Design and Simulation of Majority-Minority Logic Circuits Using CMOS and Resistor-Transistor Logic

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ABSTRACT

This report discusses the design and simulation of majority and minority logic circuits using CMOS and Resistor-Transistor Logic (RTL). These circuits are essential in digital systems for decision-making, error correction, and fault tolerance. The implementation using CMOS ensures energy efficiency and scalability, while RTL enables the realization of these circuits using resistors and transistors. Simulations were conducted using eSim to analyze the circuits' behavior and performance. The study highlights the practical applications of majority-minority circuits and their relevance in modern digital electronics.

Keywords: Majority Logic, Minority Logic, CMOS, Resistor-Transistor Logic, Digital Circuits, eSim, Circuit Simulation, Fault Tolerance.

1 . INTRODUCTION

Majority and minority logic circuits are fundamental components in digital systems, playing a vital role in decision-making, error correction, and fault-tolerant designs. The majority circuit outputs a high signal when the majority of inputs are high, while the minority circuit outputs a high signal when the majority of inputs are low. These circuits are widely used in voting mechanisms, redundant systems, and data integrity verification.

The implementation of these circuits using CMOS technology offers benefits such as low power consumption, high reliability, and scalability, making them suitable for modern VLSI designs. On the other hand, Resistor-Transistor Logic (RTL), one of the earliest digital logic designs, employs resistors and transistors to achieve logical operations. This methodology provides simplicity and ease of understanding for fundamental digital designs.

This report focuses on designing and simulating majority and minority circuits using CMOS and RTL. The simulations are performed using eSim, an open-source EDA tool, to study the behavior and validate the functionality of these circuits. Through this study, the significance and practical applications of majority-minority circuits in digital electronics are explored.

2.PURPOSE OF MAJORITY-MINORITY CIRCUIT

Decision-Making: To implement circuits that can evaluate inputs and produce outputs based on majority or minority logic conditions, making them suitable for voting systems and logic arbitration.
Fault Tolerance: To enhance system reliability by employing majority logic for error detection and correction in redundant systems.
Error Correction: To demonstrate how these circuits can be used for identifying and rectifying data inconsistencies.
Efficiency Analysis: To analyze the power consumption, speed, and scalability of circuits implemented using CMOS and Resistor-Transistor Logic (RTL).
Simulation Validation: To utilize eSim for accurate simulation and verification of circuit behavior under various input conditions.

3.PROPOSED CIRCUIT

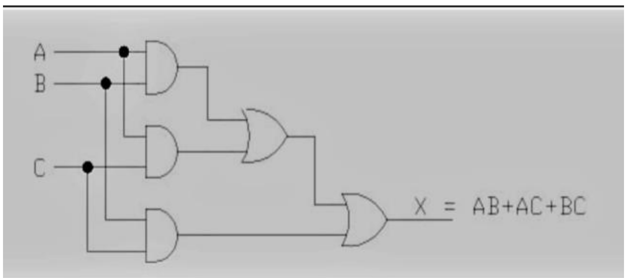

Figure:3.1.Majority circuit

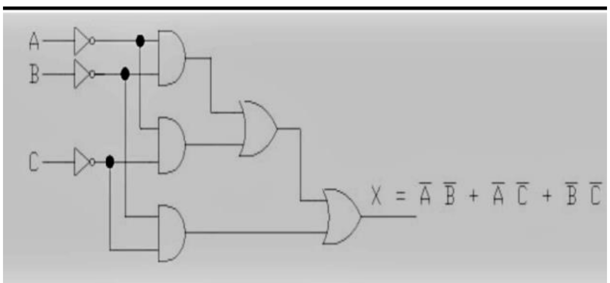

Figure:3.2.Minority circuit

Primary Inputs			Majority output	Minority Output
0	0	0	0	1
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	0

Figure 3.3.Truth table of majority minority circuit

4.SCHEMATIC DIAGRAM

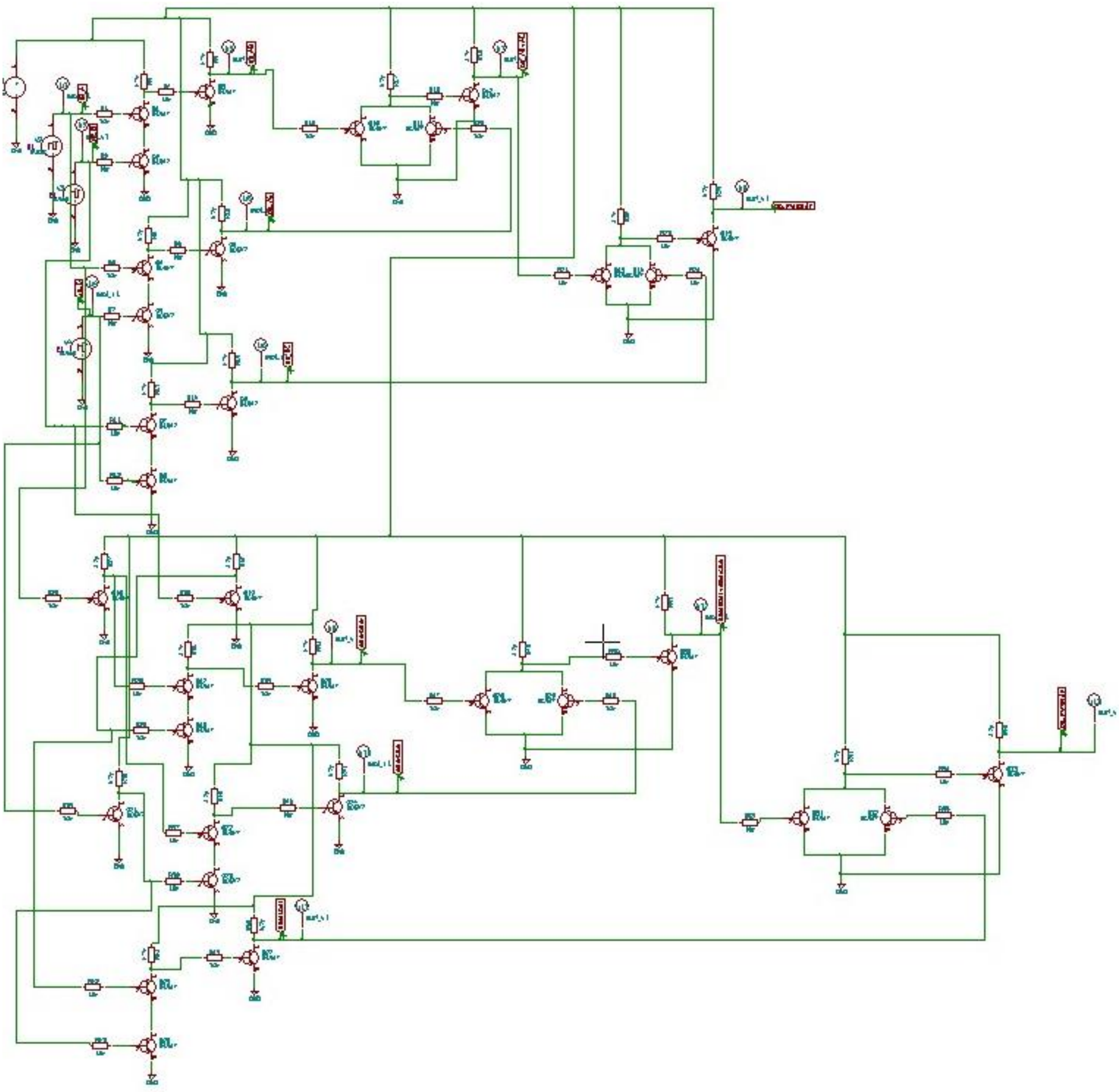

Figure:4.1.Majority-Minority Circuit Implemented Using Resistor-Transistor Logic (RTL)

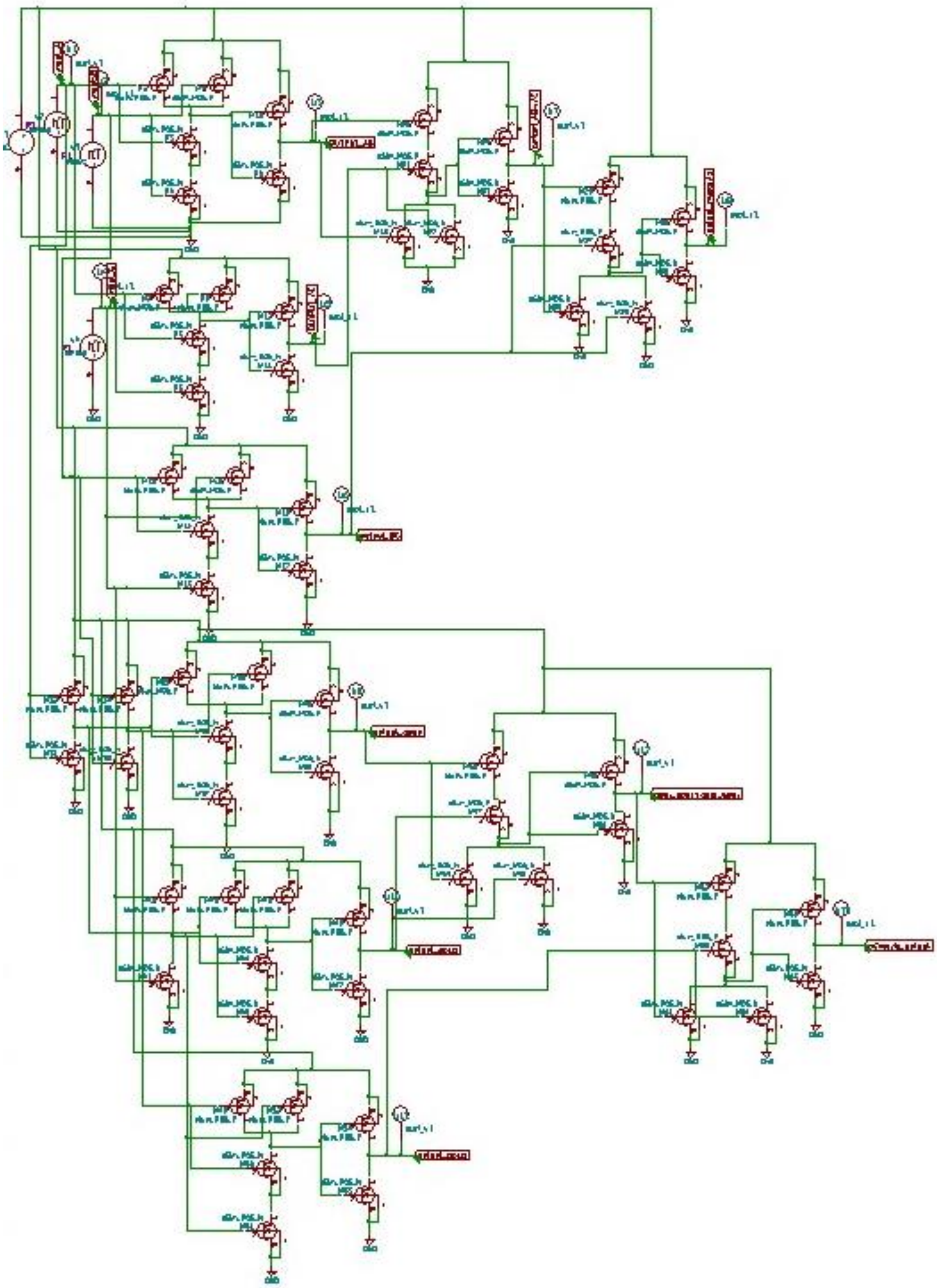

Figure:4.2. Majority- Minority Circuit Implemented Using CMOS

5. NgSpice Simulation

a)Transient Analysis:

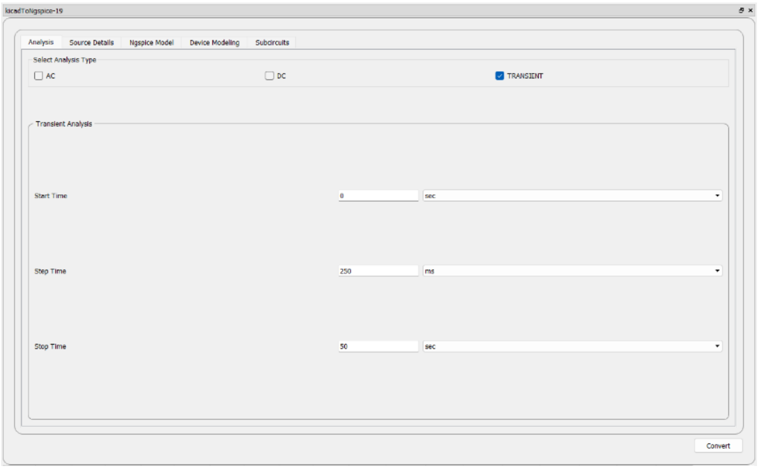

Figure: 5.1 Transient Analysis of Majority-Minority Circuit Output Waveform

b)source details

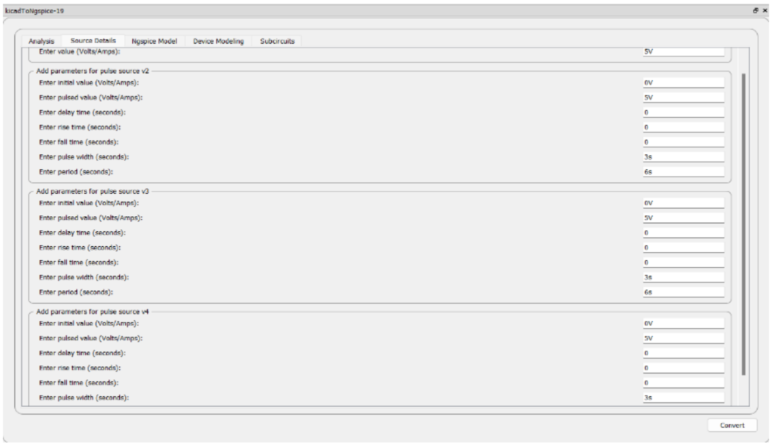

Figure: 5.2Source details of Majority-Minority Circuit Components

c)Device modelling

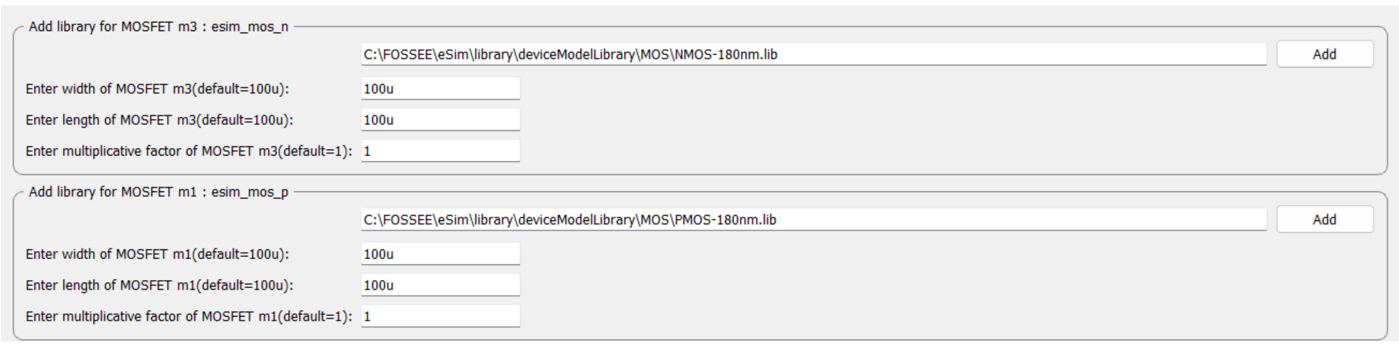

Figure: 5.3Device Modeling of Majority-Minority Circuit Components

6.WAVEFORMS

a)Input waveforms

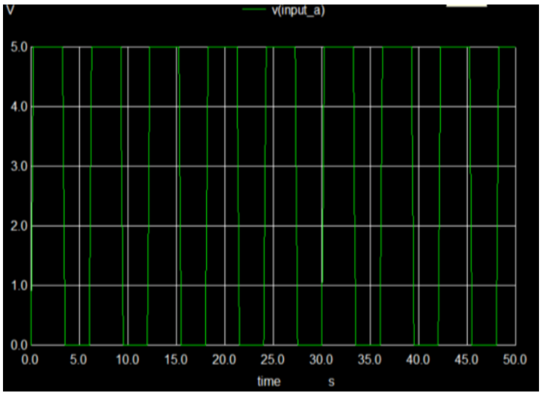

Figure:6.1

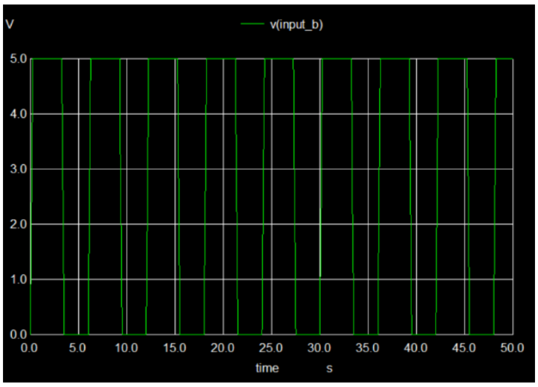

Figure:6.2

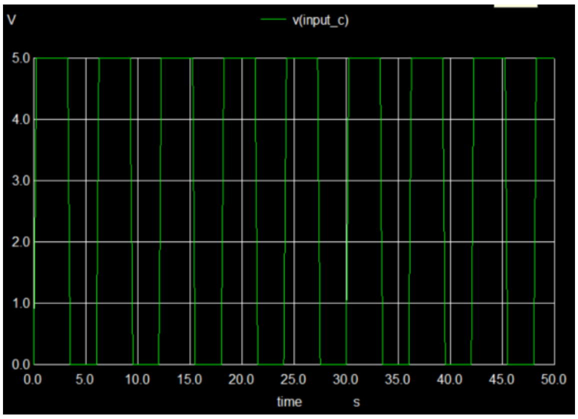

Figure:6.3

Figure 6.1,6.2,6.3 :Input waveform in Ngspice simulation

b)Output Waveforms

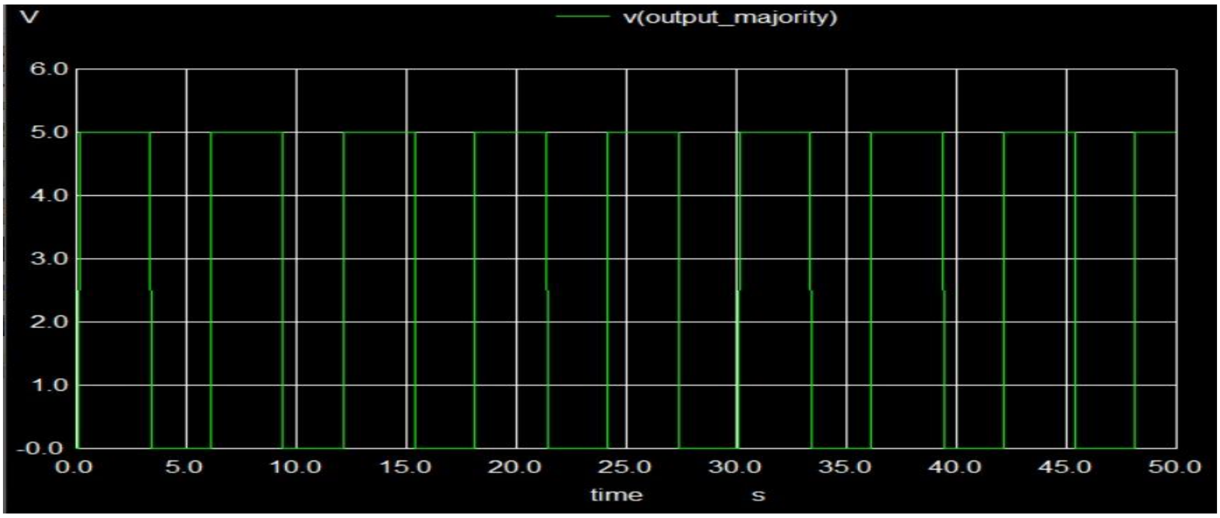

Figure:6.4. Output Waveform of Majority Circuit in Ngspice Simulation (Resistor-Transistor Logic Implementation)

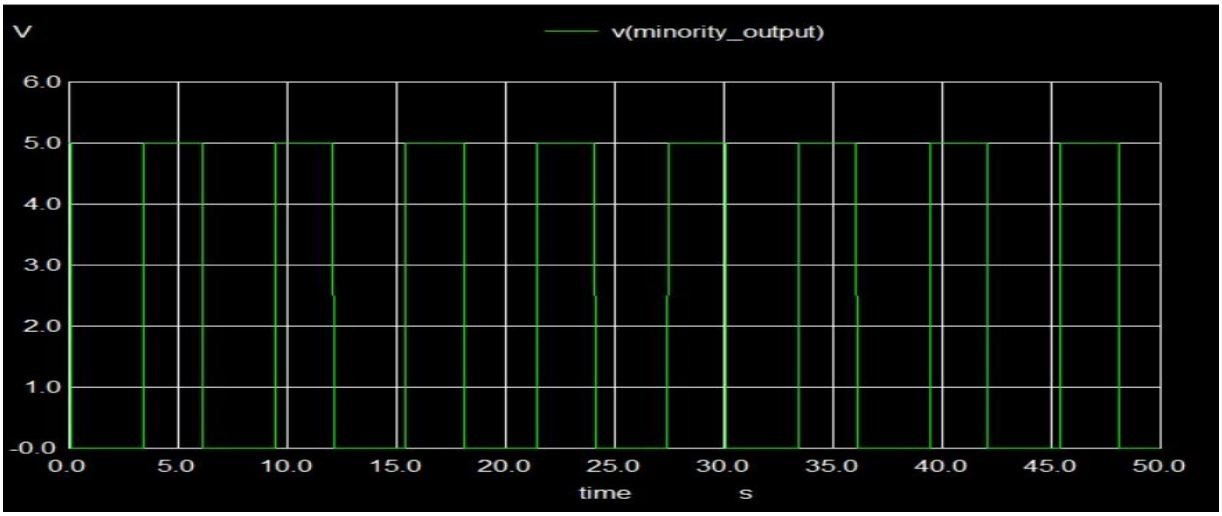

Figure:6.5. Output Waveform of Minority Circuit in Ngspice Simulation (Resistor-Transistor Logic Implementation)

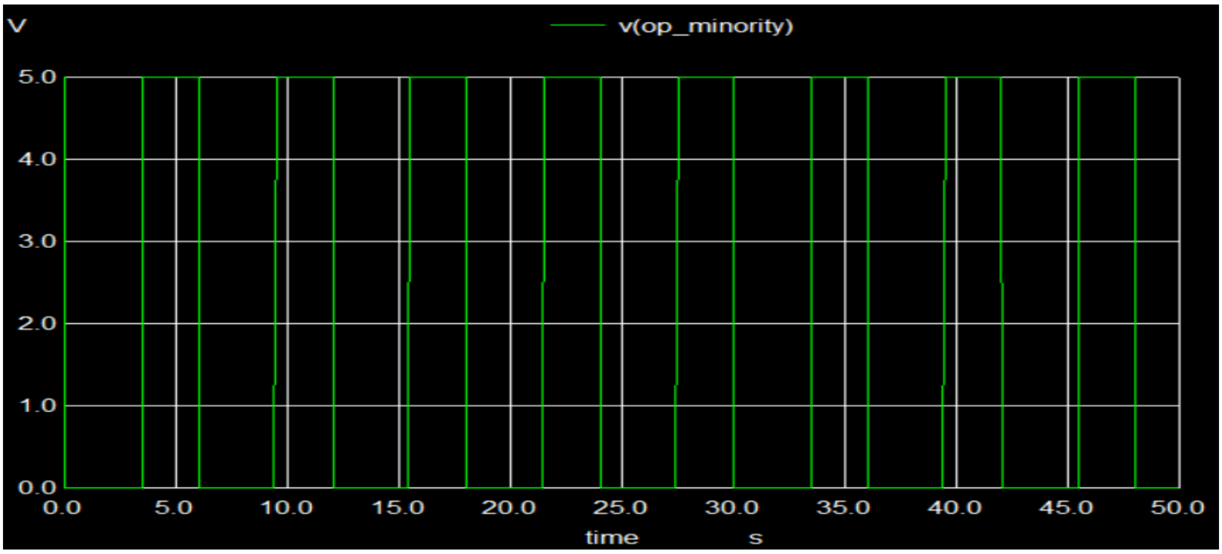

Figure:6.6. Output Waveform of Minority Circuit in Ngspice Simulation (CMOS Logic Implementation)

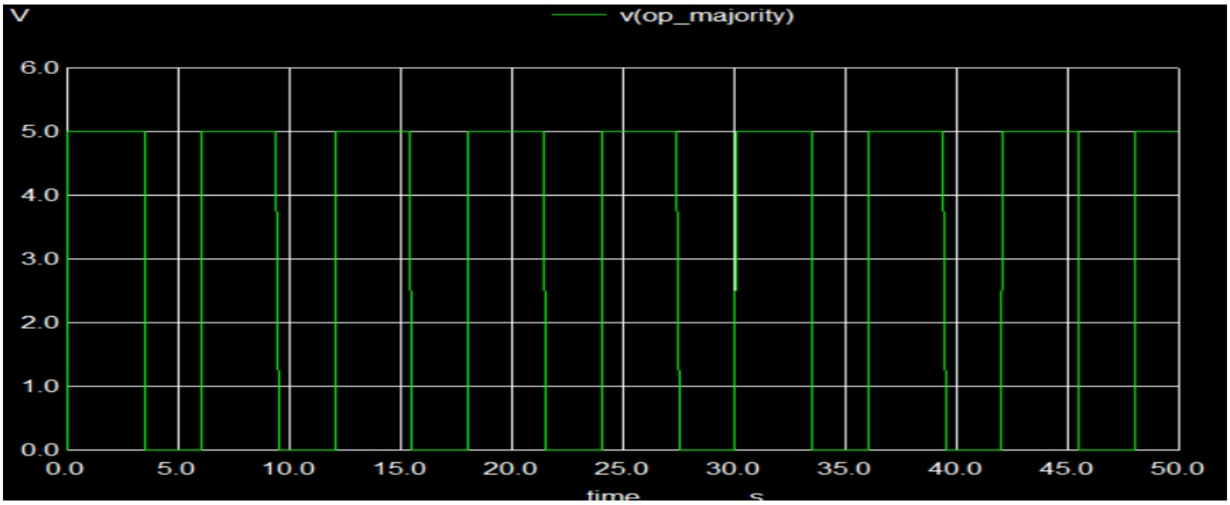

Figure:6.7. Output Waveform of Majority Circuit in Ngspice Simulation (CMOS Logic Implementation)

7.PYTHON PLOT

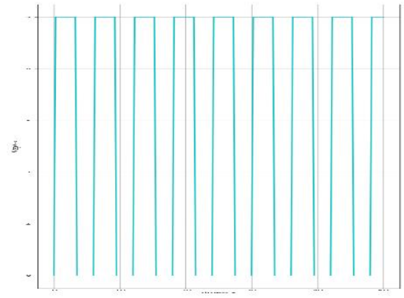

Figure:7.1

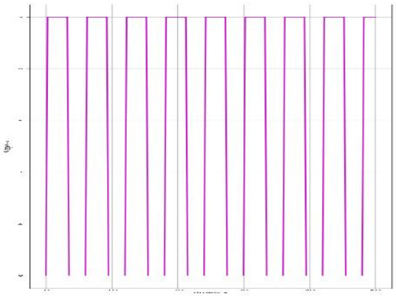

Figure:7.2

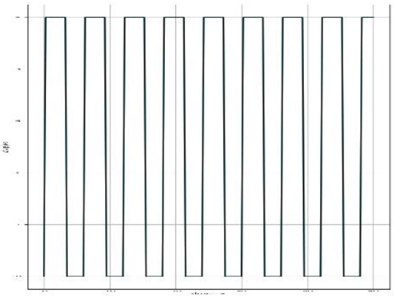

Figure:7.3

Figure:7.1,7.2,7.3 Input waveform of majority -minority circuit in python plot

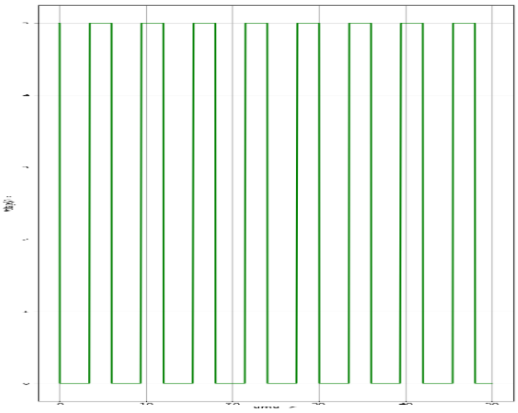

Figure:.7.4.Output Waveform of minority circuit (Rtl logic)

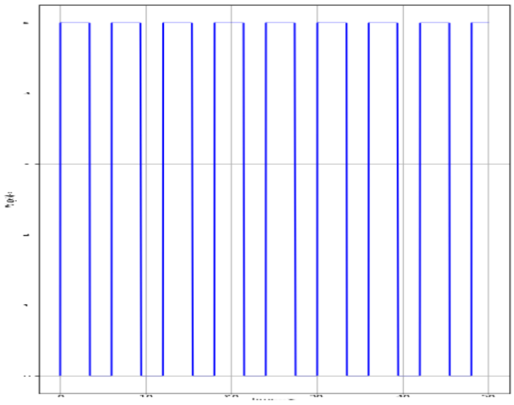

Figure:.7.5.Output Waveform of majority circuit(Rtl logic)

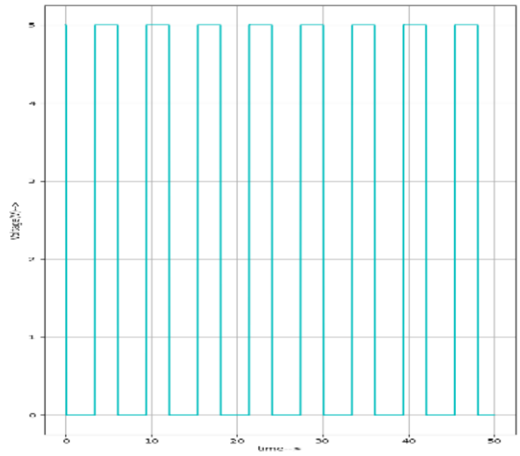

Figure:.7.6.Output Waveform of minority circuit (Cmos logic)

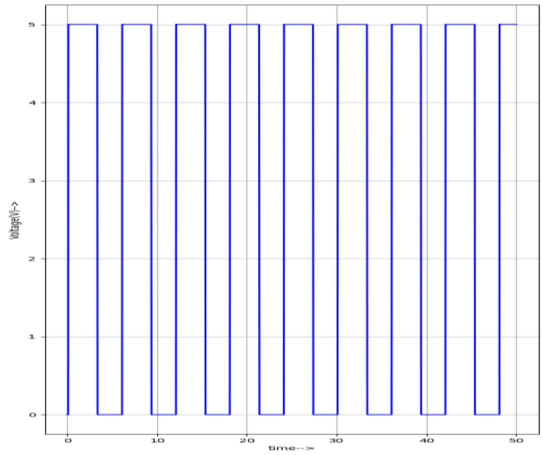

Figure:.7.7.Output Waveform of majority circuit (Cmos logic)

8.CONCLUSION

In this report, the Majority-Minority circuit was successfully implemented using both Resistor-Transistor Logic (RTL) and CMOS logic. The RTL implementation, based on the use of resistors and transistors, offered simplicity and ease of design while maintaining basic functionality. However, it had limitations in terms of speed and power efficiency when compared to CMOS logic. On the other hand, the CMOS implementation demonstrated superior performance with reduced power consumption, high noise margins, and better scalability, making it more suitable for modern digital circuits. Both implementations were validated through simulation in Ngspice, with the output waveforms confirming the correctness of the designed circuits. In conclusion, while RTL serves as a foundational design approach, CMOS logic is more advantageous for the development of efficient and reliable digital circuits in practical applications.

9.REFERENCE

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