EEN 307 Homework 2

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Question 1:

- Write a function that gets a matrix as the input. The output should be the same matrix but all the even elements of the input replaced by the next odd number. So for example if the input is [2 7 4; 5 8 3] the output will be [3 7 5; 5 9 3].

1) Matlab code:

```
function [out] = Q1(in)

%%%% in = the input matrix
%%%% out = the output matrix

inSize = size(in);
rows = inSize(1);
cols = inSize(2);

out = zeros(size(in));

 for i = 1:rows
     for j = 1:cols
        if (mod(in(i,j),2) == 0)
            out(i,j) = in(i,j)+1;
        else
            out(i,j) = in(i,j);
        end
     end
 end

end
```

2) Output Pictures

x	[2,7,4;5,8,3;4,3,10]
y	[3,7,5;5,9,3;5,3,11]

Question 2: Frequency Modulation (FM)

- Frequency modulation, or FM, uses a wider bandwidth than amplitude modulation, or AM, but it is not affected by noise as AM is. The output of an FM transmitter is of the form:

$$y(t) = \cos\left(\Omega_c t + 2\pi v \int_0^t m(\tau)d\tau\right)$$

$m(t)$ - the message signal
v – a factor in Hz/volt
Ω_c - the carrier frequency

Part (a)

- Create the message signal:

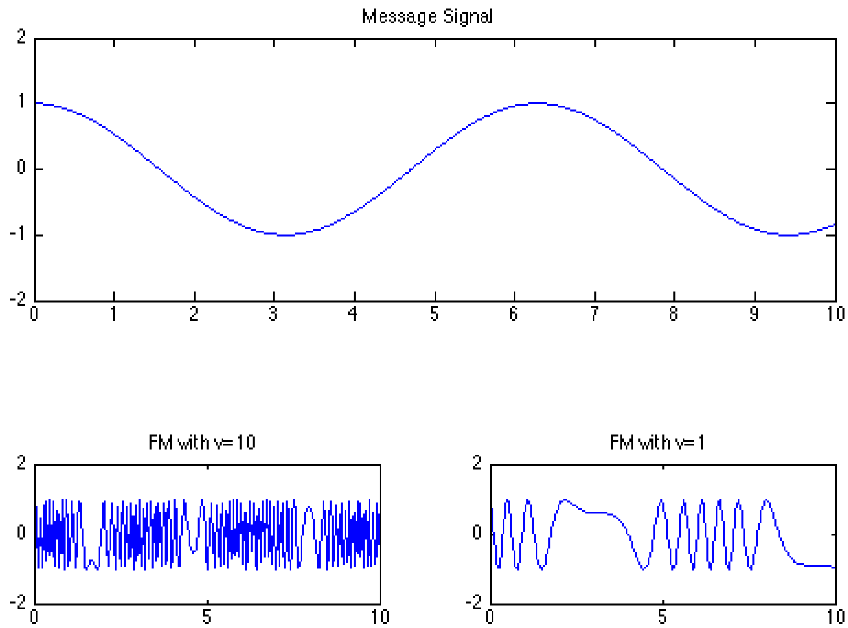
$$m(t) = \cos(t)$$

- Find the FM signal y(t) for v = 10 and then for v = 1. Let the carrier frequency $\Omega_c = 2\pi$. Use matlab to generate the different signals for times 0 ≤ t ≤ 10 at intervals of $T_s = 0.01$s. Plot m(t) and the two FM signals. Is the FM transmitter a linear system? Explain.

1) Matlab code:

```
% Real variables used for plotting the original message %
Ts = 0.01;
t = 0:Ts:10;
m = cos(t);      % The message (original signal)
omega = 2*pi;

% Symbolic variables used for plotting the FM's of the message %
t_sym = sym('t');
m_sym = cos(t_sym);
integral = int(m_sym,0,t_sym);

% Sinusoid for v = 10
v1 = 10;
y1 = cos(omega*t_sym + 2*pi*v1*integral);

% Sinusoid for v = 1
v2 = 1;
y2 = cos(omega*t_sym + 2*pi*v2*integral);

% Plotting all three waveforms together
```

```
figure(1);
plot(t,m,'-r');
hold on;
ezplot(t_sym,y1);           % Symbolic waveform
ezplot(t_sym,y2);           % Symbolic waveform
axis([0 2*pi -2 2]);        % Plotting one period
title('FM signals overlaid on the message signal (red)');
xlabel('');
ylabel('');
hold off;

% Plotting all three waveforms separately
figure(2);
subplot(2,2,[1 2]);
plot(t,m);
axis([0 10 -2 2]);
title('Message Signal');
xlabel('');
ylabel('');

subplot(2,2,3);
ezplot(t_sym,y1,[0 10]);
axis([0 10 -2 2]);
title('FM with v=10');
xlabel('');
ylabel('');

subplot(2,2,4);
ezplot(t_sym,y2,[0 10]);
axis([0 10 -2 2]);
title('FM with v=1');
xlabel('');
ylabel('');
```



2) Output Pictures

3) Lab Question – Is the FM transmitter a linear system? Explain.

The FM transmitter is a linear system because it obeys the superposition principle. It has both the scaling and additive properties.

Part (b)

- Create the message signal:

$$m(t) = \begin{cases} 1 & when\ m(t) \geq 0 \\ -1 & when\ m(t) < 0 \end{cases}$$

- Find the corresponding FM signal for v = 1.

1) Matlab code:

```
% Real variables used for plotting the original message %
Ts = 0.01;
t = 0:Ts:10;
m = cos(t);       % The message (original signal)
omega = 2*pi;
```

```
N = length(m);
m1 = zeros(1,N); % The new message (square wave)
for i=1:N
    if (m(i)>=0)
        m1(i) = 1;
    else
        m1(i) = -1;
    end
end

integral = integral(m1,0,10);

figure(3);
v3 = 1;
y3 = cos(omega*t + 2*pi*v3*integral);
plot(t,y3);
hold on;
plot(t,m1);
```