**Department of Electrical Engineering and   
Computer Science**

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**EE-351 Communication Systems**

Lab 10: Phase Modultion with MATLAB

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|  |  |  |  |  |  |  |
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# Phase Modulation

## Objectives

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

## 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:

ϕ(t) = ϕc + 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.

## 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

# Lab Procedure

## Tasks

1. Generate a PM wave with message signal as 𝐴𝑚cos (2𝜋𝑓𝑚𝑡) and carrier as 𝐴𝑐cos (2𝜋𝑓𝑐 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.

1. Generate PM wave with message *as 𝐴m square (2𝜋𝑓m 𝑡)* and carrier 𝐴𝑐cos (2𝜋𝑓𝑐𝑡).

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.

1. 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.

1. 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.

# 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.