TASK:1

OBJECTIVES:

Define the challenges involved in designing and implementing a PAM modulator and demodulator circuit.

KEYPOINS:

- **Signal Distortion:**
  Investigate how signal distortion affects the accuracy of PAM.
- **Sampling Techniques:**
  Evaluate the impact of different sampling techniques (natural sampling vs. sample-and-hold) on the signal quality.
- **Bandwidth Requirements:**
  Determine the bandwidth requirements for efficient transmission and reception.
- **Noise Sensitivity:**
  Consider how noise influences the performance of PAM circuit.

LITERATURE REVIEW:

RESEARCH PAPER 1:

PAPER TITLE: ***Digital Pulse Amplitude Modulation: Principles and Applications***

- **Summary**: This paper discusses the principles of digital PAM, including its transmission and reception processes. The focus is on the challenges of intersymbol interference (ISI) and the Nyquist ISI criterion, which are crucial for reducing errors in high-speed communication systems. The paper also explores various demodulation techniques, such as comparator-based and ADC-based methods, to accurately retrieve transmitted data.

REFRENCE:

https://www.allaboutcircuits.com/technical-articles/receiving-and-sampling-signals-in-digital-pulse-amplitude-modulation

RESEARCH PAPER 2:

PAPER TITLE: ***An Investigation into Pulse Amplitude Modulation and Demodulation Techniques for Communication Systems***

- **Summary**: This research explores various PAM modulation and demodulation techniques used in communication systems. It emphasizes the importance of accurately sampling and decoding the signal to maintain data integrity. The paper also covers the impact of signal degradation and distortion on PAM and presents methods to overcome these challenges.

REFRENCE:

https://link.springer.com/article/10.1007/s10470-017-1078-1

METHODOLOGY:

System Overview:

In Pulse Amplitude Modulation (PAM), the process involves modulating the amplitude of a series of pulse signals in accordance with the amplitude of the analog message signal. The modulated signal consists of discrete pulses where the amplitude of each pulse corresponds to the instantaneous amplitude of the message signal at the sampling instants.

Modulation Process:

Carrier Signal Generation: A periodic train of rectangular pulses is generated. The pulse repetition frequency (PRF) is selected based on the Nyquist criterion, ensuring that the sampling rate is at least twice the highest frequency present in the message signal to avoid aliasing.

Message Signal Sampling: The continuous analog message signal is sampled at discrete intervals. Depending on the sampling technique:

Natural Sampling: The message signal is sampled using the carrier pulses without any modifications. The top of each pulse matches the instantaneous amplitude of the message signal.

Sample-and-Hold Sampling: Each sampled pulse holds the amplitude of the message signal constant until the next sampling interval. This produces a "staircase" waveform where the amplitude remains constant between samples.

PAM Signal Formation: The sampled values modulate the amplitude of the carrier pulses, forming the PAM signal. The amplitude of each pulse in the PAM signal is directly proportional to the sampled amplitude of the message signal at that instant.

Transmission: The PAM signal is transmitted over a communication channel. The signal may be subject to noise, attenuation, and distortion, which can affect the integrity of the transmitted data.

Demodulation Process

- **Receiver Filtering**: A low-pass filter is applied to remove high-frequency noise and to shape the received signal for sampling.
- **Signal Sampling**: The received PAM signal is sampled at the pulse intervals. The amplitude of each pulse is measured to determine the corresponding value of the original message signal.
- **Reconstruction of the Message Signal**: The sampled amplitudes are then used to reconstruct the continuous-time message signal. In a basic system, this can be achieved using a zero-order hold circuit, which maintains the amplitude of each sample until the next one is received.

Analysis and Considerations

- **Intersymbol Interference (ISI)**: Special care must be taken to minimize ISI, which occurs when pulses overlap, causing errors in the demodulated signal. Equalization techniques may be employed to mitigate this issue.
- **Bandwidth and Noise Considerations**: The bandwidth of the channel and the presence of noise can significantly affect the quality of the received signal. Adequate filtering and signal processing techniques must be employed to maintain signal integrity.

Pulse Amplitude Modulation:

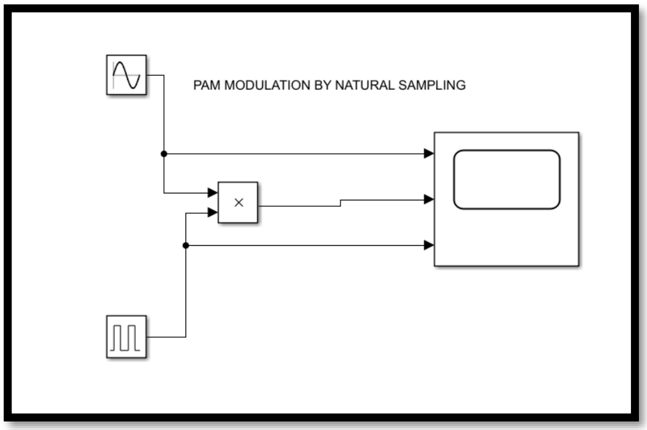
Aspect	PAM with Natural Sampling	PAM with Sample-and-Hold
Definition	The amplitude of the pulse varies according to the instantaneous value of the modulating signal at the sampling instants.	The amplitude of the pulse is held constant at the value of the modulating signal until the next sampling instant.
Sampling Method	Modulating signal is sampled at discrete intervals, and the pulse amplitude follows the instantaneous sampled value.	Modulating signal is sampled, and the pulse maintains its amplitude until the next sample is taken.
Waveform Characteristics	- The waveform appears as a series of pulses that vary smoothly in amplitude, following the shape of the modulating signal. - The pulses are narrower, and their amplitudes change continuously with time.	- The waveform appears as a series of rectangular pulses. - Each pulse has a flat top, where the amplitude remains constant until the next sampling point.

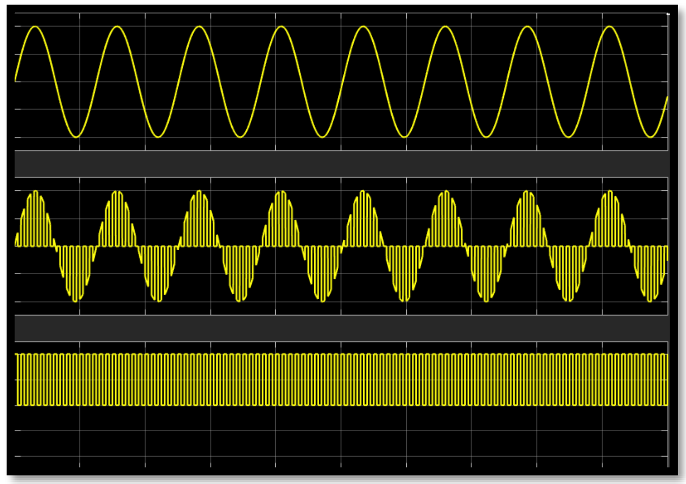
Waveforms Visuals:

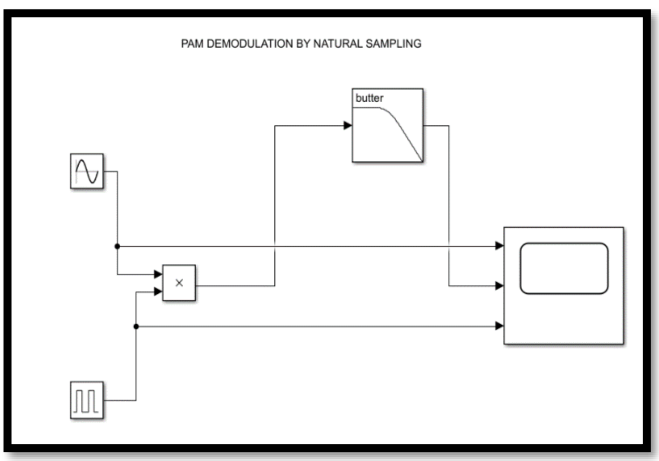
Waveform Visual		
Distortion	Less distortion in the signal as the sampling is closer to the original signal's shape.	More distortion due to the flat-top pulses, which can introduce high-frequency components in the signal.
Complexity	Slightly more complex due to the continuous variation in pulse amplitude.	Simpler implementation as the amplitude is held constant between samples.
Applications	Used in systems where accurate reproduction of the signal is crucial.	Commonly used in digital communication systems where the simplicity of the circuit is essential.
Bandwith Requirements	Typically higher because the varying pulse amplitude requires more bandwidth to accurately represent the signal.	Lower bandwidth requirements due to the constant amplitude during each sampling period.

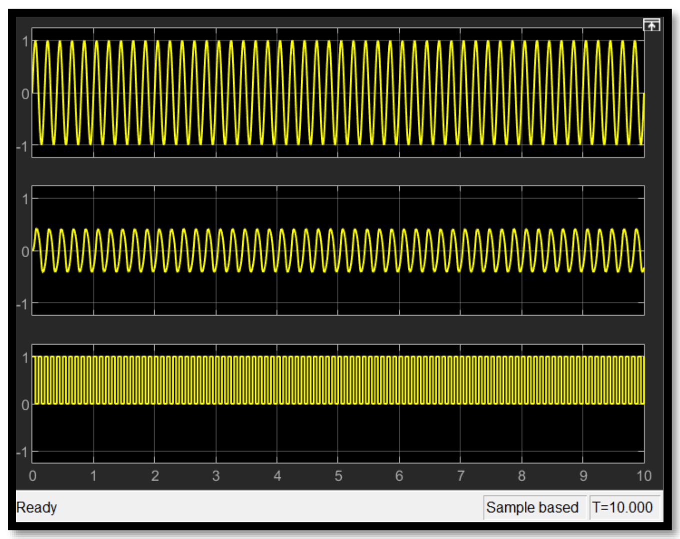
Task 2

PAM MODULATION AND DEMODULATION BY NATURAL SAMPLING

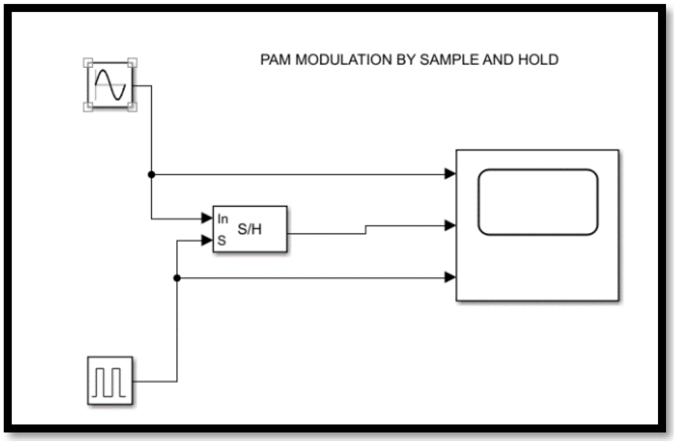


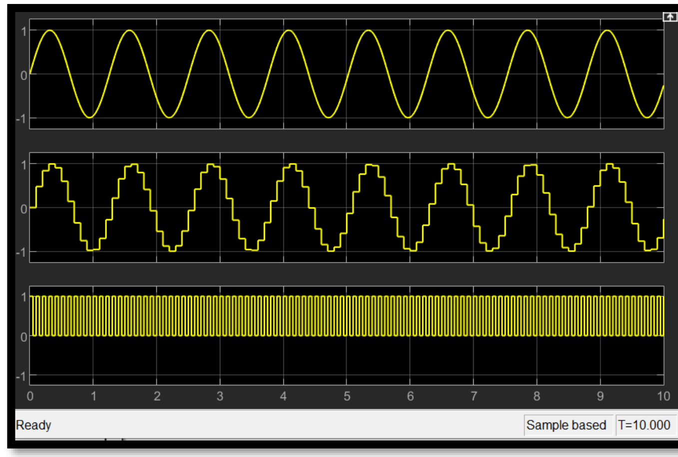


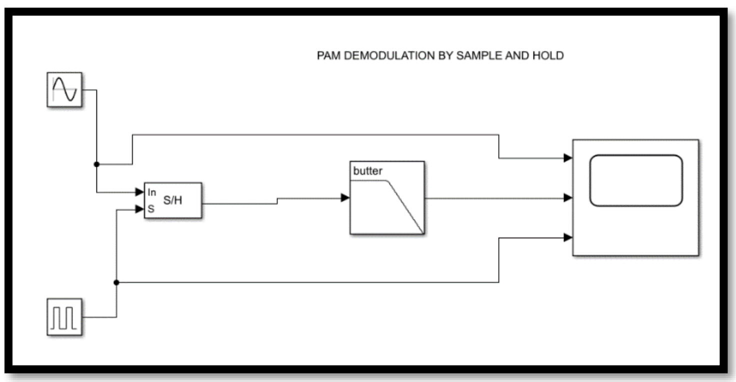


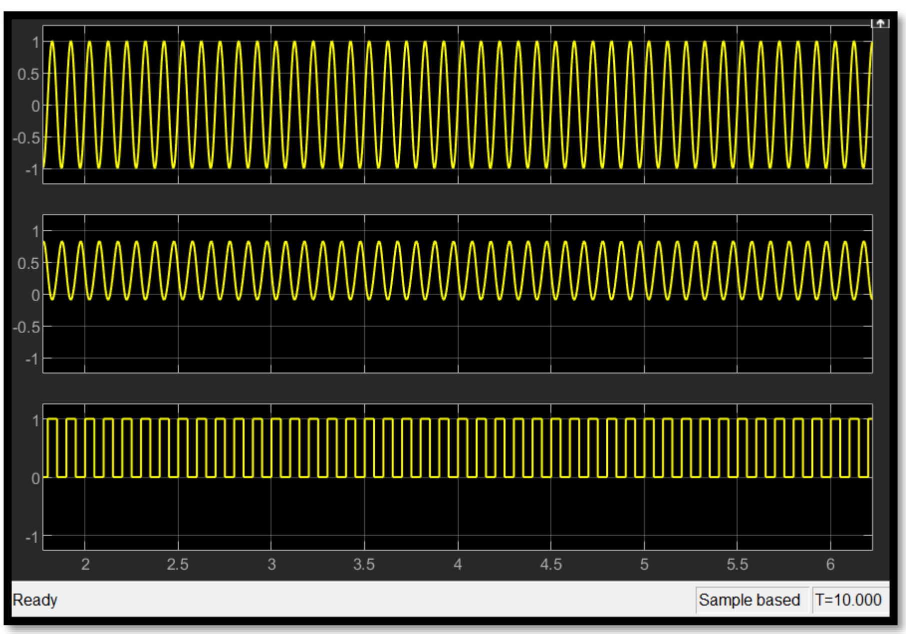


PAM MODULATION AND DEMODULATION BY SAMPLE AND HOLD:









PULSE AMPLITUDE MODULATION