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DIGITAL COMMUNICATION LAB (EC39001)

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Title Of Experiment: Generating PN Sequence
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Introduction

This experiment involves generating various Line Coding Schemes and using it with PN Sequence generated in previous experiment.

Key Objectives

For this experiment, out key objectives are:

- Generate and observe following line coding schemes:
  - Return to Zero
  - Manchester
  - AMI

Circuit Components Used

The components used for this experiment were:

- IC 74LS95B Shift Register
- IC 7486 Quad 2 input ExOR
- IC 7427 Triple 3 input NOR
- IC 7432 Quad 2 input OR
- 4 x 330Ω Resistors
- 4 LEDs
- IC 7474 D-Flip Flop
- IC 7408 Quad 2 input AND
- IC 741 Op-Amp
- Zener Diode
- 2 x 1KΩ Resistors

Theory

Line Coding Schemes can be generated by passing the input signal and the clock signal through a combinational circuit. Let us now go through how we can generate Return to Zero(RZ), Manchester and AMI using combinational circuits.

(a) Return To Zero(RZ) (b) Manchester

Figure 1: Combinational Circuit Diagram for Line Coding Techniques

We need a single **AND Gate** for Return To Zero(RZ) Line Coding. Doing AND operation with clock signal results in RZ line coded signal.

Similarly a **XOR Gate** and a **NOT Gate** is required for Manchester Line Coding. XORing the input signal with inverted clock signal results in Manchester.

However, AMI Line Coding is somewhat complicated. It requires one to generate 3 states: +5V. 0V, -5V. The state -5V can be generated using an Op Amp.

Let us look at an Inverter Circuit:

(a) An Inverter Circuit using Op AMP (b) Inverter Circuit to generate AMI Sequence

Figure 2: Usage of Op AMP to generate AMI line coding

Here, the sequence is a *sequence of Highs and Lows that alternate when RZ is high*. It can be generated using a **D Flip Flop** as shown below:

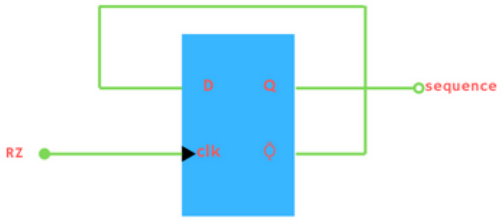


Figure 3: Sequence Generator to be used with the Inverter Circuit

Now all that remains is generating the -5V. -5V is not provided in lab and thus has to be generated using -12V supply. **Zener Diode** is a common *voltage regulator* and can be used for this purpose. Let us look at how that can be generated:

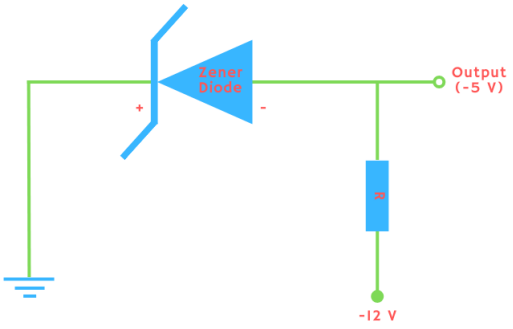
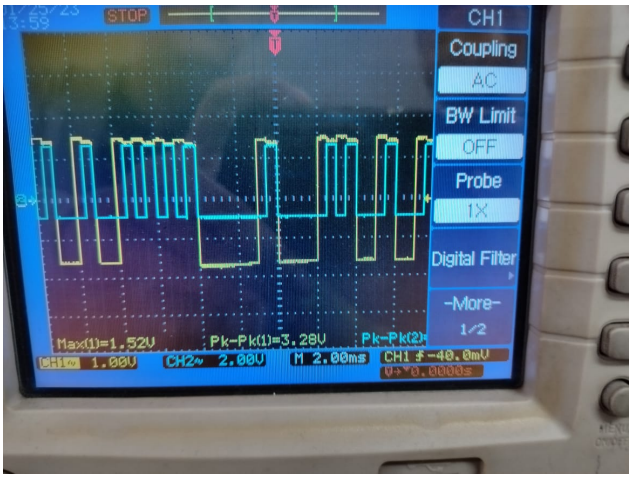


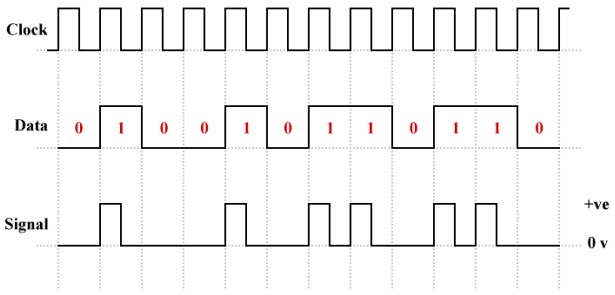
Figure 4: Voltage Regulator using Zener Diode

Results

Green Signal represents the signal(which is actually a PN Sequence generated in previous experiment), whereas *Blue Signal is the Line Coded Signal*.



(a) Return To Zero Line Coding Output

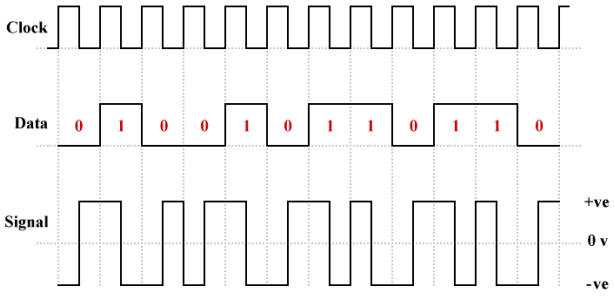


(b) Expected Return To Zero Line Coding Output

Figure 5: Return To Zero(RZ) line coding

The signal is however little different from the expected signal. This is due to the fact that we were supposed to provide **inverted clock** to the D Flip Flop, however we didn't do that.

(a) Manchester Line Coding Output



(b) Expected Manchester Line Coding Output

Figure 6: Manchester line coding

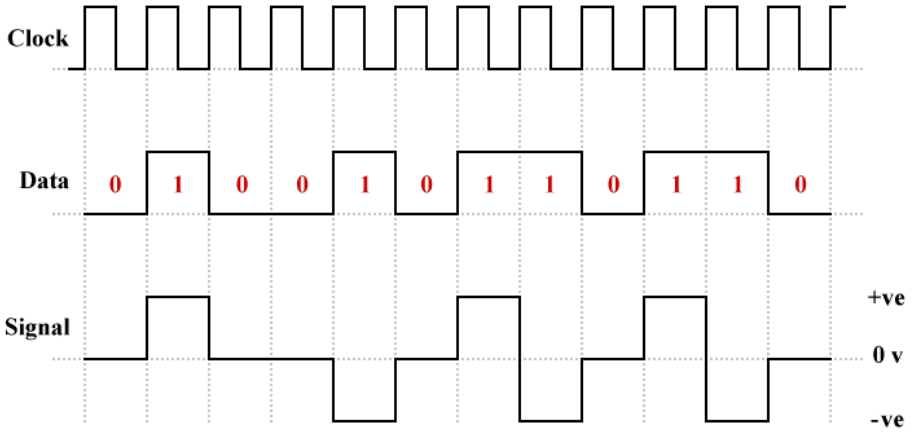


Figure 7: Expected AMI Line Coding Output

Discussion

From this experiment, our key takeaways were:

- Return To Zero Line Coding

  Return To Zero(RZ) line coding is fairly simple to implement. If the data bit is a logic "1", the signal remains high for the entire bit period, and if the data bit is a logic "0", the signal remains low for the entire bit period. This results in an **excellent signal integrity**, as the waveform of the signal retains its shape and the information content is easily recognizable. However, the signal **bandwidth utilization is poor**, as there are no transitions in the signal, which means that more bandwidth is required to transmit the same amount of data.

- Manchester Line Coding

  Manchester line coding is also simple to implement. If the data bit is a logic "1", the transition occurs from low to high, and if the data bit is a logic "0", the transition occurs from high to low. The signal remains in its high or low state for half of the bit period. This results in a **good signal integrity**, as the waveform of the signal retains its shape and the information content is easily recognizable. However, the signal **bandwidth utilization is poor**, as there is only one transition per bit period, which means that more bandwidth is required to transmit the same amount of data.

- Alternate Mark Inversion(AMI) Line Coding

  AMI line coding requires a fairly complex circuitry. Inversion(-5 V) generation is a difficult talk as it requires Op Amps and *non linear analog ICs like Op Amps make it very difficult* to debug circuits. If the data bit is a logic "1", it is transmitted as a positive voltage, and if the data bit is a logic "0", it is transmitted as a negative voltage. This results in a **reasonable signal integrity** and **great bandwidth utilization**, as the signal contains more transitions per bit period than in Manchester coding. However, the **DC balance of the signal is not as good** as Manchester coding, as the positive and negative voltage levels are not equally represented in the signal. But it comes with the added advantage of recoverable data loss.

Conclusion

In this experiment, we learnt and observed Line Coding techniques, circuits that generate them, its properties and importance.