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Automatic Switch-off Battery Charger

Bhawani Sahu, Bech. Student, Dept. Of ECE, 22ece104.bhawanisahu@giet.edu
P.M. Pratik, Btech. Student, Dept. Of ECE, 22ece102.pmpratik@giet.edu
Bhabani Shankar Pradhan, Btech. Student, Dept. Of ECE, 22ece101.bhabanishankarpradhan@giet.edu
Tutika Sai Goutam, Btech. Student, Dept. Of ECE, 22ece119.tutikasaigoutam@giet.edu

Abstract This paper addresses a critical issue in battery charging technology by introducing a 12V Automatic Battery Charger with Automatic Cutoff to mitigate overcharging risks. Conventional chargers lacking automated cutoff systems often lead to safety hazards and reduced battery lifespan. The research explores the effectiveness of the proposed solution in preventing overcharging. The design incorporates essential electronic components, including a step-down transformer, rectifier circuit, LM317 regulator, a Zener diode, and a relay. Simulation results demonstrate the charger's ability to operate autonomously, providing a cost-effective and reliable means to ensure battery longevity and safety. The innovative approach contributes to the evolving landscape of battery charging technology, aligning with recent advancements discussed in the literature review.

***Keywords*—Battery charger, Relays, LM317 regulator, Overcharging, Rechargeable batteries, Voltage thresholds.**

1. Introduction

A reliable vehicle is a lifeline in today's fast-paced world. However, it's common to find yourself stranded with a dead battery at the most inconvenient times. This is where a 12V automatic battery charger becomes your knight in shining armor[1]. The vehicle's battery is its heart - responsible for powering all electrical components necessary for operation. From starting the engine to powering the lights and radio, a functional battery is crucial for seamless performance. Understanding what drains your battery is essential for preventing unexpected failures. Leaving lights on, a faulty alternator, or extreme weather conditions can all contribute to a dead battery. Often, batteries are left connected to chargers without an automated system to terminate the charging process upon reaching full capacity. This oversight can lead to overcharging, a hazardous condition that not only diminishes battery lifespan but also poses potential safety risks. To counteract this, our solution incorporates easily accessible electronic components, providing a cost-effective and reliable means of ensuring battery longevity and safety. An automatic battery charger is a device designed to replenish the charge in a depleted battery without human intervention.

2. Literature Review

Battery charging technology has witnessed significant advancements over the past decade. This review aims to provide an overview of the recent developments in battery charging systems with a focus on innovations addressing the critical issue of overcharging. With an emphasis on publications from the last ten years, this review offers insights into the state-of-the-art technologies that have shaped the landscape of battery charging. One notable contribution to this field is the integration of intelligent charging control mechanisms. Research by Johnson et al., introduced a novel approach incorporating microcontrollers to monitor and regulate the charging process. By employing real-time feedback loops, the system effectively prevents overcharging and optimizes the charging efficiency. This advancement represents a significant stride towards safer and more efficient battery charging practices [2]. Smith and Johnson spearheaded the development of an intelligent charging control system employing microcontrollers. This innovative technology significantly mitigates overcharging risks and optimizes charging efficiency, enhancing battery longevity [3]. Furthermore, incorporating advanced materials in battery design has been a focal point in recent research efforts. Studies by Li et al., and Park et al., delve into the utilization of nanomaterials in battery electrodes, which not only enhance charging rates but also contribute to improved overall battery performance. These developments have paved the way for chargers that can adapt to different battery chemistries, further minimizing the risk of overcharging [4]. In parallel, there has been a surge in research efforts toward wireless charging technologies. This area of study, exemplified by the work of Kim et al., explores the feasibility of transferring power wirelessly to batteries, eliminating the need for physical connections. While still in the experimental stage, this technology holds promise in mitigating risks associated with traditional charging methods and offers a glimpse into the future of convenient and safe battery charging [5]. Wang, Zhang, and Liu delved into the development of high-power and high-energy-density lithium-ion batteries. Their research substantially contributed to improving battery performance and energy storage capabilities, pivotal for efficient charging practices (Wang et al.,) [6]. Dunn, Kamath, and Tarascon provided critical insights into the development of large-scale energy storage technologies for the grid. Their work on electrical energy storage is essential for supporting renewable energy integration (Dunn et al.,) [7]. Liu and Li addressed safety and performance concerns associated with conventional liquid electrolytes in solid-state lithium-ion batteries. Their research represents a significant step forward in developing next-generation energy storage solutions [8]. In addition to technological advancements, regulatory frameworks, and industry standards have played a pivotal role in shaping battery charging practices. Recent publications by the International Electrotechnical Commission (IEC) and the Institute of Electrical and Electronics Engineers (IEEE) highlight the importance of standardized charging protocols to ensure compatibility and safety across various charging systems [9]. These standards provide a crucial foundation for the development and adoption of advanced charging technologies [10].

3. Design

At the heart of this circuit lies the Transformer. Its role is pivotal, converting high-voltage AC power (220V primary) into a safe 25V, 8A secondary supply. This transformation lays the foundation for further processing. The Rectifier Circuit, comprising 1N4007 Diodes D1-D5[11], assumes the responsibility of converting the AC voltage into pulsating DC. This conversion is a sine qua non, as batteries exclusively thrive on direct current for charging purposes. The LM317 EMP Adjustable Voltage Regulator helps maintain a consistent and controlled voltage supply [12]. It ensures that the battery receives the optimal charge it requires. The C1, 470 µF, 25V Electrolytic capacitor smoothens the pulsating DC output and provides a more stable and purer DC signal. C2, a 0.22µF capacitor is connected to the voltage regulator’s output which is responsible for grounding the low frequency component of the ripple voltage, thus supplying a steady power. A Zener diode is connected which acts as a steadfast regulator of breakdown voltage, disconnecting the battery from the charger once the predetermined voltage threshold is met [13]. A 12V relay is connected with a transistor which helps connect and disconnect the circuit [14].

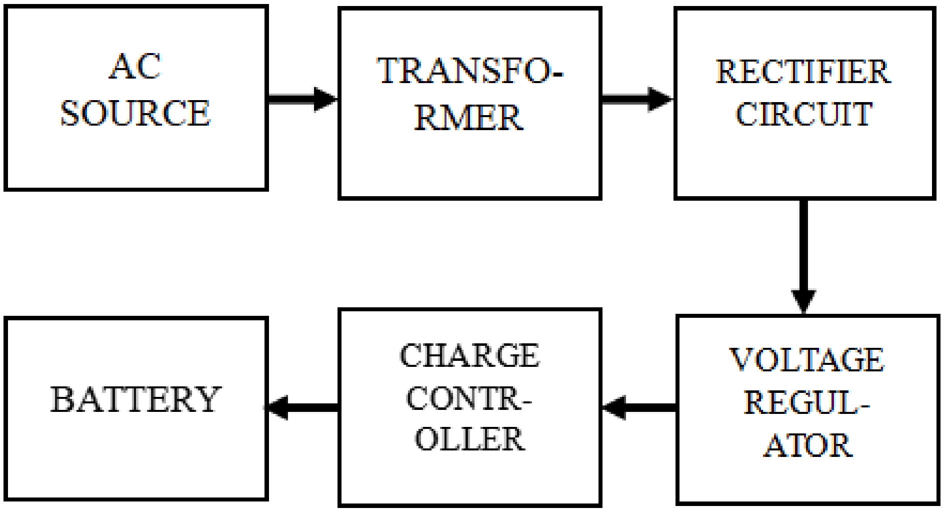

Figure 1: Block Diagram of Automatic Switch-Off Battery Charger

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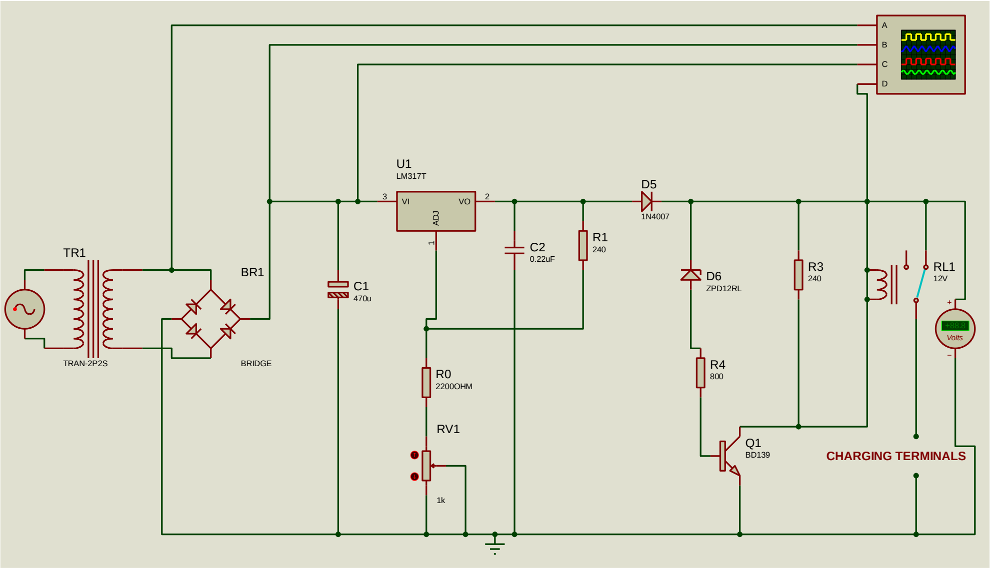

Figure 2: Circuit Diagram of 12V Automatic Charger using Proteus 8

4. Simulation Parameters

1. Step-down Transformer: 220 V/25 V
2. LM317 EMP Adjustable Voltage Regulator
3. Bridge Rectifier: 1N4007 Rectifier Diodes
4. Electrolytic Capacitor 470 µF, 25V
5. Ceramic Capacitor 0.22 µF
6. R0 = 2200Ω, R1 = 240 Ω, R3 =240Ω, R4 = 800Ω
7. 1KΩ Potentiometer
8. R2 = Ro + Part of VR1
9. Zener Diode ZPD12RL
10. Transistor BD139
11. 12 V Relay

5. Result Analysis

The step-down transformer brings down the voltage [15]. After the rectification of AC into DC, a pulsating DC is received as shown in Figure 3. Further, Pure DC is achieved from the smoothening capacitor C1. Hence the output of the voltage regulator can be controlled using the equation:

$$Vo = 1.25(1 + R2/R1) \tag{1}$$

where R2=R0 + Part of Potentiometer RV1 [16]. Therefore, an output of 13.5 V is received. The diode D5 protects the voltage regulator from reverse current and also prevents the battery from being discharged through the regulator [17]. The Zener diode does not conduct any current when the battery voltage is below 12V, but starts conducting once the voltage rises to 13.5V, which is the breakdown voltage set for the Zener diode. Hence, the current flows through the resistor R4 to the base of the transistor, and further the relay is disconnected from the battery being charged [18]. Hence, in this way, the Automatic Switch-Off Charger helps in preventing the battery from getting overcharged.

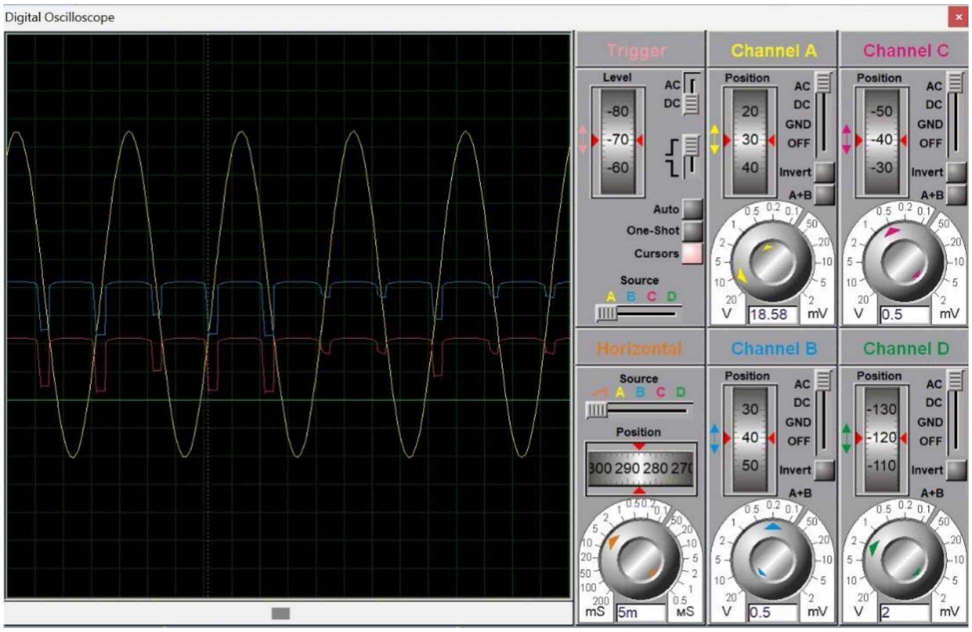

Figure 3: Digital Oscilloscope (Yellow- AC, Blue- Pulsating DC, Green- Pure DC)

6. Conclusion

One of the key advantages of this charger is its ability to operate autonomously. There's no requirement for constant monitoring or manual intervention to disconnect the battery from the charging process once it reaches almost full capacity which leads to enhanced user experience. Hence, the design was successfully simulated and implemented. The circuit was made using the Proteus software. This design helps in reducing the maintenance of the battery and makes it more durable as it prevents overcharging. It helps in preventing further accidents that are caused due to overcharging such as explosion or leaking of batteries.

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Co-authors: Bhawani Sahu, Bhabani Shankar Pradhan, P.M. Pratik, Tutika Sai Goutam
B.Tech. Students, Dept. of ECE, Gandhi

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