BIRZEIT UNIVERSITY

Faculty of Engineering and Technology

Electrical and Computer Engineering Department

ENEE3309

COMMUNICATION SYSTEMS
Project 1

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Section: 3

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Abstract:

This is a simple project that aimed to cover the concept of normal amplitude modulation and how to demodulate this signal using envelop concept through MATLAB software in plotting the given signal. Also, in this project the optimum value of the time constant that minimizes the mean square error between modulated signal and the output signal of the envelope detector was calculated using MATLAB.

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1. Procedure

1.1. Plotting s(t) and the ideal envelop detector output y(t):

$$s(t) = A_C[1 + \mu\cos(2\pi f_m t)]\cos(2\pi f_c\, t)$$

For illustrating the first part of the question, which is finding S(t), the message signal was declared `em=Am*cos(wm); % message signal`

The period of the signal was determined, two cycles of the message signal and then the above equation were written Using MATLAB to plot the modulated signal s(t).

```
s = Ac*(1+M*em).*cos(wc); % the modulated signal
```

For The second part of the Question, to find the output of the ideal envelop detector, the **abs'** function was used. To find the output the modulated signal without the carrier should be passed through the ideal envelop detector.

```
y = abs( Ac*(1+M*em));% output of the  ideal envelop detector
```

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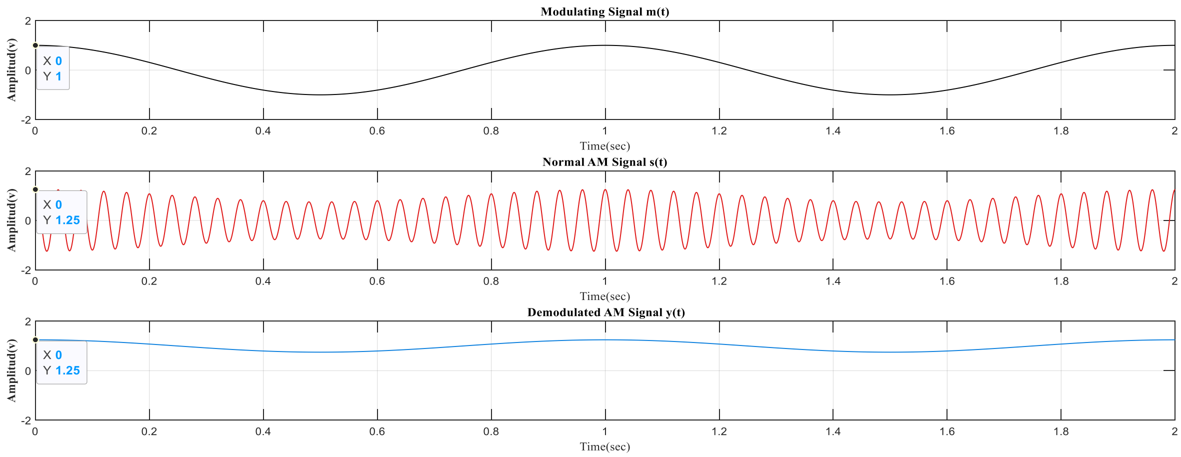
Question12.m* | ArraysInMatLab.m | TestQ3.m

```
clc;
clear;
% -*-*-*-*-*-*-*-*-*-*-*-*-
% Aseel Deek - 1190587
% -*-*-*-*-*-*-*-*-*-*-*-*-
fm=1; % the message signal frequency
fc=25; % the carrier frequency
Am=1; % Amplitude of the message signal
Ac=1; % Amplitude of the carrier signal
M=0.25;
t = 0:0.001:2; % Time for two periods
wc=2*pi*fc*t; % angular frequancy for carrier angular
wm=2*pi*fm*t; % angular frequancy for message signal
em=Am*cos(wm); % message signal
subplot(4,1,1);
plot(t,em,'k'); %% plot the message signal
axis([0 2 -2 2]);
xlabel('Time(sec)');
ylabel('Amplitud(v)');
title('Modulating Signal m(t)');
grid on;
s = Ac*(1+M*em).*cos(wc); % the modulated signal
subplot(4,1,2);
plot(t,s,'r');% plot the modulated signal AM signal
axis([0 2 -2 2]);
xlabel('Time(sec)');
ylabel('Amplitud(v)');
title('Normal AM Signal s(t)');
grid on;
```

Fig(1.1) : shows part1 code : finding s(t) the modulated signal

```
% ###  when passes through ideal envelop detector   ###
y = abs( Ac*(1+M*em));% output of the  ideal envelop detector
subplot(4,1,3);
plot(t,y,'b'); % print the output of the ideal envelop detector
axis([0 2 -2 2]);
xlabel('Time(sec)');
ylabel('Amplitud(v)');
title(' Demodulated AM Signal y(t)');
grid on;
```

Fig(1.2) : shows part2 code : finding the ideal envelop detector output y(t)



Fig(1.3) : Shows the modulating signal, the modulated s(t) signal and the y(t)

1.2. Finding the optimal value of MSE

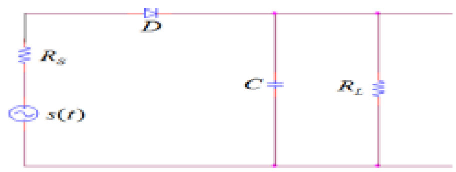
Define the mean squared error between $s(t)$ and $y(t)$ as:

$$D = \frac{1}{T_m}\int_0^{T_m}(y(t)-m(t))^2 dt$$

a. Plot D versus $\frac{1}{fc} \leq \tau \leq \frac{1}{fm}$

b. From the figure, determine the optimum value of the time constant that minimizes D.

c. Plot $y(t)$ that corresponds to the minimum D



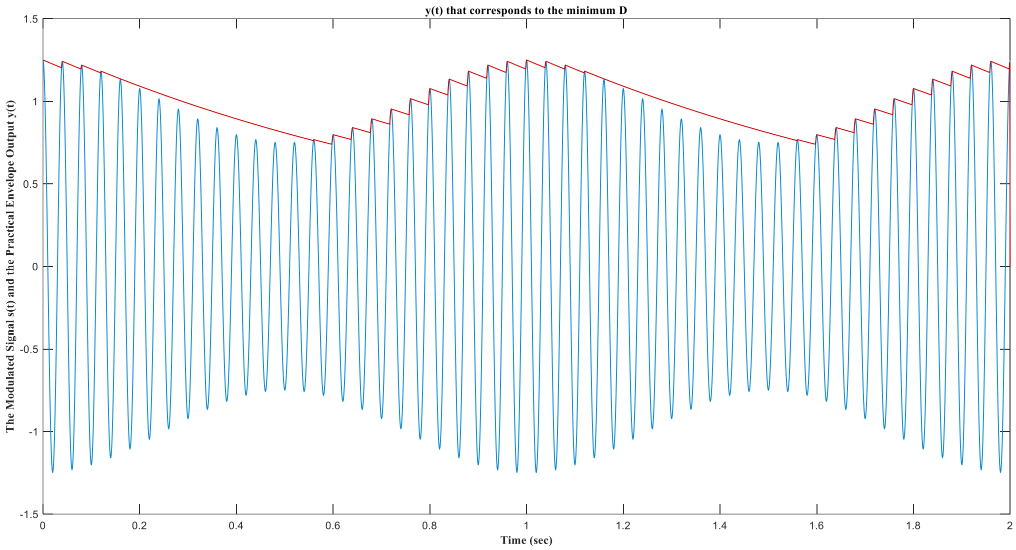
To find the D, a for loop was used to first find the output for the practical envelop. If the modulated signal is less than the maximum value of the modulated signal multiplied by $e^{-\frac{(t-T)}{\tau}}$ then the diode is on, the new signal will discharge till it equals the value of the modulated signal then the diode is off and the envelop output is the same to the modulated signal. After finding the output , using the equation

$D = \sum \frac{(y(t)-m(t))^2}{Tm} = 0.0022$, the mean square error was found, and from the plot the value of τ,

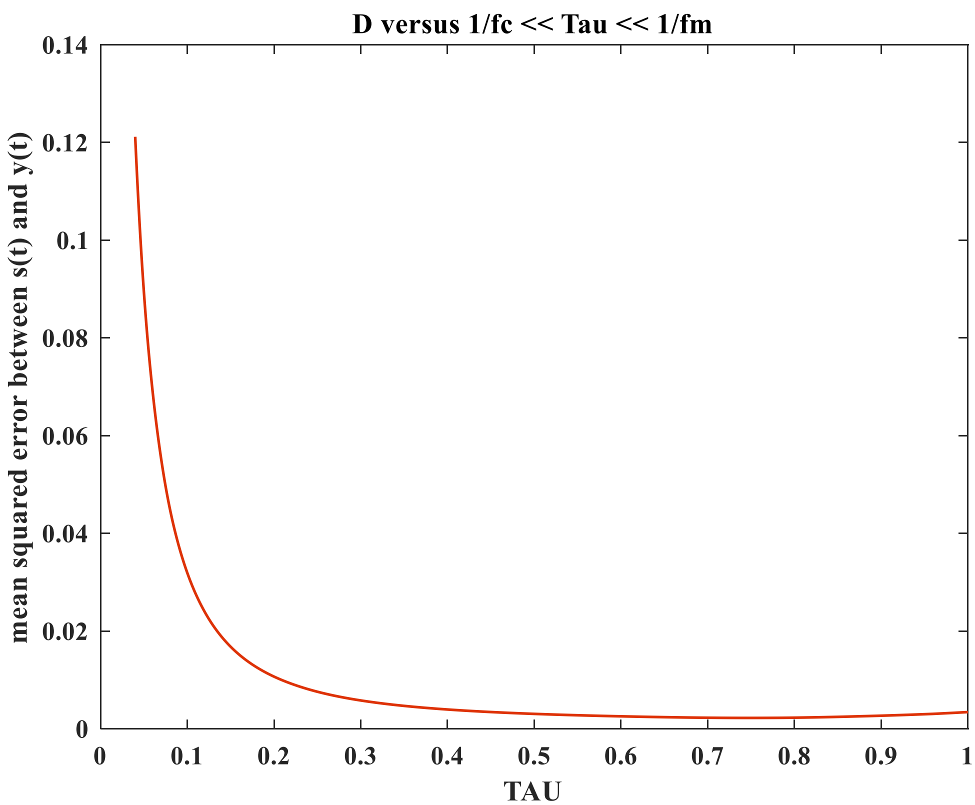
$\tau = 0.7460$ was found.

```
for i=1:tauLen
    T=0; % initial value
    max= s(1); %max value of the midulated signal
    for x=1:Tm-1
         if(s(x)< max*exp(-1*(t(x)-T)/tau(i))) % When the diode is on
             y(x)= max*exp(-1*(t(x)-T)/tau(i));
         else % otherwise when the diode is off
             y(x)=s(x);
            if (s(x) == st1(x)) % if equal the ideal envelop signal
                T=t(x);
                max=s(x);
            end
         end
    end
     sum = Function1(y,st1); % function to find the sum
     D(i)=sum/Tm; % The final answer D (mse)
end
```

Fig(1.3) : shows the main for loop to find the output of the Practical Envelope Detector



Fig(1.4) : shows the Practical Envelope Detector output



Fig(1.5) : The mean squared error between s(t) and y(t)

2. Appendix

2.2 Code for the first 2 questions

```
%% -*-*-*-*-*-*-*-*-*-*-*-
% Aseel Deek - 1190587
%% -*-*-*-*-*-*-*-*-*-*-*-
fm=1; % the message signal frequency
fc=25; % the carrier frequency
Am=1; % Amplitude of the message signal
Ac=1; % Amplitude of the carrier signal
M=0.25; % Sensitivity factor
t = 0:0.001:2; % Time for two periods
wc=2*pi*fc*t; % angular frequancy for carrier angular
wm=2*pi*fm*t; % angular frequancy for message signal
em=Am*cos(wm); % message signal
subplot(4,1,1);
plot(t,em,'k'); %% plot the message signal
axis([0 2 -2 2]);
xlabel('Time(sec)');
ylabel('Amplitud(v)');
title('Modulating Signal m(t)');
grid on;
s = Ac*(1+M*em).*cos(wc); % the modulated signal
subplot(4,1,2);
plot(t,s,'r');% plot the modulated signal AM signal
axis([0 2 -2 2]);
xlabel('Time(sec)');
ylabel('Amplitud(v)');
title('Normal AM Signal s(t)');
grid on;
%%  when passes through ideal envelop detector  ###
y = abs( Ac*(1+M*em));% output of the  ideal envelop
detector
subplot(4,1,3);
plot(t,y,'b'); % print the output of the ideal envelop
detector
axis([0 2 -2 2]);
xlabel('Time(sec)');
ylabel('Amplitud(v)');
title(' Demodulated AM Signal y(t)');
grid on;
```

2.3 Code for the last question

```
 %% Aseel deek - 1190587
t=0:0.001:2;              % Sampling time instants
Tm = length(t);           % This the length of time matrix
fm=1;                     % Message frequency
fc=25;                    % Carrier frequency
wc=2*pi*fc*t;             % angular fequency for the Carrier
wm=2*pi*fm*t;             % angular fequency for the Message
lb=1/fc;                  % Lower bound on Time Constant
hb=1/fm;                  % Upper bound on Time constant
tau=lb:0.001:hb;          % Varying time constant
tauLen=length(tau);       % Tau Matrix length
em=cos(wm);               % Message signal
ec=cos(wc);               % Carrier signal
M=0.25;                   % Sensitivity factor
s=zeros(1,Tm);            % Modulated signal array
st1=zeros(1,Tm);          % Will use in calclating MSE
y=zeros(1,Tm);            % Output of Envelope Detector y(t)
 for x=1:Tm
     s(x)=(1+M*em(x))*ec(x); % Finding the modulated signal
     st1(x)=abs(1+M*em(x));  % ideal envelop output
 end
 D=zeros(1,tauLen);          % Mean Square Error 'D'
for i=1:tauLen
    T=0;                          % initial value
    max= s(1);       %max value of the midulated signal
    for x=1:Tm-1
         if(s(x)< max*exp(-1*(t(x)-T)/tau(i))) % When the
diode is on
             y(x)= max*exp(-1*(t(x)-T)/tau(i));
         else % otherwise when the diode is off
             y(x)=s(x);
            if (s(x) == st1(x)) % if equal the ideal
envelop signal
                T=t(x);
                max=s(x);
            end
         end
    end
     sum = Function1(y,st1); % function to find the sum
     D(i)=sum/Tm; % The final answer D (mse)
end
```

```
%% soultion of b)
[~,b]=min(D);
minimizedtau=tau(b); %Optimum Value of Time Constant
x = min(D);    % value of tau
disp(x);
disp(minimizedtau);

%% soultion of a)
plot(tau,D);
xlabel('TAU');
ylabel('mean squared error between s(t) and y(t)');
title('D versus 1/fc << Tau << 1/fm');
figure(2)
 %% soultion of c)
plot(t,s,'b'); % ploting the modulated signal
hold on
plot(t,y,'r');
xlabel('Time (sec)');
ylabel('The Modulated Signal s(t) and the Practical
Envelope Output y(t)');
title('y(t) that corresponds to the minimum D');

 %% calculating the mean squared error between s(t) and
y(t)
function sum = Function1(y,st1) % find the sum
       e =norm((y-st1));
        e_squar=e.^2;
        sum=0;
        sum=sum+e_squar;
end
```