Experiment 6: Phase Modulation and Demodulation

Aim: This experiment is intended to make the student perform an experiment on Phase Modulation and Demodulation using MATLAB.

A – Generation of phase modulated signal:

Generation of the PM signal requires changing the instantaneous phase of the carrier signal, in accordance to the message signal, keeping the instantaneous frequency untouched. That is:

$$\emptyset(t) = \emptyset_0 + k_p\, m(t),$$

where k_p is a proportionality constant known as the phase sensitivity and $\emptyset_0$ is the initial (constant) phase offset of the carrier. Thus, the standard PM modulated signal is described by:

$$\varphi_{PM}(t) = A_c \cos\left(\omega_c t + \emptyset_0 + k_p\, m(t)\right).$$

Thus, for a sinusoidal message signal, the PM signal is given by

$$\varphi_{PM}(t) = A_c \cos\left(\omega_c t + \emptyset_0 + \mu_p \cos(\omega_c t)\right),$$

where $\mu_p = A_m k_p$ is the modulation index of the PM signal.

a. Consider the message signal ***m(t)*** to be a 2 KHz sine wave with excursions between (-1 V and + 1V) and the carrier signal to be a 10 KHz sine wave with 6V peak-to-peak value. Assume a phase sensitivity value of 2π rad/V. Generate the PM signal as per the above equation.

b. Plot the message, carrier and PM modulated signals one below the other in a single plot.

c. Compute the power of the PM signal using time-domain representation and tabulate it in Table 1 for various values of the modulation index. Vary the message signal amplitude, keeping the phase sensitivity fixed, to vary the modulation index. Consider values less than, greater than and equal to unity for the modulation index.

d. Obtain and plot the spectrum of the message, carrier and the PM modulated signal. The plots must be in absolute scale and in decibels. The plot in dB is obtained using the MATLAB command:

*10*log10(x)*

where *x* represents the array containing the spectrum of the respective signal.

e. Compute the power of the PM signal using time-domain representation and tabulate it in Table 1 for various values of the modulation index.
f. How do the powers from the time-domain and frequency-domain representations compare?
g. Consider the spectral points whose amplitude is above -30 dB, relative to the maximum peak on the spectrum, and designate the frequency at that point as the essential bandwidth (EBW_{PM}) of the PM modulated wave. Tabulate the essential bandwidth for various values of the modulation index.

Sl. No.	μ_p	***Power from time domain (in W)***	***Power from frequency domain (in W)***	EBW_{PM}

Table 1: Phase Modulation (Sine wave) Results

B – Demodulation of Phase Modulated Signal:

Next, we will demodulate the PM modulated signal using the Hilbert transform as follows:

a) The PM modulated signal is first Hilbert transformed. This is achieved using the MATLAB command:

hilbert(x)

where *x* is the signal whose Hilbert transform is to be computed.

b) The instantaneous phase of the PM modulated signal is then obtained from its Hilbert transform. This is achieved in MATLAB using the command:

unwrap(x)

where *x* is the signal whose instantaneous phase is to be computed.

c) For PM modulated signal, the resulting signal is of the form:

$$\omega_c t + \emptyset_0 + \mu_p \cos(\omega_c t).$$

d) The message signal is obtained from this by first subtracting the instantaneous phase of the carrier ($\omega_c t + \emptyset_0$).
e) Plot the message and demodulated signals one below the other.
f) Obtain and plot the spectra of the message and demodulated signals one below the other. Comment on the time-domain and frequency-domain plots. Bring out any differences you may notice between these.

C –Conclusions:

List out your learning's from the experiment.