QR Based EV Bulk with Overcharge Protection and Prevention

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ABSTRACT
The increasing adoption of Electric Vehicles (EVs) has highlighted the need for efficient and safe charging systems. One of the major challenges in EV charging infrastructure is preventing overcharging, which is leads to battery degradation, reduced lifespan, and potential safety hazards. Therefore, this paper presents a Quick Response (QR)-based EV bulk charging system integrated with overcharge protection and prevention mechanisms. A solar panel, an ATmega 328 microcontroller, a Node MCU, a battery, Liquid Crystal Display (LCD), and an IoT device are some of the components of this work. The proposed system utilizes QR code technology for easy identification and access control of charging stations, enabling seamless user interaction. The data gathered by the device is sent to users using an IoT, and it is monitored by the BLYNK app. The data is uploaded to the BLYNK app cloud database via the Node MCU module embedded inside the microcontroller. It also integrates advanced QR based charging algorithms and real-time battery monitoring to protect against overcharging, ensuring that the EV's battery is charged efficiently, safely, and within its optimal capacity. This system prevents overcharging, the system incorporates a smart charging algorithm that monitors the battery's charging state in real-time.

Keywords: Microcontroller, Overcharge Protection, QR Code, Battery, IoT.

1. Introduction

The global shift toward EVs has accelerated as governments, industries, and individuals increasingly prioritize environmental sustainability and energy efficiency. As EV adoption grows, so does the demand for robust and reliable charging infrastructure to support this transition [1-2]. One of the primary concerns in EV charging is the management of battery health, particularly preventing overcharging, which is significantly degrade battery life, reduce performance, and pose safety risks. The core of the overcharge protection system lies in its ability to monitor the battery status in real-time [3-5]. The charging station continuously communicates with the vehicle's Battery Management System (BMS) to track the battery's voltage, current, and temperature [6]. The smart charging algorithm adjusts the charging rate, gradually reducing the current as the battery approaches full charge. Once the battery reaches its maximum capacity, the system halts the charging process automatically, preventing overcharge. A single vehicle is charged by an EV charger, guaranteeing that the charging profile is consistent during each charge [7-8]. Overcharging occurs when a battery receives more charge than it is safely store, which leads to thermal runaway, reduced battery lifespan, or even fire hazards in extreme cases. Most EV batteries are equipped with built-in charging management systems; however, human error, system malfunctions, or outdated charging stations are still lead to overcharging scenarios [9]. To mitigate these risks, it is essential to integrate real-time monitoring and intelligent charging systems capable of dynamically adjusting the charging process to prevent overcharging. To address these challenges, a QR-based EV bulk charging system with overcharge protection and prevention mechanisms has emerged as a potential solution [10-11]. The QR-based system adds a layer of convenience to the traditional charging process. When users arrive at a charging station, they simply scan a QR code linked to their unique user profile or vehicle data. This code contains essential information such as the EV's battery type, required charging parameters, and user preferences. Once scanned, the system authenticates the user and adjusts the charging settings accordingly, ensuring that the correct parameters are used for each vehicle, preventing the risk of overcharging [12-13]. Further, the IoT technology plays a critical role in this system by enabling remote monitoring and data analytics. Through IoT sensors and cloud-based systems, users and operators are monitoring the charging progress in real-time, receiving alerts for any potential issues, and analyzing the system's performance to optimize future charging sessions [14-15]. Therefore, this paper proposes a QR-based EV bulk charging system integrated with overcharge protection and prevention mechanisms. It represents a significant advancement in EV charging infrastructure, addressing critical issues such as battery health, energy efficiency, and user convenience.

2. Proposed Methodology

The block diagram illustrated in Figure 1 presents a QR-based EV bulk charging system for enhanced system reliability and energy efficiency in real-time. The system begins with PV panels generating electricity, where devices continuously monitor key parameters such as voltage, current, and temperature.

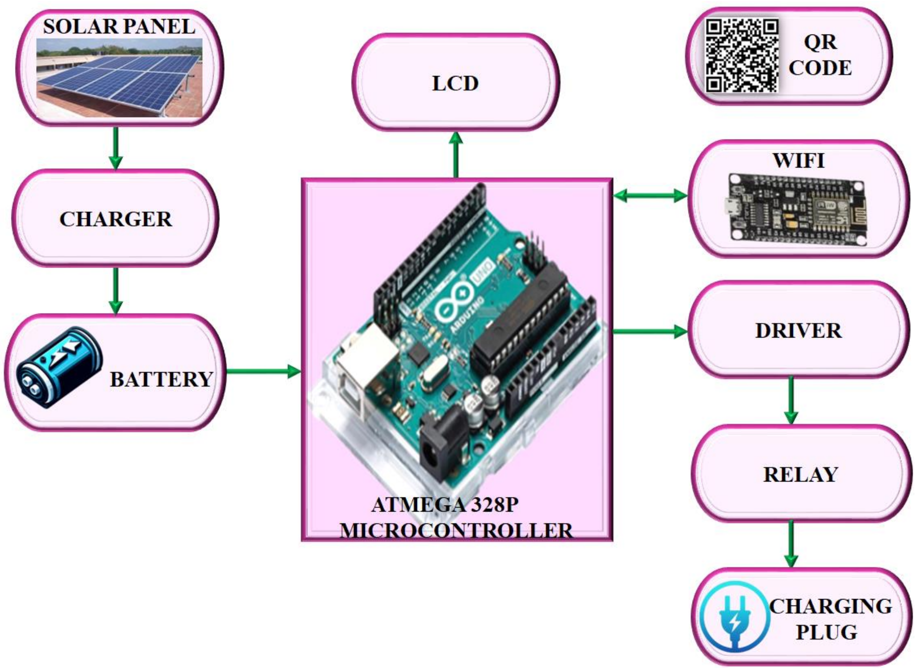

Figure 1 Block Diagram for QR-Based EV Bulk Charging System

Then, the chargers provide the necessary power to recharge portable power banks and recharge the batteries of EVs. The charge controller regulates the voltage and current from the solar panels to ensure the battery is charged safely. Additionally, it prevents overcharging and over-discharging of the battery. After that, the battery is stored and recharged in power and releases it as electrical energy when needed. Further, the ATmega 328 microcontroller collects and gathers the data uploaded to the Blynk app using the Node MCU device. Node MCU has built-in Wi-Fi connectivity, allowing it to easily connect to the internet or local networks. The microcontroller is linked to the LCD, and it displays every update. The charging plug is employed to convert and control the charging of the battery. Additionally, QR codes are used for quick user identification and access to charging stations, enabling the user to authenticate themselves without needing to manually enter information. Once authenticated, the charging station is activated and starts the charging process.

2.1 Solar Panel

The photovoltaic effect is the method by which solar panels turn sunlight into electrical power. Silicon and other semiconductor materials are used to make solar cells, which absorb sunlight. Electrons in these cells are excited by sunlight, which results in an electric current. This current is caught and converted into electrical power for buildings or other equipment. With solar panels to store extra electricity generated during the day for use at night or during cloudy days. When sunlight hits the surface of these cells, the energy from the light excites electrons, causing them to move. The solar panel is shown in Figure 2.

Figure 2 Solar Panel

It lowers carbon emissions and fights climate change by reducing dependency on non-renewable resources like coal and natural gas. The transition to solar energy is contributes significantly to sustainable living, reducing the environmental impact of energy consumption.

2.2 ATmega 328 Microcontroller

The ATmega328 microcontroller is most commonly used in the Arduino Uno development board. In this setup, the ATmega328 is programmed using the Arduino IDE, which simplifies programming through a user-friendly environment. It's most popular as the main microcontroller used in Arduino Uno and similar boards, but it has a wide range of uses beyond that. The ATmega328 is an 8-bit microcontroller, designed for low-power applications, and is highly configurable for embedded systems. The schematic representation of ATmega 328 microcontroller is represented in Figure 3.

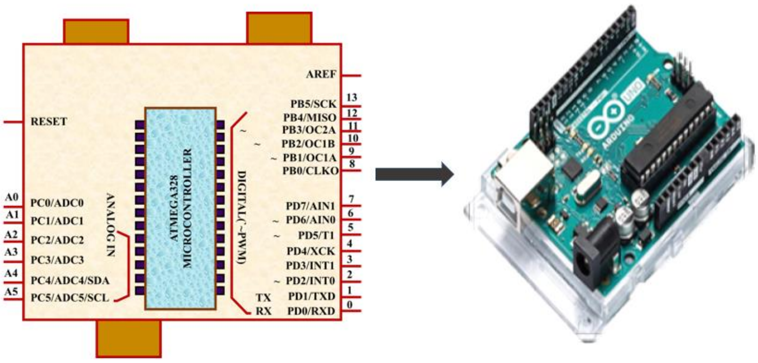

Figure 3 ATmega 328 Microcontroller

It typically comes with a pre-installed bootloader, which makes it easier to program through the USB-to-Serial connection. It reads analog sensors and process the data for logging, triggering actions, or communicating the data to external devices. Arduino boards are compatible with a huge array of sensors, motors, actuators, and communication modules, which makes it versatile for countless applications. Additionally, it is very affordable, which makes it great for both prototyping and production.

2.3 Node MCU

The NodeMCU is an open-source IoT platform based on the ESP8266 Wi-Fi module. It is widely used for creating connected devices and smart systems that is communicate over the internet. The NodeMCU development board integrates the ESP8266 with a simple-to-use microcontroller development environment and various onboard components, making it easy for developers to build Wi-Fi-enabled applications. Figure 4 illustrates the Node MCU.

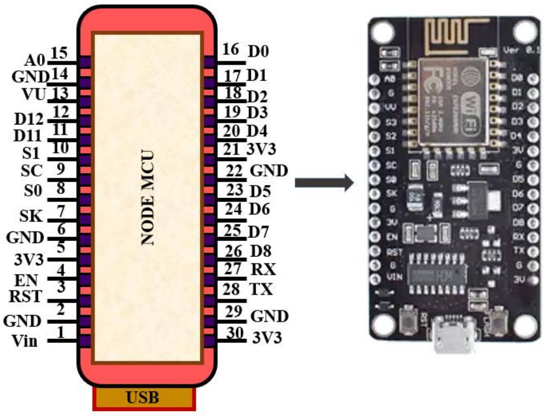

Figure 4 Node MCU

It also benefits from the large Arduino community, which provides abundant tutorials, libraries, and support. It provides full Wi-Fi connectivity, enabling NodeMCU to connect to wireless networks and communicate with web servers, and cloud platforms.

2.4 Battery

Batteries are one of the most common power sources in modern technology, powering everything from laptops and smartphones to electric cars and renewable energy storage systems. Batteries are devices that store chemical energy and transform it into electrical energy via a chemical process. These are essential in portable electronics, off-grid systems, and even large-scale power storage solutions. Batteries, particularly Li-ion and LiPo, are used to power EV, bikes, buses, and scooters. Lithium battery has a very long shelf life and are often used in high-performance electronics like cameras, medical devices, and military applications. EV batteries are a critical component in electric vehicles as they directly influence their range, performance, and overall efficiency.

2.5 LCD

A flat-panel display technology called an LCD is found in many electronic products, including digital watches, cell phones, computer displays, and televisions. LCDs use liquid crystals and a backlight to produce images, providing an efficient and compact alternative to older technologies such as Cathode Ray Tube (CRT) displays. LCD has low power consumption, slim profile, and the ability to display high-quality visuals. Figure 5 shows the LCD.

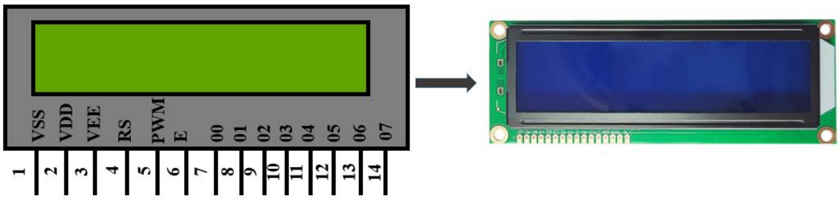

Figure 5 The LCD

It offers a compact, energy-efficient, and clear way to present visual data, making them a popular choice in various IoT systems.

2.5 Driver Circuit

A driver circuit is an electronic circuit used to control the power or signals required by a particular component or device. In general, driver circuits are designed to provide the necessary power, voltage, and current to drive components such as motors, LEDs, relays, transistors, and displays. The driver circuit is shown in Figure 6.

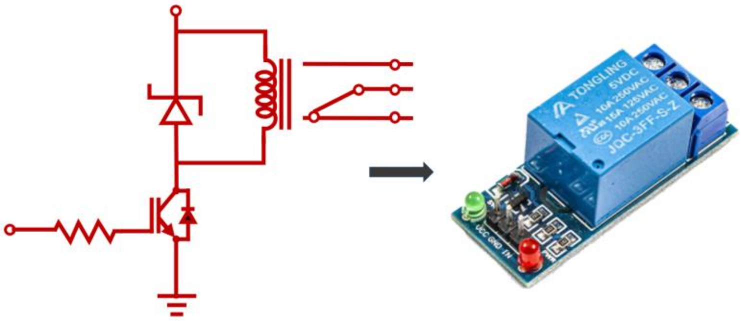

Figure 6 Driver Circuit

It ranges from simple to complex, often incorporating PWM, H-bridge configurations, and current regulation to meet specific requirements. It serves to interface low-power control signals from microcontrollers or sensors with higher-power loads like motors, LEDs, and displays.

3 Results and Discussions

In this work, QR-based EV bulk using IoT is implemented for overcharge protection and prevention.

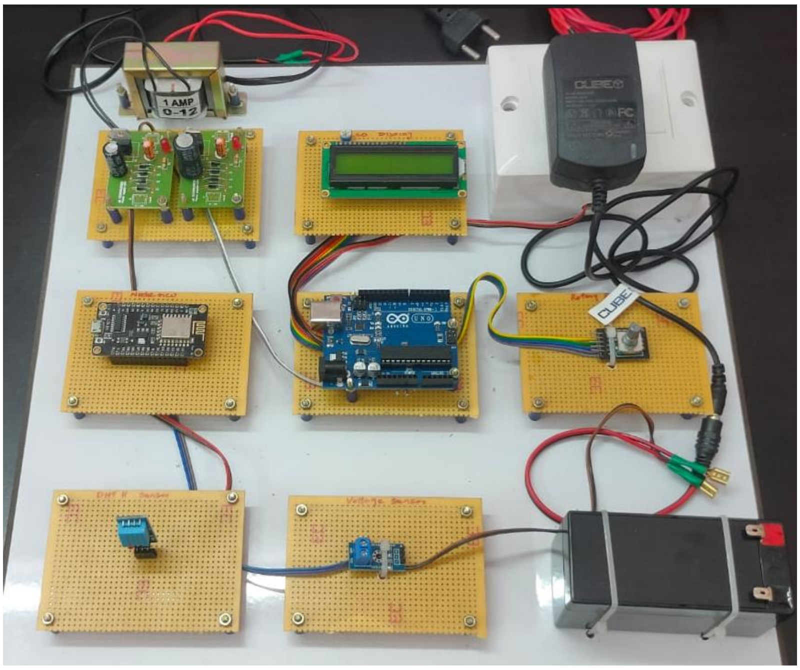

Figure 7 Hardware Image of the Overcharge Protection System

Figure 7 shows the hardware image of the overcharge protection system. This hardware board has several devices; the charger and wires are connected to the control device of the ATmega 328 microcontroller, which is completed using the IoT device.

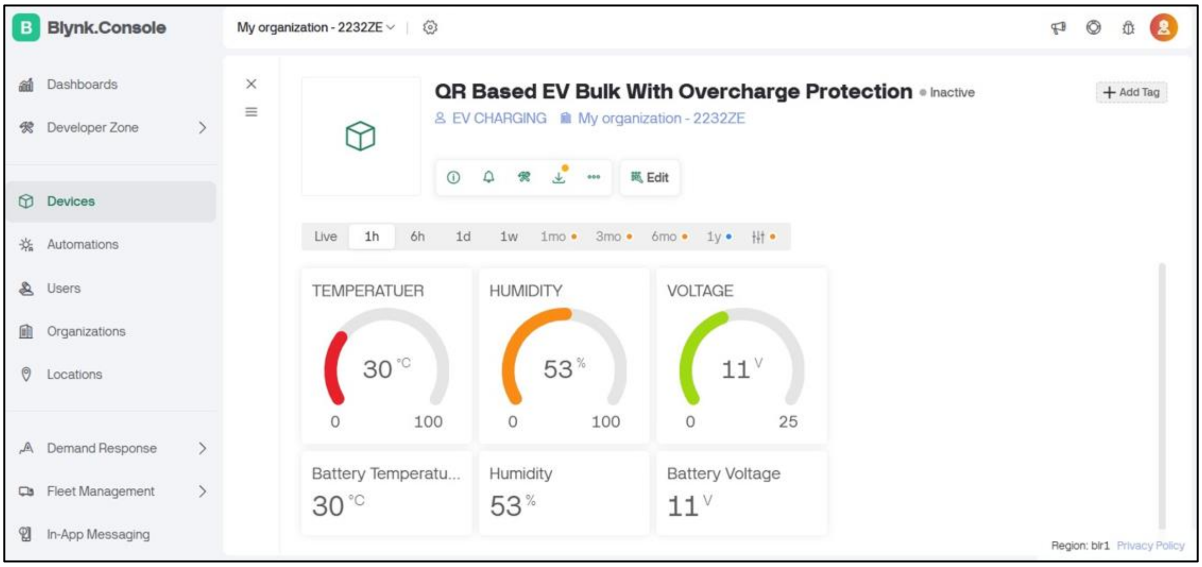

Figure 8 IoT Image of Overcharge Protection System

The IoT image of the overcharge protection system is illustrates in Figure 8. In this case, the characteristics of voltage of 11V, temperature of 30°C, and humidity of 53% are achieved via the BLYNK app in this work.

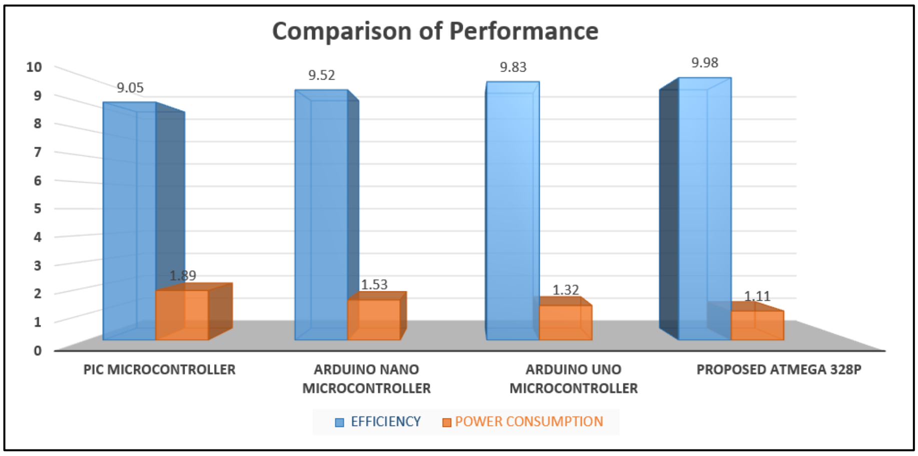

Figure 9 Comparison of Performance

A comparison of several microcontrollers' efficiency and power consumption figures is shown in Figure 9. The proposed ATMega-328 microcontroller power consumption of 1.1W is reached in the graph. The maximum power consumption Figure of 1.89 W is provided by earlier Peripheral Interface Controller (PIC) controllers; Arduino Nano and Arduino Uno achieve 1.53 W and 1.32 W, respectively. It indicates that the proposed ATMega-328 microcontroller achieves 9.98% efficiency. The proposed microcontroller achieves great efficiency in comparison to microcontrollers such as the Arduino Nano (9.52%), Arduino Uno (98.3%), and PIC (9.05%).

4. Conclusion

This paper, QR-based EV bulk charging system with IoT developed for overcharge protection and prevention mechanisms. By combining QR code-based access, real-time battery monitoring, and overcharge protection, the QR-based EV bulk charging system offers a scalable solution for public and private EV charging infrastructure. It ensures that batteries are charged safely, prolonging their lifespan and improving overall performance. Moreover, the QR-based system reduces the complexity of EV charging infrastructure, making it scalable and adaptable for both public and private sectors. This system regulates the power coming from the solar panels to the battery, ensuring the battery is charged correctly and safely. This innovation not only contributes to the safety and sustainability of EVs but also supports the growing adoption of electric mobility by providing an efficient, user-friendly, and reliable charging experience.

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