AE-2 PROJECT REPORT

SUBMITTED BY:

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SUBJECT: ANALOG ELECTRONICS-2 (EC202)

SUBMITTED TO: Prof. Rajeshwari Pandey ma'am

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May, 2021

Electronics & Communication Engg. Deptt.
DELHI TECHNOLOGICAL UNIVERSITY
(Formerly Delhi College of Engineering)
Shahbad Daulatpur, Bawana Road-Delhi-42

Certificate

I hereby certify that the Project titled "**BATTERY MANAGEMENT SYSTEM**" which is submitted by, Department of Electronics & Communication Engineering, Delhi Technological University, Delhi is a record of the project work carried out by the students under my supervision.

Prof. Rajeshwari Pandey
SUPERVISOR

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Candidate's Declaration

We, hereby, declare that the work embodied in this project entitled " **BATTERY MANAGEMENT SYSTEM** " submitted to the Department of Electronics & Communication Engineering, Delhi Technological University, Delhi is an authentic record of our own bonafide work and is correct to the best of our knowledge and belief. This work has been undertaken taking care of engineering ethics.

Names of the Students:

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Acknowledgement

We express our sincere thanks to Prof. Yogesh Singh, Vice-Chancellor, Delhi Technological University, Delhi. We pay our deep sense of gratitude to Prof. N. S. Raghava (HOD) of ECE Department, Delhi Technological University, Delhi to encourage us to the highest peak and to provide us the opportunity to prepare the project. We feel to acknowledge our indebtedness and deep sense of gratitude to our guide Prof. Rajeshwari Pandey whose valuable guidance and kind supervision given to us throughout the course which shaped the present work as its show. We are immensely obliged to our friends for their elevating inspiration, encouraging guidance and kind supervision in the completion of this project.

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ABSTRACT

INTRODUCTION:

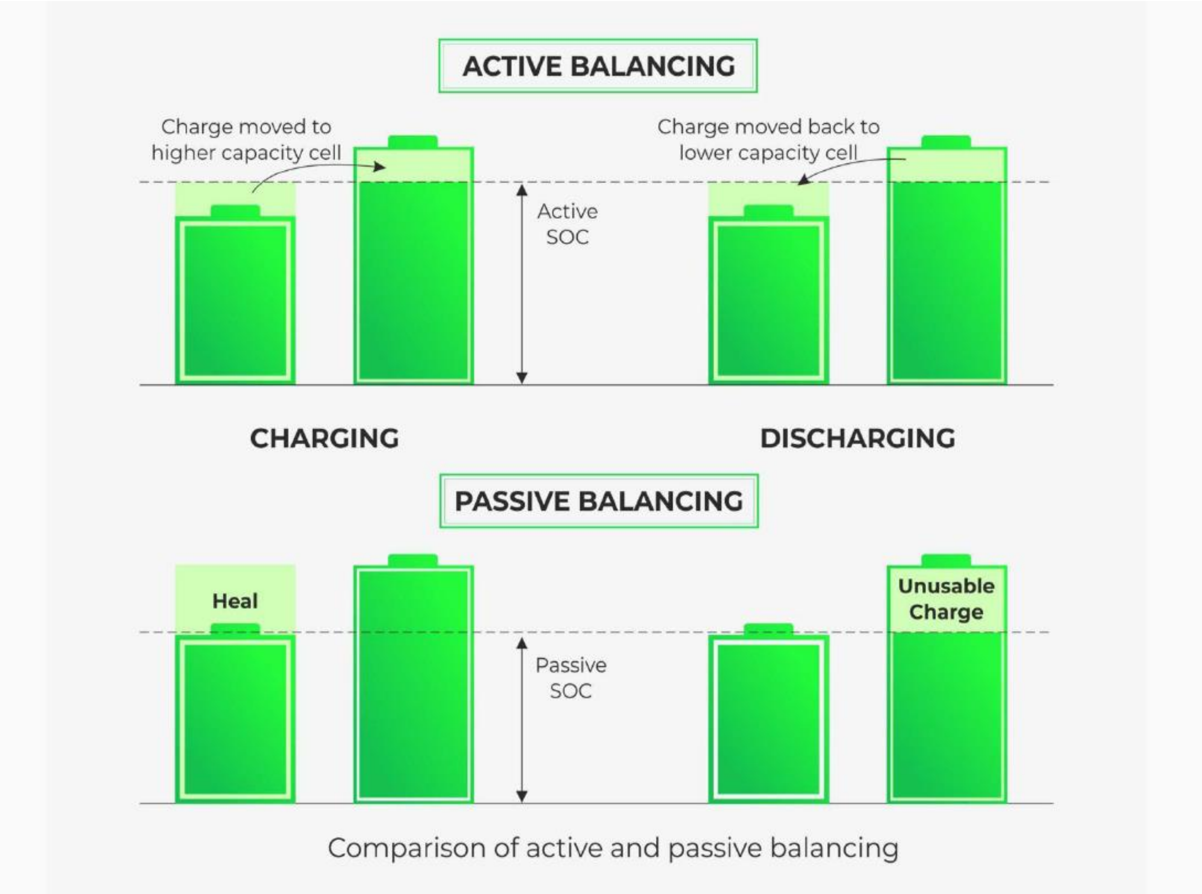
Battery management systems (BMS) are electronic control circuits that monitor and regulate the charging and discharge of batteries [6]. The battery characteristics to be monitored include the detection of battery type, voltages, temperature, capacity, state of charge, power consumption, remaining operating time, charging cycles, and some more characteristics.

CHARGE BALANCING:

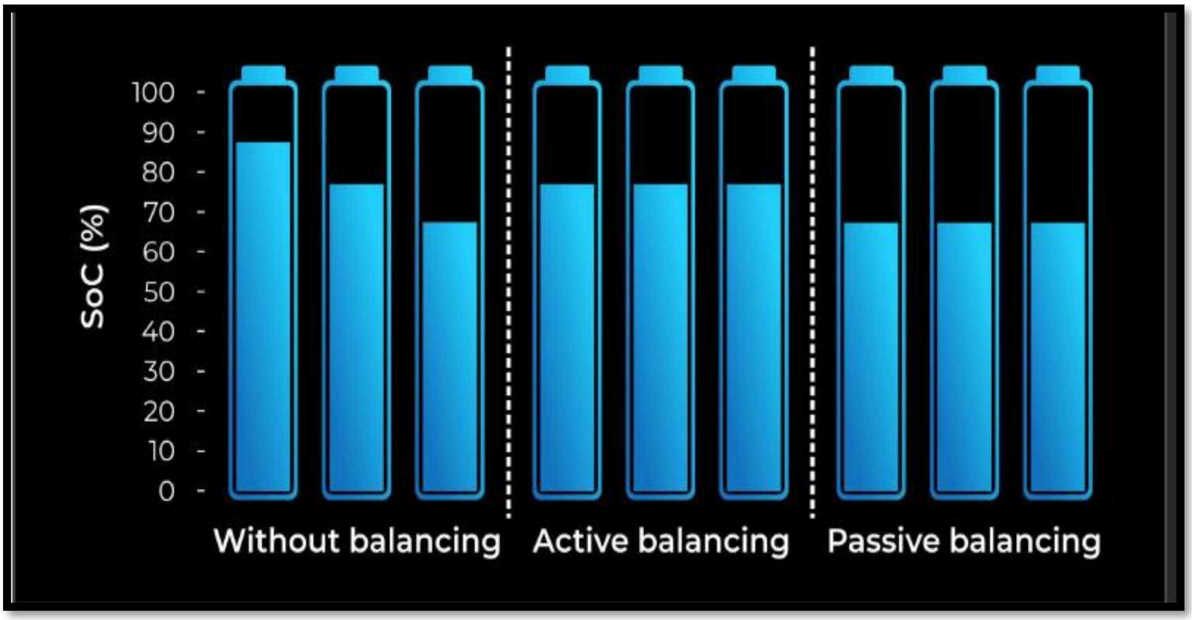
In passive cell balancing, the charge from the cell having extra charge is dissipated through a load. This makes charge in in each equal.

In active cell balancing, the charge is transferred from one cell to another. This makes the charge in each cell equal.

Pictures explaining active and passive charge balancing:



(source of picture: https://www.ionenergy.co/resources/blogs/cell-balancing-battery-life/)



(source of picture: https://www.ionenergy.co/resources/blogs/cell-balancing-battery-life/)

SoC is state of Charge [1]. Here we can observe in 1st diagram, the cells have unequal charge content, and our aim is to distribute charge among them equally. In Active balancing, we observe that the final SoC is around 80% while in passive charge balancing, it's around 65%.

The final SoC is lesser in passive balancing because some of the charge is dissipated through a load, which is not the case in active balancing.

AIM: The aim of our project is to implement passive balancing method of charge balancing where we have self- defined a threshold value for the battery as 4.2V, and calculated the values of resistors required to be implemented in the circuit for effectively balancing the threshold value.

COMPONENTS USED IN HARDWARE IMPLEMENTATION:

- 1 BD140 BJT Transistor
- 1 TL431 Zener diode
- 4 PN junction diodes (10A01)
- 20k ohm resistor
- 33k ohm resistor
- Function generator

ACTUAL CIRCUIT USED IN HARDWARE PROJECT (SIMULATED ON PROTEUS):

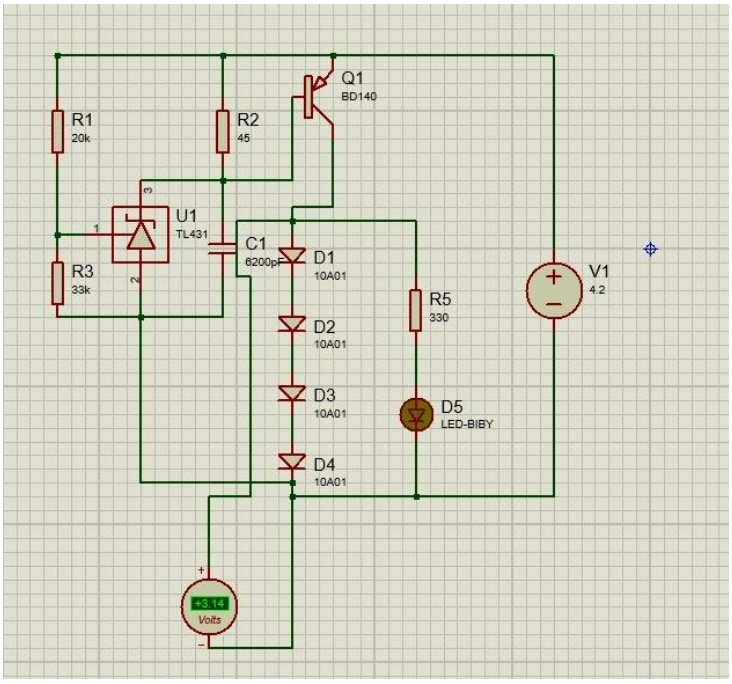
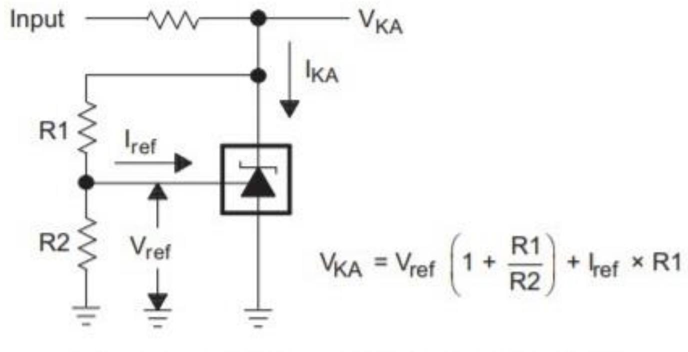


Fig. 1

CIRCUIT EXPLAINATION:

In the circuit shown in figure 1, the threshold is set at 4.2V by adjusting the values of R1 and R3 in the simulated circuit, according to given formula taken from the datasheet of TL431 [4]:



The values for V_{ref} and I_{ref} are:

7.5 Electrical Characteristics, TL431C, TL432C

over recommended operating conditions, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CIRCUIT	TEST CONDITIONS		TL431C, TL432C MIN	TYP	MAX	UNIT
V_{ref}	Reference voltage	See Figure 20	$V_{KA} = V_{ref}$, I_{KA} = 10 mA		2440	2495	2550	mV
$V_{I(dev)}$	Deviation of reference input voltage over full temperature range(1)	See Figure 20	$V_{KA} = V_{ref}$, I_{KA} = 10 mA,	SOT23-3 and TL432 devices		6	16	mV
				All other devices		4	25	
ΔV_{ref} / ΔV_{KA}	Ratio of change in reference voltage to the change in cathode voltage	See Figure 21	I_{KA} = 10 mA	ΔV_{KA} = 10 V – V_{ref}		–1.4	–2.7	mV/V
				ΔV_{KA} = 36 V – 10 V		–1	–2	
I_{ref}	Reference input current	See Figure 21	I_{KA} = 10 mA, R1 = 10 kΩ, R2 = ∞			2	4	µA
$I_{I(dev)}$	Deviation of reference input current over full temperature range(1)	See Figure 21	I_{KA} = 10 mA, R1 = 10 kΩ, R2 = ∞			0.4	1.2	µA
I_{min}	Minimum cathode current for regulation	See Figure 20	$V_{KA} = V_{ref}$			0.4	1	mA
I_{off}	Off-state cathode current	See Figure 22	V_{KA} = 36 V, V_{ref} = 0			0.1	1	µA
$\lvert z_{KA}\rvert$	Dynamic impedance(2)	See Figure 20	$V_{KA} = V_{ref}$, f ≤ 1 kHz, I_{KA} = 1 mA to 100 mA			0.2	0.5	Ω

The transistor Q1 is acting as a switch, and the 4 diodes D1, D2, D3, D4 are the loads for the passive balancing mechanism, where the extra charge is dissipated by in the form of heat.

When the voltage across the Zener diode U1 is low (lesser than the Zener voltage), the base current of the BJT is negligible, and since $I_{collector} = \beta * I_{base}$, $I_{collector}$ is negligible, so no current flows through the diodes, and no heat is dissipated [1].

Now, whenever the charging voltage exceeds the threshold, the overcharging protection mechanism becomes operational. The voltage across the Zener diode exceeds it's Zener voltage and Zener breakdown occurs, and base current of the BJT is no longer negligible, so it produces considerable amount of collector current since $I_{collector} = \beta * I_{base}$, so current starts flowing through the diodes, and heat starts dissipating through them hence protecting the battery from getting overcharged.

Both these scenarios are explained and analysed in simulation results and analysis section.

BATTERY MANAGEMENT CIRCUIT FOR 3 CELLS:

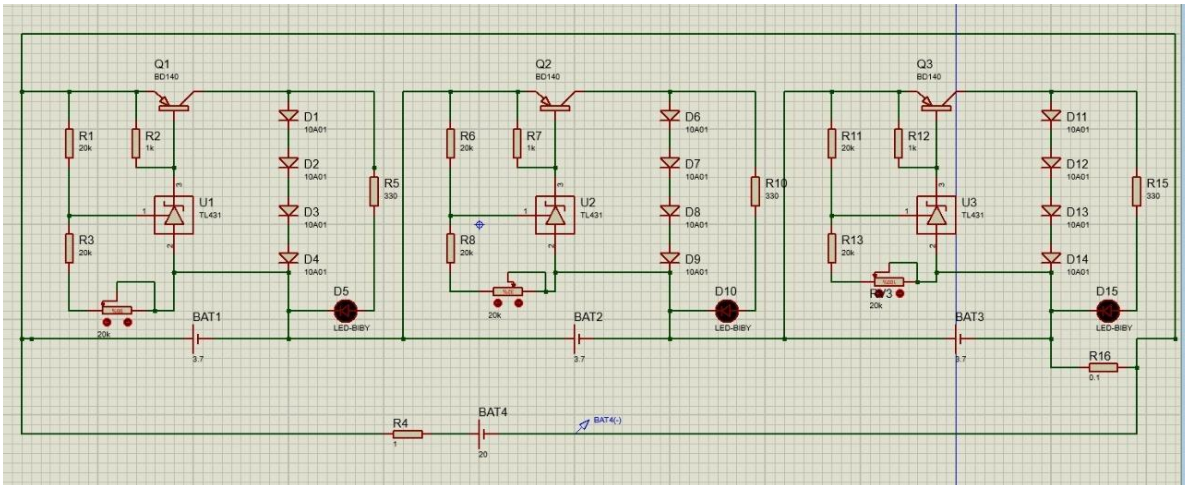


Fig.2

SIMULATION RESULTS AND ANALYSIS:

The scenario when charging voltage is below the threshold is depicted in the following pictures, where source voltage V is 4Volts in figure 3 and 3.5Volts in figure 4, hence both are lesser than the threshold of 4.2V and we can observe the voltmeter readings across the diodes is 0.18V (fig.3) and 0.31V(fig.4) which is essentially negligible, so no extra electrical energy is getting dissipated. These readings have been obtained from Proteus simulation.

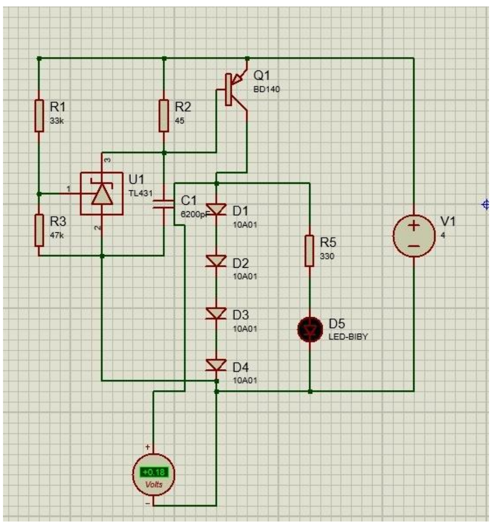


Fig3.

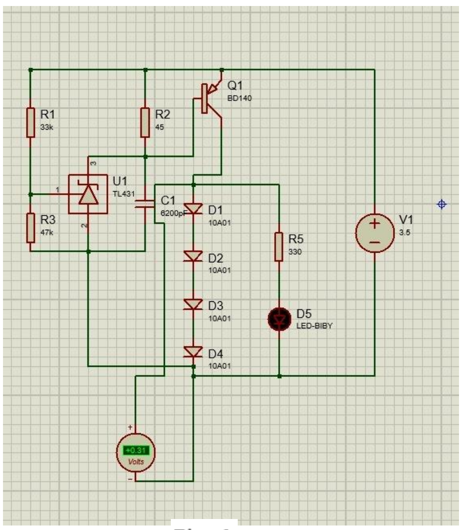


Fig.4

The case when charging voltage is above the threshold is depicted in the following observations, when charging voltage V is 4.2Volts in figure 5 and 4.5Volts in figure 6, hence both are greater than the threshold of 4.2V and we can observe the voltmeter readings across the diodes is 3.14V (fig.5) and 3.19 V(fig.6) which is a considerable quantity, so extra charge is getting dissipated through the loads (the diodes D1,D2,D3,D4) in form of heat, hence protecting the battery from getting overcharged and damaged. These readings have been obtained from Proteus simulation.

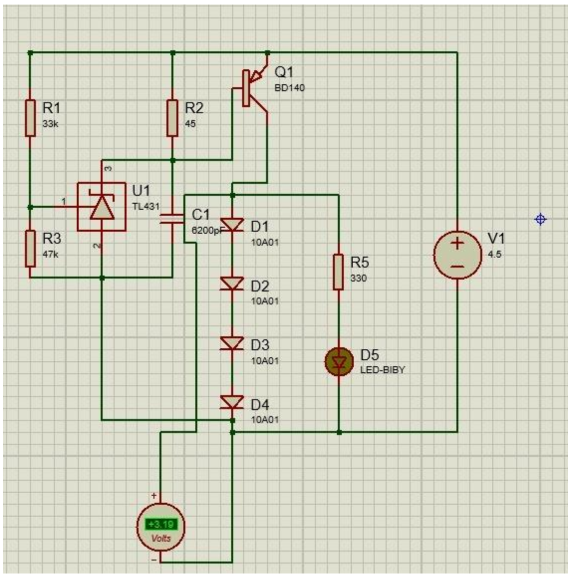
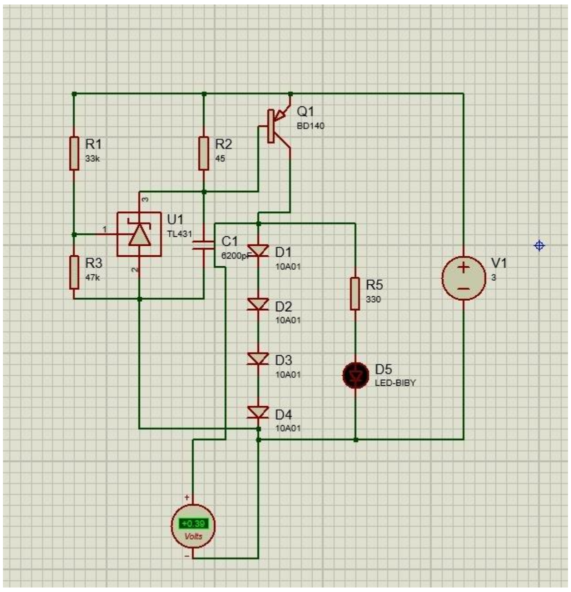
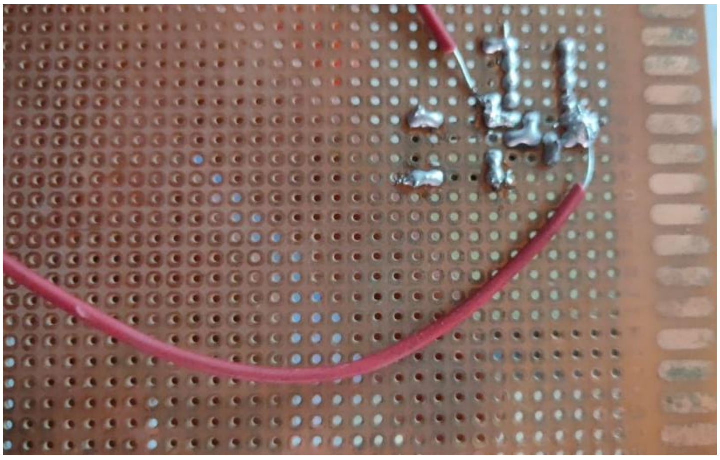


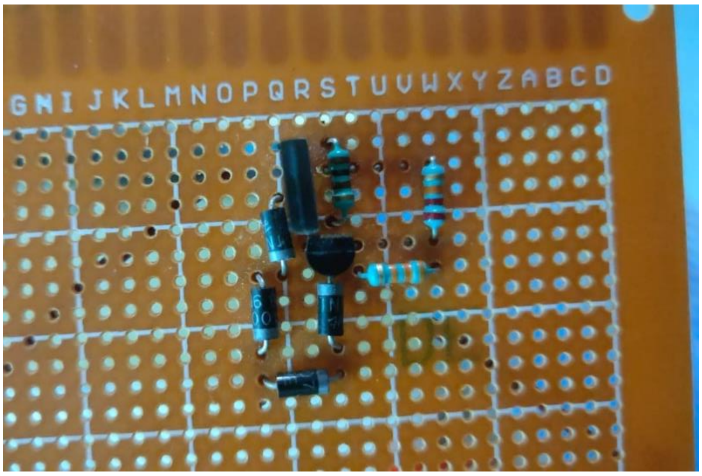
Fig.6



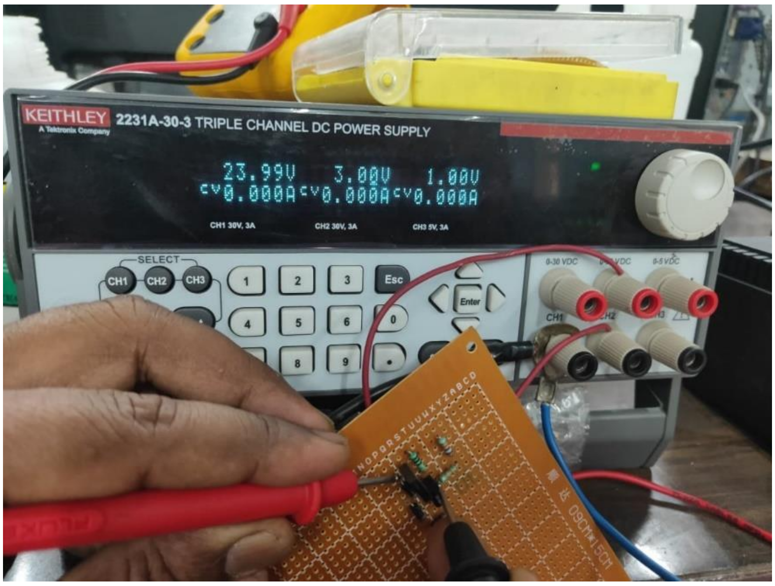
When charging voltage is 3volts, no current through the loads, as potential across the diodes is merely 0.39V as calculated from the simulation.

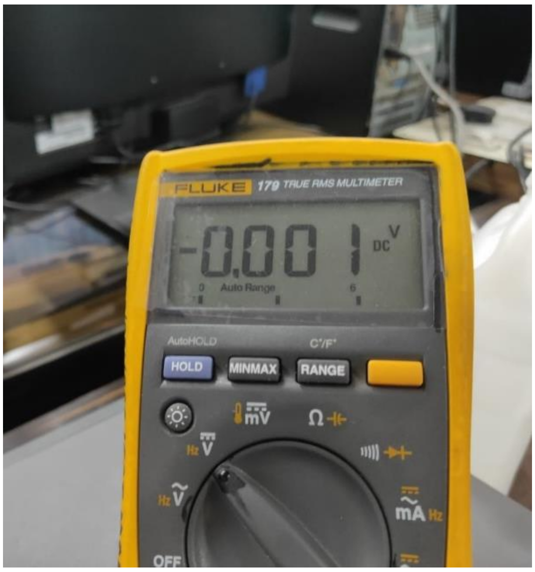
HARDWARE PHOTOS:



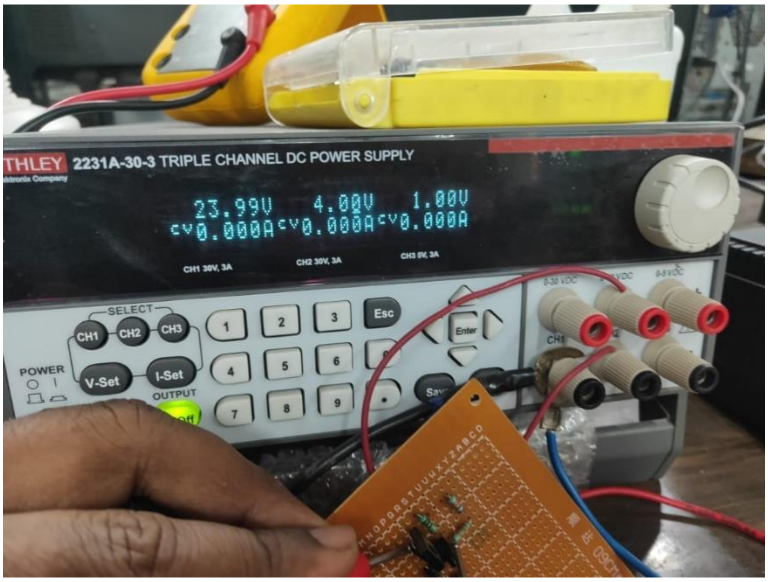


Circuit soldered on general purpose PCB.





Here, when the charging voltage is 3volts (lesser than the threshold), the reading of voltage across the diodes is obtained as 0.001 Volts.



Here, when the charging voltage is 4 volts (lesser than the threshold), the reading of voltage across the diodes is obtained as 0.211 Volts.

VIDEO LINK CONTAINING HARDWARE RESULTS:

https://drive.google.com/folderview?id=1hkGTQ5zAzphzq8UMaqE4VGzngMvmNDo7

DIFFICULTIES ENCOUNTERED AND SOURCES OF ERROR:

- Arrangement of a function generator: Since this is an instrument which can be found in laboratories and can't be arranged at home, but was needed for this project to generate variable voltages and take readings across the diodes at different charging voltage, we had to use the laboratory facility of the university. However, this was done when COVID-19 cases were low, and all COVID-19 guidelines were followed sincerely.
- Wrong connections: Removed from testing voltages across individual components in the lab and debugging the circuit.
- Damage to diodes and other components: Caution had to be taken to prevent excessive current flow across semiconductor devices which might damage them.
- Errors in soldering: Since the circuit when implemented on the PCB was very small in size, care had to be taken to solder the circuit correctly, otherwise the circuit would have been short circuited.

CONCLUSION:

We've successfully implemented battery management and protection system with a threshold value of 4.2V, which we verified by applying different charging voltages and checking if the extra charge is dissipating in the loads(diodes) when the charging potential exceeds the safe threshold value for the battery. This is verified both in Proteus simulations and hardware implementations whose results are mentioned as above.

This project can be implemented in real life applications to protect batteries from overcharging like in mobile phones and laptops, and thus improves the battery life and efficiency [2,5]. This can also be extended to any number of cells and to any threshold value depending on the battery system for which we are implementing the circuit.

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