National University of Sciences and Technology (NUST)
School of Electrical Engineering and Computer Science

Department of Electrical Engineering and Computer Science

Faculty Member: Dr. Huma Ghafoor   Dated: 16/04/2023

Semester: 6th   Section: BEE 12C

EE-351 Communication Systems

Lab 10: Phase Modultion with MATLAB

Group Members

Name	Reg. No	Viva / Quiz / Lab Performance	Teamwork	Ethics	Software Tool Usage	Analysis of data in Lab Report
		5 Marks	5 Marks	5 Marks	5 Marks	5 Marks
Muhammad Ali Farooq	331878					
Danial Ahmad	331388					
Muhammad Umer	345834					
Tariq Umar	334943					

1 Table of Contents

2 Phase Modulation

2.1 Objectives

- To understand the concept of phase modulation with the help of MATLAB and observe its results.

2.2 Introduction

Phase modulation (PM) is a form of angle modulation in which the phase of a carrier wave varies in accordance with the modulating signal. The instantaneous phase of the carrier wave is given by:

$$\phi(t) = \phi_c + kp*m(t)$$

The phase modulation index is a measure of the depth of modulation. It is defined as the ratio of the maximum phase deviation to the maximum amplitude of the modulating signal. In this lab report, we will use MATLAB to generate and observe the results of phase modulation. We will first generate a carrier wave and a modulating signal. We will then use MATLAB to modulate the carrier wave with the modulating signal. Finally, we will observe the results of the modulation.

2.3 Lab Report Instructions

All questions should be answered precisely to get maximum credit. Lab report must ensure following items:

- Lab objective
- Results (screen shots) duly commented and discussed.
- Conclusion

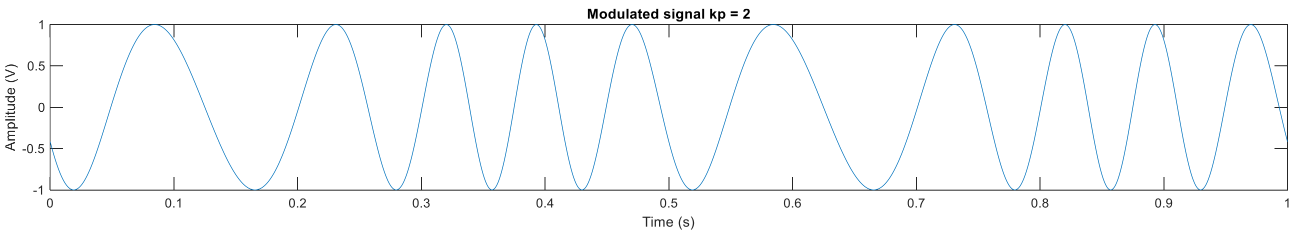
3 Lab Procedure

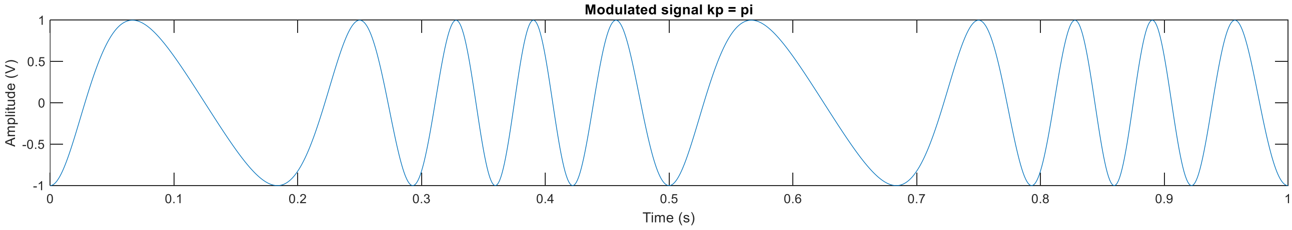
3.1 Tasks

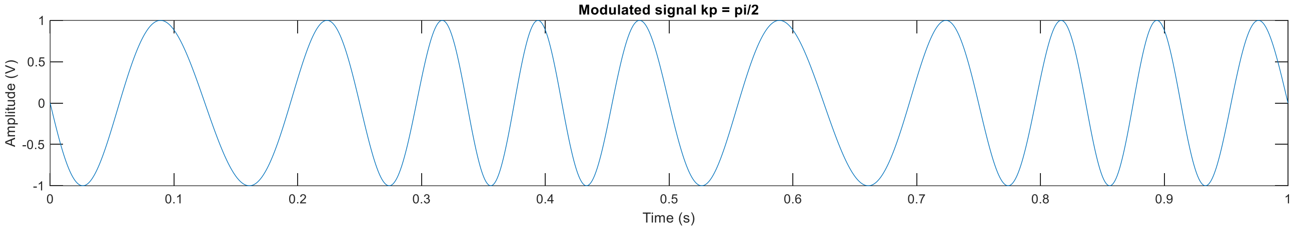
1. Generate a PM wave with message signal as $Am\cos(2\pi fmt)$ and carrier as $Ac\cos(2\pi fc\ t)$ where:
   - Am=1, Ac=1
   - Fm=2, Fc=10
   - t=0:0.001:1, fs=100

Make observations of waveform with sensitivity = 2, pi and pi/2 using MATLAB code.

```
Am = 1; % Amplitude of the message signal
Ac = 1; % Amplitude of the carrier signal
fm = 2; % Frequency of the message signal
fc = 10; % Frequency of the carrier signal
fs = 1000; % Sampling frequency
t = 0:1 / fs:1; % Time vector

kp = 2;
m_t = Am * cos(2 * pi * fm * t);
s_t = Ac * cos(2 * pi * fc * t + kp * m_t);
subplot(311)
plot(t, s_t)
xlabel('Time (s)');
ylabel('Amplitude (V)');
title ('Modulated signal kp = 2');

kp = pi;
m_t = Am * cos(2 * pi * fm * t);
s_t = Ac * cos(2 * pi * fc * t + kp * m_t);
subplot(312)
plot(t, s_t)
xlabel('Time (s)');
ylabel('Amplitude (V)');
title ('Modulated signal kp = pi');

kp = pi / 2;
m_t = Am * cos(2 * pi * fm * t);
s_t = Ac * cos(2 * pi * fc * t + kp * m_t);
subplot(313)
plot(t, s_t)
xlabel('Time (s)');
ylabel('Amplitude (V)');
title ('Modulated signal kp = pi/2');
```





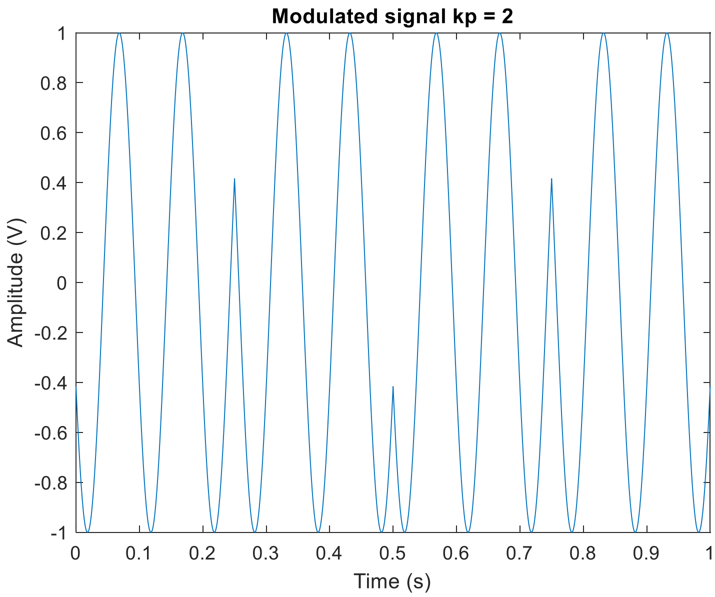


Observations:

As the sensitivity factor kp decreases, the phase of the carrier wave varies less. This can be inferred from the figures attached above, which show that the modulated signal has the highest variations, or in other words, the maximum frequency deviation, when kp = π = 3.1415, followed by kp = 2, followed by kp = π/2 = 1.570.

2. Generate PM wave with message *as* $Am\ square\ (2\pi fm\ t)$ and carrier $Ac\cos\ (2\pi fct)$.

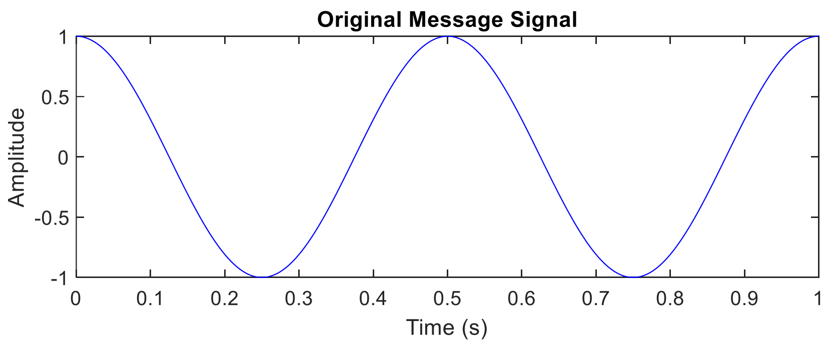
```
kp = 2;
m_t = Am * square(2 * pi * fm * t);
s_t = Ac * cos(2 * pi * fc * t + kp * m_t);
plot(t, s_t)
xlabel('Time (s)');
ylabel('Amplitude (V)');
title ('Modulated signal kp = 2');
```

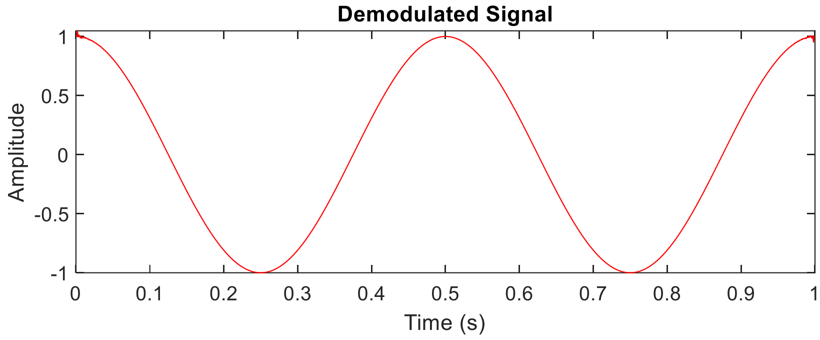


As shown in the attached graph, the carrier wave undergoes a 180° phase shift whenever the square message signal transitions from HIGH to LOW, and vice versa.

3. Use MATLAB function pmmod and pmdemod to perform modulation and demodulation with the following values:
   - t=0:0.001:1
   - Fc=10
   - Fm=2
   - Kp=pi/2
   - fs=100

```
% Define parameters
t = 0:0.001:1;
fc = 10;
fm = 2;
Kp = pi / 2;
fs = 100;
Am = 1;
phase_dev = Kp*Am;
m_t = Am * cos(2 * pi * fm * t);

% Perform PM modulation
pm_t = pmmod(m_t, fc, fs, phase_dev);

% Perform PM demodulation
demod_m_t = pmdemod(pm_t, fc, fs, phase_dev);

% Plot original and demodulated signals
figure
subplot(211)
xlabel('Time (s)');
ylabel('Amplitude');
title('Original Message Signal')
plot(t, m_t, 'b');
subplot(212)
plot(t, demod_m_t, 'r');
xlabel('Time (s)');
ylabel('Amplitude');
title('Demodulated Signal');
```





The built-in MATLAB functions pmmod and pmdemod can be used to recover the original message signal completely, as is evident from the attached figures.

4. Define Angle Modulation and Modulation Index?

Angle modulation is a class of modulation in which the instantaneous angle of the carrier wave is varied in accordance with the modulating signal. This can be done by varying the frequency or the phase of the carrier signal.

Modulation index is a measure of the depth of modulation. It is defined as the ratio of the maximum frequency deviation to the modulating signal frequency.

4 Conclusion

In conclusion, we have successfully generated and observed the results of phase modulation with the help of MATLAB. We have learned that phase modulation is a form of angle modulation in which the phase of a carrier wave varies in accordance with the modulating signal. We have also learned that the phase modulation index is a measure of the depth of modulation. It is defined as the ratio of the maximum phase deviation to the maximum amplitude of the modulating signal.