Date:

SIGNAL CONVERSION

01. AIM :

To study the conversion of Digital to Digital, Analog to Digital and Digital to Analog techniques.

02. FACILITIES : –

03. SCOPE :

This experiment focuses on understanding the conversion processes and their underlying theoretical concepts for:

- **Digital to Digital Conversion**: Encoding schemes and data integrity methods.
- **Analog to Digital Conversion**: Sampling, quantization, and encoding methods, as well as ADC types.
- **Digital to Analog Conversion**: Techniques for converting discrete digital values back into continuous analog signals.

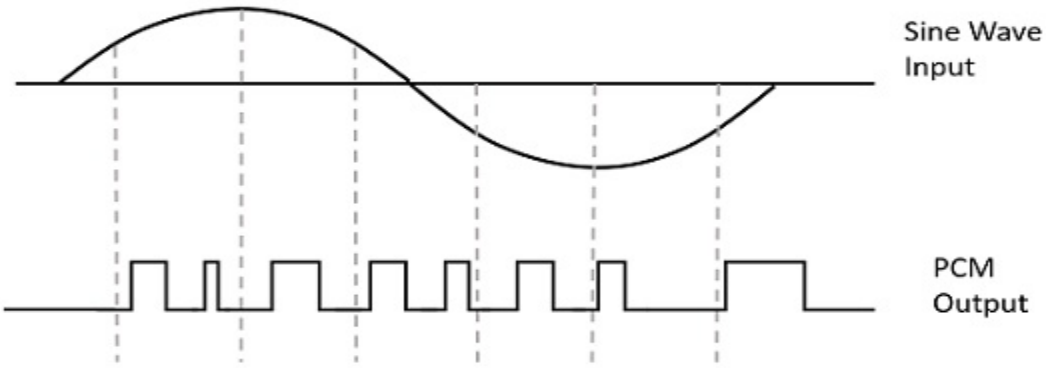
04 THEORY:

Digital to Digital Conversion:

Digital to digital conversion refers to transforming digital data from one format to another while ensuring that the data's integrity remains intact for transmission or storage. Several encoding schemes and error detection/correction methods are used in this conversion process.

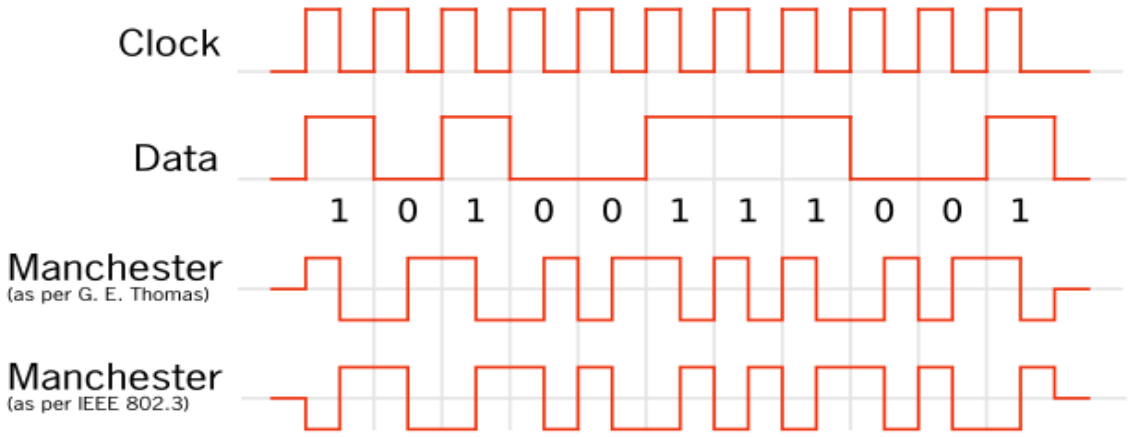
1. Pulse Code Modulation (PCM):

- PCM is a method of converting an analog signal into a digital signal by first sampling the analog signal at a certain rate and then quantizing the samples into discrete levels.
- The **sampling theorem** (Nyquist-Shannon theorem) states that a signal must be sampled at least twice the frequency of its highest frequency component to avoid aliasing (the distortion that occurs when signals are undersampled).
- PCM is typically used in **audio signals**, where the analog sound is sampled, quantized, and then encoded into binary form.



2. Manchester Encoding:

- Manchester encoding is a form of **bipolar encoding** where each bit is represented by two voltage transitions within a clock cycle. A binary '1' might be represented by a high-to-low transition, and a binary '0' by a low-to-high transition within the clock period.
- This method is advantageous because it ensures that there is a transition at the midpoint of every bit period, which aids in synchronization and reduces the likelihood of clock drift.



Analog to Digital Conversion (ADC):

An ADC converts continuous, real-world analog signals (such as sound, light, or temperature) into a digital format that can be processed by digital systems. The main stages in the ADC process are **sampling**, **quantization**, and **encoding**.

1. Sampling:

- Sampling is the process of measuring the analog signal at discrete intervals. The sampling rate (or sampling frequency) determines how often the analog signal is measured. According to the **sampling theorem**, the sampling

frequency must be at least twice the highest frequency component of the analog signal to prevent **aliasing**.

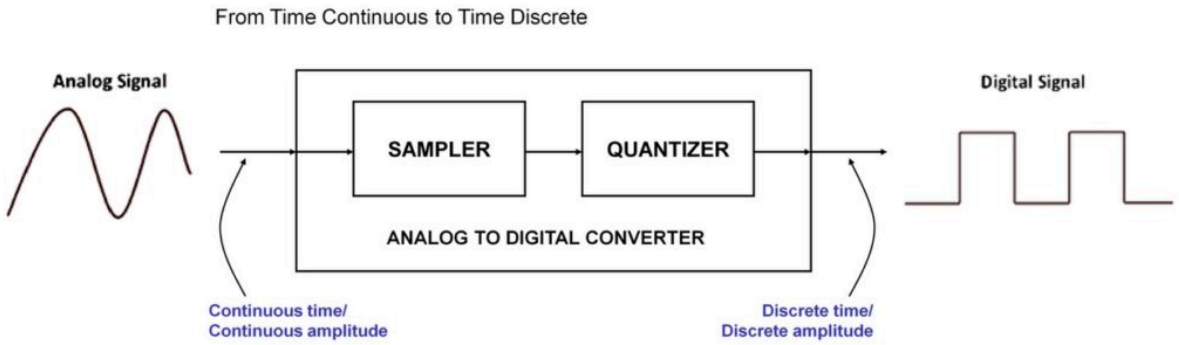
- **Aliasing** occurs when higher frequencies in the analog signal are misrepresented as lower frequencies in the sampled signal, causing distortion.

2. Quantization:

- Quantization is the process of converting continuous amplitude values into a finite set of discrete values. The precision of this process is determined by the **bit depth** of the ADC. A higher bit depth results in a finer quantization and a more accurate representation of the original signal, but requires more bits for storage and processing.
- The quantization error is the difference between the actual sampled value and the nearest available quantized value. This error can introduce **quantization noise**, which is inversely proportional to the resolution (bit depth) of the ADC.

3. Encoding:

- After quantization, each discrete value is encoded into a binary format for digital processing or transmission. The number of bits required for encoding depends on the quantization levels. For example, a 10-bit ADC has 1024 quantization levels, and each sampled value is represented by a 10-bit binary number.



Types of ADCs:

- **Successive Approximation ADC**: A method that uses a binary search algorithm to iteratively approximate the input signal's value.
- **Flash ADC**: A parallel approach that uses multiple comparators to convert the input signal in a single step, making it faster but more complex.
- **Delta-Sigma ADC**: Uses oversampling and noise shaping to achieve high resolution, making it ideal for precision measurements like audio or instrumentation.

Digital to Analog Conversion (DAC):

A DAC is a device that converts discrete digital values (binary numbers) into a continuous analog signal. The digital data must be reconstructed into a form that can be understood by analog devices such as speakers, motors, or sensors.

1. Binary-Weighted DAC:

- In a binary-weighted DAC, each bit of the digital input controls a current (or voltage) that is weighted according to powers of 2 (binary). The sum of these weighted currents or voltages produces the desired output.
- This method requires precise resistor matching, and it becomes impractical for high-resolution DACs due to the increasing number of resistors needed.

2. R-2R Ladder DAC:

- The R-2R ladder DAC is a more efficient method that uses only two resistor values, R and 2R, to create a series of binary-weighted outputs. This configuration is simpler and less prone to errors than the binary-weighted DAC, making it more commonly used in practical applications.
- The resistor network forms a "ladder" structure that allows for a more compact and cost-effective design.

3. Pulse Width Modulation (PWM):

- PWM is a method for generating an analog signal by varying the width of pulses in a square wave. The **duty cycle** (the percentage of time the signal is high versus low) determines the average voltage level. A higher duty cycle results in a higher average voltage.
- This technique is widely used in applications such as motor control, audio generation, and LED dimming. Although PWM signals are inherently digital, they can be filtered to approximate a continuous analog waveform.

08 CONCLUSION:

This experiment covers the key processes of converting between analog and digital signals. Digital to Digital conversion ensures reliable transmission with encoding and error detection. ADC digitizes analog signals through sampling, quantization, and encoding, while DAC reconstructs analog signals from digital data. These techniques are crucial in digital communication and signal processing.

09 VIVA QUESTIONS: