Winter Internship Report

On

Integrated Circuit Design using Subcircuit feature of eSim

Submitted by

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Under the guidance of

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Acknowledgment

We take this occasion to offer our heartfelt gratitude to the FOSSEE, IIT Bombay Team for offering us this wonderful opportunity to work on the design and integration of multiple sub-circuits in eSim. Working on eSim has prov ided us with invaluable insights into various open-source EDA tools for circuit simulation and their applications in the practical world.

We extend our sincere regards to Prof. Kannan M. Moudgalya for his valuable guidance and motivation to throughout this fellowship program.

We would like to express our heartfelt appreciation to the entire FOSSEE team including our mentors Mr. Sumanto Kar, Mrs. Vineeta Ghavri, and Mrs. Usha Vishwanathan for constantly guiding and mentoring us throughout the duration of our internship.

It is with their support that we have been able to fulfill our project demands successfully. Whenever faced with an issue, our mentors were always accessible to help us assess and debug them. Our learnings from them have been invaluable and shall be of paramount importance to us in the future.

Overall, it was a delightful experience interning at FOSSEE and contributing to its growth and I take away some great insights and knowledge from it. As enthusiastic beginners in the semiconductor industry, this internship is a milestone for us in our pursuit of a successful career.

Contents

Chapter 1

Introduction

FOSSEE which stands for Free/Libre and Open Source Software for Education is an organization, based at IIT Bombay, as a remarkable initiative aimed at promoting the use of open-source software in education and research. It was established with the mission to reduce the dependency on proprietary software and to encourage the adoption of open-source alternatives. FOSSEE offers a wide range of tools and resources that cater to various academic and professional needs.

It provides comprehensive documentation, tutorials, workshops, and hands-on training sessions, for empowering students, educators, and professionals to leverage open-source software for their projects and coursework. The organization's commitment to fostering a collaborative and inclusive environment has significantly contributed to the democratization of technology and has opened up new avenues for innovation and learning.

1.1 eSim

eSim, created by the FOSSEE project at IIT Bombay, is a versatile open-source software tool for circuit design and simulation. It combines various open-source software packages into one cohesive platform, making it easier to design, simulate, and analyze electronic circuits. This tool is particularly useful for students, educators, and professionals who need an affordable and accessible alternative to proprietary software.

eSim offers features for schematic creation, circuit simulation, PCB design, and includes an extensive library of components. The Subcircuit feature is a significant enhancement, enabling users to design complex circuits by integrating simpler subcircuits. Through eSim, FOSSEE promotes the use of open-source solutions in engineering education and professional fields, encouraging innovation and collaboration.

1.2 NgSpice

NgSpice is the open-source spice simulator for electric and electronic circuits. Such a circuit may comprise JFETs, bipolar and MOS transistors, passive elements like R, L, or C, diodes, transmission lines and other devices, all interconnected in a netlist.

Digital circuits are simulated as well, event-driven and fast, from single gates to complex circuits and the combination of both analog and digital as well as a mixed-signal circuits. NgSpice offers a wealth of device models for active, passive, analog, and digital elements. Model parameters are provided by our collections, by the semiconductor device manufacturers, or from semiconductor foundries. The user adds her circuits as a netlist, and the output is one or more graphs of currents, voltages and other electrical quantities or is saved in a data file.

1.3 Makerchip

Makerchip is a platform that offers convenient and accessible access to various tools for digital circuit design. It provides both browser-based and desktop-based environments for coding, compiling, simulating, and debugging Verilog designs. Makerchip supports a combination of open-source tools and proprietary ones, ensuring a comprehensive range of capabilities.

One can simulate Verilog/SystemVerilog/Transaction-Level Verilog code in Makerchip. eSim is interfaced with Makerchip using a Python based application called Makerchip-App which launches the Makerchip IDE. Makerchip aims to make circuit design easy and enjoyable for users of all skill levels. The platform provides a user-friendly interface, intuitive workflows, and a range of helpful features that simplify the design process and enhance the overall user experience.

The main drawback of these open source tools is that they are not comprehensive. Some of them are capable of PCB design (e.g. KiCad) while some of them are capable of performing simulations (e.g. gEDA). To the best of our knowledge, there is no open source software that can perform circuit design, simulation and layout design together. eSim is capable of doing all of the above.

Chapter 2

Feautures Of eSim

The objective behind the development of eSim is to provide an open source EDA solution for electronics and electrical engineers. The software should be capable of performing schematic creation, PCB design and circuit simulation (analog, digital and mixed-signal). It should provide facilities to create new models and components. Thus, eSim offers the following features -

1. Schematic Creation: eSim provides an easy-to-use graphical interface for drawing circuit schematics, making it accessible for users of all levels. Users can drag and drop components from the library onto the schematic, simplifying the design process. Comprehensive editing tools allow for easy modification of schematics, including moving, rotating, and labeling components.

2. Circuit Simulation: eSim supports SPICE (Simulation Program with Integrated Circuit Emphasis), a standard for simulating analog and digital circuits. Users can perform various types of analysis such as transient, AC, and DC, providing insights into circuit behavior over time and frequency.An integrated waveform viewer helps visualize simulation results, aiding in the analysis and debugging of circuit designs.

3. PCB Design: The PCB layout editor allows users to place components and route traces with precision. eSim includes DRC capabilities to ensure that the PCB design adheres to manufacturing constraints and electrical rules. Users can generate Gerber files, which are standard for PCB fabrication, directly from their designs.

4. Subcircuit Feature: This feature enables users to create complex circuits by integrating smaller, simpler subcircuits, promoting modular and hierarchical design approaches. Subcircuits can be reused in different projects, saving time and effort in redesigning common circuit elements.

5. Open Source Integration: eSim integrates several open-source tools like KiCad, Ngspice, and GHDL, providing a comprehensive suite for electronic design automation. Being open-source, eSim is free to use, making advanced circuit design tools accessible without the need for expensive licenses.

Chapter 3

Problem Statement

To design and develop various Analog and Digital Integrated Circuit Models in the form of sub-circuits using device model files already present in the eSim library. These IC models should be useful in the future for circuit designing purposes by developers and users, once they get successfully integrated into the eSim subcircuit Library.

3.1 Approach

Our approach to implementing the problem statement began with examining datasheets from prominent Integrated Circuit (IC) manufacturers such as Texas Instruments, Analog Devices, and NXP Semiconductors. we selected ICs that offer a diverse range of functionalities, including precision amplifiers, comparators, encoders, and audio amplifiers. After building the subcircuits, we tested them to verify basic circuit configurations using NgSpice simulations. The step-by-step roadmap of this process is outlined below :

1. Analyzing Datasheets : The primary step is to browse through various analog and digital IC datasheets, and hence find suitable circuits to implement in eSim, that are not previously included into the eSim library. Check for the detailed schematic of the IC's and once the component values and the truth table is ascertained, then finalise the IC to be created.

2. Subcircuit Creation : After deciding the IC, we start modeling it as a sub-circuit in eSim, using the model files present in the eSim device model library only. The design is strictly according to the information given in the official data-sheets of the ICs.This step also includes building the Symbol/Pin diagram of the IC according to the packaging and pin description given in the data-sheets only.

3. Test Circuit Design : Once the component of the IC is ready, now we can build the test circuits, according to the data-sheets. In this step we build the test cases and test circuits using the component IC.

4. Schematic Testing : Once the test circuits are ready, now it's time to simulate the test circuits so that the output can be obtained in the form of wave-forms and plots. Here we take help of KiCad to NgSpice conversion and Simulation feature in eSim

If the output of the test circuit is not as per expectation, this implies that the test case has failed, and there is some error in the schematic. In such cases we go back to the design phase of the IC or the test circuits, to look for possible errors and then repeat the testing process again after making required changes.

Once the expected output of the test cases are correct and satisfy the expected results, then in such a case the IC is declared successfully working. The test case has been verified and the designing process is complete.

Chapter 4

Analog IC's

4.1 LM392-N low-power operational amplifier and voltage comparator

The LM392 is an integrated circuit that combines a low-power operational amplifier and a voltage comparator in a single package. It is designed to function efficiently across a broad voltage range, making it suitable for battery-operated and low-power applications. The device features an op-amp for signal amplification and a comparator for voltage level detection, offering versatility in analog circuit design.

Key Characteristics:

1. Low Power Consumption : Suitable for energy-efficient designs

2. Wide Operating Voltage Range : Functions within 3V to 32V (single supply) or ±1.5V to ±16V (dual supply).

3.High Input Impedance : Ensures minimal loading on input signals.

4. Comparator with Open-Collector Output : Allows easy interfacing with digital logic circuits.

5. Internal Frequency Compensation : Provides stable operation without external components.

6. Internal Frequency Compensation : Includes ground level, enhancing flexibility in single-supply applications .

Common application

The LM392 finds use in various domains requiring signal amplification and threshold detection, including

- **1.Power Management:** Monitoring battery levels. Detecting under-voltage or over-voltage conditions in circuits.
- **2.Sensor-Based Applications:** Conditioning signals from temperature or light sensors. Implementing threshold detection in environmental monitoring systems.
- **3.Automotive Systems:** Voltage monitoring in vehicle electronics. Safety and diagnostic circuits.
- **4.Industrial Automation:** Process control applications. Motor feedback systems and fault detection.
- **5.Consumer Electronics:** Battery-powered devices needing efficient power use. Basic signal amplification in audio applications.
- **6.Alarm Systems:** Motion detection and security alerts based on sensor input. Voltage level-based triggering mechanisms.

4.1.1 Ic Layout

This figure represents the 9-Pin Package Diagram of the LM392-N low-power operational amplifier and voltage comparator

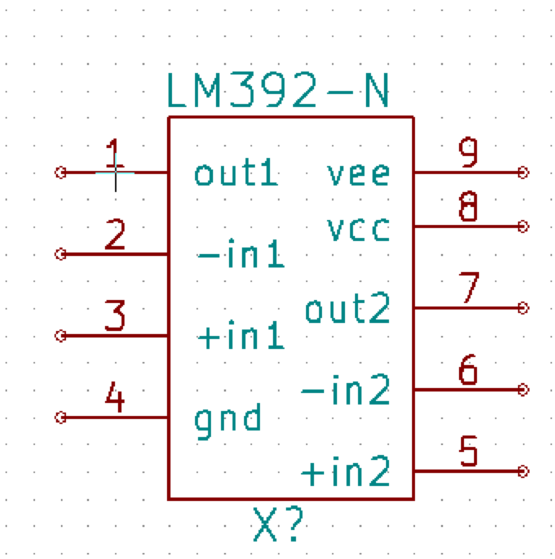

Figure 4.1: LM392-N low-power operational amplifier and voltage comparator

4.1.2 Subcircuit Schematic Diagram

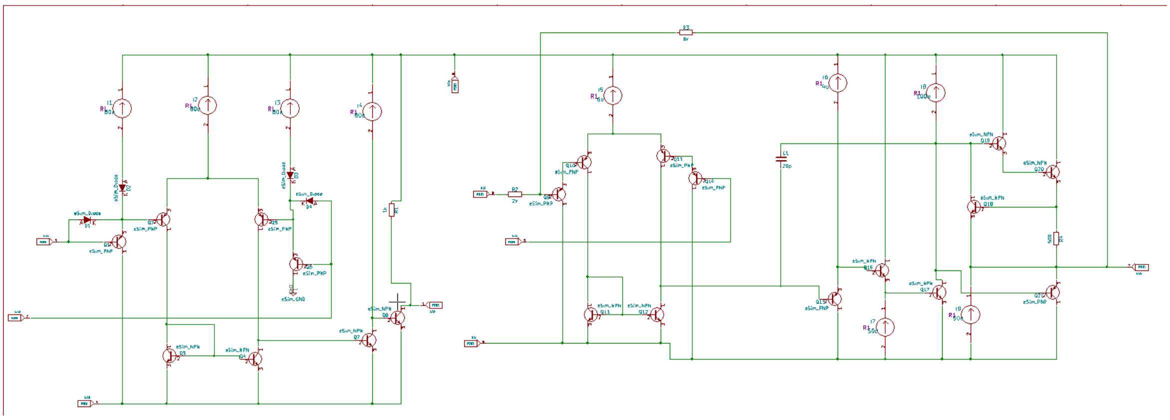

Figure 4.2: Subcircuit Schematic of LM392-N

4.1.3 Test Circuit

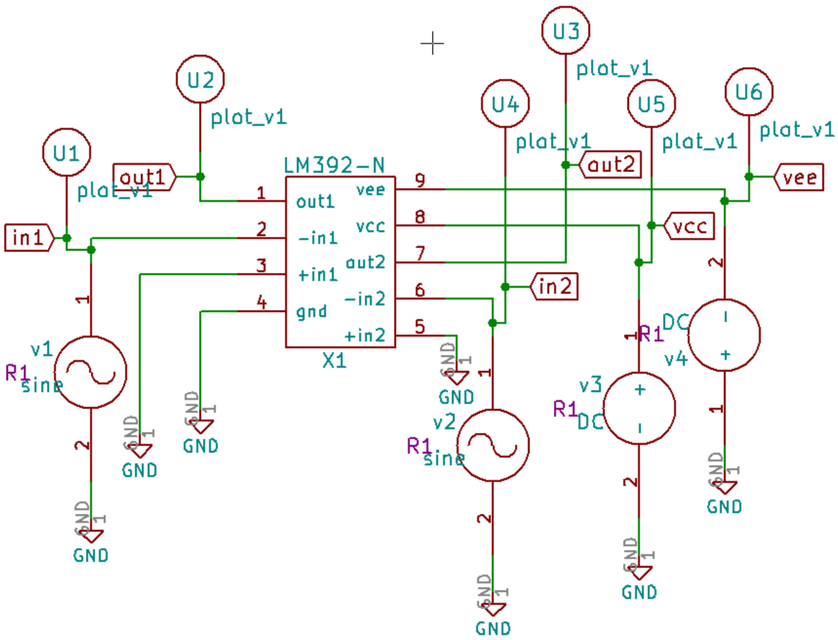

Figure 4.3: Test Circuit of LM392-N IC

4.1.4 Input Plot 1

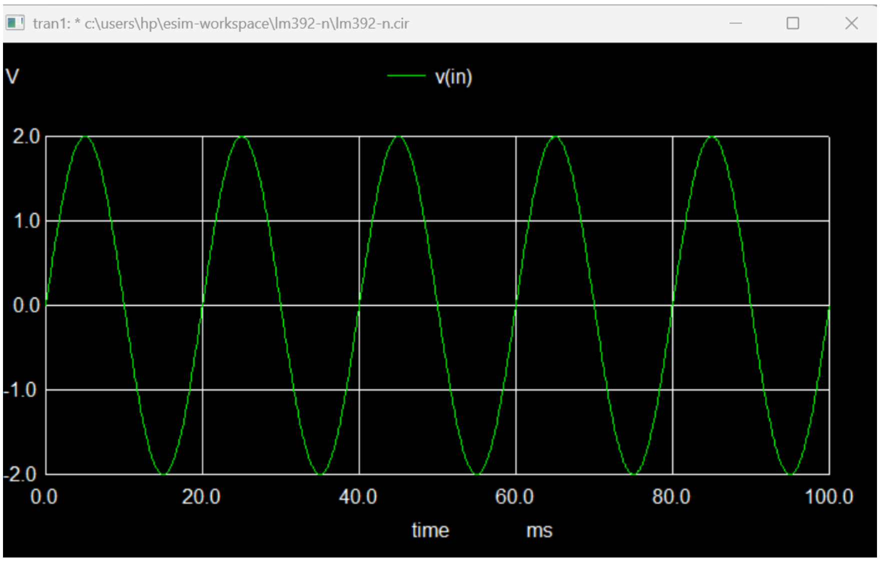

Figure 4.4: First Input Voltage Waveform of LM392-N

4.1.5 Input Plot 2

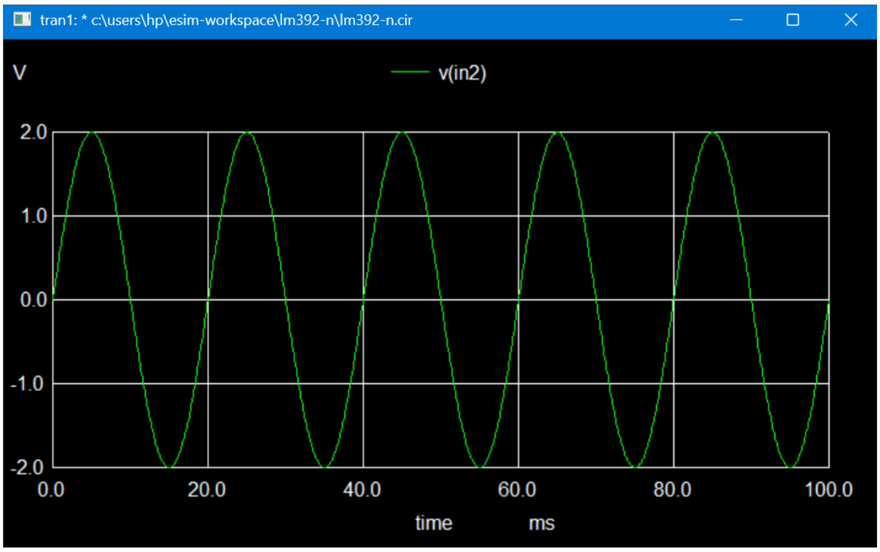

Figure 4.5: Second Input Voltage Waveform of LM392-N

4.1.6 Output Plot 1

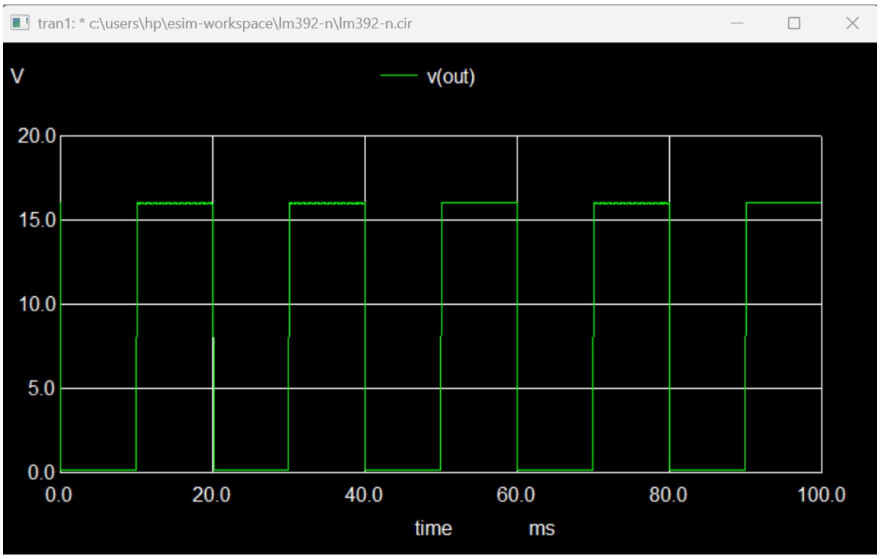

Figure 4.6: First Output Voltage Waveform of LM392-N

4.1.7 Output Plot 2

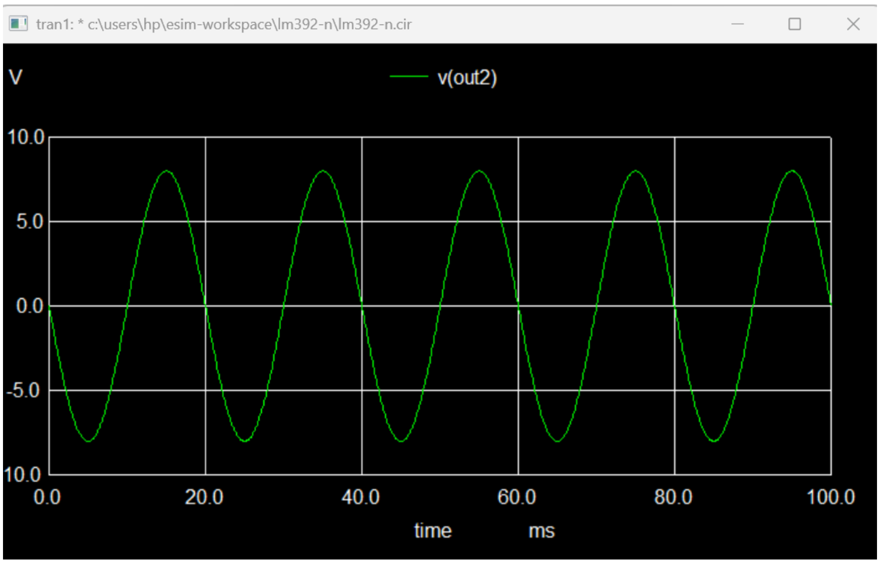

Figure 4.7: Second Output Voltage Waveform of LM392-N

4.2 LM6511 180 ns 3V Comparator

Description: The LM6511180 is a high-speed, low-power voltage comparator designed to operate at a low supply voltage of 3V. It offers fast response times with minimal power consumption, making it ideal for applications requiring precise signal threshold detection. The comparator features an open-drain output, allowing easy interfacing with various logic circuits. Its wide input voltage range and low offset voltage enhance accuracy in critical applications.

Applications:

- **Battery-Powered Devices:**: Efficient power monitoring and low-voltage detection.
- **Sensor Signal Processing:**: Threshold detection in temperature, light, and motion sensors.
- **Power Management Systems:** Over-voltage and under voltage monitoring.
- **Embedded Systems:** Integration with micro controllers for decision-making based on analog signals.
- **Consumer Electronics:** Used in devices like alarms, power-saving circuits, and automatic shutdown systems

4.2.1 IC Layout

This figure represents the 8-Pin Package Diagram of the LM6511 180 ns 3V Comparator

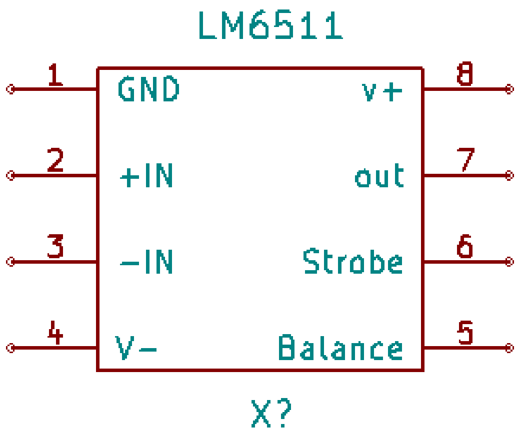

Figure 4.8: LM6511 180 ns 3V Comparator

4.2.2 Subcircuit Schematic Diagram

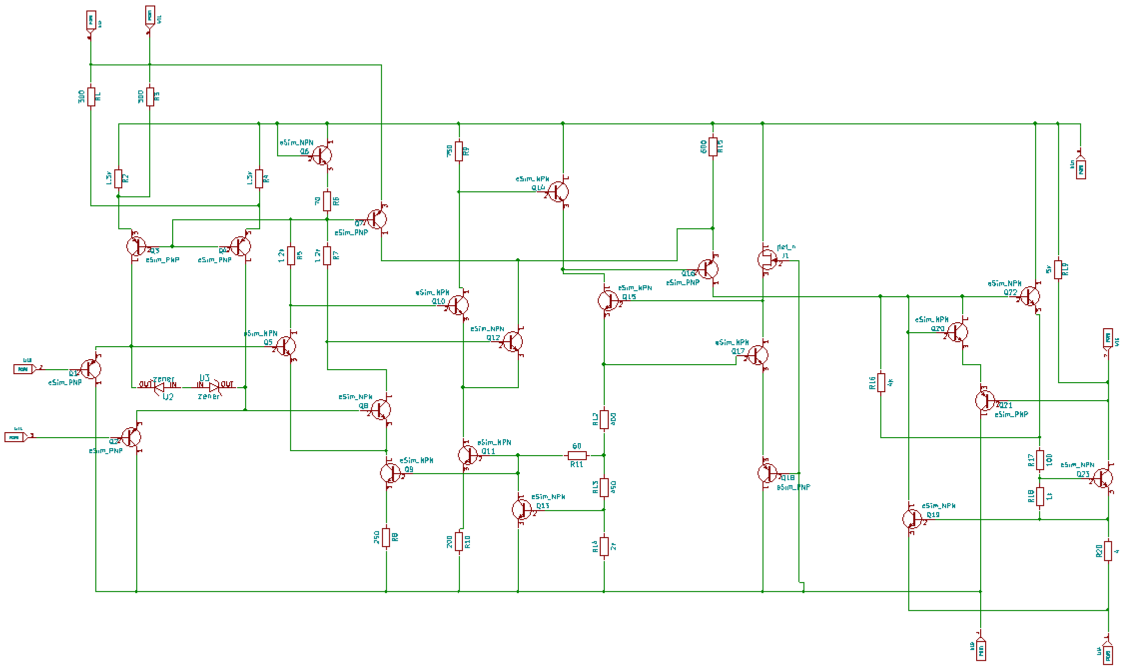

Figure 4.9: Subcircuit Schematic of LM6511

4.2.3 Test Circuit

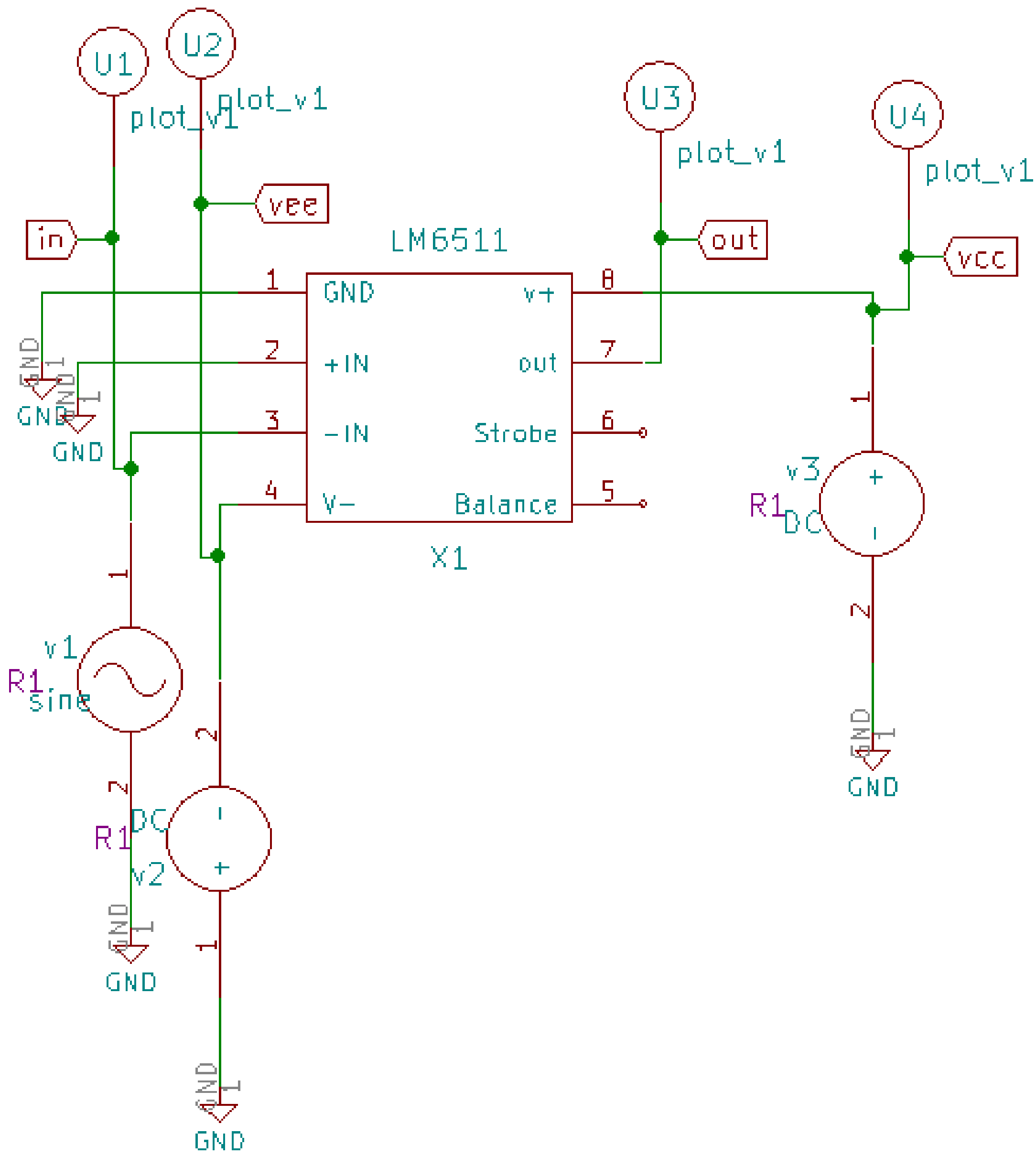

Figure 4.10: Test Circuit of LM6511 IC

4.2.4 Input Plot

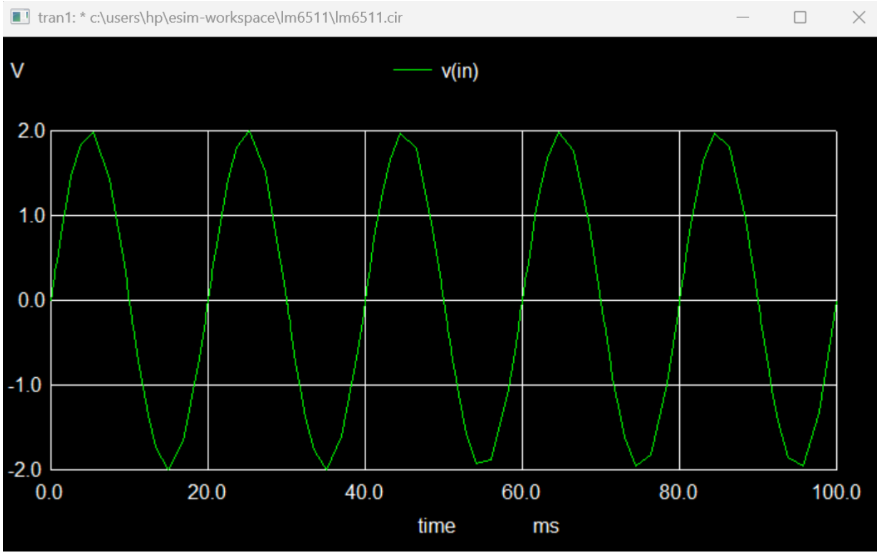

Figure 4.11: Input Voltage Waveform of LM6511

4.2.5 Outptut Plot

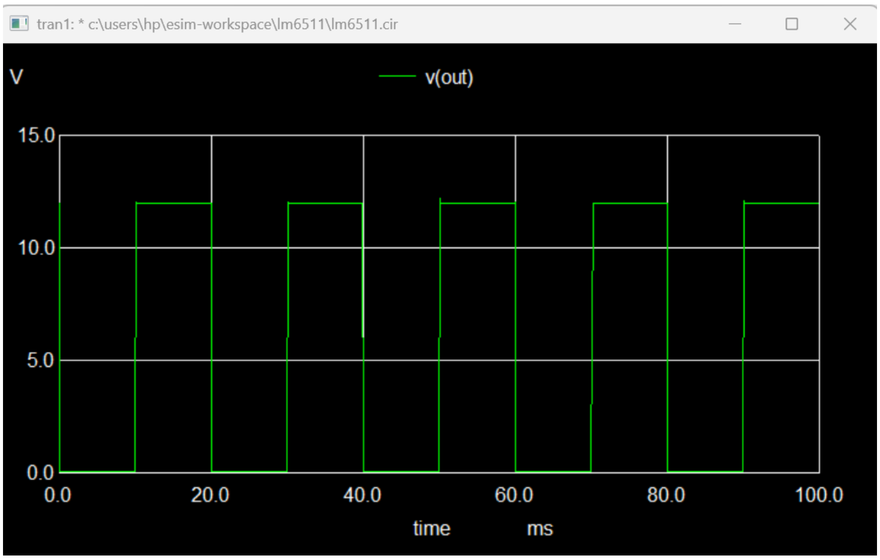

Figure 4.12: Output Voltage Waveform of LM6511

4.3 LMV331 Single, general-purpose low-voltage comparators

The LMV331 is a single-channel, general-purpose, low-voltage comparator designed for operation in low-power applications. It operates with a supply voltage as low as 2.7V and up to 5V, making it suitable for battery-operated devices. The device features an open-drain output, allowing easy interfacing with logic circuits. It offers fast response times, low offset voltage, and low power consumption, making it ideal for precision voltage monitoring and comparison tasks.

Applications of LMV331:

- **Voltage detection** : Monitors input voltage levels for threshold crossing.
- **Battery monitoring** :Tracks battery voltage to prevent over-discharge.
- **Zero-crossing detection**: Identifies AC signal transitions for timing applications.
- **Sensor interfacing**:Compares sensor outputs for control decisions.
- **Protection circuits:** Helps in overvoltage and overcurrent protection systems.

4.3.1 IC Layout

This figure represents the 5-Pin Package Diagram of the LMV331 Single, General-purpose Low-voltage Comparators

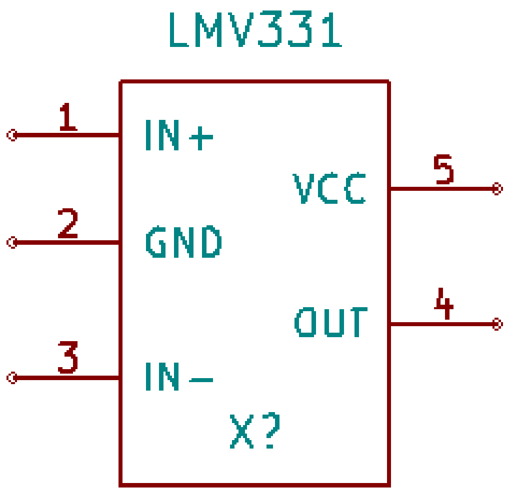

Figure 4.13: LMV331 Single, General-purpose Low-voltage Comparators

4.3.2 Subcircuit Schematic Diagram

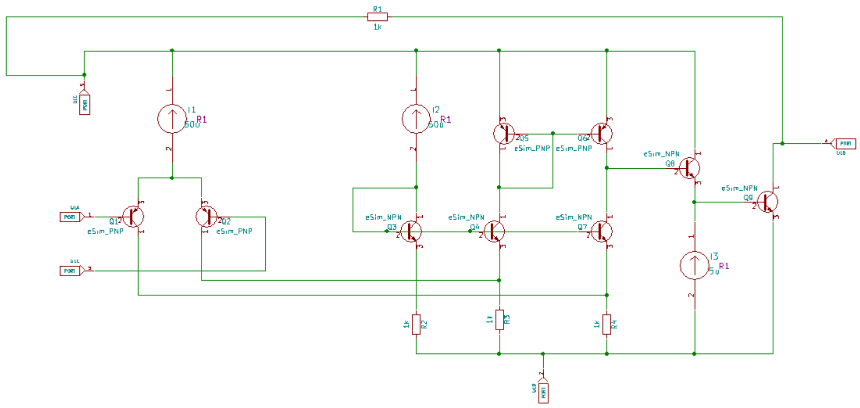

Figure 4.14: Subcircuit Schematic of LMV331

4.3.3 Test Circuit

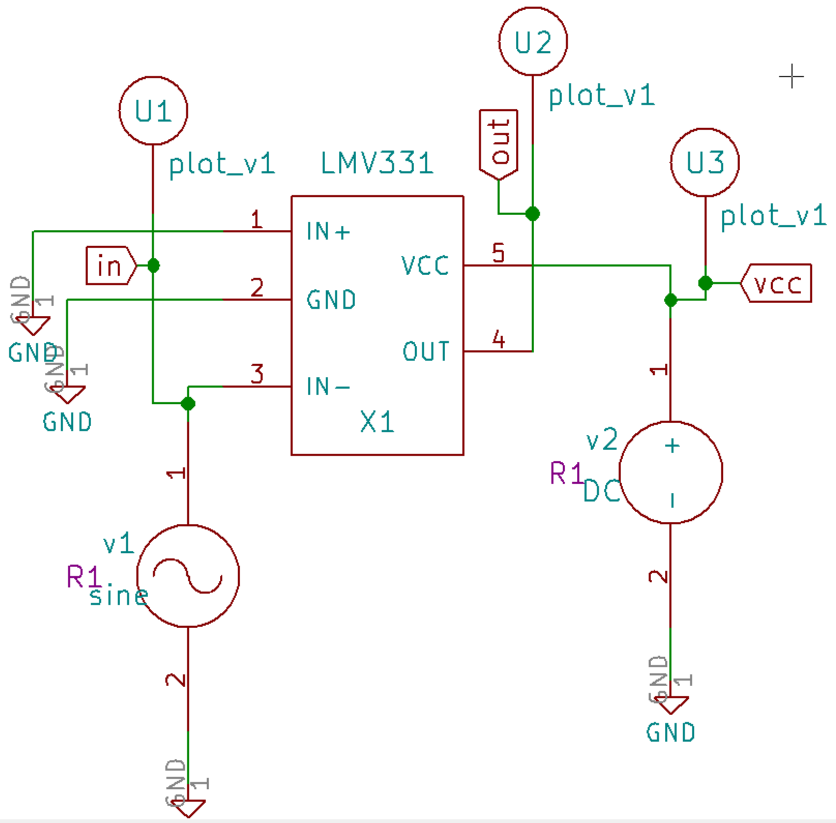

Figure 4.15: Test Circuit of LMV331 IC

4.3.4 Input Plot

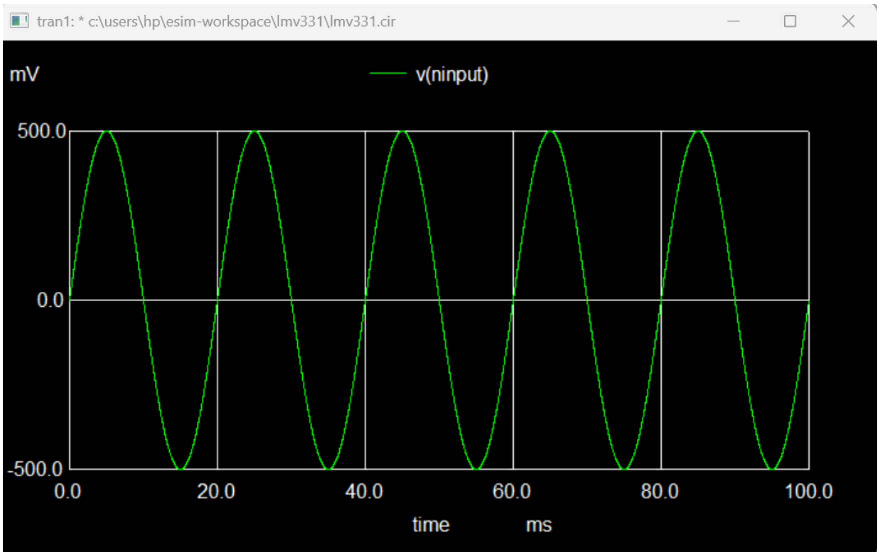

Figure 4.16: Input Voltage Waveform of LMV331

4.3.5 Output Plot

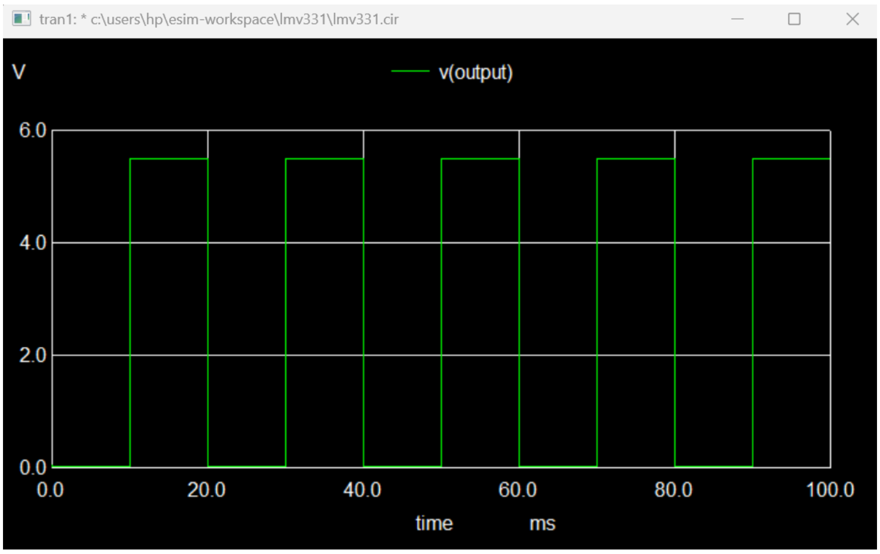

Figure 4.17: Output Voltage Waveform of LMV331

4.4 TL074 Low-noise J-FET quad operational amplifiers.

The TL074 is a low-noise, JFET-input quad operational amplifier that provides high input impedance, low input bias current, and low offset voltage. It offers excellent slew rate and bandwidth characteristics, making it suitable for precision and high-speed applications. The TL074 operates with a wide supply voltage range and has low power consumption, making it ideal for battery-powered devices and analog signal processing.

Applications:

- **Audio processing:** Used in mixers, equalizers, and pre-amplifiers.
- **Signal conditioning:** Amplifies and filters sensor signals in measurement systems.
- **Active filters:** Used in designing low-pass, high-pass, and band-pass filters.
- **Instrumentation:** Provides accurate signal amplification in test equipment.
- **Analog computation:** Performs mathematical operations in analog computers and circuit.

4.4.1 IC Layout

This figure represents the 8-Pin Package Diagram of the TL074-Low Noise J-FET quad operational amplifiers.

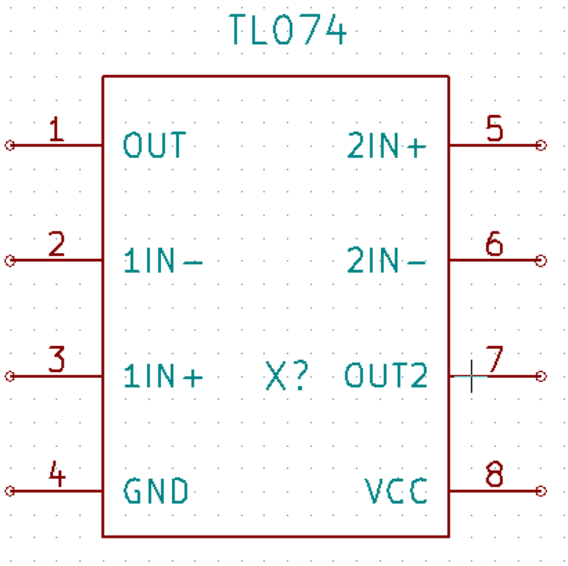

Figure 4.18: TL074-Low Noise J-FET quad operational amplifiers

4.4.2 Subcircuit Schematic Diagram

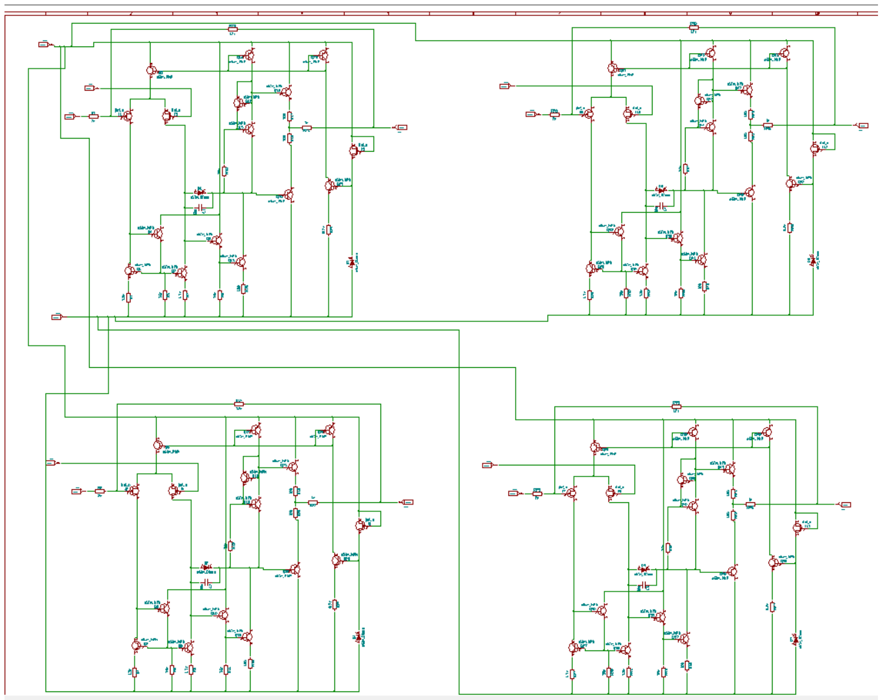

Figure 4.19: Subcircuit Schematic of TL074

4.4.3 Test Circuit

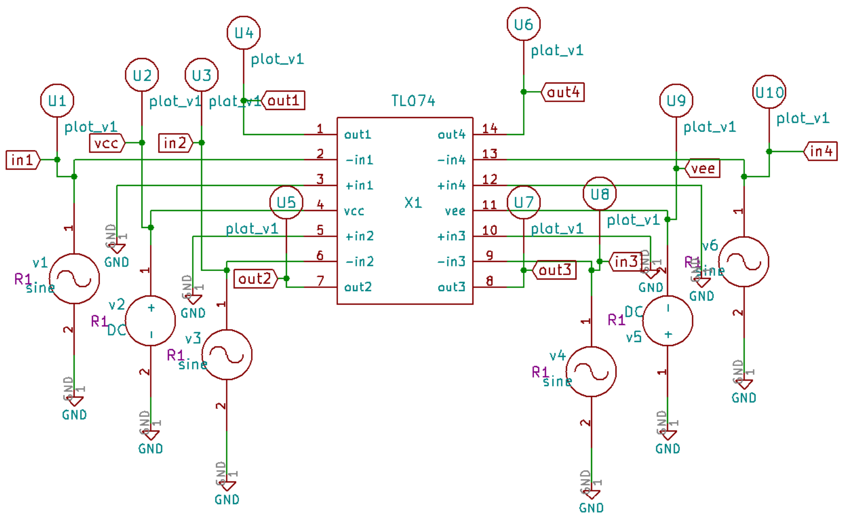

Figure 4.20: Test Circuit of TL074 IC

4.4.4 Input Plot

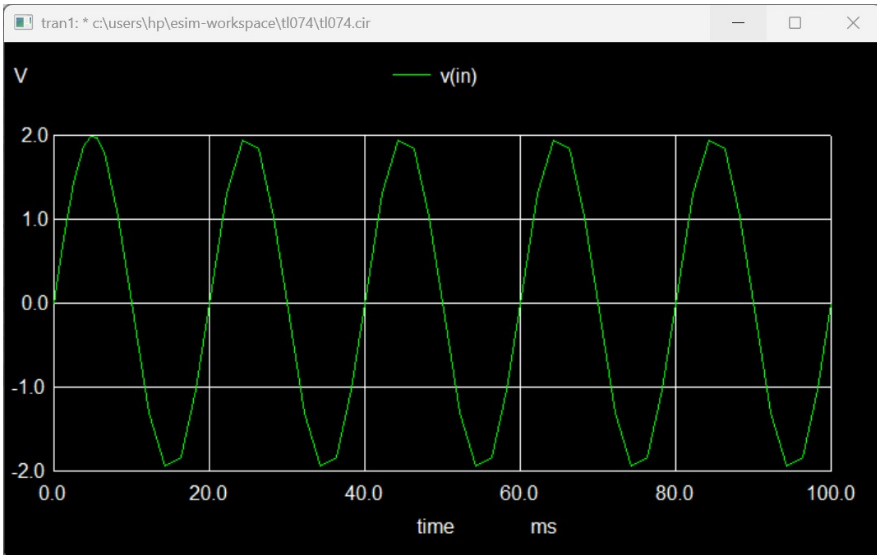

Figure 4.21: Input Voltage Waveform of TL074

4.4.5 Output Plot

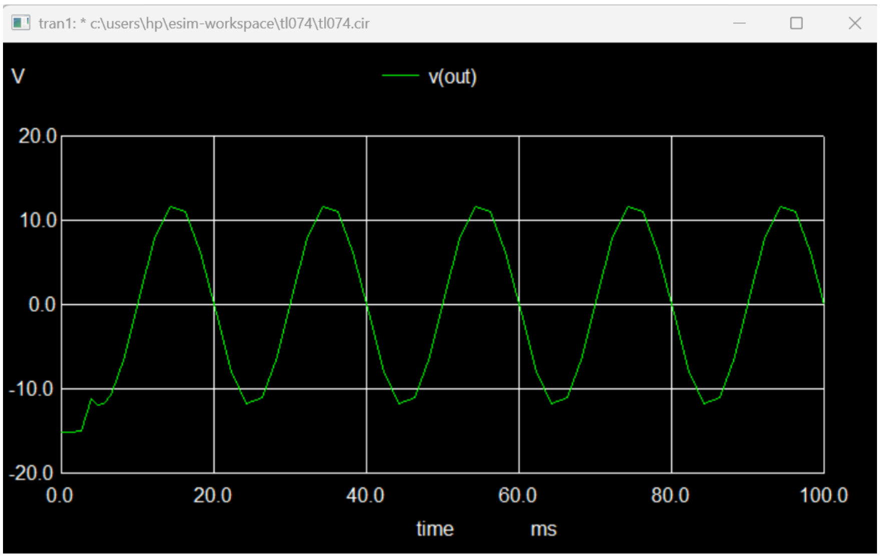

Figure 4.22: Output Voltage Waveform of TL074

4.5 TLV1391 Single differential comparator

The TLV1391 is a single differential comparator designed for low-power and high-speed applications. It operates with a low supply voltage, making it suitable for battery-powered devices. The comparator features an open-drain output, allowing easy interfacing with various logic levels. It provides fast response times and low offset voltage, ensuring accurate signal comparison in precision applications.

Applications:

- **Voltage level detection:** Monitors signal levels for threshold crossing.
- **Overvoltage/undervoltage protection:** Protects circuits by detecting abnormal voltage conditions.
- **Zero-crossing detection:** Identifies signal transitions in AC applications.
- **Pulse and square wave generation:** Converts analog signals to digital pulses.
- **Battery management systems:** Ensures efficient power monitoring and control.

4.5.1 IC Layout

This figure represents the 5-Pin Package Diagram of the TLV1391 single differential comparators.

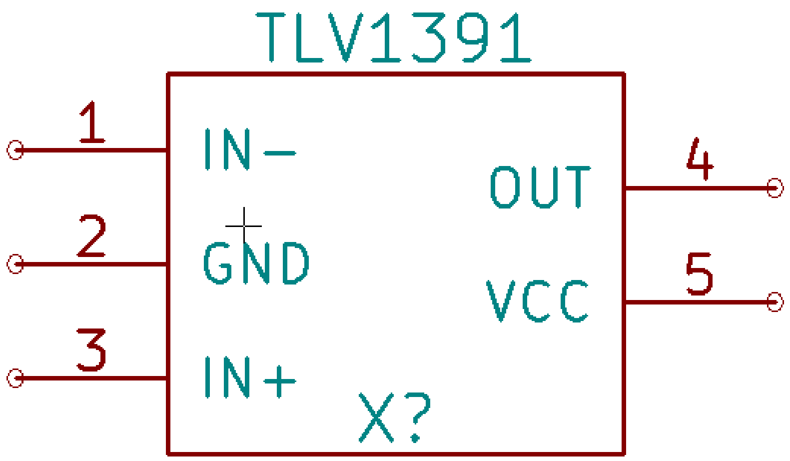

Figure 4.23: TLV1391 single differential comparators

4.5.2 Subcircuit Schematic Diagram

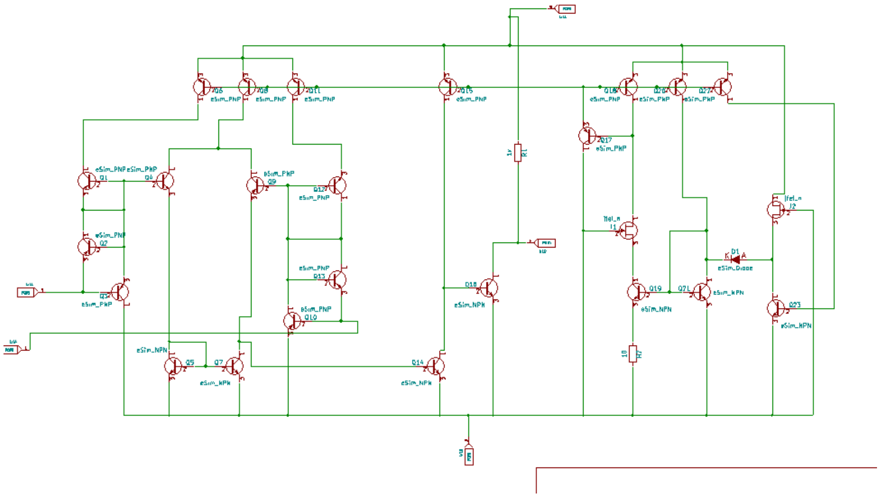

Figure 4.24: Subcircuit Schematic of TLV1391

4.5.3 Test Circuit

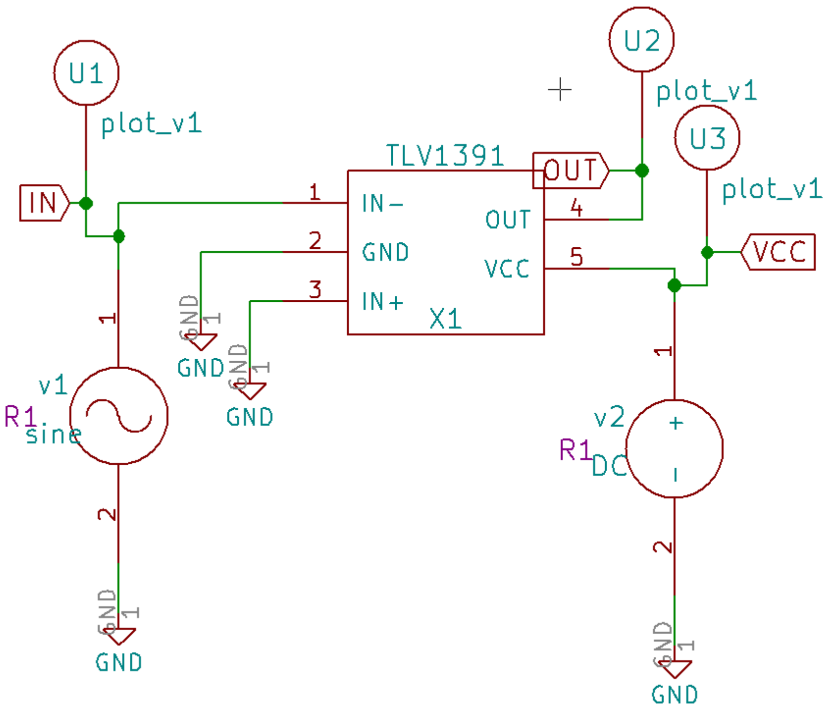

Figure 4.25: Test Circuit of TLV1391 IC

4.5.4 Input Plot

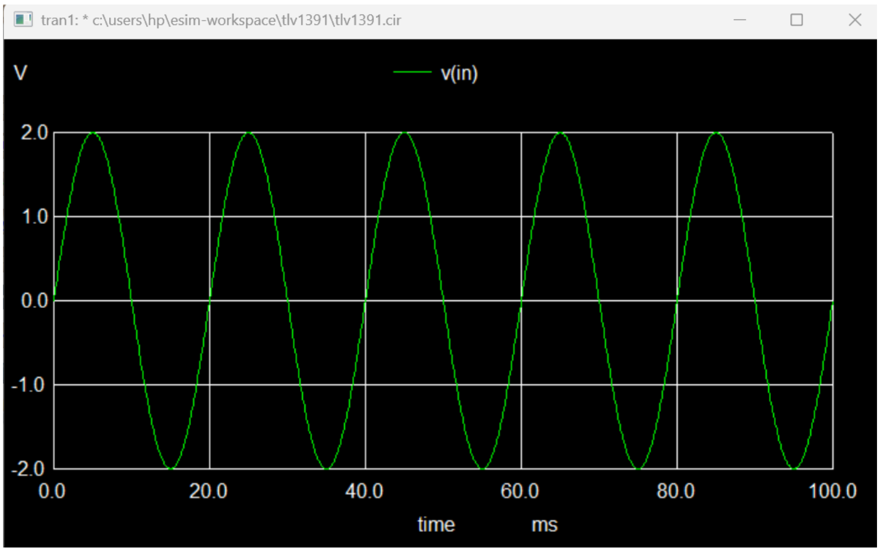

Figure 4.26: Input Voltage Waveform of TLV1391

4.5.5 Output Plot

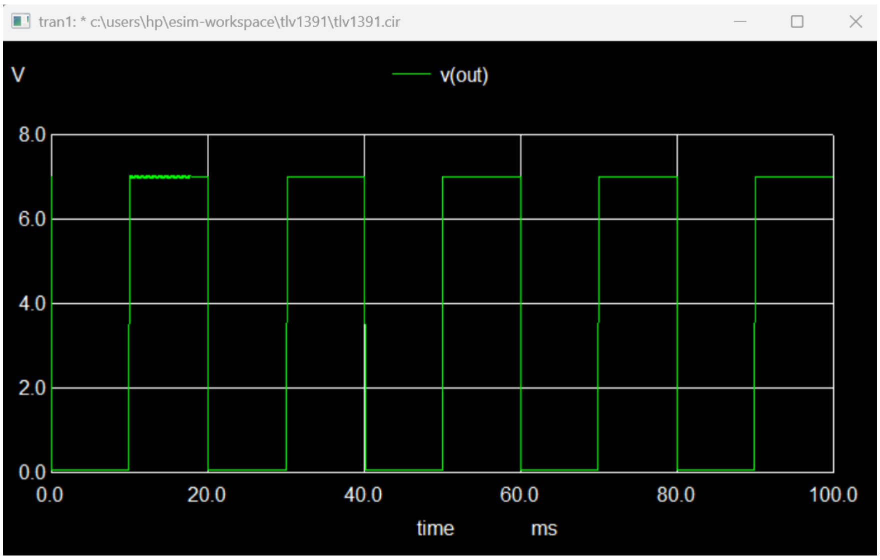

Figure 4.27: Output Voltage Waveform of TLV1391

4.6 LMV393 Dual general purpose Low-Voltage comparator

The MC7900 is a series of negative voltage regulators used to provide a stable and consistent negative output voltage. It is commonly used in electronic circuits that require a fixed negative voltage supply. These regulators come in various output voltage options, such as -5V, -12V, and -15V, to suit different needs. The MC7900 is designed to maintain a steady voltage despite changes in load current or input voltage, making it ideal for powering analog and digital circuits that need a reliable negative voltage. It includes built-in protection features like thermal shutdown and current limiting to prevent damage from overheating or excessive current.

Applications:

- **Voltage detection:** Monitors circuit voltage levels for control and protection.
- **Battery-powered devices:** Ensures efficient power usage and monitoring.
- **Sensor signal processing:** Converts analog sensor outputs into digital signals.
- **Current monitoring:** Helps in detecting excessive current flow in circuits.
- **Timing circuits:** Used in waveform generation and pulse detection applications.

4.6.1 IC Layout

This figure represents the 8-Pin Package Diagram of the LMV393 Dual General Purpose Low-Voltage Comparator.

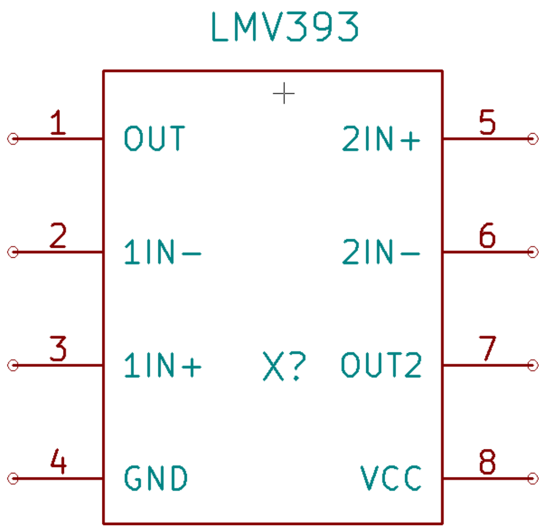

Figure 4.28: LMV393 Dual General Purpose Low-Voltage Comparator

4.6.2 Subcircuit Schematic Diagram

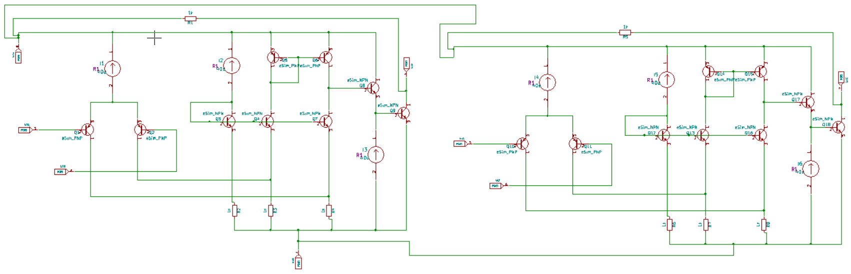

Figure 4.29: Subcircuit Schematic of LMV393

4.6.3 Test Circuit

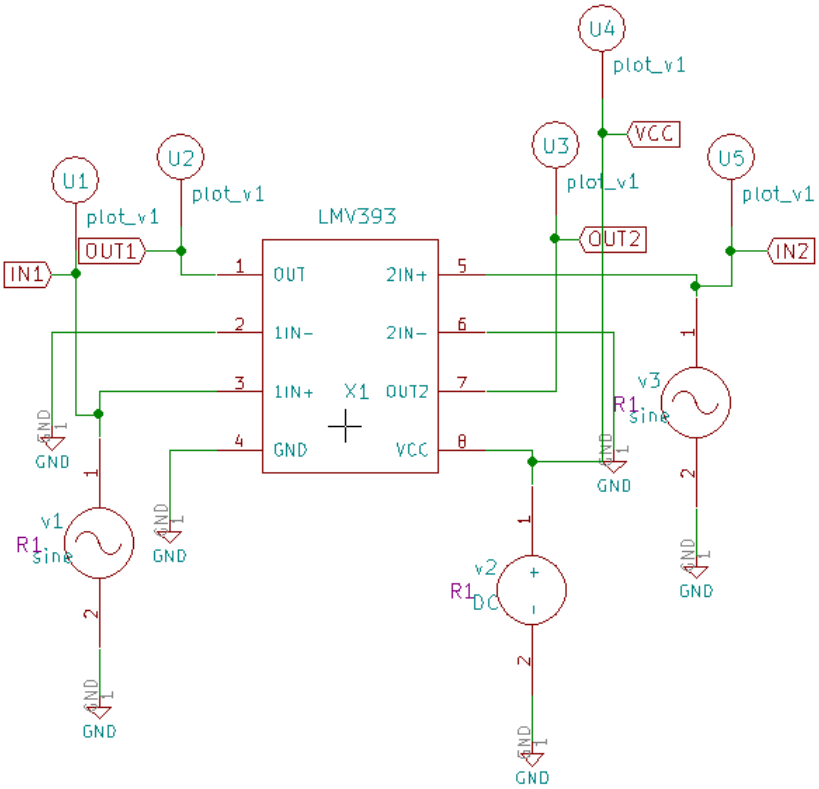

Figure 4.30: Test Circuit of LMV393 IC

4.6.4 Input Plot

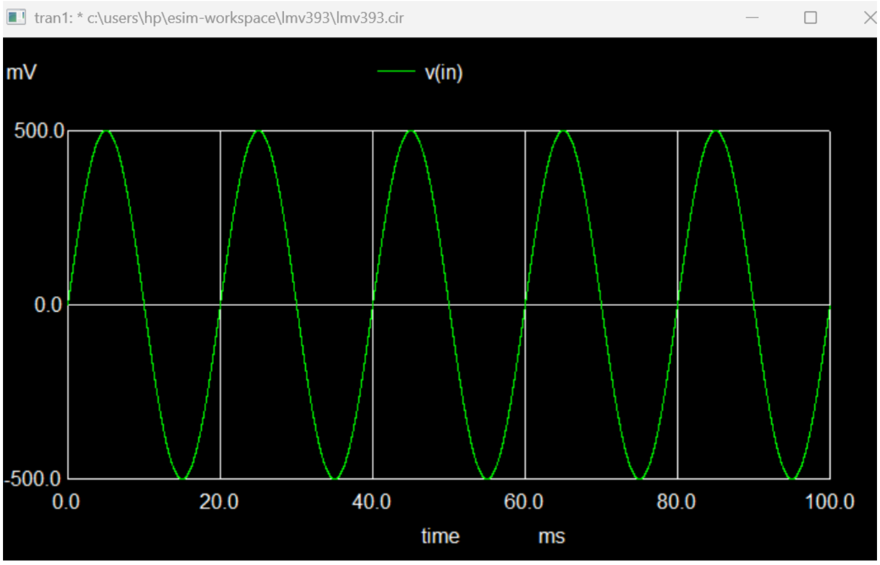

Figure 4.31: Input Voltage Waveform of LMV393

4.6.5 Output Plot

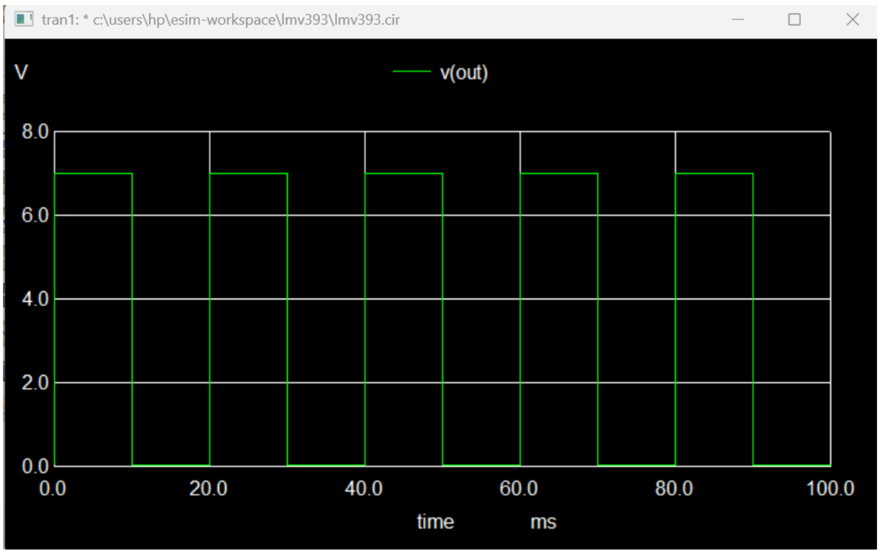

Figure 4.32: Output Voltage Waveform of LMV393

4.7 LM148 Quad 741 Op Amps

The LM148, LM248, and LM348 are quad operational amplifiers based on the 741 architecture, offering four independent op-amps in a single package. These op-amps provide high gain, internal frequency compensation, and a wide operating voltage range, making them suitable for various analog applications. They feature low input offset voltage, good stability, and high common-mode rejection, ensuring reliable performance in precision circuits.

Applications:

- **Signal amplification:** Used to boost weak signals in measurement systems.
- **Active filters:** Designed for low-pass, high-pass, and band-pass filtering.
- **Analog computation:** Performs arithmetic operations such as addition and integration.
- **Instrumentation systems:** Used in data acquisition and processing circuits.
- **Control systems:** Applied in automation and feedback control loops

4.7.1 IC Layout

This figure represents the 14-Pin Package Diagram of the LM148 Quad 741 Op Amps

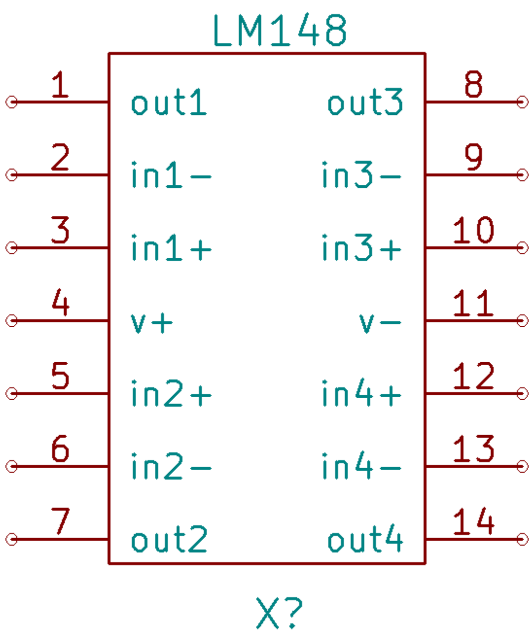

Figure 4.33: LM148 Quad 741 Op Amps

4.7.2 Subcircuit Schematic Diagram

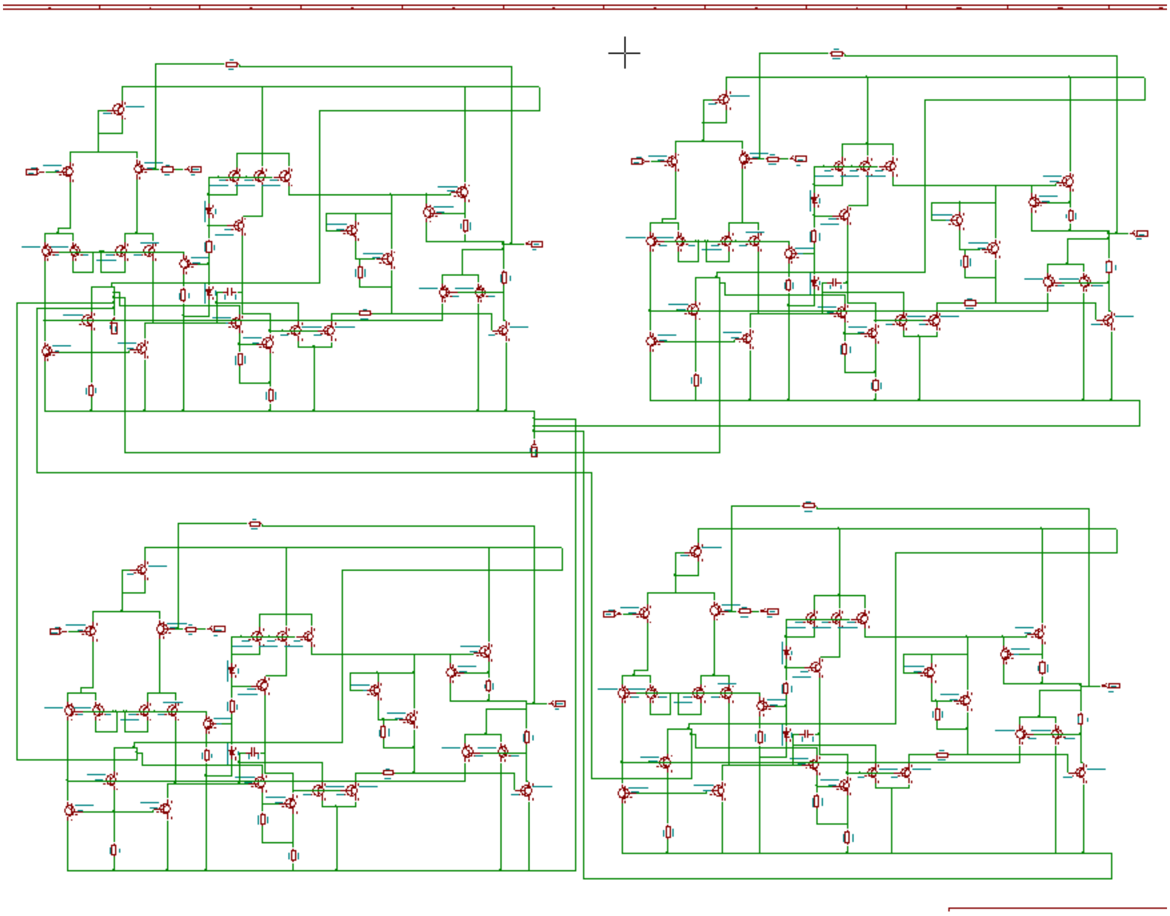

Figure 4.34: Subcircuit Schematic of LM148

4.7.3 Test Circuit

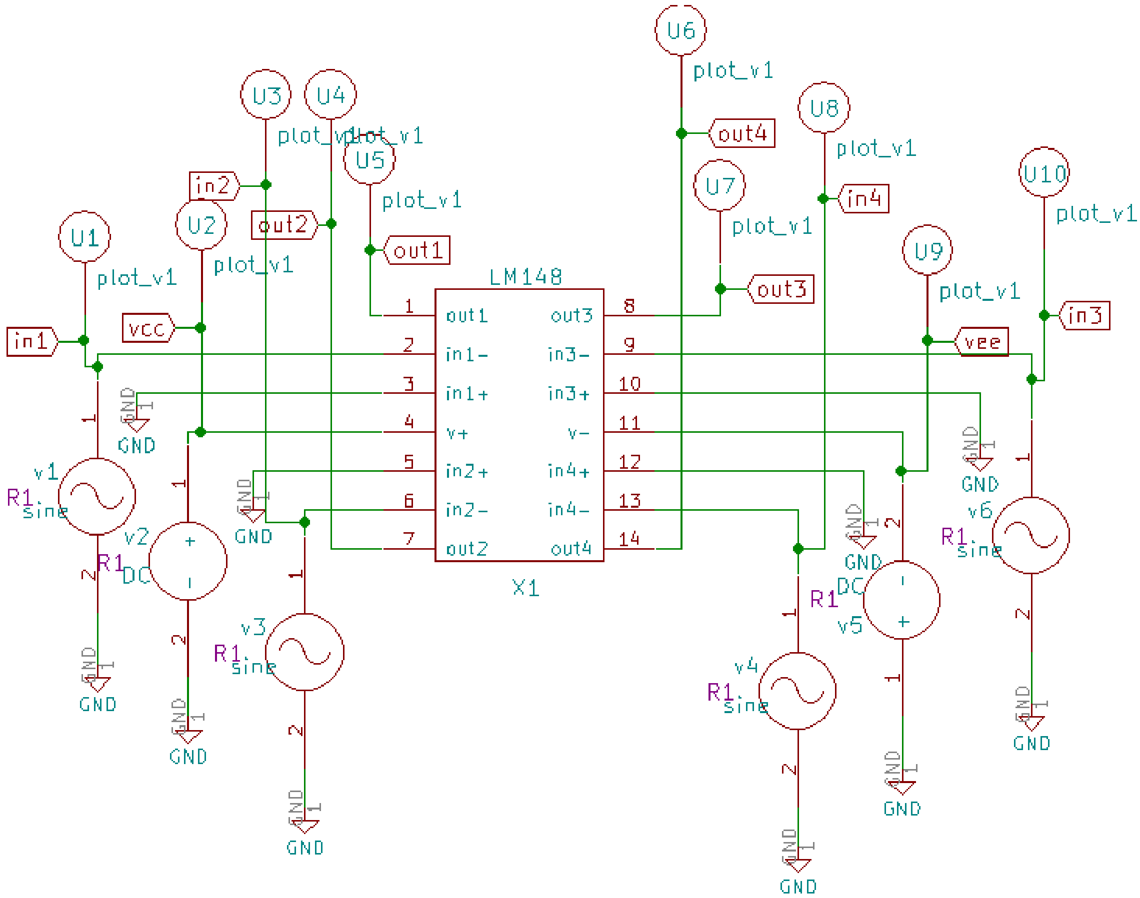

Figure 4.35: Test Circuit of LM148 IC

4.7.4 Input Plot

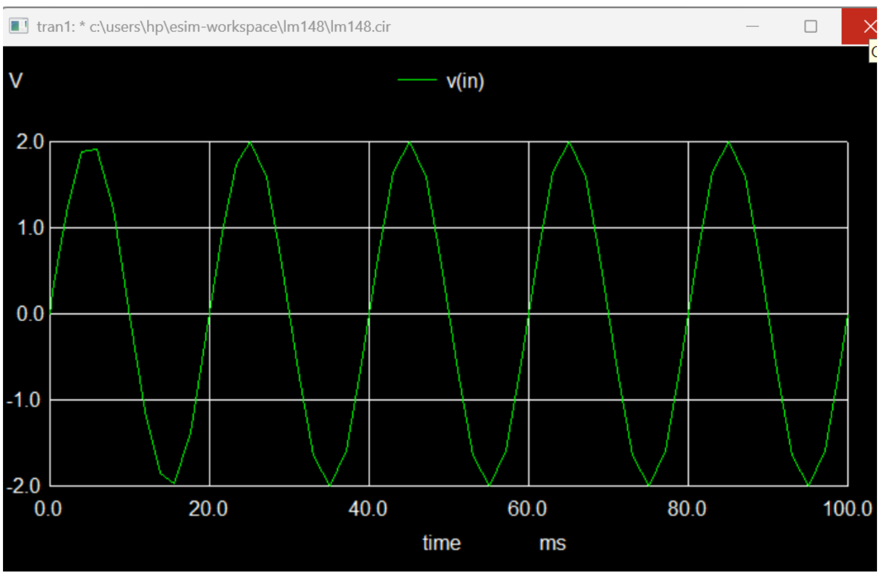

Figure 4.36: Input Voltage Waveform of LM148

4.7.5 Output Plot

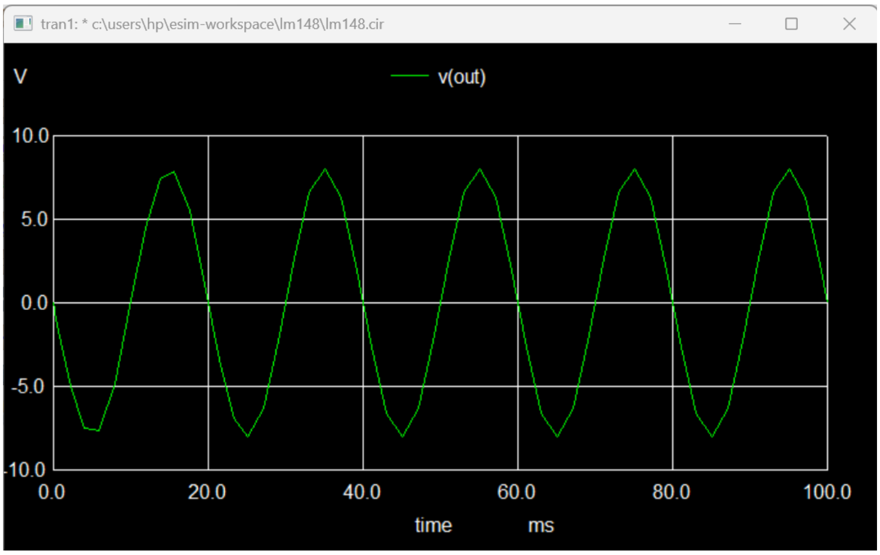

Figure 4.37: Output Voltage Waveform of LM148

Chapter 5

Research Migration Project

5.1 The LM139 quad bipolar voltage comparator

The LM139 is a quad bipolar voltage comparator designed for applications requiring precise voltage level detection. It operates over a wide voltage range and provides stable performance across varying environmental conditions. With its low offset voltage, low input bias current, and high-speed response, the LM139 is ideal for applications that demand accurate signal comparison. The open-collector output allows for easy interfacing with various digital and analog circuits. It is commonly used in industrial and automotive environments due to its robustness and reliability.

Applications:

- **Voltage monitoring:** Detects overvoltage and undervoltage conditions in power systems.
- **Zero-crossing detection:** Identifies signal transitions for timing applications.
- **Level shifting:** Converts analog signal levels to digital logic levels.
- **Oscillator circuits:** Generates pulses and timing signals.
- **Threshold detection:** Used in sensor circuits for triggering actions based on predefined levels.

5.1.1 IC Layout

This figure represents the 14-Pin Package Diagram of the The LM139 is a quad bipolar voltage comparator

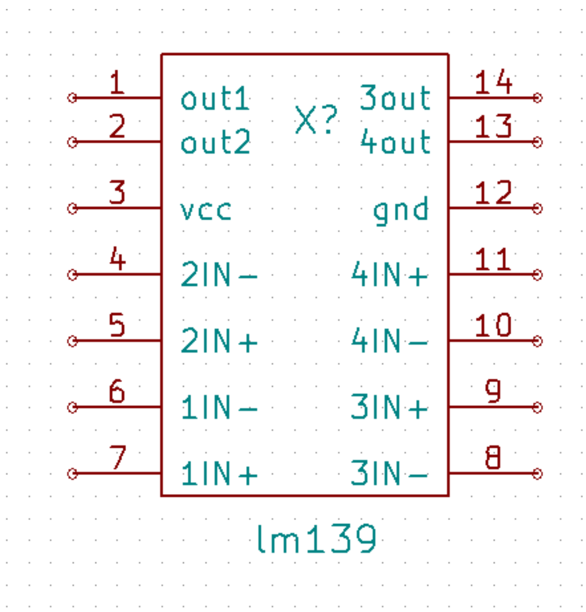

Figure 5.1: The LM139 quad bipolar voltage comparator

5.1.2 Subcircuit Schematic Diagram

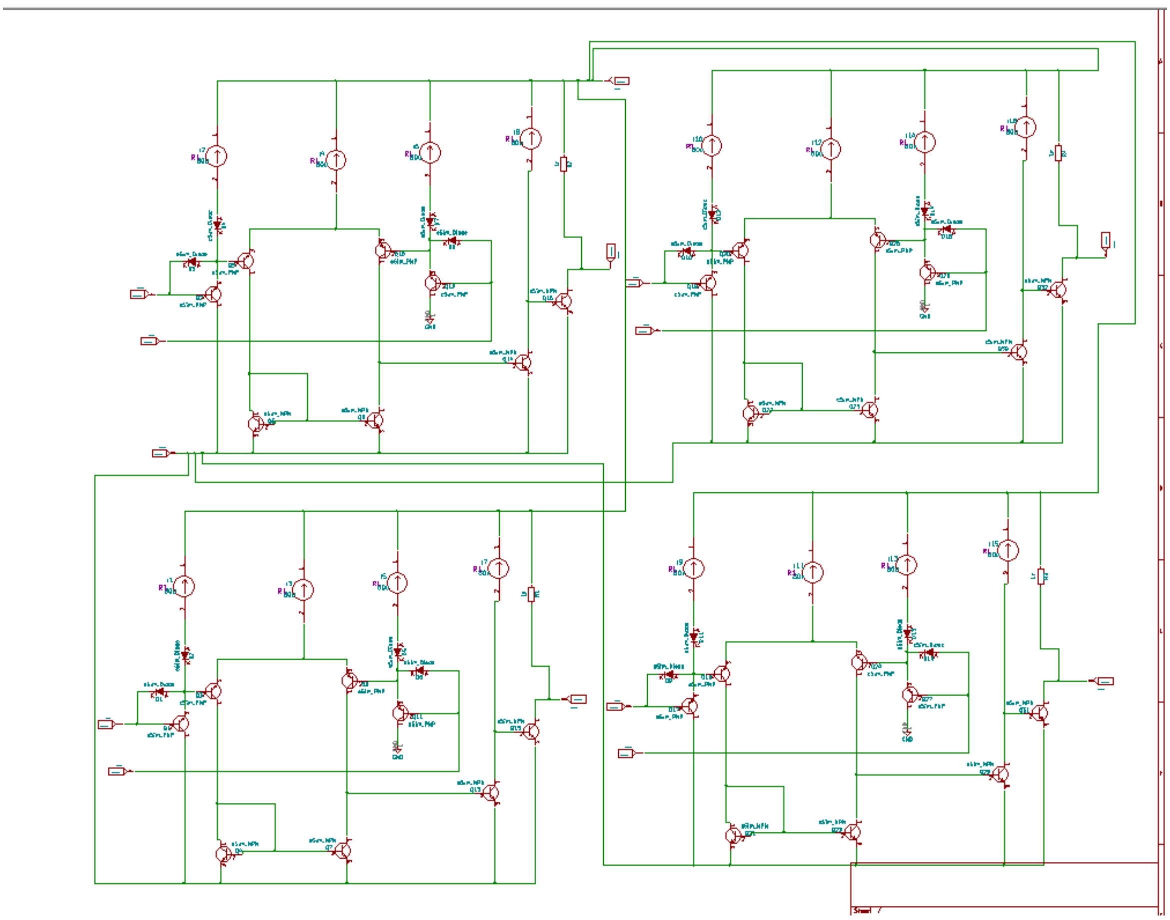

Figure 5.2: Subcircuit Schematic of LM139

5.1.3 Test Circuit

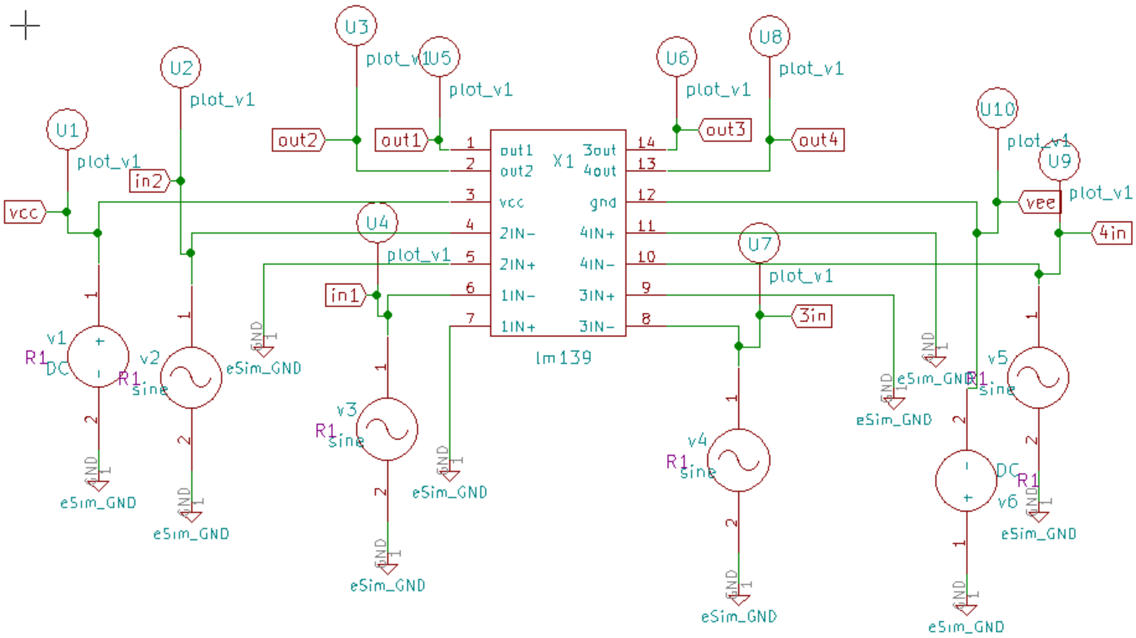

Figure 5.3: Test Circuit of LM139 IC

5.1.4 Input Plot

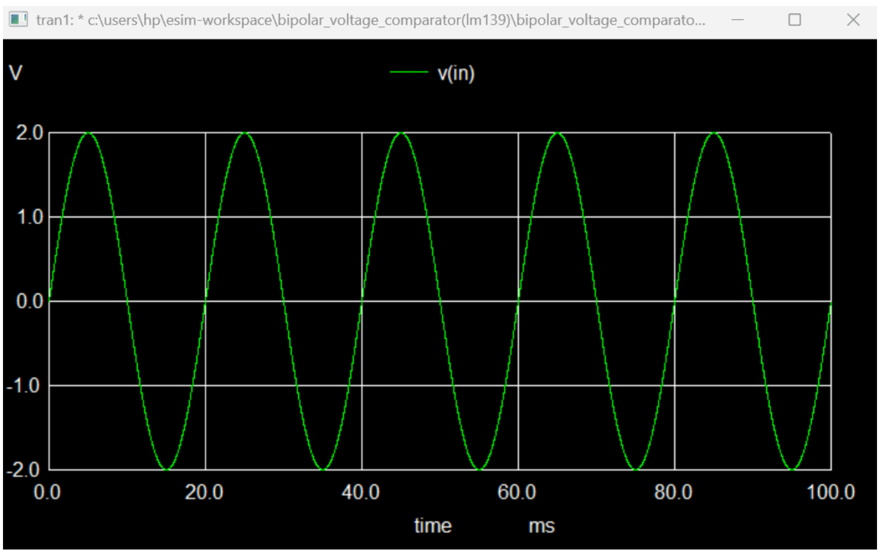

Figure 5.4: Input Voltage Waveform of LM139

5.1.5 Output Plot

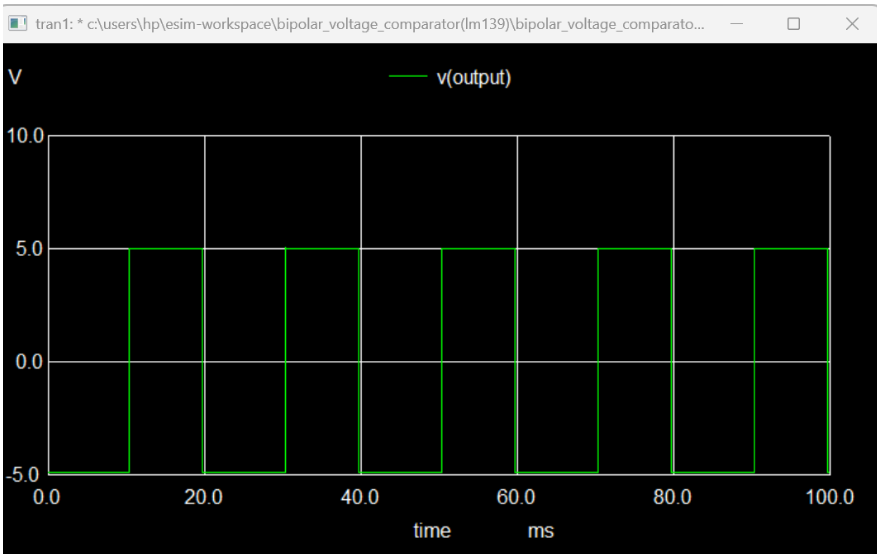

Figure 5.5: Output Voltage Waveform of LM139

Research paper link
https://ieeexplore.ieee.org/document/7107168

research paper name: Variation of Offset Voltage in the Irradiated Bipolar Voltage Comparators

5.1.6 References:

[1]. R. L. Pease. "Total ionizing dose effects in bipolar devices and circuits," IEEE Trans. Nucl. Sci., vol. 50, no. 3, pp. 539-551, 2003

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[3]. A. Johnston and B. Rax, "Testing and qualifying linear integrated cir-duits for radiation degradation in space,"IEEE Trans. Nucl. Sci., vol.53, no. 6, pp. 1779–1786, Dec. 2006.

5.2 A single-ended primary-inductor converter (SEPIC)

The LM78L series are fixed-output voltage regulators that provide a stable output voltage for low-power applications. They typically offer output voltages of 5V, 6V, 8V, 9V, 10V, 12V, and 15V, with a maximum output current of 100 mA. These regulators require an input voltage that is 2-3 volts higher than the output voltage.

Applications:

- **Battery-Powered Devices:** Stable voltage for gadgets.
- **Automotive Systems:** Powers subsystems in vehicles.
- **LED Drivers:** Maintains constant brightness.
- **Renewable Energy:** Regulates voltage in solar and wind systems.
- **Power Supplies:** Used in industrial and medical devices.
- **Consumer Electronics:** Ensures efficient voltage regulation.

5.2.1 Circuit diagram

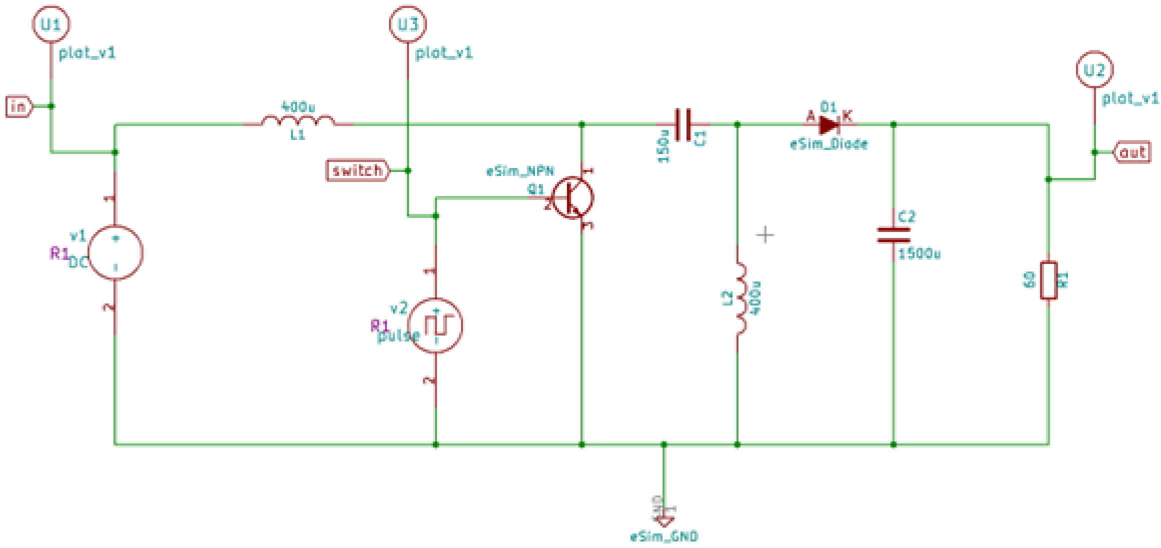

Figure 5.6: Circuit Diagram SEPIC

5.2.2 Pulse waveform

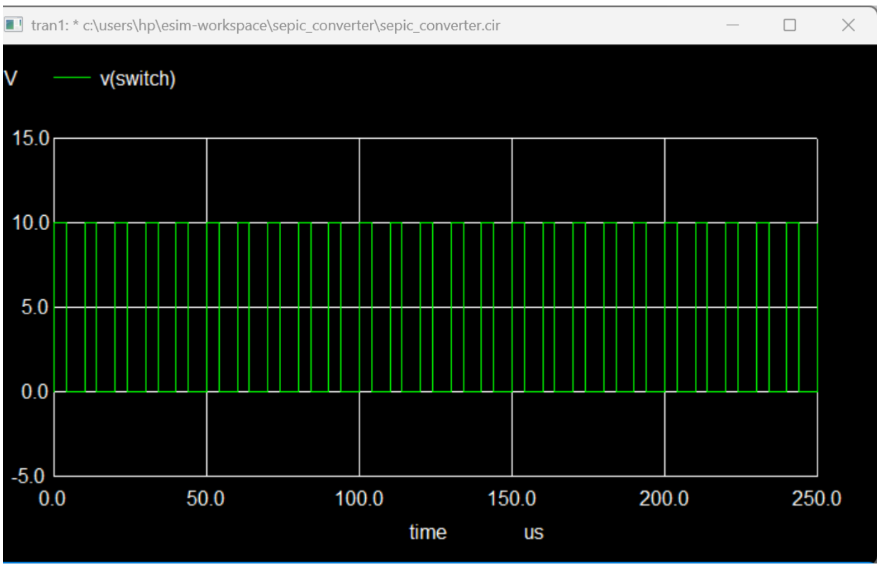

Figure 5.7: Pulse waveform of SEPIC

5.2.3 Input Plot

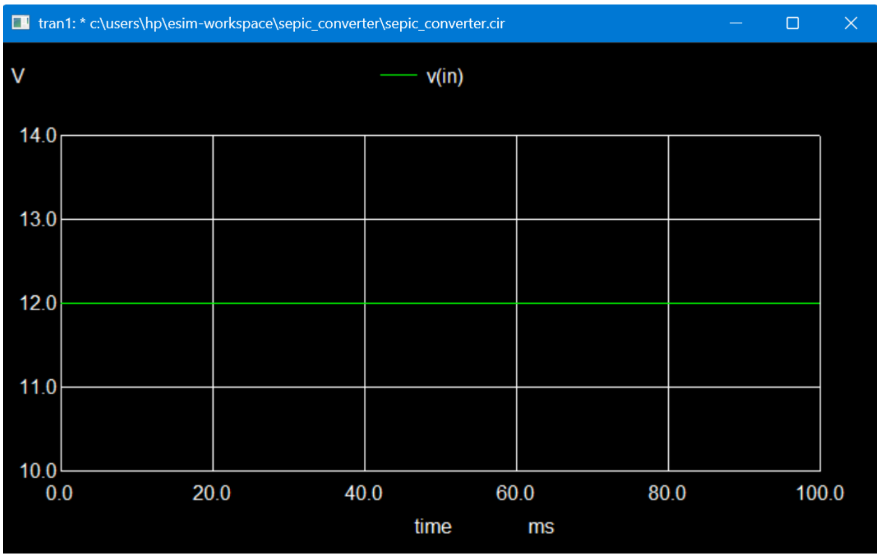

Figure 5.8: Input Voltage Waveform of SEPIC

Calculations for boost converter :

Given Values
Input Voltage = 12v
Time period = 10u
Pulse width = 6u

Step 1: Duty Cycle Calculation
The duty cycle (D) is the ratio of the ON time to the total switching period:
D = Ton/T
D = 6u/10u = 0.6u

Step 2: Calculate Frequency *Fs = 1/T*
*Fs = 1/10*10ˆ6*
Fs = 100KHZ

Step 3: Output Voltage Determination *The SEPIC converter follows the voltage conversion ratio similar to a buck-boost converter:*
*Vout = (D/1-D)*vin*
Substituting the Values:
*Vout = (0.6/1-0.6)*12v = 18v*
Here it will act like boost converter

5.2.4 Output for boost

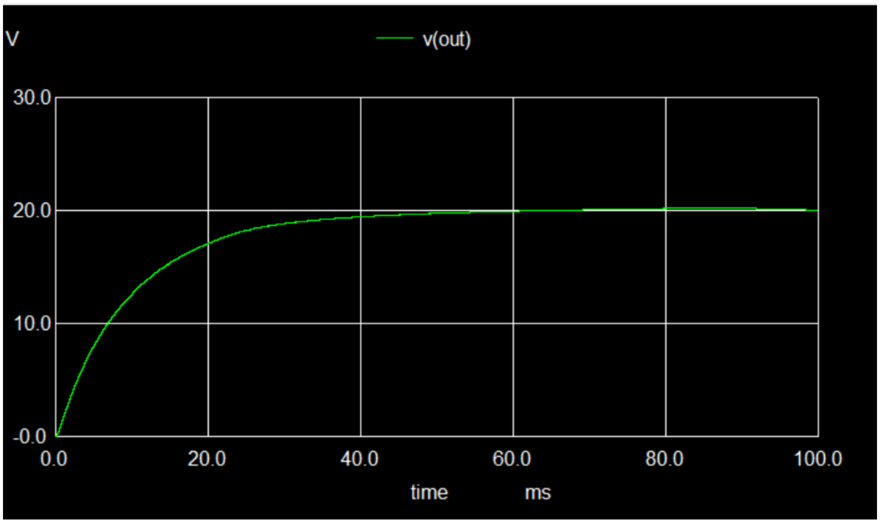

Figure 5.9: Output Voltage Waveform of SEPIC

Calculations for buck converter :

Given Values

Input Voltage = 12v
Time period = 10u
Pulse width = 4u

Step 1: Duty Cycle Calculation
The duty cycle (D) is the ratio of the ON time to the total switching period:
D = Ton/T
D = 4u/10u = 0.4u

Step 2: Output Voltage Determination
The SEPIC converter follows the voltage conversion ratio similar to a buck-boost converter:
*Vout = (D/1-D)*vin*
Substituting the Values:
*Vout = (0.4/1-0.4)*12v = 8v*

Here it will act like buck converter

5.2.5 Output for Buck

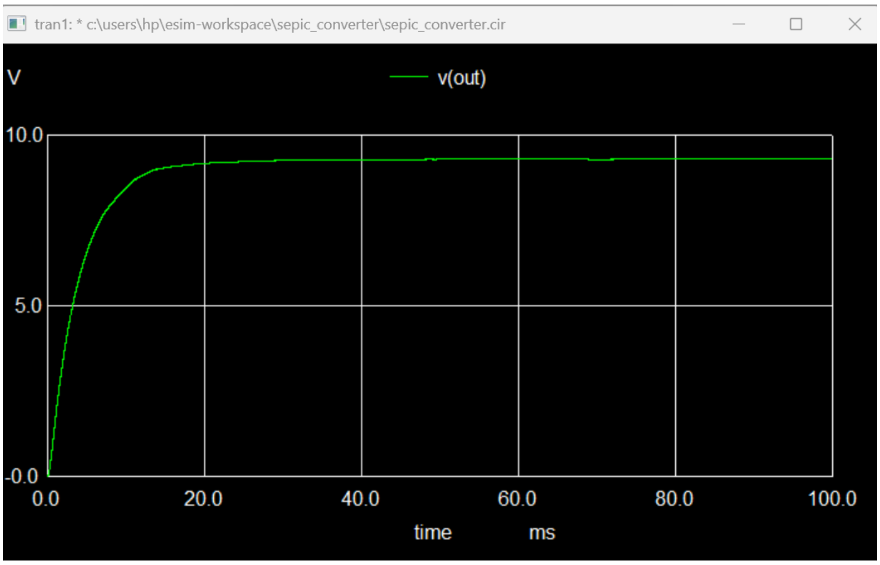

Figure 5.10: Output Voltage Waveform of SEPIC

Research paper link
https://ieeexplore.ieee.org/document/8117668

Research Paper Name : Performance of closed loop SEPIC converter with DC-DC converter for solar energy system

5.2.6 References:

[1] S. S. Martin, A. Chebak and N. Barka, "Development of renewable energy laboratory based on integration of wind, solar and biodiesel energies through a virtual and physical environment," 2015 3rd International Renewable and Sustainable Energy Conference, Marrakech, 2015, pp. 1-8.

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Chapter 6

Conclusion and Future Scope

We successfully met our goal of developing various subcircuits for both Analog and Digital Integrated Circuits. Each IC model was meticulously created based on the specifications provided in their official datasheets. The output of each IC was thoroughly verified and tested using their respective test circuits. The IC models developed during this fellowship include fundamental circuit components such as Op-Amps, Voltage Regulators, Precision Rectifiers, Schmitt Triggers, Differential Amplifiers, Instrumentation Amplifiers, Comparators, Multiplexers, De-Multiplexers, and various Logic Gate ICs. These models are now ready to be incorporated into the subcircuit library of eSim, allowing developers and students to utilize them as building blocks in their projects and circuit designs. As the device model library in eSim continues to grow, we anticipate the development of more such ready-to-use IC models for use in eSim.

6.1 Bibliography

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URL:https://www.alldatasheet.com/

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