

Figure 1: Schematic diagram of 4B5B NRZI transceiver and transmission line model in KiCad

Circuit Operation and Working:

- **Data Generation and Synchronization:** The circuit takes the primary DC input data stream V1 (5V, Logic 1) and synchronizes it using a 1MHz pulse clock source V5 across the digital logic flip-flops.
- **Line Encoding (NRZI):** The synchronized binary stream is passed through 4B5B mapping logic and D flip-flops to generate Non-Return-to-Zero Inverted (NRZI) encoded signals, converting logic transitions into clean square pulses at node U10.
- **DAC Conversion:** The digital NRZI signal passes through dac_bridge U10, converting the discrete binary logic levels into a physical 0V–5V analog voltage signal ready for physical line transmission.
- **Channel Degradation and Noise Injection:** The signal enters the analog transmission channel, where resistor R1 100ohm and capacitor C110pF create an RC low-pass network that rounds the sharp edges of the square pulses. Simultaneously, AC source V6 adds a 10MHz, 0.2V sinusoidal interference to simulate high-frequency line noise at channel node u24.
- **Data Recovery:** The distorted, noisy analog signal at node u24 feeds into adc_bridge U24. The internal comparator thresholding of U24 filters out the sinusoidal noise and exponential decay, restoring the clean 0V–5V digital signal at out_recovered.

Simulation Results:

1. Python Plots:

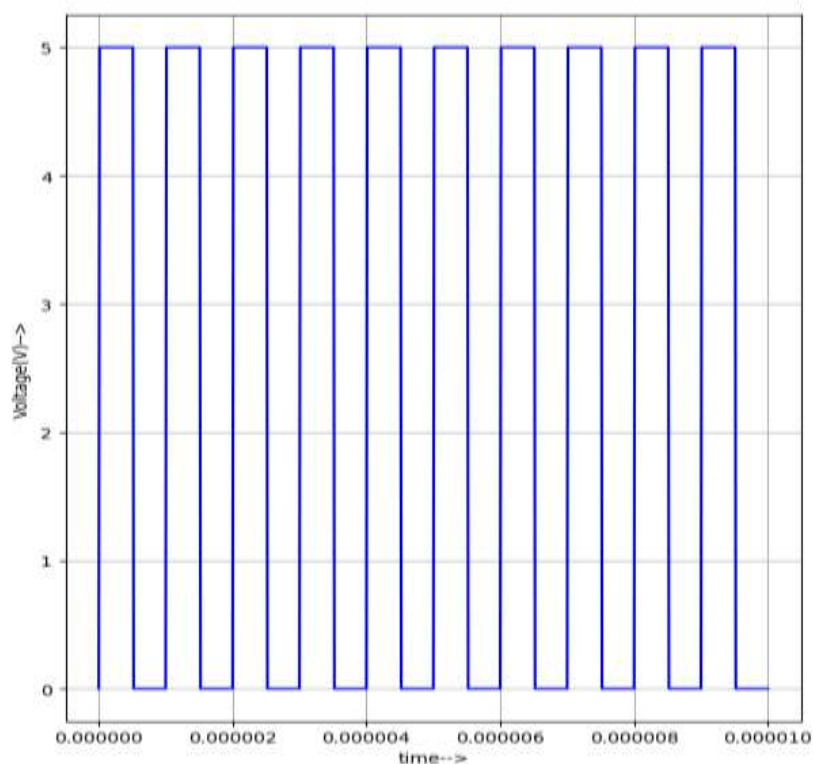


Figure 2: Clock source waveform V5 at 1MHz.

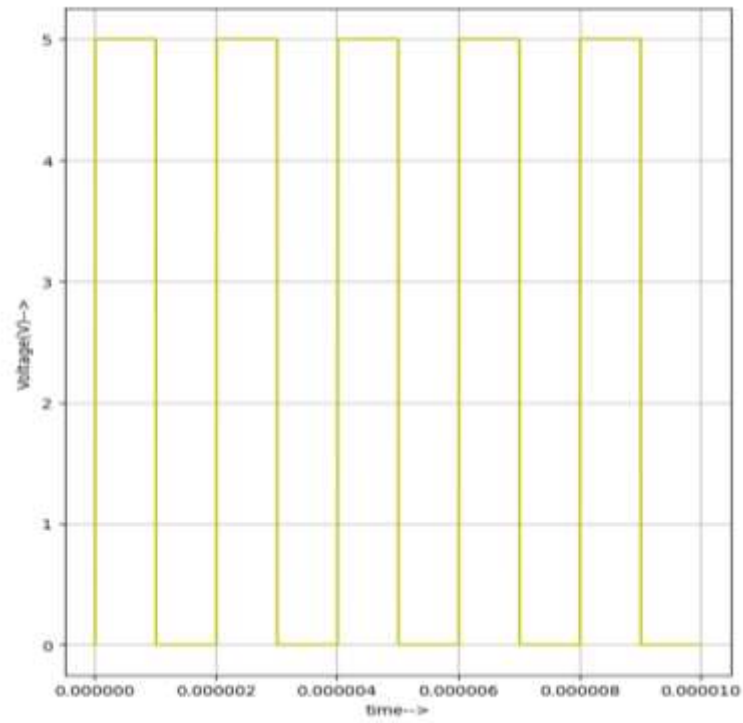


Figure 3: Transmitted NRZI signal (u10)

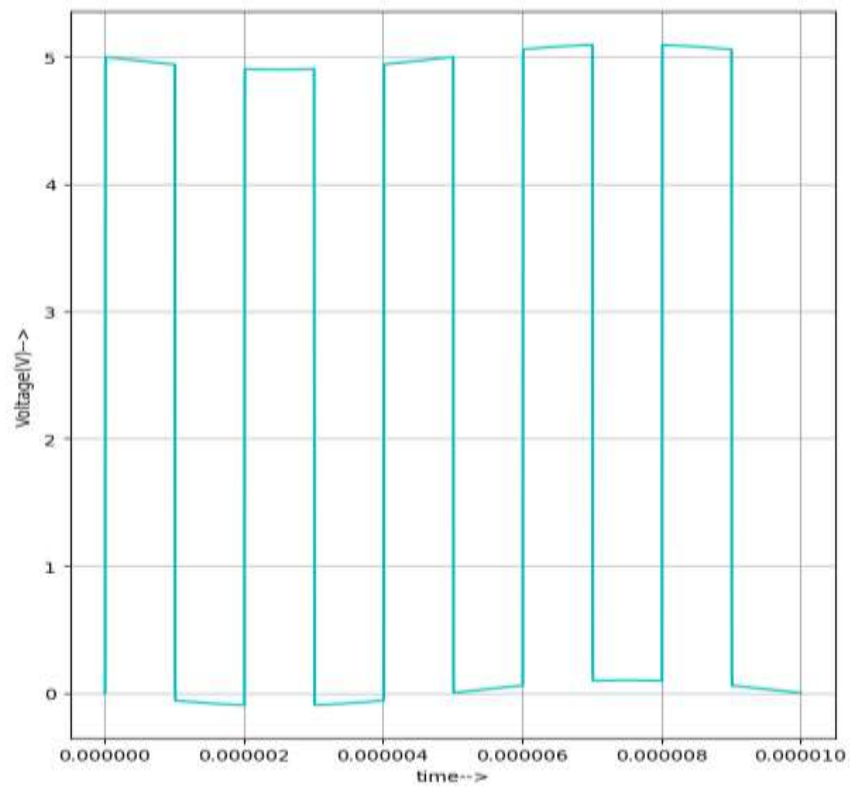


Figure 4: noisy channel response (u24)

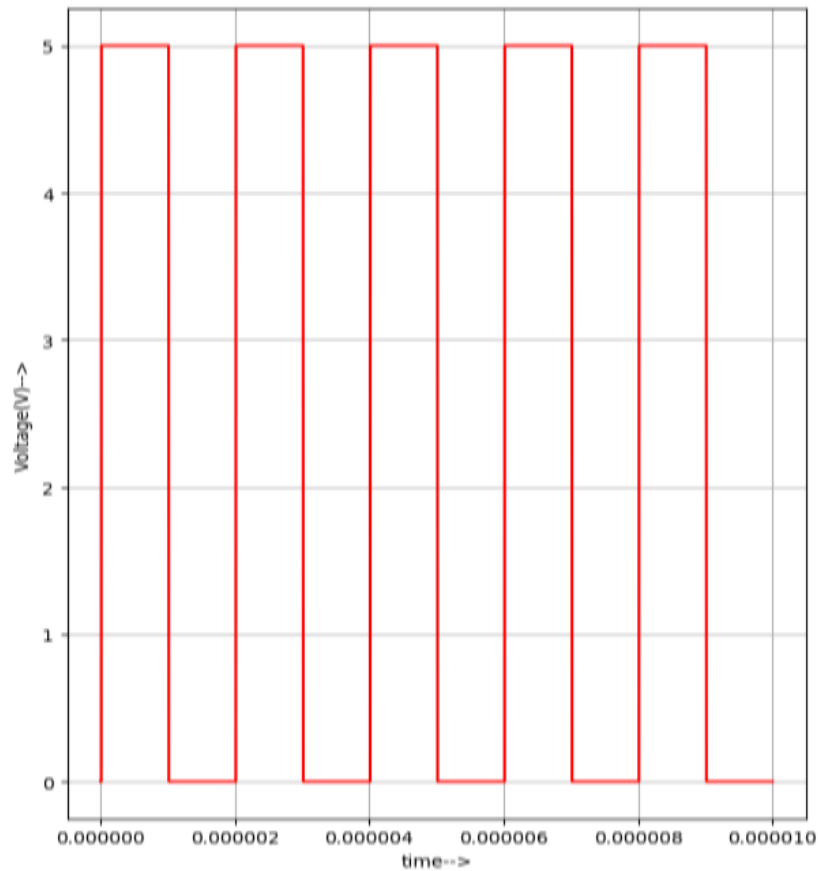


Figure 5: restored digital output(out_recovered)

Conclusion:

Thus, we have designed and simulated a 4B5B NRZI line-coded digital transceiver over an analog channel using eSim. The receiver successfully thresholded the noisy channel waveform and fully recovered the original digital data stream.

References:

1. <https://www.geeksforgeeks.org/computer-network-line-coding-schemes/>
2. eSim User Manual: <https://esim.fossee.in/resource-documentation>