Centre for Electronic Design and Technology

Netaji Subhas University of Technology , New Delhi

Electronic Electroscope

A Project in Analog Electronics

Student: Talha Parvez and Dhruv Saini

Date: JULY 2023

Acknowledgement

I am filled with immense gratitude as I pen down this acknowledgement, expressing my sincere appreciation to all those who have contributed to the successful completion of the "Electronic Electroscope" project. This endeavor would not have been possible without the support, guidance, and encouragement of several remarkable individuals.

First and foremost, I extend my deepest thanks to Professor D.V. Gadre, whose unwavering support and expertise have been instrumental in shaping this project. His invaluable insights, constant encouragement, and commitment to fostering innovative ideas have been the driving force behind our journey towards completion of this project.

CEDT gave me the optimal environment to learn, research, and implement my newly acquired knowledge. My thanks and appreciation also goes to my friends and seniors at the centre who have helped me out willingly throughout the course of this project. I would also like to express gratitude to my family who has always supported me in my endeavours.

Contents

1. Introduction

In the realm of scientific instrumentation, the electroscope has long been an invaluable tool for detecting and measuring electric charges. Traditionally, the electroscope was constructed using metal foils or leaves suspended within an insulated container. When an electric charge was introduced to the electroscope, the leaves would repel each other, providing a visual indication of the presence of the charge.

With advancements in technology, the classical electroscope has undergone a remarkable transformation into what we now know as the "Electronic Electroscope." This modern variant harnesses the power of electronics and sophisticated circuitry to enhance the capabilities and precision of charge detection.

Now in this form of electronic electroscope a charge amplifier is used to detect the charge's polarity, a simple charge amplifier takes charge as input and gives respective voltage at its output. Which is further fed to a galvanometer which shows deflection and confirms the detection of charge .

2. Charge Amplifier

A charge amplifier is an electronic current integrator that produces a voltage output proportional to the integrated value of the input current, or the total charge injected.

The amplifier offsets the input current using a feedback reference capacitor, and produces an output voltage inversely proportional to the value of the reference capacitor but proportional to the total input charge flowing during the specified time period. The circuit therefore acts as a charge-to-voltage converter. The gain of the circuit depends on the values of the feedback resistor.

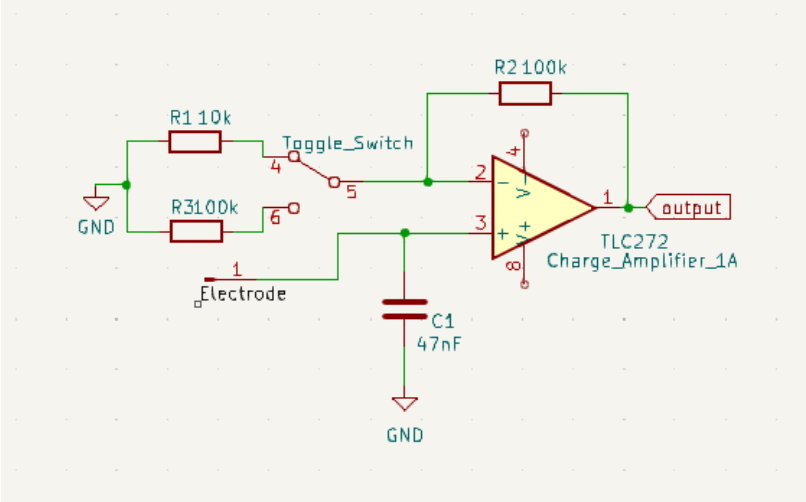

Figure 1: Charge Amplifier Schematic

Gain of Non Inverting Amplifier ,

$$Gain = 1 + \frac{R_f}{R_i}$$

In the above Circuit the op- amp is working as a Non Inverting Amplifier , Also at the input side of the operational amplifier , a single pole double throw type of toggle switch is placed which further enhances the circuit to work in two modes which are

1. Mode 1 Where gain is equal to 2.
2. Mode 2 where gain is equal to 11.

3. Voltage inverter

A voltage inverter is a simple circuit which converts positive voltage into negative voltage and vice versa , this circuit was implemented using TJ 7660 IC , 2 X 10 uf capacitors and couple of jumpers.

Here is the circuit diagram of the charge inverter.

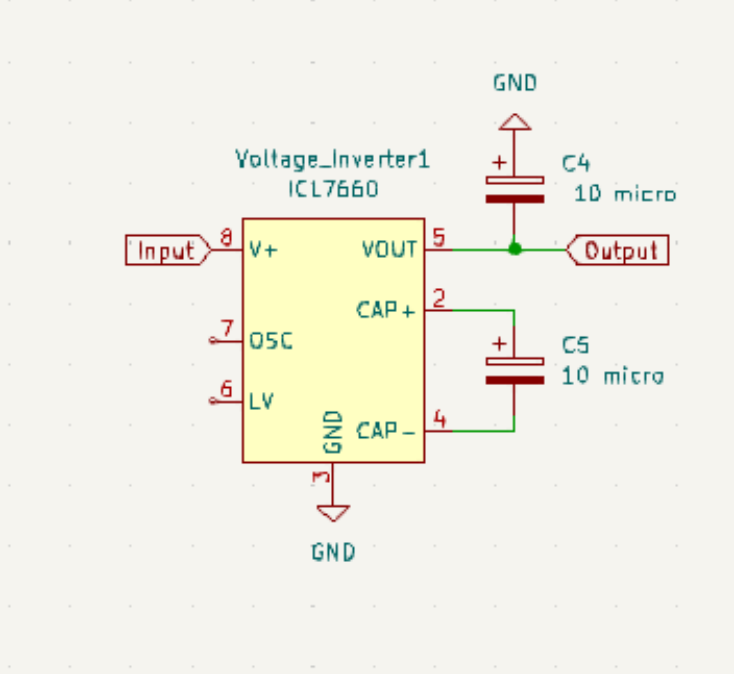

Figure 2: Circuit diagram of Voltage Inverter using TJ 7660 IC

The TJ 7660 contains all the necessary circuitry to complete a negative voltage converter, with the exception of 2 external capacitors which may be inexpensive 10uF polarized electrolytic types. The mode of operation of the device may be best understood by considering Figure 2, which shows an idealized negative voltage converter. Capacitor C5 is Charged to a voltage, V+, for the half cycle when switches S1 and S3 are closed. (Note:Switches S2 and S4 are open during this half cycle.) During the second half-cycle of operation, switches S2 and S4 are closed, with S1 and S3 open, thereby shifting capacitor C5 negatively by V+ volts. Charge is then transferred from C5 to C4 such that the voltage on C4 is exactly V+, assuming ideal switches and no load on C4.

4. Low Battery Detector

This circuit alerts the user when the battery needs charging. I have chosen the simplest way of determining that the battery capacity is low, and that's using the battery terminal voltage. This circuit lights up a warning LED whenever the voltage drops below a certain value.

A circuit was constructed using TLC 431 (Precision Programmable Reference) and a couple of resistors which were used to glow the led that indicates a low battery level. Here is the Circuit diagram of

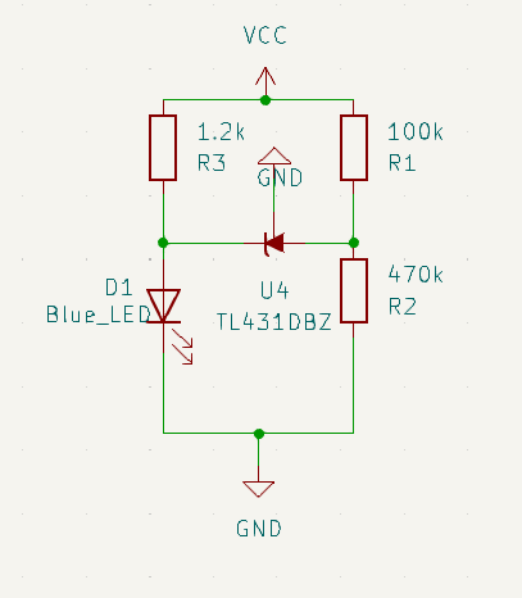

Figure 3: Circuit Diagram of Low Battery Detector

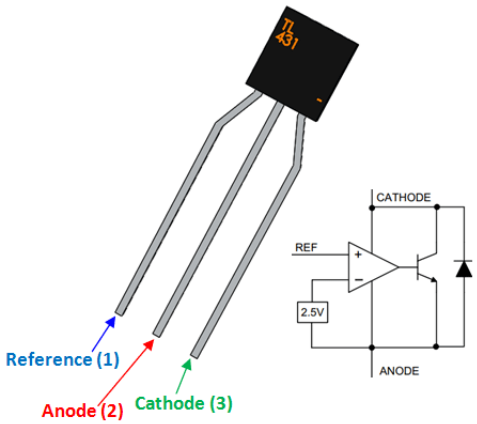

Figure 4: Pin out of TL-431

5. Galvanometer

A galvanometer is a device that is used to detect a small electric current or measure its magnitude. The current and its intensity are usually indicated by a magnetic needle's movement or that of a coil in a magnetic field, which is an important part of a galvanometer. Since its discovery in the 1800s, the galvanometer has seen many iterations. Some of the different types of galvanometer include Tangent galvanometer, Astatic galvanometer, Mirror galvanometer and Ballistic galvanometer. However, today, the main type of galvanometer that is used widely is the moving coil type. A galvanometer is basically a historical name that has been given to a moving coil electric current detector.

Figure 5: Moving Coil Galvanometer

6. Project Description

6.1 Block diagram

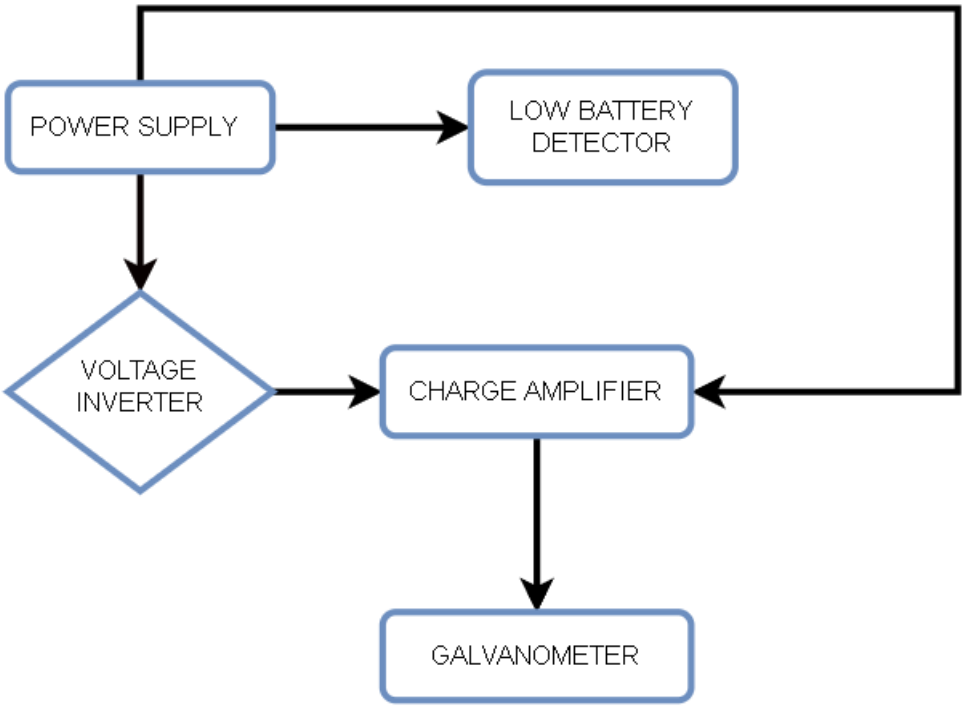

Figure 6: Block Diagram of Electronic Electroscope

6.2 Circuit Diagram

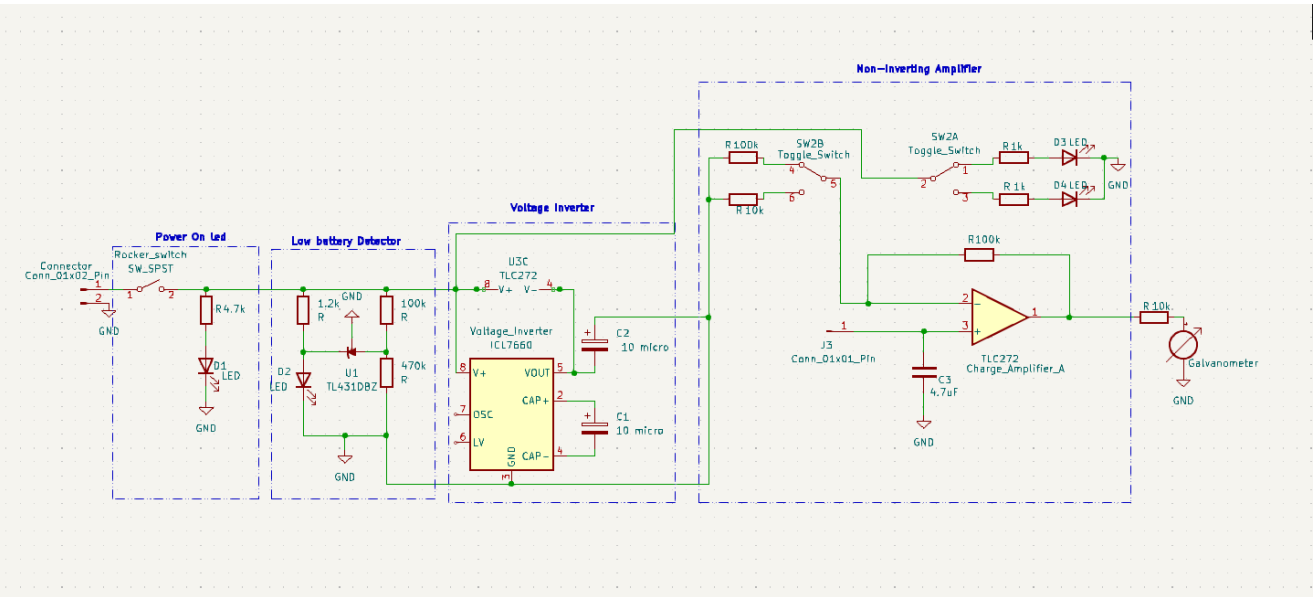

Figure 7: Circuit Diagram of the Electronic Electroscope

6.3 Component list

Component List			
Resistors	**Capacitors**	**Integrated Circuits**	**Miscellaneous**
R1= 100k	C1=10uf	IC1=TLC 272 BC	1 Double pole double throw switch
R2=100k	C2=10uf	IC2=TJ7660	2 Pin Molex connector X2
R3=10k	C3=47nf	IC3=TL431	Galvanometer
R4=1k			Rocker Switch
R5=1.2k			Lithium polymer battery
R6=4.7k			Copper wire Electrode
R7=470k			
R8=100k	**LEDs**		
R9=1k	L1=Red		
R10=10k	L2=Blue		
	L3=Green		

Figure 8: Component list of Electronic Electroscope

6.4 Working of the Project

In this Project we have used a lithium polymer battery to power the circuit .

First Current goes into a Power on led circuit, afterwards the current goes into a low battery detector circuit to detect when the voltage goes below a specific level(Particularly 3.1 V) to remind the User to recharge the battery , then the voltage is inverted using a Voltage Inverter circuit to provide the biasing voltage across the operational Amplifier (as the operational amplifiers requires both positive and negative voltage for biasing to operate) .

Now , when the static charge is transferred to the non-inverting pin of the op-amp , the capacitor connected to same leg gets charged, which provides voltage at the input . after which a voltage is developed at the output of the operational amplifier (a Non Inverting amplifier), which is further fed to the Galvanometer which shows deflection on positive side when positive charge is given and vice versa.

7. End Result

Figure 9: Electronic Electroscope in Power off Mode

Figure 10: E. Electroscope when charged with negative charge

Figure 11: E. Electroscope when charged with Positive charge

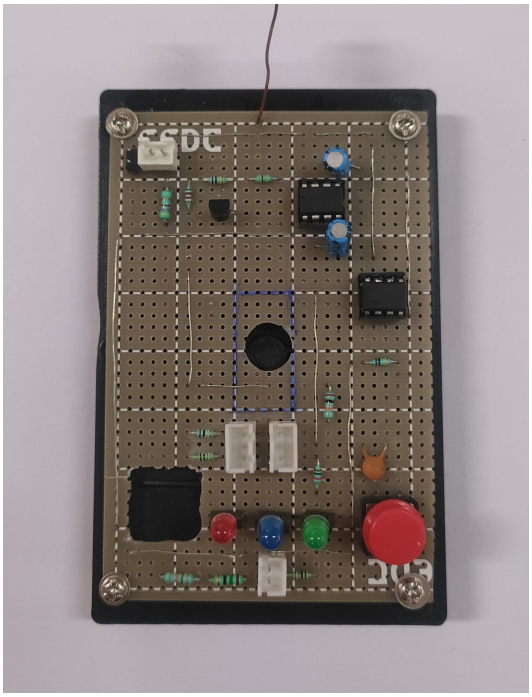

Figure 12: PCB of Electronic Electroscope

8. Bibliography

- Datasheet of TLC 272 BC
  https://www.ti.com/lit/ds/symlink/tlc272.pdf?ts=1690783846438&ref_url=https%253A%252F%252Fwww.google.com%252F

- Datasheet of TJ7660
  http://www.htckorea.co.kr/Datasheet/Converter-Controller/TJ7660.pdf

- Charge sniffer for electrostatics demonstrations
  https://www.researchgate.net/publication/253780812_Charge_sniffer_for_electrostatics_demonstrations

- An Electronic Electroscope
  https://iopscience.iop.org/article/10.1088/0031-9120/49/1/18/meta