Aim ↬ To study the concept and fundamentals of Pulse Position Modulation and Demodulation.

Software Required ↬ MATLAB

Theory ↬

Pulse Position Modulation (PPM) is a modulation technique where the position of a series of pulses is varied according to the instantaneous amplitude of the message signal. This technique is widely used in applications such as optical communication, remote sensing, and wireless data transmission. PPM can be viewed as a method for converting an analog signal into a digital signal by encoding the signal information into the timing of pulses.

The modulated signal in PPM can be expressed as:

$$s(t) = \sum a_n \cdot p(t - nT_s)$$

where:

- a_n is the amplitude of the nth pulse,
- p(t) is the pulse shape,
- T_s is the sampling period.

In PPM, the position of each pulse is directly proportional to the instantaneous amplitude of the message signal. Unlike continuous modulation techniques like AM or FM, PPM deals with discrete pulse positions, making it effective for various applications, including signal processing and communication.

Generation of PPM Signal ↴

The PPM signal is generated by sampling the message signal at regular intervals and varying the position of the pulses according to the sampled values. The pulses can take various shapes, depending on system requirements. PPM can be classified as analog or digital based on the application.

Demodulation of PPM Signal ↴

PPM demodulation involves converting the variable-position pulses back into the original message signal. A low-pass filter can be used to smooth the PPM signal and reconstruct the continuous signal. Additionally, sample-and-hold circuits may be employed to hold the amplitude of incoming pulses to accurately recreate the original message signal.

Frequency Spectrum of PPM Signal ↴

The frequency spectrum of a PPM signal consists of a fundamental frequency component along with harmonics due to pulse position variation. The bandwidth of a PPM signal depends on the bandwidth of the message signal and the pulse position.

Applications of PPM ↴

PPM is used in optical communication systems for high-speed data transmission, in remote sensing for accurate data representation, and in wireless communication to ensure efficient use of bandwidth.

Method ↴

The code implements PPM by defining parameters for the message and comparator signals, generating a sawtooth wave as the comparator, and creating a sine wave for the message signal. The PPM waveform is formed by adjusting the position of the pulses based on the message signal values. To recover the original message, a low-pass filter is applied to the modulated PPM signal, allowing visualization of the comparator wave, message signal, modulated PPM, and demodulated output.

Code ↬

```
% Pulse Position Modulation
clc;
clear;
close all;

fc = 100;
fs = 1000;
f1 = 80;
t = 0:1/fs:0.1;

x1 = 0.4*cos(2*pi*f1*t) + 0.5;

subplot(3, 1, 1);
plot(t, x1);
title('Message Signal');
xlabel('Time (s)');
ylabel('Amplitude');
```

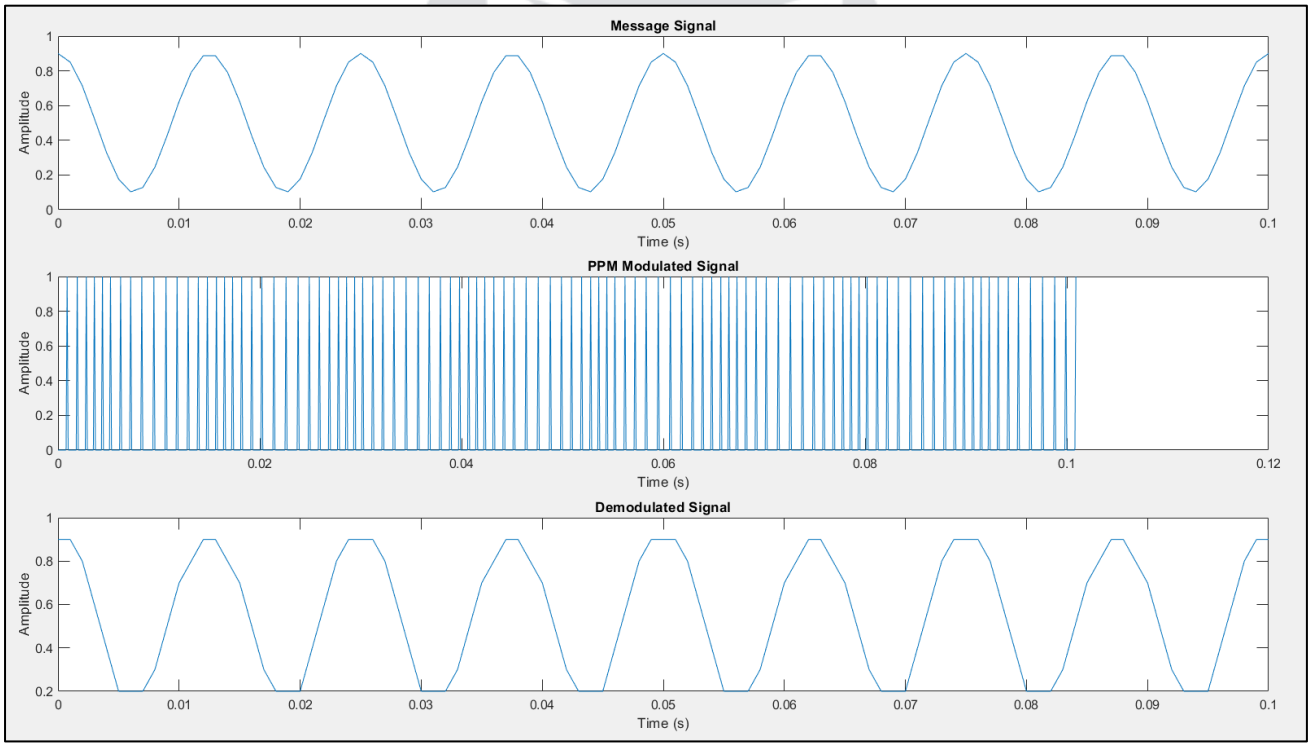
```
y1 = modulate(x1, fc, fs, 'ppm');

subplot(3, 1, 2);
plot((0:length(y1)-1)/(10*fs), y1);
title('PPM Modulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');

x1_recov = demod(y1, fc, fs, 'ppm');

subplot(3, 1, 3);
plot(t, x1_recov);
title('Demodulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');
```

Output ↬



Result ↬

The experiment demonstrated the generation and demodulation of a Pulse Position Modulation (PPM) signal. The message signal was sampled to create a

pulse-position modulated signal, and a low-pass filter was used to recover the original signal.

Conclusion ↬

PPM is a robust modulation technique for transmitting data by varying pulse positions according to the message signal. The recovered signal accurately reflects the original message, demonstrating PPM's utility in various applications.

Precautions ↬

- Ensure accurate sampling to avoid aliasing.
- Use an appropriate low-pass filter to recover the message signal without distortion.
- Select the correct sampling frequency for efficient modulation and demodulation.