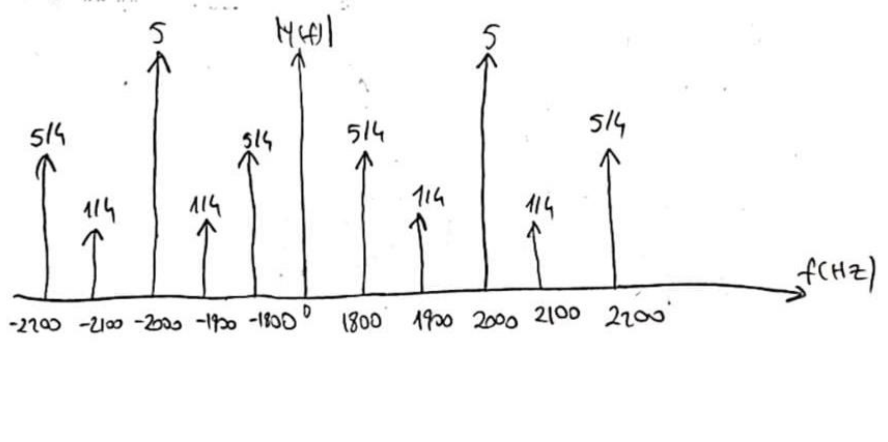
$$\sin(2\pi f_0 t) \xrightarrow{F} \frac{-1}{2j}\left[\delta(f+f_0) - \delta(f-f_0)\right]$$

$$\cos(2\pi f_0 t) \xrightarrow{F} \frac{1}{2}\left[\delta(f+f_0) + \delta(f-f_0)\right]$$

$$y(t) = 10\cos(2\pi 2k t) + \underbrace{\sin(2\pi 100 t) . \cos(2\pi 2k t) + 5\cos(2\pi 200 t) . \cos(2\pi 2k t)}$$

$$y(t) = 10\cos(2\pi 2000 t) + \frac{1}{2}\sin(2\pi 2100 t) + \frac{1}{2}\sin(2\pi 1900 t) + \frac{5}{2}\cos(2\pi 2200 t) + \frac{5}{2}\cos(2\pi 1800 t)$$

$F\downarrow$



ii. Demodulate the AM signal generated in part (i) by the computing the envelope of the AM signal and subtracting the DC value term to obtain the demodulated signal. Plot the demodulated signal. (With only simulation)

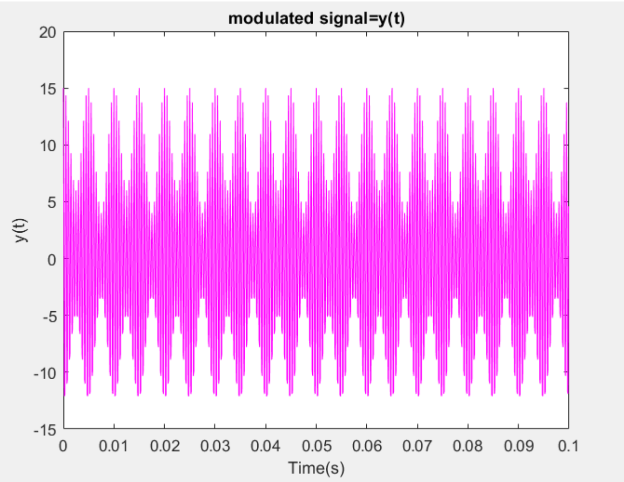


Figure 7. Matlab output for y(t)

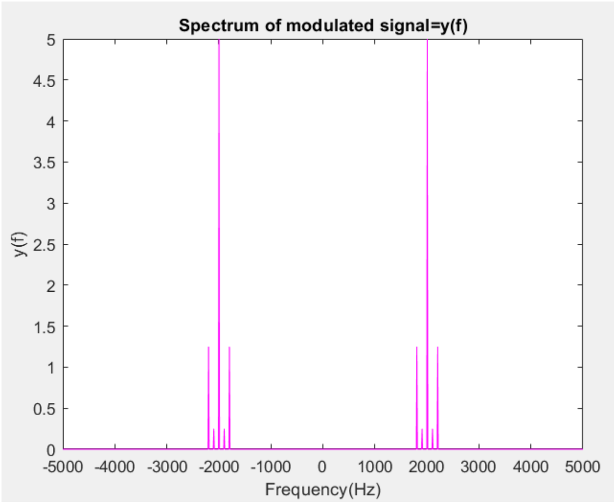


Figure 8. Matlab output for y(f)

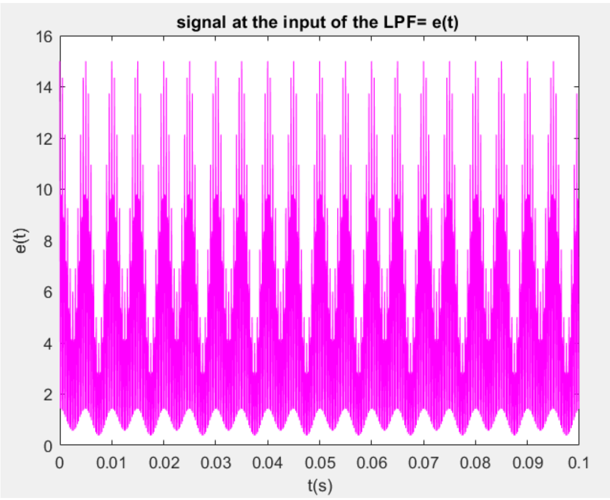


Figure 9. Matlab output for e(t)

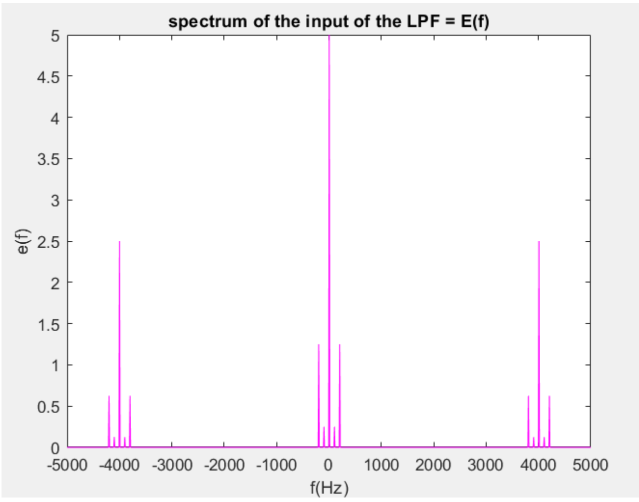


Figure 10. Matlab output for E(F)

In large carrier amplitude modulation, the demodulation process is done by going through the same steps. Looking at the Matlab outputs, it is seen that the graphs are large carriers.

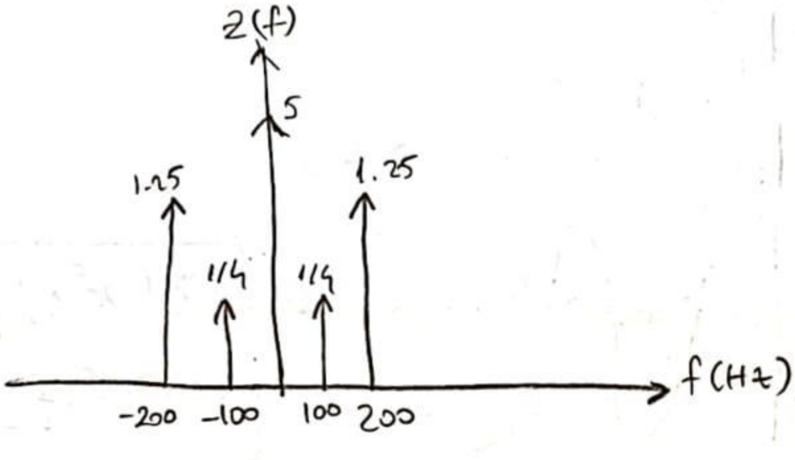
Matlab codes

```
%Merve TUTAR 1901022050
fs =10^4; % Sampling frequency
ts = 1/fs; % Sampling time
t = 0:ts:(5/50-ts); % Time axis

% the message signal m(t)
mt = sin(200*pi*t) + 5*cos(400*pi*t);
f_mt = fftshift(fft(mt)/length(mt)); %Fourier transform
f = linspace(-fs/2,fs/2,length(t)); % Frequency

% the carrier signal c(t)
ct = 10*cos(2*pi*2000*t);
%modulated signal y(t)
yt =(1+ 0.1.*mt) .* ct
f_yt = fftshift(fft(yt)/length(mt));%Fourier transform
figure(3);
plot(t,yt,'m');
xlabel('Time(s)');
ylabel('y(t)');
title('modulated signal=y(t)');
figure(4);
plot(f,abs(f_yt),'m');
xlabel('Frequency(Hz)');
ylabel('y(f)');
title('Spectrum of modulated signal=y(f)');
%demodulator
c2 = cos(pi*4000*t);
%e(t)
et = yt.*c2; % the input of the LPF
f_et = fftshift(fft(et)/length(mt));%Fourier transform
figure(5);
plot(t,et,'m');
xlabel('t(s)');
ylabel('e(t)');
title('signal at the input of the LPF= e(t) ');
figure(6);
plot(f,abs(f_et),'m');
xlabel('f(Hz)');
ylabel('e(f)');
title('spectrum of the input of the LPF = E(f)');
```

After LPF;



$$Z(f) = 5\delta(f) + \frac{1}{4}\left[\delta(f-100) + \delta(f+100)\right] + \frac{5}{4}\left[\delta(f+200) + \delta(f-200)\right]$$

$$z(t) = 5 + \frac{1}{2}\cos(2\pi 100t) + \frac{5}{2}\cos(2\pi 200t)$$