Heaven's Light is Our Guide

Rajshahi University of Engineering and Technology

Course Code

ECE 3208

Course Title

Communication Engineering Sessional

Experiment Date: February 25, 2025,

Submission Date: April 22, 2025

Lab Report 5: Study of Pulse Code Modulation (PCM)

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Contents

Study of Pulse Code Modulation (PCM)

Theory

Pulse Code Modulation (PCM) digitally represents analog signals, used in digital audio, telephony, and more. It involves sampling and quantization [1].

Sampling

Sampling converts a continuous signal into discrete samples. According to the Nyquist-Shannon theorem, the sampling rate must be at least twice the highest frequency in the signal [2]. Mathematically:

$$x[n] = x(nT_s)$$

where T_s is the sampling interval.

Quantization

Quantization maps sampled values to a finite set of levels, introducing quantization error. The quantized signal is:

$$x_q[n] = Q(x[n])$$

Encoding

Quantized values are encoded into binary form. The number of bits used determines the resolution [3].

Advantages of PCM

- High noise immunity
- Efficient storage and transmission
- Compatibility with digital systems

Applications of PCM

- Digital telephony
- Audio recording
- Data communication

Required Apparatus

- DigitalModulationDemodulationKit (DL 3155M61)
- Oscilloscope
- ConnectingWires
- PowerSupply

Diagrams

Block Diagram of PCM System

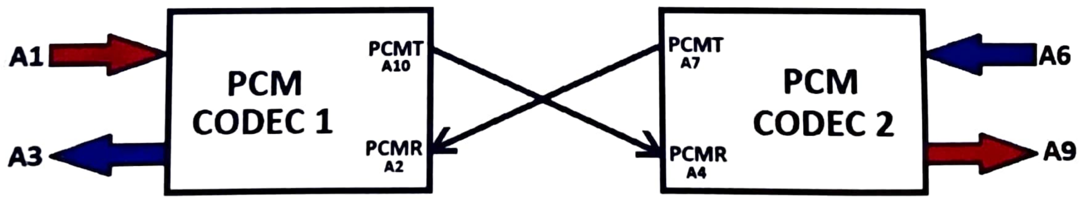

Figure 1: Block Diagram of PCM System

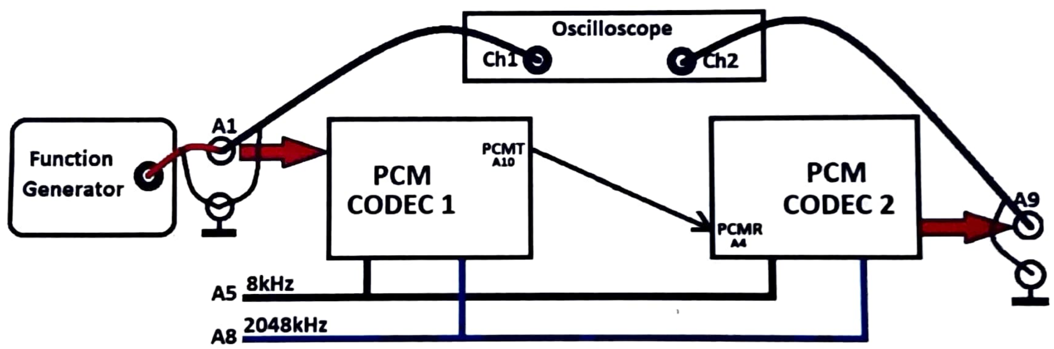

Figure 2: Block Diagram of PCM System (Detailed)

PCM Section of Kit DL 3155M61

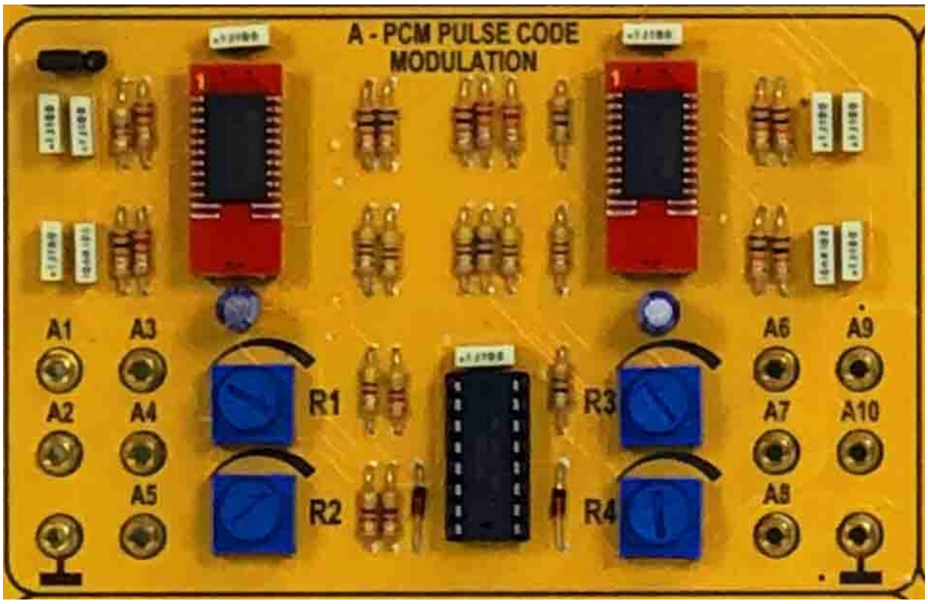

Figure 3: PCM Section of Kit DL 3155M61

Procedure

1. The signal input (analog signal) was connected to pin A1.
2. The PCM signal was observed on pins A10 and A4.
3. The demodulated signal was observed on pin A9.
4. Alternatively, the signal input was connected to pin A6.
5. The PCM signal was observed on pins A7 and A2.
6. The output signal was observed on pin A3.
7. The 8kHz and 2048kHz signals were noted on pins A5 and A8.
8. An oscilloscope was used to observe and verify the signals.

Observation

We observed significant noise in the PCM and demodulated signals due to:

- Faulty connections or components.
- External interference.

- Inaccurate sampling or quantization.
- Insufficient filtering of the analog signal.

Ensure secure connections, functional components, and proper shielding and filtering to reduce noise.

Matlab Simulation

Code:

```
% Parameters
fs = 10000;             % Sampling frequency
t = 0:1/fs:0.01;        % Time vector for 10 ms
f = 1000;               % Frequency of input signal
A = 1;                  % Amplitude of input signal
n_bits = 8;             % Number of bits for quantization

% Generate input signal
input_signal = A * sin(2 * pi * f * t);

% Quantization
L = 2^n_bits;           % Number of quantization levels
q_step = (2 * A) / L; % Quantization step size
quantized_signal = round(input_signal / q_step) * q_step;

% PCM Encoding
pcm_encoded = de2bi((quantized_signal / q_step) + (L/2), n_bits, 'left-msb');

% PCM Decoding
decoded_signal = (bi2de(pcm_encoded, 'left-msb') - (L/2)) * q_step;

% Plotting
figure;

% Plot input signal
subplot(3,1,1);
plot(t, input_signal);
title('Input Signal');
xlabel('Time (s)');
ylabel('Amplitude');

% Plot PCM modulated signal
subplot(3,1,2);
```

```
stairs(t, quantized_signal);
title('PCM Modulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');

% Plot demodulated signal
subplot(3,1,3);
plot(t, decoded_signal);
title('Demodulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');
```

Output

Experimental Output

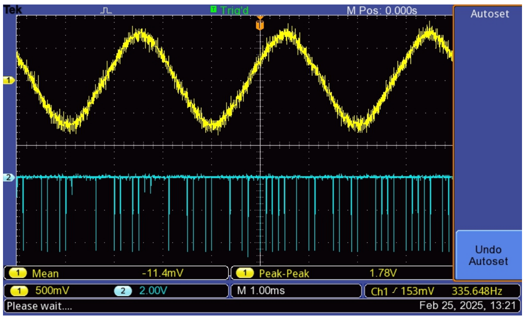

Figure 4: Input Signal (Yellow) and PCM Signal (Blue)

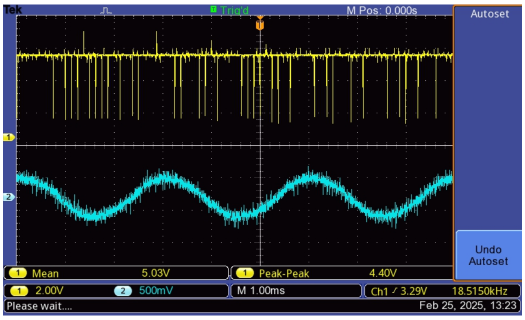

Figure 5: PCM Signal (Yellow) and Demodulated Signal (Yellow)

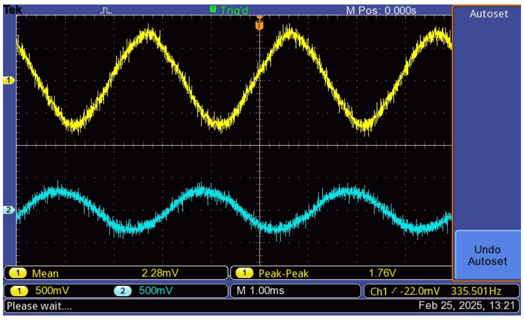

Figure 6: Input Signal (Yellow) and Demodulated Signal (Blue)

Matlab Simulation Output

Discussion and Conclusion

The core principles of Pulse Code Modulation (PCM) were effectively demonstrated through the experiment. By adhering to the outlined procedure, the PCM signal and its demodulated output were successfully observed, thereby validating the theoretical concepts of sampling, quantization, and encoding. Notably, significant noise in the PCM and demodulated signals was highlighted, which could be attributed to factors such as faulty connections, external interference, and inaccuracies in sampling or quantization. Addressing these issues through secure connections, functional components, and proper shielding and filtering was deemed crucial.

The theoretical understanding was further reinforced by the Matlab simulation, which provided a clear visualization of the PCM process. The simulation output closely aligned with the expected results, confirming the accuracy of the implemented code. Overall, a comprehensive understanding of PCM was offered by the experiment and simulation together, emphasizing the importance of precision in electronic communication systems. Future work could focus on enhancing noise reduction techniques and exploring advanced PCM applications.

References

[1] A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, *Signals and Systems*. Prentice-Hall, Inc., 1996.

[2] C. E. Shannon, "Communication in the presence of noise," *Proceedings of the IRE*, vol. 37, no. 1, pp. 10–21, 1949.

[3] J. G. Proakis and D. G. Manolakis, *Digital Signal Processing: Principles, Algorithms, and Applications*. Pearson Prentice Hall, 2007.