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

Software Required ↬ MATLAB

Theory ↬

Pulse Amplitude Modulation (PAM) is a technique where the amplitude of a series of pulses is varied according to the instantaneous amplitude of the message signal. This type of modulation is commonly used in digital data communication systems where the message is transmitted by modulating the amplitude of discrete pulses. PAM can be considered an analog-to-digital modulation technique since the message signal is converted into a pulse train.

The modulated signal in PAM 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 PAM, the amplitude of each pulse is directly proportional to the instantaneous amplitude of the message signal. Unlike continuous modulation techniques like AM or FM, PAM deals with discrete pulses, making it more suitable for time-division multiplexing and digital signal processing.

Generation of PAM Signal ↴

The PAM signal is generated by sampling the message signal at regular intervals and using these samples to modulate the amplitude of a series of pulses. The pulses can be rectangular, triangular, or of other shapes, depending on the system requirements. PAM can be further classified as single-level PAM (binary) or multilevel PAM (analog), where the number of possible pulse amplitudes varies.

Demodulation of PAM Signal ↴

PAM demodulation can be performed using a low-pass filter to recover the original message signal from the pulse train. The filter smooths out the discrete pulses and reconstructs the continuous signal. In some cases, a sample-and-hold circuit is also used to hold the amplitude of the incoming pulses for a specific duration to recreate the message signal accurately.

Frequency Spectrum of PWM Signal ↴

The frequency spectrum of a PAM signal is composed of a continuous spectrum centered around the pulse repetition frequency. The spectrum contains both the baseband components of the message signal and higher-frequency harmonics caused by the pulse modulation. The bandwidth of a PAM signal is determined by both the bandwidth of the message signal and the pulse width.

Applications of PWM ↴

PAM is used in various applications, including Pulse-code modulation (PCM), Data communication systems (Ethernet), and Audio and video transmission over digital.

Method ↴

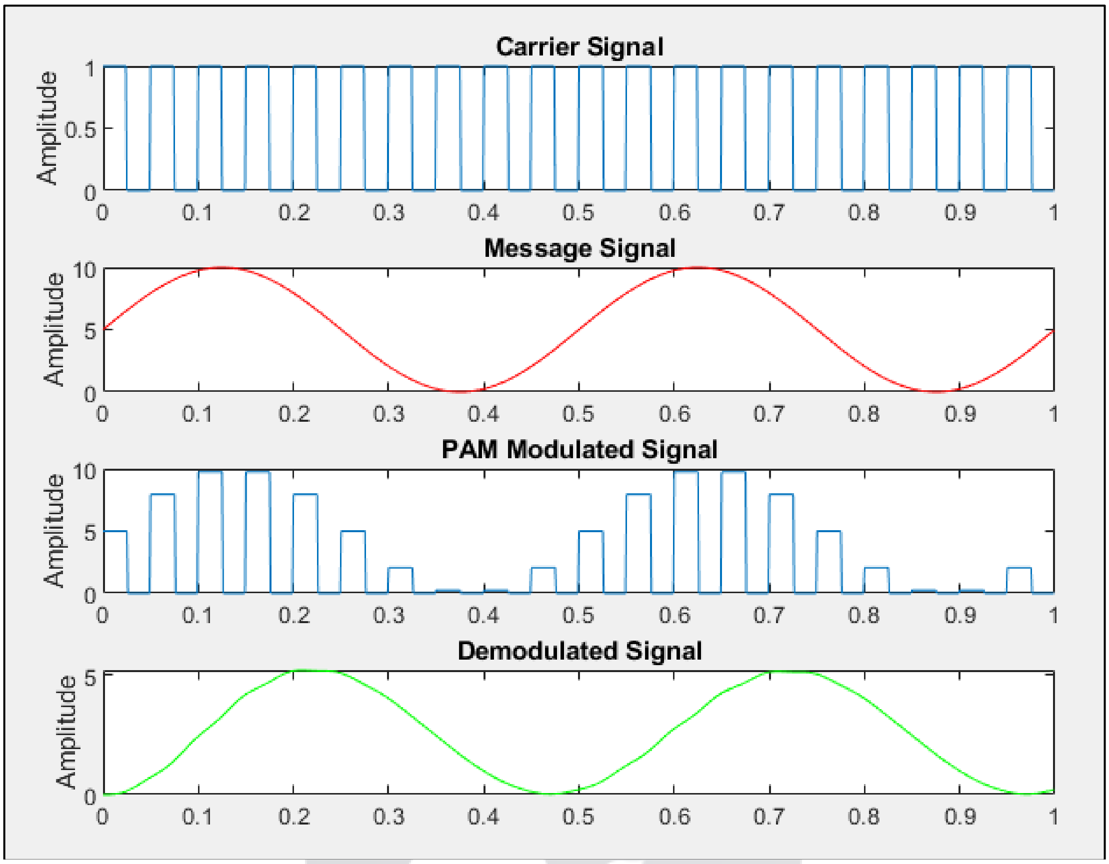
The code implements PAM by defining parameters for the message and carrier signals, generating a square wave as the carrier, and creating a sine wave for the message signal. The PAM waveform is formed by sampling the message signal at the carrier frequency intervals. To recover the original message, a low-pass Butterworth filter is applied to the modulated PAM signal, allowing visualization of the carrier, message, modulated PAM, and demodulated signals.

Code ↬

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

am = 5;
fc = 20;
fm = 2;
fs = 1000;
t = 1;

n = 0:1/fs:t;
n = n(1:end-1);

dutycycle = 50;
```

```
s = square(2*pi*fc*n, dutycycle);
s(s < 0) = 0;

m = am * sin(2*pi*fm*n);
m = m + am;

period_sam = length(n)/fc;
ind = 1:period_sam:length(n);
on_samp = ceil(period_sam * dutycycle / 100);
pam = zeros(1, length(n));

for i = 1:length(ind)
   pam(ind(i):ind(i)+on_samp) = m(ind(i));
end

[b, a] = butter(3, 4*fm/fs);
demodulated_pam = filter(b, a, pam);

subplot(4,1,1);
plot(n, s);
title('Carrier Signal');
ylabel('Amplitude');

subplot(4,1,2);
plot(n, m, 'r');
title('Message Signal');
ylabel('Amplitude');

subplot(4,1,3);
plot(n, pam);
title("PAM Modulated Signal");
ylabel('Amplitude');

subplot(4,1,4);
plot(n, demodulated_pam, 'g');
title('Demodulated Signal');
ylabel('Amplitude');
```

Output ↬



Result ↬

The experiment demonstrated the generation and demodulation of a Pulse Amplitude Modulation (PAM) signal. The message signal was sampled to create a pulse train, and a low-pass filter was used to recover the original signal.

Conclusion ↬

PAM is an effective modulation technique for transmitting data by varying pulse amplitudes based on the message signal. The recovered signal closely matches the original message after demodulation, proving PAM's utility in communication systems.

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.