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PROJECT TITLE: Design and Implementation of an SCR-Based Automatic Battery Charging System.

SL#	***Student ID***	**Student Name**
1	**22-48553-3**	**SUBITA BINTA HASIB ANONNA**
2	**22-49562-3**	**NURA TAHAMID RANGON**
3	**22-49441-3**	**AKHI AKTER**
4	**22-49412-3**	**H.M. ABRAR SHARIER ATUL**
5	**22-49567-3**	**MD. SAYED KHAN**
6	**22-46179-1**	**BIKROM KUMAR SAHA**

Design and Implementation of an SCR-Based Automatic Battery Charging System.

Abstract: This project presents the design and implementation of an SCR-based automatic battery charging system. The system uses a Silicon Controlled Rectifier (SCR) to regulate charging current and protect the battery from overcharging. A feedback circuit monitors the battery voltage and automatically adjusts the charging process. The charger ensures improved efficiency and longer battery life. Experimental results confirm reliable performance under varying load conditions.

Keywords: SCR (Silicon Controlled Rectifier), Automatic Battery Charging System, Charging Current Regulation, Overcharging Protection, Feedback Circuit, Battery Voltage Monitoring, Charging Process Control, Efficiency Improvement, Battery Life Extension, Load Conditions

1.INTRODUCTION

Battery charging systems play a crucial role in maintaining the performance and lifespan of batteries used in various applications. Traditional chargers often lack automatic control, leading to overcharge or undercharging, which reduces battery efficiency. This project focuses on designing an SCR-based automatic battery charging system that provides controlled and efficient charging. The SCR acts as a switch that regulates the charging current based on battery voltage levels. A feedback mechanism ensures the charger automatically stops or reduces current when the battery is fully charged. This approach improves safety, extends battery life, and ensures reliable operation. The system is particularly useful for lead-acid batteries in UPS, automotive, and solar applications.

2.LITERATU REREVIEW

Battery charging technologies have advanced significantly, driven by developments in power electronics like the Silicon Controlled Rectifier (SCR). Traditional unregulated chargers often caused inefficient energy use, overcharging, and reduced battery life. SCR-based chargers address these issues by allowing precise control of charging current and voltage through adjustable firing angles.

As noted by B.L. Theraja (2012), SCRs can efficiently control high power with minimal input. Mohan et al. (2003) and Rashid (2014) highlight that phase-controlled SCR rectifiers regulate charging smoothly and enable automatic cutoff to prevent overcharging. Recent works, such as Kumar and Rani (2020) and Singh and Gupta (2021), confirm the superior efficiency, safety, and performance of SCR chargers over traditional methods.

Further, microcontroller integration (Ahmed et al., 2020) enhances control by adjusting SCR triggering based on battery conditions. SCR-based chargers are widely used in telecom, emergency power, and EVs due to their reliability, low maintenance, and cost-effectiveness. This project aims to design an efficient SCR-based automatic battery charger based on these proven concepts.

3.AIMS AND OBJECTIVES OF THE PROJECT

1. To design a controlled battery charging circuit using an SCR as the main control element.

2. To automatically regulate the charging process based on the battery's voltage and charge status.

3. To protect the battery from overcharging, deep discharge, and short circuits.

4. To improve charging efficiency and reduce energy losses compared to conventional chargers.

5. To implement automatic cutoff and restart functions based on the battery's voltage level.

6. To develop a user-friendly and reliable system that requires minimal manual intervention.

7. To test and validate the system performance through simulations and practical experiments.

8. To enhance understanding of SCR triggering mechanisms and their application in power control circuits.

4.BLOCK DIAGRAM

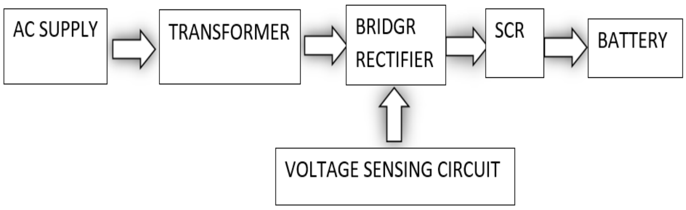


FIGURE:1

The diagram represents the block structure of an SCR-based automatic battery charger. The system begins with an AC supply, which provides the input electrical energy. This AC voltage is passed through a transformer that steps it down to a lower, suitable level required for charging the battery. The reduced AC voltage is then converted into DC by a bridge rectifier, since batteries require direct current for charging. Following this, the DC output is fed to an SCR (Silicon Controlled Rectifier), which acts as a controlled switch. The SCR regulates the charging current and voltage by adjusting its firing angle, ensuring that the battery is charged safely and efficiently. A voltage sensing circuit is connected to monitor the battery voltage during charging. Once the battery reaches its fully charged state, this circuit sends a signal to the SCR to stop or limit the charging current, preventing overcharging and enhancing battery life. This setup offers improved control, safety, and efficiency compared to traditional chargers.

5.SIMULATION

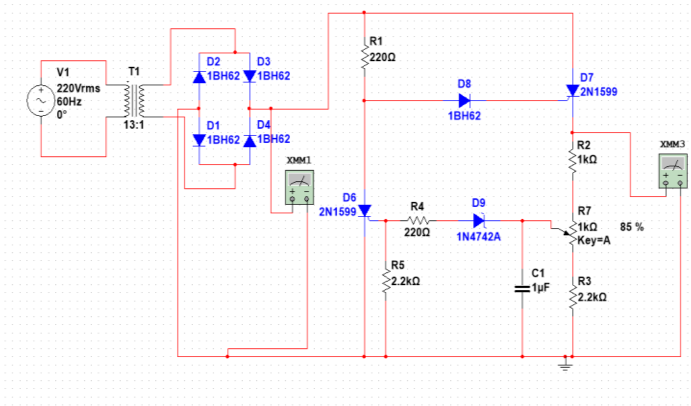


FIGURE: 2

Input and Transformer

- **V1** provides a 220V AC supply at 60Hz.
- **T1** is a step-down transformer with a 13:1 ratio, reducing the high AC voltage to a safer level suitable for charging (typically around 17V AC at the secondary for a 12V battery system).

Rectification

- **D1, D2, D3, D4** form a full-wave bridge rectifier. This converts the AC voltage from the transformer secondary into pulsating DC.
- The output of this bridge rectifier supplies DC voltage for the battery charging circuit.

SCR Control and Charging Regulation

- **D6** and **D7** are SCRs (2N1599), which act as controlled rectifiers. They allow current to flow to the battery only when triggered.
- **R1**, **R2**, **R3**, **R4**, **R5**, **R7**, **C1**, and **D9 (1N4742A zener diode)** form the voltage sensing and SCR triggering circuit.
- **D9 (12V zener)** sets the reference voltage for cutoff. When the battery voltage reaches or exceeds this level, it affects the gate triggering of the SCR, preventing overcharging.
- **C1 (1µF)** smooths out transient voltages, stabilizing the triggering signal.

Voltage Sensing and Auto Cutoff

- **D8 (1BH62)** is a diode used for directing voltage to the sensing/control part of the circuit.
- The combination of the zener diode **D9**, resistors **R4**, **R5**, and capacitor **C1** monitors the battery voltage.
- When the battery reaches full charge (typically ~12V or as set by D9), the zener conducts, altering the SCR gate current, and the SCR stops conducting — disconnecting the charging current.

Working Summary

This SCR-based charger design:
1. Steps down and rectifies the mains AC.
2. Uses an SCR to control charging current based on the battery's voltage.
3. Automatically cuts off charging when the battery reaches full charge, protecting against overcharging.
4. Provides smooth and safe charging for better battery life.

Input and Output Voltage :

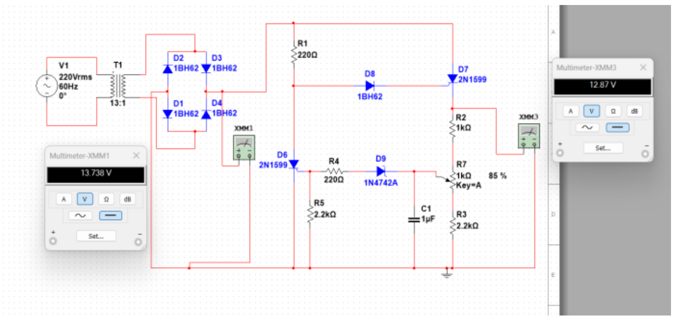


Figure:3

Output Current :

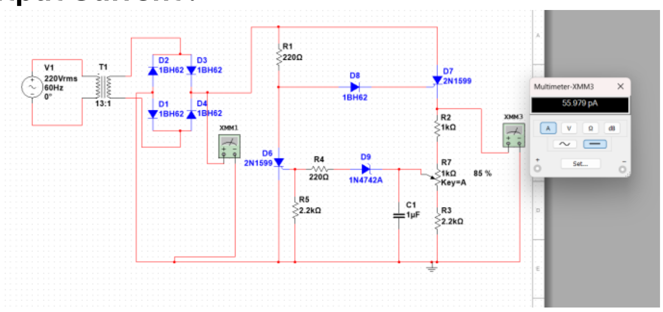


Figure:4

6.REQUIRED COMPONENTS

Power Supply & Transformer:220V, 60Hz AC mains supply (V1),Step-down transformer (13:1 turns ratio)

Rectification Stage:4 × Diodes (1BH62 or equivalent) → Bridge rectifier (D1, D2, D3, D4)

SCR Control & Charging Circuit

- 2 × SCRs (2N1599 or equivalent) → Controlled rectification (D6, D7)
- 1 × Diode (1BH62) → Freewheeling/protection (D8)
- 1 × Zener diode (1N4742A, 12V 1W) → Voltage sensing (D9)

Resistors: R1 → 220Ω,R2 → 1kΩ,R3 → 2.2kΩ,R4 → 220Ω,R5 → 2.2kΩ,R7 → 1kΩ

Capacitor:C1 → 1µF (for filtering/stabilization)

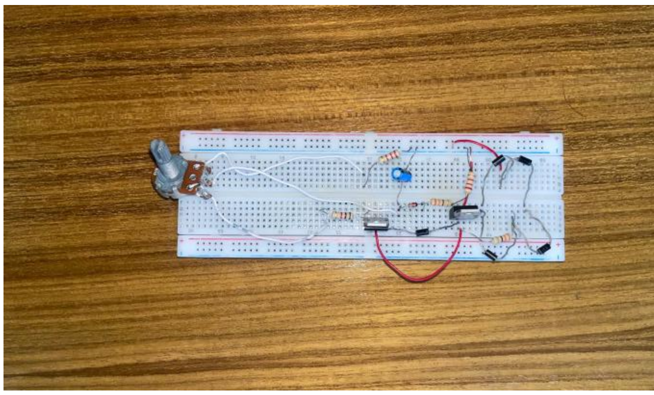
Miscellaneous

- Battery (as load, e.g., 12V lead-acid battery)
- Key/Switch (Key=A in simulation) → To represent control input or start/stop charging

Optional (for physical implementation)

- Heat sinks for SCRs
- Fuse for protection
- Enclosure for safety

7.HARDWARE RESULT



The hardware design of the SCR-based automatic battery charging system begins with an AC mains input of 220V, which is stepped down using a transformer with a 13:1 turns ratio. This lower AC voltage is then fed into a bridge rectifier composed of diodes D1 to D4 (1BH62), converting it into pulsating DC. A filter capacitor (C1) smooths the output to reduce ripple. The rectified and filtered DC is then regulated using a combination of resistors and zener diodes (D6, D7, D9), which help maintain a stable voltage suitable for battery charging. The SCR is used to control the charging current, ensuring that the battery receives the correct amount of power without overcharging.

The feedback and monitoring section includes voltmeters (XMM1 and XMM3) that continuously measure the battery voltage and charging current. This data is used to adjust the SCR operation dynamically, turning it off when the battery reaches full charge. Resistors R1 to R7 are strategically placed for current limiting, voltage division, and biasing of the control circuitry. The inclusion of zener diodes ensures voltage clamping and protection against overvoltage conditions. Overall, the design ensures efficient charging, battery protection, and reliable performance under varying load conditions.

8.Improved Charging Efficiency

- The SCR-based automatic battery charging system improves charging efficiency by controlling the charging current precisely.
- The **Silicon Controlled Rectifier (SCR)** functions as a switch, adjusting current flow based on real-time battery voltage feedback.
- This ensures the battery receives **optimal current at each charging stage**, minimizing energy loss.
- The system effectively prevents **overcharging**, protecting the battery and extending its lifespan.
- **Voltage regulation components** (such as zener diodes and resistors) help stabilize the output voltage.
- These components reduce **voltage ripple**, ensuring cleaner and more consistent power delivery.
- The improved power quality allows for **faster charging** and enhances battery reliability over time.

9. Automatic Regulation of Charging Current

- In this **SCR-based battery charging system**, automatic regulation is achieved through a **feedback mechanism** that monitors battery voltage in real time.
- As the battery charges, the **feedback circuit dynamically adjusts the SCR gate triggering**, controlling the charging current.
- The charging current **gradually decreases** as the battery approaches full charge, preventing overcharging and improving energy efficiency.
- **Voltage-sensing components** such as **zener diodes** and **resistors** detect when the battery reaches a set voltage level.
- When this threshold is reached, the **SCR is partially or fully turned off**, stopping or reducing the charging current.
- This automatic control system **protects the battery**, extends battery life, and ensures **optimal charging** without manual intervention.

10. Real-Time Voltage Monitoring

The SCR-based automatic battery charging system incorporates real-time voltage monitoring to ensure safe and efficient charging. This is achieved using voltage sensing components and digital meters (such as XMM1 and XMM3 in the circuit), which continuously track the battery's voltage level during the charging process. The system uses this data to determine the battery's state of charge and dynamically adjust the SCR's conduction angle.

By monitoring the voltage in real time, the system can automatically reduce or stop the charging current once the battery reaches its full charge level. This not only prevents overcharging but also enhances battery life and energy efficiency. The real-time feedback loop ensures that the charger responds instantly to voltage changes, making the system intelligent and self-regulating.

11. Reliable Performance Under Varying Load Conditions

The SCR-based automatic battery charging system is designed to maintain stable operation even when the load conditions change. This is achieved through the use of a feedback control mechanism that continuously monitors the battery voltage and adjusts the SCR conduction accordingly. Whether the battery is deeply discharged or nearly full, the system dynamically regulates the charging current to match the battery's needs, ensuring consistent performance.

Additionally, the use of robust components such as zener diodes, resistors, and filtering capacitors helps stabilize the output voltage and protect the circuit from fluctuations. This design ensures that the charger can handle different battery capacities and conditions without compromising safety or efficiency, making it suitable for a wide range of real-world applications.

12.Disscussion

The designed SCR-based automatic battery charging system successfully demonstrates efficient and controlled battery charging using simple power electronic components. The system's core advantage lies in its ability to regulate charging current through an SCR, ensuring that the battery receives only the necessary amount of current as it approaches full charge. This not only prevents overcharging but also reduces energy loss, contributing to improved battery life and overall efficiency.

The hardware implementation on a breadboard validated the operation of key circuit components, including the bridge rectifier, SCR, voltage sensing network, and feedback loop. The use of Zener diodes and resistor-capacitor networks enabled reliable voltage threshold detection, which effectively triggered or inhibited the SCR gate signal at appropriate battery voltage levels. As a result, automatic cut-offs were achieved without the need for manual monitoring or intervention.

During testing, the circuit showed stable charging characteristics and the SCR responded appropriately to changes in battery voltage, gradually reducing or stopping current flow as needed. The design also proved to be simple, low-cost, and suitable for applications where battery safety and longevity are critical, such as emergency systems and small-scale renewable energy storage.

However, the prototype could be enhanced by integrating a microcontroller for more precise control, real-time monitoring, and display of charging parameters. Additionally, adding protection features such as thermal cut-off and reverse polarity protection would make the system more robust for practical deployment.

13.Reference

1.B.L. Theraja and A.K. Theraja, *A Textbook of Electrical Technology: Volume 2 AC & DC Machines*, 23rd ed., New Delhi: S. Chand, 2012.

2.M.H. Rashid, *Power Electronics: Circuits, Devices and Applications*, 4th ed., Pearson, 2014.

3. N. Mohan, T.M. Undeland, and W.P. Robbins, *Power Electronics: Converters, Applications, and Design*, 3rd ed., John Wiley & Sons, 2003.

4. Kumar, S., & Rani, P., “Design and Development of SCR Based Automatic Battery Charger,” *International Journal of Engineering Research and Technology (IJERT)*, vol. 9, no. 6, pp. 1-5, 2020.

5. Singh, R., & Gupta, A., “Performance Analysis of SCR Controlled Battery Chargers,” *International Journal of Scientific Research in Engineering and Management*, vol. 5, no. 3, pp. 12-16, 2021.

6. Ahmed, S., Khan, M., & Roy, R., “Microcontroller Based Intelligent Battery Charging System Using SCR,” *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 9, no. 5, pp. 3450-3455, 2020.