INTRODUCTION

Modulation

Modulation is the process of superimposing a message signal (also called as modulation signal) with a carrier signal.

A modulator performs modulation whereas a demodulator performs demodulation (the inverse of modulation).

The frequency band that is occupied by the modulation signal is called the baseband and therefore modulation signal is also known as baseband signal.

Depending on the signal there are 2 types of modulation:

- Analog Modulation
- Digital Modulation

Analog signal is a continuous signal in which a time varying quantity (amplitude/ frequency/ phase) represents another time-based variable.

Angle modulation is a modulation technique classified into frequency and phase modulation. Angle modulation is associated with frequency. We can derive frequency modulation from phase and vice-versa.

FREQUENCY AND PHASE MODULATION

Frequency Modulation

- Change of frequency based on input modulating signal is called frequency modulation.
- Carrier will have constant frequency. The modulating signal when superimposed, will change the frequency of the output signal. (This will take longer time to finish wave function, therefore number of cycles increases.
- Integrating the angular frequency of the frequency modulation, we get the phase value (theta)

Phase Modulation

- In Phase modulation, carrier frequency is added with (phase constant*sinusoidal function) and phase shift occurs
- In SIMULINK, we integrate baseband signal and pass it through phase modulator to get frequency modulated output.
- Similarly, if we differentiate baseband signal and pass it through frequency modulator, we get phase modulated signal.

ASSIGNMENT 1: FM and PM

Problem Statement:

For the given data below,

- **Modulating signal: square wave of frequency 1KHz**
- **Modulation Index for PM =4**
- **Modulating Index for FM =4**
- **Carrier: Sinusoidal wave of 42KHz**

Q1. Plot the Modulating signal

Q2. Plot the Phase modulated signal for the given modulating signal

Q3. Plot the Frequency modulated signal.

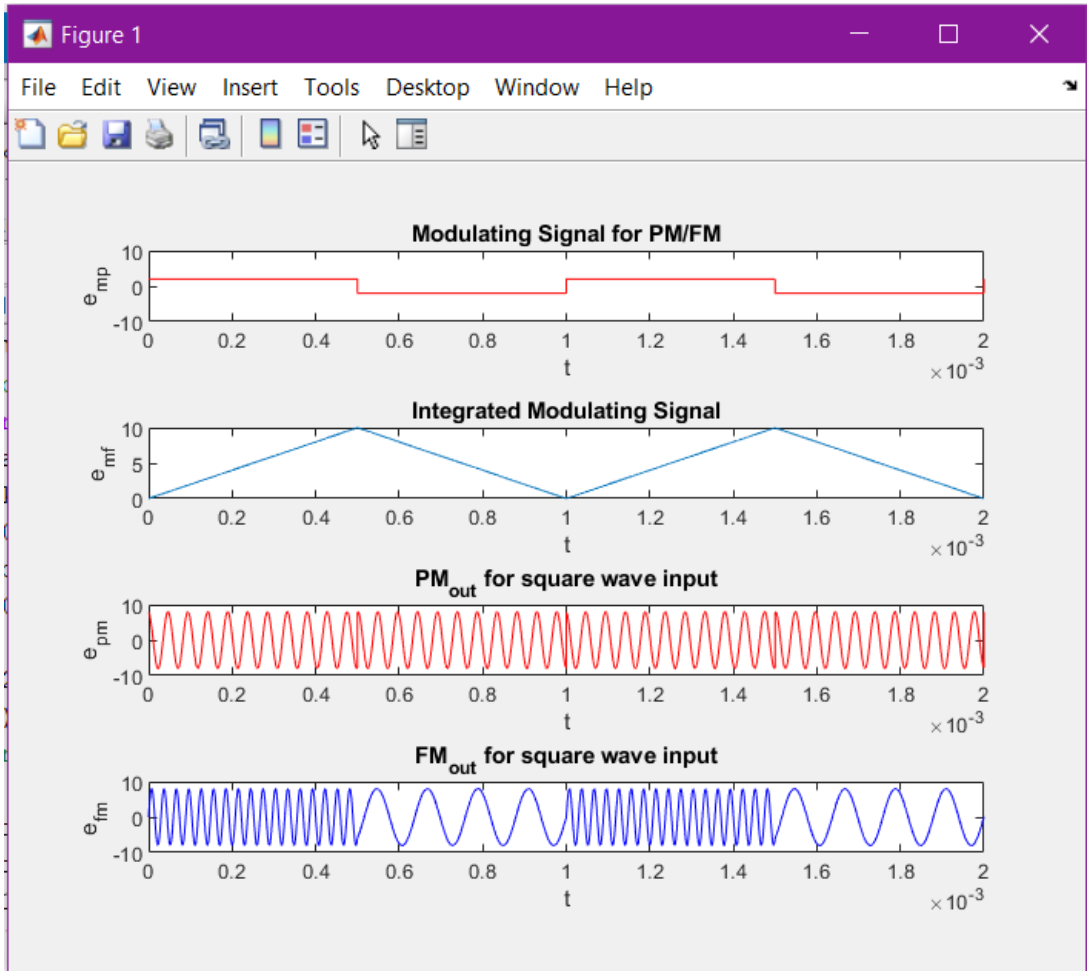
MATLAB Script:

Editor - D:\College\MATLAB\Coms\Rhea_Comms_Assignment.m

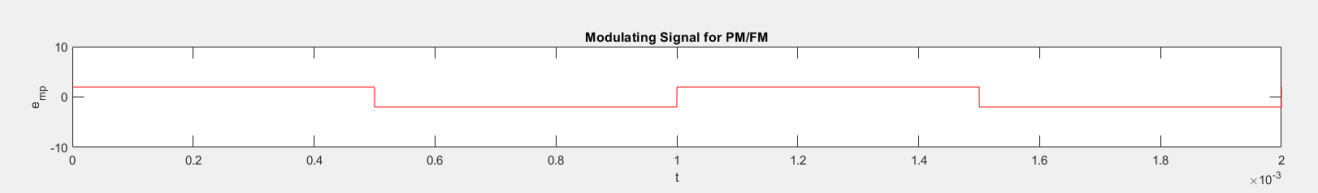
Rhea_Comms_Assignment.m

```
%Script to generate FM and PM
format long;
t = linspace(0,0.002,10000); %Time vector
fm=1000; kp=4; %Modulation index for PM
tau = 0.0001; %Time constant for the integrator
emp = 2*square(2*pi*fm*t);
emf(1) = 0; %first sample of integrated input
kf = kp;
for  i = 2:length(emp)
    emf(i) = trapz(t(1:i), emp(1:i))/tau; %Trapezoidal integration
end %of input (modulating signal)

epm = 8*sin(42000*pi*t + kp*emp);
efm = 8*sin(42000*pi*t + kp*emf);
subplot(411), plot(t,emp,'r'), axis([0 0.002 -10 10]);
xlabel('t'), ylabel('e_{mp}');
title('Modulating Signal for PM/FM');
subplot(412), plot(t,emf);
xlabel('t'), ylabel('e_{mf}');
title('Integrated Modulating Signal');
subplot(413), plot(t,epm,'r');
xlabel('t'), ylabel('e_{pm}');
title('PM_{out} for square wave input');
subplot(414), plot(t,efm,'b');
xlabel('t'), ylabel('e_{fm}');
title('FM_{out} for square wave input');

```

Output:

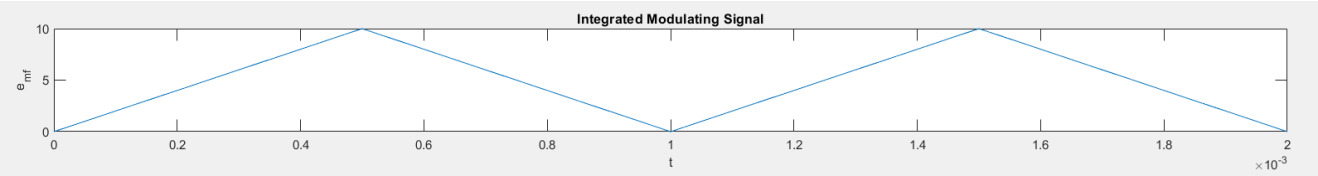


Plot of Modulating signal



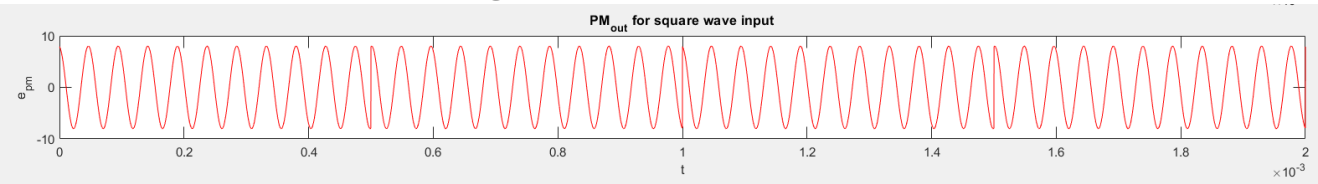
- Has 50% duty cycle
- Time period is 1 millisecond

Plot of Integrated Modulating signal



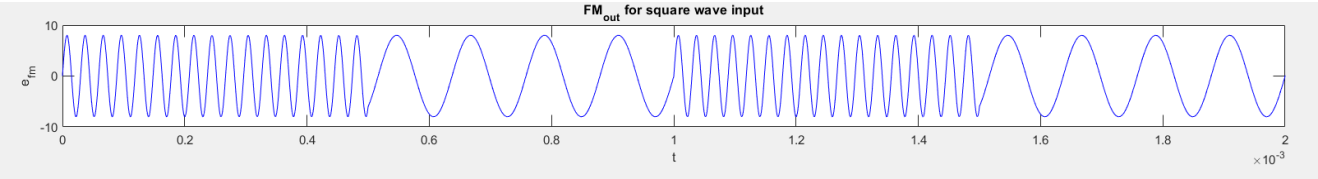
- At the point when the duty cycle changes its status (off or on), there will be discontinuity and falls to the opposite side
- When there is discontinuity around 0.5 milli seconds, it falls to the negative side.
- When we integrate a rectangular pulse, it becomes a triangular function
- Periodicity matches

Plot of Phase Modulated signal



- The integrated signal information is used by phase modulation function.
- We can observe a sharp transition of phase here.
- It shortly becomes discontinuous and shifts phase of 180 degree

Plot of Frequency Modulated signal



- The integrated signal information is also used by frequency modulation function.
- We can observe that according to the emf graph frequencies, the modulated signal frequencies also change
- Note the compression and rarefication of the frequencies depending on the emf graph.