

Research Migration Project

<https://esim.fossee.in/research-migration-project>



The Research Migration Project is an initiative of FOSSEE, IIT Bombay that promotes the use of eSim for reproducing published research circuits originally implemented using proprietary simulation tools. The objective is to migrate these validated designs to eSim to build an open source resource database.

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Title of the circuit : Design and CMOS Implementation of Manchester Encoding for Low-Power VLSI Communication Systems

Theory/Description : Manchester encoding is a digital line coding technique used in communication systems to embed clock information within the data stream. Each data bit is represented by a guaranteed mid-bit transition, enabling reliable clock recovery at the receiver. A logic '1' and logic '0' are distinguished by the direction of transition within the bit period.

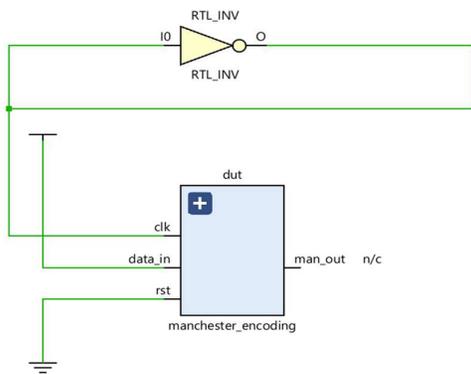
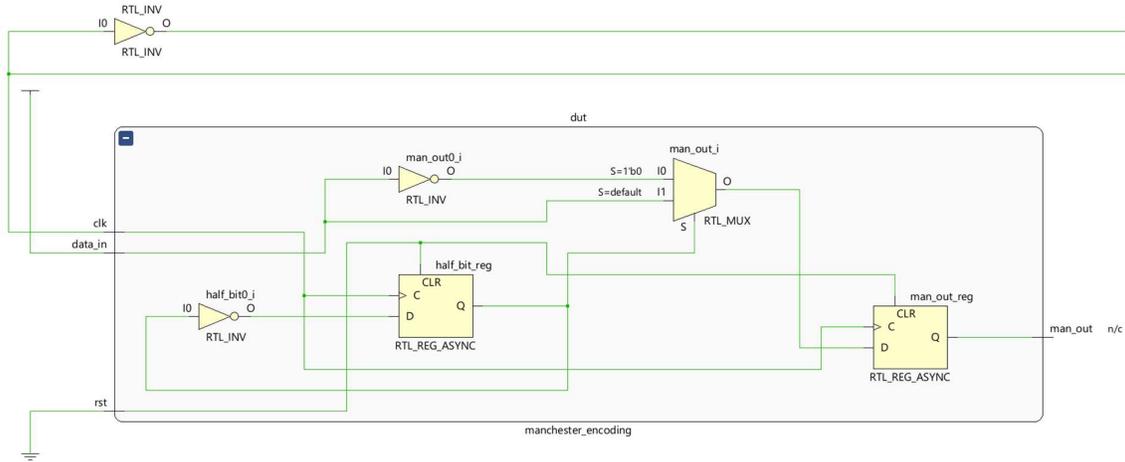
In this circuit, synchronized NRZ data and clock signals are processed using optimized CMOS logic to generate the Manchester-encoded output. The design ensures a transition at the center of every bit period, eliminating long sequences of constant logic levels. Additional transition monitoring logic can be used to detect missing or invalid transitions, improving robustness against noise. The complete circuit is implemented at the schematic level and verified through simulation.

Reason to reproduce with eSim : This circuit is well suited for reproduction using eSim due to its support for schematic-level CMOS design and SPICE-based simulation. eSim enables accurate verification of timing behavior, transitions, and power efficiency using open-source tools. The project has strong educational value for understanding digital encoding techniques and transistor-level implementation, and it allows validation and optimization of low-power VLSI designs without relying on proprietary software.

Expected Outcome/outputs : When simulated, the circuit is expected to generate a Manchester-encoded output waveform corresponding to the input NRZ data and clock signals. Each input data bit will be converted into two half-bit periods with a guaranteed mid-bit transition. The output behavior can be validated through waveform analysis, confirming correct encoding, timing alignment, and transition presence.

Circuit Diagram :

The circuit performs Manchester encoding by using a 2× clock to divide each data bit into two halves. A half-bit control signal selects either the inverted or original data, ensuring a mid-bit transition for every bit. The output is registered to produce a stable, self-clocking Manchester-encoded signal.



Top-level schematic of the Manchester encoding module showing clock, data, and reset inputs producing a Manchester-encoded output.

Expected Results (Input, Output waveforms and/or Multimeter readings) :

- Inputs:

NRZ data input signal (data_in), clock signal (clk) operating at twice the data rate, and reset signal (rst)

- Output:

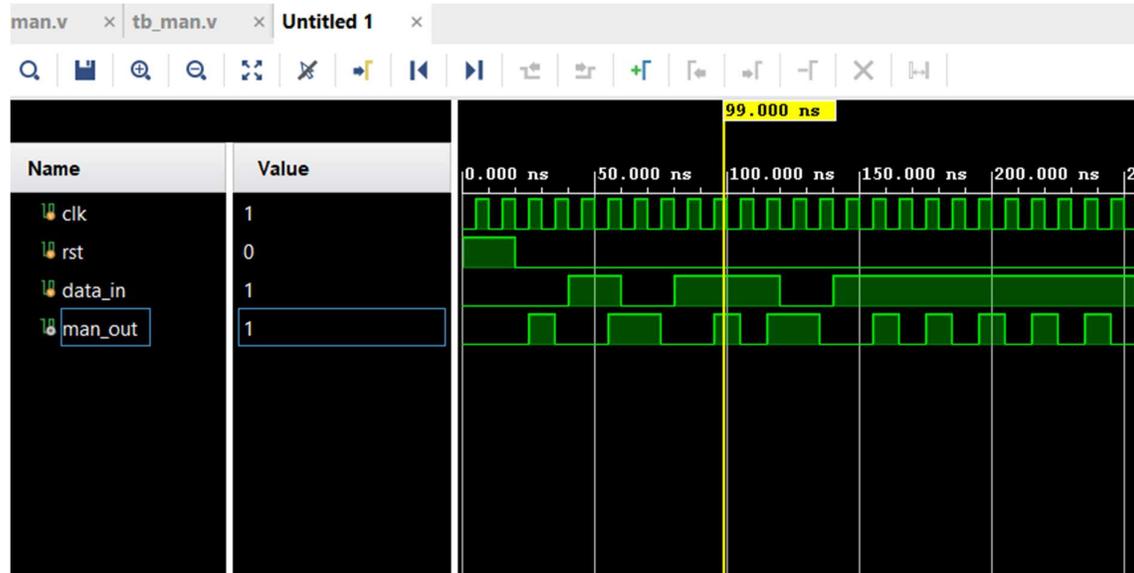
Manchester-encoded output signal (man_out)

Simulation waveforms are expected to show correct Manchester encoding behavior with a guaranteed mid-bit transition for each input data bit. The output toggles in the middle of every bit period, enabling self-clocking operation.

For example:

- data_in = 1 → man_out shows a low-to-high transition (01) at mid-bit
- data_in = 0 → man_out shows a high-to-low transition (10) at mid-bit

The correctness of the circuit is verified through waveform analysis in the simulator, confirming proper timing, transitions, and encoding behavior.



Research Paper/Journal/etc. :

Title:

Line Codes for Data Transmission and Clock Recovery (Manchester Encoding)

Author:

John G. Proakis

PageNo.:

Relevant sections on Manchester encoding and line coding techniques

Link:

<https://ieeexplore.ieee.org/document/1057842>

Source / Reference(s)

1. John G. Proakis, *Digital Communications*, McGraw-Hill Education
2. Behzad Razavi, *Design of Integrated Circuits for Optical Communications*, McGraw-Hill
3. IEEE Standard 802.3 – *Ethernet Physical Layer Specifications (Manchester Encoding)*
4. eSim Official Documentation and Ngspice User Manual
5. Wikipedia – *Manchester Code* (for basic conceptual understanding)