eSim Semester Long Internship Autumn 2025

On

IC Integration and Subcircuit Creation

Submitted by

Karthick Naveen S

Department of Electronics and Communication Engineering

Sri Eshwar College of Engineering

Under the guidance of

Prof Prabhu Ramachandran

Principal Investigator
Department of Aerospace Engineering
Indian Institute of Technology Bombay

January 17 , 2025

Acknowledgment

I would like to express my deepest gratitude to **Prof. Prabhu Ramachandran** for providing me the opportunity to be a part of the FOSSEE internship program and for supporting open-source engineering tool development at IIT Bombay. His guidance and vision have encouraged students and researchers to actively contribute to the opensource ecosystem..

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.

I would also like to thank my internal mentors, **Mr. Varad Patil**, **Ms. Shanthi Priya K**, and **Mr. Aditya M**, for their valuable guidance, coordination, and technical inputs during the internship. Their mentorship contributed significantly to the clarity, progress, and successful execution of the work.

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.

Contents

1 Introduction 5

1.1 eSim 5
1.2 NgSpice 6
1.3 Makerchip 6

2 Feautures Of eSim 7

3 Problem Statement 8

3.1 Approach 8

4 Analog IC’s 10

4.1 LM442 - Voltage Follower 10
4.1.1 IC Layout 10
4.1.2 Subcircuit Schematic Diagram 11
4.1.3 Test Circuit 11
4.1.4 Input Plots 12
4.1.5 Output Plots 12

4.2 LF356 – JFET Input Operational Amplifier 13
4.2.1 IC Layout 13
4.2.2 Subcircuit Schematic Diagram 14
4.2.3 Test Circuit 14
4.2.4 Input Plots 15
4.2.5 Output Plots 15

4.3 LM7810 - 10V Positive Voltage Regulator 16
4.3.1 IC Layout 16
4.3.2 Subcircuit Schematic Diagram 17
4.3.3 Test Circuit 17
4.3.4 Input Plots 18
4.3.5 Output Plots 18

4.4 LM334 – Adjustable Current Source 19
4.4.1 IC Layout 19
4.4.2 Subcircuit Schematic Diagram 20
4.4.3 Test Circuit 20
4.4.4 Input Plots 21
4.4.5 Output Plots 21

4.5 LT1007 – Precision Operational Amplifier 22

4.5.1 IC Layout 22
4.5.2 Subcircuit Schematic Diagram 23
4.5.3 Test Circuit 23
4.5.4 Input Plots 24
4.5.5 Output Plots 24

4.6 LM335 – Precision Temperature Sensor 25
4.6.1 IC Layout 25
4.6.2 Subcircuit Schematic Diagram 26
4.6.3 Test Circuit 26
4.6.4 Input Plots 27
4.6.5 Output Plots 27

4.7 CA3078 - High Voltage Operational Amplifier 28
4.7.1 IC Layout 28
4.7.2 Subcircuit Schematic Diagram 29
4.7.3 Test Circuit 29
4.7.4 Input Plots 30
4.7.5 Output Plots 30

4.8 LT1013 – Dual Precision Operational Amplifier 31
4.8.1 IC Layout 31
4.8.2 Subcircuit Schematic Diagram 32
4.8.3 Test Circuit 32
4.8.4 Input Plots 33
4.8.5 Output Plots 33

4.9 LM1558 - Dual Operational Amplifier 34
4.9.1 IC Layout 34
4.9.2 Subcircuit Schematic Diagram 35
4.9.3 Test Circuit 35
4.9.4 Input Plots 36
4.9.5 Output Plots 36

4.10 LT1002 – precision Operational Amplifier 37
4.10.1 IC Layout 37
4.10.2 Subcircuit Schematic Diagram 38
4.10.3 Test Circuit 38
4.10.4 Input Plots 39
4.10.5 Output Plots 39

4.11 LT1097 - Precision Operational Amplifier 40
4.11.1 IC Layout 40
4.11.2 Subcircuit Schematic Diagram 41
4.11.3 Test Circuit 41
4.11.4 Input Plots 42

4.11.5 Output Plots 42

4.12 LM358B – Dual Low Operational Amplifier 43
5.3.1 IC Layout 43
5.2.2 Subcircuit Schematic Diagram 44
5.3.2 Test Circuit 44
5.2.4 Input Plots 45
5.2.5 Output Plots 45

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. 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.

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 semi-conductor 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 LM442 – Voltage Follower

The LM442 is a dual operational amplifier designed for general-purpose analog applications. To ensure stable and reliable operation, it offers low input bias current and consistent performance when used in voltage follower and buffer configurations. The internal design of the IC allows accurate signal tracking, making it suitable for basic analog signal processing tasks.

The LM442 can operate over a wide range of supply voltages and supports low-frequency input signals. When configured as a voltage follower, the output voltage follows the input voltage with unity gain, ensuring that the signal amplitude remains unchanged. This configuration is particularly useful in applications where isolation between stages is required without affecting the signal level.

Due to its voltage follower characteristics, the LM442 is commonly used in impedance matching, signal buffering, data acquisition systems, and general-purpose analog circuits. Its ability to maintain signal integrity while providing stable operation makes it suitable for educational, experimental, and practical electronic applications

4.1.1 IC Layout

This figure represents the Pin Package Diagram of LM442 ic

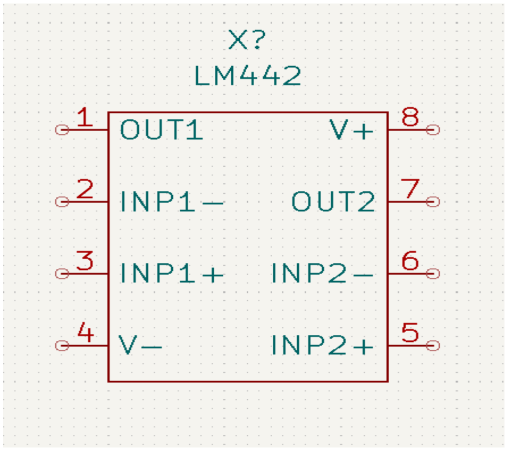

Figure 4.1: Pin diagram of LM442

4.1.2 Subcircuit Schematic Diagram

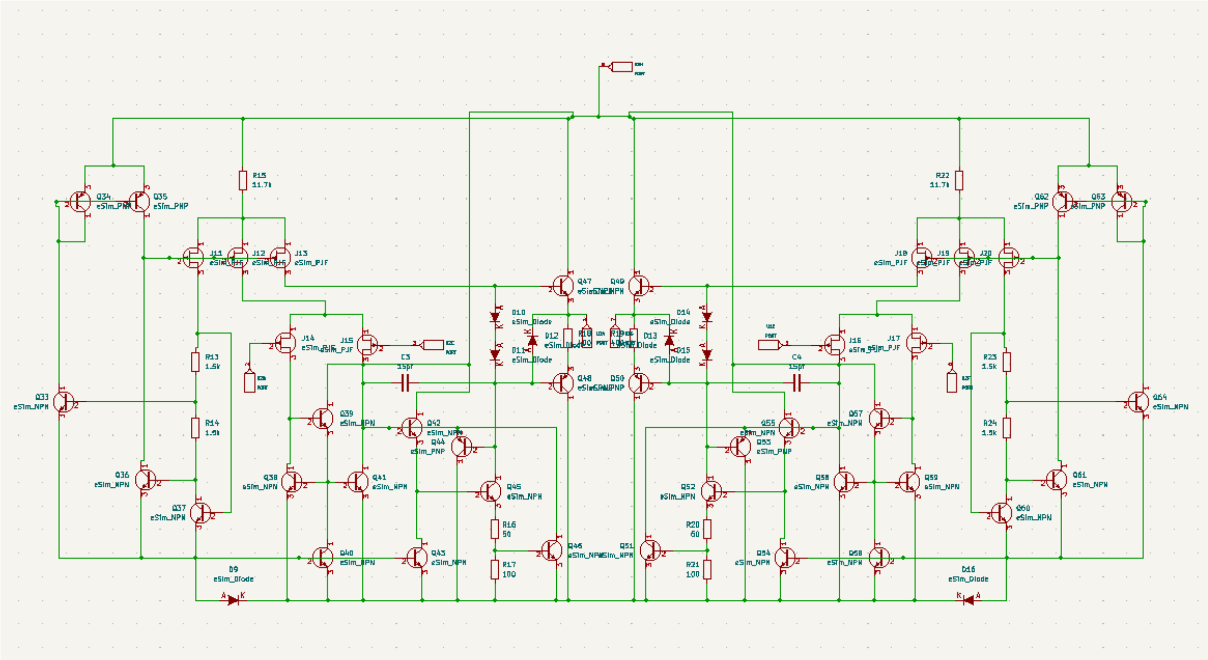

Figure 4.2: Subcircuit Schematic of LM442

4.1.3 Test Circuit

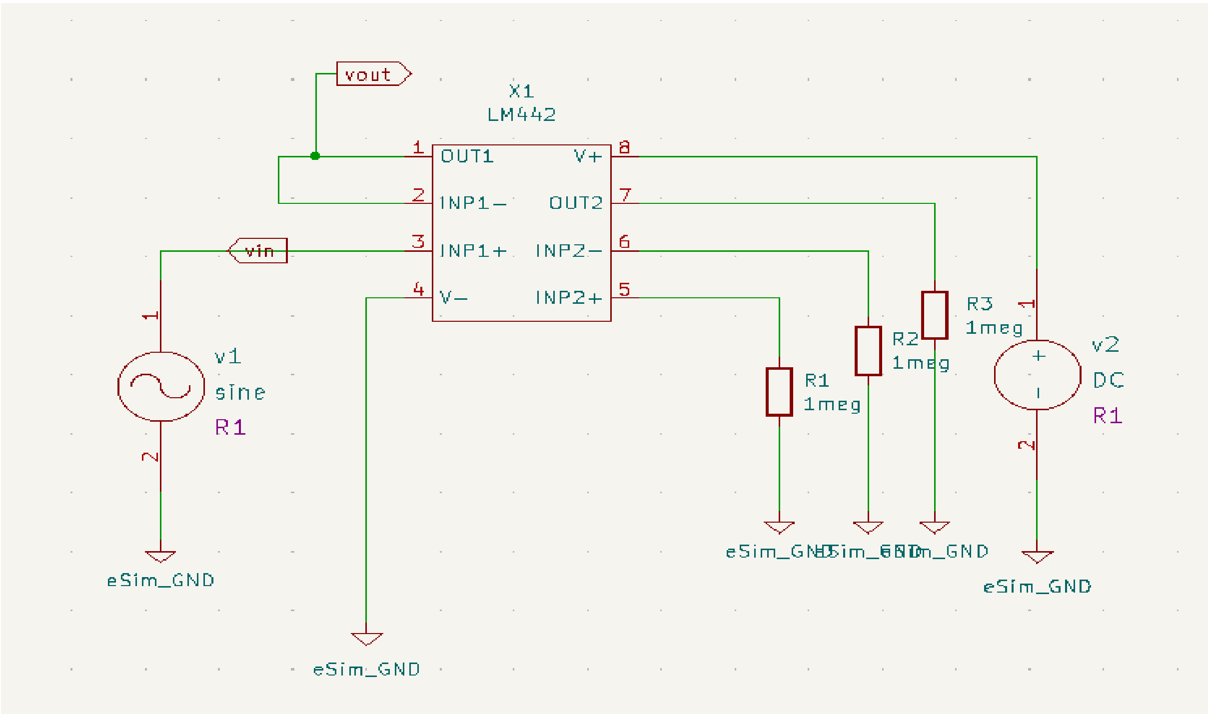

Figure 4.3: Test Circuit of LM442 IC

4.1.4 Input Plots

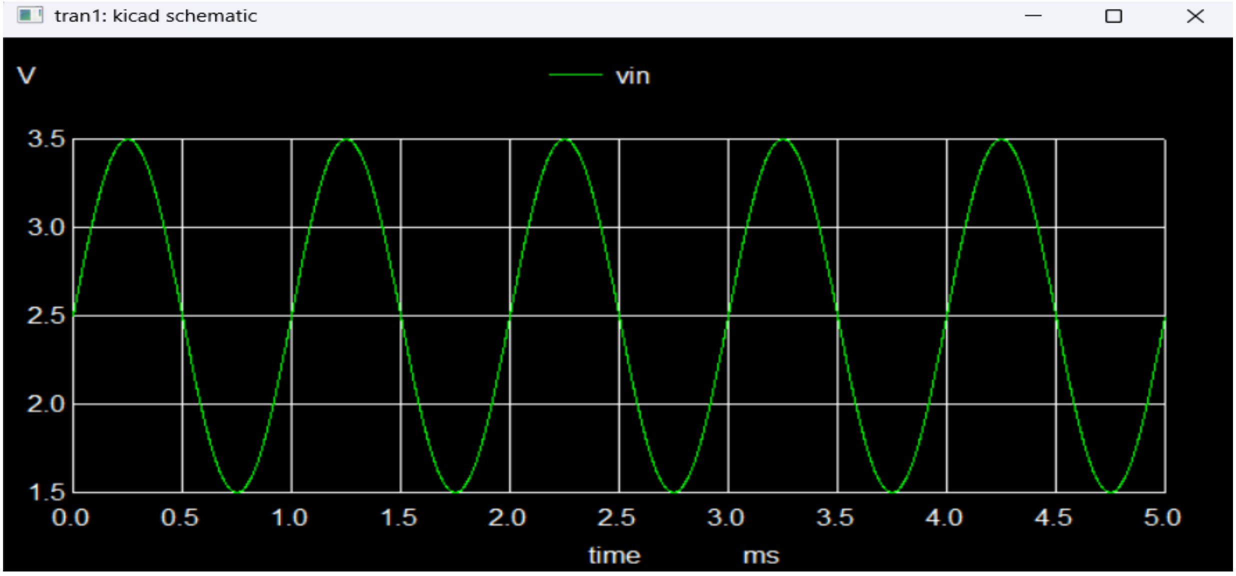

Figure 4.4: Input Voltage Waveform of LM442

4.1.5 Output Plots

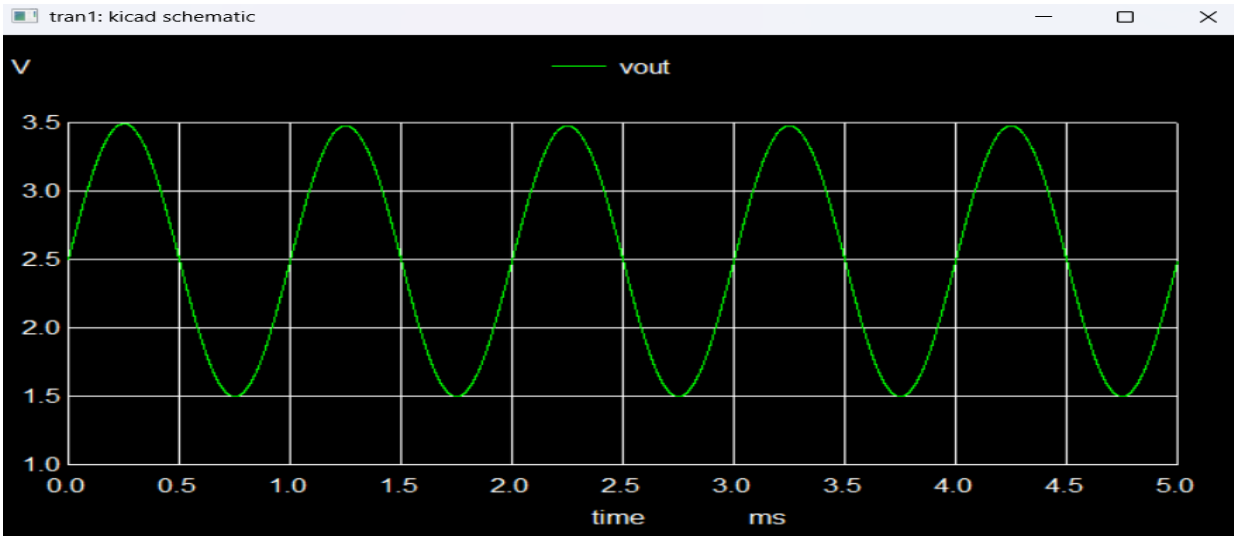

Figure 4.5: Output Voltage Waveform of LM442

4.1.6 Description

In this circuit, the IC is connected as a voltage follower, where the output is fed back to the inverting input and the signal is applied to the non-inverting input. Ideally, the output should be equal to the input, but in practical ICs the output depends on the internal properties of the operational amplifier.

The slight difference seen between the input and output waveforms is due to the internal characteristics of the IC such as internal transistor stages, biasing, and non-ideal gain. Because of these practical limitations, the output is not exactly equal to the input but still closely follows it. This behavior confirms correct voltage follower operation of the IC.

4.2 LF356 - JFET Input Operational Amplifier

The LF356 is a high-performance operational amplifier featuring a JFET input stage, designed for applications requiring high input impedance and low input bias current. It offers low noise and fast response, making it suitable for precision analog signal processing. The internal design of the LF356 ensures stable operation over a wide range of supply voltages.

The LF356 is capable of operating at higher slew rates compared to general-purpose operational amplifiers, allowing it to handle rapidly changing input signals with minimal distortion. When configured as a voltage follower, the output voltage accurately follows the input voltage, maintaining unity gain operation. This characteristic makes the device suitable for buffering and signal isolation applications.

Due to its high input impedance and fast response, the LF356 is commonly used in data acquisition systems, active filters, sample-and-hold circuits, and instrumentation applications. Its reliable performance and precision characteristics make it well suited for both educational and practical electronic design purposes.

4.2.1 IC Layout

This figure represents the Pin Package Diagram of LF356

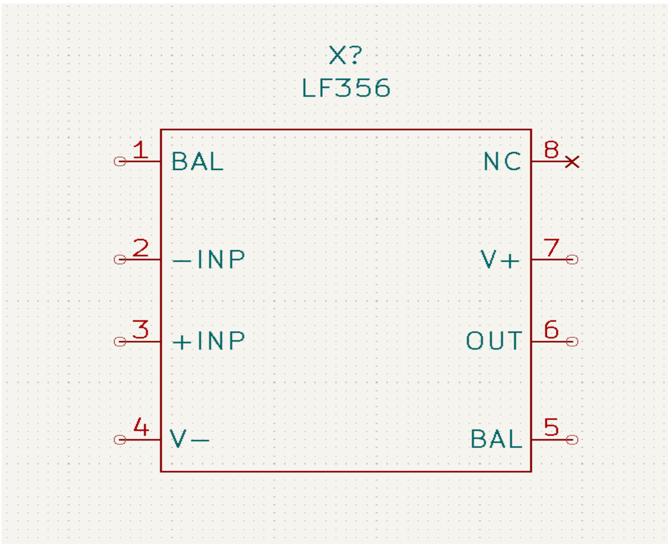

Figure 4.6: Pin diagram of LF356

4.2.2 Subcircuit Schematic Diagram

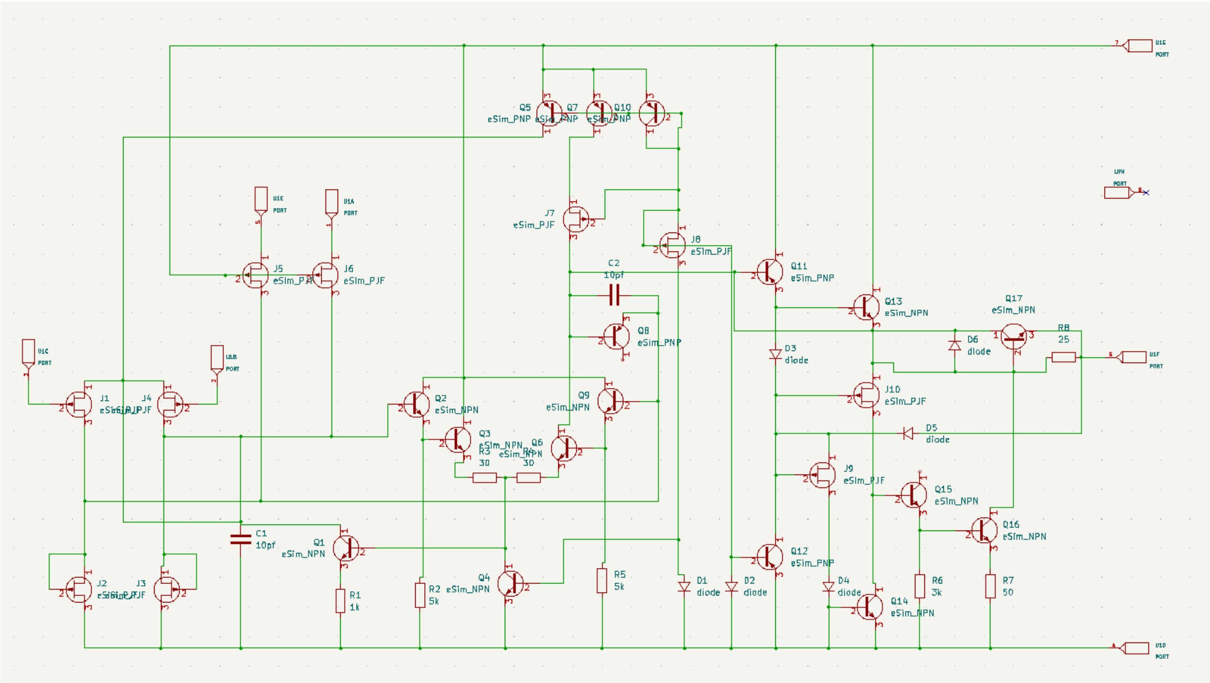

Figure 4.7: Subcircuit Schematic of LF356

4.2.3 Test Circuit

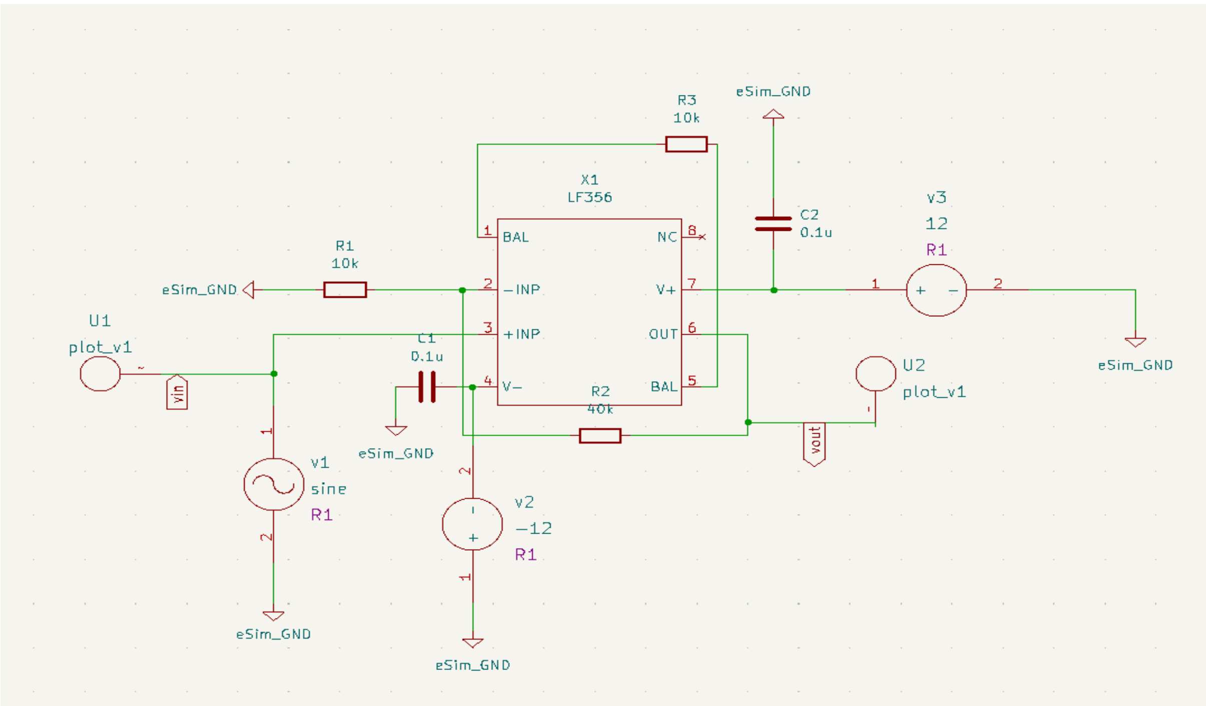

Figure 4.8: Test Circuit of LF356 IC

4.2.4 Input Plots

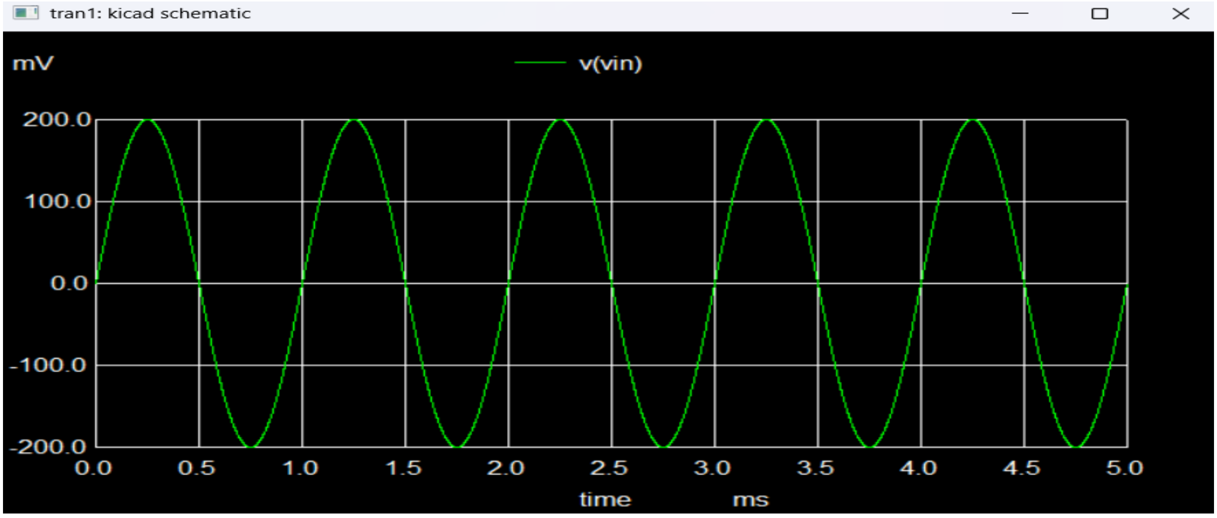

Figure 4.9: Input Voltage Waveform of LF356

4.2.5 Output Plots

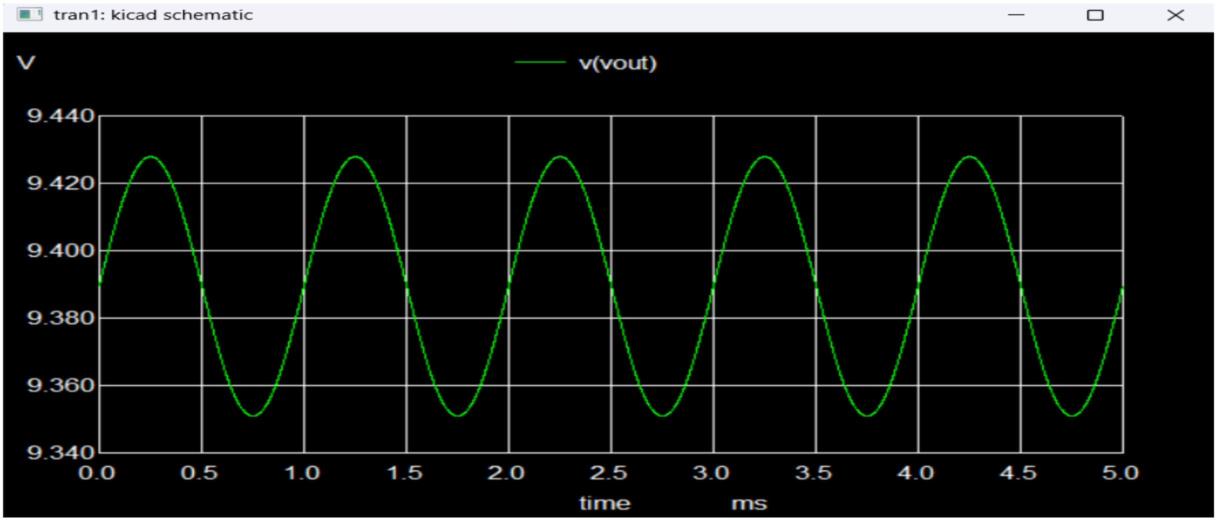

Figure 4.10: Output Voltage Waveform of LF356

4.2.6 Description

The LF356 is a JFET input operational amplifier, and in this circuit it is configured as a voltage follower. The input signal is applied to the non-inverting terminal, and the output is connected to the inverting terminal through feedback. This configuration makes the output follow the input signal.

From the waveforms, the output has the same shape and frequency as the input, but with a DC level determined by the supply voltage and internal biasing of the IC. This variation is expected in practical operational amplifiers. The observed results show that the LF356 operates correctly according to its characteristics.

4.3 LM7810 - 10V Positive Voltage Regulator

The LM7810 is a three-terminal positive voltage regulator designed to provide a fixed and regulated output voltage of 10 V. It is widely used in power supply circuits due to its simplicity, reliability, and ease of use. The IC includes internal current limiting, thermal shutdown, and safe operating area protection, which help protect the device from overload and overheating conditions.

The LM7810 operates with an input voltage higher than the regulated output voltage and maintains a constant 10 V output despite variations in input voltage or load current. Its internal regulation circuitry ensures stable voltage output, making it suitable for powering sensitive electronic components. The device requires minimal external components for proper operation, simplifying circuit design.

Due to its stable voltage regulation and built-in protection features, the LM7810 is commonly used in regulated power supplies, embedded systems, instrumentation circuits, and general-purpose electronic applications. Its robust performance and dependable operation make it suitable for educational, experimental, and industrial electronic designs.

4.3.1 IC Layout

This figure represents the Pin Package Diagram of LM7810

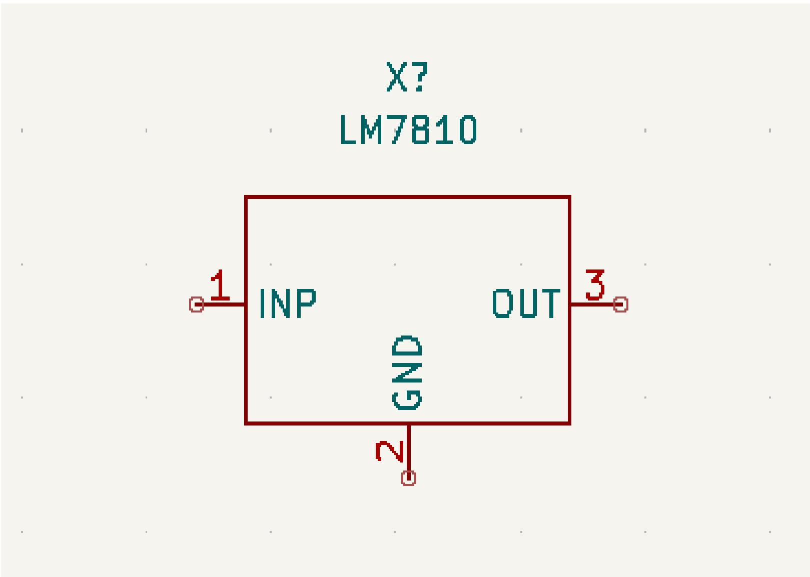

Figure 4.11: Pin diagram of LM7810

4.3.2 Subcircuit Schematic Diagram

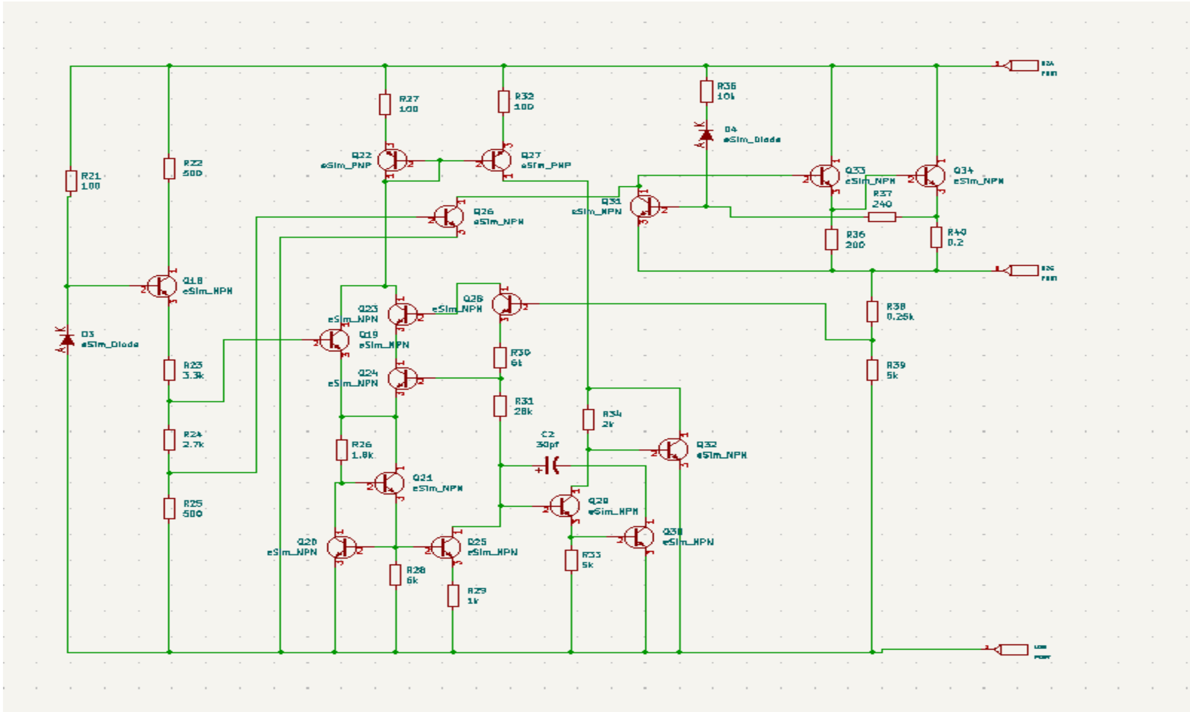

Figure 4.12: Subcircuit Schematic of LM7810

4.3.3 Test Circuit

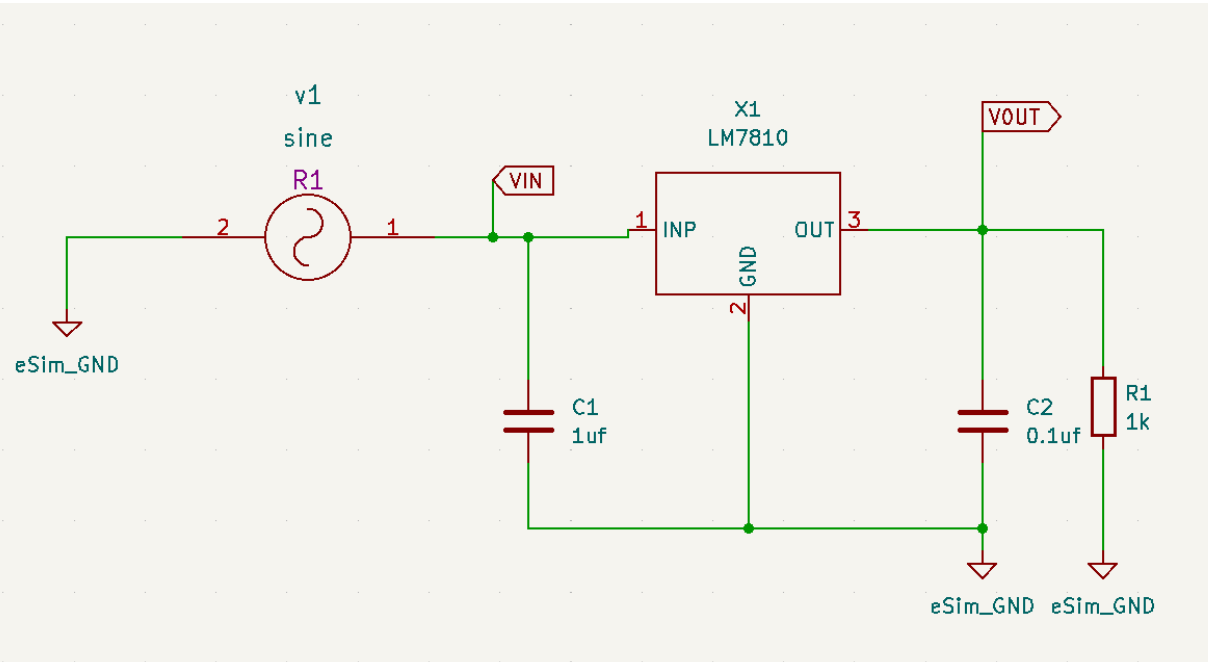

Figure 4.13: Test Circuit of LM7810 IC

4.3.4 Input Plots

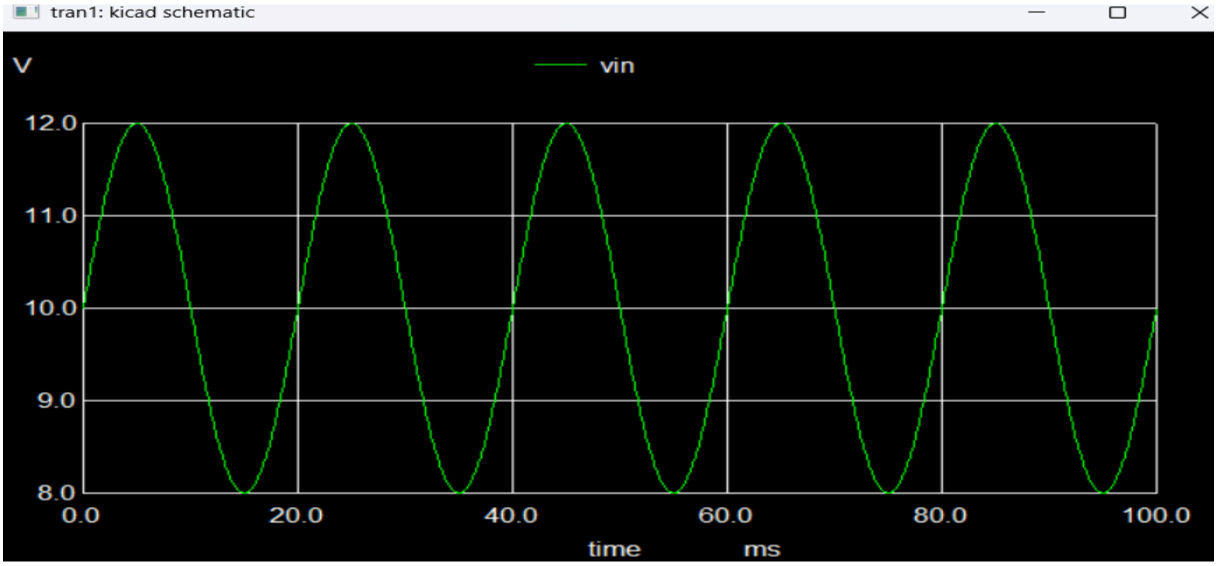

Figure 4.14: Input Voltage Waveform of LM7810

4.3.5 Output Plots

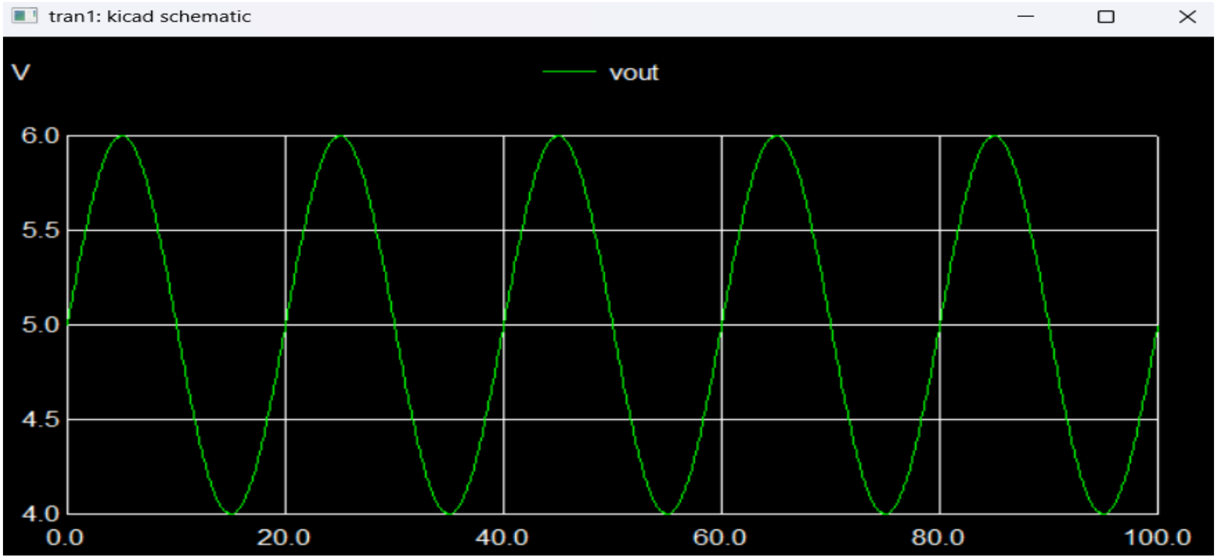

Figure 4.15: Output Voltage Waveform of LM7810

4.3.6 Description

The LM7810 is a 10 V positive voltage regulator. Its purpose is to provide a fixed and stable output voltage. The input voltage applied to the IC is higher than 10 V and changes with time.

From the waveforms, the input voltage varies, but the output voltage remains regulated by the LM7810. The output does not follow the input waveform because the IC is designed to regulate voltage, not to amplify or follow the input signal. This shows that the LM7810 is working as a voltage regulator.

4.4 LM334 - Adjustable Current Source

The LM334 is a three-terminal adjustable current source designed to provide a stable and programmable output current over a wide range. It operates by maintaining a constant current set by an external resistor, making it suitable for current regulation applications. The device is capable of operating with low supply voltages and offers reliable performance across varying temperature conditions.

The output current of the LM334 can be easily adjusted using a single external resistor, allowing flexibility in circuit design. Its internal design ensures that the current remains relatively constant despite changes in supply voltage, provided the device operates within its specified limits. This characteristic makes the LM334 useful in circuits where precise current control is required rather than voltage regulation.

Due to its adjustable current regulation capability, the LM334 is commonly used in biasing circuits, current limiting applications, temperature sensors, and reference current sources. Its simplicity, low component count, and stable operation make it suitable for educational experiments, analog circuit design, and practical electronic applications.

4.4.1 IC Layout

This figure represents the Pin Package Diagram of LM334

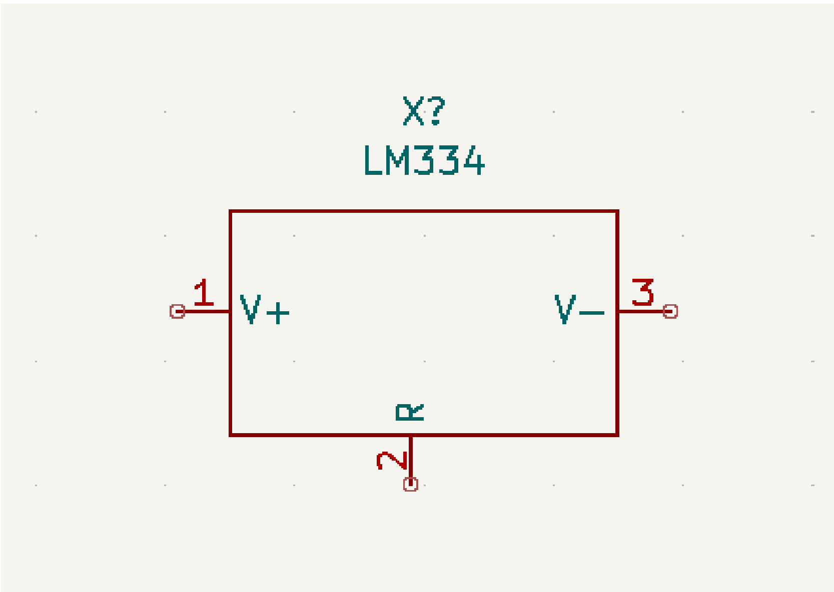

Figure 4.16: Pin diagram of LM334

4.4.2 Subcircuit Schematic Diagram

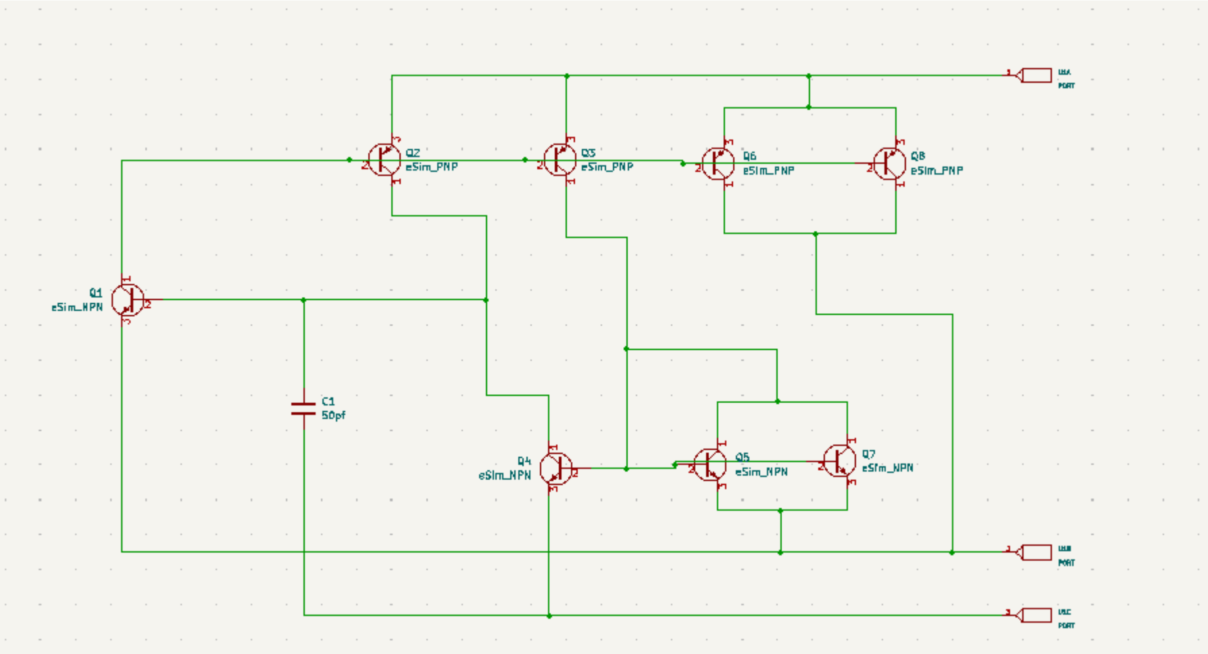

Figure 4.17: Subcircuit Schematic of LM334

4.4.3 Test Circuit

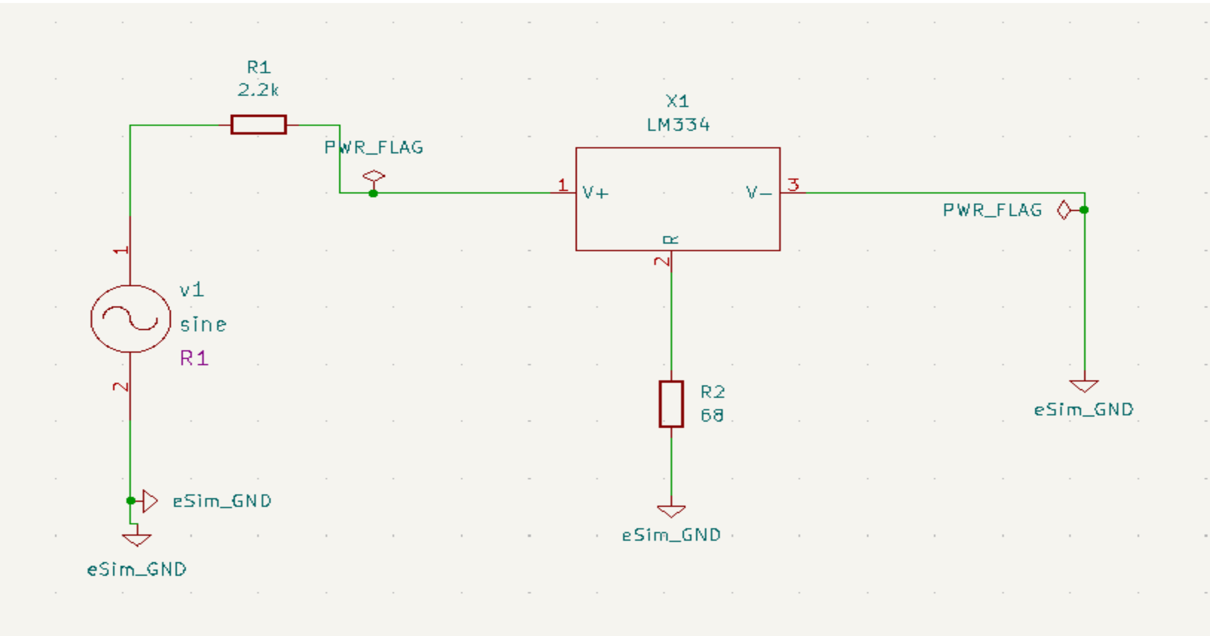

Figure 4.18: Test Circuit of LM334 IC

4.4.4 Input Plots

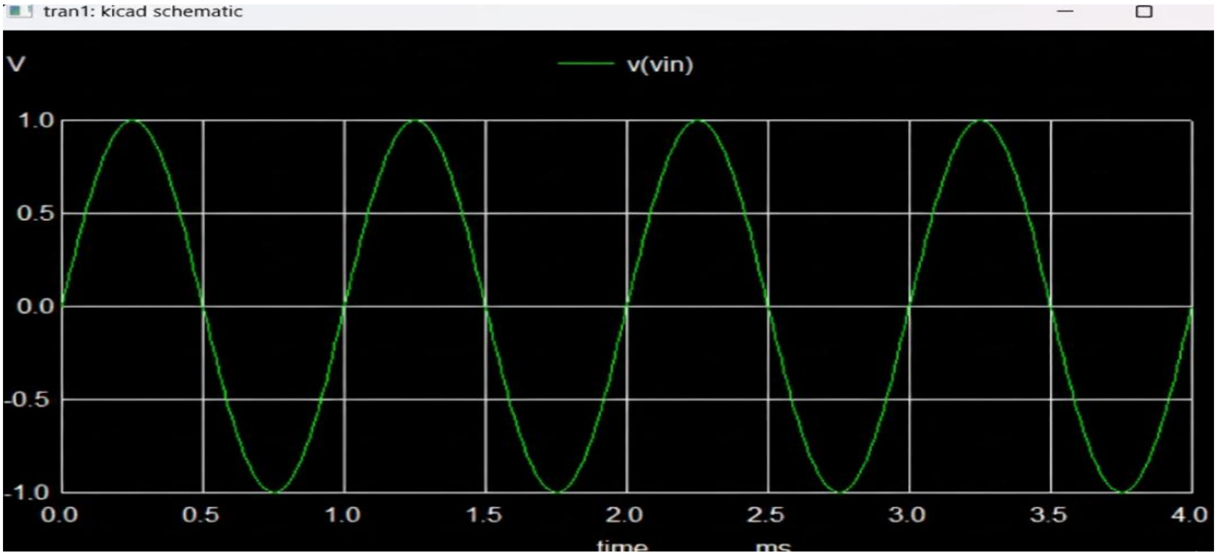

Figure 4.19: Input Voltage Waveform of LM334

4.4.5 Output Plots

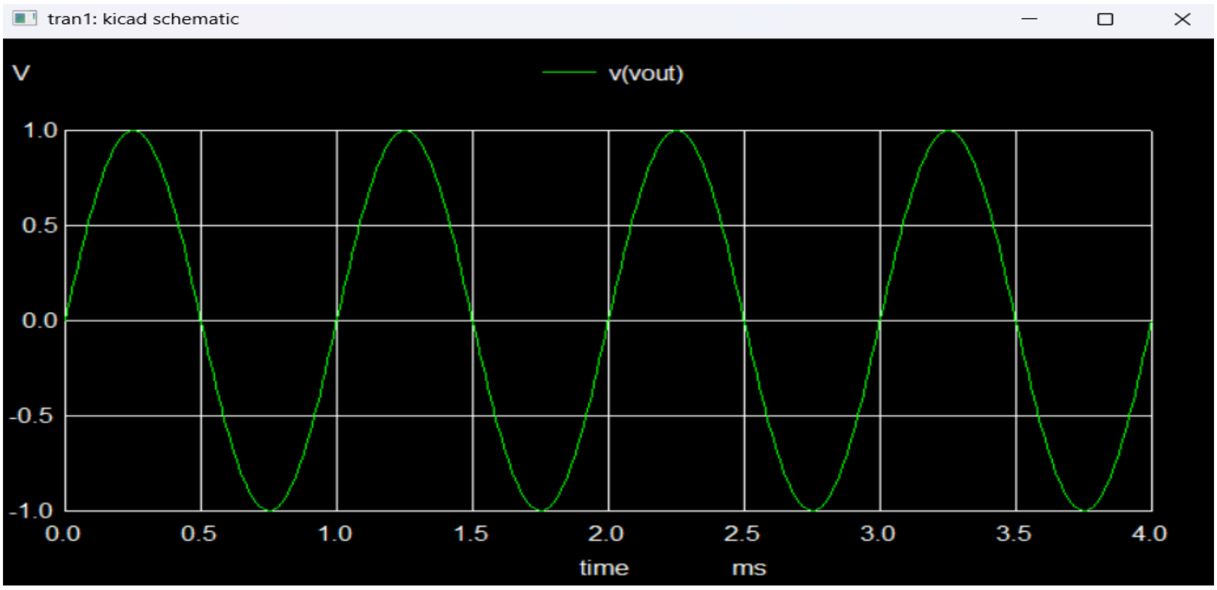

Figure 4.20: Output Voltage Waveform of LM334

4.4.6 Description

The LM334 is an adjustable current source. Its main function is to control the output current using an external resistor. The input voltage applied to the IC varies with time.

From the waveforms, even though the input voltage changes, the LM334 controls the current internally. The output voltage changes based on the load, which is expected. This shows that the LM334 is working correctly as a current source.

4.5 LT1007 - Precision Operational Amplifier

The LT1007 is a precision operational amplifier designed for applications requiring very low input offset voltage and high accuracy. It provides excellent DC performance with minimal drift, making it suitable for precision signal processing applications. The internal design of the LT1007 ensures stable operation and reliable performance over a wide range of supply voltages.

The LT1007 offers high open-loop gain and low noise characteristics, allowing it to amplify small signals with high accuracy. When configured in voltage follower or amplifier configurations, the output accurately represents the input signal with minimal distortion or offset.

Due to its precision characteristics and stable performance, the LT1007 is commonly used in instrumentation amplifiers, data acquisition systems, sensor signal conditioning circuits, and precision measurement applications. Its high accuracy and reliability make it suitable for both educational and practical electronic design purposes.

4.5.1 IC Layout

This figure represents the Pin Package Diagram of LT1007

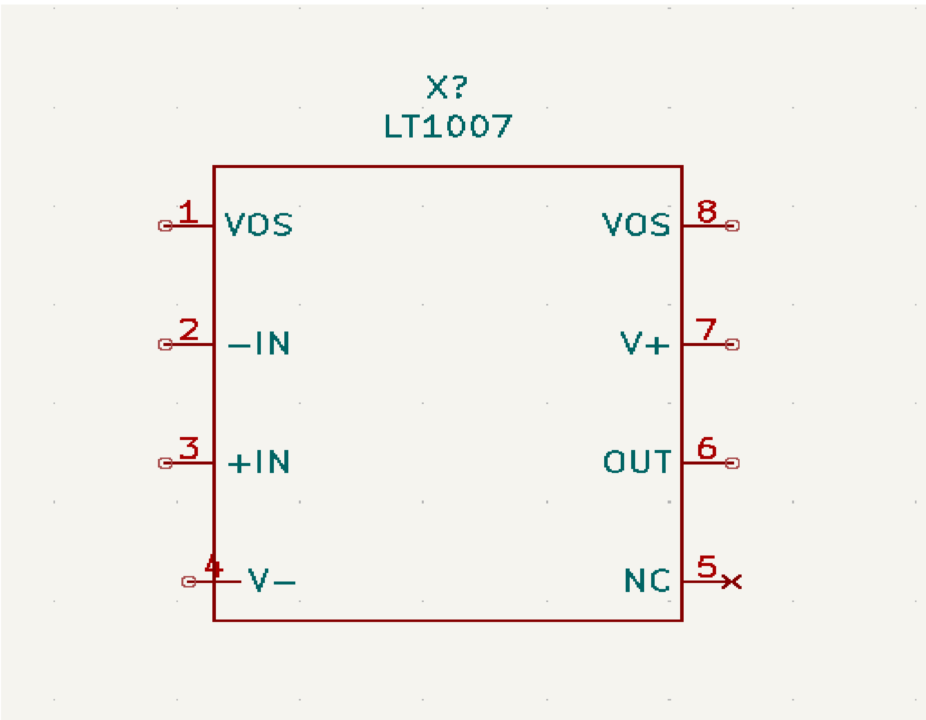

Figure 4.21: Pin diagram of LT1007

4.5.2 Subcircuit Schematic Diagram

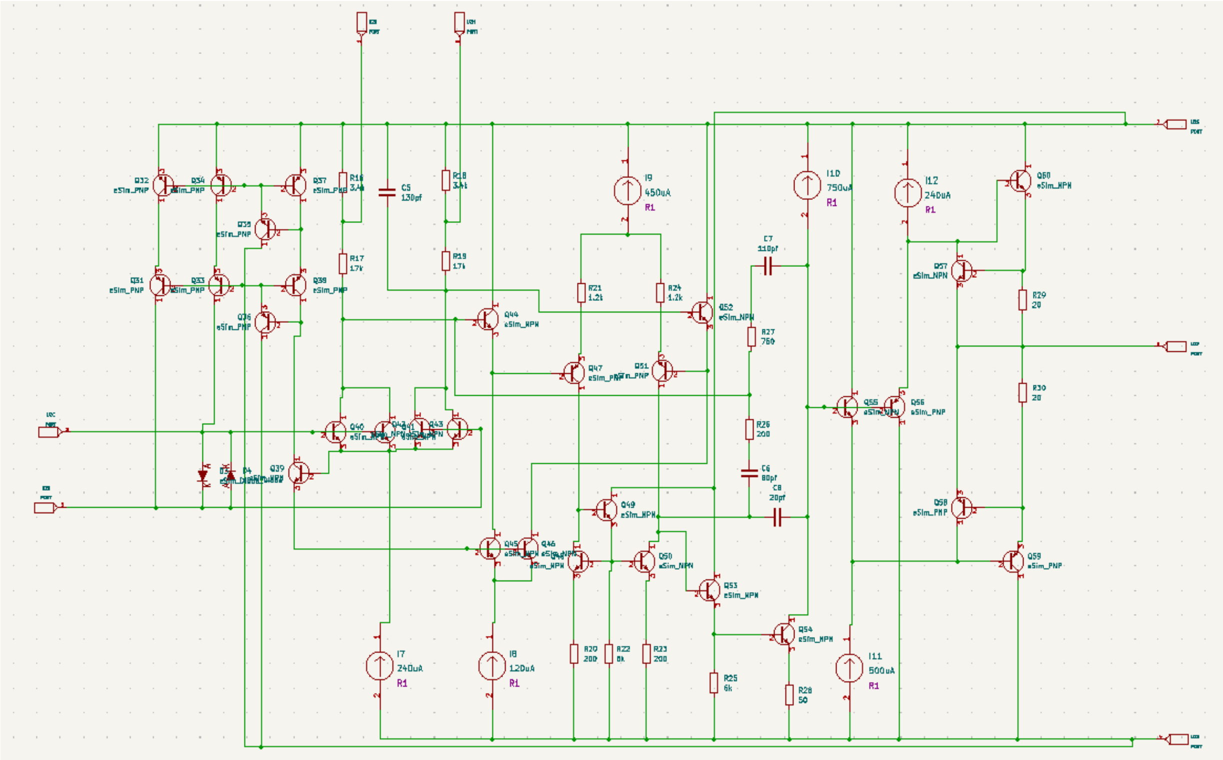

Figure 4.22: Subcircuit Schematic of LT1007

4.5.3 Test Circuit

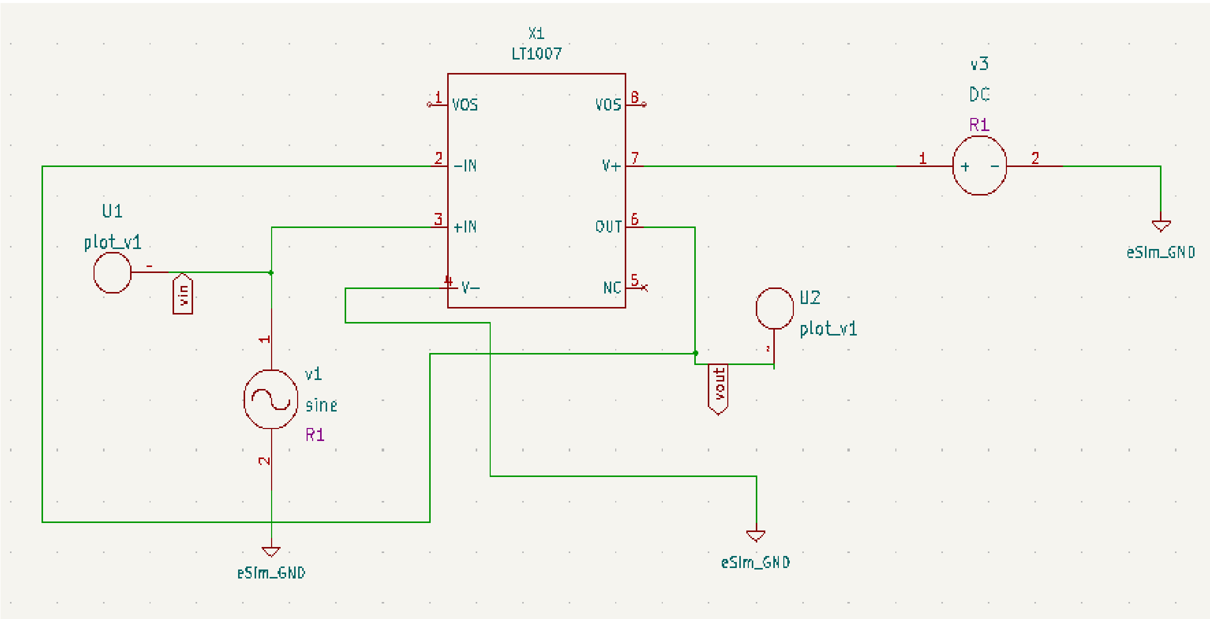

Figure 4.23: Test Circuit of LT1007 IC

4.5.4 Input Plots

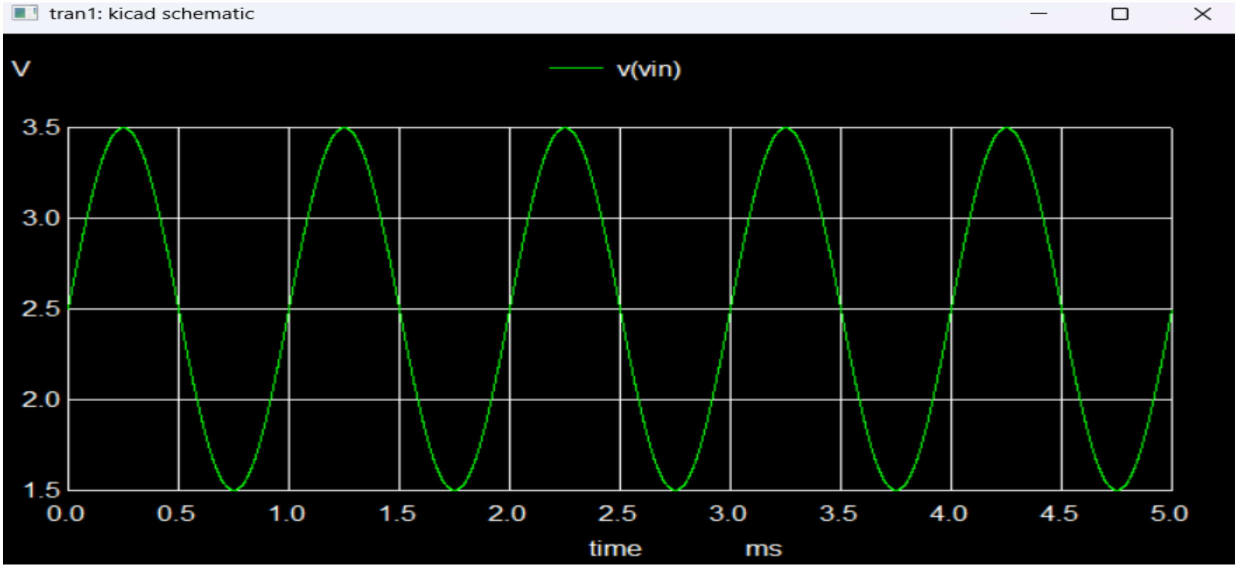

Figure 4.24: Input Voltage Waveform of LT1007

4.5.5 Output Plots

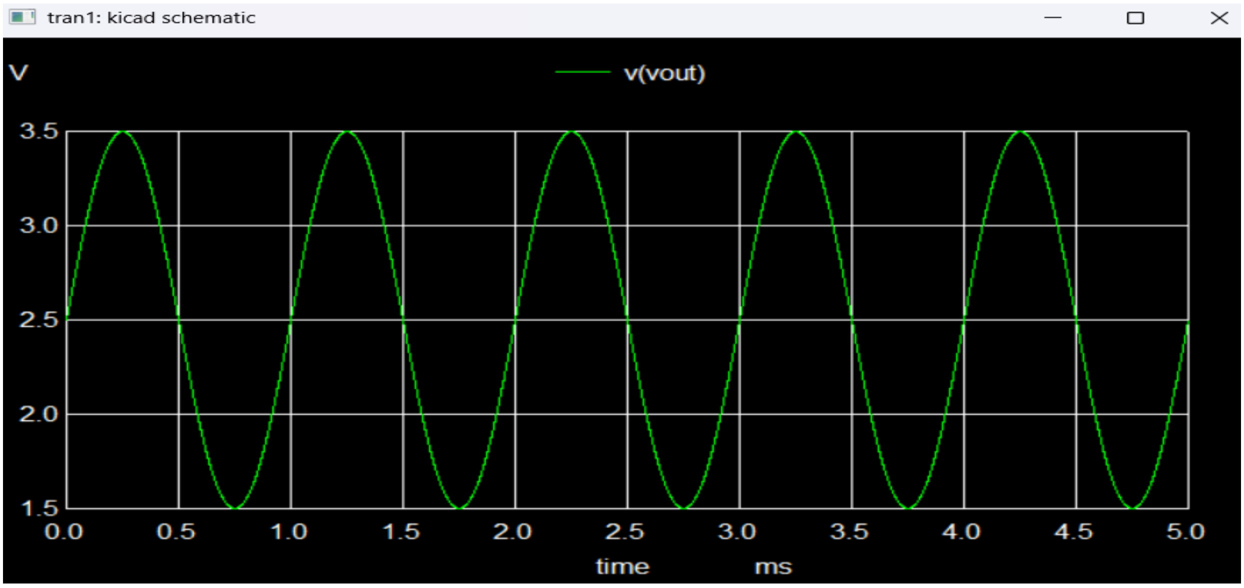

Figure 4.25: Output Voltage Waveform of LT1007

4.5.6 Description

The LT1007 is a precision operational amplifier, and in this circuit it is used to process the input voltage signal. The input signal is applied to the IC, and feedback is used so that the output follows the input signal.

From the waveforms, the output has the same shape and frequency as the input waveform. A small difference in amplitude is observed due to the internal characteristics of the LT1007. This behavior is expected and shows that the LT1007 operates correctly according to its function.

4.6 LM335 - Precision Temperature Sensor

The LM335 is a precision temperature sensor designed to provide an output voltage that is directly proportional to absolute temperature. It operates as a temperature-dependent voltage reference, producing a linear output of 10 mV per Kelvin. The device is designed for easy interfacing with analog and digital circuits and offers reliable temperature sensing performance.

The LM335 operates over a wide temperature range and requires minimal external components for proper operation. Its output voltage varies predictably with temperature, allowing accurate temperature measurement and monitoring. The internal design ensures stable operation and good linearity, making it suitable for temperature sensing applications in electronic systems.

Due to its accurate and linear temperature-to-voltage relationship, the LM335 is commonly used in temperature measurement systems, thermal monitoring circuits, environmental sensing, and calibration applications. Its simplicity, reliability, and precision make it suitable for educational experiments, instrumentation, and practical electronic designs.

4.6.1 IC Layout

This figure represents the Pin Package Diagram of LM335

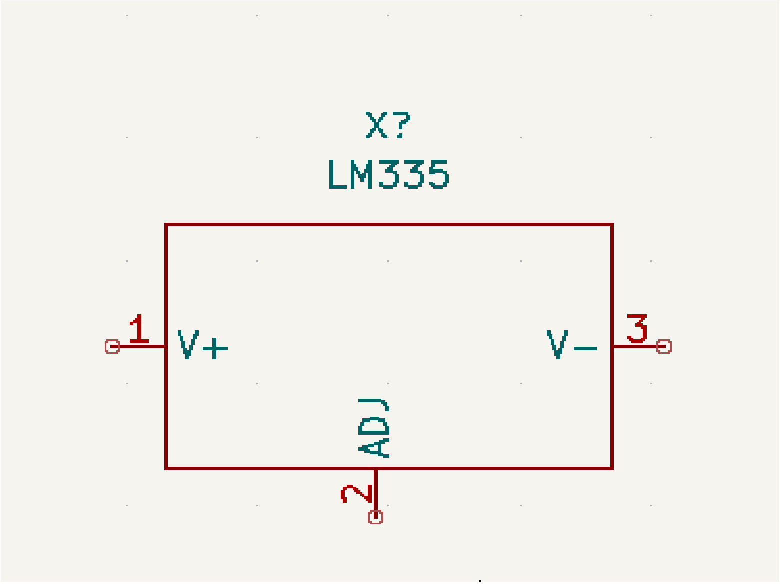

Figure 4.26: Pin diagram of LM335

4.6.2 Subcircuit Schematic Diagram

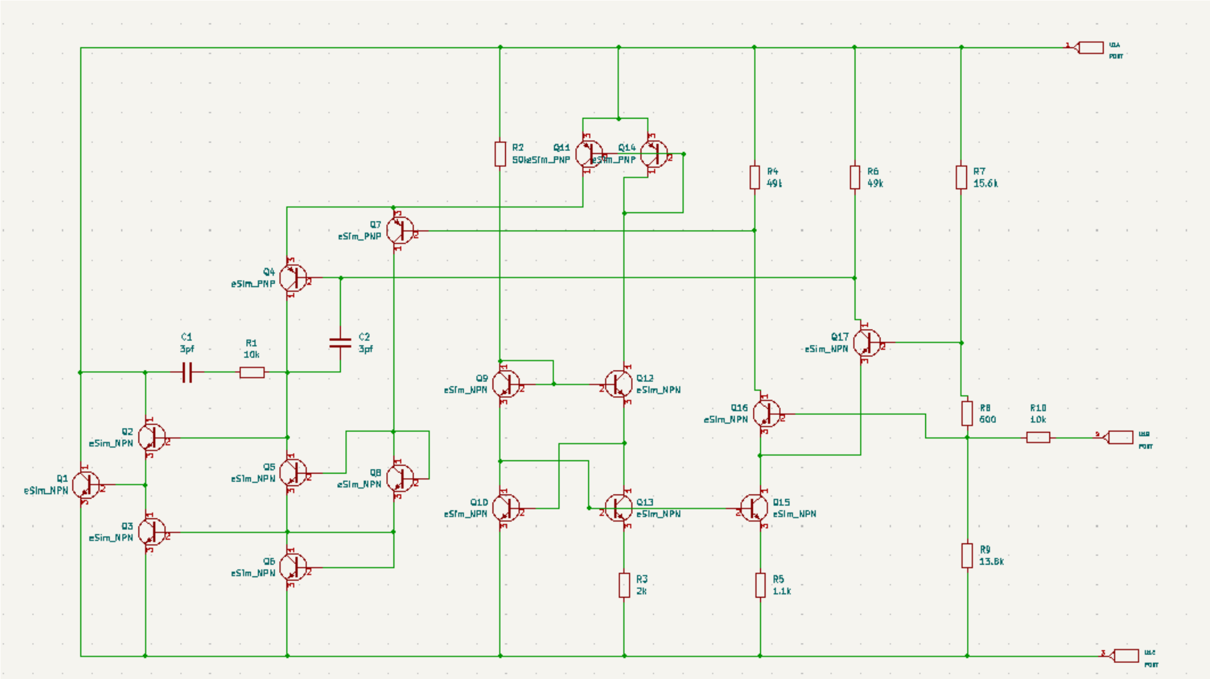

Figure 4.27: Subcircuit Schematic of LM335

4.6.3 Test Circuit

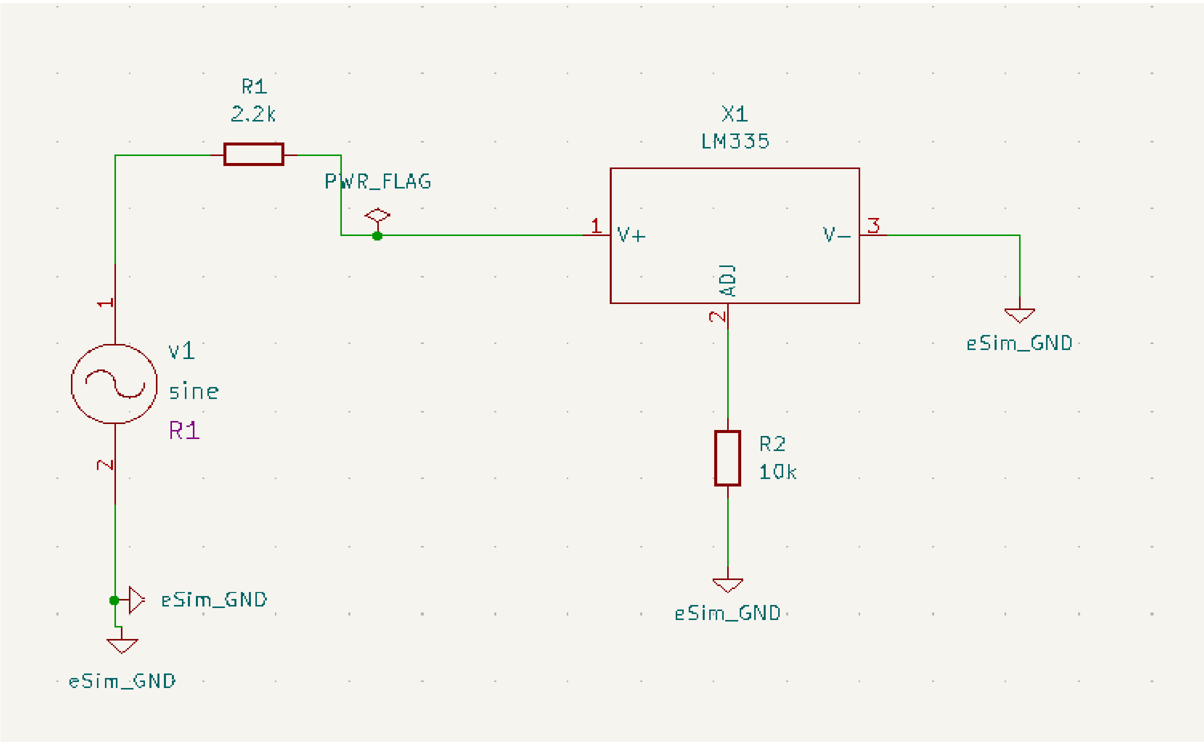

Figure 4.28: Test Circuit of LM335 IC

4.6.4 Input Plots

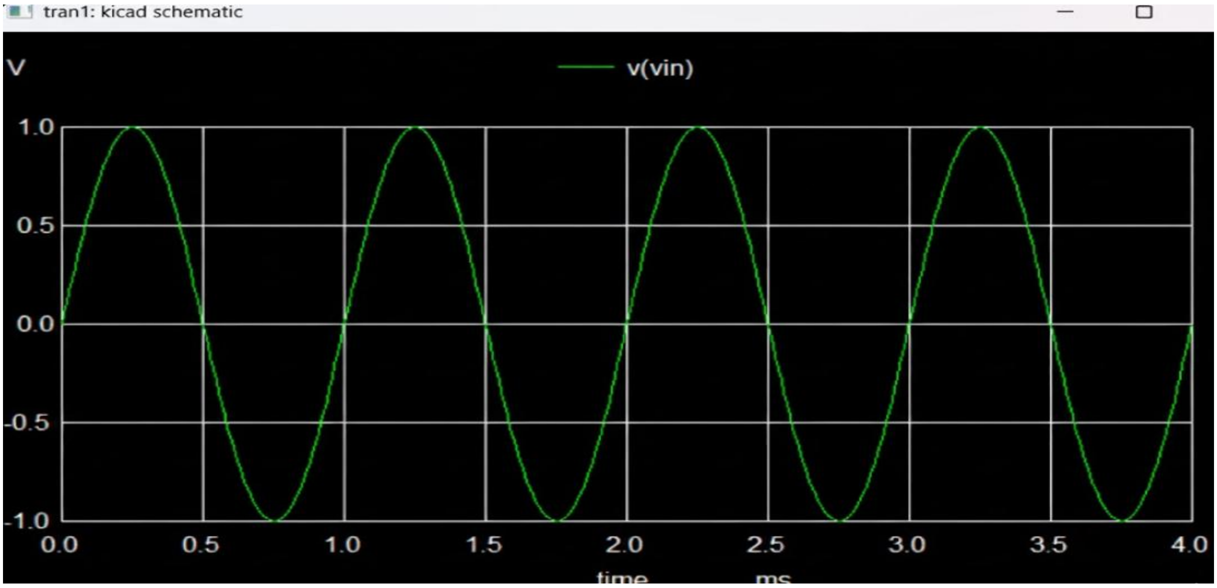

Figure 4.29: Input Voltage Waveform of LM335

4.6.5 Output Plots

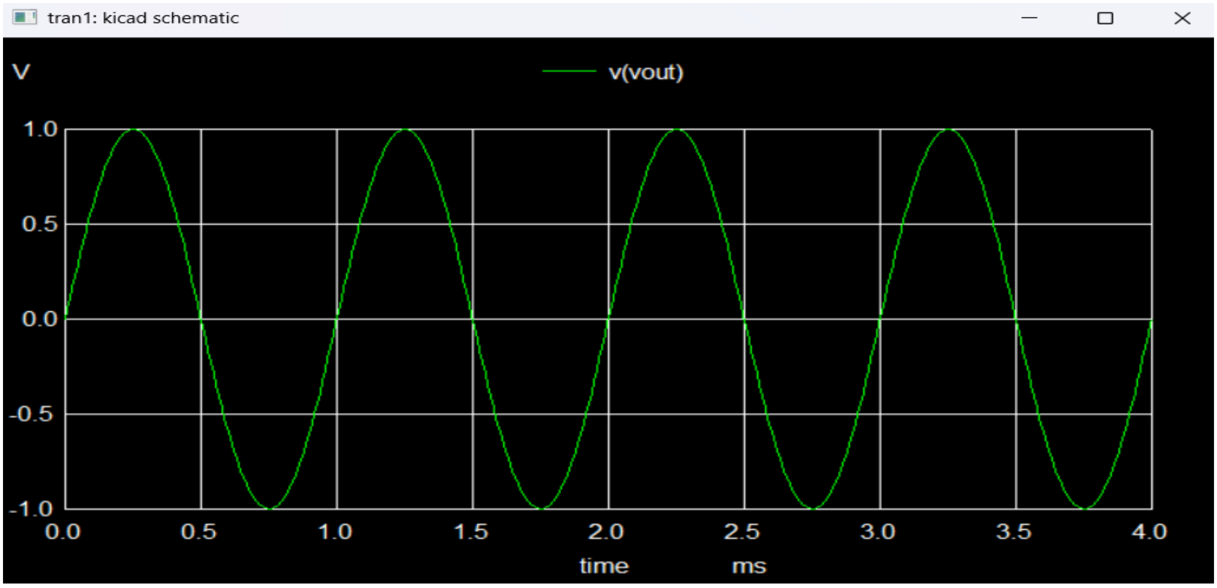

Figure 4.30: Output Voltage Waveform of LM335

4.6.6 Description

The LM335 is a temperature sensor IC. It gives an output voltage that depends on temperature. The input supply is used only to power the IC.

From the waveforms, the output voltage changes based on the internal operation of the LM335. The output does not follow the input signal because this IC is meant for temperature sensing, not for signal amplification. This shows that the LM335 is working correctly.

4.7 CA3078 - High Voltage Operational Amplifier

The CA3078 is a high-voltage operational amplifier designed for applications requiring operation at higher supply voltages and wide input ranges. It is capable of handling large signal swings and provides stable performance in both linear and non-linear circuit configurations. The internal architecture of the CA3078 ensures reliable operation in demanding analog applications.

The CA3078 can operate over a wide range of supply voltages and supports various amplifier configurations such as voltage followers, amplifiers, and comparators. Its design allows it to process analog signals with good stability and accuracy, making it suitable for signal conditioning and control applications. When properly biased, the device delivers consistent output performance.

Due to its high-voltage handling capability and stable operation, the CA3078 is commonly used in industrial control circuits, instrumentation systems, power supply monitoring, and general-purpose analog applications. Its robustness and versatility make it suitable for educational use, experimental setups, and practical electronic circuit designs.

4.7.1 IC Layout

This figure represents the Pin Package Diagram of CA3078

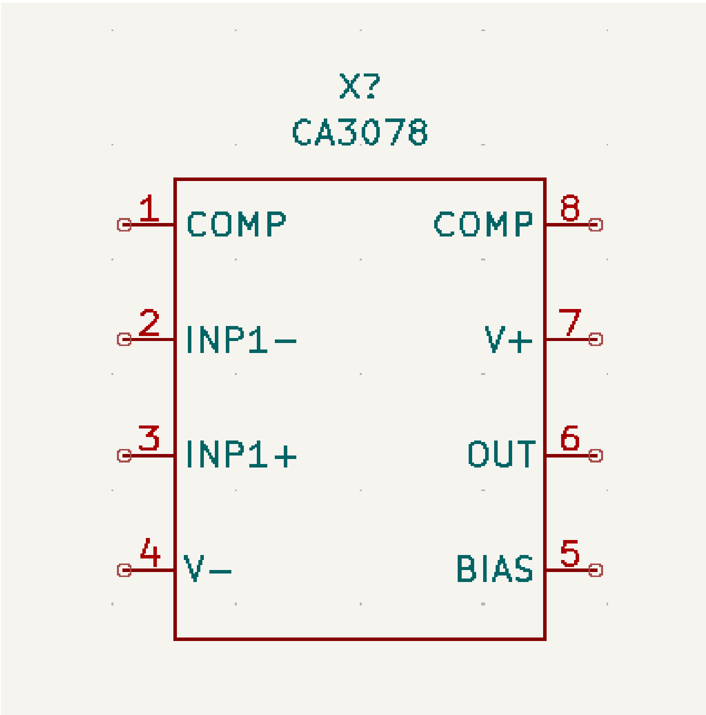

Figure 4.31: Pin diagram of CA3078

4.7.2 Subcircuit Schematic Diagram

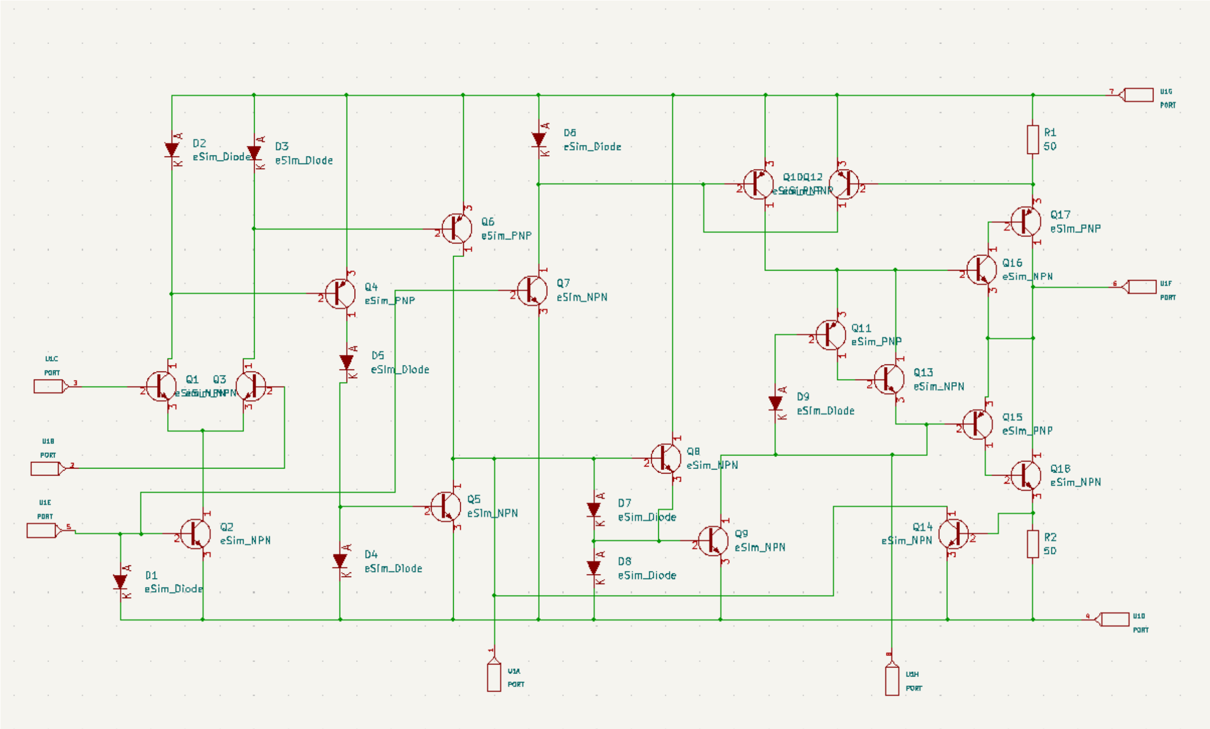

Figure 4.32: Subcircuit Schematic of CA3078

4.7.3 Test Circuit

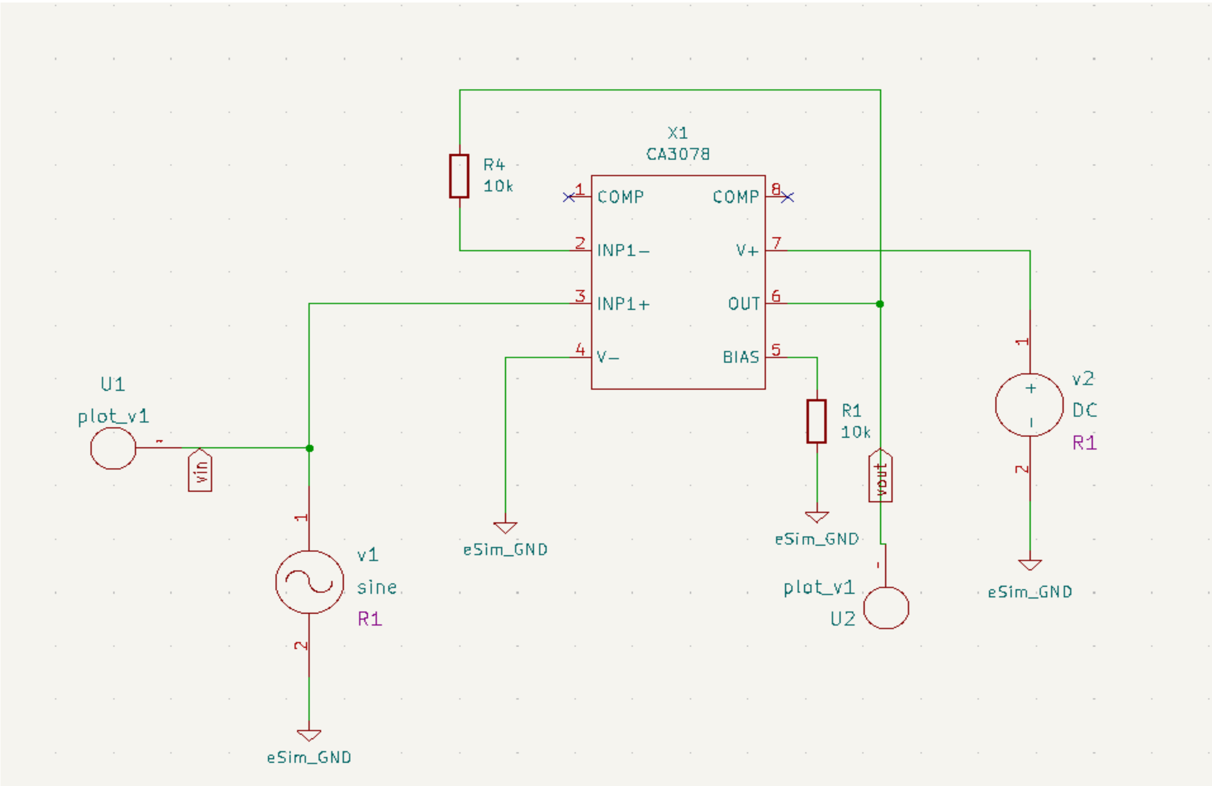

Figure 4.33: Test Circuit of CA3078 IC

4.7.4 Input Plots

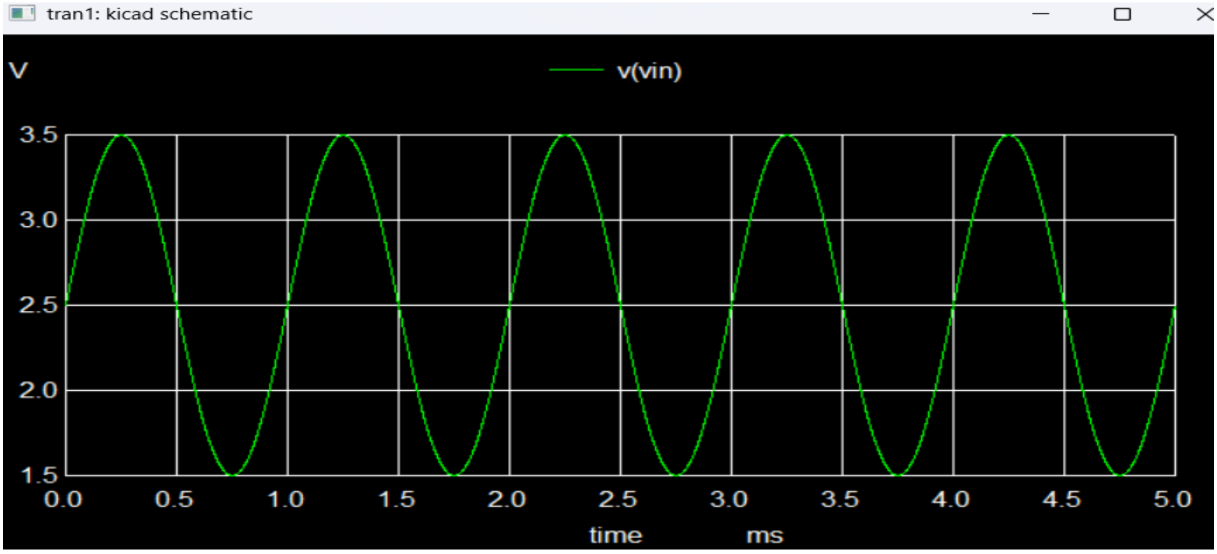

Figure 4.34: Input Voltage Waveform of CA3078

4.7.5 Output Plots

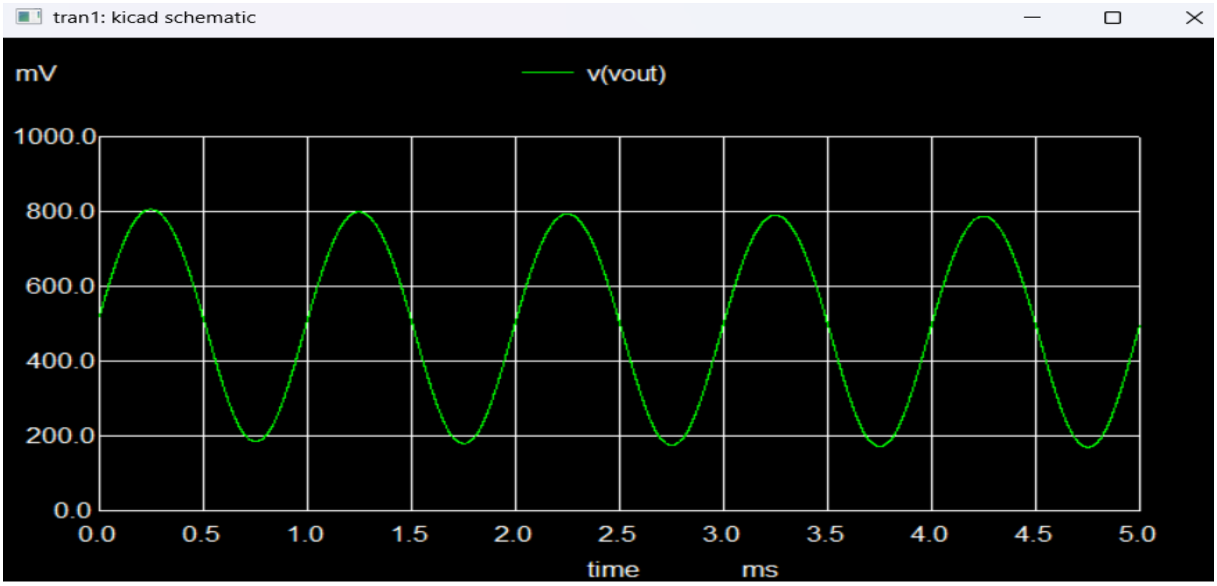

Figure 4.35: Output Voltage Waveform of CA3078

4.7.6 Description

The CA3078 is a high-voltage operational amplifier used to process the input voltage signal. In this circuit, the input is applied to the IC with proper biasing so that it operates within its limits. From the waveforms, the output follows the input in shape and frequency, but the amplitude is different due to the internal gain and biasing of the CA3078. This behavior is expected and confirms that the CA3078 operates correctly according to its characteristics.

4.8 LT1013 - Dual Precision Operational Amplifier

The LT1013 is a dual precision operational amplifier designed for low power and high accuracy applications. It features low input offset voltage and low input bias current, making it suitable for precision signal processing. The internal architecture of the LT1013 ensures stable operation over a wide range of supply voltages.

The LT1013 can operate from a single supply or dual supply configuration and supports rail-to-rail input operation near ground. When configured in voltage follower or amplifier configurations, the output accurately follows the input signal with minimal distortion. This makes the device suitable for low-frequency and low-power analog circuit applications.

Due to its precision characteristics and low power consumption, the LT1013 is commonly used in sensor signal conditioning, instrumentation circuits, battery-powered systems, and general-purpose analog applications. Its reliable performance and efficiency make it suitable for educational experiments, laboratory work, and practical electronic designs.

4.8.1 IC Layout

This figure represents the Pin Package Diagram of LT1013

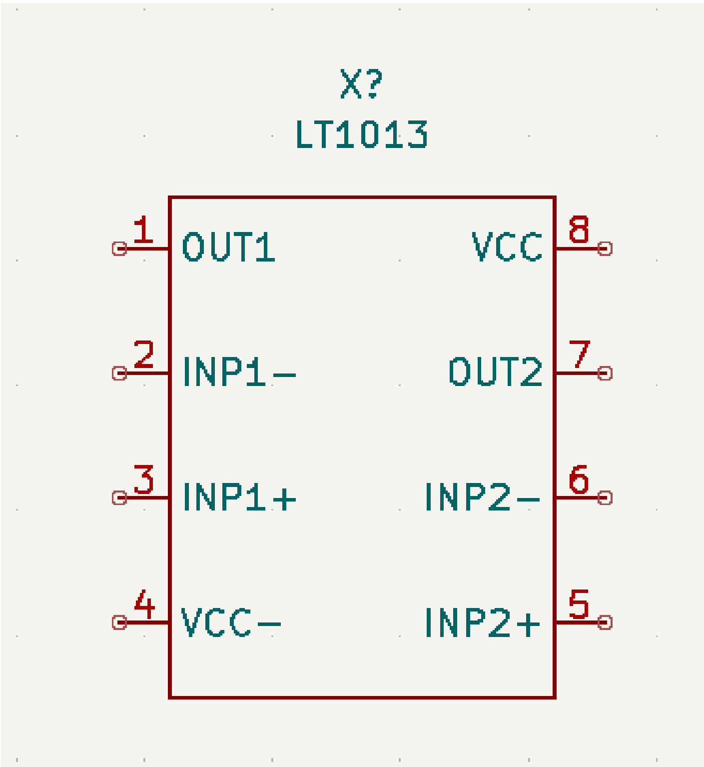

Figure 4.36: Pin diagram of LT1013

4.8.2 Subcircuit Schematic Diagram

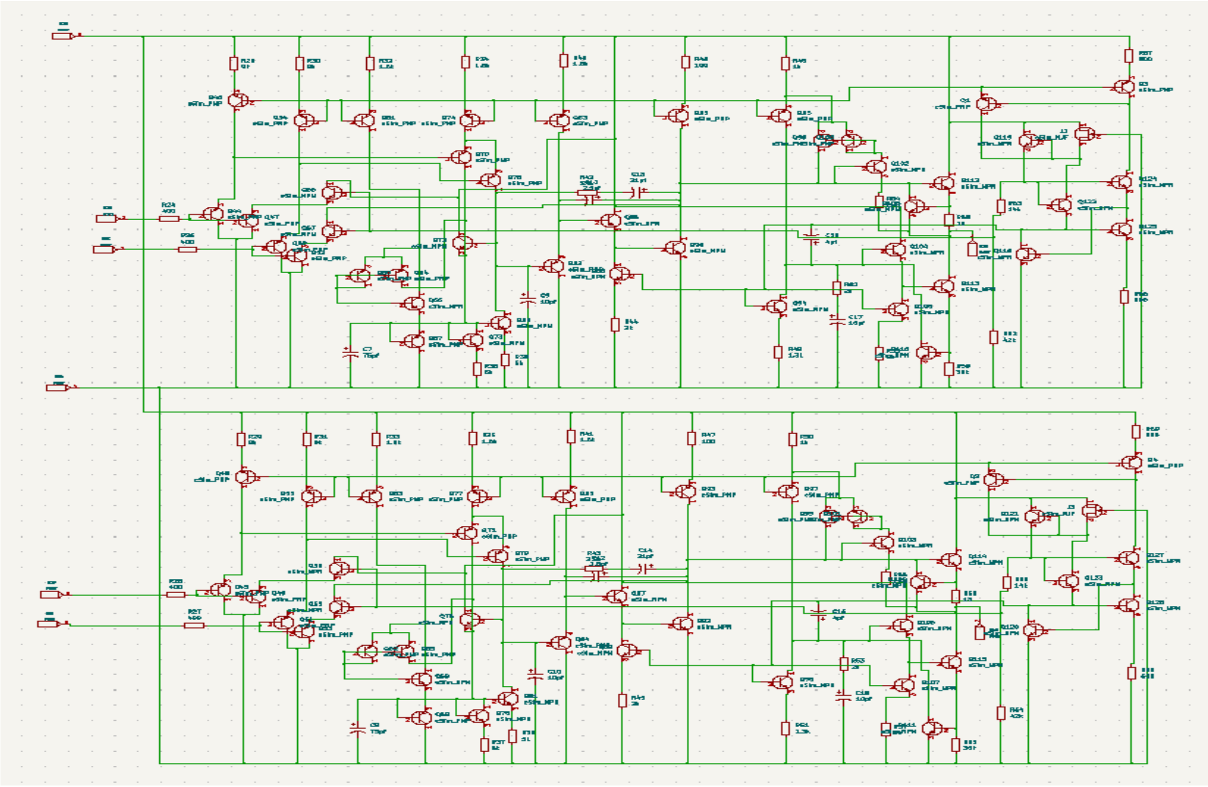

Figure 4.37: Subcircuit Schematic of LT1013

4.8.3 Test Circuit

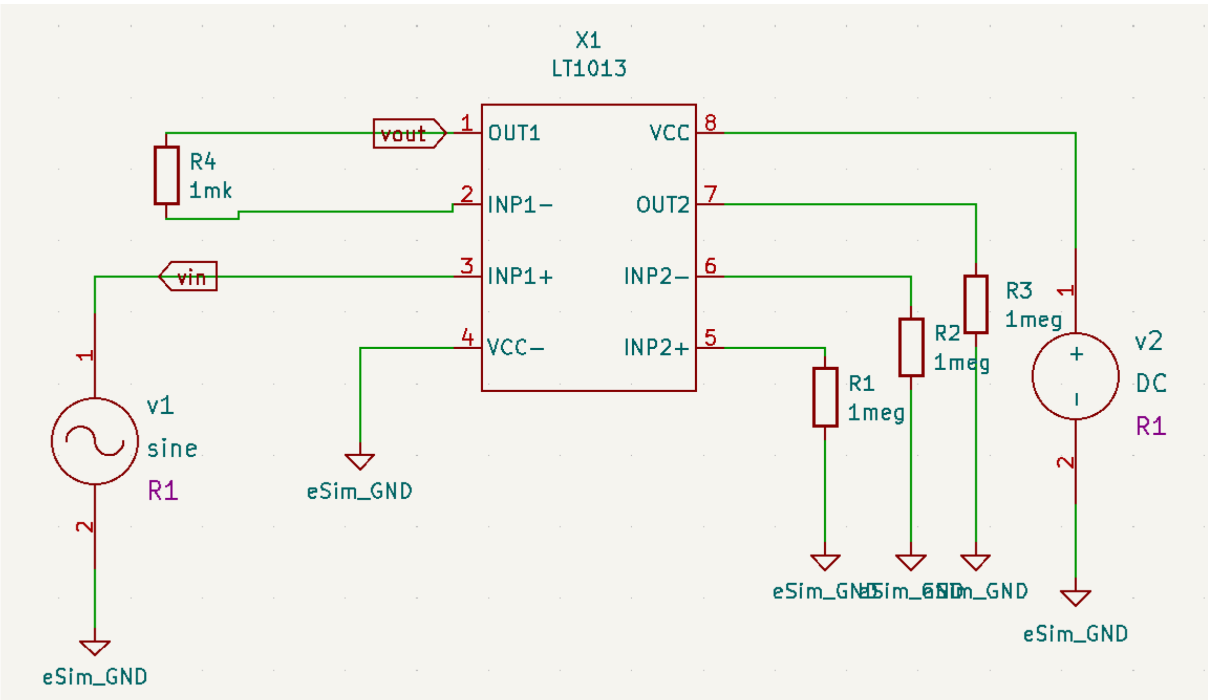

Figure 4.38: Test Circuit of LT1013 IC

4.8.4 Input Plots

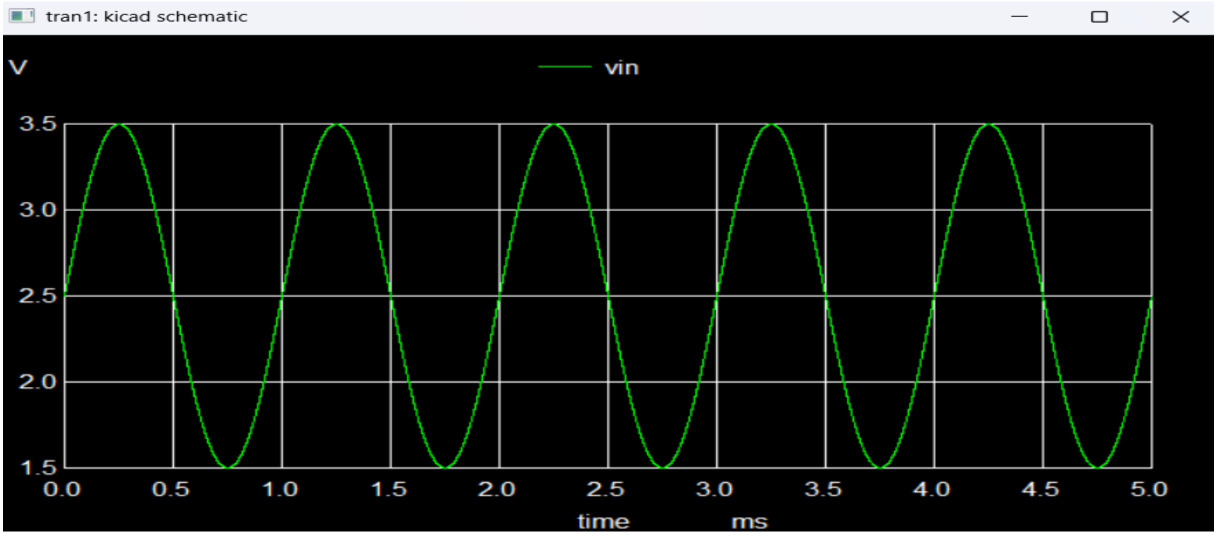

Figure 4.39: Input Voltage Waveform of LT1013

4.8.5 Output Plots

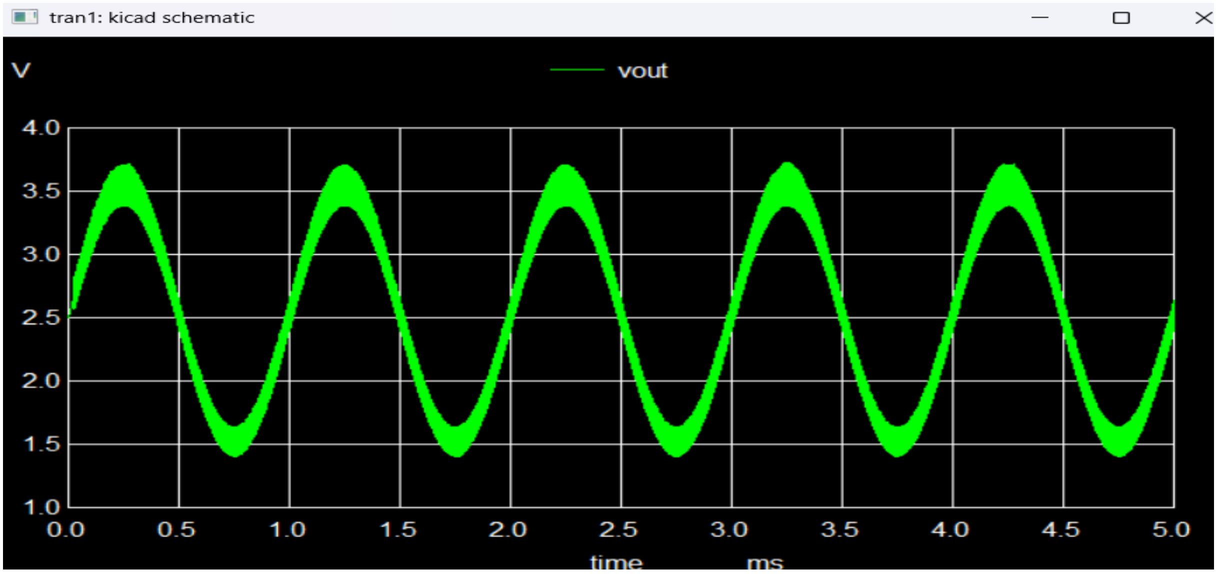

Figure 4.40: Output Voltage Waveform of LT1013

4.8.6 Description

The LT1013 is a dual precision operational amplifier used to amplify and process analog input signals. In this circuit, the input voltage is applied to the IC and proper power supply is given so that it works correctly. The IC is designed to provide stable and accurate output for low-frequency signal applications.

From the waveforms, the output follows the input signal in shape and frequency. A small difference in amplitude is due to the internal characteristics of the LT1013 and the circuit conditions. This result is expected and shows that the LT1013 is operating correctly.

4.9 LM1558 - Dual Operational Amplifier

The LM1558 is a dual operational amplifier designed for general-purpose analog applications. It consists of two independent, internally compensated operational amplifiers in a single package. The device is widely used in signal amplification, buffering, and analog signal processing circuits due to its stable and reliable performance.

The LM1558 operates with dual power supplies and is capable of handling a wide range of input signals when properly biased. In voltage follower and amplifier configurations, the output signal follows the input with appropriate DC biasing. This characteristic makes the LM1558 suitable for applications where signal amplification and conditioning are required with stable operating points.

Due to its dual amplifier structure and consistent performance, the LM1558 is commonly used in audio amplifiers, active filters, waveform generators, and general-purpose analog circuits. Its versatility and robustness make it suitable for educational experiments, laboratory applications, and practical electronic system designs.

4.9.1 IC Layout

This figure represents the Pin Package Diagram of LM1558

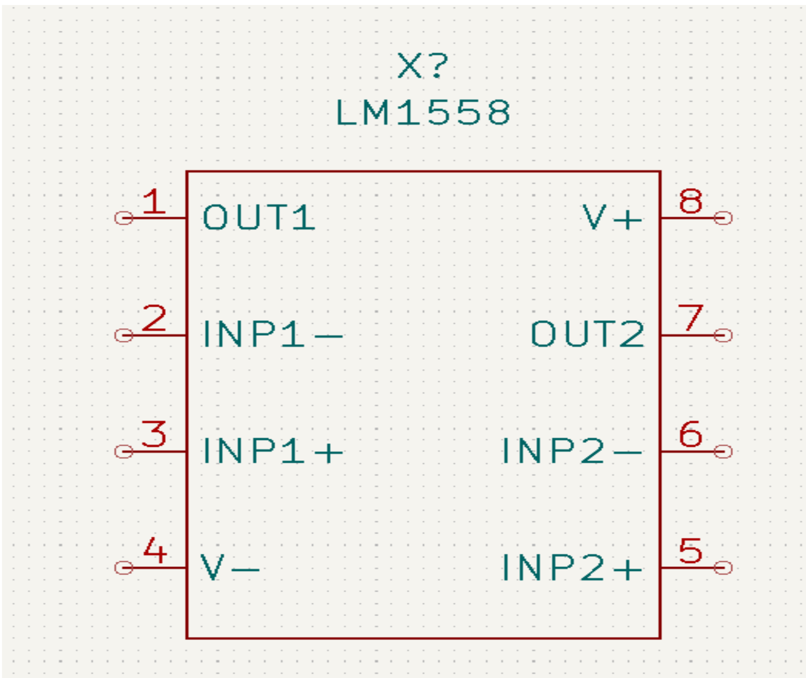

Figure 4.41: Pin diagram of LM1558

4.9.2 Subcircuit Schematic Diagram

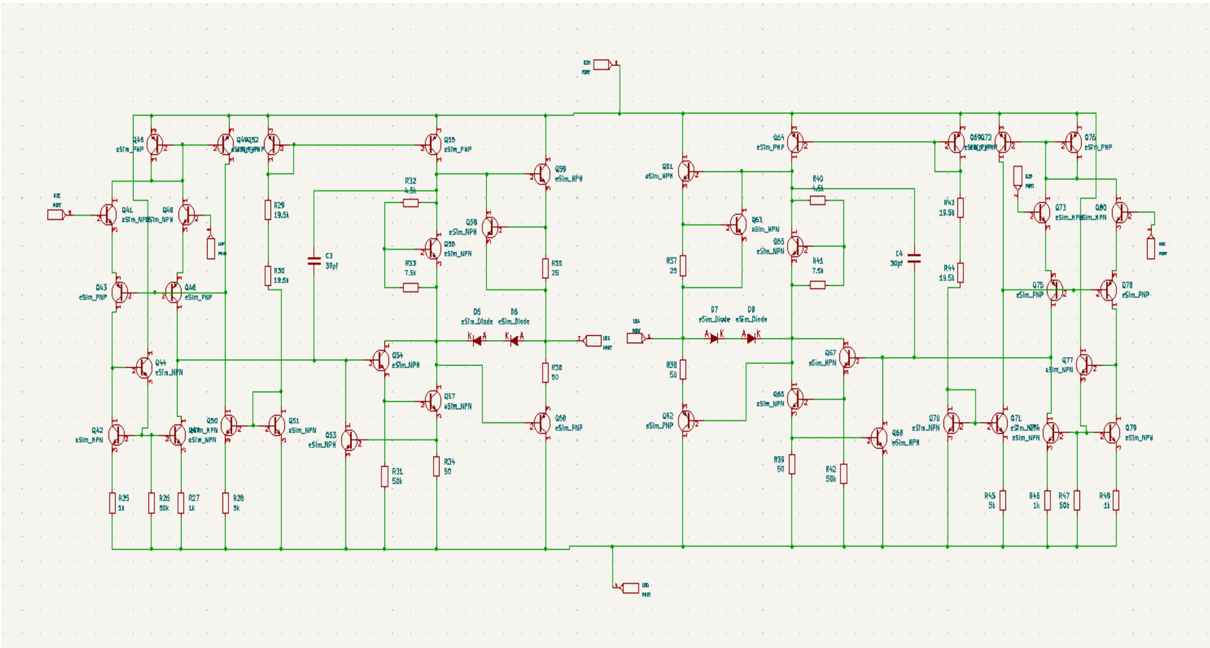

Figure 4.42: Subcircuit Schematic of LM1558

4.9.3 Test Circuit

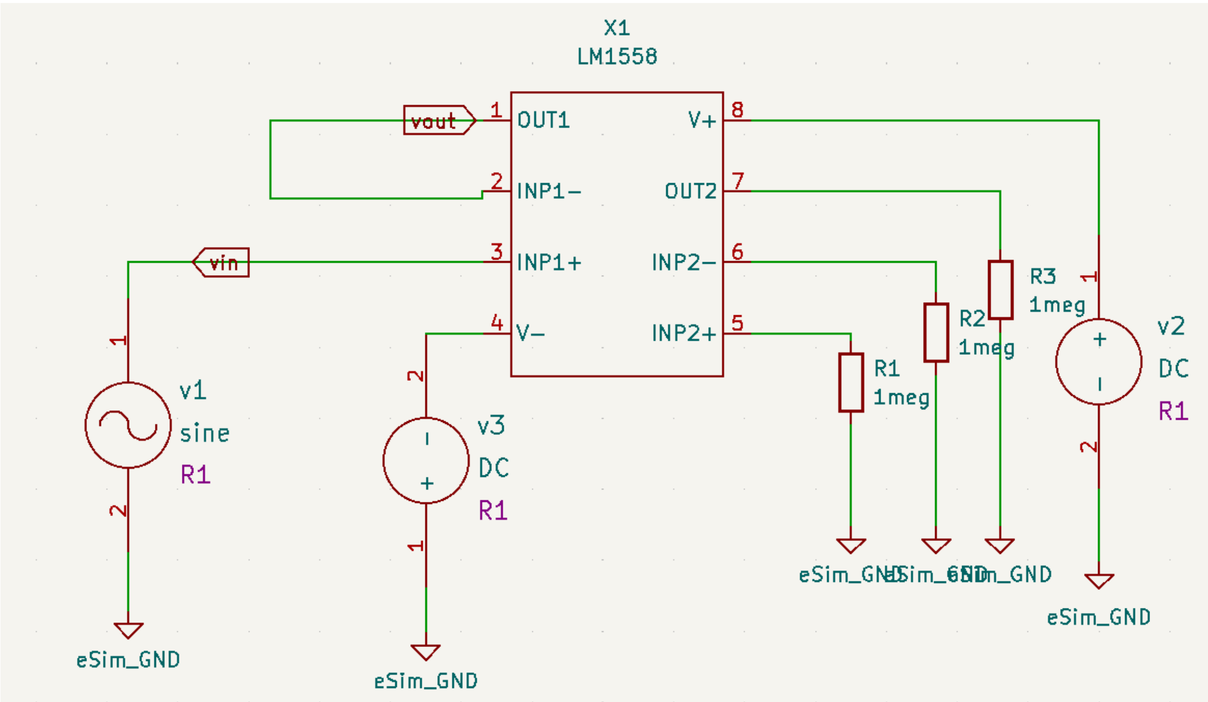

Figure 4.43: Test Circuit of LM1558 IC

4.9.4 Input Plots

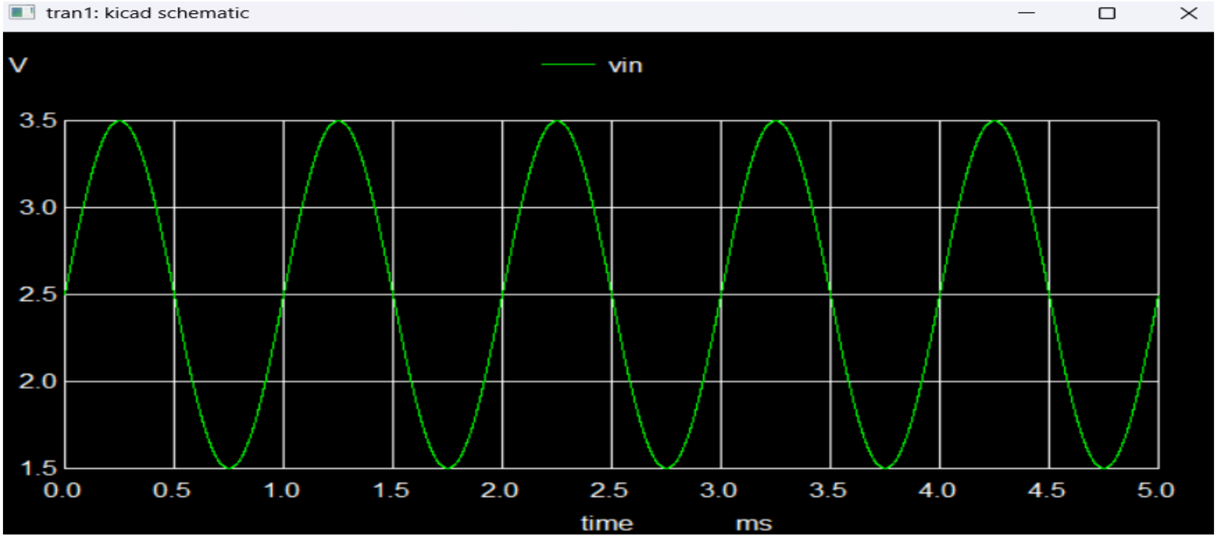

Figure 4.44: Input Voltage Waveform of LM1558

4.9.5 Output Plots

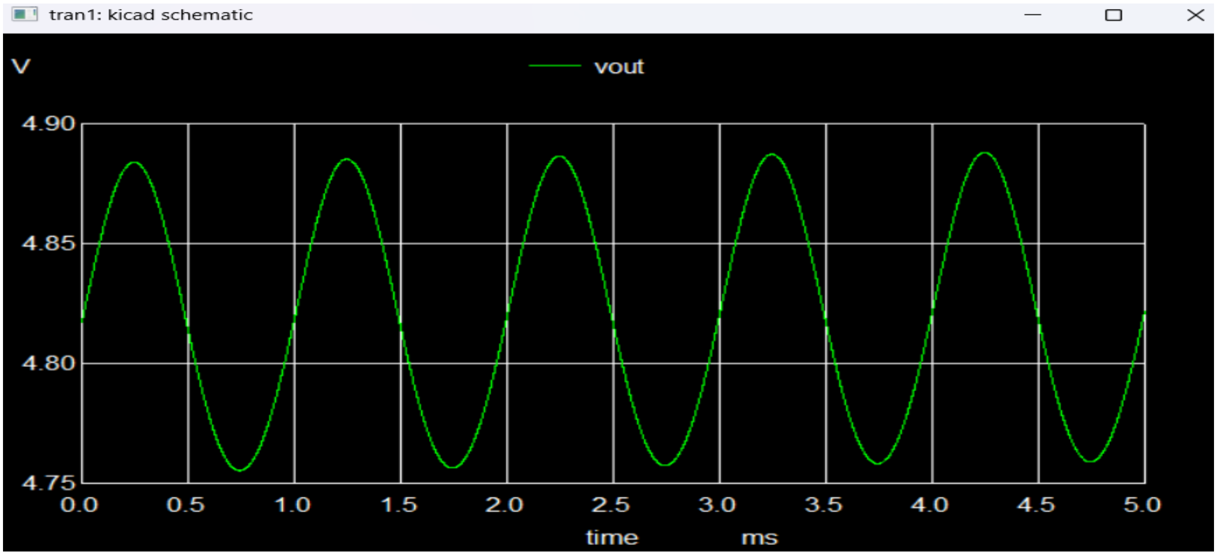

Figure 4.45: Output Voltage Waveform of LM1558

4.9.6 Description

The LM1558 is a dual operational amplifier used for basic signal processing. In this circuit, a sine wave input is applied to the IC, and proper power supply is given so that it operates correctly.

From the waveforms, the output follows the input signal in shape and frequency. A small change in amplitude is due to the internal characteristics of the LM1558. This result is expected and shows that the LM1558 is working correctly.

4.10 LT1002 – Precision Operational Amplifier

The LT1002 is a precision operational amplifier designed for applications requiring high accuracy and low input offset voltage. It offers excellent DC performance with low offset drift and low input bias current, making it suitable for precision analog signal processing. The internal architecture of the LT1002 ensures stable and reliable operation over a wide range of supply voltages.

The LT1002 provides high open-loop gain and low noise characteristics, allowing it to accurately process small input signals. When configured in voltage follower or amplifier configurations, the output closely follows the input signal with minimal error.

Due to its high precision and stable performance, the LT1002 is commonly used in instrumentation systems, sensor signal conditioning circuits, data acquisition systems, and precision measurement applications. Its accuracy and reliability make it suitable for educational experiments, laboratory use, and practical electronic circuit designs.

4.10.1 IC Layout

This figure represents the Pin Package Diagram of LT1002

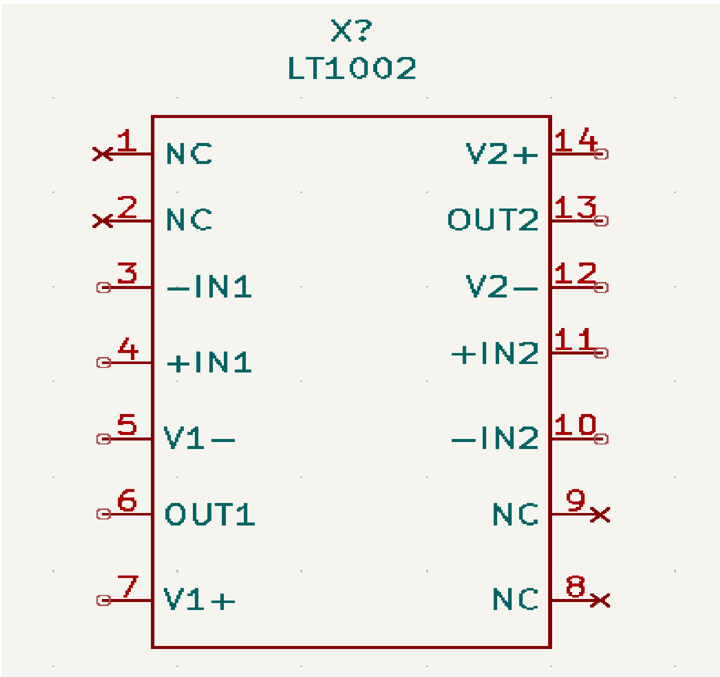

Figure 4.46: Pin diagram of LT1002

4.10.2 Subcircuit Schematic Diagram

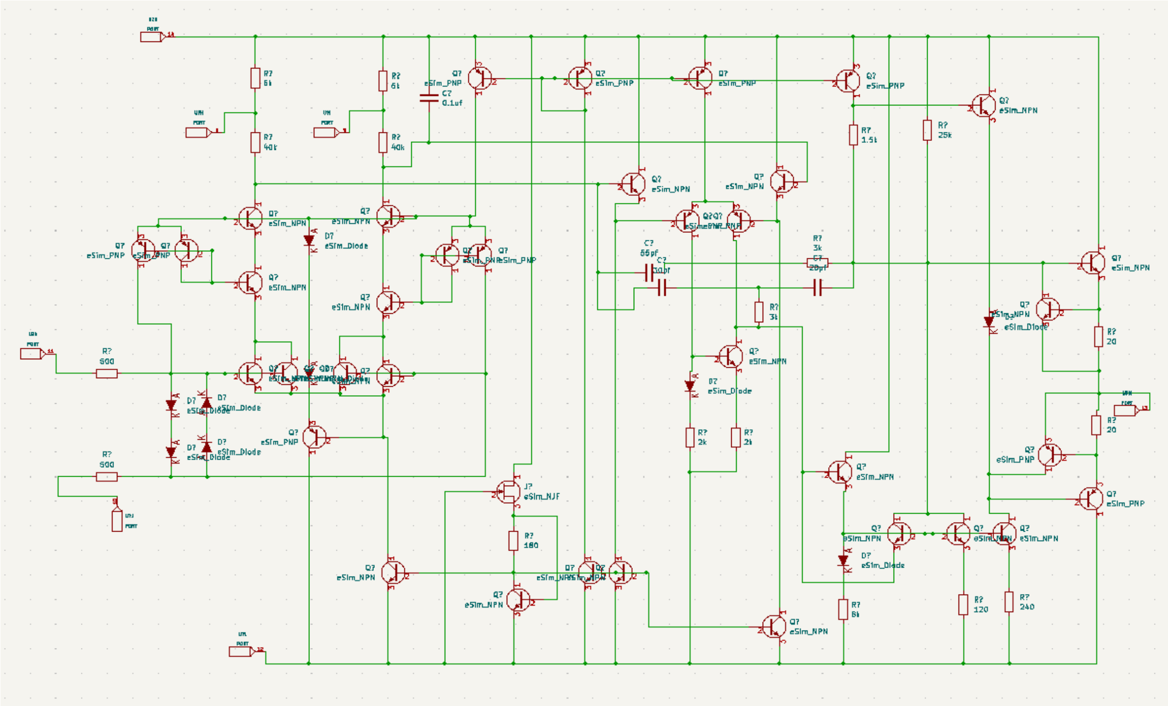

Figure 4.47: Subcircuit Schematic of LT1002

4.10.3 Test Circuit

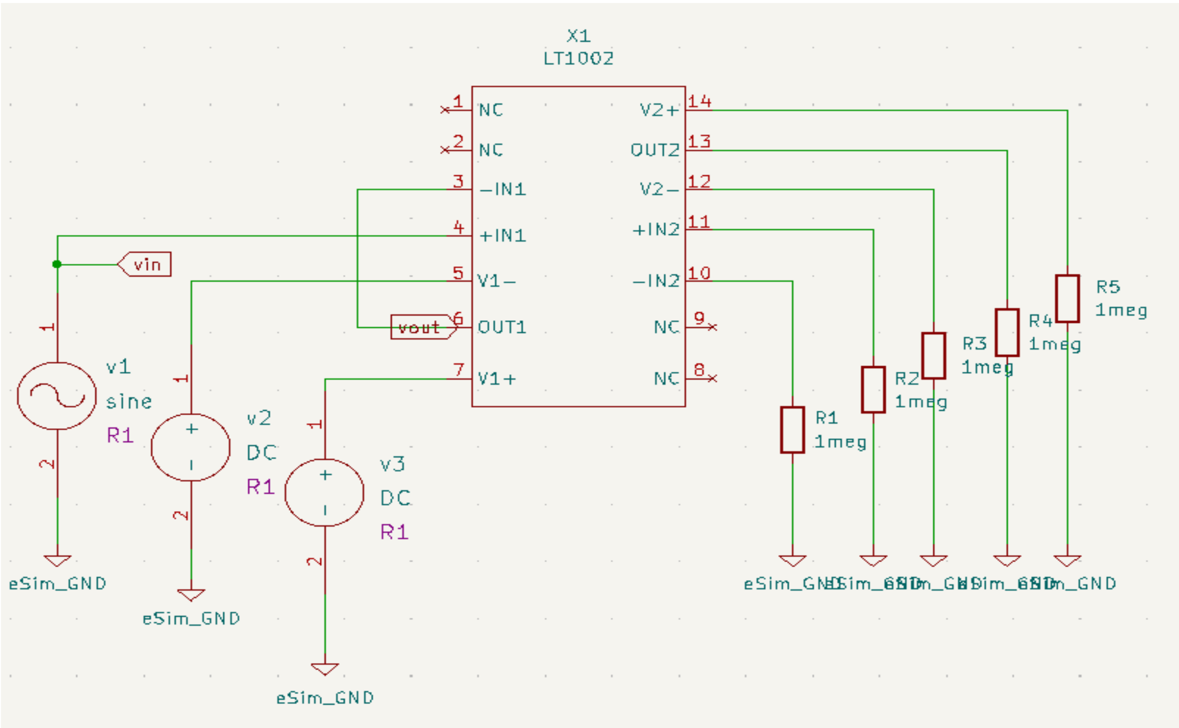

Figure 4.48: Test Circuit of LT1002 IC

4.10.4 Input Plots

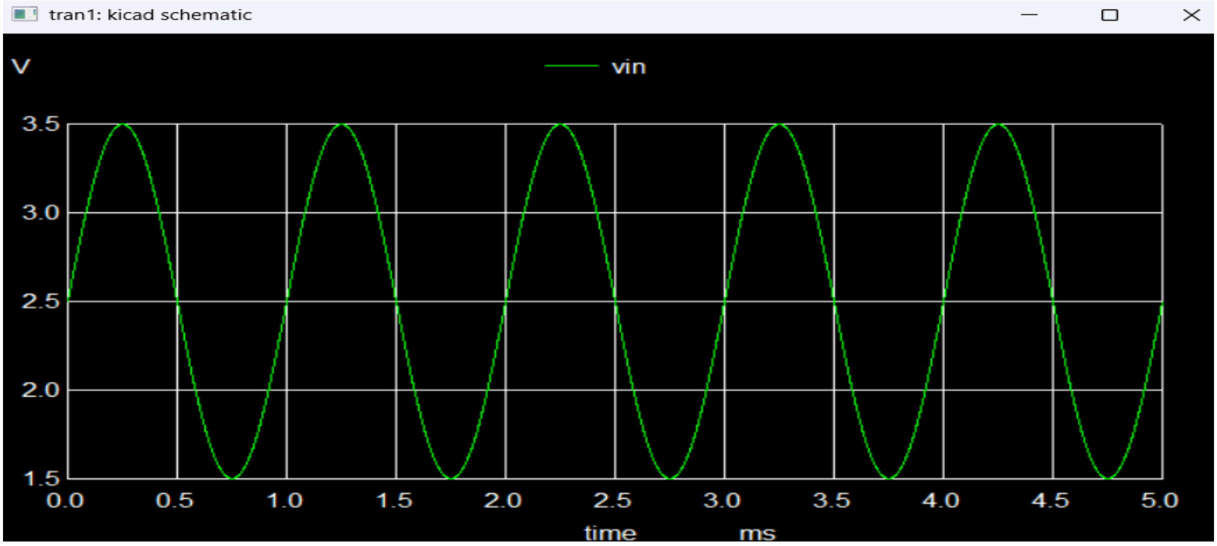

Figure 4.49: Input Voltage Waveform of LT1002

4.10.5 Output Plots

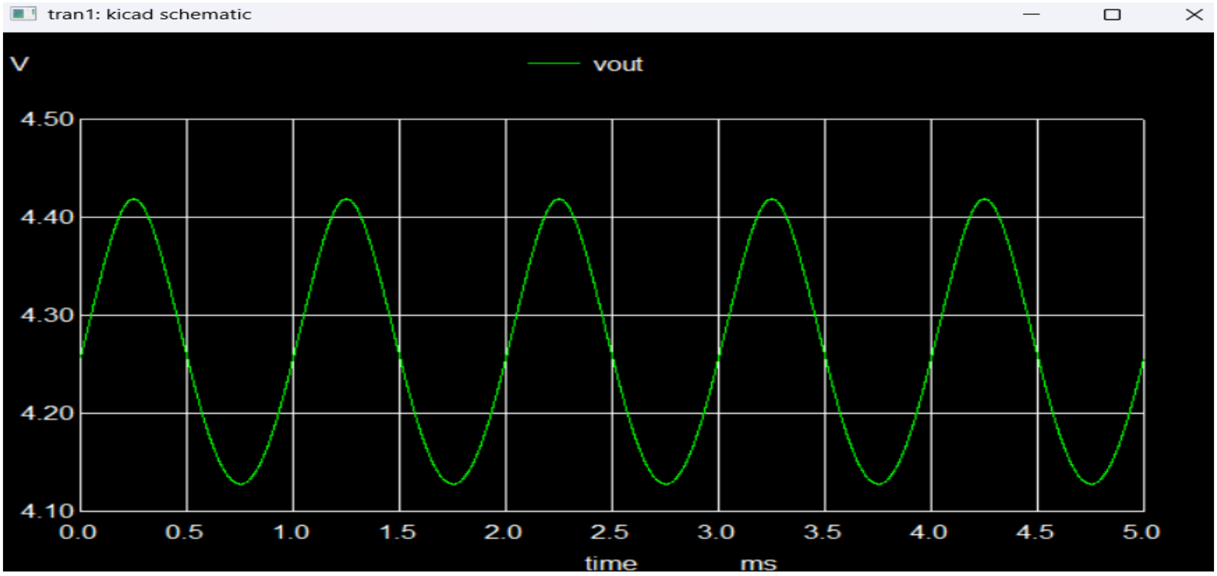

Figure 4.50: Output Voltage Waveform of LT1002

4.10.6 Description

The LT1002 is a precision operational amplifier used to amplify analog signals accurately. In this circuit, a sine wave input is given to the IC, and a proper DC power supply is applied so that the IC works correctly within its operating range.

From the waveforms, the output follows the input signal in shape and frequency. A small change in amplitude or DC level occurs due to the internal characteristics and biasing of the LT1002. This result is expected and shows that the LT1002 is operating correctly.

4.11 LT1097 - Precision Operational Amplifier

The LT1097 is a precision operational amplifier designed for applications requiring low input offset voltage and stable DC performance. It provides accurate signal amplification with minimal offset drift, making it suitable for precision analog signal processing.

The LT1097 offers low noise and high open-loop gain, allowing it to process small input signals with high accuracy. When configured in voltage follower or amplifier configurations, the output closely follows the input signal with minimal distortion. This makes the device suitable for precision amplification and signal conditioning applications.

Due to its precision characteristics and stable performance, the LT1097 is commonly used in instrumentation circuits, sensor signal conditioning, data acquisition systems, and precision measurement applications. Its reliability and accuracy make it suitable for educational experiments, laboratory work, and practical electronic designs.

4.11.1 IC Layout

This figure represents the Pin Package Diagram of LT1097

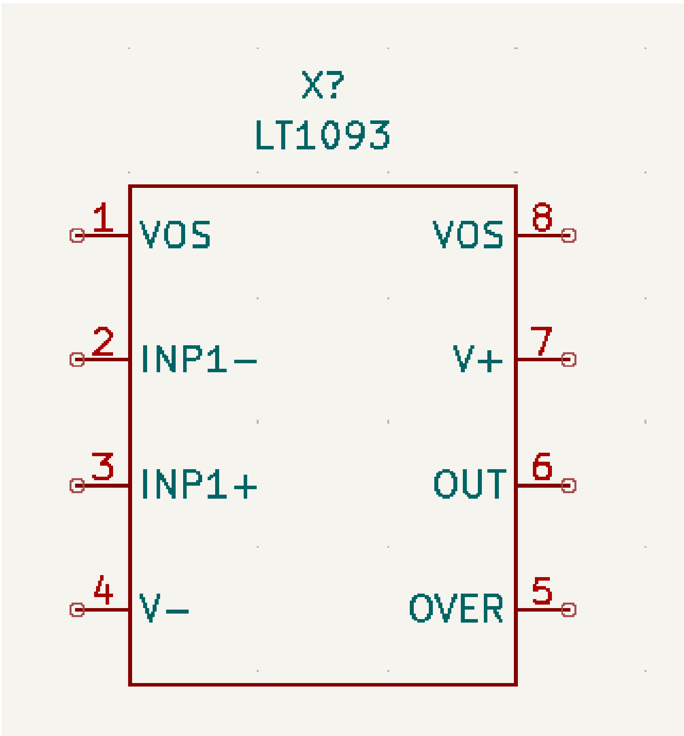

Figure 4.51: Pin diagram of LT1097

4.11.2 Subcircuit Schematic Diagram

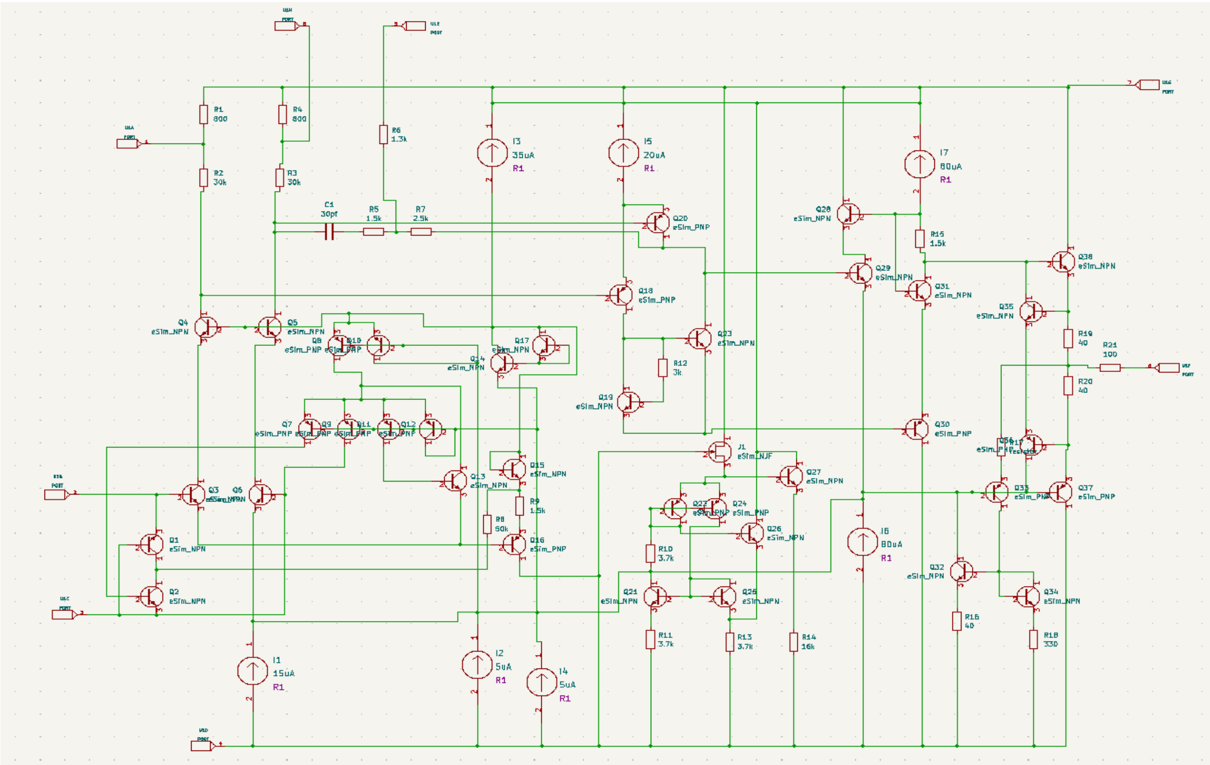

Figure 4.52: Subcircuit Schematic of LT1097

4.11.3 Test Circuit

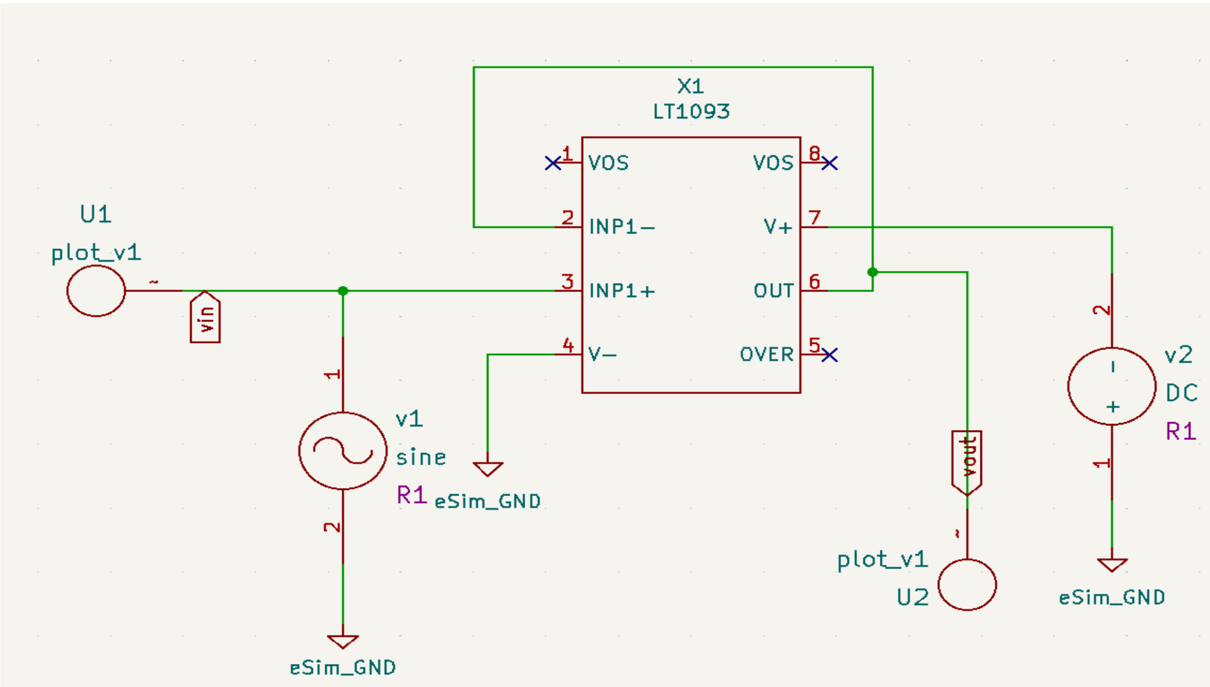

Figure 4.53: Test Circuit of LT1097 IC

4.11.4 Input Plots

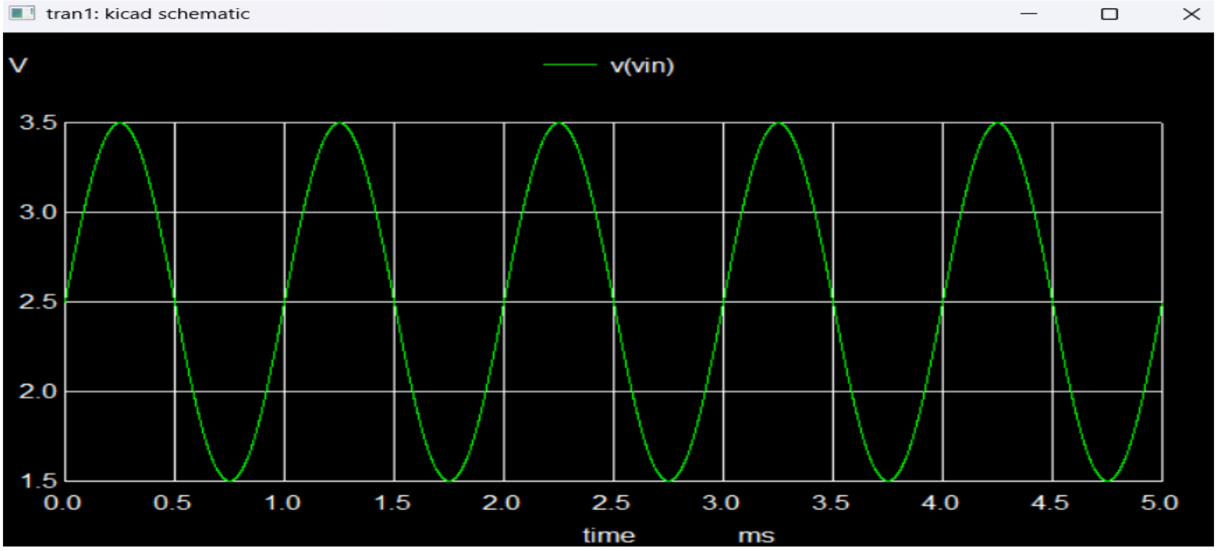

Figure 4.54: Input Voltage Waveform of LT1097

4.11.5 Output Plots

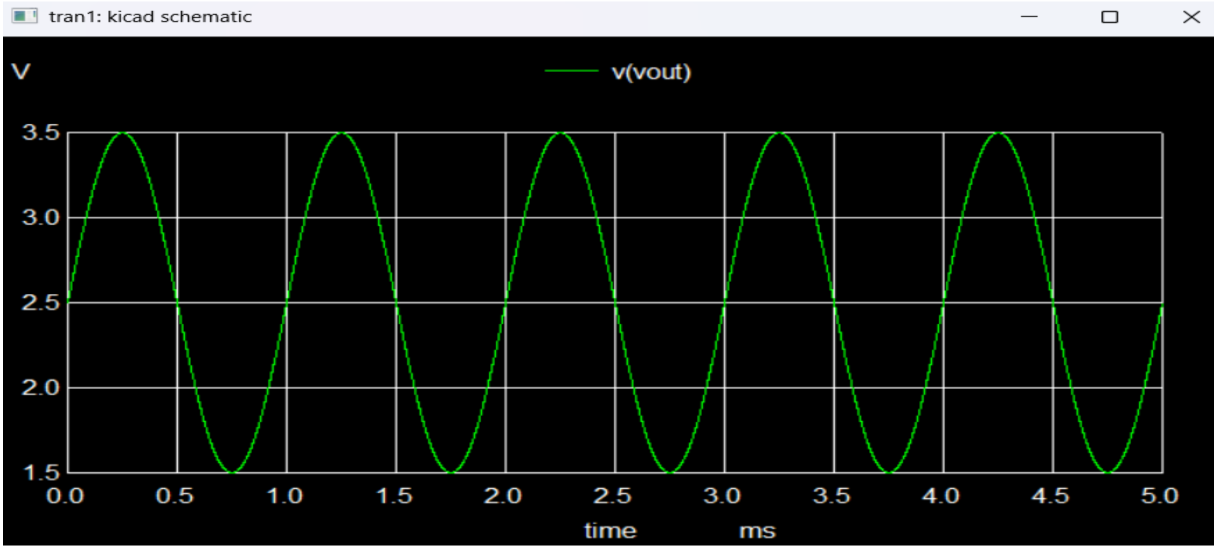

Figure 4.55: Output Voltage Waveform of LT1097

4.11.6 Description

The LT1097 is a precision operational amplifier used for accurate amplification of analog signals. In this circuit, a sine wave input is applied to the IC, and proper DC power supply is provided so that it operates within its specified limits. The LT1097 is designed to give stable and low-noise performance for precision signal applications.

The LT1097 is a precision operational amplifier used for accurate amplification of analog signals. In this circuit, a sine wave input is applied to the IC, and proper DC power supply is provided so that it operates within its specified limits. The LT1097 is designed to give stable and low-noise performance for precision signal applications.

4.12 LM358B - Dual Low-Power Operational Amplifier

The LM358B is a dual low-power operational amplifier intended for general-purpose analog applications. It is designed to operate from a single power supply while providing reliable performance for signal amplification and buffering. The IC integrates two independent operational amplifiers in a single package, making it suitable for compact and low-power circuit designs.

The LM358B supports single-supply operation and allows the input voltage range to include the ground level. When configured in voltage follower or amplifier configurations, the output accurately follows the input signal within the specified operating limits. This makes the device suitable for low-frequency signal conditioning and basic analog processing applications.

Due to its low power consumption and ease of use, the LM358B is commonly used in sensor interfaces, signal conditioning circuits, active filters, and general-purpose analog systems. Its robustness and versatility make it suitable for educational experiments, laboratory applications, and practical electronic circuit designs.

4.12.1 IC Layout

This figure represents the Pin Package Diagram of LM358B

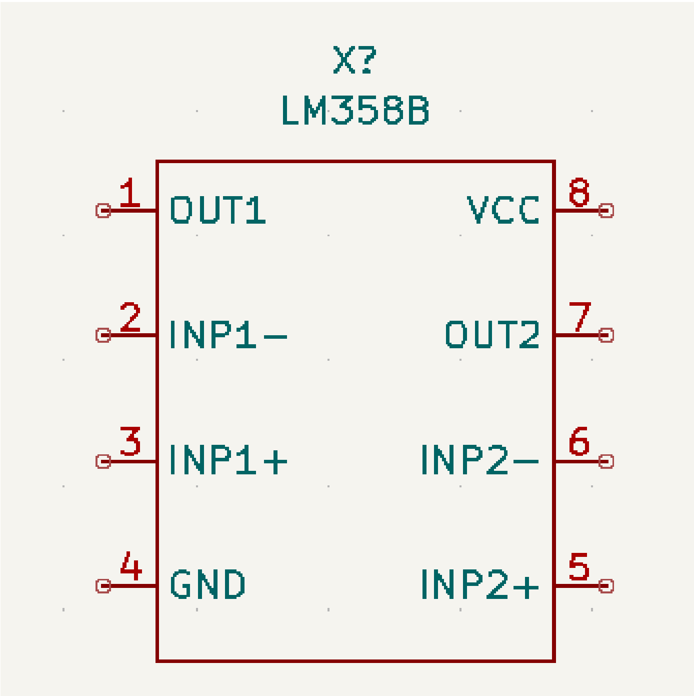

Figure 4.56: Pin diagram of LM358B

4.12.2 Subcircuit Schematic Diagram

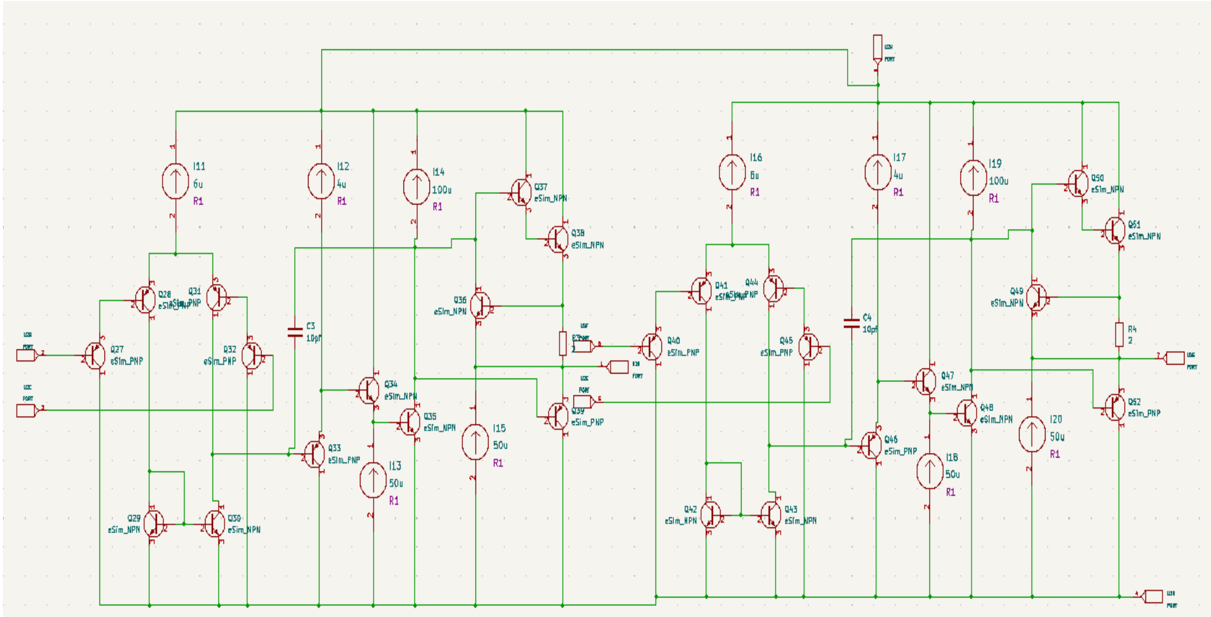

Figure 4.57: Subcircuit Schematic of LM358B

4.12.3 Test Circuit

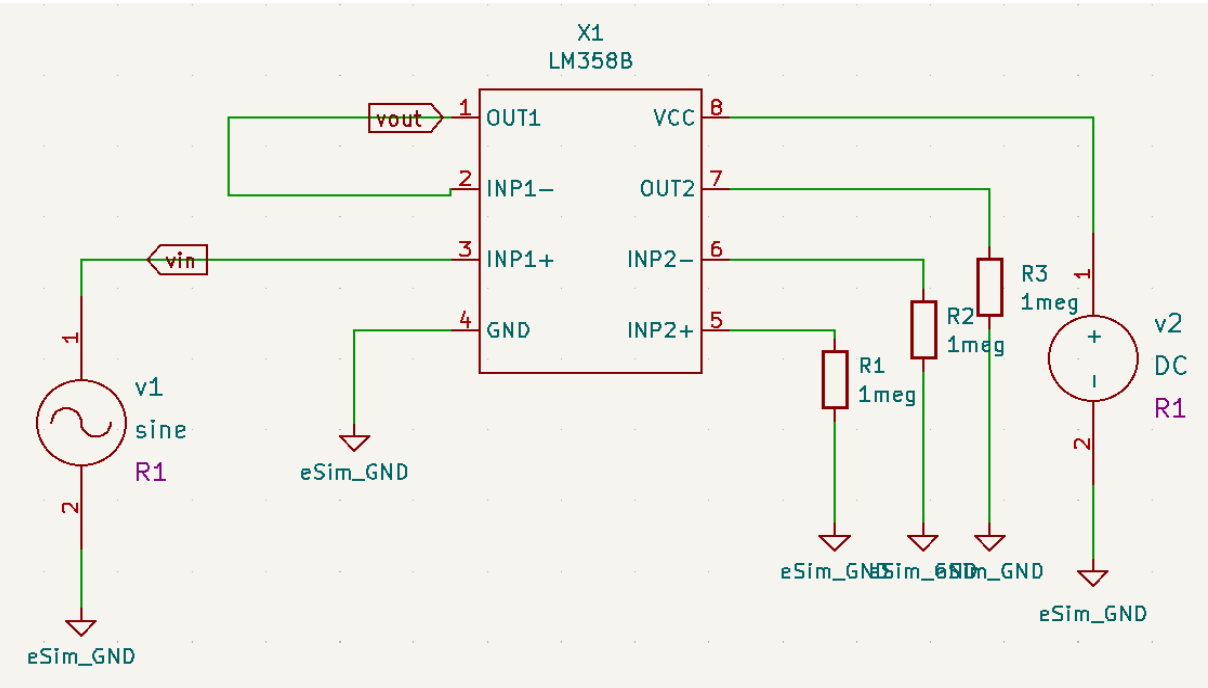

Figure 4.58: Test Circuit of LM358B IC

4.12.4 Input Plots

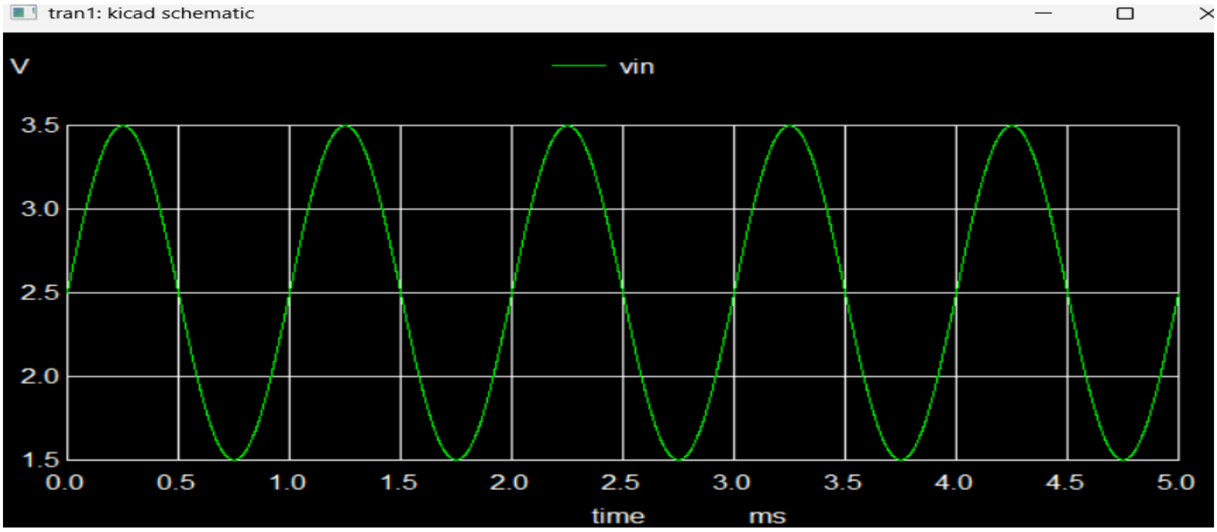

Figure 4.59: Input Voltage Waveform of LM358B

4.12.5 Output Plots

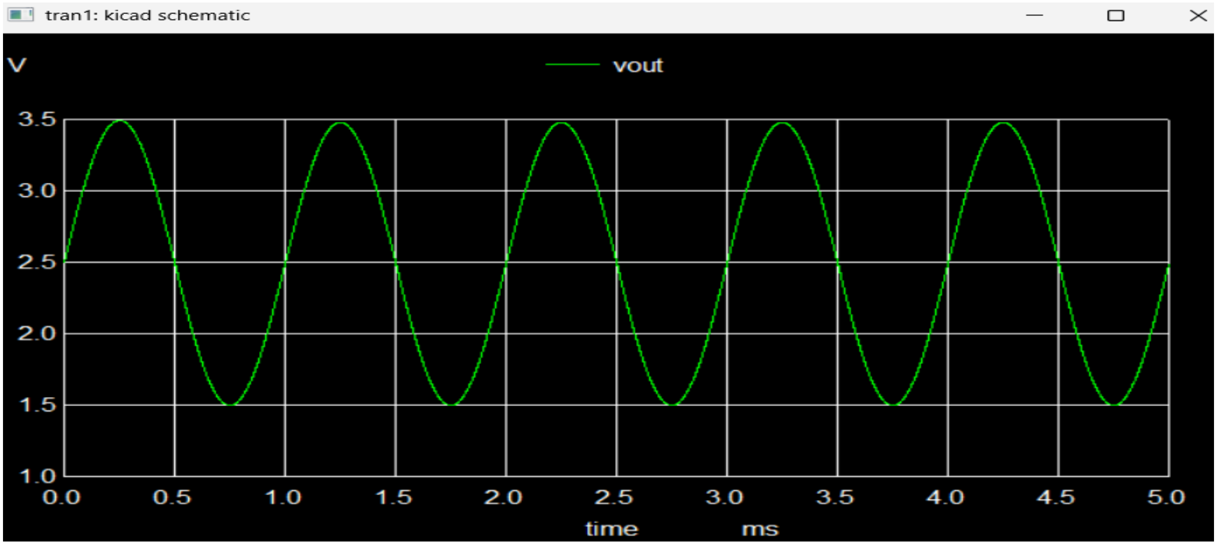

Figure 4.60: Output Voltage Waveform of LM358B

4.12.6 Description

The LM358B is a dual low-power operational amplifier used for general-purpose signal processing. In this circuit, a sine wave input is applied to the IC, and a single DC power supply is provided so that it operates correctly. The LM358B is suitable for low-frequency applications and can work with input signals close to ground.

From the input and output waveforms, it is observed that the output follows the input signal in shape and frequency. A small difference in amplitude occurs due to the internal characteristics and operating limits of the LM358B. This behavior is expected and shows that the LM358B is functioning correctly as a dual low-power operational amplifier.

Bibliography

[1] FOSSEE Official Website
https://fossee.in/

[2] eSim Official website
https://esim.fossee.in/

[3] Datasheet Catalog
https://www.datasheetcatalog.com

[4] AllDatasheet
https://www.alldatasheet.com/

[5] Mouser.in
https://www.mouser.in/

[6] Texas Instrument
https://www.ti.com/

[7] Datasheet4u National Semiconductor
https://www.datasheet4u.com/

[8] Analog Devices
https://www.analog.com/en/product-category.html

[9] LM442 Datasheet
https://www.ti.com/lit/ds/symlink/lf442-mil.pdf

[10] LF356 Datasheet
https://www.ti.com/lit/ds/symlink/lf356.pdf?ts=1768485814490&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FLF356

[11] LM7810 Datasheet
https://www.mouser.com/datasheet/2/149/LM7812-461970.pdf

[12] LM334 Datasheet
https://www.ti.com/lit/ds/symlink/lm334.pdf?ts=1768444536549

[13] LT1007 Datasheet
https://www.analog.com/media/en/technical-documentation/data-sheets/LT1007-LT1037.pdf

[14] LM335 Datasheet
https://www.ti.com/lit/ds/symlink/lm335.pdf?ts=1768486261784&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FLM335

[15] CA3078 Datasheet
https://www.alldatasheet.com/html-pdf/66314/INTERSIL/CA3078/320/1/CA3078.html

[16] LT1013 Datasheet
https://www.analog.com/media/en/technical-documentation/data-sheets/LT1013-LT1014.pdf

[17] LM1558 Datasheet
https://www.ti.com/lit/ds/symlink/lm1558.pdf?ts=1768487106909&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FLM1558

[18] LT1002 Datasheet
https://www.analog.com/media/en/technical-documentation/data-sheets/LT1002.pdf

[19] LT1097 Datasheet
https://www.analog.com/media/en/technical-documentation/data-sheets/1097fas.pdf