Experiment 10.

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AIM: To demonstrate the pulse code modulation (PCM) and demodulation technique. To show the sampled, quantized/encoded and decoded time domain signal for different bit-codes.

Software: MATLAB

THEORY:

1. Pulse Code Modulation (PCM)

- PCM is a technique, which is used to convert an analog signal into digital signal.
- PCM is a preferred method of communication within the public switched telephone network (PSTN).
- A PCM stream is determined by the following steps:

a) Sampling rate - which is the number of times per second that samples are taken.

b) Bit depth - which determines the number of possible digital values that can be used to represent each sample.

- Hence, the output of a PCM resembles a binary sequence.

2. Reason for digital transmission

- Less susceptible to interference cause by noise due to discrete level.
- Easy to detect errors due to discrete level.

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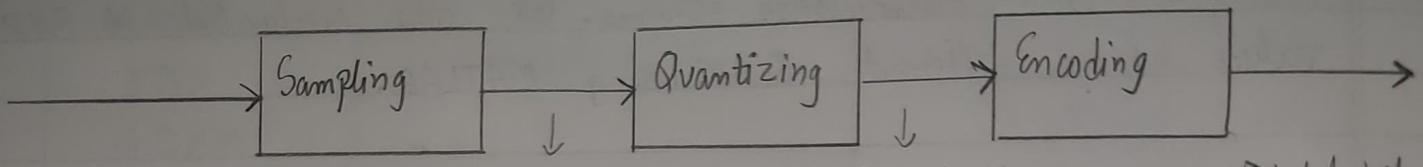
Block Diagram of PCM

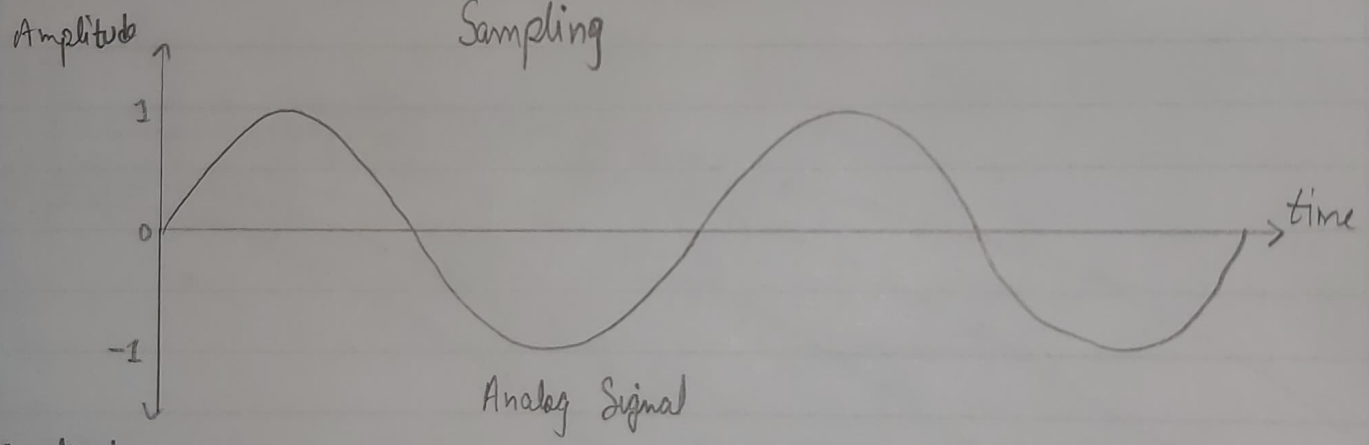


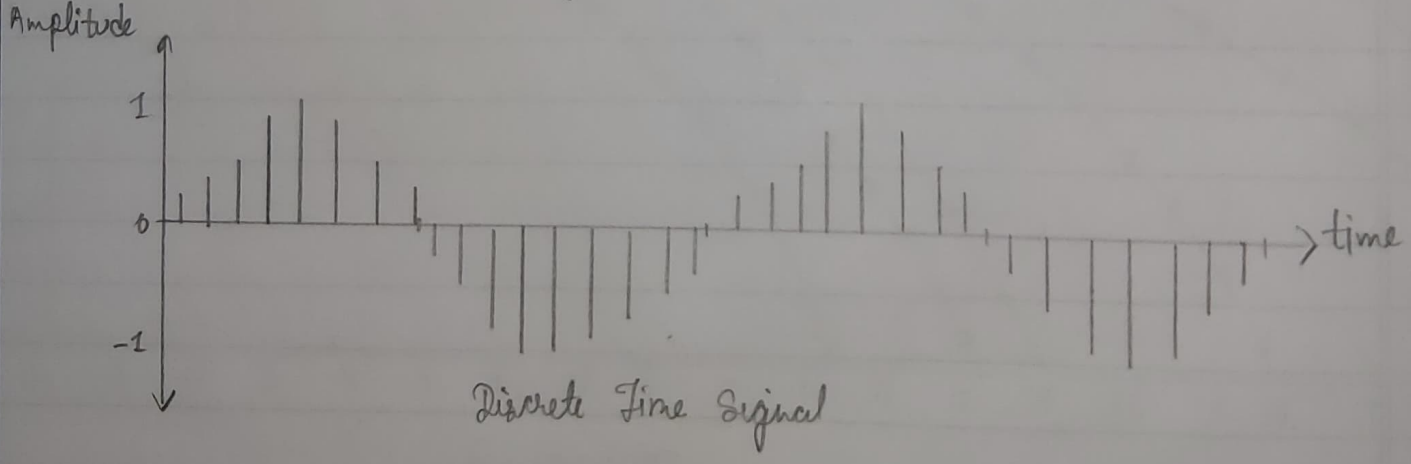
Continuous-time continuous amplitude (analog) input signal

Discrete-time continuous amplitude signal (PAM pulses)

Discrete-time discrete-amplitude signal (PCM pulses)

Digital bit stream output signal.





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AIM :

- Easy to encrypt (Higher security)
- Simpler to store digital data

3. Sampling

- Sampler extract samples of a continuous signal.
- Sampler produces samples that are equivalent to the instantaneous value of the continuous signal at the specified various points.
- The Sampling process generates Flat-top Pulse Amplitude Modulated (PAM) signal.

4. Quantization

- Quantization is done by dividing the range of possible values of the analog samples into some different levels and assigning the center value of each level to any sample in the quantization interval.
- Quantization approximates the analog signal values with the nearest quantization values.

5. Pulse Code Modulation (PCM) is a method of converting an analog signal into a digital signal (A/D conversion)
- PCM produces a series of number or digits instead of pulse train.

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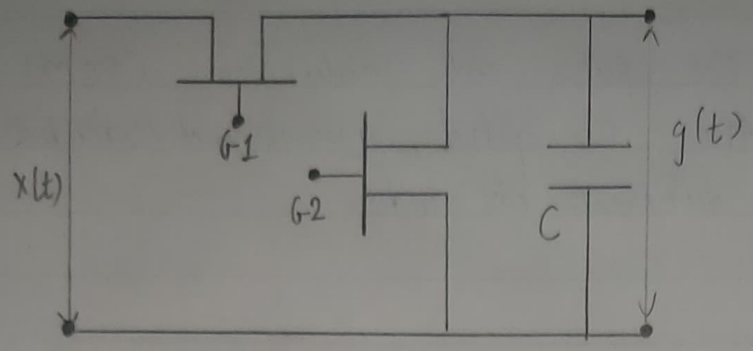
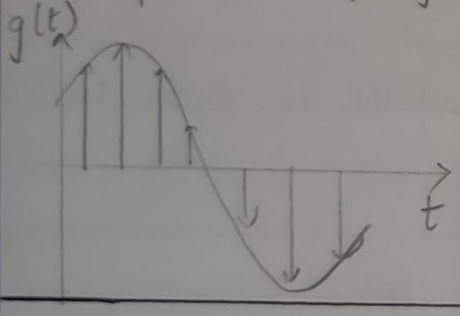
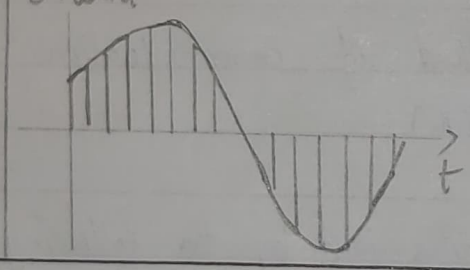
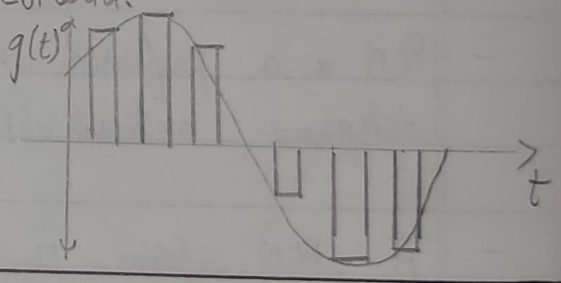
Flat Top PAM



Instantaneous sampling	Natural Sampling	Flat top Sampling
It is not practical method	This method is used practically	This is also used practically.
Sample rate infinity	Sample rate satisfied Nyquist Criteria	Sample rate satisfied Nyquist Criteria.

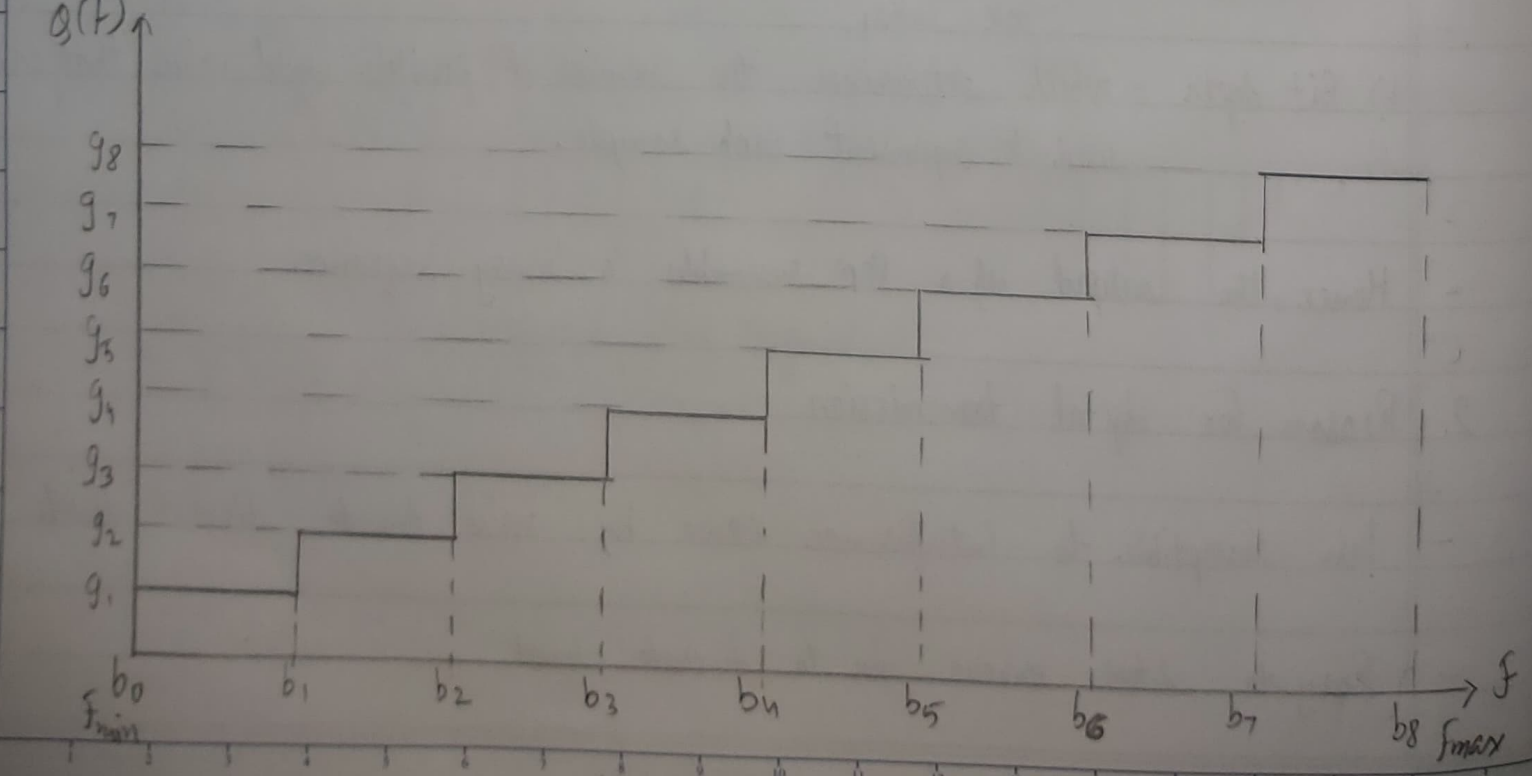






Uniformly Quantised Signal

A/D output = n bits per sample (quantization level $M = 2^n$)



AIM :

- Each one of these digits, in binary code, represent the approximate amplitude of the signal sample at that instant.

6. Conclusion for PCM

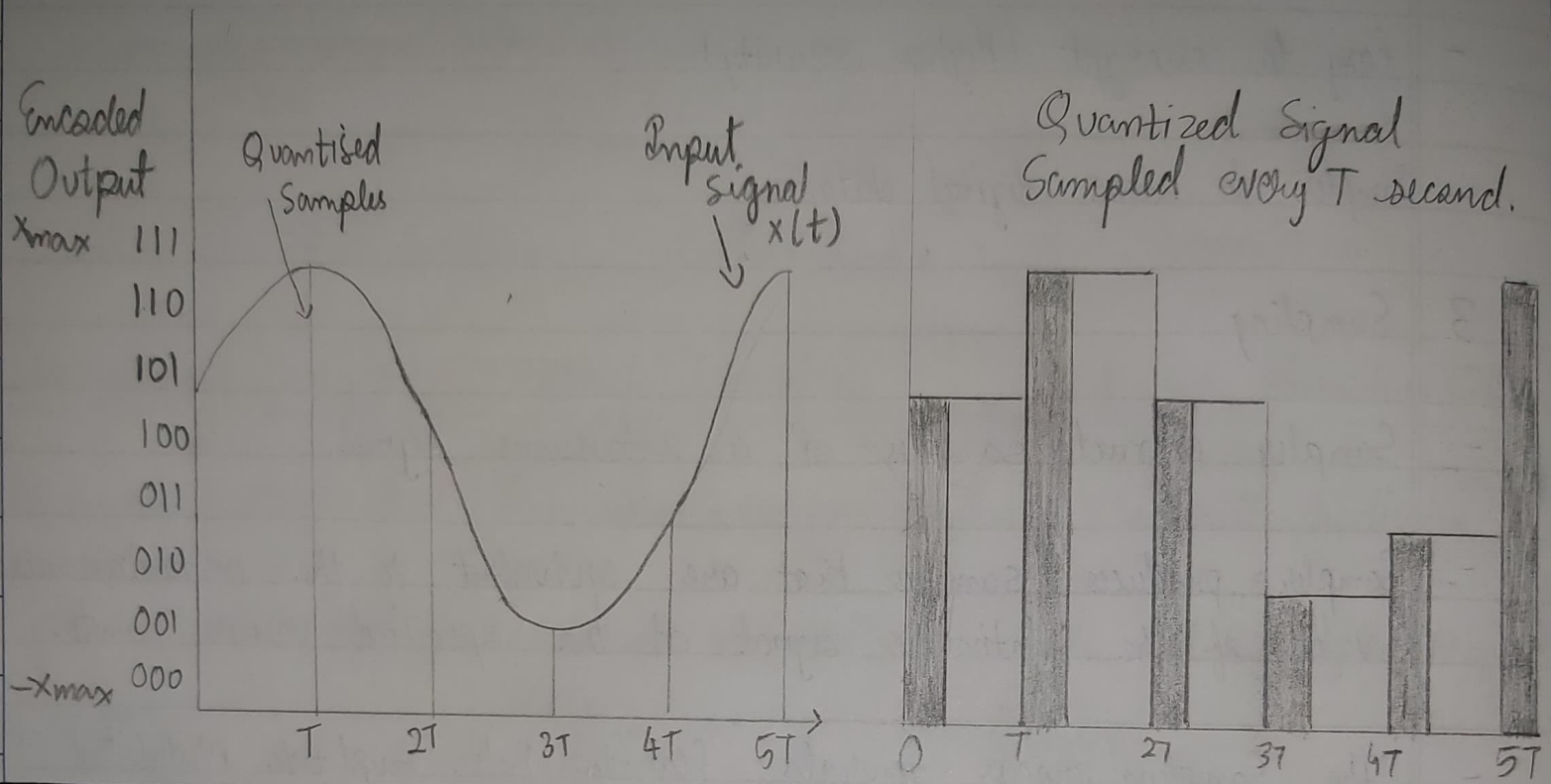
- In PCM transmitter, the signal $x(t)$ is first passed through the low-pass filter of cut-off frequency f_m Hz.
- This low-pass filter blocks all the frequency components above f_m Hz. This means that now the signal $x(t)$ is band-limited to f_m Hz.
- The sample and hold circuit then samples this signal at the rate of f_s.
- Sampling frequency f_s is selected sufficiently above Nyquist rate to avoid aliasing.
- The output of from sample and hold circuit is denoted by $x(nT_s)$.
- This signal $x(nT_s)$ is discrete in time and continuous in amplitude.
- A q-level quantizer compares input $x(nT_s)$ with its fixed digital levels.
- Quantized signal is then encoded in PCM output using encoder.

7. PCM Standards

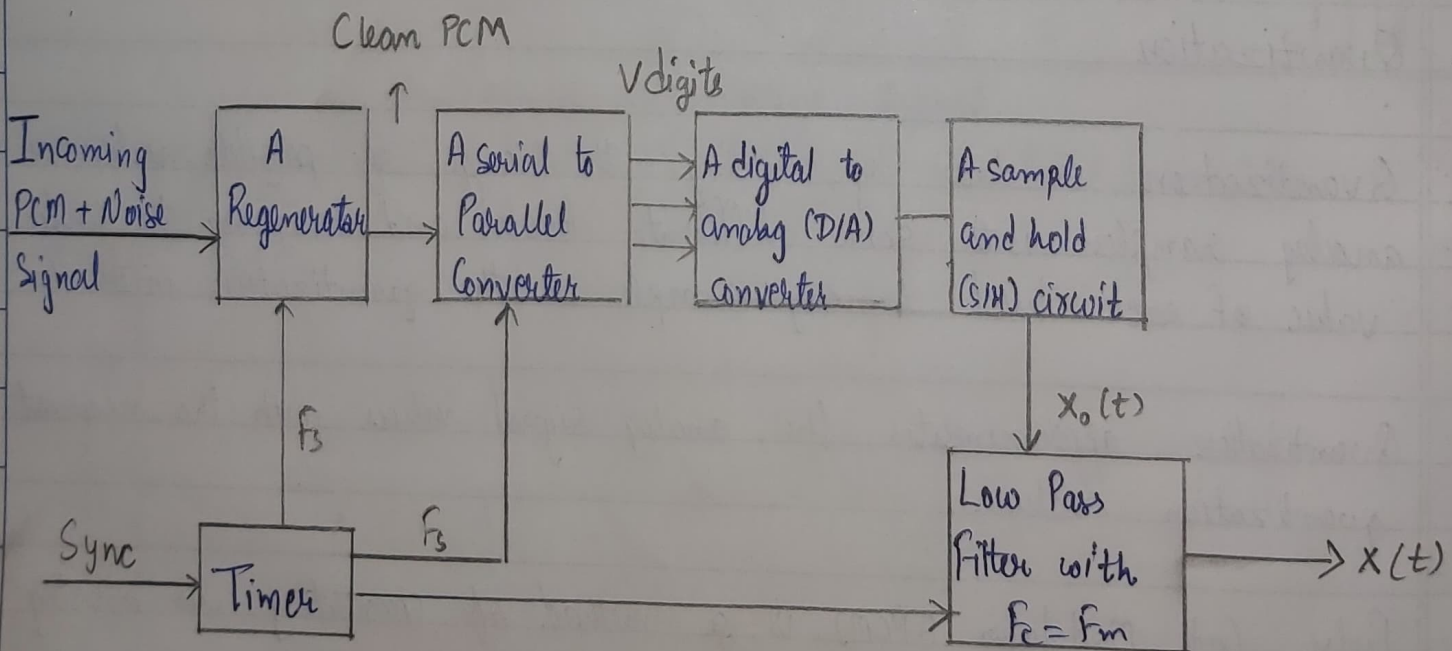
-> There are two standards of PCM namely 1) The European Standard
2) The American Standard

Transmitter

Figure ↓ : Quantization of a sampled analog signal.



PCM Receiver.



AIM :

→ They differ slightly in the detail of their working but the principles are the same.

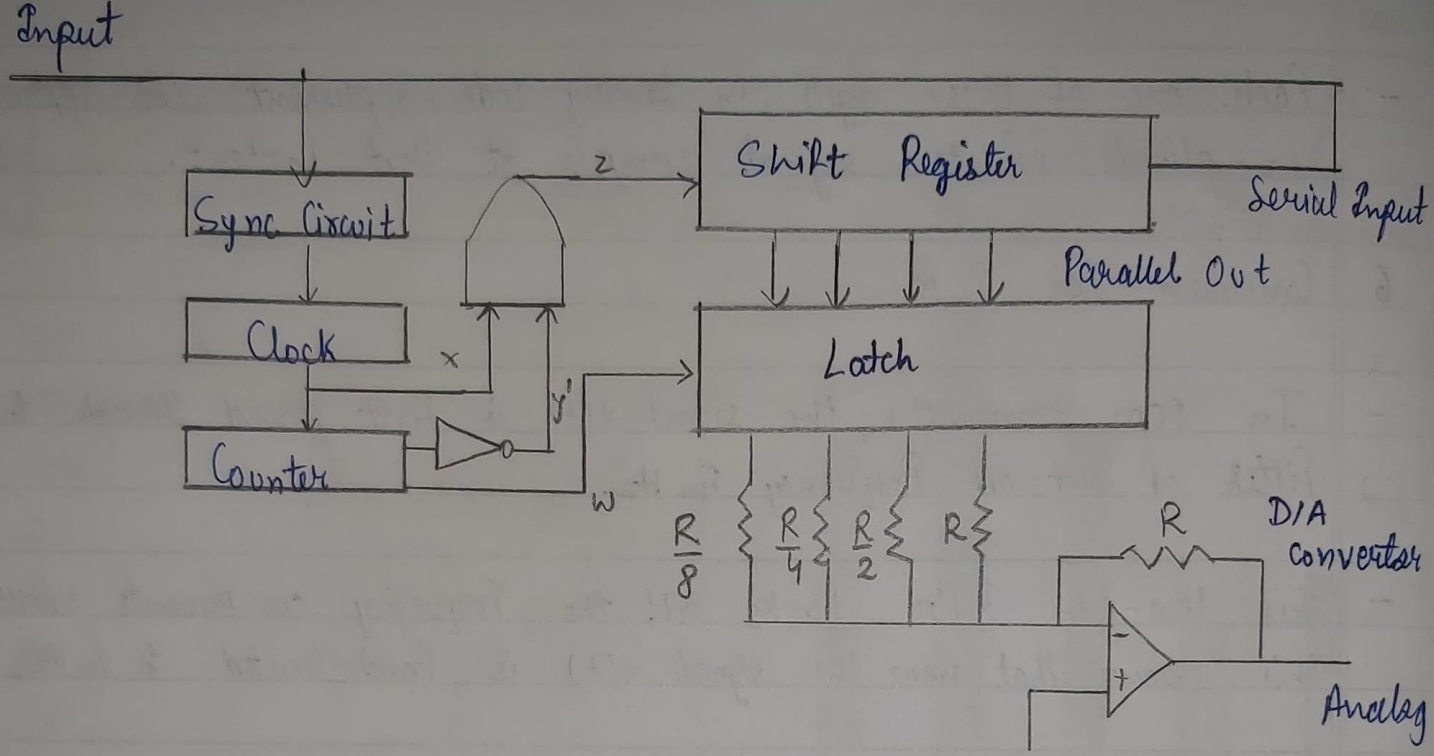
→ European PCM = 30 channels
→ North American PCM = 24 channels
→ Japanese PCM = 24 channels

→ In India, we follow the european PCM of 30 channels system working.

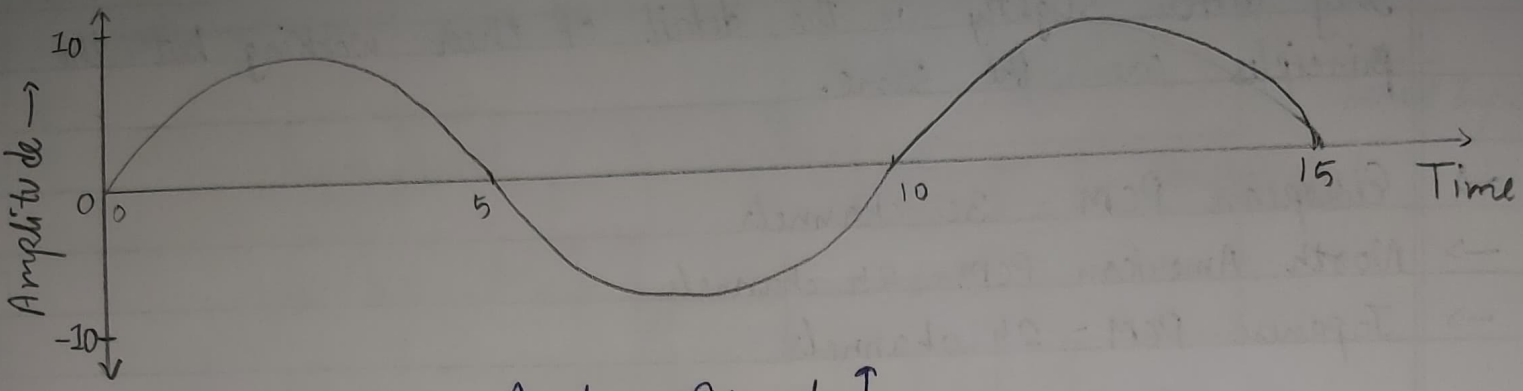
8. Application

- In compact disk
- Digital telephony
- Digital audio applications

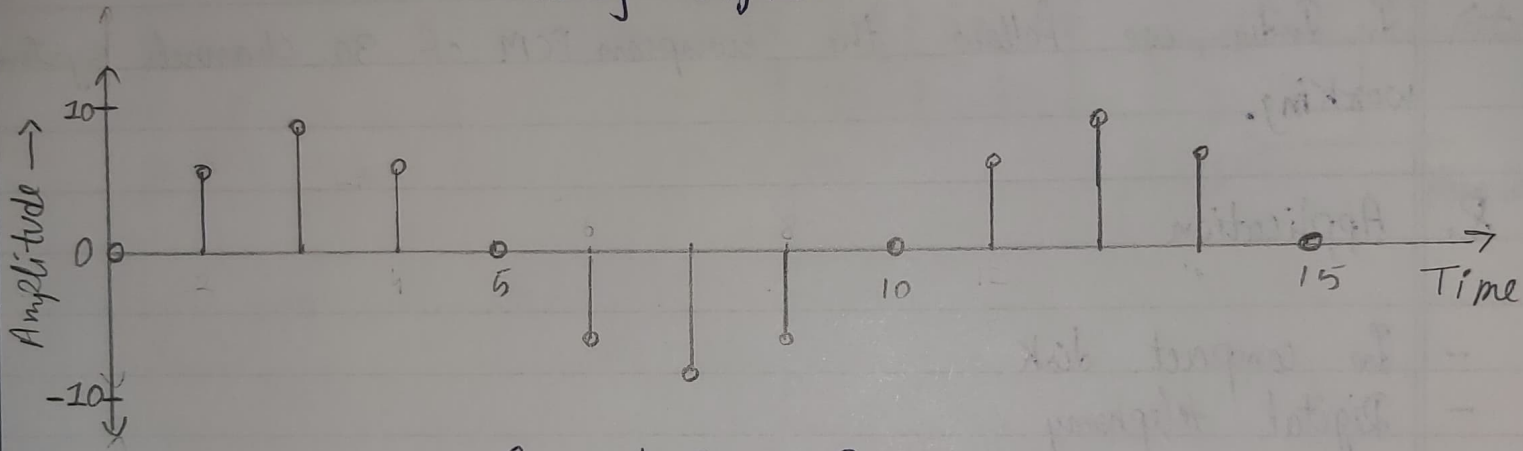
PCM Demodulator



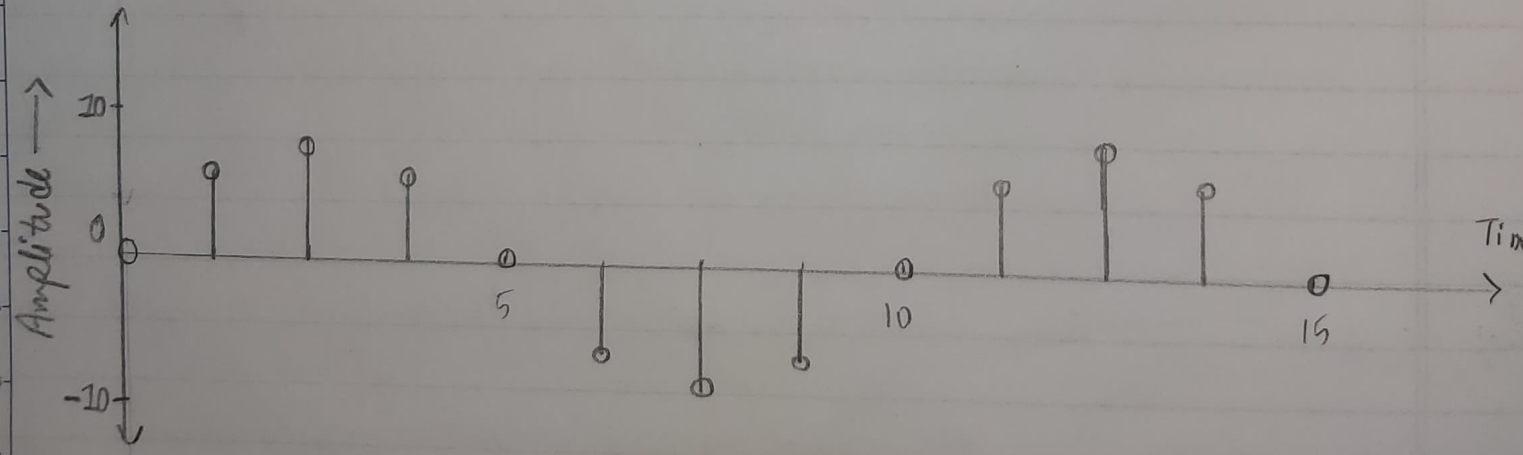
Outputs from MATLAB



Analog Signal ↑



Sampled Signal ↑



Quantized Signal

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AIM :

CONCLUSION: We successfully demonstrated the Pulse code modulation (PCM) and demodulation technique. We also observed block diagrams for Receiver and transmitter of PCM signals. In later stage we also observed Demodulation circuit which consists of Shift Register, Latch and Opamp. In the last phase, we executed MATLAB code and observed Sampling, Quantization, Encoding and Demodulation waves and drawn them.

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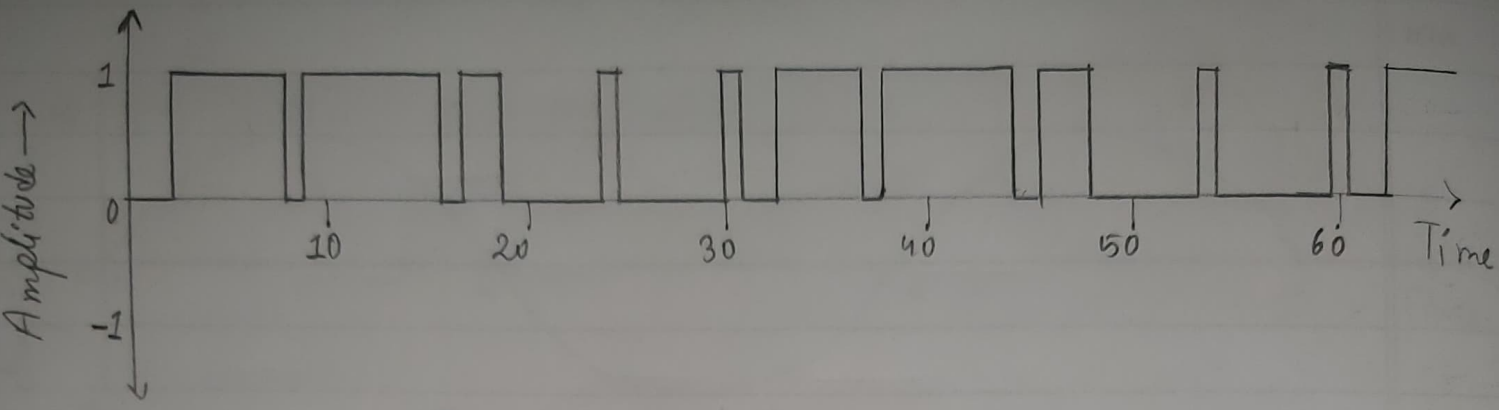
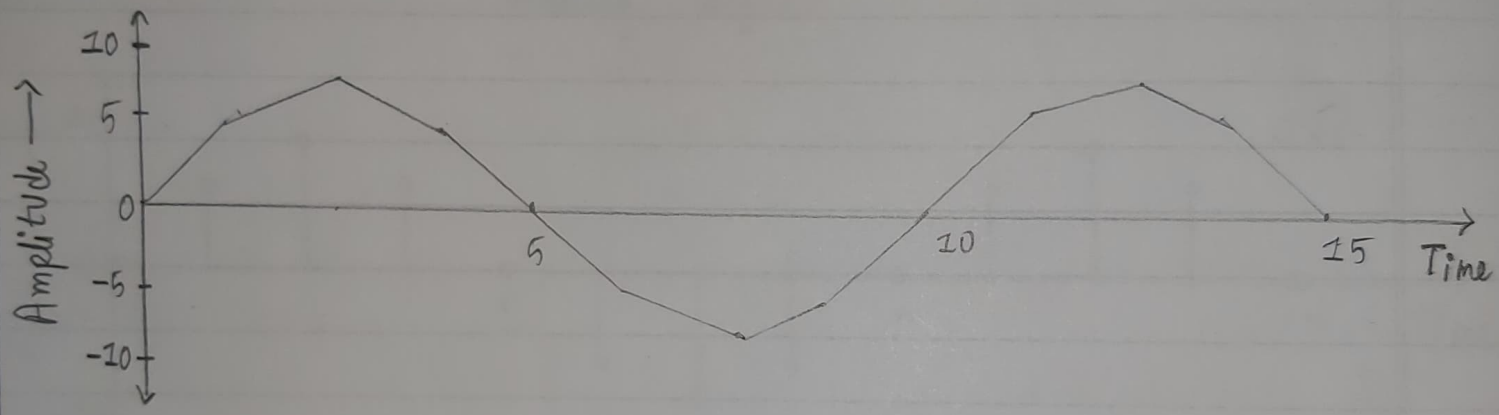


Encoded Signal ↑



Demodulated Signal