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.

Modulation

- One of the modulation techniques is angle modulation. We can classify angle modulation as frequency and phase modulation.
- Angle modulation is associated with frequency. We can derive frequency modulation from phase and vice-versa.
- Carrier Signal 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.

Frequency Modulation

- Change of frequency based on input modulating signal is called frequency modulation.
- Integrating the angular frequency of the frequency modulation, we get the phase value (theta)
- Integrating the baseband signal and passing it through phase modulator, we will get frequency modulated output.

$$e = A\sin(\omega_c t + m_p \sin\omega_m t)$$

$A\sin(\omega_c t)$ → Instantaneous carrier signal

m_p → Frequency Modulation index

Phase Modulation

- Phase Modulation is the process of varying the phase of the carrier signal linearly with the message signal.
- Carrier frequency is added with the phase constant*sinusoidal function. Thus, phase shift occurs
- Differentiating the baseband signal and passing it through a frequency modulator, we get the phase modulated signal.

$$e = A\sin(\omega_c t + \varphi_m \sin \omega_m t)$$

$A\sin(\omega_c t)$ → Instantaneous carrier signal

φ_m → Phase Modulation index

MATLAB code

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

Rhea_Comms_Assignment.m

```matlab
%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

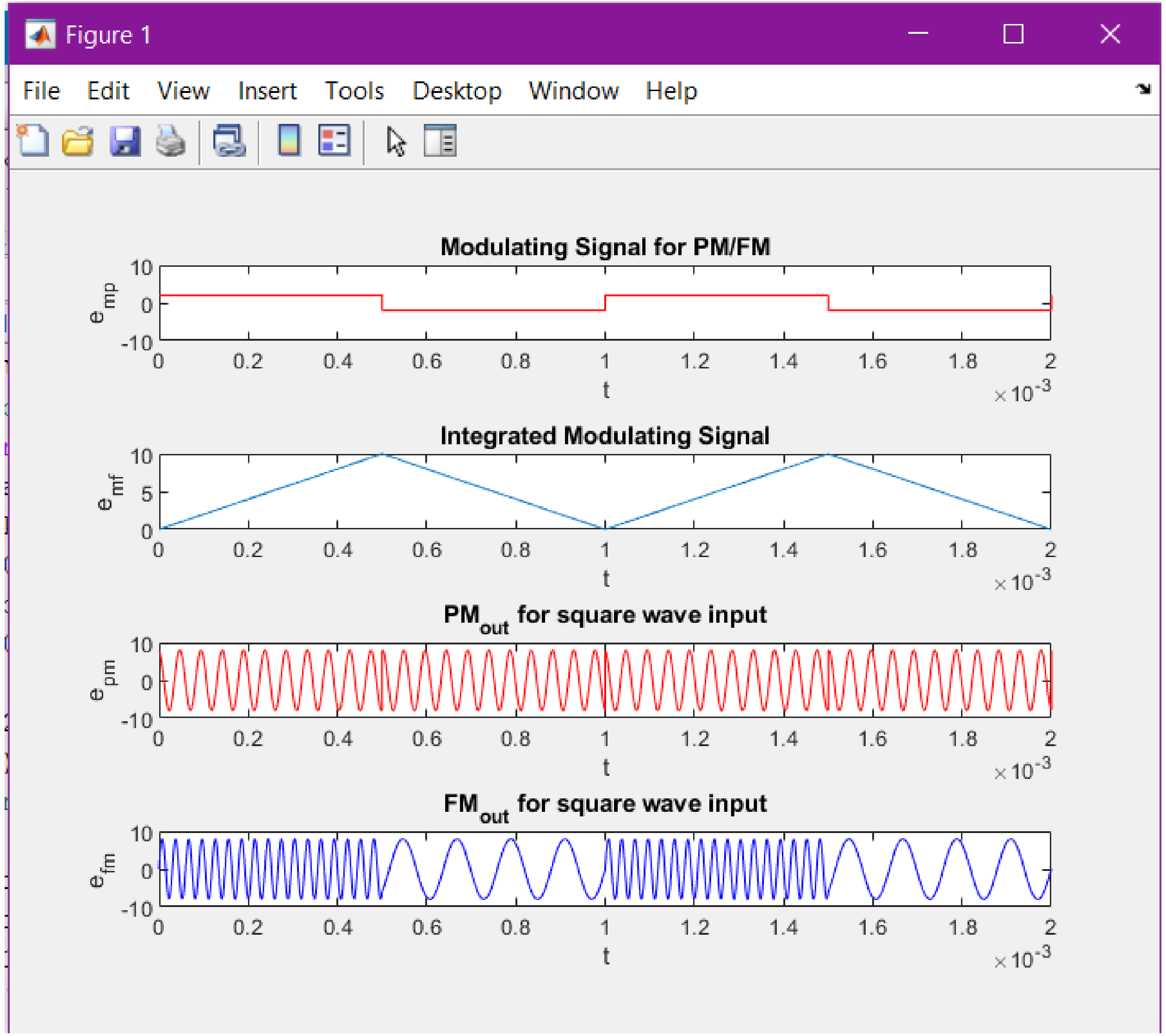
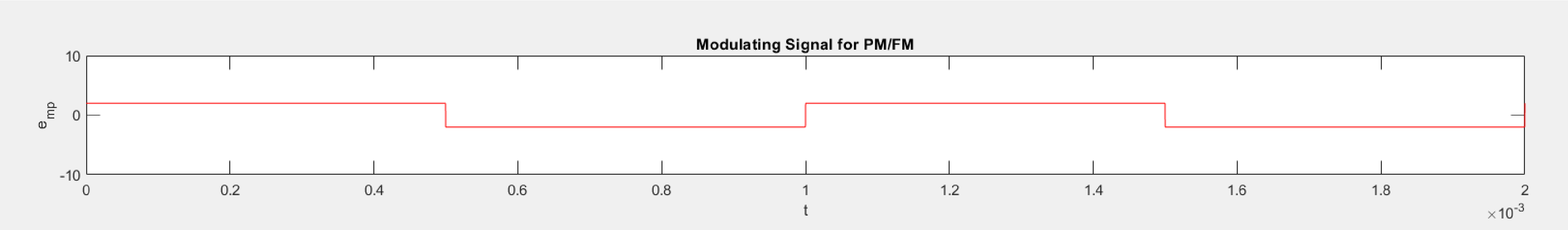


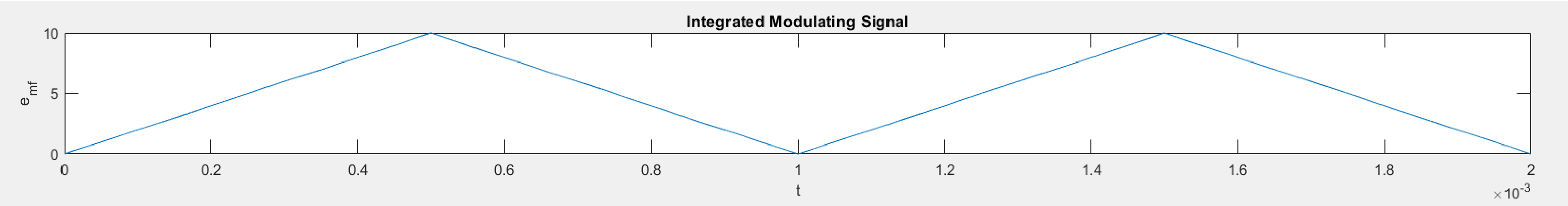
Figure 1
File Edit View Insert Tools Desktop Window Help
Modulating Signal for PM/FM
Integrated Modulating Signal
PM_out for square wave input
FM_out for square wave input
e_mp
e_mf
e_pm
e_fm
t
× 10^-3

Plot of Modulating signal



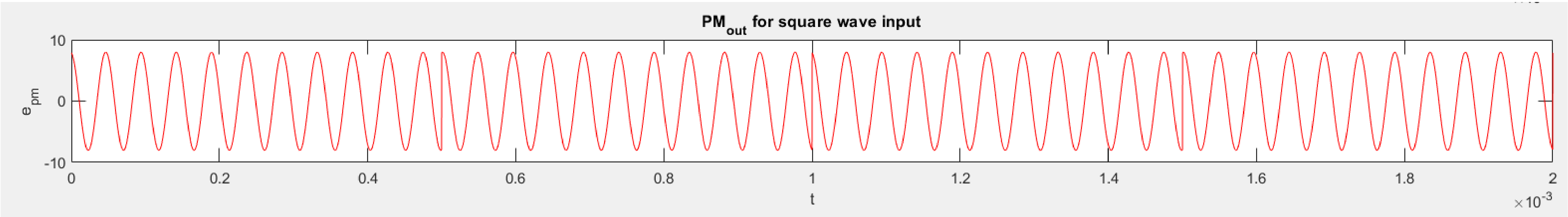
- Has 50% duty cycle
- Time period is 1 millisecond

Plot of Integrated Modulating signal



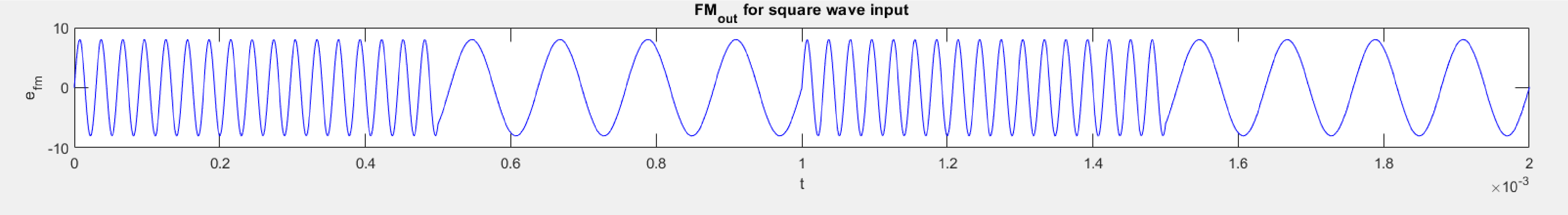
- At the point when the duty cycle changes its status (off or on), there will be discontinuity and falls to the opposite side
- When there is discontinuity around 0.5 milli seconds, it falls to the negative side.
- When you integrate a rectangular pulse, it becomes a triangular function
- Periodicity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

Plot of Phase Modulated signal



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