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Smart Auto Cutoff Charger or Socket

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Abstract - The Smart Auto Cutoff Charger or Socket project addresses the common issue of electronic device overcharging, which can lead to battery degradation, overheating, reduced efficiency, and safety risks. The system employs a microcontroller (Arduino or ESP32) paired with voltage and current sensors (INA219 or ACS712) to monitor the charging process in real time. A relay module regulates the power supply, automatically cutting off charging based on preset voltage and current thresholds to prevent overcharging. A built-in display (LCD or OLED) provides live feedback on the charging status. Key safety features include overcharge protection, short-circuit detection, and customizable thresholds. Future enhancements envision IoT integration for remote monitoring and control via mobile applications, temperature-based cutoffs, energy usage tracking, and timer-based charging. Designed for a wide range of battery-powered devices such as smartphones, laptops, and power banks, the system optimizes charging cycles, enhances safety, and extends battery life, making it suitable for smart homes and modern IoT environments.

Key Words: Smart Charger, Auto Cutoff, Overcharging Protection, ESP32/Arduino, Voltage & Current Sensors, Relay Control, Battery Safety.

1.INTRODUCTION

The rapid integration of electronic devices like smartphones, laptops, and tablets into daily life has created a pervasive issue: overcharging. Users frequently leave devices connected long after the battery is full, a practice that severely shortens battery lifespan and causes issues such as excessive heating, unnecessary electricity consumption, and potential safety hazards like fire. This problem is aggravated because traditional chargers and power sockets lack

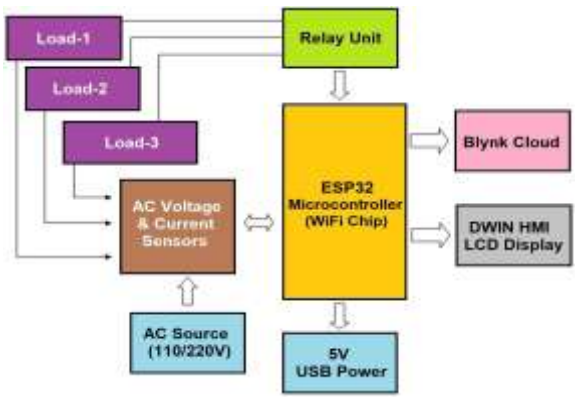
the necessary intelligence to monitor charging status and automatically prevent overcharging. There is a critical demand for a smarter, more reliable solution to enhance device safety and energy management.

The IoT Based Auto Cut-Off Power Charger is designed to solve these major limitations. Its core function is to automatically disconnect the power supply once the battery reaches full charge, thereby protecting the device from damage and preventing the risks associated with overcharging. Beyond basic safety, the system integrates IoT technology, allowing users to remotely monitor, control, and schedule charging via a smartphone or web application, addressing the inconvenience of manual management and the desire for remote control. Furthermore, its "multi-utility" nature enables it to handle multiple devices and appliances simultaneously, making it highly practical for households and offices.

The primary objective of this Smart Auto Cutoff Charger/Socket is to offer a safe, efficient, and convenient charging solution. By automatically disconnecting power when a device (like a phone or laptop) is fully charged, it directly prevents overcharging, extends battery life, and reduces the risk of overheating and fire hazards. The system eliminates the need for manual monitoring, providing users with peace of mind.

Ultimately, this innovation offers substantial benefits toward energy saving and sustainability. By cutting off unnecessary power consumption, it helps reduce electricity bills and promotes the efficient use of resources. The IoT Based Multi-Utility Auto Cut-Off Power Charger therefore contributes to building a safer, smarter, and greener charging infrastructure for the future

2. OVERVIEW OF PROJECT



In today's digital world, electronic devices such as smartphones, tablets, laptops, and other rechargeable gadgets require frequent charging. Many users often leave these devices plugged in even after the battery is

fully charged, which leads to overcharging, overheating, unnecessary energy consumption, and a reduction in battery lifespan. Traditional charging sockets and adapters lack intelligent monitoring systems, creating the need for a safer and more efficient charging method. To address this issue, the Smart Auto Cutoff Charger or Socket was developed to automatically disconnect the power supply once the device is fully charged. With the addition of IoT capabilities, users can remotely monitor charging status, receive alerts, and control the socket from anywhere. This system is particularly useful in households, offices, and industries where multiple devices may need charging simultaneously. It not only enhances safety and convenience but also promotes energy efficiency and environmental sustainability by reducing idle power consumption and extending battery life.

The problem arises mainly because users forget to unplug their devices after reaching 100% charge. Continuous charging leads to battery degradation, excessive heat generation, higher electricity bills, and in extreme cases, even fire hazards. Existing chargers are not capable of detecting the charging status of connected devices, making manual monitoring necessary. Furthermore, with the increasing number of devices in homes and workplaces, managing multiple chargers becomes inconvenient. Users also lack the ability to monitor or control charging remotely, especially when away from home. Therefore, a smart, automated, and remotely accessible charging system is essential to overcome these limitations.

The main objective of the Smart Auto Cutoff Charger or Socket is to offer a safe, reliable, and energy-efficient charging solution. It automatically cuts off power when a device is fully charged, preventing overcharging and potential hazards. The system helps extend battery life, reduces energy wastage, and provides users with the convenience of remote monitoring through IoT platforms. By eliminating the need for manual supervision, it ensures a safer and smarter charging experience.

The Smart Auto Cutoff Charger or Socket uses sensors, a microcontroller, a relay control switch, and a display or IoT interface. Voltage and current sensors like INA219 and ACS712 constantly monitor the electrical parameters of the connected device. This real-time data is sent to an ESP32 microcontroller, which analyzes voltage and current levels to detect when the battery is fully charged. The ESP32 also connects to the internet via Wi-Fi, sending data to IoT dashboards such as Blynk or ThingSpeak so that users can view charging status, energy consumption, and notifications on their smartphones. When the device reaches full charge, the microcontroller automatically triggers the relay to cut off the power supply. This prevents overheating and eliminates unnecessary energy usage. Users can also manually control the socket through IoT applications, even when they are not physically present. Additional safety features like overcurrent detection and fault alerts make the system more reliable.

The system's hardware consists of the ESP32 controller, voltage and current sensors, a relay module, a power supply, and a display unit. The ESP32 is chosen because it supports Wi-Fi and Bluetooth, has multiple GPIO pins, low-power operation modes, and is easy to program using Arduino IDE or MicroPython. The INA219 voltage sensor measures load voltage and current by detecting the drop across a shunt resistor, while the ACS712 current sensor uses the Hall-effect principle to measure current flow safely. The relay module acts as an intelligent switch that handles the actual power supply to the socket. It is controlled by the microcontroller and ensures electrical isolation between high-power and low-power circuits. An LCD or OLED display can show voltage, current, and charging status directly on the device, while IoT connectivity provides remote visibility and control.

Overall, the system operates by continuously monitoring the charging status, processing data through the microcontroller, controlling the power supply through a relay, and updating users locally or remotely. This makes it suitable for charging mobile phones, laptops, power banks, small appliances, and even larger systems such as electric vehicles or battery-powered equipment. Its ability to conserve energy, improve safety, and enhance user convenience makes it a valuable addition to smart home and industrial energy management.

In conclusion, the Smart Auto Cutoff Charger or Socket successfully addresses the issues of overcharging, energy wastage, and safety hazards. It provides users with a more intelligent, efficient, and automated charging solution. With IoT integration, users gain remote access, real-time updates, and greater control over the charging process. The system contributes to prolonging battery health, reducing electricity consumption, and ensuring safe operation. Looking ahead, the concept has potential for further development through AI-based predictive charging, faster wireless technologies, renewable energy integration, and compatibility with smart grids. These improvements can make the system even more efficient and adaptable to future smart home and industrial applications.

3.LITERATURE SURVEY

Several studies and projects have focused on preventing overcharging and improving battery safety using embedded systems and sensor-based automation. Key references supporting these concepts are now added and cited appropriately.

Sensor-Based Charging Control Systems: Prior work demonstrates the use of voltage and current sensors such as INA219 and ACS712 for precise monitoring of electrical parameters during charging. These systems improve safety and efficiency by enabling dynamic control based on sensor feedback [Ref. 4, 5].

Microcontroller-Based Protection Circuits: Numerous projects using Arduino and ESP32 show their effectiveness in handling automation tasks in charging systems. Their programmable nature allows easy implementation of voltage cutoff thresholds, relay control, and digital displays [Ref. 6, 7].

Relay and MOSFET Switching for Safety: Switching mechanisms such as electromechanical relays and MOSFET-based smart switching have been researched extensively to provide isolation and overcurrent protection in power electronics applications [Ref. 8].

IoT-Enabled Smart Chargers: Several recent studies examine IoT-enabled charging systems that use cloud platforms and mobile apps for real-time tracking, notifications, energy analytics, and predictive battery health monitoring [Ref. 9, 10].

Battery Life Optimization Research: Literature on lithium-ion battery degradation highlights that overcharging causes thermal stress and capacity loss, confirming the necessity of smart cutoff systems for maintaining battery health and longevity [Ref. 11, 12]. Several studies and projects have focused on preventing overcharging and improving battery safety using embedded systems and sensor-based automation:

Sensor-Based Charging Control Systems: Previous research has explored the use of INA219 and ACS712 sensors for accurate voltage and current monitoring in battery-operated devices. These studies highlight the importance of real-time measurement in controlling charging cycles and preventing battery stress.

Microcontroller-Based Protection Circuits: Works involving Arduino and ESP32 demonstrate their effectiveness in implementing smart cut-off mechanisms, offering flexibility in setting charge thresholds and integrating additional features such as displays and alarms.

Relay and MOSFET Switching for Safety: Earlier designs have employed relay modules and MOSFETs for automated switching to provide electrical isolation, reducing the chances of short circuits and overheating.

IoT-Enabled Smart Chargers: Recent advancements show widespread adoption of Wi-Fi/Bluetooth-enabled chargers for remote monitoring of battery health, energy consumption, and temperature, promoting user awareness and preventive maintenance.

Battery Life Optimization Research: Studies on lithium-ion battery safety stress that overcharging significantly shortens battery lifespan. Smart cutoff systems inspired by these findings aim to maintain optimal charge limits and improve long-term device performance.

4. CONCLUSIONS

The Smart Auto Cutoff Charger/Socket successfully demonstrates itself as an efficient, safe, and eco-friendly solution to the prevalent issue of device overcharging. By implementing automatic power disconnection upon charge completion, the system effectively saves energy, which in turn reduces electricity costs and contributes significantly to sustainable energy practices. Fundamentally, the design ensures battery protection by preventing overcharging and enhances user safety by minimizing the risks of overheating and short circuits. Integrating IoT features like real-time monitoring and remote control enables a superior blend of safety, convenience, and automation, positioning this system as a future-oriented technological advancement applicable across a wide range of uses, from personal gadgets to industrial systems and Electric Vehicle (EV) charging stations.

Looking ahead, the system is primed for evolution through the incorporation of next-generation technologies focused on increasing speed, efficiency, and intelligence. This includes transitioning to wireless and ultra-fast charging using advanced GaN/SiC-based semiconductors, which will enable solutions that are more compact and highly efficient. Furthermore, the integration of cutting-edge concepts like bi-directional wireless charging and Vehicle-to-Everything (V2X) technology will fundamentally transform connected devices, allowing electric vehicles and other devices to function as dynamic energy hubs capable of sharing power across homes and industries.
Finally, the long-term potential of the smart charging solution centers on holistic energy management. Compatibility with renewable energy sources and smart grids will be key to enhancing overall environmental sustainability. Crucially, the implementation of AI-enabled predictive power management will optimize energy usage dynamically, moving beyond simple cutoffs to anticipatory control. These strategic advancements in versatility, efficiency, and intelligence will make smart charging solutions indispensable components of modern smart homes, workplaces, and large-scale power infrastructure.

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