eSim Semester Long Internship-Autumn 2025

On

IC Design Using Subcircuit in eSim

Submitted by

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I would also like to acknowledge Prof. Kannan M. Moudgalya for his foundational role in establishing and nurturing the FOSSEE initiative. His contributions toward open-source education and the creation of the FOSSEE fellowship framework have directly shaped the platform through which this internship was undertaken.

My sincere appreciation extends to my mentor, Sumanto Kar, for his continual support, technical guidance, and encouragement throughout the duration of this project. His insights and feedback played a key role in refining ideas, overcoming challenges, and ensuring timely completion of the tasks assigned to me.

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This internship has been an enriching learning experience, allowing me to work closely with open-source EDA tools, develop IC subcircuits in eSim, and gain exposure to real-world circuit modeling and simulation workflows. The knowledge acquired during this period will undoubtedly support my future academic and professional pursuits. I would also like to thank the entire FOSSEE team for their coordination, assistance, and timely interactions at various stages of this work. Their collective efforts ensured smooth workflow, resource accessibility, and effective project execution.

Chapter 1

Introduction

FOSSEE, abbreviated as Free/Libre and Open Source Software for Education, is an initiative based at IIT Bombay that focuses on promoting the use of open-source software in academic and research domains. The primary objective of FOSSEE is to reduce reliance on proprietary software by providing high-quality open-source alternatives. Through its efforts, FOSSEE supports students, educators, and researchers by offering a variety of software tools that address diverse technical and educational requirements.

The organization provides detailed documentation, tutorials, workshops, and practical training programs to enable effective adoption of open-source technologies. By encouraging collaboration and knowledge sharing, FOSSEE has played a significant role in making advanced technological resources accessible to a wider audience. This approach has helped create an inclusive learning environment while fostering innovation and skill development.

FOSSEE operates under the National Mission on Education through Information and Communication Technology (NME-ICT), an initiative of the Ministry of Education, Government of India. As part of this mission, FOSSEE has successfully developed and maintained multiple open-source software platforms that enhance the quality of education. These tools are freely available and are continuously updated to ensure they remain robust, reliable, and comparable to commercial software solutions.

1.1 eSim

eSim, developed under the FOSSEE initiative at IIT Bombay, is a powerful opensource software tool used for electronic circuit design and simulation. It integrates multiple open-source applications into a single unified environment, enabling users to efficiently design, simulate, and analyze electronic circuits. The software serves as a cost-effective and accessible alternative to proprietary Electronic Design Automation (EDA) tools, making it especially beneficial for students, educators, and practicing engineers.

The platform supports schematic capture, circuit simulation, and PCB design, and provides a comprehensive library of electronic components. One of the key features of eSim is the Subcircuit Builder, which allows users to create complex circuit designs by combining smaller functional blocks. This modular approach simplifies design reuse and enhances productivity. By offering such capabilities, eSim encourages the adoption of open-source tools in both academic learning and professional applications.

eSim functions as a Computer-Aided Design (CAD) tool that assists electronic system designers in developing, testing, and validating their circuit designs. Being open source, it allows users to customize and extend the software according to their specific requirements. Built using several free and open-source software components, eSim provides a flexible and extensible framework for experimenting with and understanding electronic systems.

1.1.1 KiCad

KiCad is an open-source software suite used for electronic design automation, primarily for schematic capture and printed circuit board (PCB) layout. It provides a user-friendly environment that enables designers to create and modify electronic schematics with ease. KiCad is widely used in both academic and industrial settings due to its reliability, flexibility, and free availability.

The software supports multi-layer PCB design and offers a comprehensive library of electronic components. KiCad also allows users to create custom symbols and footprints, making it adaptable to a wide range of design requirements. As an open-source tool, KiCad encourages community-driven development and continuous improvement, making it a valuable resource for electronics education and research.

1.1.2 Ngspice

Ngspice is an open-source mixed-level circuit simulation software derived from SPICE. It is used to perform various types of circuit analyses, including DC, AC, and transient simulations. Ngspice plays a crucial role in verifying circuit functionality and performance before hardware implementation.

The simulator supports analog, digital, and mixed-signal circuits, providing accurate and efficient simulation results. Its compatibility with multiple design tools makes it highly versatile. Being free and open source, Ngspice enables users to study, modify, and extend its capabilities, which is particularly beneficial for learning and experimentation in electronics.

1.1.3 KiCad to Ngspice Converter

The KiCad to Ngspice Converter is a utility that enables seamless integration between KiCad schematics and the Ngspice simulation engine. It converts schematic designs created in KiCad into Ngspice-compatible netlists, allowing users to simulate their circuits without manual intervention.

This conversion process ensures accuracy and consistency between the schematic and simulation stages. By automating the translation of circuit information, the converter simplifies the design workflow and reduces errors. This feature enhances productivity and makes the overall design and simulation process more efficient within the eSim environment..

Chapter 2

Abstract

The objective of this internship was to design and develop various integrated circuits using the Subcircuit Builder Method in eSim. This involved modeling the ICs with eSim library files and subsequently simulating them with different circuits. The goal was to expand the eSim Subcircuit Library for future use, enhancing its utility and application in educational and practical scenarios.

2.1 Approach

- Identify and research an integrated circuit (IC) that is not currently available in the eSim library.
- Obtain and study the datasheet of the selected IC thoroughly
- Carefully examine the schematic provided in the datasheet.
- Accurately recreate the schematic in eSim using the Subcircuit Builder Method.
- Model the IC in eSim, ensuring all parameters and configurations match those in the datasheet. • Simulate the integrated circuit within eSim, testing it with various circuits to verify its functionality.
- Document the process and results to contribute to the future use and expansion of the eSim Subcircuit Library.

2.2 Execution

The following information outline the method for creating a subcircuit in eSim 2.5 for the Windows version.

When eSim is launched, the main application window opens, and by default, all project files are stored in the eSim workspace. A new project is created within this workspace to begin the design process. After creating the project, the Subcircuit Builder environment is opened to start developing the required integrated circuit. A new subcircuit schematic is then created by providing an appropriate schematic name. This opens the Eeschema window, where the internal circuit of the IC is recreated based on the corresponding datasheet. After completing the schematic

and properly connecting all input and output ports, the schematic symbols are annotated to uniquely identify each component.

Once annotation is completed, a netlist is generated from the schematic. This netlist serves as an essential input for simulation and further processing within eSim. After generating the netlist, the design is converted into an NgSpicecompatible format using the KiCad to NgSpice conversion process.

During the conversion stage, suitable device models are added from the available model library based on the components used in the circuit. After successful modeling, a custom symbol for the designed subcircuit is created using the Symbol Editor. The device details are entered, and the pin diagram is drawn according to the datasheet specifications.

After completing the symbol creation, the subcircuit is used to build a test circuit for simulation. The schematic is then converted to NgSpice format, and simulation is performed. The output waveforms obtained from the simulation are analyzed and verified against the expected results provided in the datasheet to confirm correct functionality.

Chapter 3

Integrated Circuit Design

3.1 74LS48

3.1.1 Description

The 74LS48 is a BCD to seven-segment decoder designed to drive common-anode display devices. It converts a 4-bit Binary Coded Decimal (BCD) input into corresponding seven-segment output signals, enabling the display of numerical digits from 0 to 9. This IC is widely used in digital display systems such as calculators, counters, clocks, and instrumentation panels.

The 74LS48 includes additional control features such as lamp test and blanking inputs, which enhance its flexibility in display control applications. In this project, the internal decoding logic of the IC was implemented using the eSim Subcircuit Builder and verified through simulation by applying different BCD input combinations.

3.1.2 Pin Diagram

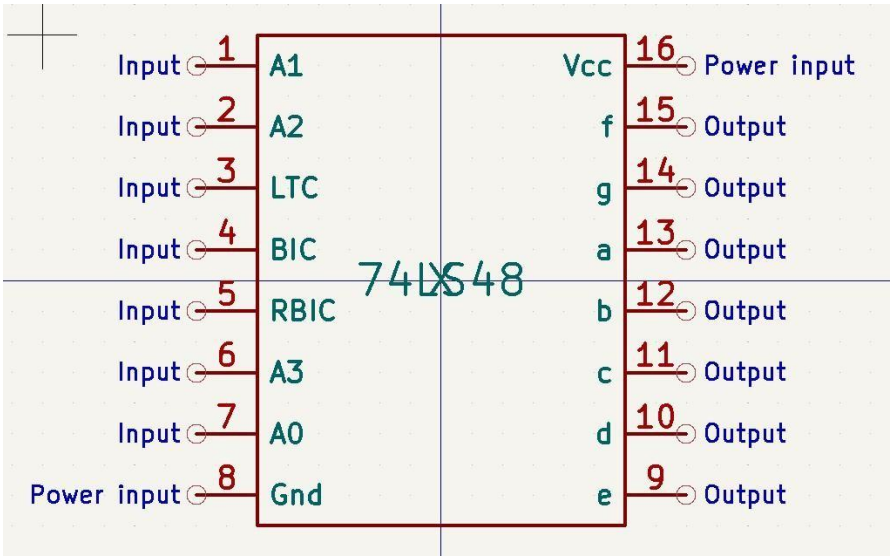


Figure 3.1: Pin Diagram of 74LS48

3.1.3 Schematic Diagram

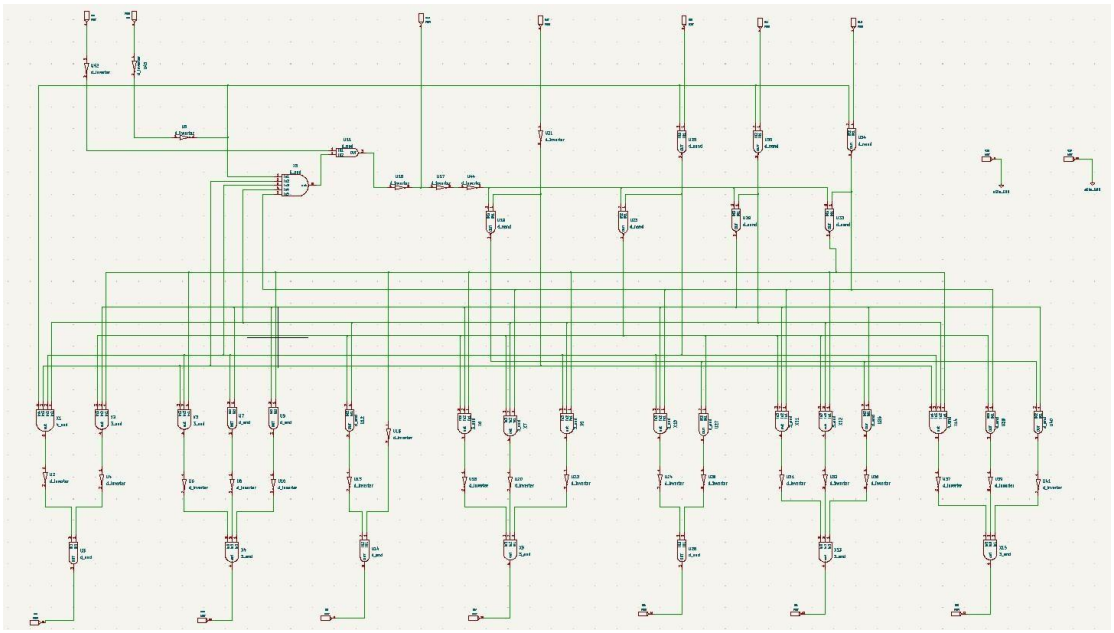


Figure 3.2: Schematic Diagram of 74LS48

3.1.4 Simulation Circuit

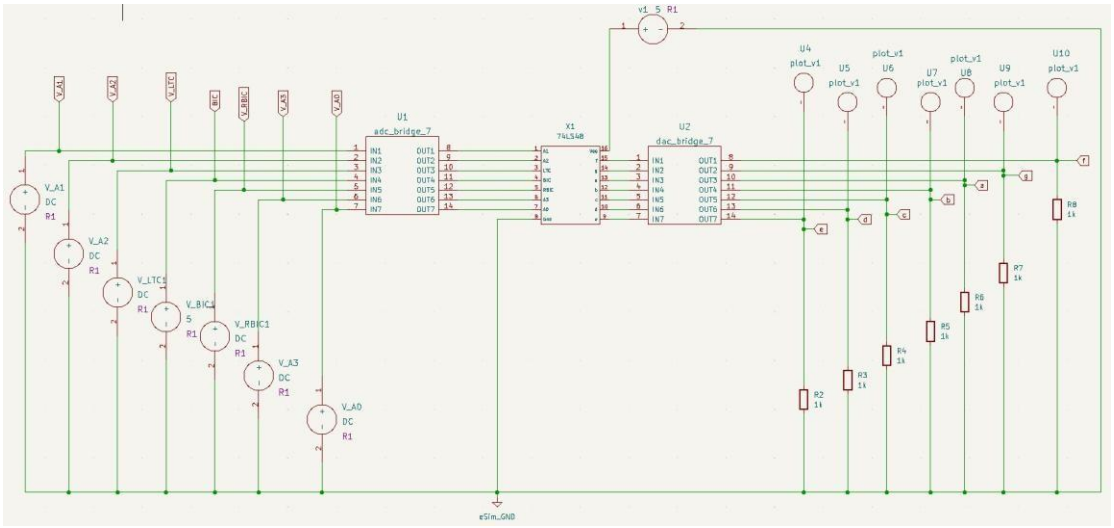


Figure 3.3: Simulation Circuit of 74LS48

3.1.5 Inputs

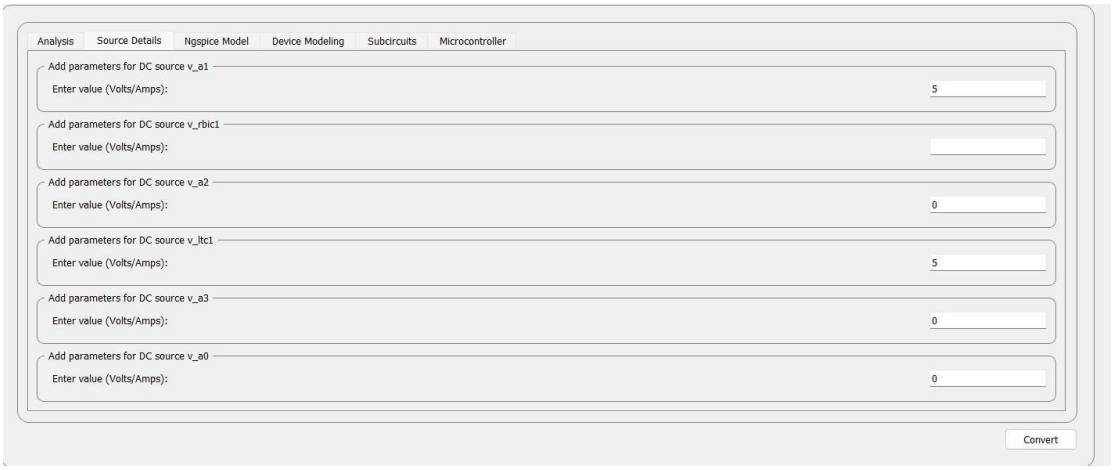


Figure 3.4: Inputs given to the Simulation Circuit

3.1.6 Output Plot

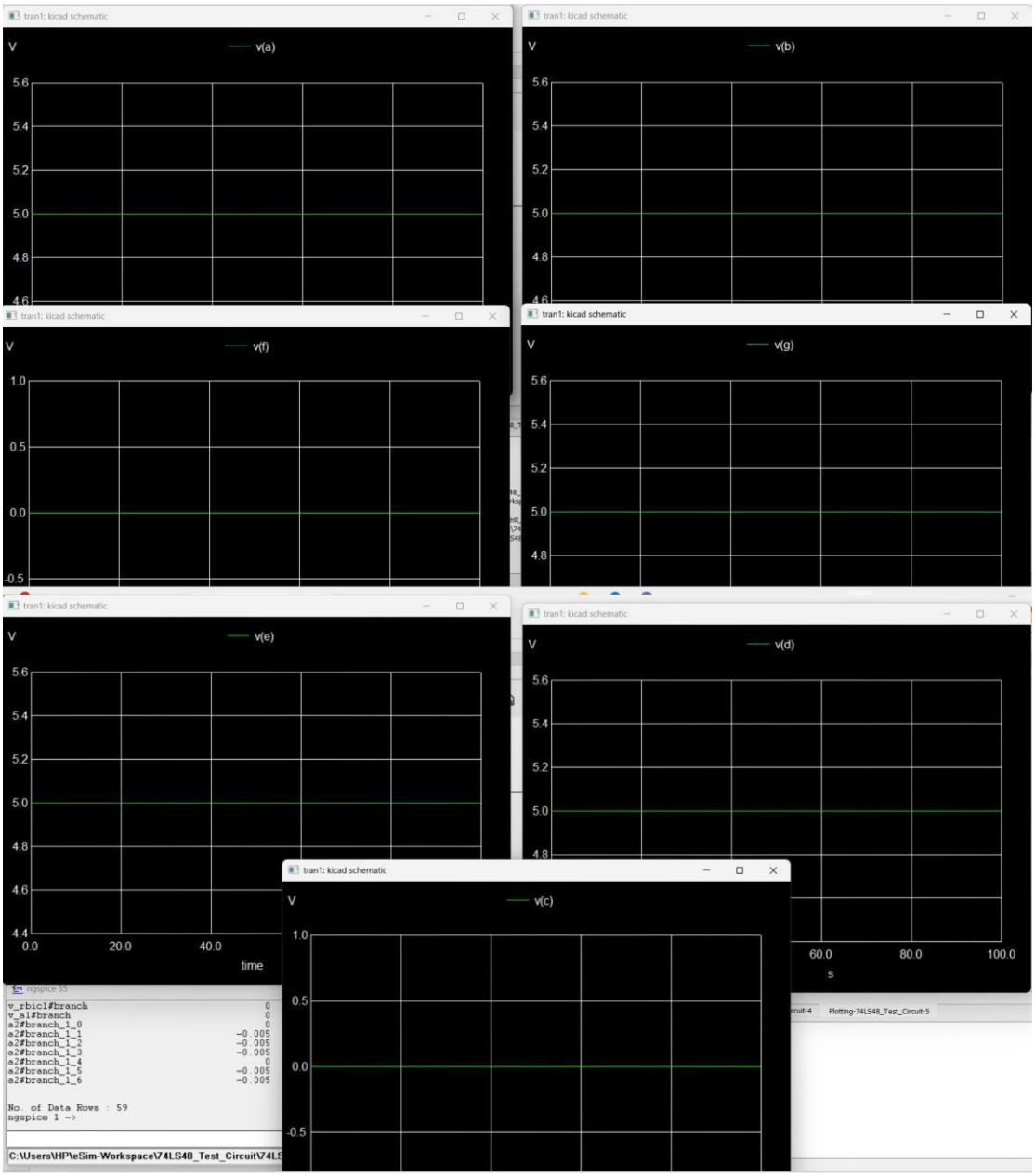


Figure 3.5: Output waveform of 74LS48

3.1.7 Functional Table

TRUTH TABLE
SN54/74LS48

	INPUTS							OUTPUTS							
DECIMAL OR FUNCTION	$\overline{LT}$	$\overline{RBI}$	D	C	B	A	$\overline{BI/RBO}$	a	b	c	d	e	f	g	NOTE
0	H	H	L	L	L	L	H	H	H	H	H	H	H	L	1
1	H	X	L	L	L	H	H	L	H	H	L	L	L	L	1
2	H	X	L	L	H	L	H	H	H	L	H	H	L	H	
3	H	X	L	L	H	H	H	H	H	H	H	L	L	H	
4	H	X	L	H	L	L	H	L	H	H	L	L	H	H	
5	H	X	L	H	L	H	H	H	L	H	H	L	H	H	
6	H	X	L	H	H	L	H	L	L	H	H	H	H	H	
7	H	X	L	H	H	H	H	H	H	H	L	L	L	L	
8	H	X	H	L	L	L	H	H	H	H	H	H	H	H	
9	H	X	H	L	L	H	H	H	H	H	L	L	H	H	
10	H	X	H	L	H	L	H	L	L	L	H	H	L	H	
11	H	X	H	L	H	H	H	L	L	H	H	L	L	H	
12	H	X	H	H	L	L	H	L	H	L	L	L	H	H	
13	H	X	H	H	L	H	H	H	L	L	H	L	H	H	
14	H	X	H	H	H	L	H	L	L	L	H	H	H	H	
15	H	X	H	H	H	H	H	L	L	L	L	L	L	L	
$\overline{BI}$	X	X	X	X	X	X	L	L	L	L	L	L	L	L	2
$\overline{RBI}$	H	L	L	L	L	L	L	L	L	L	L	L	L	L	3
$\overline{LT}$	L	X	X	X	X	X	H	H	H	H	H	H	H	H	4

Figure 3.6: truth table of 74LS48

3.2 74C04

3.2.1 Description

The 74C04 is a CMOS-based hex inverter IC that consists of six independent NOT gates. Inverters are fundamental logic elements used for signal inversion, waveform shaping, and logic conditioning in digital circuits. The CMOS architecture ensures low power consumption and improved noise immunity.

The 74C04 is commonly used in oscillators, signal buffering, and logic level conversion applications. In this project, each inverter stage was modeled using eSim, and the logical inversion behavior was verified through simulation waveforms.

3.2.2 Pin Diagram

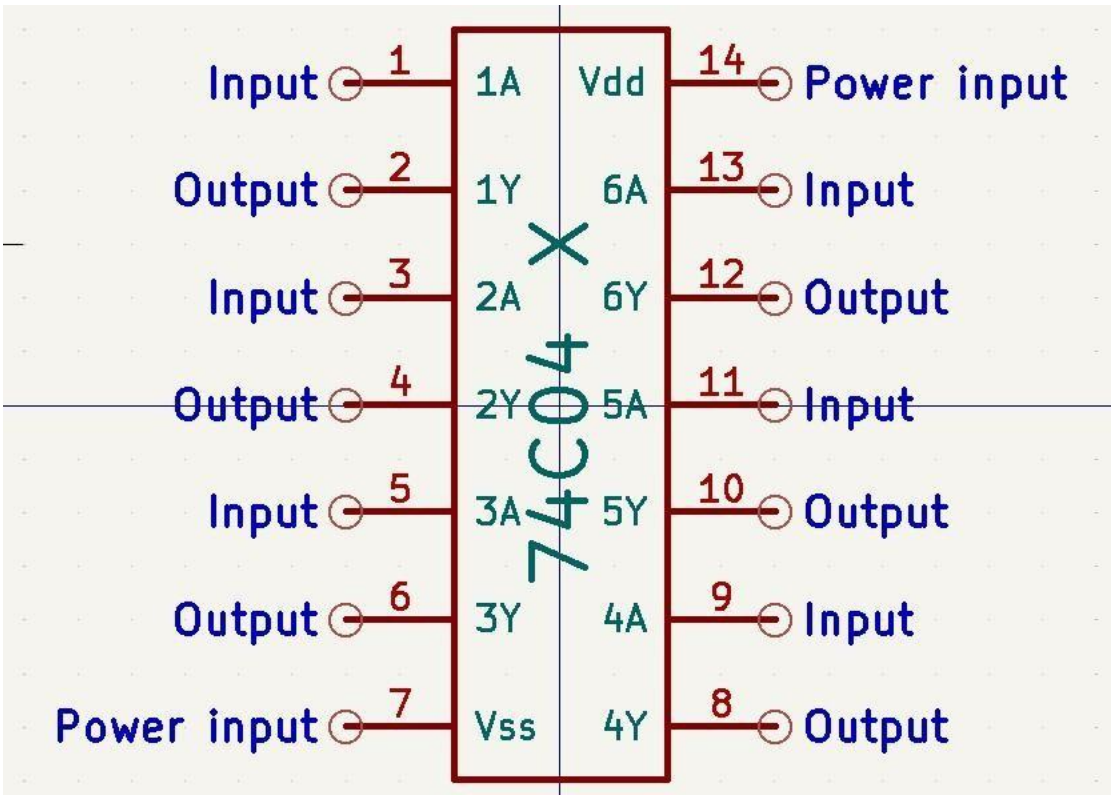


Figure 3.7: Pin Diagram of 74C04

3.2.3 Schematic Diagram

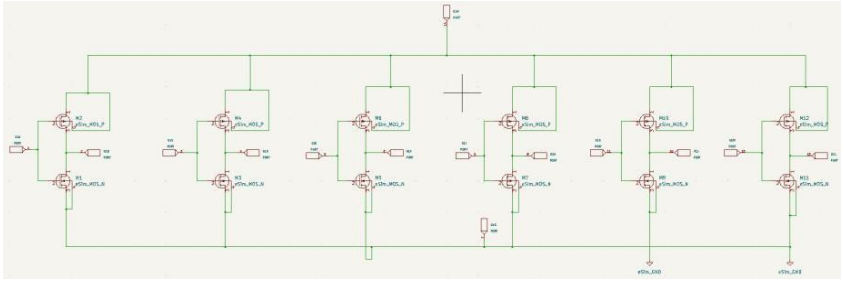


Figure 3.8: Schematic Diagram of 74C04

3.2.4 Simulation Circuit

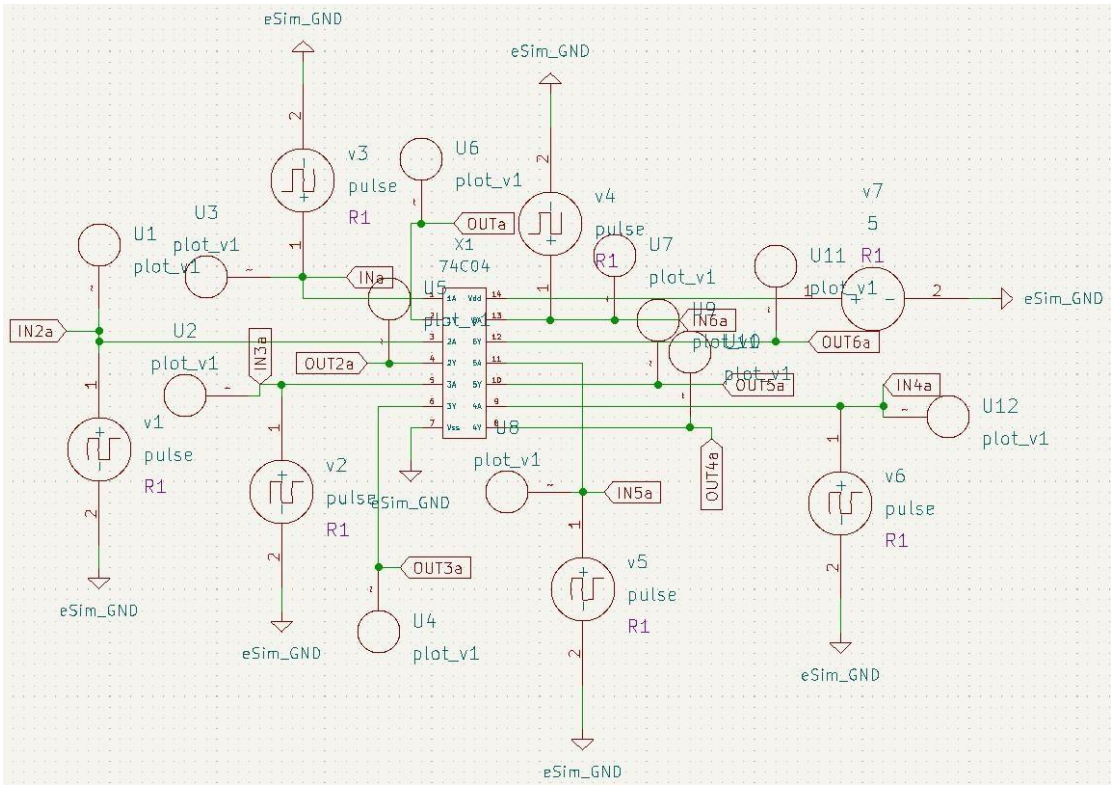


Figure 3.9: Simulation Circuit of 74C04

3.2.5 Inputs

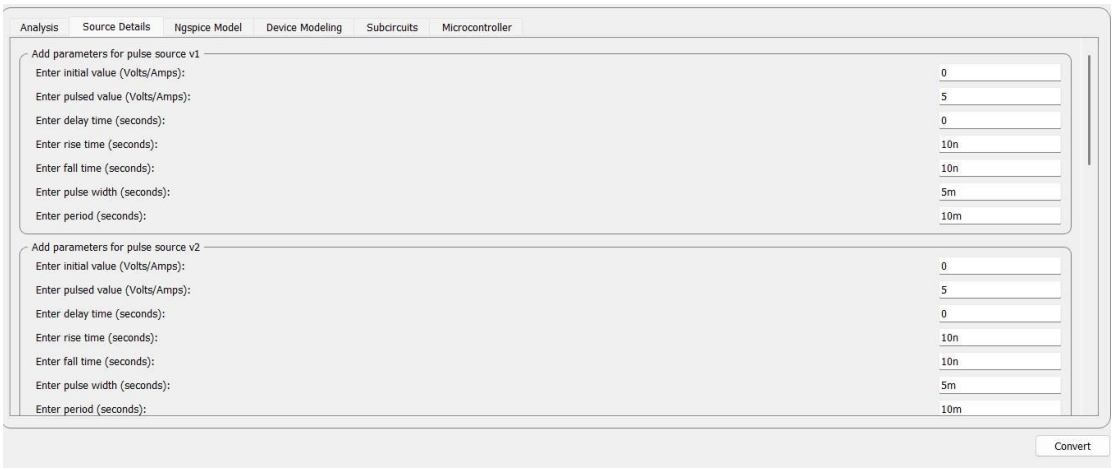
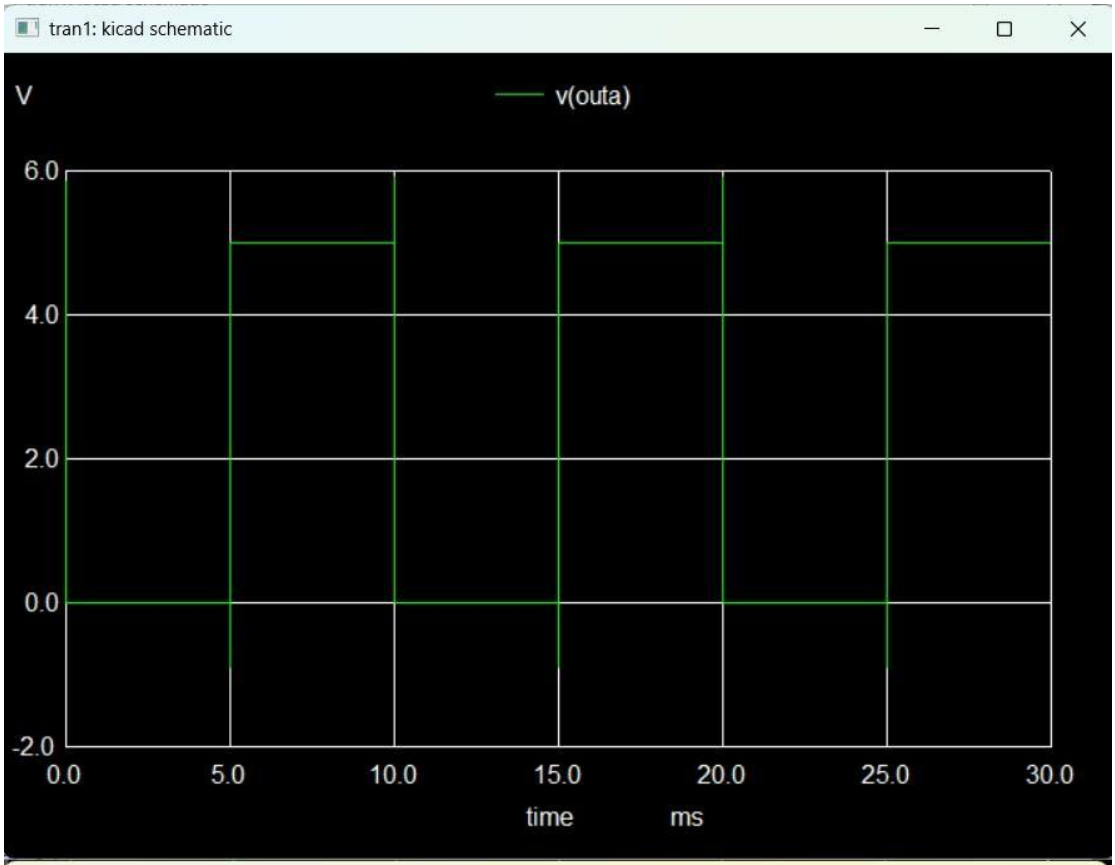


Figure 3.10: Inputs given to the Simulation circuit

3.2.6 Output Plot



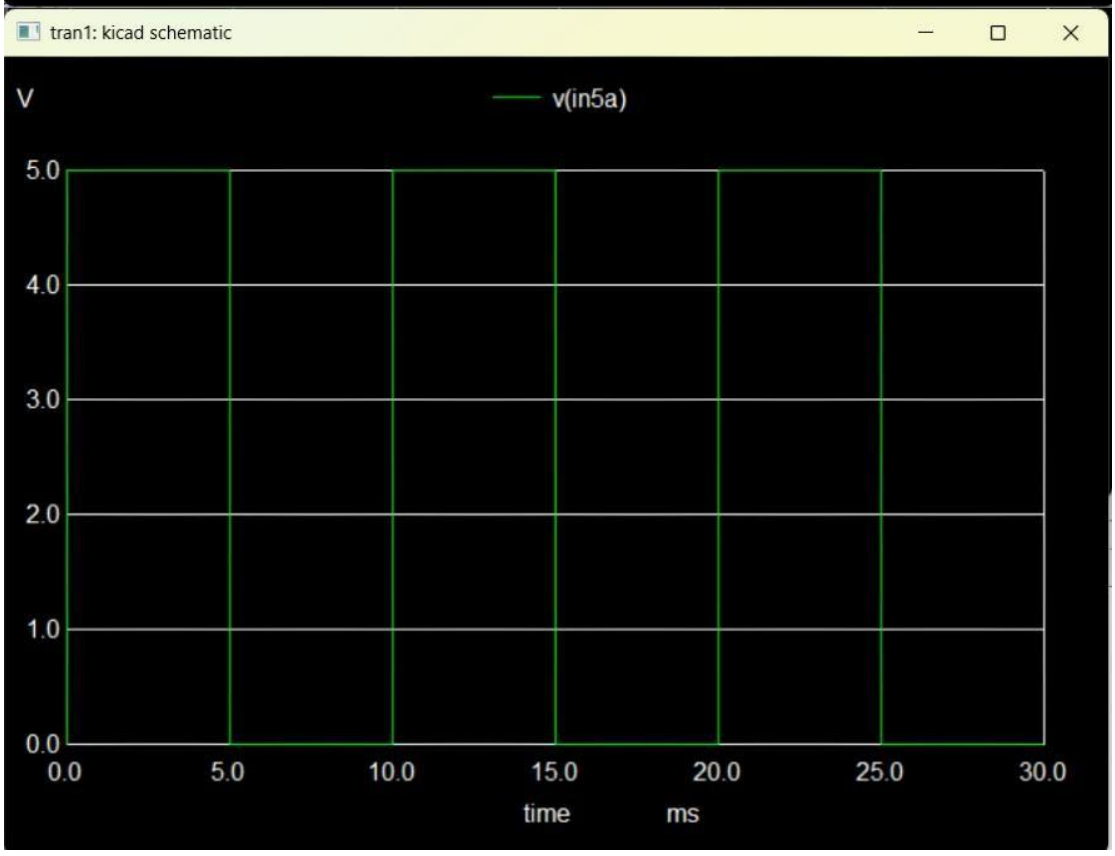


Figure 3.11: Output waveform of 74C04

3.2.7 Functional Table

A	Q
0	1
1	0

Figure 3.12: Truth table for 74C04

3.3 74HC386

3.3.1 Description

The 74HC386 is a high-speed CMOS integrated circuit that contains four independent 2-input Exclusive-OR (XOR) gates. XOR gates are widely used in arithmetic circuits, error detection systems, parity generators, and digital comparison applications. The output of the XOR gate is high only when the two inputs differ, making it ideal for comparison-based logic operations.

The CMOS implementation of the 74HC386 ensures low power dissipation and fast switching speeds. This IC is commonly used in adders, subtractors, and digital communication circuits. In this work, the XOR logic was modeled using the eSim Subcircuit Builder, and its behavior was verified through simulation by applying various input combinations.

3.3.2 Pin Diagram

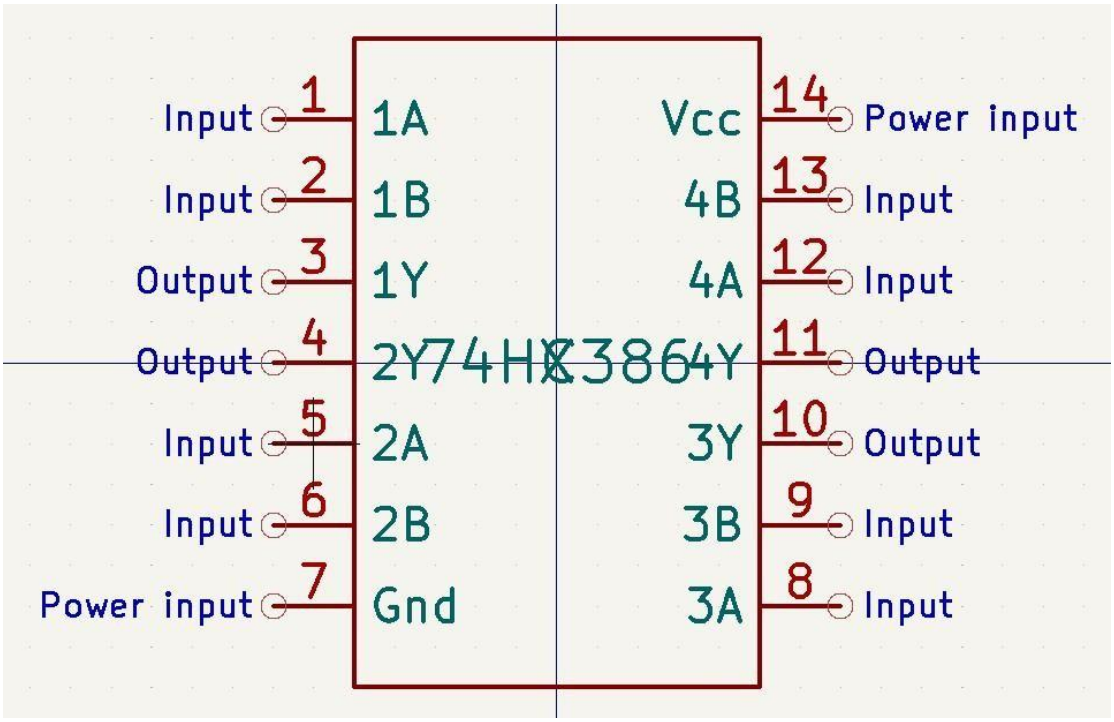


Figure 3.13: Pin Diagram of 74HC386

3.3.3 Schematic Diagram

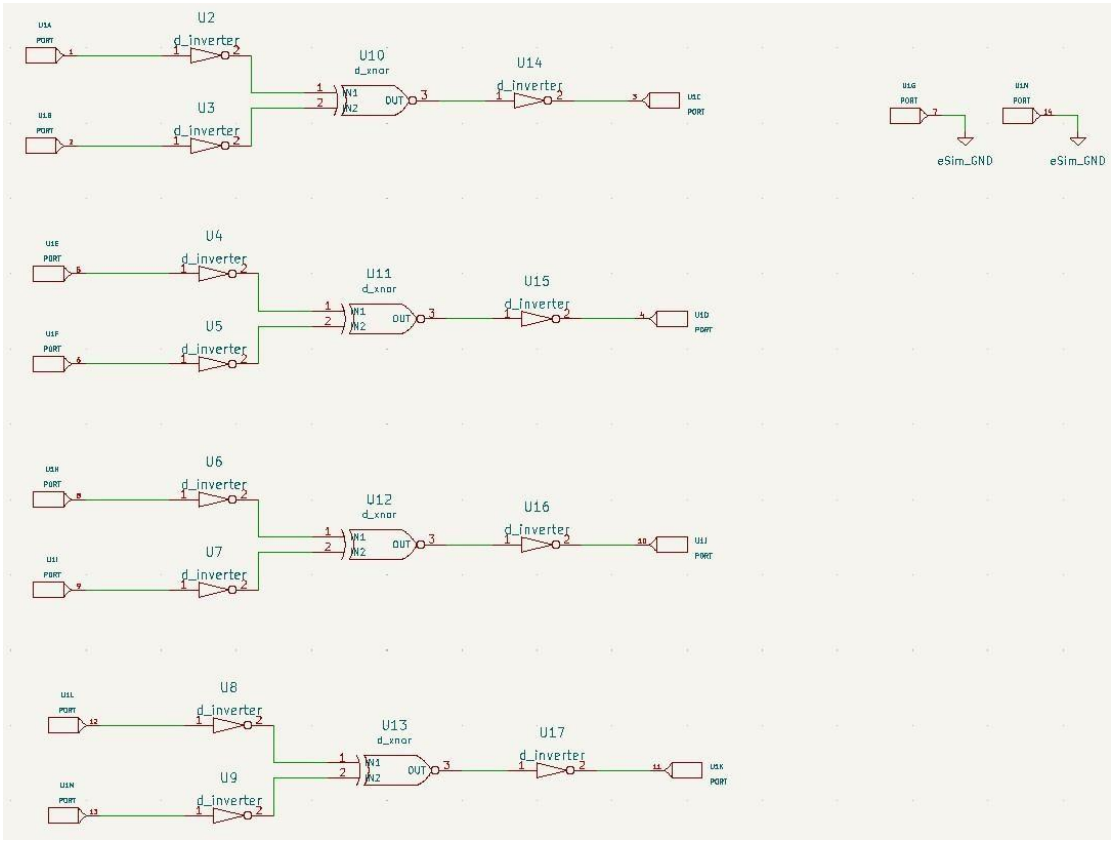


Figure 3.14: Schematic Diagram of 74HC386

3.3.4 Simulation Circuit

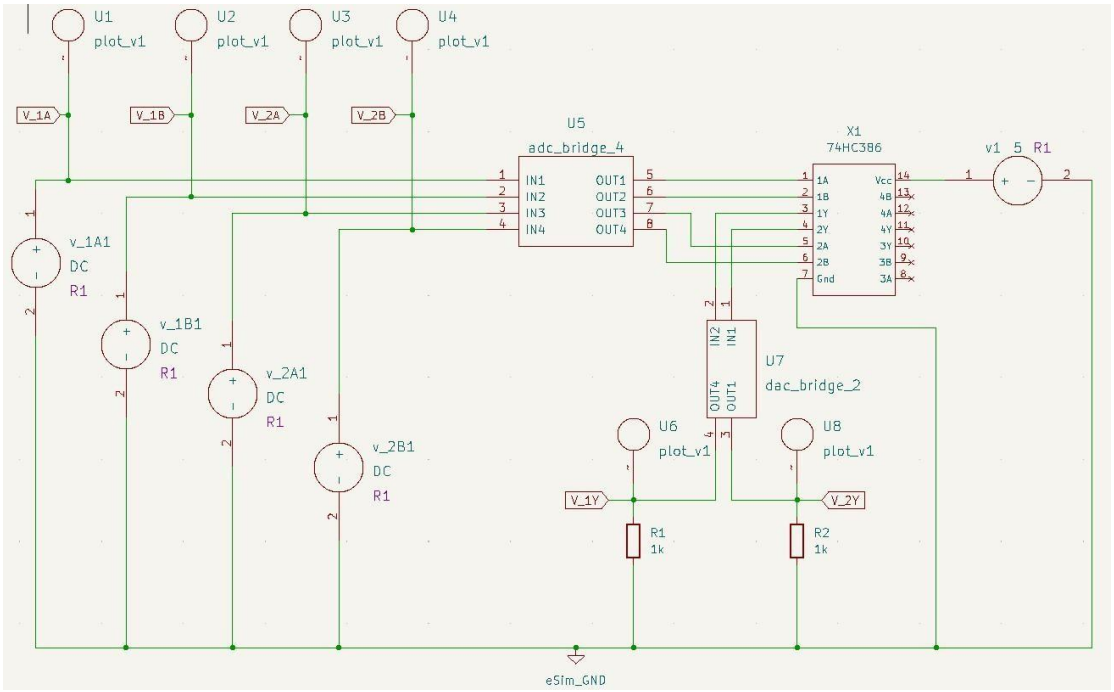


Figure 3.15: Simulation Circuit of 74HC386

3.3.5 Inputs

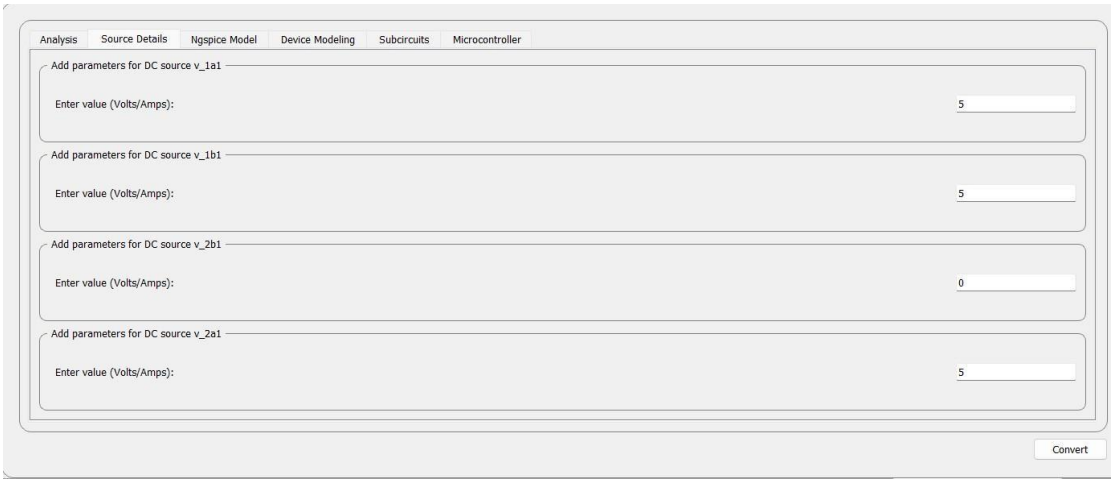


Figure 3.16: Inputs given to the Simulation Circuit of 74HC386

3.3.6 Output Plot

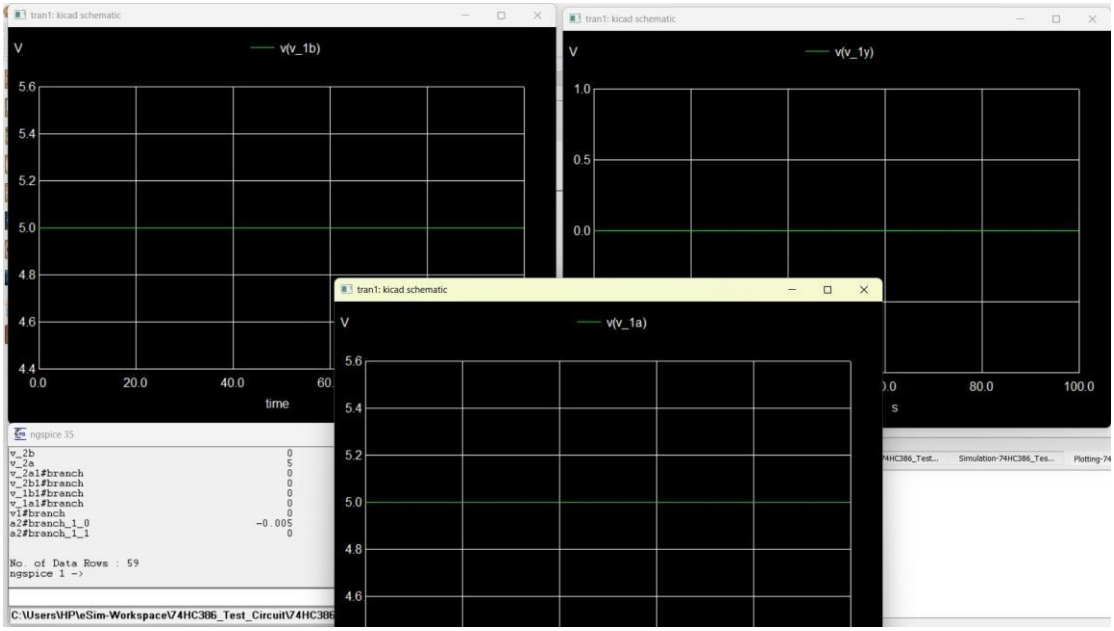


Figure 3.17: Output waveform of 74HC386

3.3.7 Functional Table

Inputs		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

Figure 3.18: Truth Table for 74HC386

3.4 74LS85

3.4.1 Description

The 74LS85 is a 4-bit magnitude comparator designed to compare two 4-bit binary numbers and generate three output signals indicating whether one number is greater than, less than, or equal to the other. Comparators play a critical role in arithmetic logic units, digital control systems, and decision-making circuits. The IC supports cascading, allowing multiple devices to be connected together to compare numbers larger than 4 bits. The 74LS85 belongs to the LS-TTL logic family and provides reliable performance in digital systems. In this project, the comparator logic was implemented in eSim and verified by applying various binary input values.

3.4.2 Pin Diagram

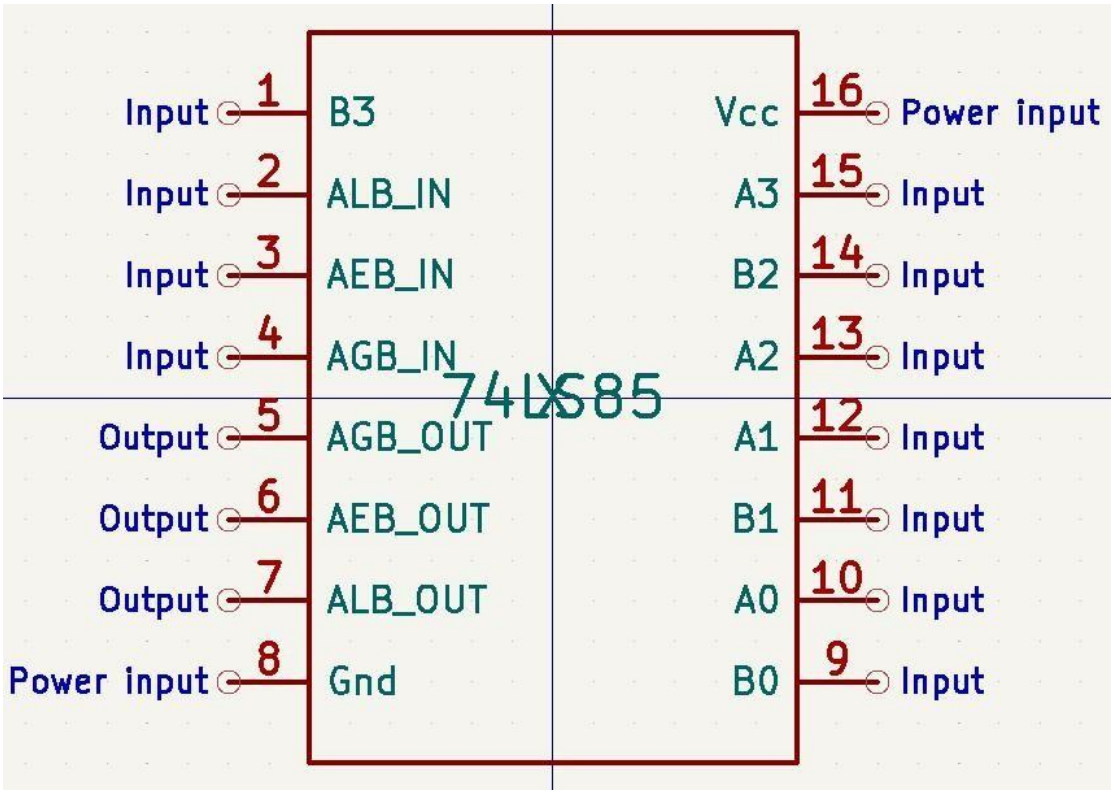


Figure 3.19: Pin Diagram of 74LS85

3.4.3 Schematic Diagram

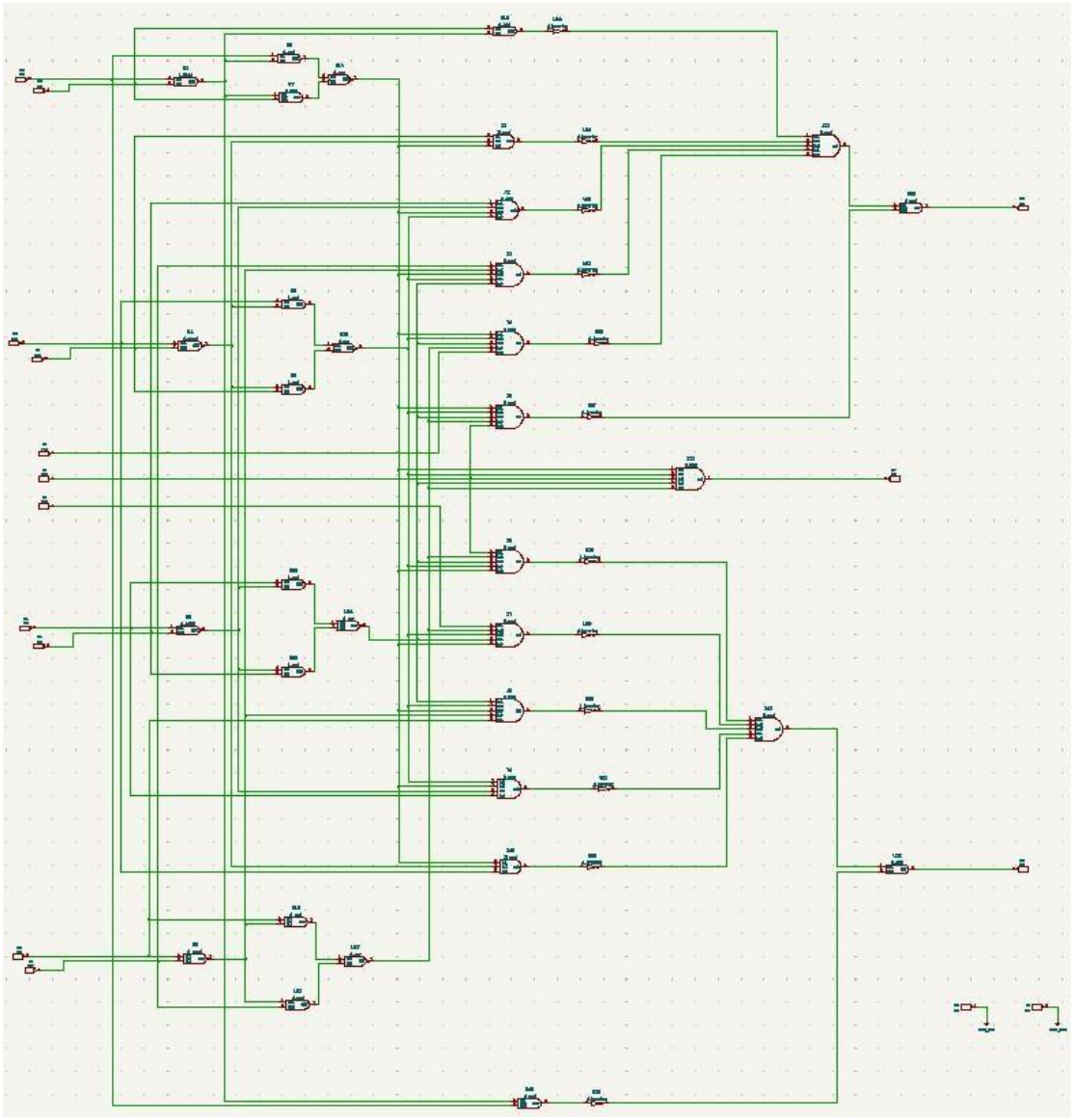


Figure 3.20: Schematic Diagram of 74LS85

3.4.4 Simulation Circuit

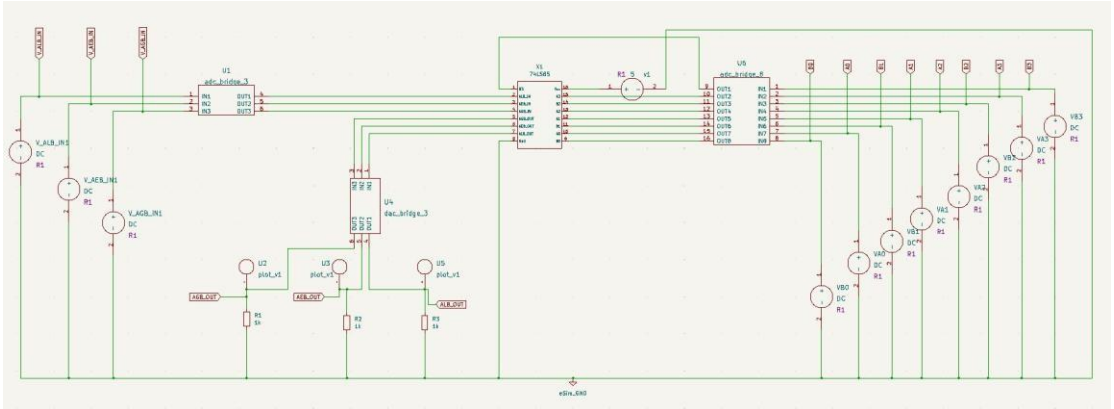


Figure 3.21: Simulation Circuit of 74LS85

3.4.5 Inputs

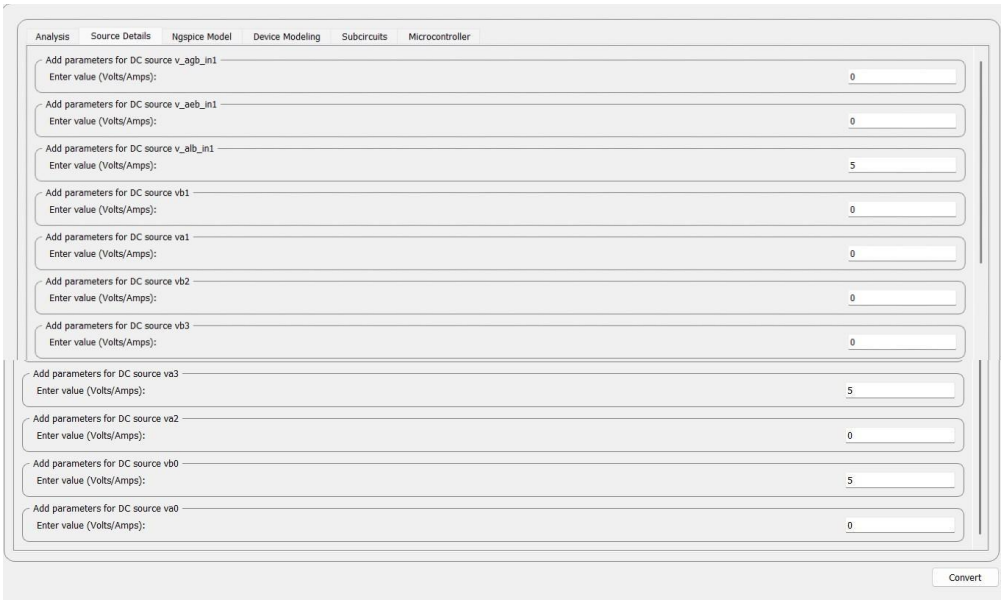


Figure 3.22: Inputs given to Simulation Circuit of 74LS85

3.4.6 Output Plot

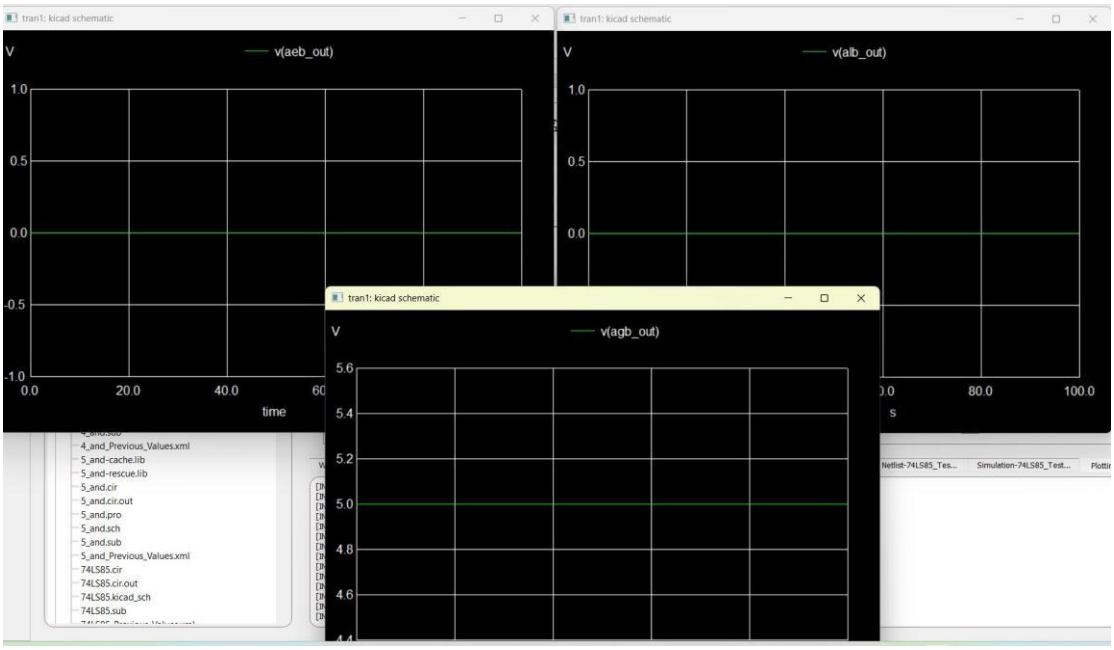


Figure 3.23: Output waveform of 74LS85

3.4.7 Functional Table

TRUTH TABLE

COMPARING INPUTS				CASCADING INPUTS			OUTPUTS		
A_3,B_3	A_2,B_2	A_1,B_1	A_0,B_0	$I_{A>B}$	$I_{A<B}$	$I_{A=B}$	$O_{A>B}$	$O_{A<B}$	$O_{A=B}$
$A_3>B_3$	X	X	X	X	X	X	H	L	L
$A_3<B_3$	X	X	X	X	X	X	L	H	L
$A_3=B_3$	$A_2>B_2$	X	X	X	X	X	H	L	L
$A_3=B_3$	$A_2<B_2$	X	X	X	X	X	L	H	L
$A_3=B_3$	$A_2=B_2$	$A_1>B_1$	X	X	X	X	H	L	L
$A_3=B_3$	$A_2=B_2$	$A_1<B_1$	X	X	X	X	L	H	L
$A_3=B_3$	$A_2=B_2$	$A_1=B1$	$A_0>B_0$	X	X	X	H	L	L
$A_3=B_3$	$A_2=B_2$	$A_1=B_1$	$A_0<B_0$	X	X	X	L	H	L
$A_3=B_3$	$A_2=B_2$	$A_1=B_1$	$A_0=B_0$	H	L	L	H	L	L
$A_3=B_3$	$A_2=B_2$	$A_1=B_1$	$A_0=B_0$	L	H	L	L	H	L
$A_3=B_3$	$A_2=B_2$	$A_1=B_1$	$A_0=B_0$	X	X	H	L	L	H
$A_3=B_3$	$A_2=B_2$	$A_1=B_1$	$A_0=B_0$	H	H	L	L	L	L
$A_3=B_3$	$A_2=B_2$	$A_1=B_1$	$A_0=B_0$	L	L	L	H	H	L

Figure 3.24: Truth Table for 74LS85

3.5 74LS112

3.5.1 Description

The 74LS112 is a dual JK flip-flop with asynchronous preset and clear inputs. JK flip-flops are versatile sequential logic elements capable of performing toggle, set, reset, and hold operations depending on the input conditions. They are widely used in counters, registers, and control circuits.

The asynchronous preset and clear inputs allow immediate control of the output states independent of the clock signal. The 74LS112 operates reliably in LS-TTL logic environments. In this work, the flip-flop behavior was modeled in eSim and verified using clock-driven simulation inputs.

3.5.2 Pin Diagram

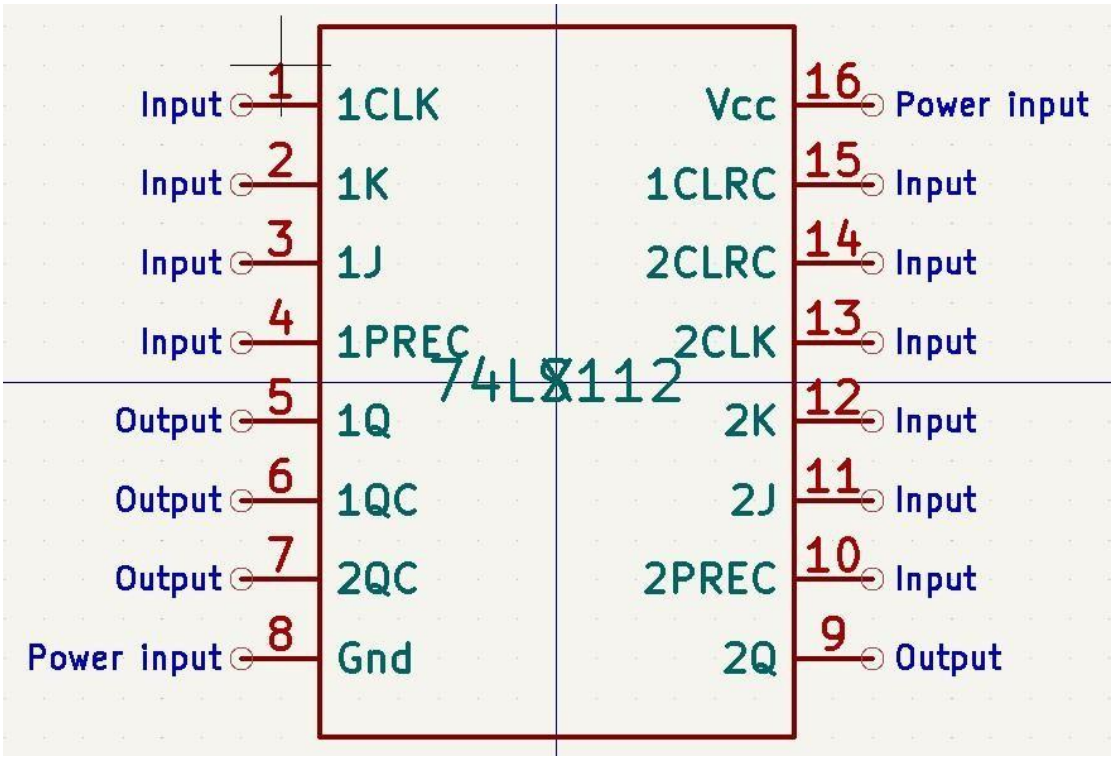


Figure 3.25: Pin Diagram of 74LS112

3.5.3 Schematic Diagram

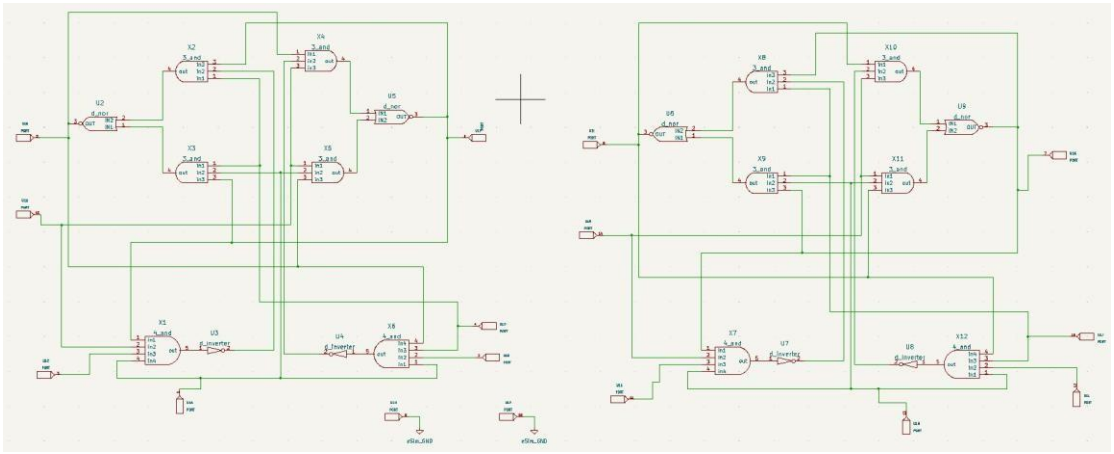


Figure 3.26: Schematic Diagram of 74LS112

3.5.4 Simulation Circuit

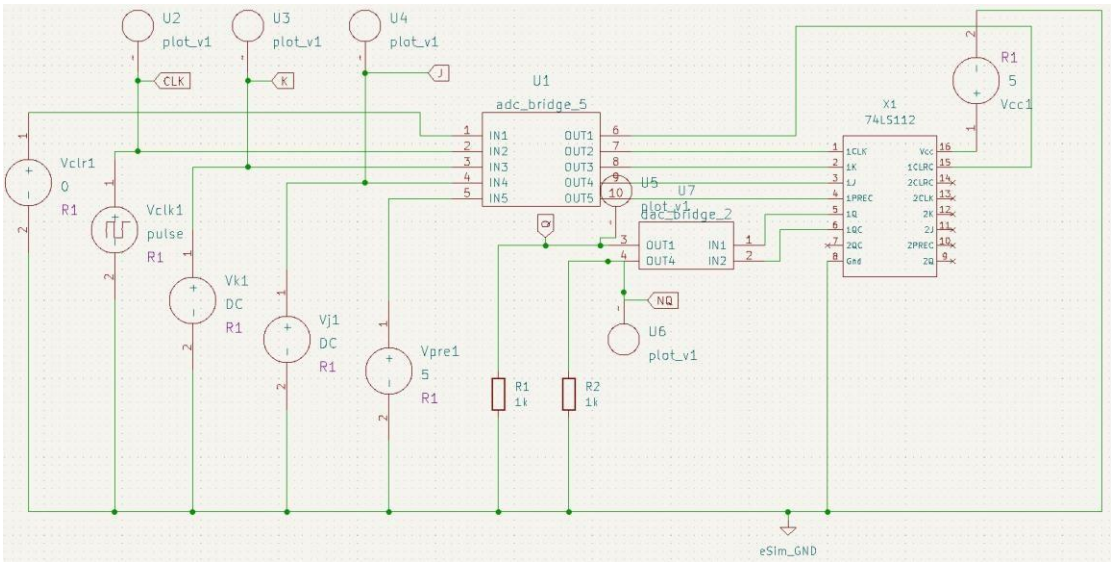


Figure 3.27: Simulation Circuit of 74LS112

3.5.5 Inputs

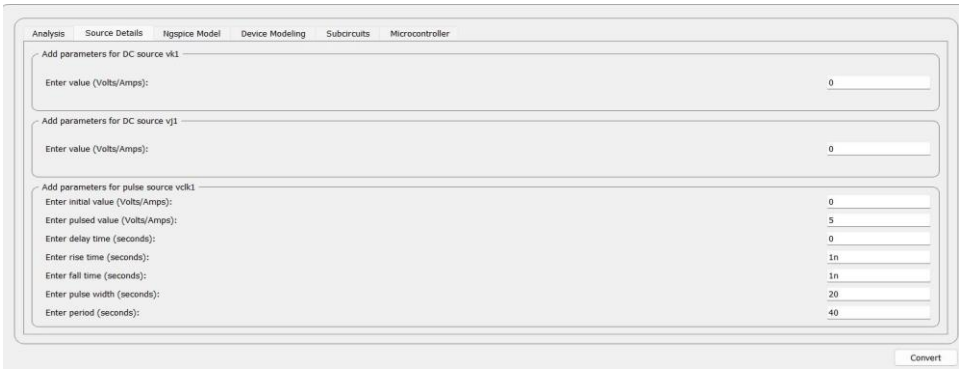


Figure 3.28: Inputs given to Simulation Circuit of 74LS112

3.5.6 Output Plot

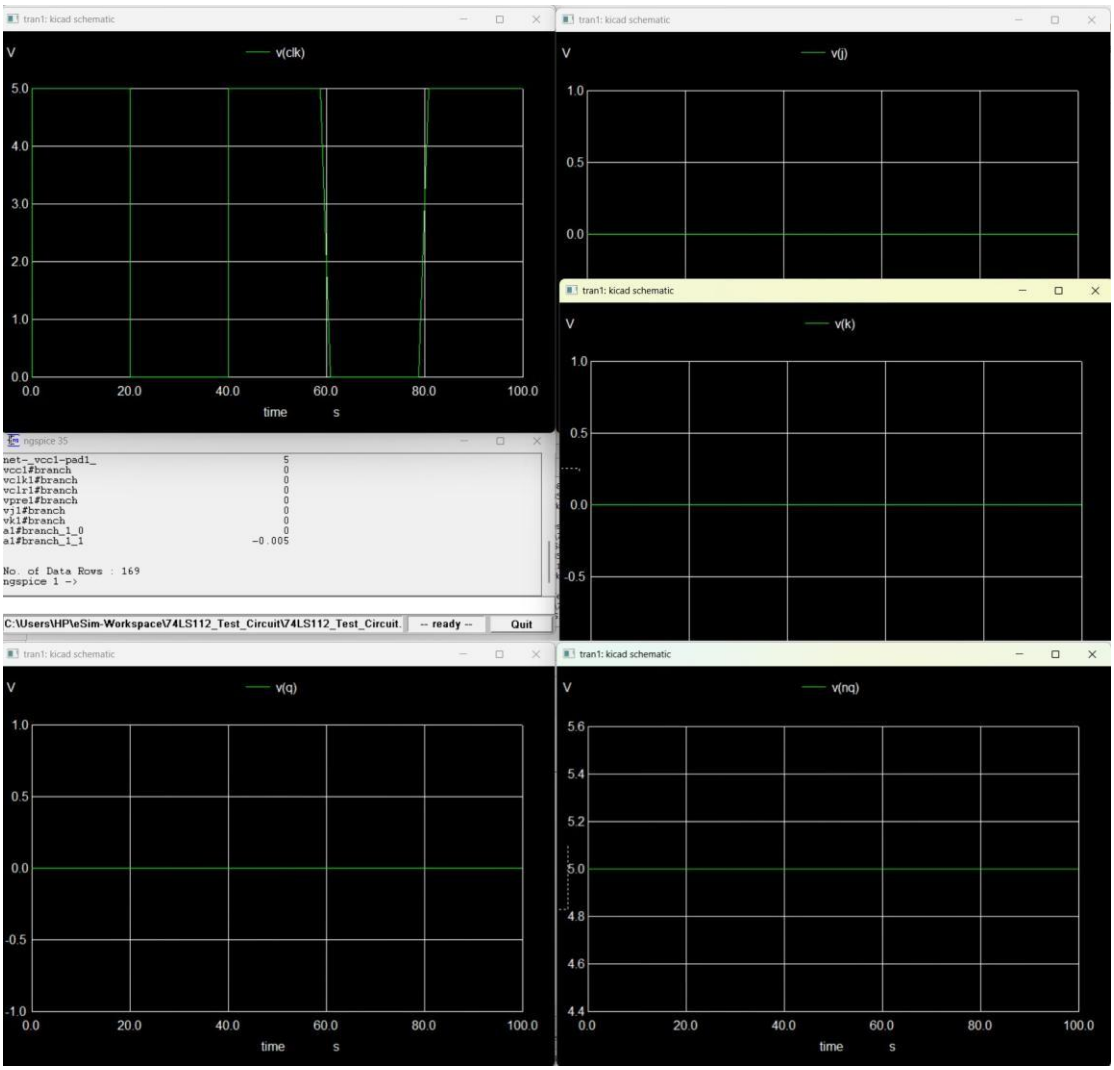


Figure 3.29: Output waveform of 74LS112

3.5.7 Functional Table

FUNCTION TABLE (each flip-flop)

INPUTS					OUTPUTS	
PRE	$\overline{CLR}$	CLK	J	K	Q	$\overline{Q}$
L	H	X	X	X	H	L
H	L	X	X	X	L	H
L	L	X	X	X	H†	H†
H	H	↓	L	L	Q_0	$\overline{Q}_0$
H	H	↓	H	L	H	L
H	H	↓	L	H	L	H
H	H	↓	H	H	TOGGLE	
H	H	H	X	X	Q_0	$\overline{Q}_0$

Figure 3.30: Truth Table for 74LS112

3.6 74LS126

3.6.1 Description

The 74LS126 is a quad buffer with tri-state outputs designed for bus interfacing and signal isolation in digital systems. Each buffer includes an enable input that allows the output to be placed in a high-impedance state, preventing bus contention when multiple devices share a common data line.

This IC is widely used in microprocessor systems, memory interfacing, and data bus control applications. The LS-TTL design ensures stable operation and compatibility with standard TTL logic levels. In this project, the tri-state behavior of the buffer was modeled and verified using enable control signals in eSim.

3.6.2 Pin Diagram

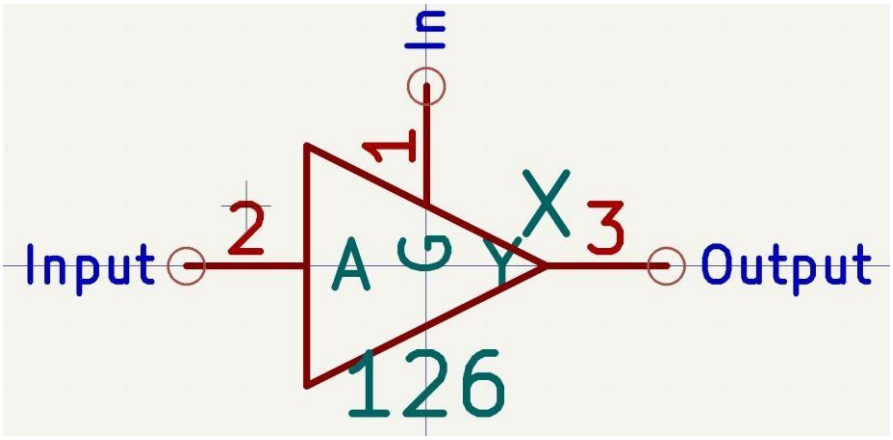


Figure 3.31: Pin Diagram of Tristate Buffer

3.6.3 Pin Diagram

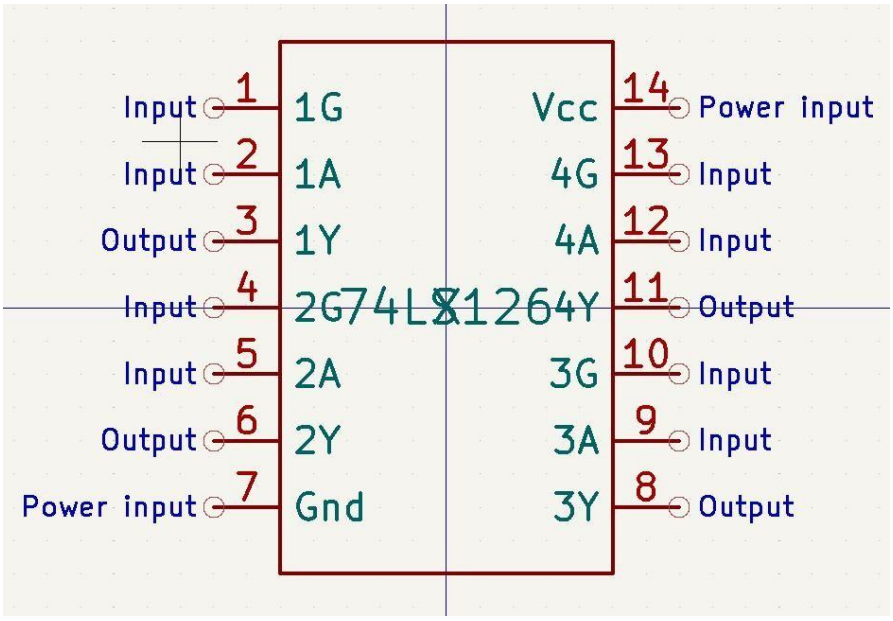


Figure 3.32: Pin Diagram of 74LS126

3.6.4 Schematic Diagram

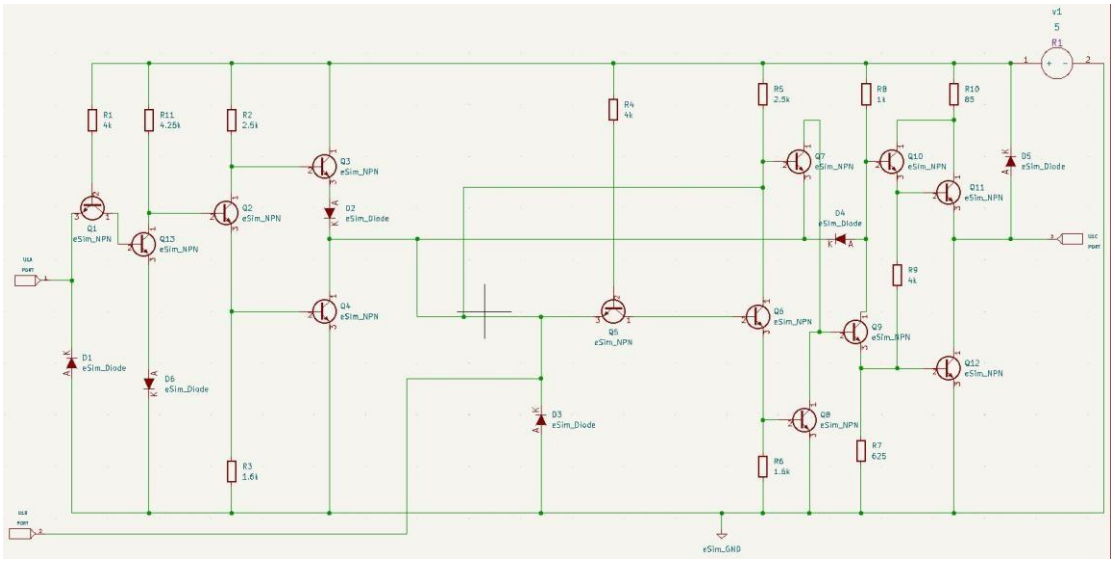


Figure 3.33: Schematic Diagram of 3-State Buffer

3.6.5 Schematic Diagram

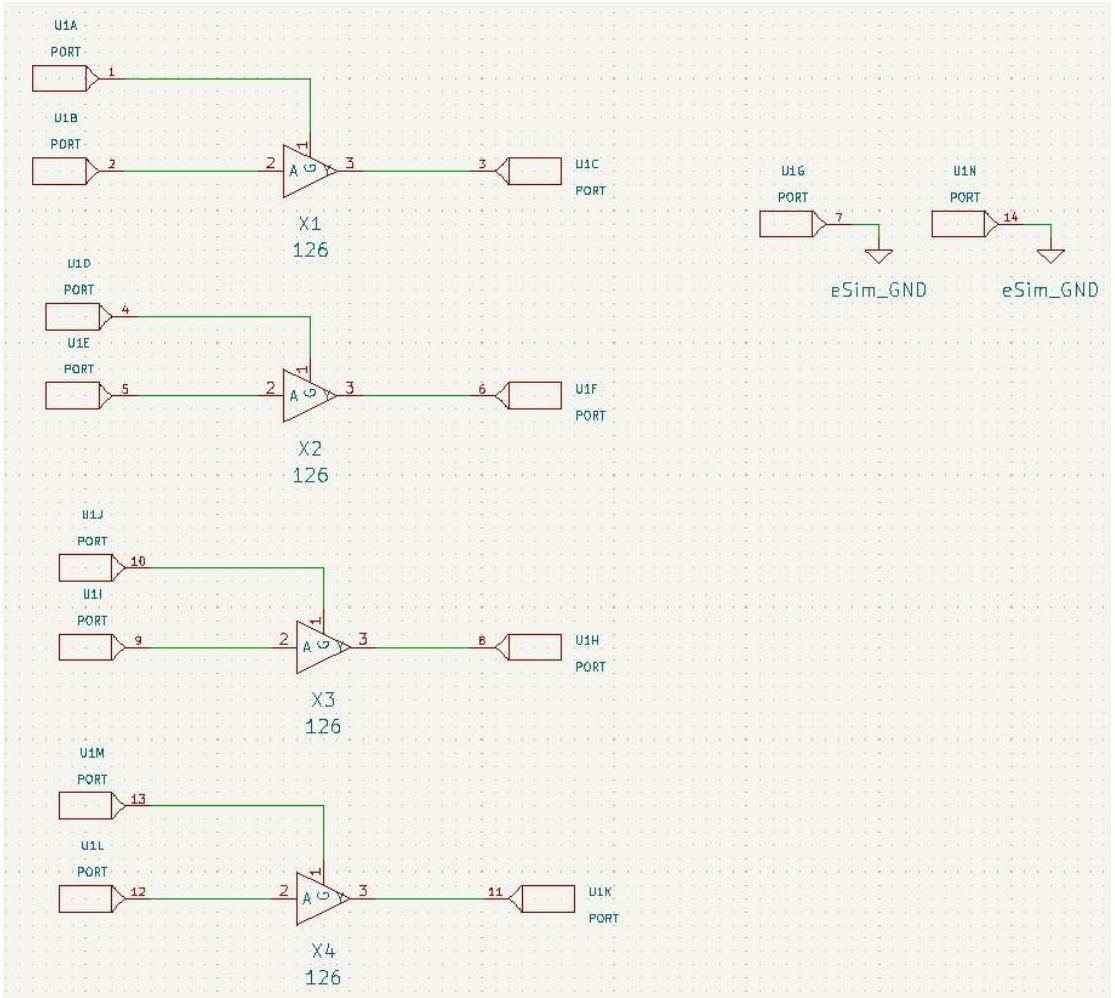


Figure 3.34: Schematic Diagram of 74LS126

3.6.6 Simulation Circuit

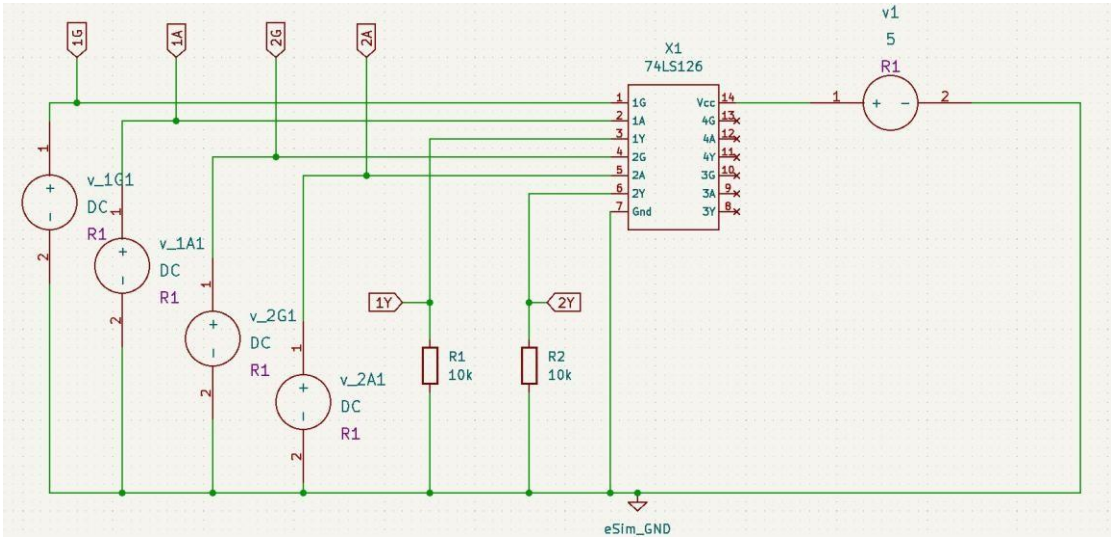


Figure 3.35: Simulation Circuit of 74LS126

3.6.7 Inputs

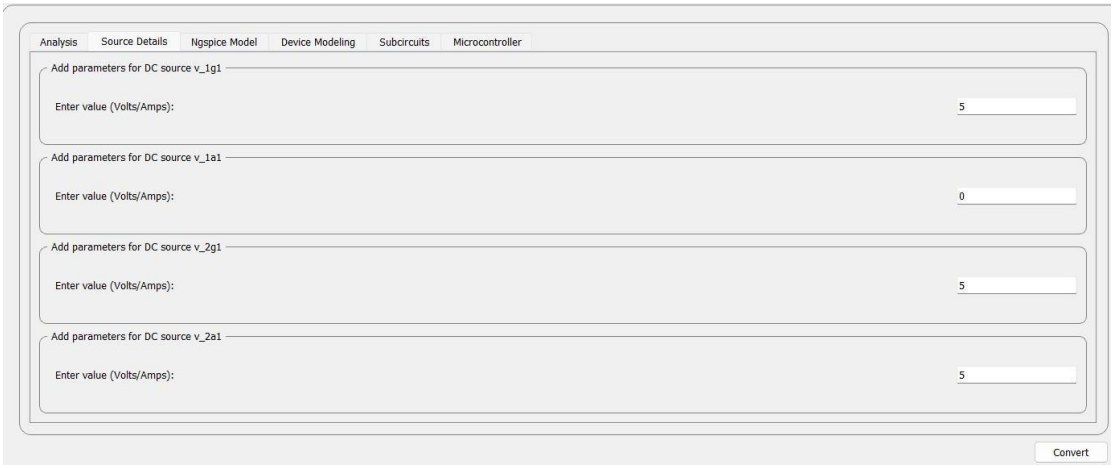


Figure 3.36: Inputs given to Simulation Circuit of 74LS126

3.6.8 Output Plot

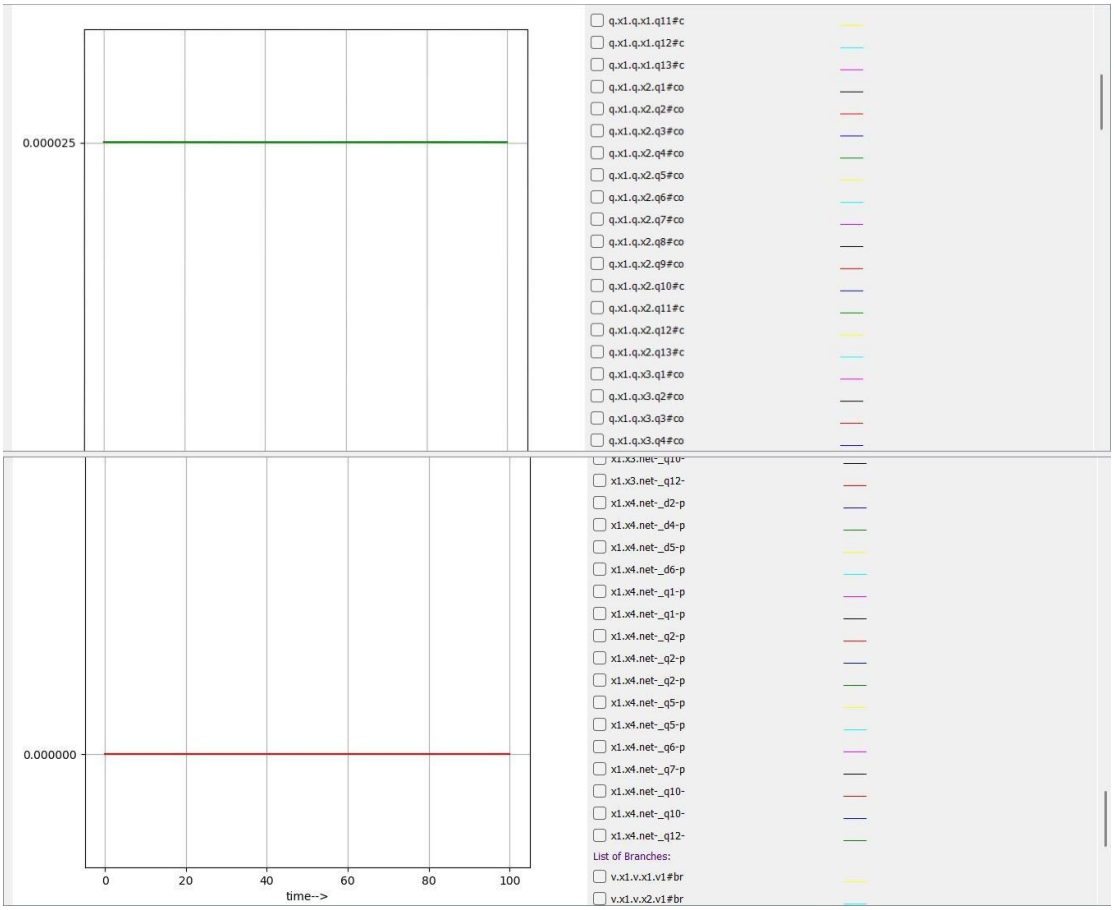


Figure 3.37: Output Waveform of 74LS126

3.6.9 Output Plot

3.6.10 Functional Table

TRUTH TABLE

INPUTS		OUTPUT
E	D	
H	L	L
H	H	H
L	X	(Z)

L = LOW Voltage Level
H = HIGH Voltage Level
X = Don't Care
(Z) = High Impedance (off)

Figure 3.38: Truth Table for 74LS126

3.7 74LS153

3.7.1 Description

The 74LS153 is a dual 4-line to 1-line data selector/multiplexer that allows selection of one data input from four possible inputs for each section. Multiplexers are fundamental building blocks in digital systems and are widely used in data routing, signal selection, and resource sharing applications.

Each multiplexer section has common select inputs, enabling synchronized data selection. The IC belongs to the LS-TTL family and provides reliable operation in high-speed digital circuits. In this project, the multiplexer functionality was implemented using the eSim Subcircuit Builder and verified through simulation by varying select lines and data inputs.

3.7.2 Pin Diagram

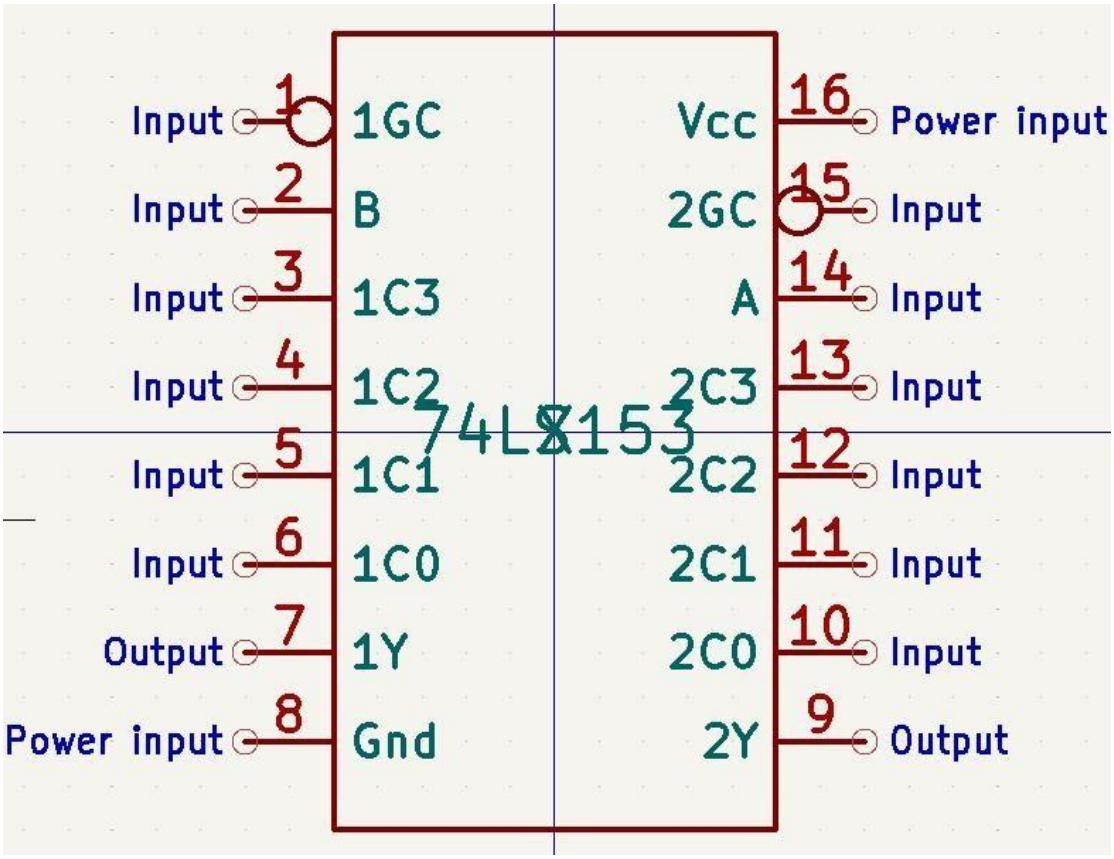


Figure 3.39: Pin Diagram of 74LS153

3.7.3 Schematic Diagram

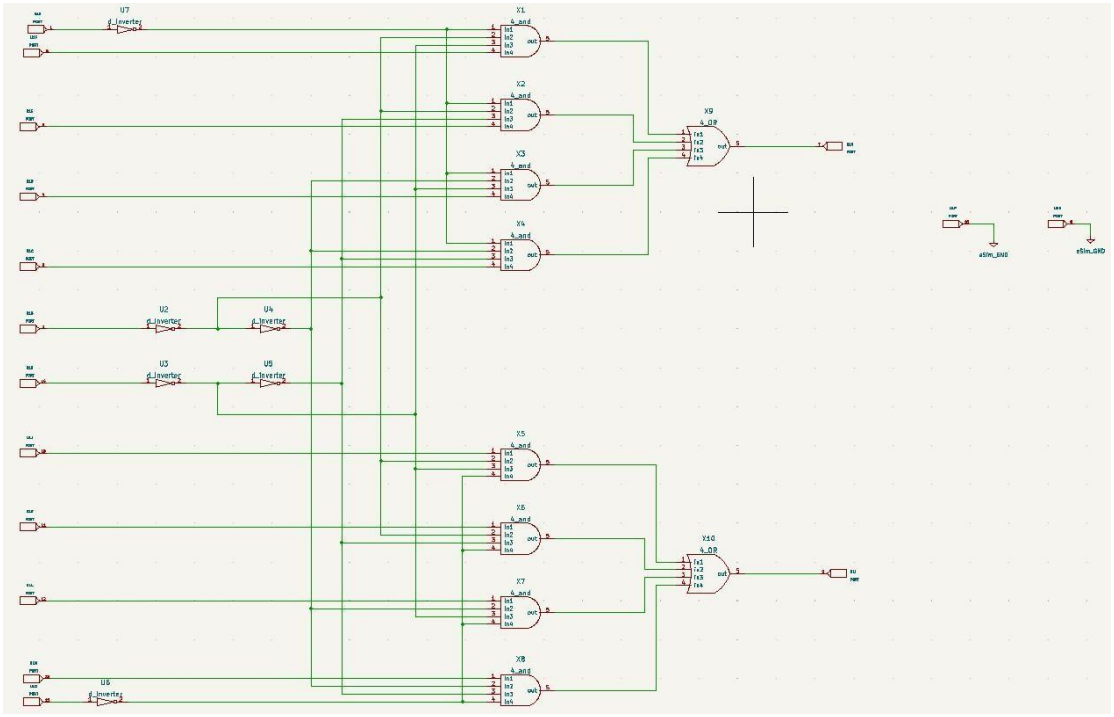


Figure 3.40: Schematic Diagram of 74LS153

3.7.4 Simulation Circuit

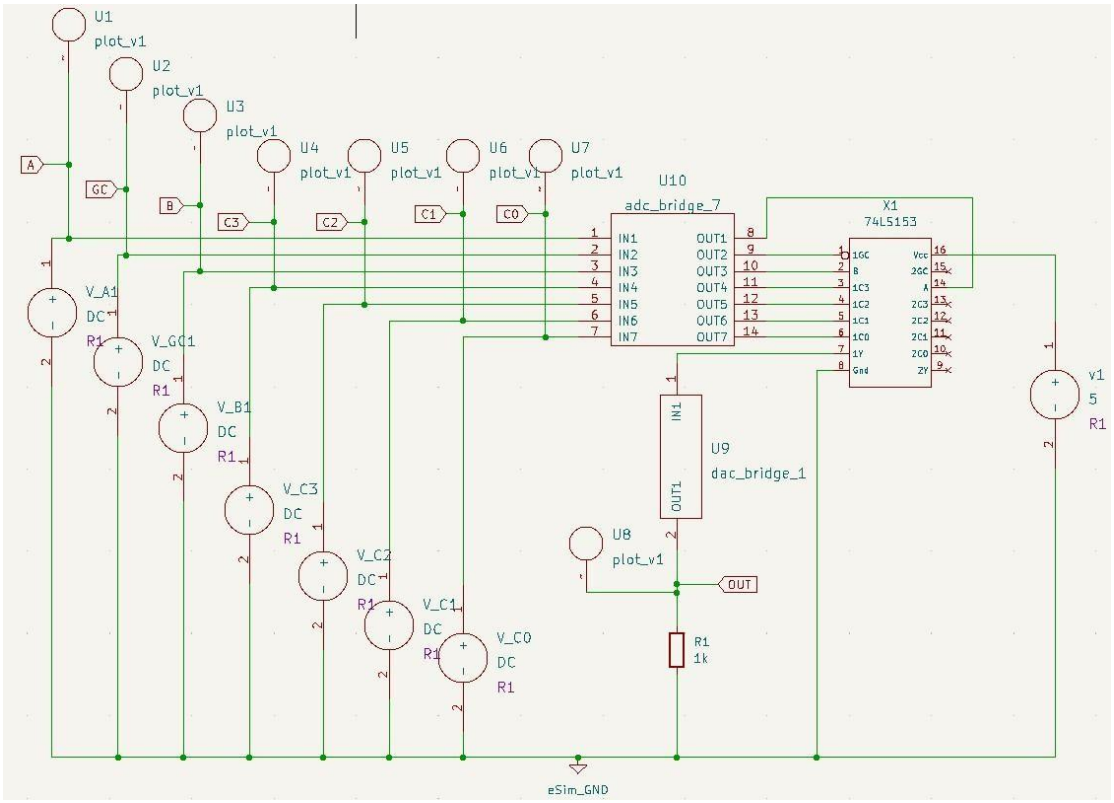


Figure 3.41: Simulation Circuit of 74LS153

3.7.5 Inputs

Figure 3.42: Inputs given to Simulation Circuit of 74LS153

3.7.6 Output Plot

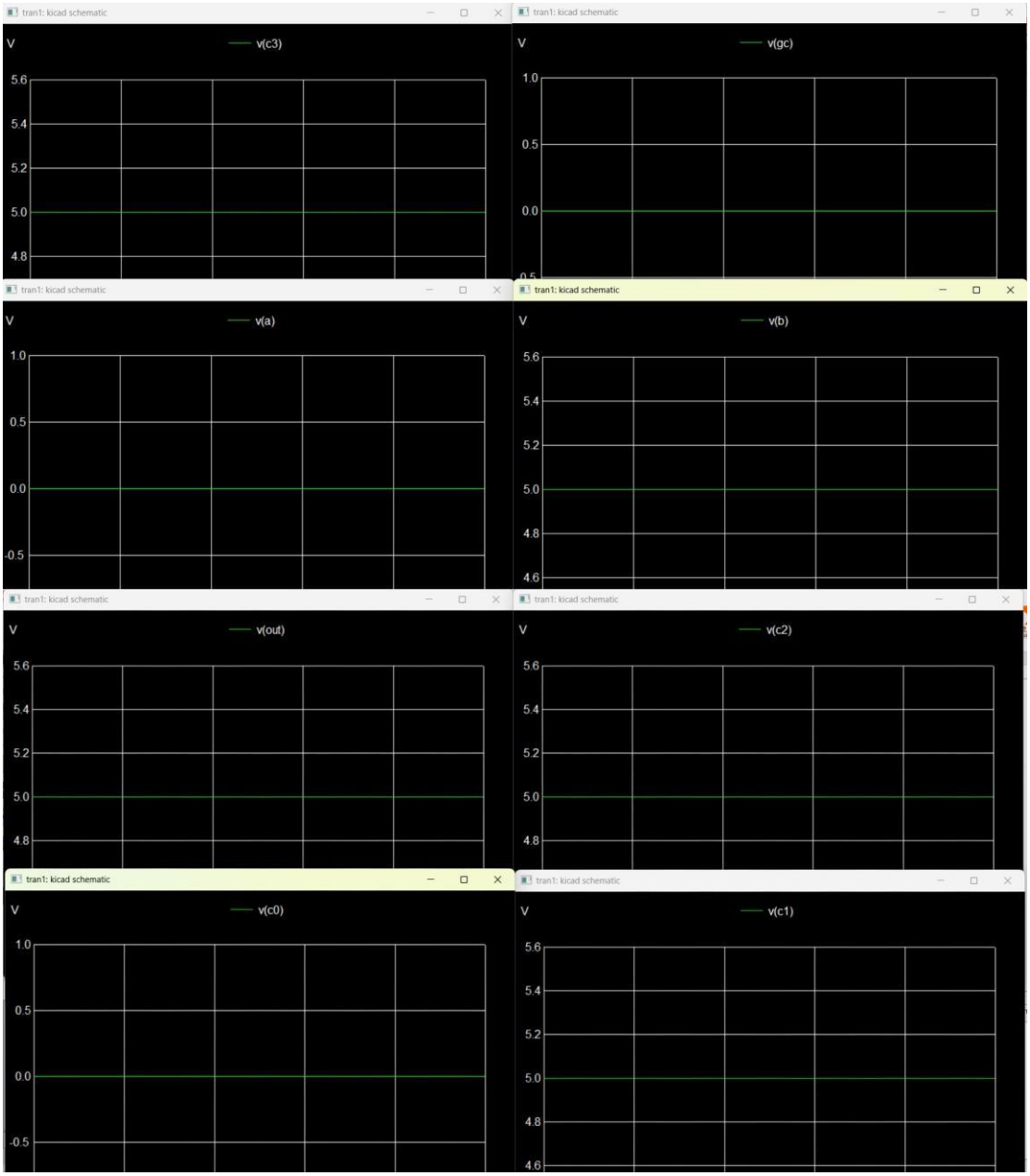


Figure 3.43: Output waveforms of 74LS153

3.7.7 Functional Table

FUNCTION TABLE

SELECT INPUTS		DATA INPUTS				STROBE	OUTPUT
B	A	C0	C1	C2	C3	$\bar{G}$	Y
X	X	X	X	X	X	H	L
L	L	L	X	X	X	L	L
L	L	H	X	X	X	L	H
L	H	X	L	X	X	L	L
L	H	X	H	X	X	L	H
H	L	X	X	L	X	L	L
H	L	X	X	H	X	L	H
H	H	X	X	X	L	L	L
H	H	X	X	X	H	L	H

Select inputs A and B are common to both sections.
H = high level, L = low level, X = irrelevant

Figure 3.44: Truth Table for 74LS153

3.8 74LS251

3.8.1 Description

The 74LS251 is an 8-line to 1-line data selector/multiplexer with a tri-state output. This IC allows selection of one input from eight data sources based on three select lines, making it useful in data routing and digital control applications.

The tri-state output enables easy interfacing with shared data buses by allowing the output to enter a high-impedance state when disabled. The LS-TTL architecture ensures compatibility with standard TTL logic levels. In this work, the multiplexer operation and tri-state behavior were modeled and verified using eSim simulations.

3.8.2 Pin Diagram

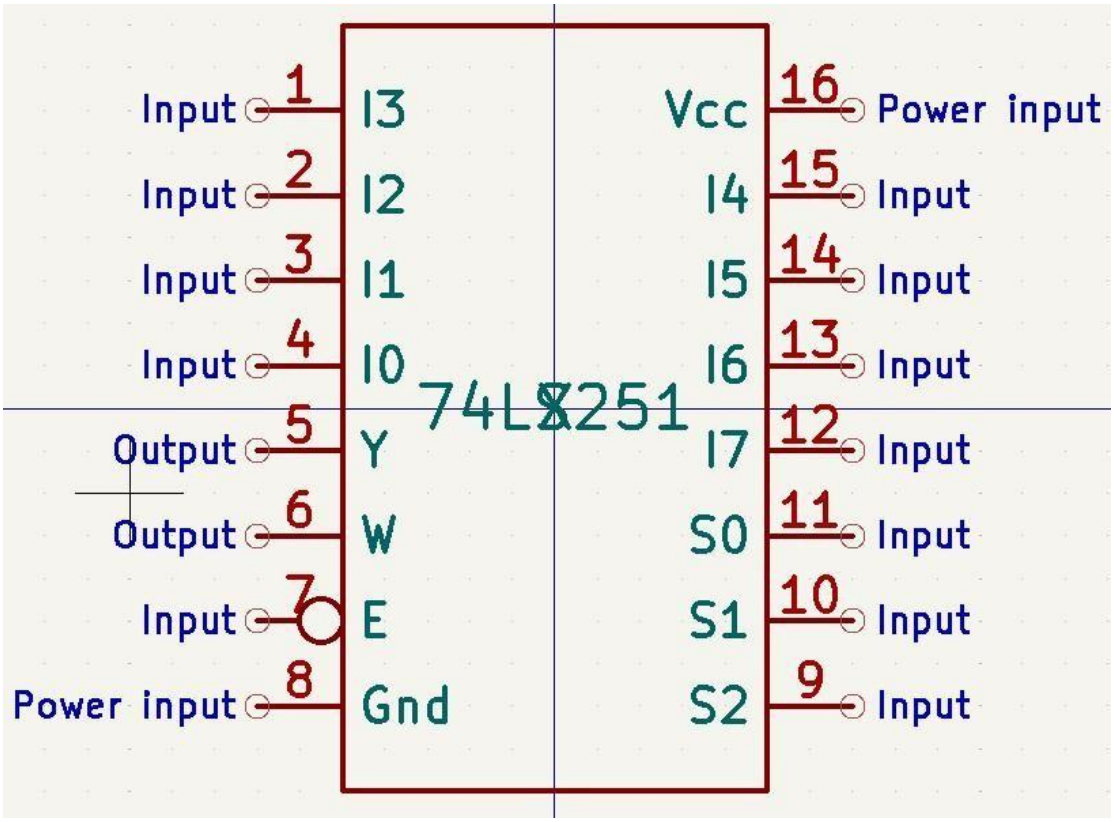


Figure 3.45: Pin Diagram of 74LS251

3.8.3 Schematic Diagram

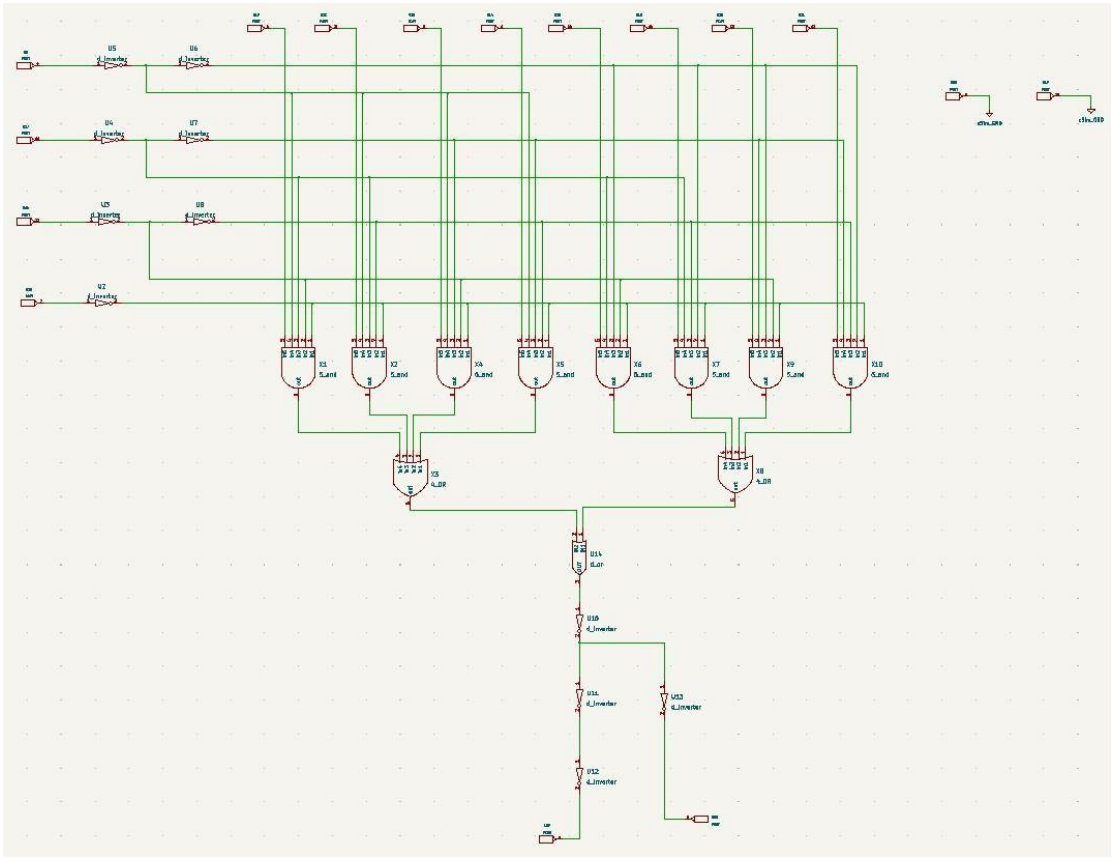


Figure 3.46: Schematic Diagram of 74LS251

3.8.4 Simulation Circuit

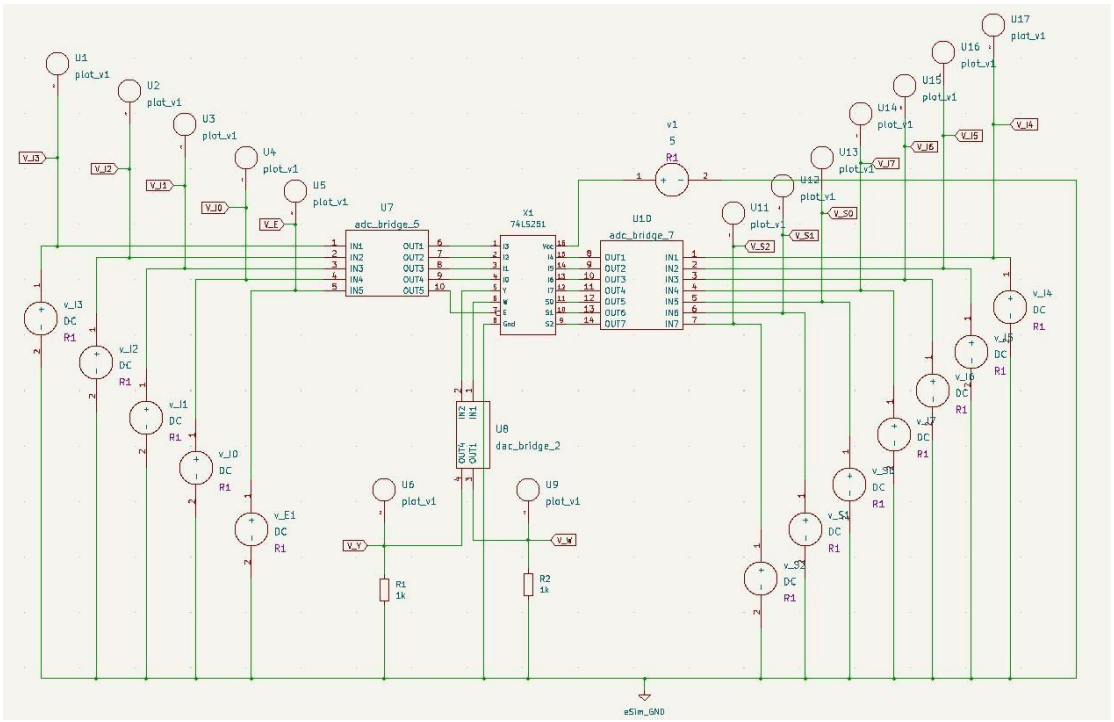


Figure 3.47: Simulation Circuit of 74LS251

3.8.5 Inputs

Figure 3.48: Inputs given to Simulation Circuit of 74LS251

3.8.6 Output Plot

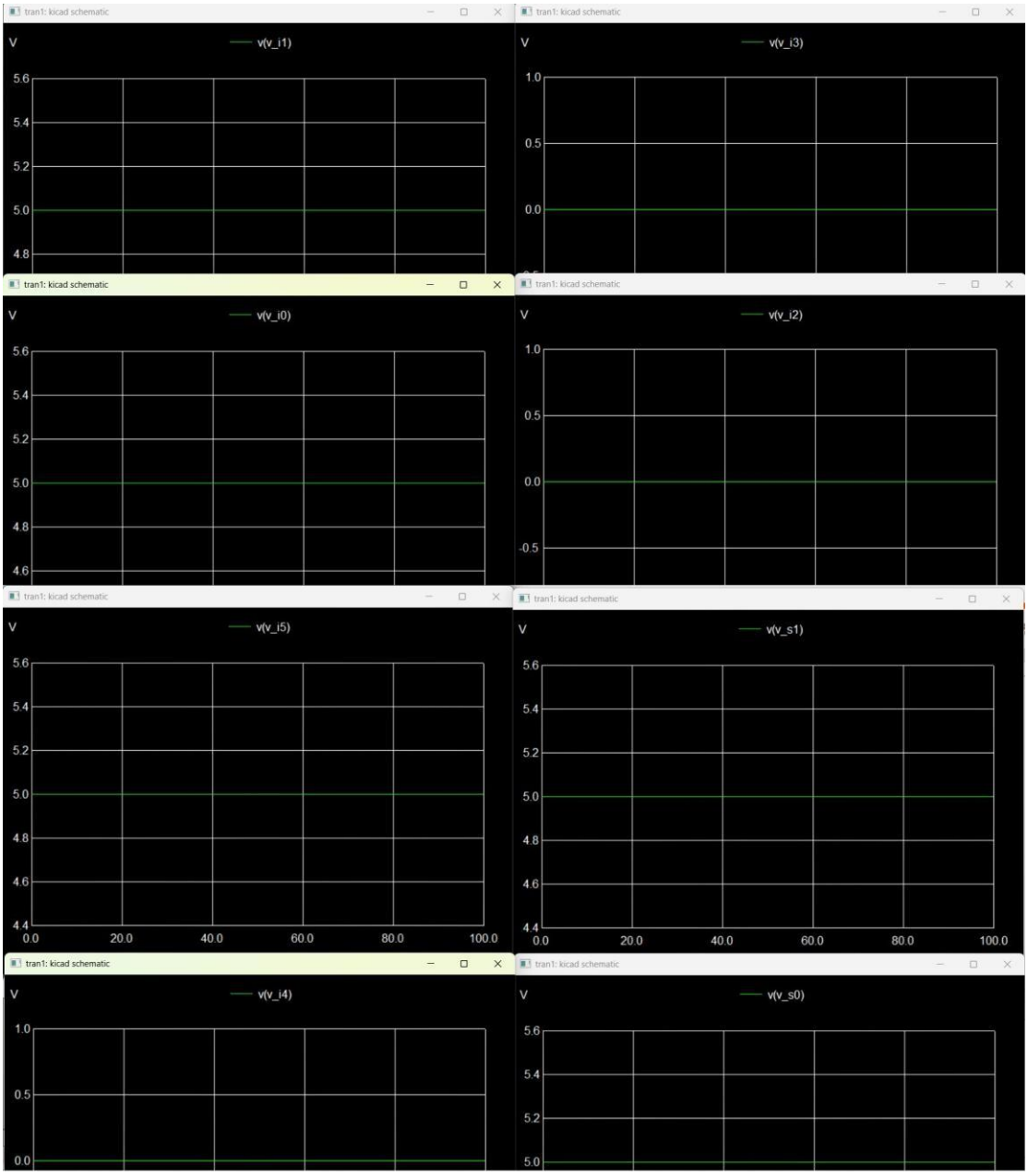


Figure 3.49: Output waveform of 74LS251

3.8.7 Output Plot

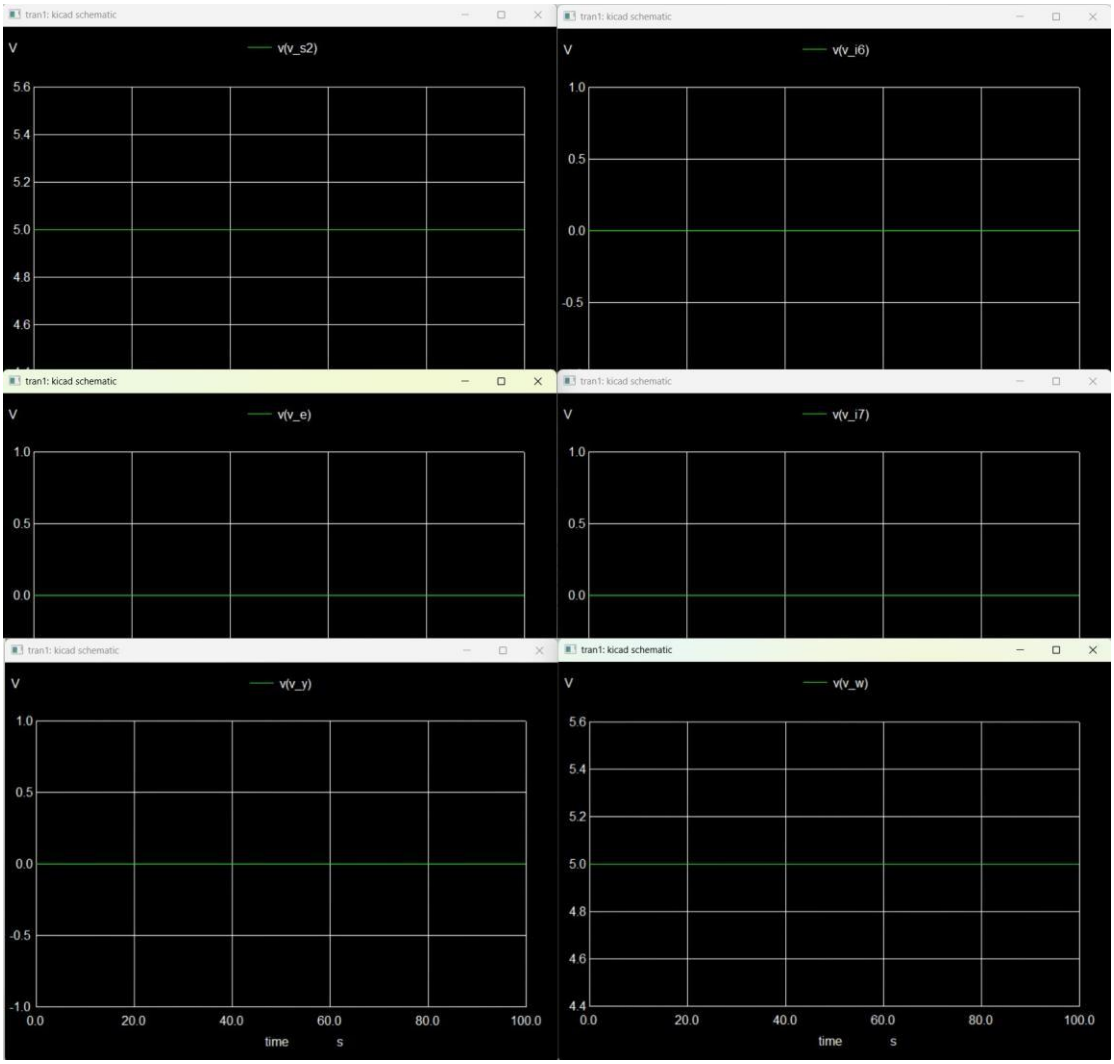


Figure 3.50: Output waveform of 74LS251

3.8.8 Functional Table

TRUTH TABLE

$\overline{E}_0$	S_2	S_1	S_0	I_0	I_1	I_2	I_3	I_4	I_5	I_6	I_7	$\overline{Z}$	Z
H	X	X	X	X	X	X	X	X	X	X	X	(Z)	(Z)
L	L	L	L	L	X	X	X	X	X	X	X	H	L
L	L	L	L	H	X	X	X	X	X	X	X	L	H
L	L	L	H	X	L	X	X	X	X	X	X	H	L
L	L	L	H	X	H	X	X	X	X	X	X	L	H
L	L	H	L	X	X	L	X	X	X	X	X	H	L
L	L	H	L	X	X	H	X	X	X	X	X	L	H
L	L	H	H	X	X	X	L	X	X	X	X	H	L
L	L	H	H	X	X	X	H	X	X	X	X	L	H
L	H	L	L	X	X	X	X	L	X	X	X	H	L
L	H	L	L	X	X	X	X	H	X	X	X	L	H
L	H	L	H	X	X	X	X	X	L	X	X	H	L
L	H	L	H	X	X	X	X	X	H	X	X	L	H
L	H	H	L	X	X	X	X	X	X	L	X	H	L
L	H	H	L	X	X	X	X	X	X	H	X	L	H
L	H	H	H	X	X	X	X	X	X	X	L	H	L
L	H	H	H	X	X	X	X	X	X	X	H	L	H

H = HIGH Voltage Level
L = LOW Voltage Level
X = Don't Care
(Z) = High impedance (Off)

Figure 3.51: Truth Table for 74LS251

3.9 74145

3.9.1 Description

The 74145 is a BCD-to-decimal decoder that converts a 4-bit binary-coded decimal input into one of ten mutually exclusive outputs. Each output corresponds to a decimal digit from 0 to 9, making the IC useful in display systems, counters, and digital decoding applications.

The outputs of the 74145 are active low, meaning the selected output is driven low while all others remain high. This decoder is commonly used in driving numeric displays and control logic circuits. In this project, the decoding operation was implemented and verified through simulation in eSim by applying various BCD inputs.

3.9.2 Pin Diagram

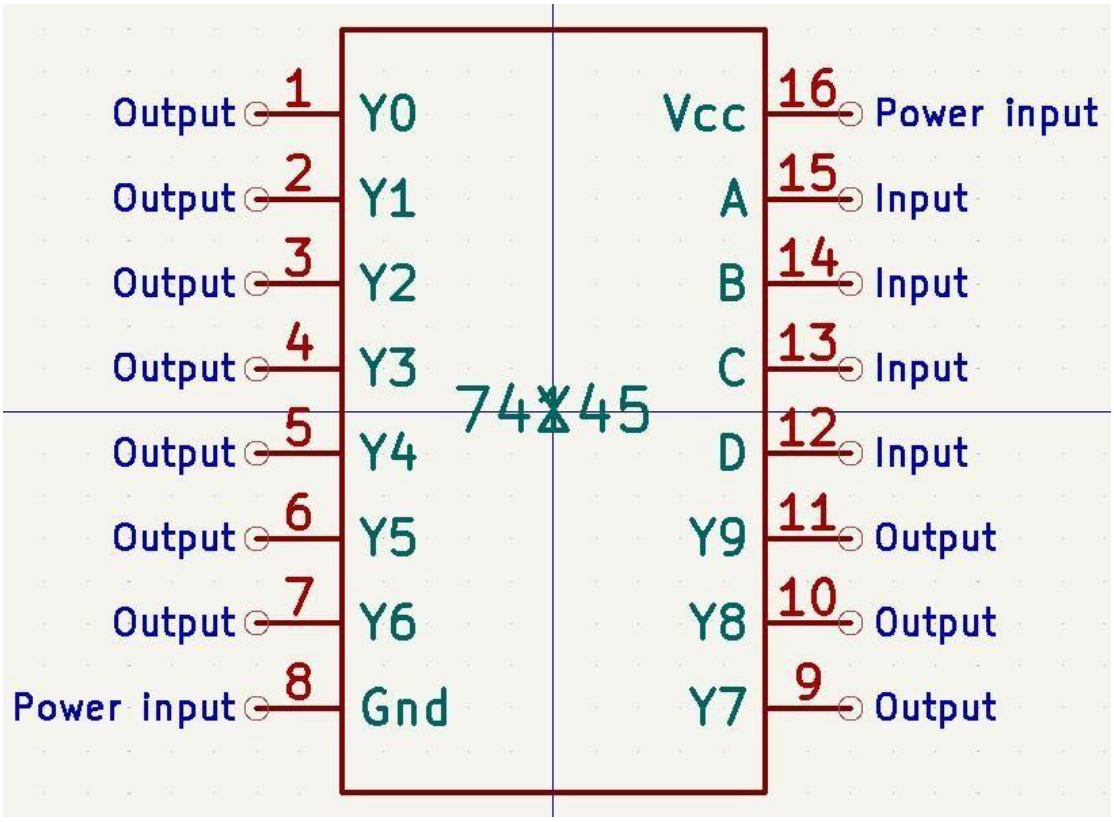


Figure 3.52: Pin Diagram of 74145

3.9.3 Schematic Diagram

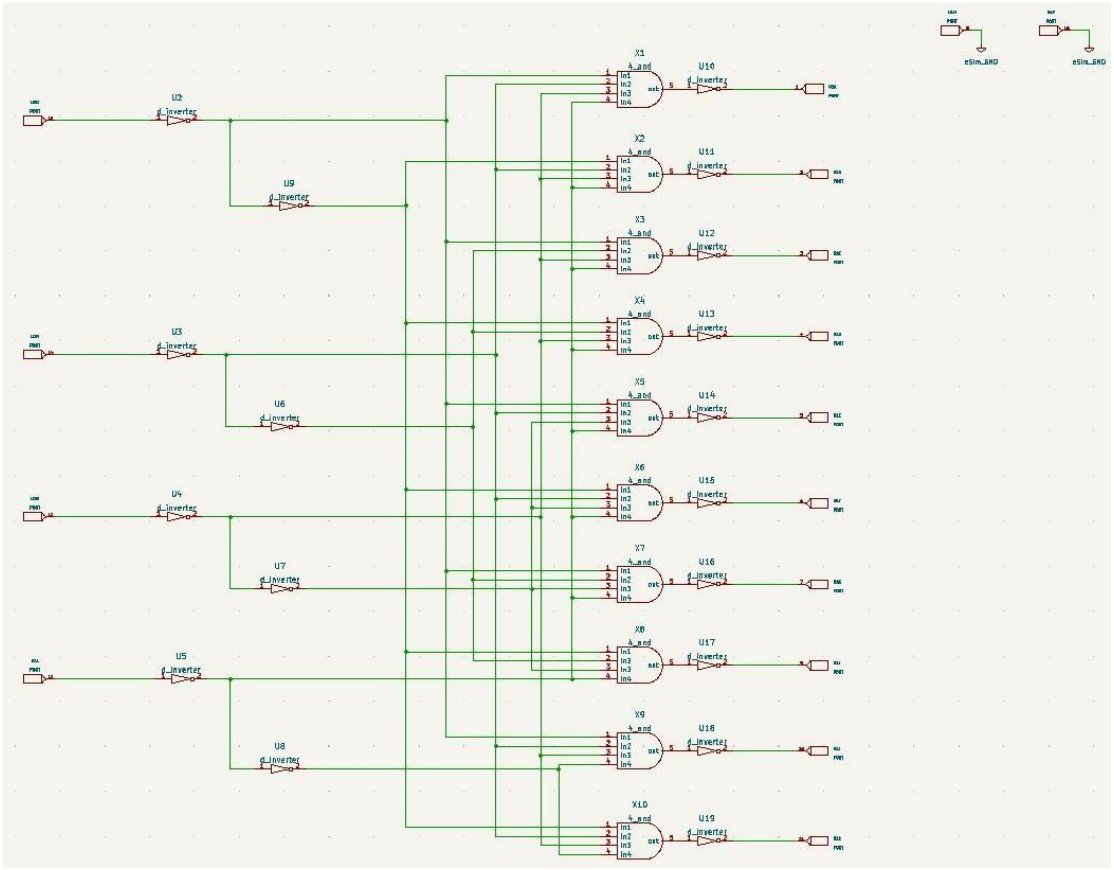


Figure 3.53: Schematic Diagram of 74145

3.9.4 Simulation Circuit

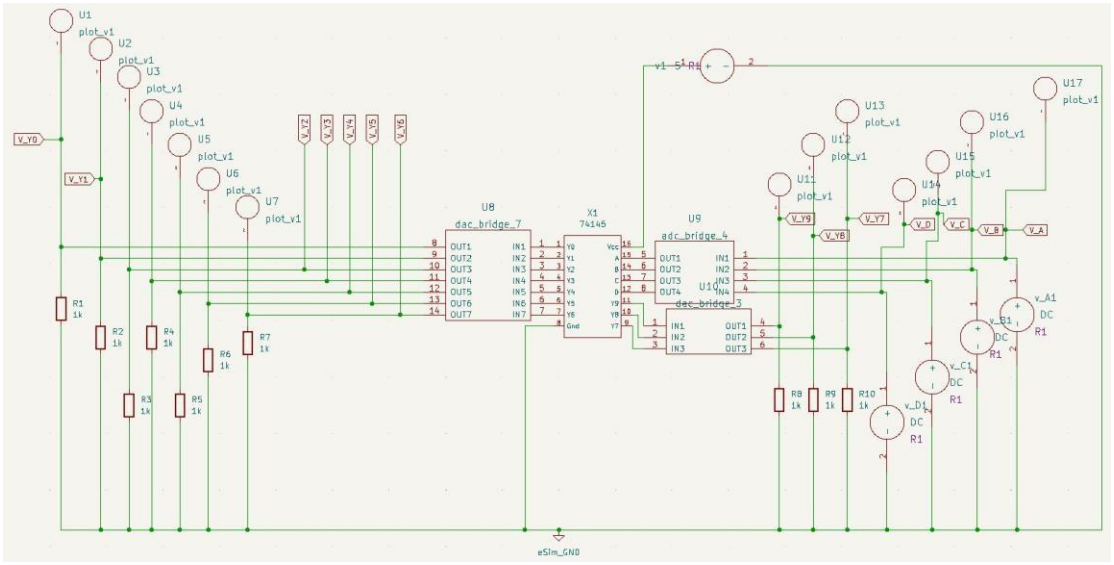


Figure 3.54: Simulation Circuit of 74145

3.9.5 Inputs

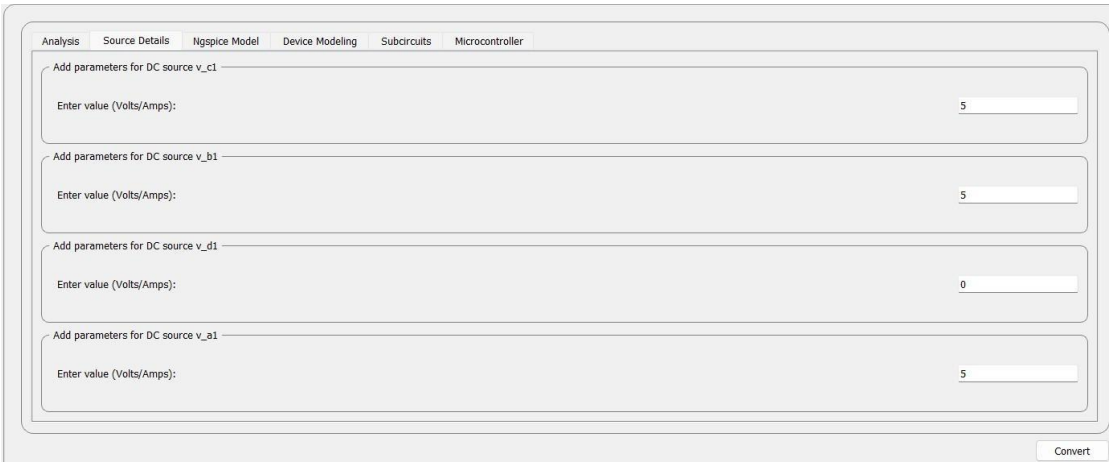


Figure 3.55: Inputs given to Simulation Circuit of 74145

3.9.6 Output Plot

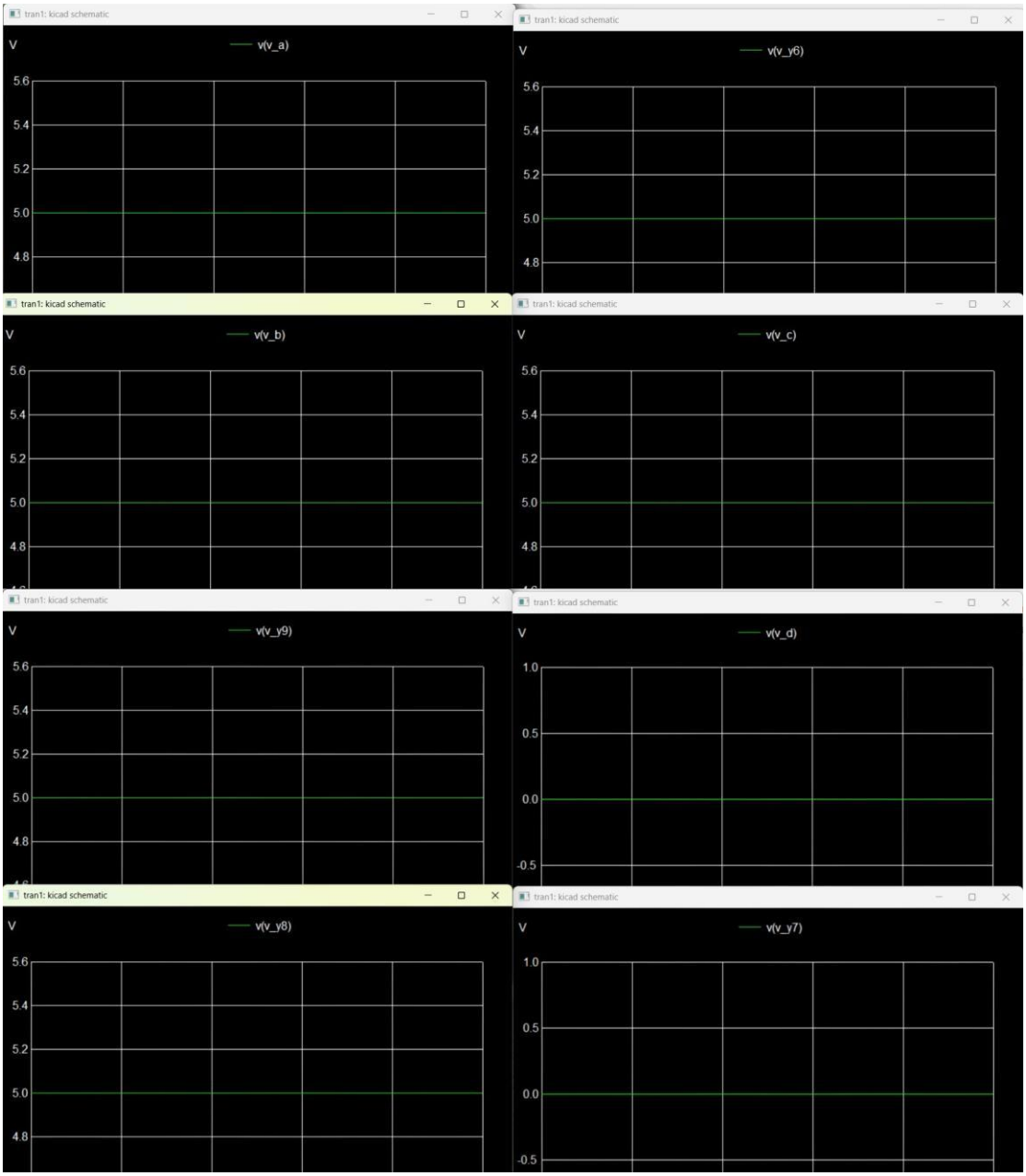


Figure 3.56: Output waveform of 74145

3.9.7 Output Plot

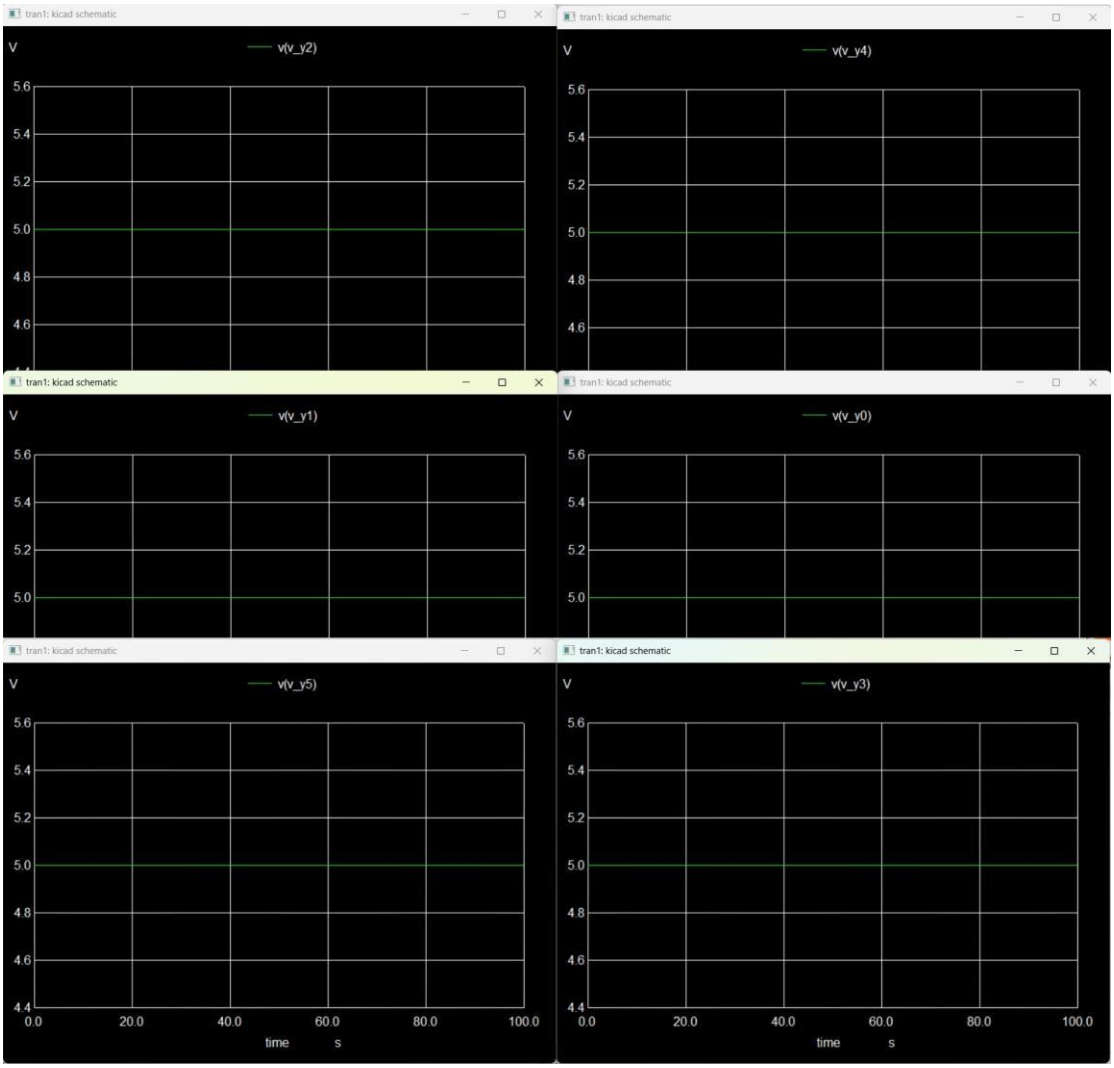


Figure 3.57: Output waveform of 74145

3.9.8 Functional Table

FUNCTION TABLE

NO.	INPUTS				OUTPUTS									
	D	C	B	A	0	1	2	3	4	5	6	7	8	9
0	L	L	L	L	L	H	H	H	H	H	H	H	H	H
1	L	L	L	H	H	L	H	H	H	H	H	H	H	H
2	L	L	H	L	H	H	L	H	H	H	H	H	H	H
3	L	L	H	H	H	H	H	L	H	H	H	H	H	H
4	L	H	L	L	H	H	H	H	L	H	H	H	H	H
5	L	H	L	H	H	H	H	H	H	L	H	H	H	H
6	L	H	H	L	H	H	H	H	H	H	L	H	H	H
7	L	H	H	H	H	H	H	H	H	H	H	L	H	H
8	H	L	L	L	H	H	H	H	H	H	H	H	L	H
9	H	L	L	H	H	H	H	H	H	H	H	H	H	L
INVALID	H	L	H	L	H	H	H	H	H	H	H	H	H	H
	H	L	H	H	H	H	H	H	H	H	H	H	H	H
	H	H	L	L	H	H	H	H	H	H	H	H	H	H
	H	H	L	H	H	H	H	H	H	H	H	H	H	H
	H	H	H	L	H	H	H	H	H	H	H	H	H	H
	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Figure 3.58: Truth Table for 74145

3.10 SN5473

3.10.1 Description

The SN5473 is a dual JK flip-flop with asynchronous clear inputs, designed for use in sequential logic systems such as counters, registers, and timing circuits. The JK configuration allows flexible operation including toggle, set, reset, and hold functions depending on the input conditions.

The asynchronous clear input provides immediate reset capability independent of the clock signal, which is useful during system initialization. The IC is designed for reliable operation in TTL logic environments. In this work, the flip-flop behavior was modeled and verified using clocked simulation inputs in eSim.

3.10.2 Pin Diagram

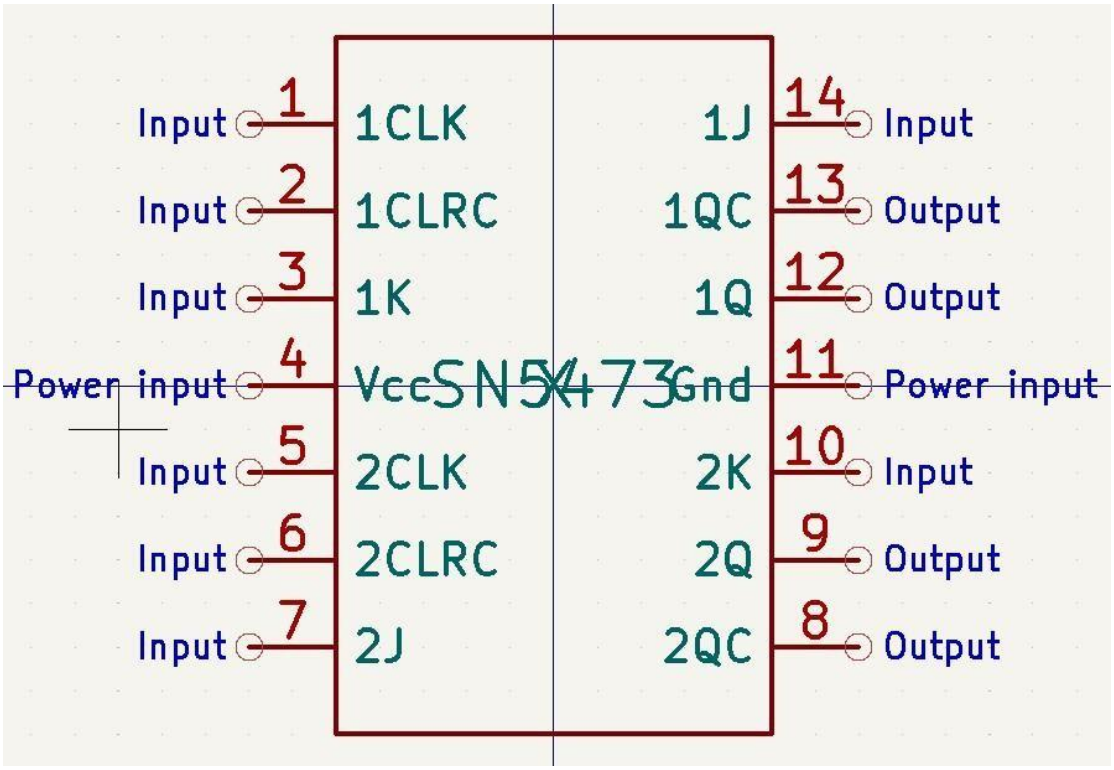


Figure 3.59: Pin Diagram of SN5473

3.10.3 Schematic Diagram

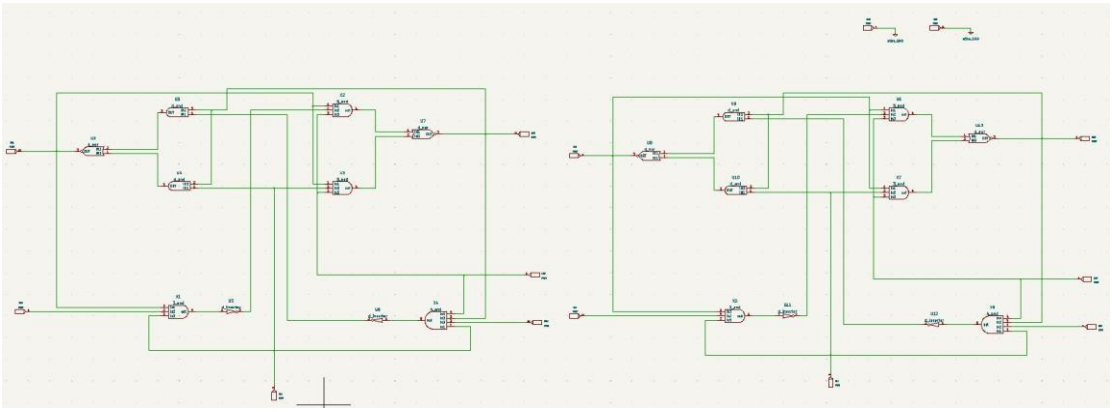


Figure 3.60: Schematic Diagram of SN5473

3.10.4 Simulation Circuit

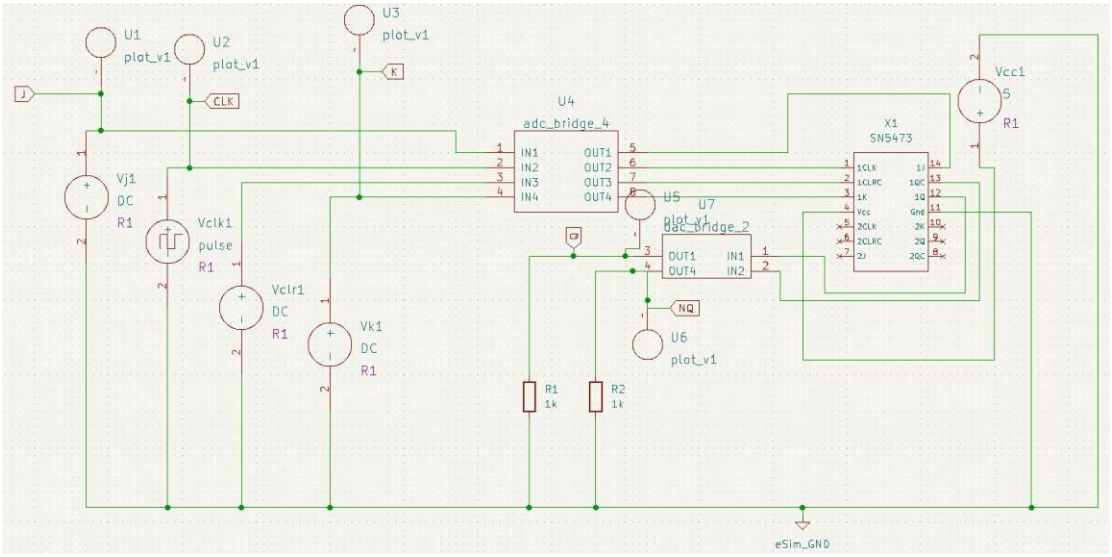


Figure 3.61: Simulation Circuit of SN5473

3.10.5 Inputs

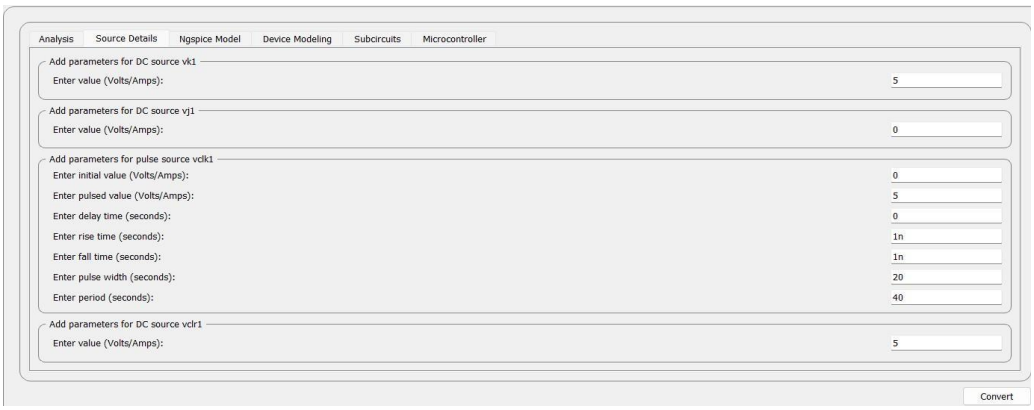


Figure 3.62: Inputs given to Simulation Circuit of SN5473

3.10.6 Output Plot

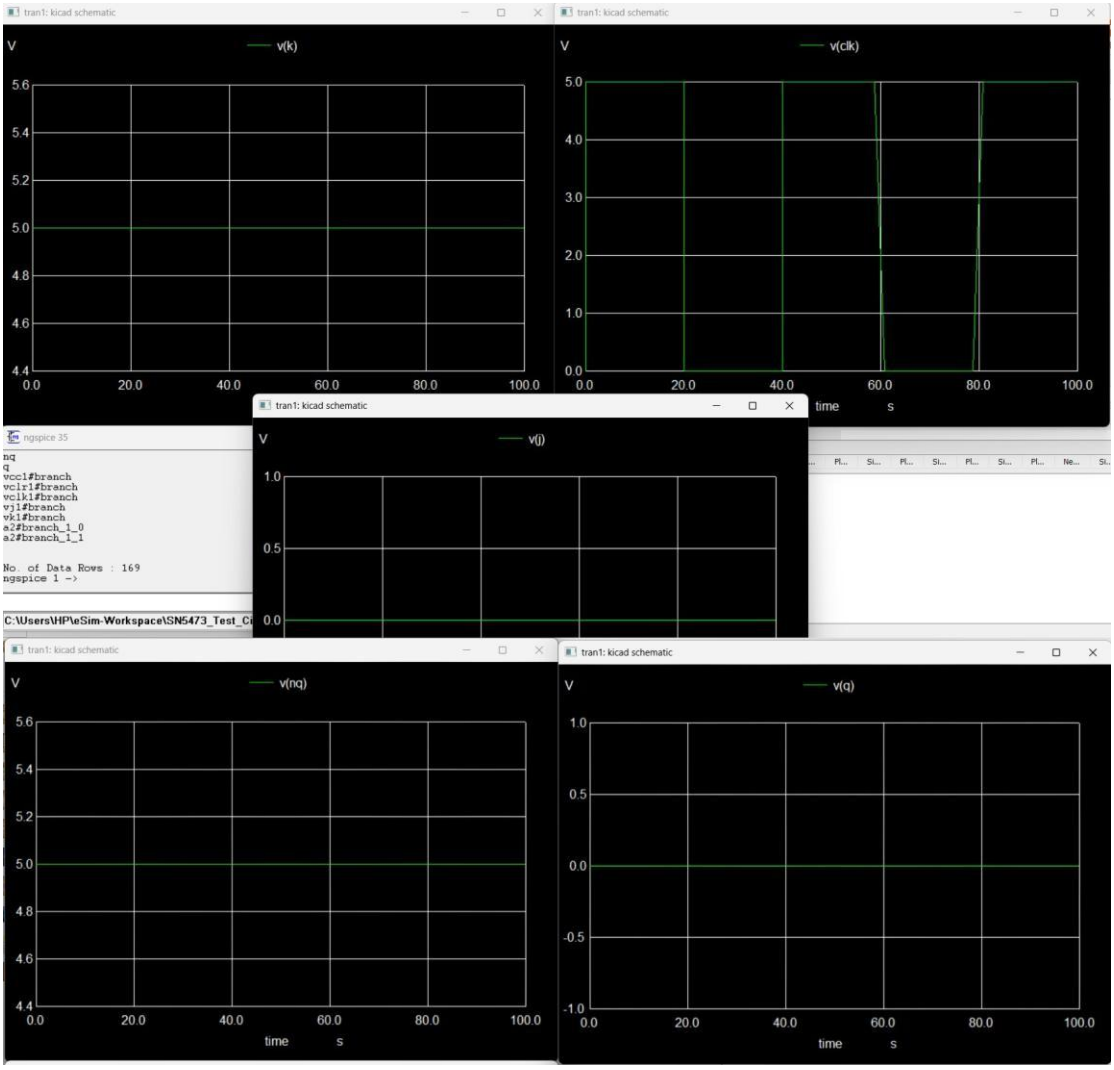


Figure 3.63: Output waveform of SN5473

3.10.7 Functional Table

'LS73A
FUNCTION TABLE

INPUTS				OUTPUTS	
$\overline{CLR}$	CLK	J	K	Q	$\overline{Q}$
L	X	X	X	L	H
H	↓	L	L	Q_O	$\overline{Q}_O$
H	↓	H	L	H	L
H	↓	L	H	L	H
H	↓	H	H	TOGGLE	
H	H	X	X	Q_O	$\overline{Q}_O$

Figure 3.64: Truth Table for SN5473

3.11 74HC4066

3.11.1 Description

The 74HC4066 is a quad bilateral analog switch IC that allows both analog and digital signals to pass in either direction when enabled.Each switch operates independently and can be controlled using a digital control input. This IC is commonly used in signal routing, analog multiplexing, and data acquisition systems.When the control input is high, the corresponding switch is closed, allowing the signal to pass through with low ON resistance. When the control input is low, the switch is opened, isolating the input and output terminals. In this internship, the bilateral switching behavior was modeled in eSim and verified by passing analog signals through the switch under different control conditions.

3.11.2 Pin Diagram

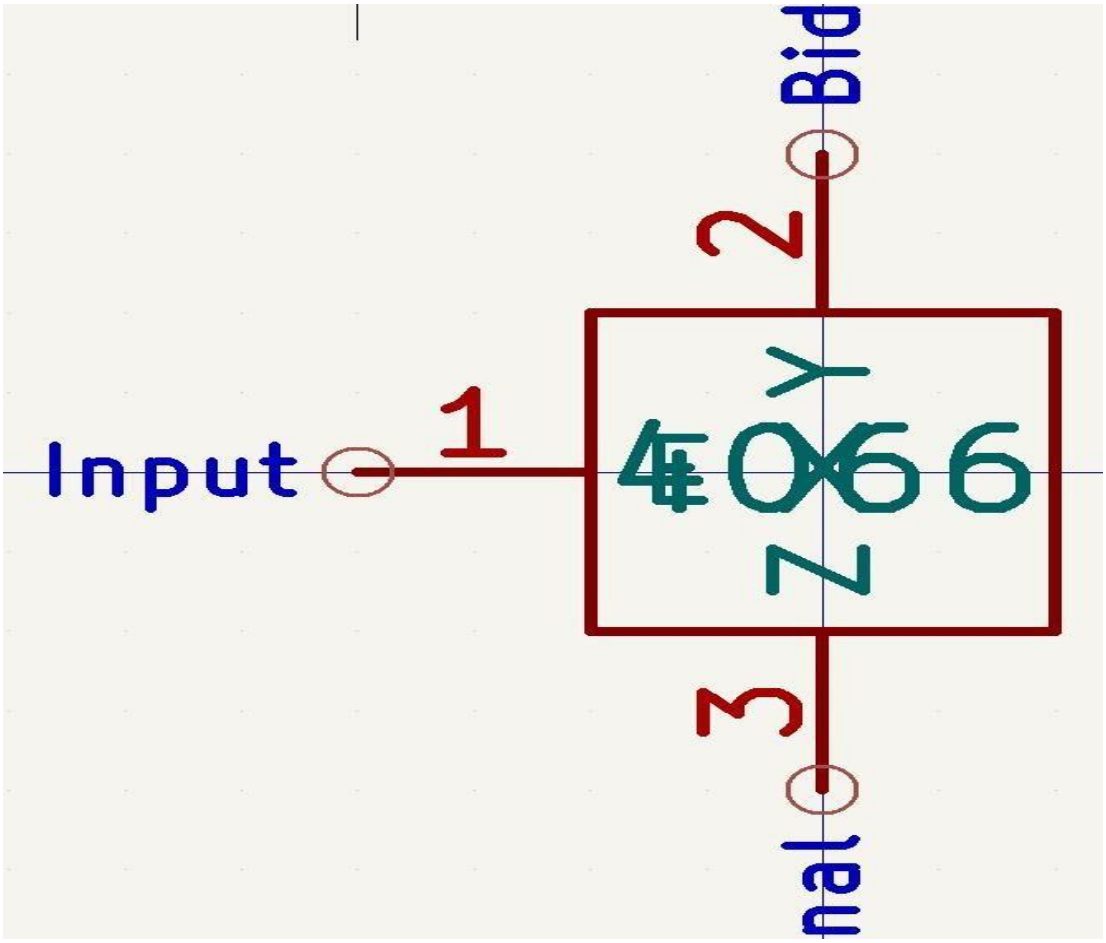


Figure 3.65: Pin Diagram of 74HC4066

3.11.3 Pin Diagram

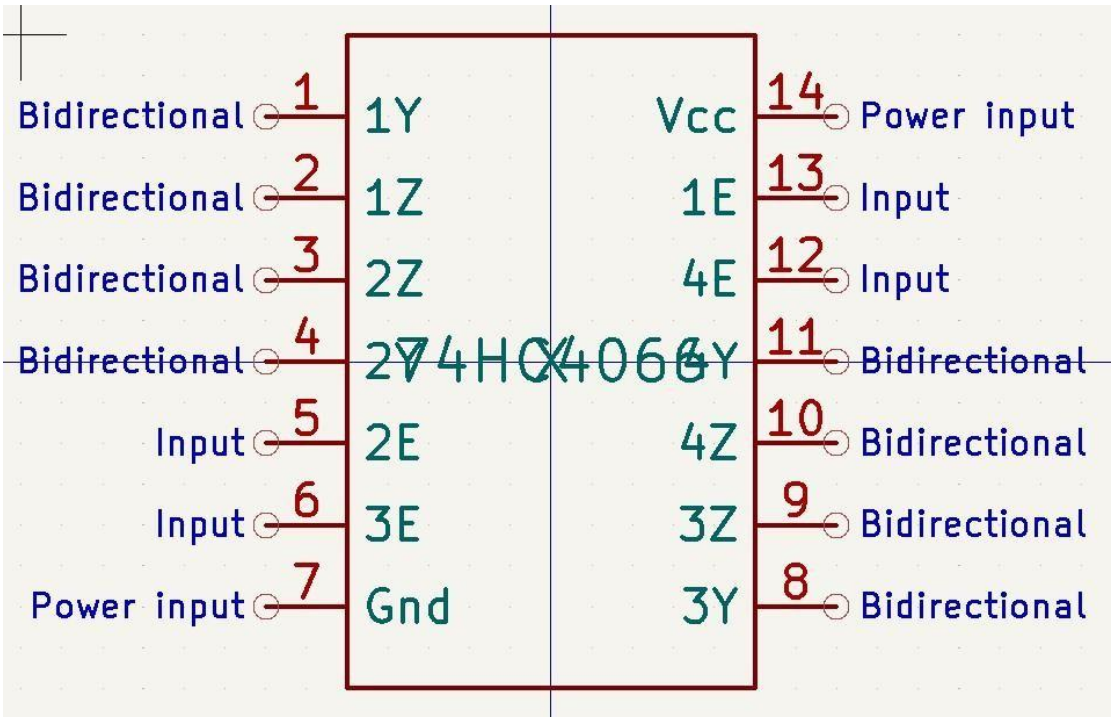


Figure 3.66: Pin Diagram of 74HC4066

3.11.4 Schematic Diagram

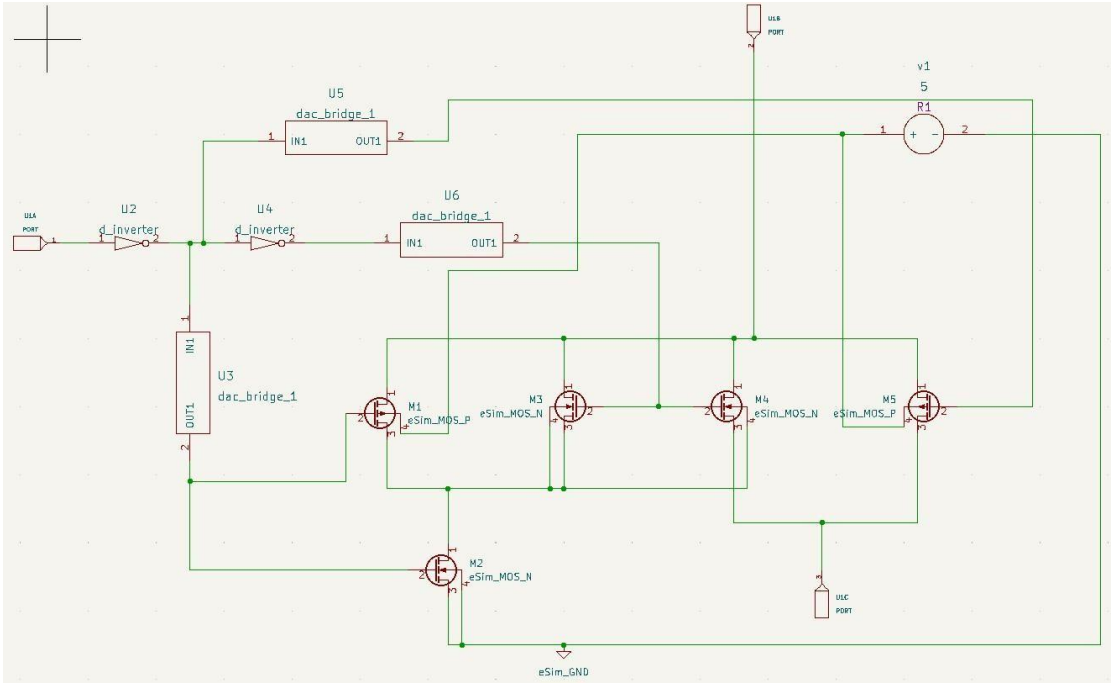


Figure 3.67: Schematic Diagram of 74HC4066

3.11.5 Schematic Diagram

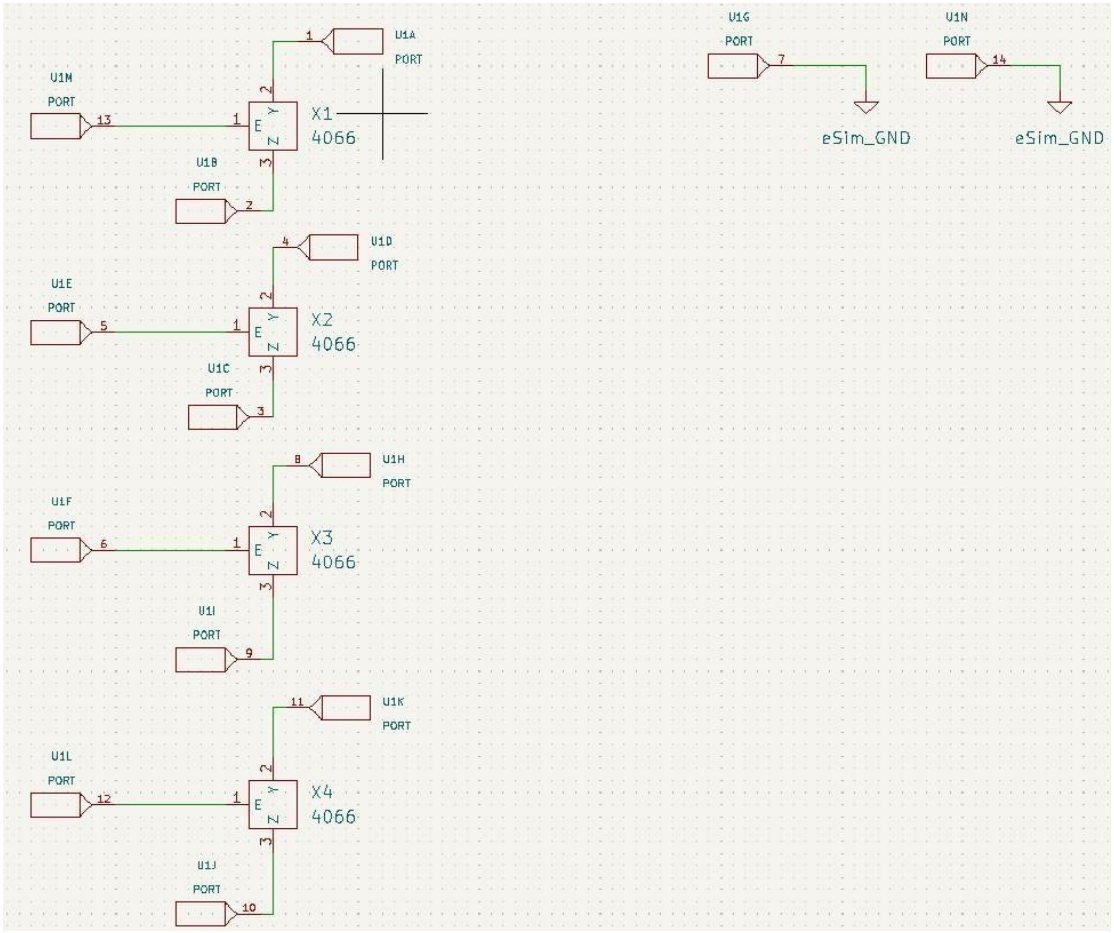


Figure 3.68: Schematic Diagram of 74HC4066

3.11.6 Simulation Circuit

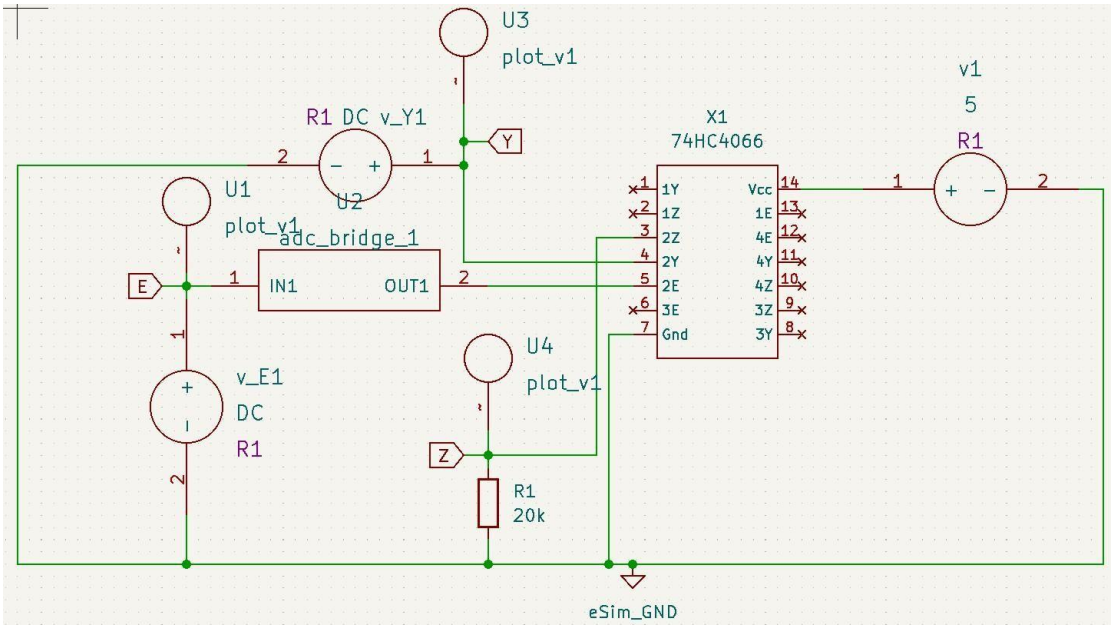


Figure 3.69: Simulation Circuit of 74HC4066

3.11.7 Inputs

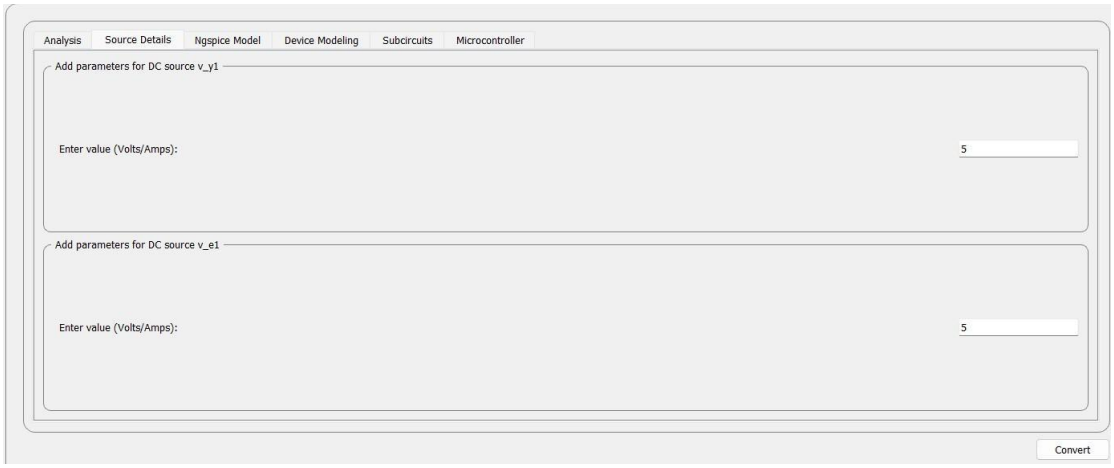


Figure 3.70: Inputs given to Simulation Circuit of 74HC4066

3.11.8 Output Plot

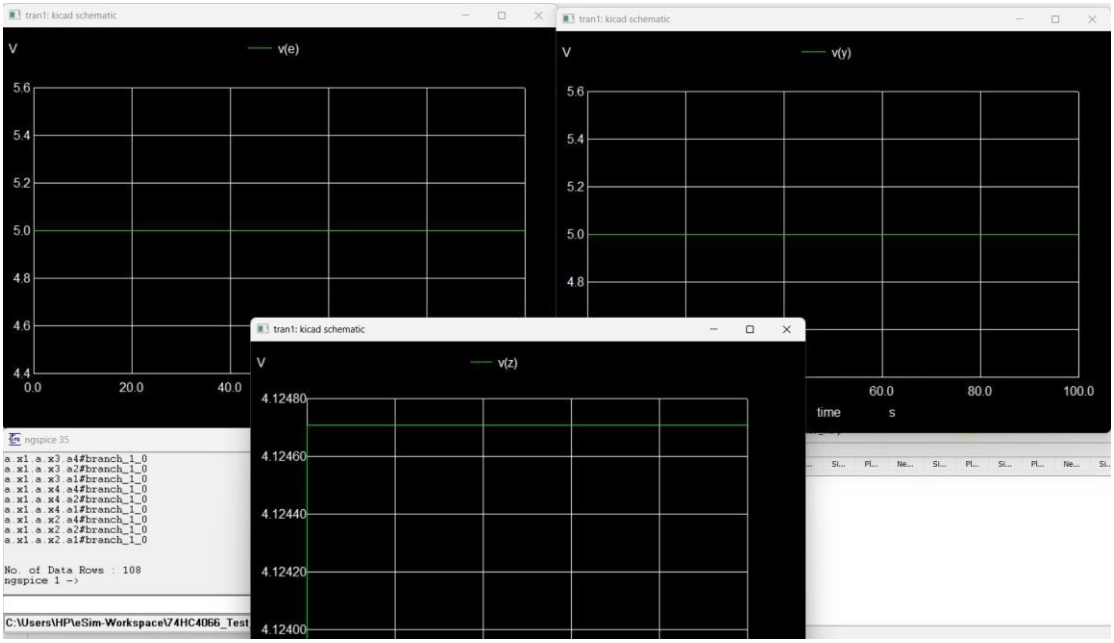


Figure 3.71: Output waveform of 74HC4066

3.12 LH0003

3.12.1 Description

The LH0003 is a high-speed buffer amplifier designed for applications requiring impedance matching, signal conditioning, and isolation between circuit stages. It is capable of driving low-impedance loads while maintaining signal integrity, making it suitable for analog signal processing systems.

This IC is often used in data acquisition systems, instrumentation circuits, and high-speed communication interfaces. During this internship, the LH0003 was modeled as an analog subcircuit in eSim and its buffering behavior was verified by observing the output response for varying input signals and load conditions.

3.12.2 Pin Diagram

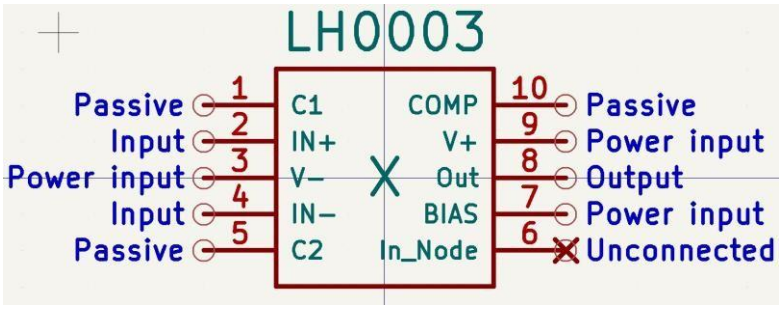


Figure 3.72: Pin Diagram of LH0003

3.12.3 Schematic Diagram

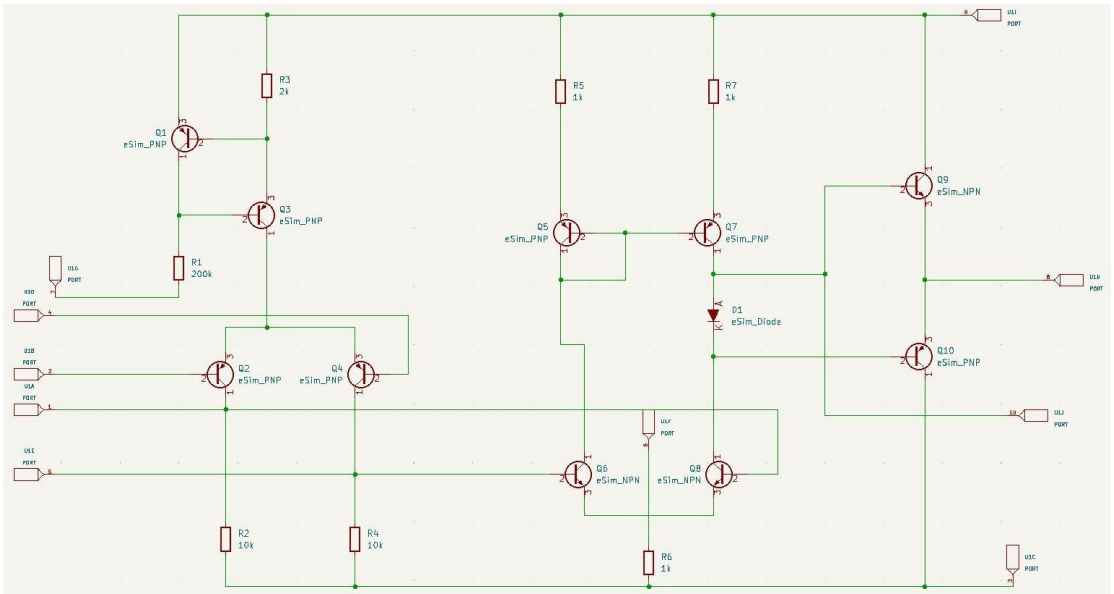


Figure 3.73: Schematic Diagram of LH0003

3.12.4 Simulation Circuit

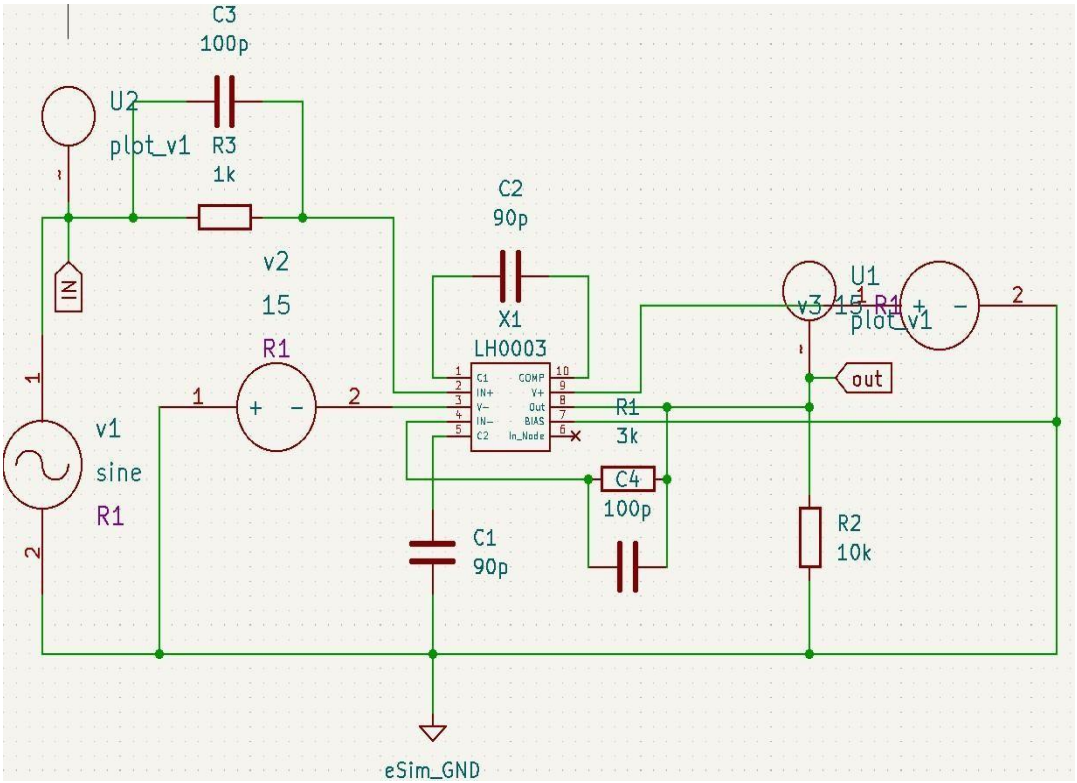


Figure 3.74: Simulation Circuit of LH0003

3.12.5 Output Plot

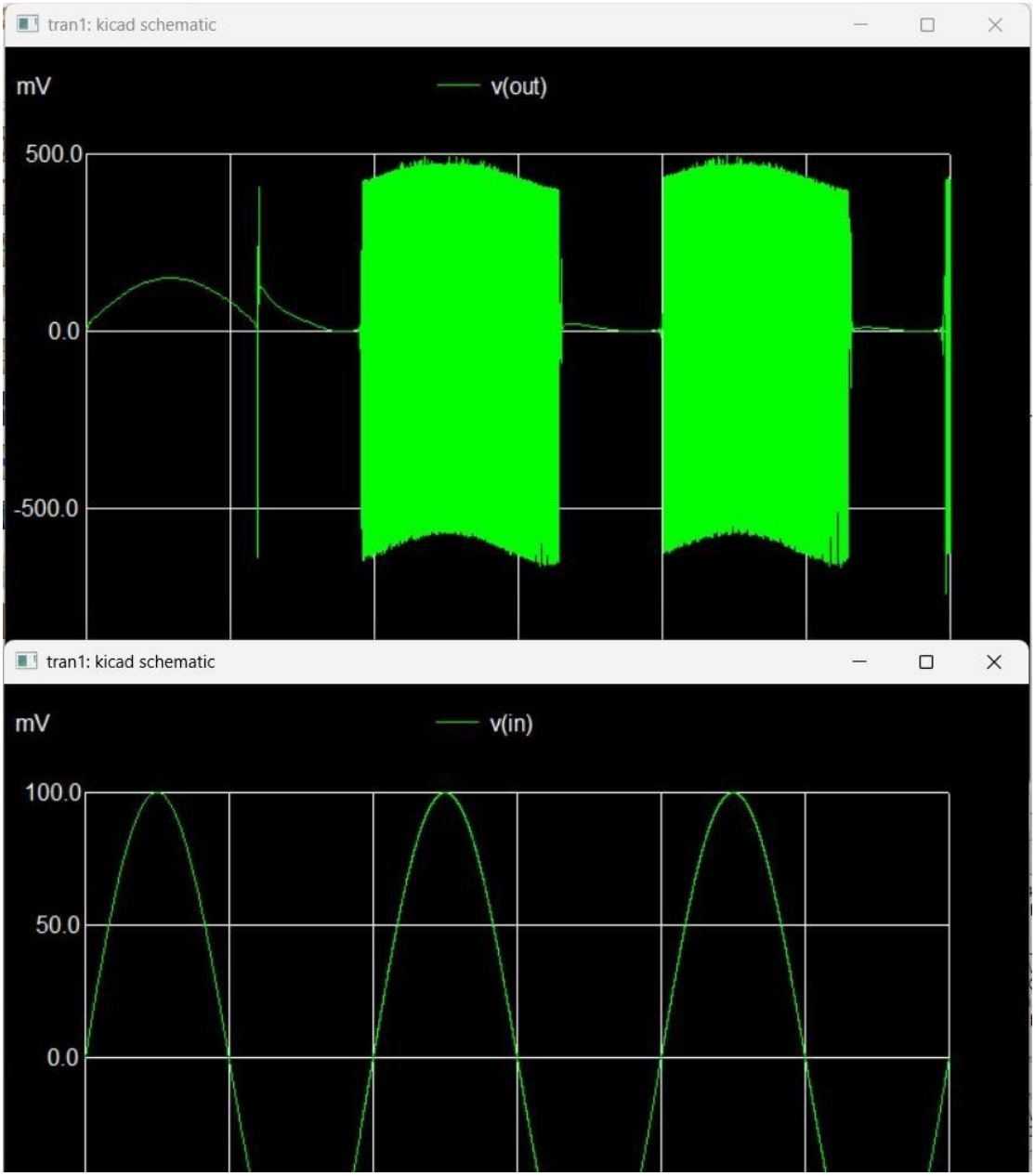


Figure 3.75: Output waveform of LH0003

Chapter 4

Conclusion and Future Scope

The project successfully achieved its objective of contributing a comprehensive set of accurately modeled integrated circuits to the eSim subcircuit library. Each IC was implemented by carefully analyzing its respective datasheet and was validated through appropriate simulation test circuits to ensure correct functionality and reliability. The contributions include a combination of widely used digital logic ICs and essential analog components, such as logic gates, multiplexers, decoders, flip-flops, buffers, bus transceivers, adders, comparators, and frequency detection circuits.

These IC models serve as fundamental building blocks for designing and simulating complex electronic systems within the eSim environment. By integrating these verified subcircuits into the eSim library, the project enhances the platform's usability for students, educators, and researchers engaged in digital and mixedsignal circuit design. The availability of these models supports practical learning, experimentation, and rapid prototyping of real-world applications.

This initiative highlights the significance of open-source Electronic Design Automation tools in academic and research domains. As the eSim device library continues to expand, it is expected to attract wider adoption within the engineering community and enable the development of more advanced and integrated circuit designs. The outcomes of this work represent a valuable contribution toward strengthening the open-source ecosystem for circuit design and simulation.

Chapter 5

Circuits Contribution

This chapter presents the list of Integrated Circuits (ICs contributed during the internship. Each IC has been carefully modeled, verified through simulation, and successfully added to the eSim subcircuit library. The contributions include both digital and analog ICs covering a broad range of functionalities commonly used in electronic system design. List of ICs Contributed

- 74LS48 – BCD to 7-Segment Decoder
- 74C04 – Hex Inverter
- 74HC386 – Quad XOR Gate
- 74LS85 – 4-Bit Magnitude Comparator
- 74LS112 – Dual JK Flip-Flop
- 74LS126 – Quad Tri-State Buffer
- 74LS153 – Dual 4-to-1 Multiplexer
- 74LS251 – 8-to-1 Multiplexer
- 74145 – BCD to Decimal Decoder
- SN5473 – JK Flip-Flop
- 74HC4066 – Quad Bilateral Analog Switch
- LH0003 – High-Speed Buffer Amplifier

Chapter 6

Bibliography

- https://www.alldatasheet.com/datasheet-pdf/pdf/27442/TI/74LS48.html
- https://www.alldatasheet.com/datasheetpdf/pdf/230204/FAIRCHILD/74C04.html
- https://www.alldatasheet.com/datasheet-pdf/pdf/15584/PHILIPS/74HC30.html
- https://www.alldatasheet.com/datasheet-pdf/pdf/12664/ONSEMI/74LS85.html
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- https://www.alldatasheet.com/datasheet-pdf/pdf/836814/TI1/LH0003.html