EEE 3208

Communication Theory Lab

Experiment No: 07

Experiment Name: Study of Pulse Code Modulation

Submitted by,

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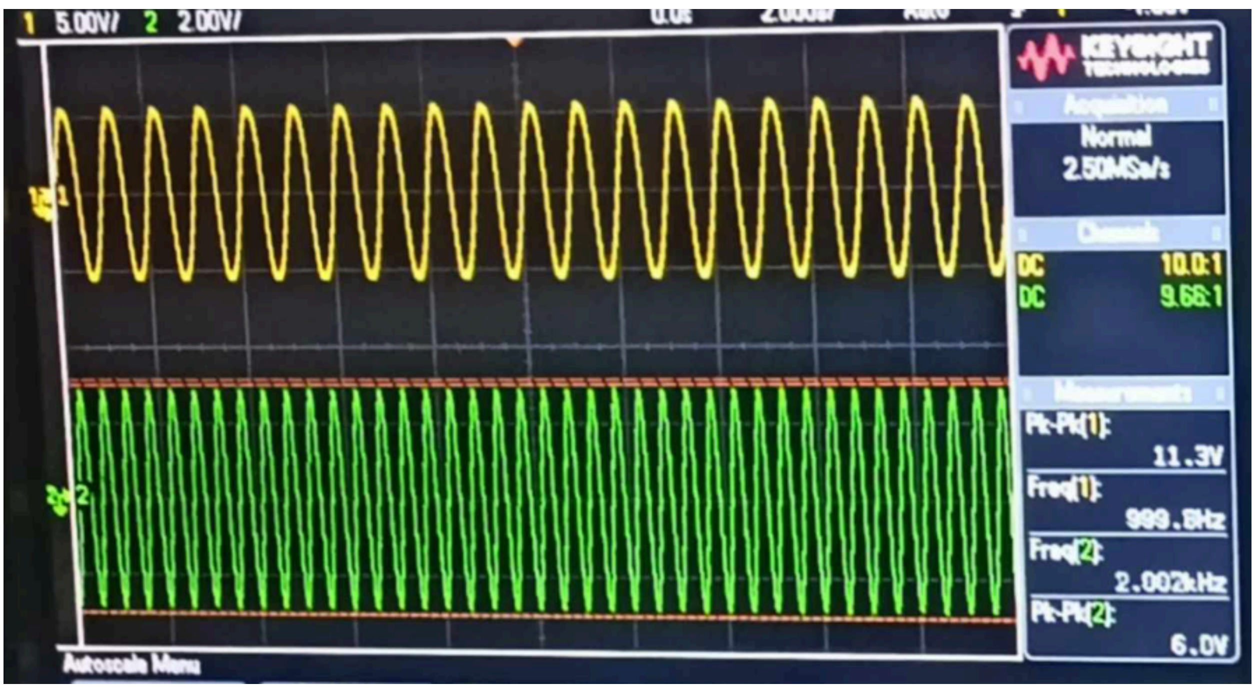
Objective:

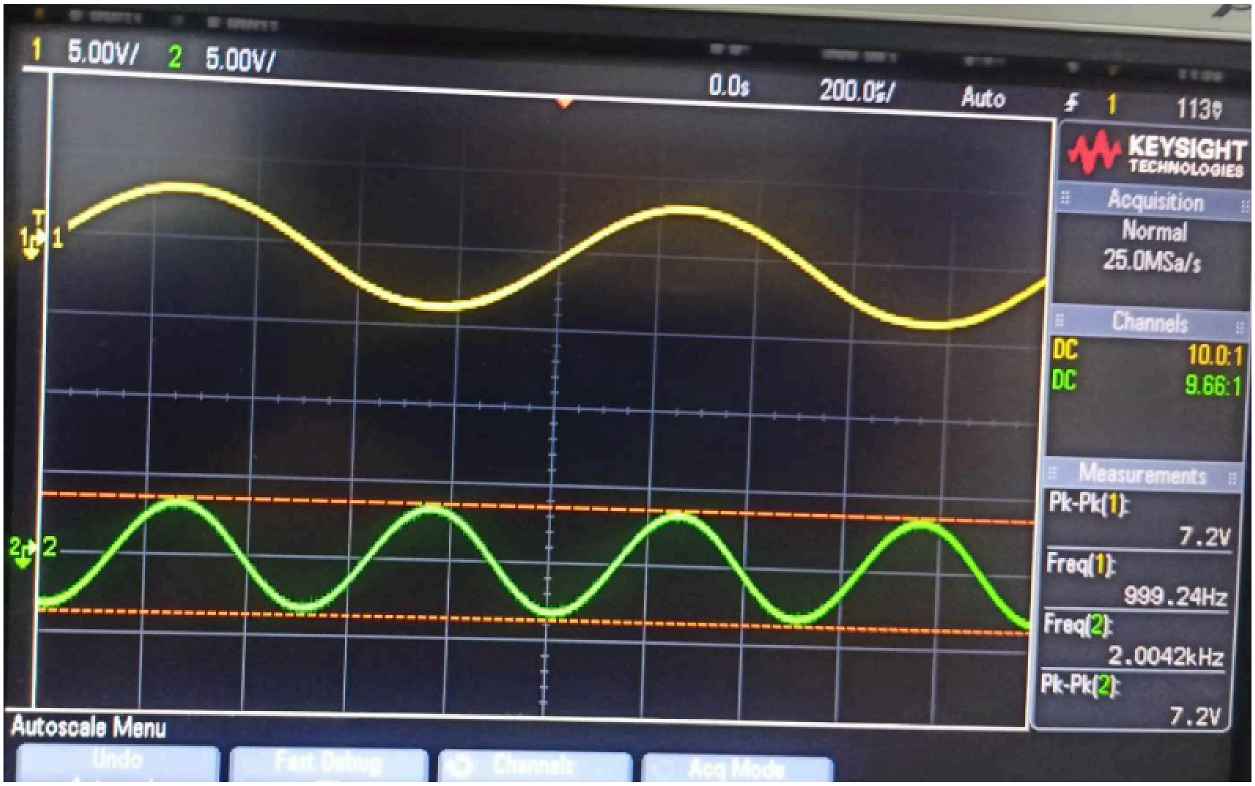
The aim here is acquiring knowledge regarding the basic idea of Pulse Code Modulation (PCM), e.g., quantization, sampling, and coding. It is a thought regarding how improved noise immunity and quality signals are offered in digital signals compared to signals in analog. The study encompasses primary PCM steps, e.g., receiving the signal in a digital signal and transmission with minimal distortion. It is a thought regarding μ-law and A-law compression and how they impact performance. The test is a thought regarding how PCM is applied in everyday life in telephony, sound process, and digital communications.

Graphs:

Channel1: Input signal and Channel2: Sample signal

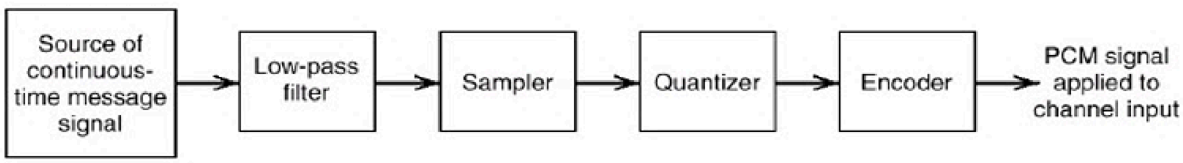


Channel-0 and Output in Mode-1

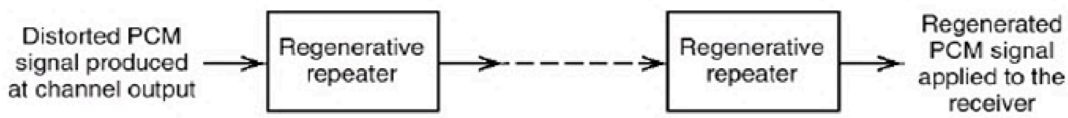


Channel-0 and Output in Mode-3

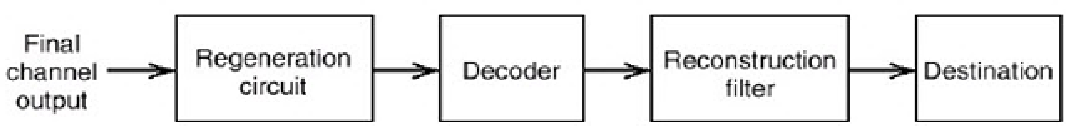
1. Block diagram of transmitter and receiver block:



(*a*) Transmitter



(*b*) Transmission path



(*c*) Receiver

2. Comment on the function of various blocks:

(a) Transmitter Section:

1.Source of Continuous-Time Message Signal:

The first analog signal to be sent is introduced here. This signal can include any form of analog data, such as voice, music, or others.
The signal is a continuous-time waveform, meaning it has infinite values within a given range.

2.Low-Pass Filter (LPF):

The low-pass filter is utilized in order to remove high-frequency components from the analog signal.
This is necessary to prevent aliasing, a process that occurs when high-frequency signals get mixed with lower-frequency components during sampling.
The LPF ensures that the highest frequency in the signal is below the Nyquist rate (half of the sampling rate).

3.Sampler:

The sampler converts the signal from continuous-time form to discrete-time form by sampling uniform sample points.
The Nyquist Theorem specifies the rule about sampling frequencies and mandates that in order to retain information in a true and accurate way, the sampling frequency is not lower than twice the highest frequency in the original signal.

4.Quantizer:

Since real-world signals have infinite precision, they must be approximated to a finite number of discrete levels.
The quantizer approximates every sample by rounding it to the next level predetermined, resulting in a slight inexactness called quantization noise. This methodology converts sample values into distinct categories, thus allowing them to be presented in a binary system.

5.Encoder:

The encoder converts the quantized values into a digital signal, making them suitable for digital transmission. Each quantized sample is assigned a unique sequence of binary digits, allowing a true digital reconstruction of the original signal. The output of this stage is a PCM signal, which is now a series of digital bits that can be transmitted over a communication channel.

(b) Transmission Path:

1. Regenerative Repeater:

When the PCM signal travels through the transmission channel, it gets affected by attenuation, noise, and distortion.
The regenerative repeater amplifies and reconditions the signal by removing noise, thus restoring it to its original digital state.

2. Regenerative Repeater:

In long-distance communication, multiple repeaters are used to maintain signal quality. The second repeater again conditions the PCM signal back to the original state, and thus makes the data transmission dependable.

(c) Receiver Section:

1. Regeneration Flow:
This block filters the input PCM signal and eliminates residual noise and distortion.
It ensures the reconstructed signal is quite close to the original PCM signal transmitted.

2. Decoder:
The decoder reformats the sound level reading in the binary.

This takes away the encoding, and the digital signal is reduced back to a sequence of measured samples.

3. Reconstruction Filter:
The reconstruction filter is a low pass filter that smoothes the signal. It eliminates sudden changes taking place in the process of quantization.
It helps restore the original analog signal in a way that other people and other systems are able to interpret.

4. Destination: This is the final step where the still analog signal is dispatched to the intended person. The output could be in speech, in music, in anything in fact in order to show it.

3. Discuss about Synchronization:

Synchronization is very important in Pulse Code Modulation (PCM). It ensures the transmitted digital signal is interpreted properly on the other hand. In the case of a low level of synchronization, the receiver could interpret the information and reconstruct the signal in a wrong way.
In PCM transmission, information is transmitted in the form of a sequence of samples and quantised values representing information. The receiver is required to receive the following:
When to start reading a short segment (bit synchronism).
Where each binary word begins and ends (word synchronization).
This is where everything starts in the frame data (frame synchronism).
Synchronization is initiated by
Clock Signals: An unsynced clock ensures information reaches the receiver in the proper times.
Preamble Bits: An initial sequence of particular bits is transmitted at the beginning of a message in order to guide the timing of the receiver.
Frame Synchronization Characters: These are particular character strings that identify where a frame is beginning and distinguish among varying data packets.

Discussion:

In this experiment, we examined Pulse Code Modulation (PCM). It is a significant process in converting analog signals into digital signals in order to get them sent and received with ease. PCM is widely utilized in contemporary communications because it functions even with distortion and noise.

The PCM process has a few key steps. It begins with sampling, in which we take an analog signal at regular time intervals. The Nyquist theorem states that the sampling rate should be at least double the highest frequency of the input signal so that we do not have issues such as aliasing. Following sampling, quantization assigns discrete levels to the sampled values, which introduces some noise referred to as quantization noise. The quantized values are then converted into binary codes by encoding, forming a digital signal that can be sent.

When PCM signals are transmitted, noise and distortion may occur, but regenerative repeaters play a crucial role in correcting the signal quality. The digital data remains pristine with these repeaters, and it may go a long distance without degradation. The original signal is corrected with the reconstruction filter and the decoder at the receiver end.

The only thing favorable about PCM is that it is not disturbed by noise and performs better than in analog transmission. Analog signals are attenuated with distance, but PCM signals could be restored with minimal loss. Due to this, PCM is utilized widely in communication systems, digital sound recordings, and video transmission.

PCM has a few drawbacks. It uses more bandwidth due to the need for binary coding, and there are also inaccuracies that occur while digitizing. In order to refine and make the signal efficient, sophisticated techniques such as companding (μ-law and A-law) are utilized. This experiment provided significant information regarding digital signal processing and demonstrated how PCM is applied in communication today.