Project 2

ELM 361 Project 2

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Analog Communication Systems
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Electronic Engineering

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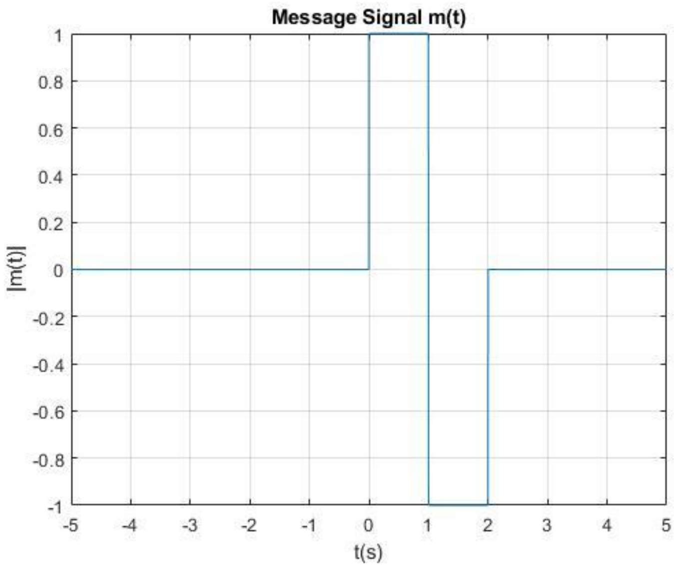
1) Plot the message signal. Obtain and plot the magnitude spectrum of the message signal.

$$m(t) = \prod\left(t-\frac{1}{2}\right) - \prod\left(t-\frac{3}{2}\right)$$

$$k_f = 50$$

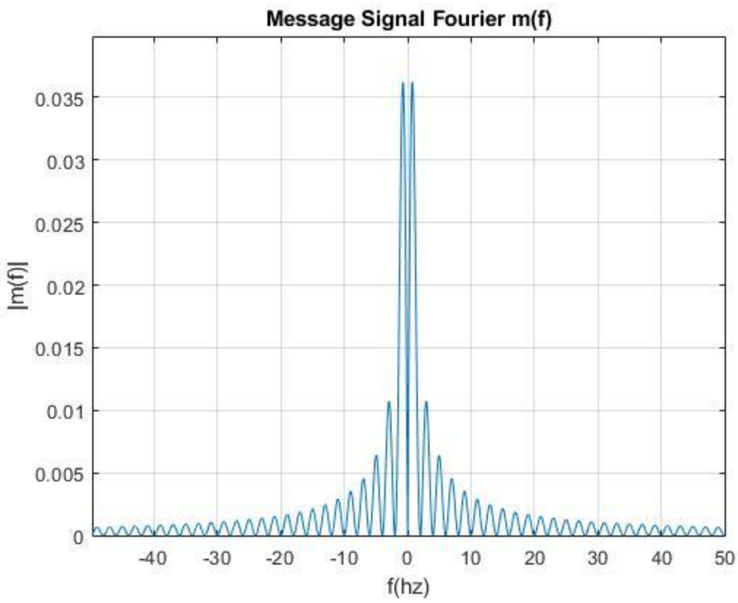
If m(t) is plotted in Matlab;



(Figure 1)

When m(t) is plotted, the square wave in the figure is obtained. If the Fourier transform of m(t) is made and its graph is plotted;

$$M(f) = sinc(f).e^{-\frac{j2\pi 1}{2}f} - sinc(f).e^{-\frac{j2\pi 3}{2}f}$$



(Figure 2)

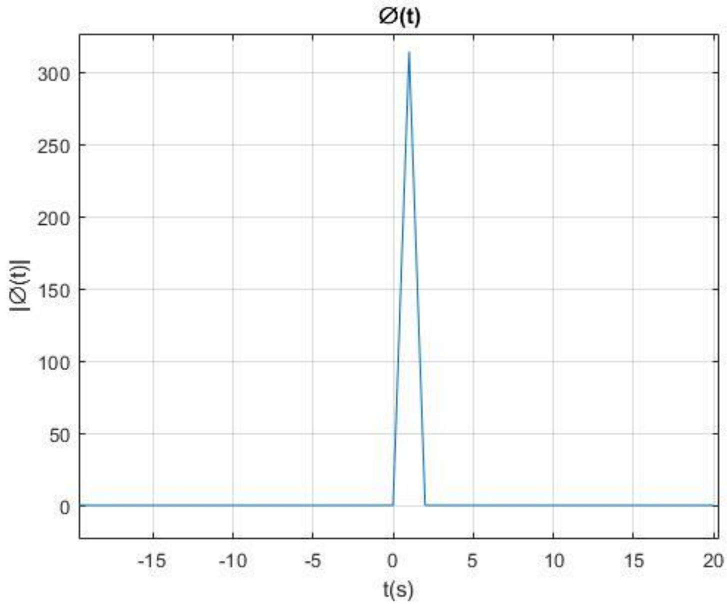
2) Obtain and plot the time-domain representation and magnitude spectrum of the phase $\emptyset(t)$.

$$\emptyset(\mathrm{t}) = 2\pi k_f \int \mathrm{m}(\tau)\mathrm{d}\tau$$

We know that the derivative of the triangular pulse is the square pulse. Therefore, the integral of the message signal, which is a square pulse, is a triangular pulse.

$$\emptyset(\mathrm{t}) = 2\pi k_f \bigwedge(t-1)$$

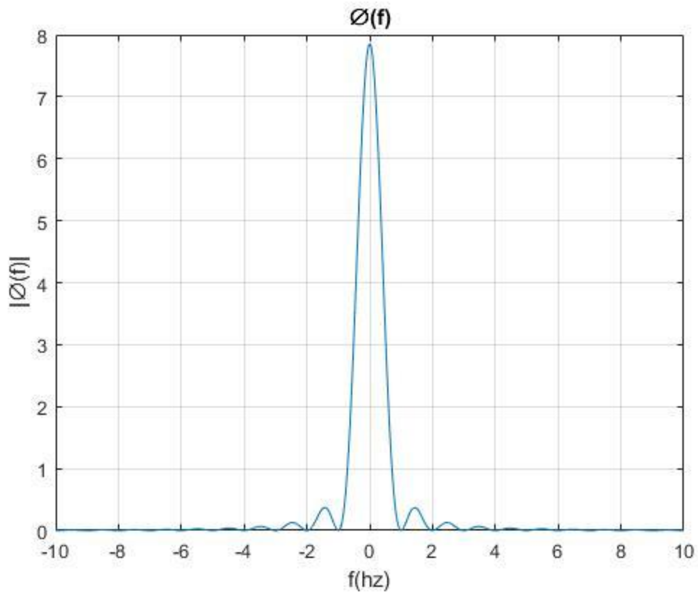
If the graph of Ø(t) is drawn;



(Figure 3)

If the Fourier transform of Ø(t) is made and its graph is drawn;

$$\emptyset(\mathrm{f}) = 2\pi k_f \,\mathrm{sinc}^2(f).\, e^{-j2\pi f}$$



(Figure 4

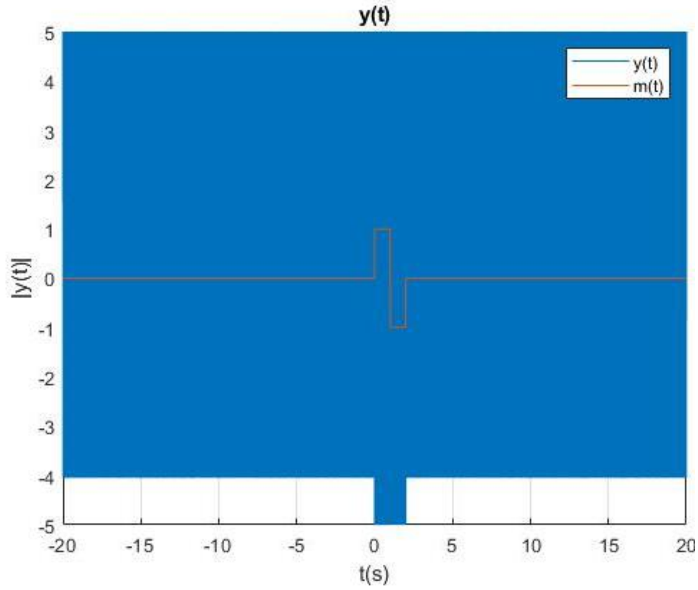
3) Obtain and plot the time-domain representation and magnitude spectrum of the modulated signal $y(t)$.

$$y(t) = 5\text{Cos}(400\pi t + \emptyset(t))$$

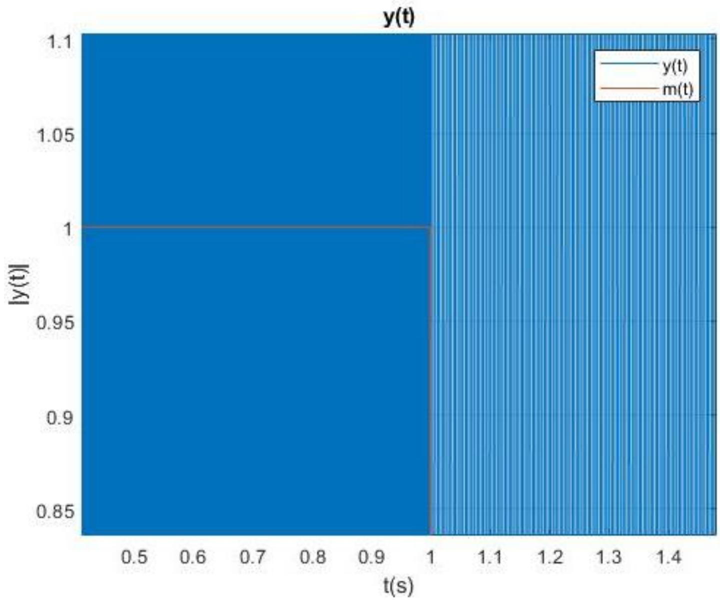
Substituting Ø(t) in y(t);

$$y(t) = 5\text{Cos}(400\pi t + 2\pi k_f \bigwedge(t-1))$$

If the graph of y(t) is drawn;



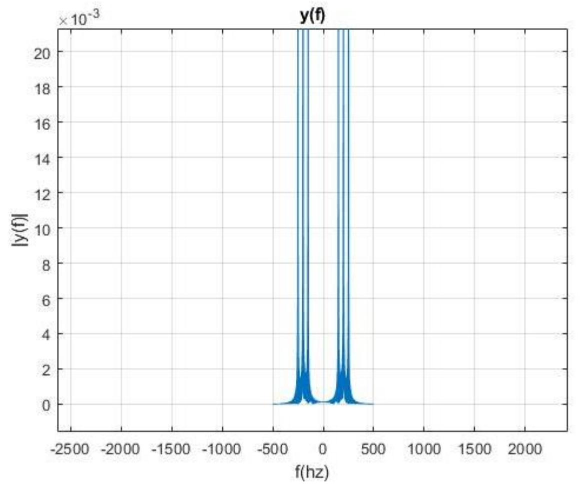
(Figure 6)



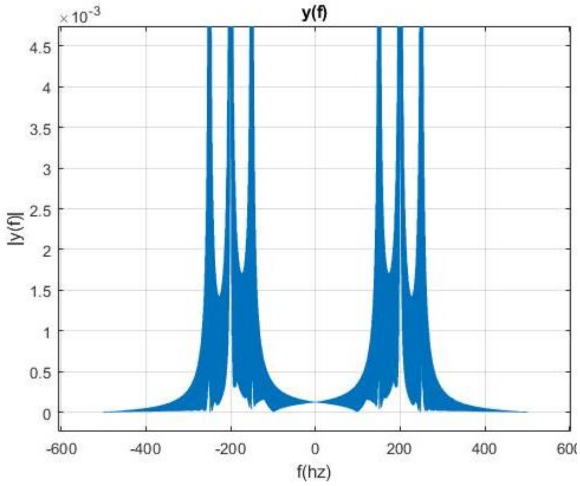
(Figure 5)

Figure 5 shows the graph of y(t). If we take a closer look at Figure 5, the frequency difference in some regions can be seen. The frequency is higher where the message sign is. The small distortion in Figure 5 is due to the scaling number. It gets better when divided into smaller intervals, but the program runs very slowly.

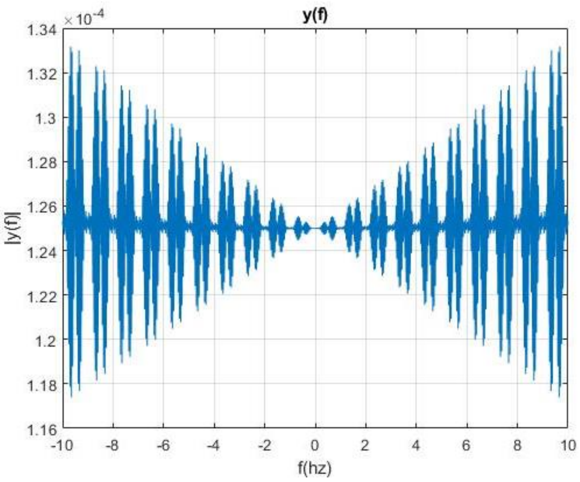
If the Fourier transform of y(t) is made on Matlab and its graph is drawn;



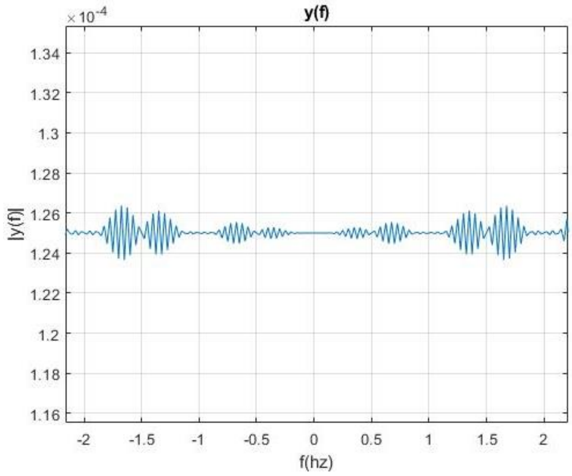
(Figure 7)



Figure(8)



(Figure 9)

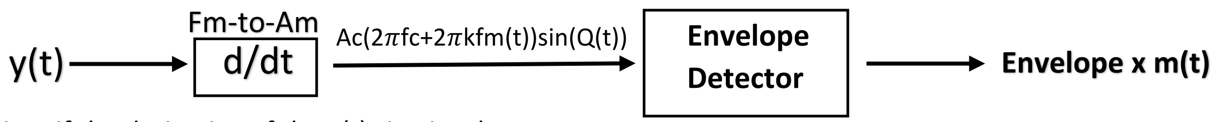


Figure(10)

The graphs of y(f) are shown by converging to the graph in the above order.

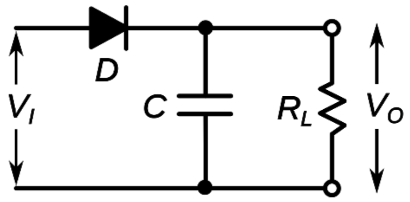
4) Obtain and plot the time-domain representation and magnitude spectrum of the signal at each step of the demodulator. (Do the filtering in frequency domain.) Comment on the signal at each step. Compare the message signal and demodulated signal, and comment on them.

In this section, the Demodulator structure will be defined and the message signal will be obtained again from the y(t) we have found.



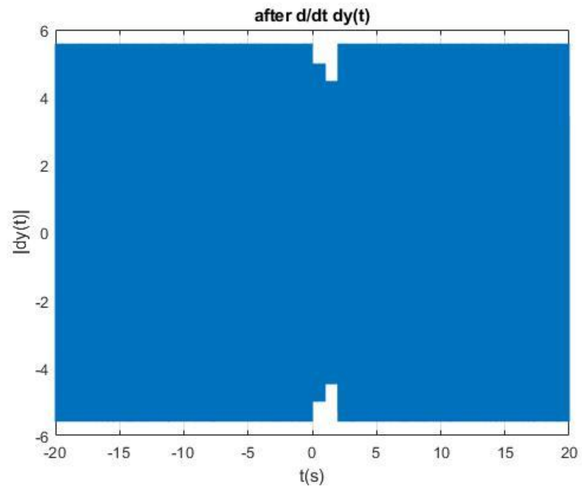
First, if the derivative of the y(t) sign is taken;

$$\frac{dy(t)}{dt} = 5(\cos(400\pi + 2\pi k_f(\prod(t-\frac{1}{2}) - \prod(t-\frac{3}{2}))) . -\sin(400\pi t + 2\pi k_f \bigwedge(t-1))$$



(Envelope Detector)

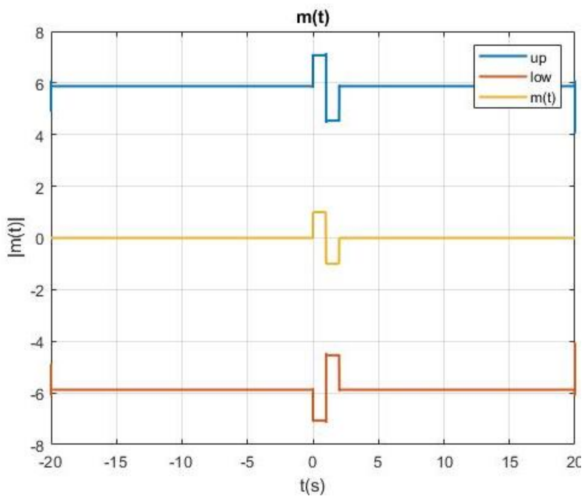
If the graph is drawn after taking the derivative of the y(t) sign;



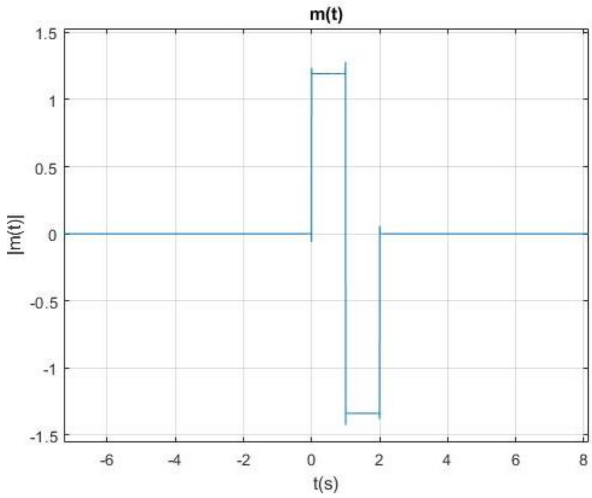
(Figure 11)

If the signal obtained after taking its derivative is inserted into the envelope detector, the message signal is obtained again. Minor distortion in Figure 11 is due to the scaling error. It gets better when divided into smaller intervals, but the program runs very slowly.

If the graph of the resulting message sign is drawn;



(Figure 12)



(Figure 13)

As seen in the graphics, a message sign has been obtained.

5) Do the steps above that can be done analytically, and compare to the simulation results and comment on them.

When we modulated the given message sign, we saw that the graphs we obtained on Matlab were consistent with the results we made analytically. Then we defined the Demodulation structure and obtained the message signal again from the modulated signal. We saw that the signal we obtained analytically in demodulation was the same as the signal we obtained on Matlab.

CODES:

```
    ...MUHAMMET ASIM UYANIK...
    ...1801022012...
    clc;
    clear all;
    % Define Equations
    t=-20:0.001:20;
    c=5*cos(400*pi*t);
    m=rectangularPulse(t-(1/2))-rectangularPulse(t-(3/2));
    kf=50;

    ...1) Plot the message signal. Obtain and plot the magnitude spectrum of the
message signal.
    % Message Signal m(t)
    figure(1)
    plot(t,m);
    title('m(t)')
    xlabel('t(s)')
    ylabel('|m(t)|')
    xlim([-1 3])
    grid on;

    % Message Signal Fourier Transform m(f)
    N = length(m);
    f = linspace(-500,500,N);
    Mf = fftshift(fft(m)/N);
    figure(2);
    plot(f,abs(Mf));
    title('Message Signal Fourier m(f)')
    xlabel('f(hz)')
    ylabel('|m(f)|')
    grid on;
    xlim([-50 50])

    ...2) Obtain and plot the time-domain representation and magnitude spectrum of
the phase Ø(t).
    %fi=2*pi*kf*int((rectangularPulse(x-(1/2))-rectangularPulse(x-(3/2))),0,2);
%çalışmadı

    fi=2*pi*kf*(triangularPulse(t-1)); % 2πkf∫m(T)dT
    figure(3)
    plot(t,fi);
    title('Ø(t)')
    xlabel('t(s)')
    ylabel('|Ø(t)|')
    grid on;

    % Ø(t) Fourier Transform Ø(f)
    N1 = length(fi);
    f1 = linspace(-500,500,N1);
```

```
    Fi1 = fftshift(fft(fi)/N1);
    figure(4);
    plot(f1,abs(Fi1));
    title('Ø(f)')
    xlabel('f(hz)')
    ylabel('|Ø(f)|')
    grid on;
    xlim([-10 10])

    ...3) Obtain and plot the time-domain representation and magnitude spectrum of
the modulated signal y(t).
    y=5*cos(400*pi*t+fi);
    figure(5)
    plot(t,y,t,m);
    legend('y(t)','m(t)');
    title('y(t)')
    xlabel('t(s)')
    ylabel('|y(t)|')
    grid on;
    hi=hilbert(y);

    % y(t) Fourier Transform y(f)
    N2 = length(y);
    f2 = linspace(-500,500,N2);
    Yf = fftshift(fft(y)/N2);
    figure(6);
    plot(f2,abs(Yf));
    title('y(f)')
    xlabel('f(hz)')
    ylabel('|y(f)|')
    grid on;
    xlim([-10 10])

    ...4) Obtain and plot the time-domain representation and magnitude spectrum of
the signal
    ...at each step of the demodulator. (Do the filtering in frequency domain.)
Comment on
    ...the signal at each step. Compare the message signal and demodulated signal,
and comment on them

    % % BP LIMITER (çalışmadı)
    % for i=1:N2
    %     if y(i)>1
    %         y(i)=0;
    %     end
    %     if y(i)<-1
    %         y(i)=0;
    %     end
    % end
    % figure(7)
    % plot(t,y);
    % title('After BP Limiter Yfm(t)')
    % xlabel('t(s)')
    % ylabel('|Yfm(t)|')
    % grid on;
    % xlim([-1 1])

    dy=diff(y);
    dy=[dy 0];
```

```
figure(7)
plot(t,dy);
title('after d/dt dy(t)')
xlabel('t(s)')
ylabel('|dy(t)|')
grid on;

figure(8)
[up,low] = envelope(dy);...Envelope dedektörü
plot(t,up,t,low,t,m,'linewidth',1.5)
legend('up','low','m(t)');
title('m(t)')
xlabel('t(s)')
ylabel('|m(t)|')
grid on;

dhi=diff(hi);
dhi=[dhi 0];
figure(9)
plot(t,abs(dhi)-5.87775);...DC Bileşeni çıkardım.
title('m(t)')
xlabel('t(s)')
ylabel('|m(t)|')
grid on;
```