A SIMPLE BATTERY CHARGER WITH OVERCHARGE PROTECTION

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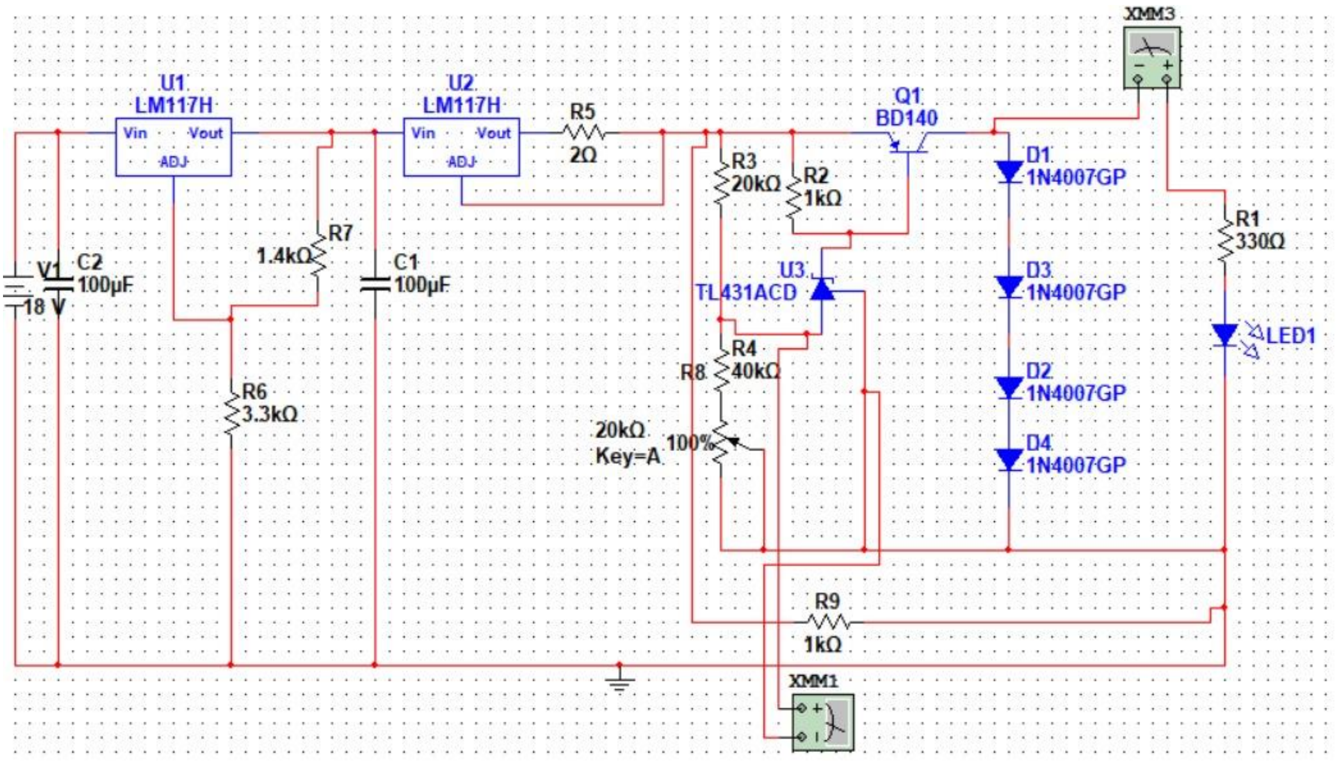
OBJECTIVE:

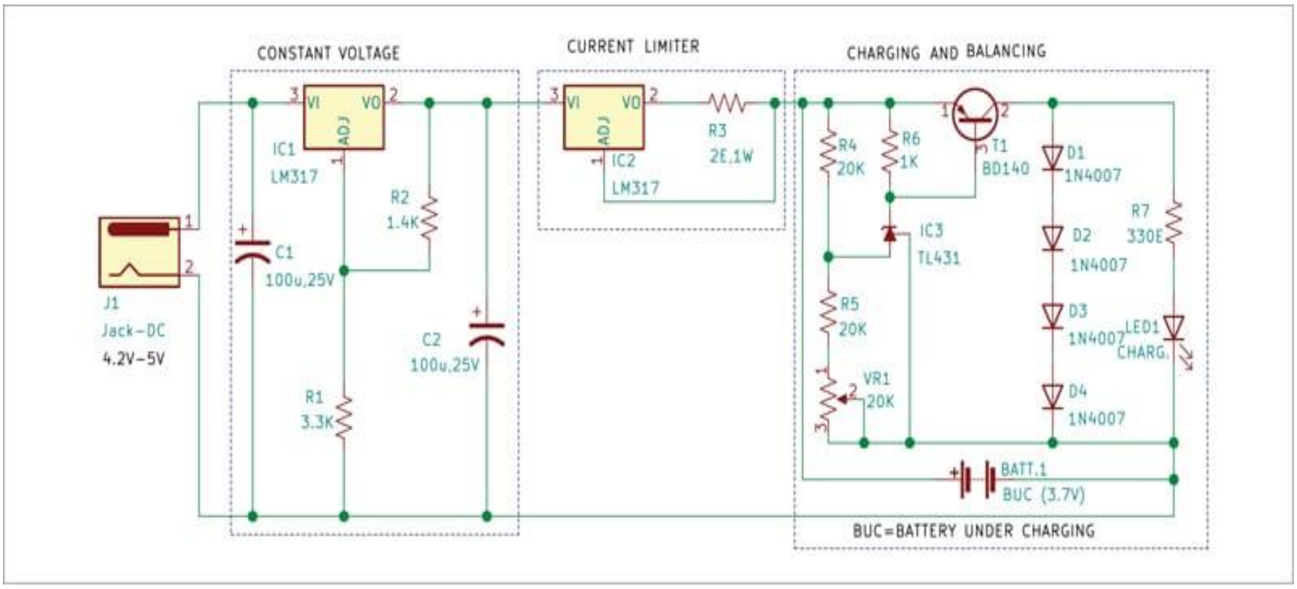
The objective of a simple battery charger with overcharge protection project is to design and implement a circuit that can efficiently charge a rechargeable battery while ensuring that it doesn't overcharge.

COMPONENTS REQUIRED:

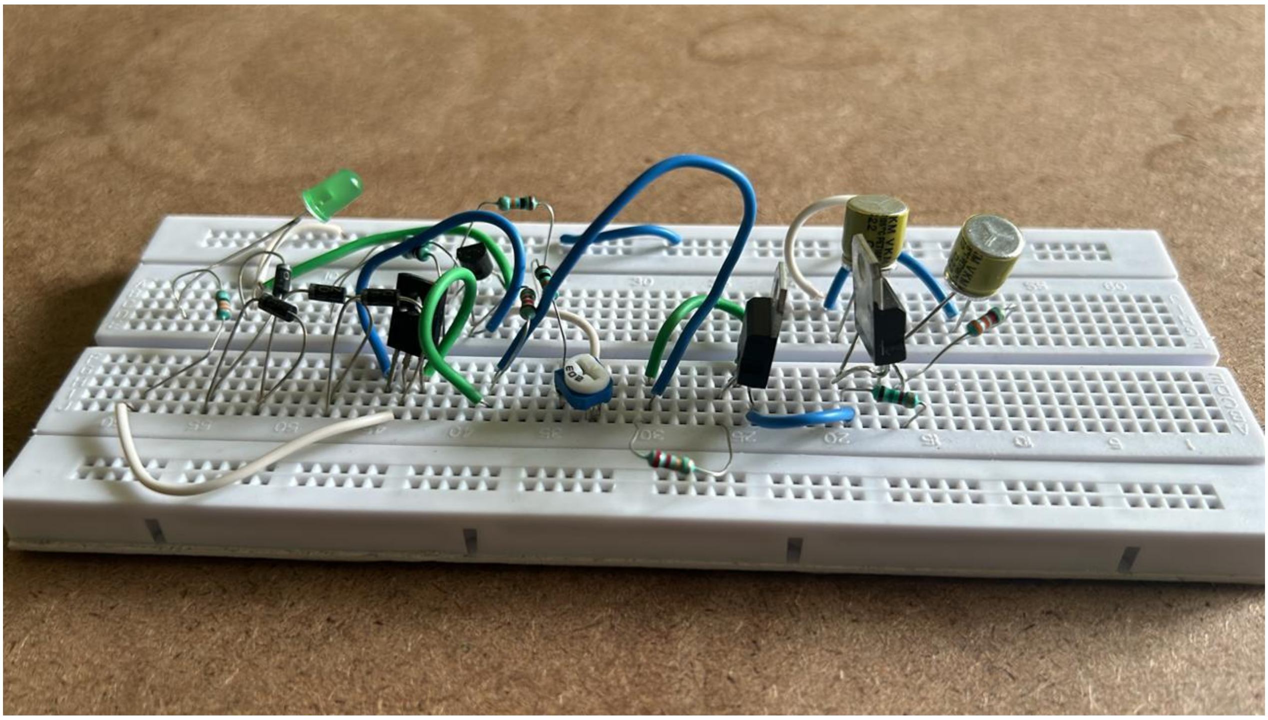
Semicoductors:
IC1, IC2 – LM317, adjustable voltage regulator
IC3 – TL431 shunt regulator IC
LED – 5mm LED
Resistors (all 1/4 -watt, 5+-% carbon), unless stated otherwise:
R – 3.3-kilo-ohm, 1.4-kilo-ohm, 2-kilo-ohm, 20-kilo-ohm, 1-kilo-ohm, 330-ohm
VR1 – 20-kilo-ohm
Capacitors:
C1, C2 - 100µF, 25V electrolytic
Miscellaneous:
J1 – DC jack/2-pin terminal connector
BATT.1 - 2-pin terminal connector
- Battery to charged

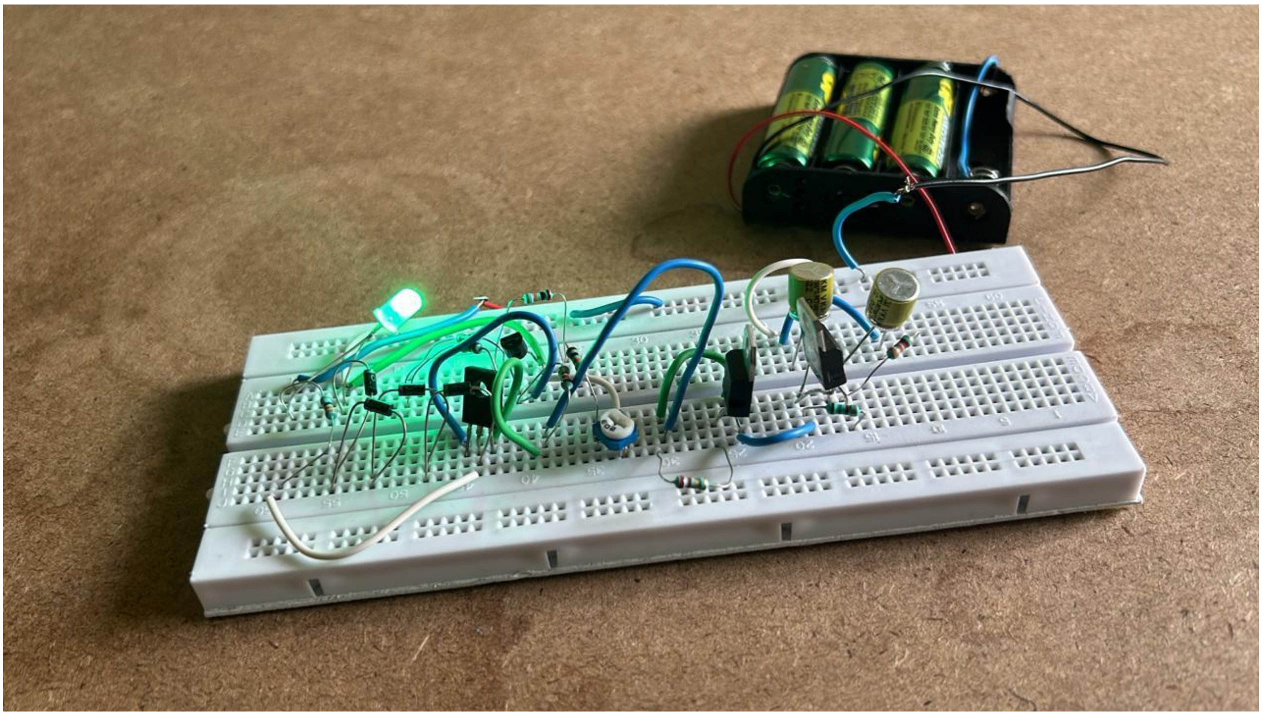
CIRCUIT DIAGRAM:





PROJECT PHOTO:





THEORY:

This simple battery charger, with overcharge protection, can be used to charge multiple cells in a battery. It indicates when the cells are fully charged. The charger requires minimal components, which can be procured easily.

The circuit of the Li-ion battery charger, shown in Fig. 2, has three parts—charging and balancing circuit, current limiter, and constant voltage source. The circuit is capable of providing a maximum of 1.5A current and can take input up to 27 volts.

The most important part of the charger is the charging and balancing circuit that incorporates Zener diode TL431, which acts as an adjustable shunt regulator to control the PNP transistor BD140. The TL431 works as a linear regulator whose threshold voltage can be adjusted through trim pot VR1.

WORKING OF THE CIRCUIT:

- CHARGING AND BALANCING CIRCUIT

When the voltage across Zener diode TL431 is below the threshold voltage, the Zener is in off state. Since the base of the transistor is connected to the cathode of TL431, the transistor remains in off stage as well. Therefore, the current flows through the battery, which is connected in parallel, and thus starts charging it.

On the completion of charging, when the voltage of the battery rises over the upper threshold voltage, the TL431 gets activated and connects the base of the transistor to the ground, thus turning the transistor to its conducting state. In this state, the transistor creates a new path for the current to flow, bypassing the battery, and so the charging stops.

The transistor is connected in series with four diodes, which act as a load. The diodes are also connected to a resistor and an LED in parallel to them. When the transistor is conducting, the current flows through the four diodes and the LED simultaneously, thus turning on the LED to indicate that the battery is fully charged.

The circuit also offers a cell balancing feature, which is important when we charge a battery with multiple cells in series. With the cells connected in series, we need to make sure that the total voltage of the battery pack after charging does not exceed the maximum specified voltage of the battery pack. Also, the voltage of each charged cell should not exceed the maximum specified voltage of that individual cell.

- CURRENT LIMITTER CIRCUIT:

Every cell has a maximum limit of charging current it can take, which is denoted by its C-rate. The C-rate of a cell depends on multiple factors, such as its chemistry, size, internal structure, etc. Charging with overcurrent may cause irreplaceable damage to the cell and may also cause thermal runaway in the battery, which can result in a fire. Therefore, IC LM317 is used as a current limiter. As shown in figure, the voltage input pin VI of LM317 is connected to the positive of the source, and voltage output pin VO is connected to resistor R3. The adjust pin ADJ is connected to the other end of the resistor. The value of current I_out can be adjusted by changing the value of resistor R3, as per the relationship given below. Though, for this charger, we will keep the maximum output current (Iout) as 0.6A.

$$Iout = \frac{V_{ref}}{R3}$$

Here, Vref is 1.25V.

$$0.6 = \frac{1.25}{R3}$$

R3 is 2.08 ohm

- CONSTANT VOLTAGE SOURCE

To make the circuit more versatile and make it work over a wide voltage range, we employ voltage control by using another LM317 IC. The input terminal VI of this IC is connected to the ground through capacitor C1, which should be kept as close as possible to the input terminal. The adjust pin ADJ of the IC is connected to the Vout with resistor R2 in between and to the ground through resistor R1. To improve the transient response of the output, capacitor C2 is connected across Vout pin of the IC and the ground. The output voltage of IC1 can be adjusted as per following relationship:

$$Vout = 1.25\left(1+\frac{R2}{R1}\right) + Iadj\ R2$$

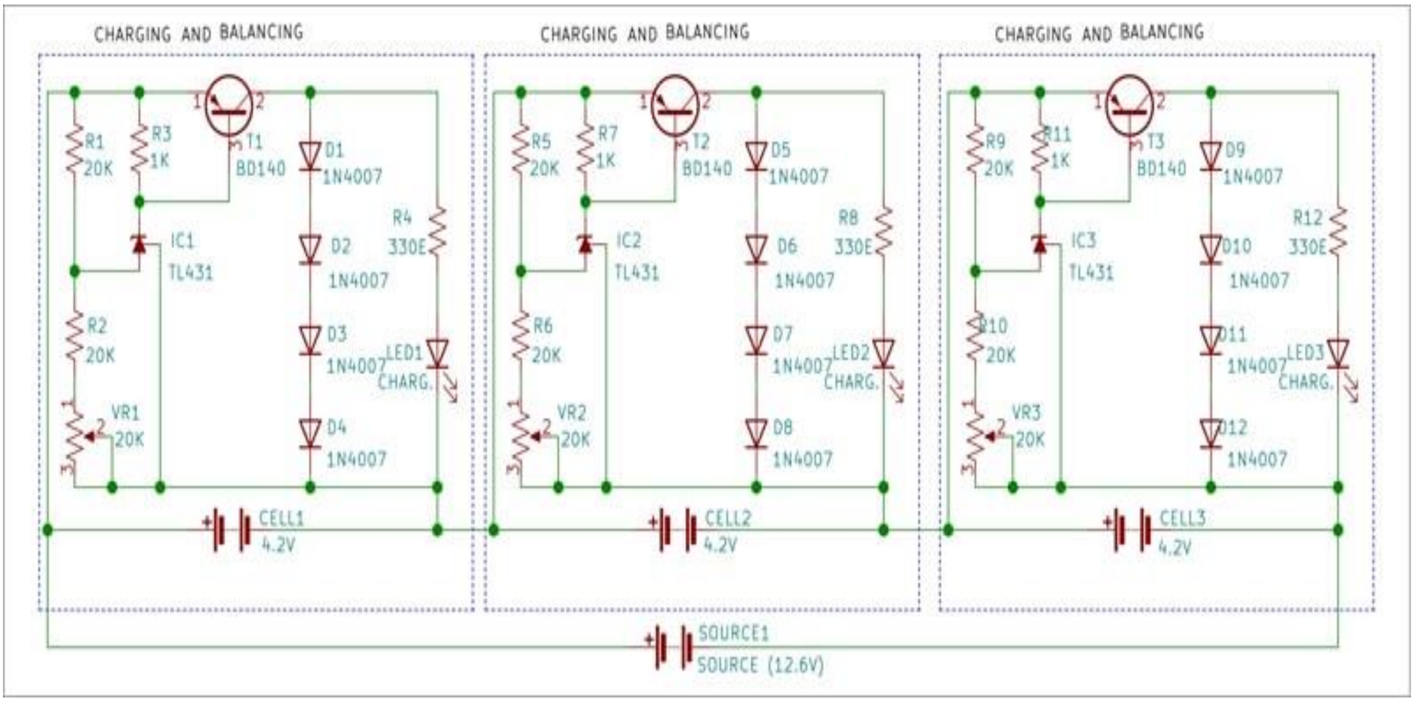
CONSTRUCTION AND TESTING:

An actual-size, single-side PCB for the charger circuit is shown in Fig. 3 and its component layout in Fig. 4. After assembling the circuit on PCB, enclose it in a suitable box. Connect the input across J1 and the battery under charge (BUC) at BATT.1. For setting the threshold voltage for the adjustable shunt regulator, in place of the cell connect a regulated power supply. Keep the output voltage the same as the threshold voltage you want to keep as cutoff voltage for the cell. Now, turn pot VR1 until LED1 starts glowing. This is the cutoff voltage at which the circuit will bypass the cell and current will start flowing through the series of diodes. You can use the same circuit for charging different cell chemistries, such as lithium ion phosphate (LFP), lithium nickel manganese colbalt oxide (NMC), or even lithium-ion polymer (Li-Po) batteries, by setting the cutoff voltage for the adjustable shunt regulator TL431.

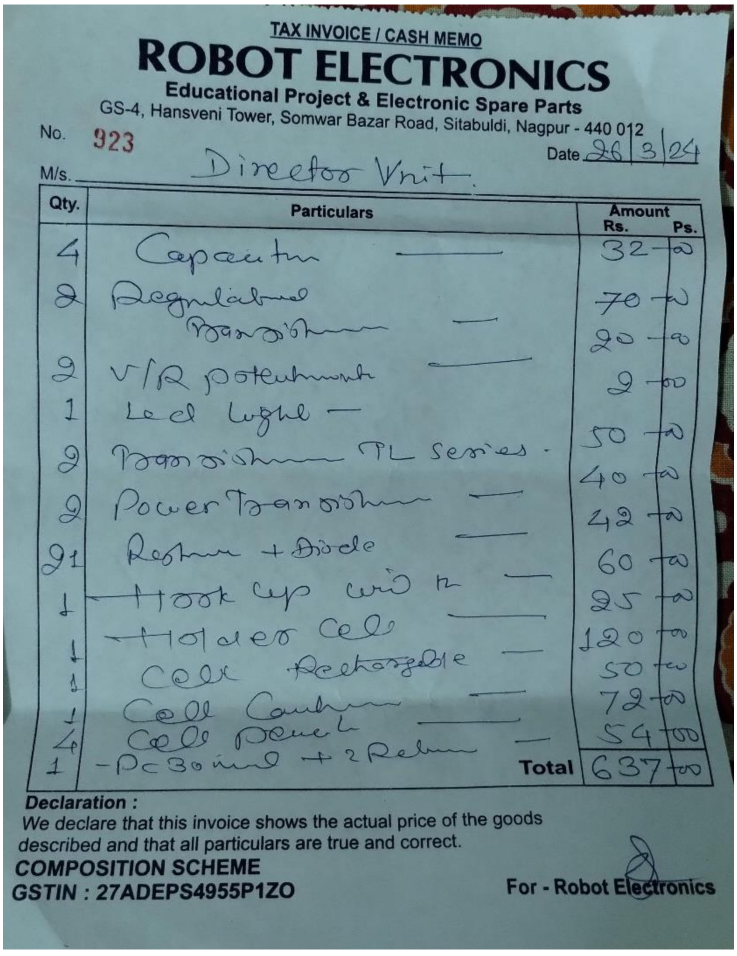
BETTERMENT:

- CHARGING MORE THEN ONE CELL

To charge more than a single cell, which are connected in series, we need to replicate the charging and balancing circuit in series. The connections for a 3-cell charger are shown in Fig. From Fig. 5 it is clear that the charging and balancing circuits are connected in series with each other and the whole series is connected in parallel to a power source. The cells that need to be charged are connected individually to a charging circuit each. Since the cells may take different times to charge and discharge, the voltage of each cell in the battery pack may not be the same. Hence, when one of the cells is charged, the threshold voltage of TL431 in that specific circuit is reached and the cell in that circuit is bypassed, so the current flows through the four diodes in series and the indicator LED turns on.



COST:



TAX INVOICE / CASH MEMO

ROBOT ELECTRONICS

Educational Project & Electronic Spare Parts

GS-4, Hansveni Tower, Somwar Bazar Road, Sitabuldi, Nagpur - 440 012

No. 923

Date 26/3/24

M/s. Director Vnit.

Qty.	Particulars	Amount Rs.	Ps.
4	Capacitor	32	00
2	Regulator Transistor	70	00
		20	00
2	V/R potentiometer	2	00
1	Led light	50	00
2	Transistor TL series	40	00
2	Power Transistor	42	00
21	Resistor + Diode	60	00
1	Hook up wire	25	00
1	Holder Cell	120	00
1	Cell Rechargeable	50	00
1	Cell Cushion	72	00
4	Cell pencil	54	00
1	PC Board + 2 Relay		
	Total	637	00

Declaration :
We declare that this invoice shows the actual price of the goods described and that all particulars are true and correct.

COMPOSITION SCHEME
GSTIN : 27ADEPS4955P1ZO

For - Robot Electronics

APPLICATIONS:

1. Consumer Electronics: Battery chargers with overcharge protection are commonly used for charging rechargeable batteries in consumer electronics such as smartphones, laptops, tablets, digital cameras, and portable gaming devices. They ensure the safe and efficient charging of these devices, extending their battery life.
2. Automotive: Battery chargers with overcharge protection are used in automotive applications for charging vehicle batteries, especially in electric and hybrid vehicles. They help prevent overcharging of the vehicle's battery pack, ensuring optimal performance and longevity.
3. Renewable Energy Systems: It is an essential component of renewable energy systems such as solar power systems and wind turbines. They charge battery banks to store excess energy generated by renewable sources, preventing overcharging of the batteries and maximizing the efficiency of the energy storage system
4. Emergency and Backup Power Systems: Battery chargers with overcharge protection are used in emergency and backup power systems, such as uninterruptible power supplies (UPS), to charge backup batteries that provide power during outages or emergencies. Overcharge protection ensures that the backup batteries remain in optimal condition and are ready for use when needed.

RESULT AND CONCLUSION:

The battery charger with overcharge protection was successfully designed, implemented and tested. The charger efficiently transferred power from the source to the battery, ensuring fast and effective charging. The overcharge protection mechanism effectively detected when the battery was fully charged and prevented overcharging, thus enhancing battery longevity and safety. The charger incorporated safety features such as thermal sensors and current limiting circuits to prevent overheating, short circuit and other hazards. The charger featured user-friendly design elements such as LED indicators to display charging status and clear labelling of ports.

In conclusion, the simple battery charger with overcharge protection project has successfully achieved its objectives of designing a reliable, safe and efficient charging solution for rechargeable batteries