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IMPLEMENTATION OF RFID BASED SMART ELECTRIC VEHICLE CHARGING SYSTEM

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Abstract— With the global surge in electric vehicle (EV) adoption, the necessity for efficient and secure charging infrastructure has escalated. This paper explores the integration of RFID technology into EV charging systems to enhance authentication, monitoring, and data management capabilities. The proposed solution employs an ATmega328P microcontroller to orchestrate RFID-based authentication, real-time charging parameter display via LCD, and communication through a GSM module for payment and information dissemination. Current and voltage sensor readings facilitate accurate billing computations. This research highlights the pivotal role of RFID technology in revolutionizing EV charging infrastructure.

Keywords— RFID, ATmega328P microcontroller, GSM module, Electric Vehicle (EV), Charging, Current and Voltage Sensor.

I. INTRODUCTION

Electric vehicle (EV) charging infrastructure plays a pivotal role in fostering sustainable transportation and mitigating environmental impact by reducing greenhouse gas emissions. As the popularity of EVs continues to soar, the demand for advanced charging technologies at private and public locations has surged. GSM modules emerge as indispensable components, acting as primary communication gateways that facilitate seamless interaction among charging stations, EVs, and backend systems. These modules enable real-time monitoring of charging station status, ensuring reliability and minimizing downtime. Furthermore, Radio Frequency Identification (RFID) technology significantly enhances the safety and efficiency of EV charging stations. RFID enables robust access control, thwarting unauthorized usage or tampering. By automating authentication, RFID streamlines the charging process, allowing users to effortlessly initiate charging by swiping or tapping their RFID-enabled cards or devices, thereby enhancing convenience and operational efficiency. Additionally, the integration of current and voltage sensors enables precise energy consumption measurement, facilitating accurate billing. This paper presents a comprehensive exploration of the integration of GSM modules, RFID technology, and sensor systems in modern EV charging infrastructure, elucidating their collective role in advancing sustainability and convenience in transportation.

II. OBJECTIVES

- Develop an RFID authentication system to accurately identify and authenticate electric vehicle users, enhancing security and preventing unauthorized access to the charging station.
- Implement real-time monitoring and control capabilities using sensors to measure charging current and voltage, enabling precise management of the charging process and ensuring safety and efficiency.
- Integrate a GSM module into the system to send notifications to users regarding the charging process, providing updates on charging status and completion alerts for enhanced user convenience.
- Create a billing system capable of generating comprehensive bills for users, including total units consumed, tariff rates applied, total cost incurred, and payment details, ensuring transparency and accountability in charging transactions.

III. LITERATURE SURVEY

The increasing adoption of electric vehicles (EVs) worldwide has necessitated the development of efficient charging infrastructure. Ajithkumar et al. [1] explores the implementation of Radio Frequency Identification (RFID) technology in EV charging stations, emphasizing its role in streamlining authentication and tracking processes. Similarly, Joyce Jacob et al. [3] propose EV wireless charging using RFID, presenting advantages such as cable elimination and integration with renewable energy sources. Moreover, RFID technology extends beyond EV charging to encompass vehicle monitoring systems [4] and smart energy meters [5]. These systems leverage RFID tags for vehicle identification and energy consumption tracking, facilitating efficient management and billing processes.

In the realm of smart energy meters, advancements in technology have led to the development of IoT-based solutions [11]. Sahani et al. [11] propose smart energy meters using IoT and Arduino, enabling real-time data monitoring and remote management. Additionally, Kumar et al. [12] introduce a prepaid/postpaid energy meter system, integrating GSM communication for billing and theft control.

The integration of GSM modules in energy meters [8][9] further enhances communication capabilities, enabling real-time data transmission and remote monitoring. Karthi et al. [8] emphasizes the efficiency of GSM technology in automated meter reading systems, supporting both postpaid and prepaid billing models.

Furthermore, research efforts focus on improving energy metering accuracy and efficiency through microcontroller-based systems [10][14]. Haque et al. [10] present a digital prepaid energy meter utilizing microcontrollers for enhanced metering and billing. Arif et al. [14] highlights the role of IoT in smart energy meters for smart grid applications, emphasizing real-time monitoring and optimization of energy consumption.

Overall, the literature underscores the significance of RFID, IoT, and GSM technologies in advancing smart energy metering and EV charging systems. These innovations offer solutions for efficient energy management, billing, and monitoring, contributing to the development of sustainable transportation and energy infrastructure.

IV. METHODOLOGY

The methodology followed in the RFID-based smart electric vehicle charging system integrates several components to ensure effective and secure charging operations. It involves the utilization of various hardware and software elements, including a robust power supply unit providing stable output, an Arduino UNO microcontroller serving as the central processing unit, RFID card and reader for user authentication, a real-time clock module for accurate timestamping, voltage and current detectors for monitoring power parameters, an energy meter for calculating total energy consumption, a relay for controlling power flow to the charger, an LCD display for real-time information presentation, a buzzer for audible alerts, and a GSM module for remote monitoring and control. Each component plays a crucial role in enabling seamless charging experiences, enhancing user convenience, and ensuring system reliability.

A. BLOCK DIAGRAM

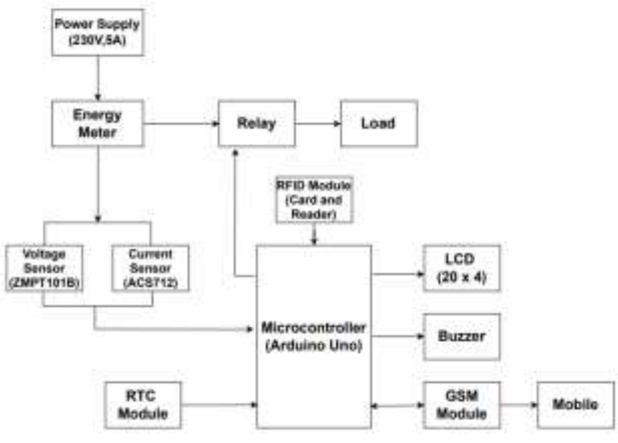


Figure 1: Block Diagram

The proposed prototype model of the RFID-based smart electric vehicle charging system integrates several crucial components to facilitate effective and secure charging operations. Central to this model is a robust power supply unit delivering a stable output of 230V, 5A, ensuring consistent and reliable power provision. Serving as the brain of the system, an Arduino UNO microcontroller orchestrates the interaction between various modules, providing control and coordination. User authentication is achieved through the utilization of an RFID card and reader, allowing only authorized individuals to access the charging station, thereby enhancing security. Additionally, a real-time clock (RTC) module tracks the current date and time, enabling accurate timestamping of charging events for record-keeping and billing purposes. Continuous monitoring of power parameters, including voltage and current, is facilitated by voltage (ZMPT101B) and current (ACS712) detectors, supplying essential data for power operation and billing calculations while ensuring safe charging processes. An energy meter calculates the total energy consumed by the electric vehicle during the charging process, supporting cost estimation and resource planning. Control over the power flow to the output load, which is the electric vehicle charger, is regulated by a relay based on user authentication and power parameters. User interaction and feedback are facilitated through a 20x4 LCD display, providing real-time information on the charging status, power consumption, and other relevant details. Audible alerts for important events such as successful authentication or charging completion are provided by an integrated buzzer. Furthermore, remote monitoring and control of the charging system are enabled by a GSM module, allowing users and administrators to receive announcements and manage the system from anywhere, enhancing accessibility and convenience. Together, these integrated components form a comprehensive and effective charging solution for electric vehicles, promoting sustainable transportation initiatives and advancing electric vehicle infrastructure.

B. HARDWARE COMPONENTS

ARDUINO UNO: The Arduino Uno microcontroller board, powered by the ATmega328P 8-bit AVR microcontroller, is a versatile platform with 14 digital I/O pins, 6 analog input pins, and various essential components. With 32KB flash memory, 2KB SRAM, and 1KB EEPROM, it drives code execution and interaction with sensors and devices. The Uno facilitates user-friendly hardware projects with features like USB connection, power jack, ICSP header, and reset button.

Figure 2: Arduino Uno

RFID MODULE: The RFID module enables wireless object identification and tracking through radio waves. It consists of RFID tags and readers, with different forms like passive, active, and semi-passive. RFID finds applications in various sectors, including EV charging systems, to streamline user authentication and billing processes.

Figure 3: RFID Module

VOLTAGE SENSOR (ZMPT101B): The ZMPT101B voltage sensor is renowned for its accuracy in AC voltage measurement, handling up to 250V AC. With exceptional reliability, it features a multi-turn trim potentiometer for precise adjustment of analog-to-digital converter (ADC) output, enhancing adaptability across applications like battery charging systems.

Figure 4: Voltage Sensor (ZMPT101B)

CURRENT SENSOR (ACS712): The ACS712 current sensor utilizes the Hall Effect principle to measure electric currents in circuits. Available in different variants with varying measurement ranges, it provides analog output voltage proportional to the sensed current. Widely used in battery management systems, it monitors charging and discharging currents for optimizing battery performance.

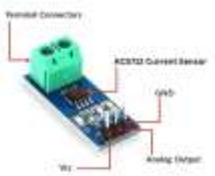


Figure 5: Current Sensor (ACS712)

RTC MODULE: The Real-Time Clock (RTC) module ensures accurate timekeeping even during power loss, featuring a clock chip and battery backup. It communicates with microcontrollers via serial protocols like sssss I2C or SPI and boasts additional features like alarms and temperature sensors, enhancing versatility across applications.

Figure 6: RTC Module

RELAY MODULE: The relay module is an electromechanical device used to control electricity flow in circuits, acting as an electronically operated switch. It consists of a coil, contacts (normally open and normally closed), and operates with a 5V DC power supply. Used in various applications for circuit control.

Figure 7: Relay Module

LCD DISPLAY (20X4): The 20x4 LCD display module provides real-time information to users regarding charging status, power consumption, and other relevant details. With liquid crystal display (LCD) technology and built-in backlight, it ensures clear visibility and easy readability, enhancing user experience throughout the charging process.

Figure 8: LCD Display (20x4) with I2C Module

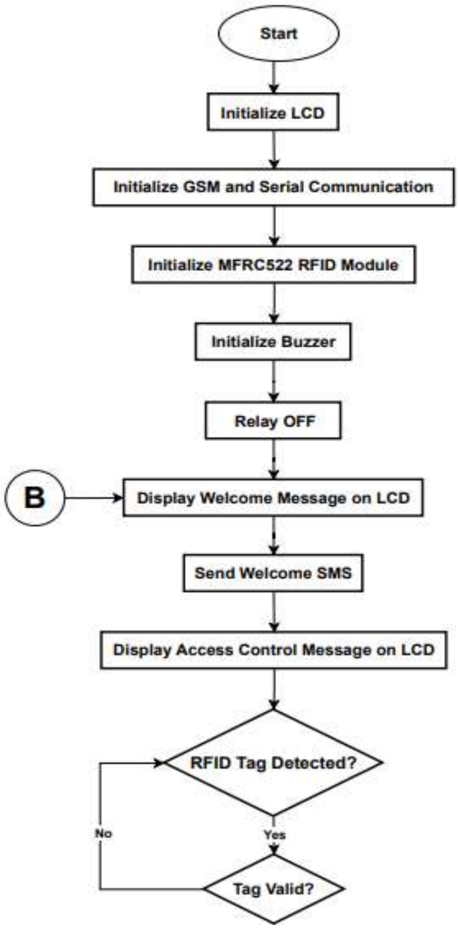
GSM MODULE: The SIM900A GSM Module facilitates wireless communication via the cellular network, supporting GPRS and GSM technologies for data transmission, voice calls, and SMS messaging. Operating on the 900 and 1800MHz frequency bands, it offers flexibility for custom applications with interactive features.

Figure 9: GSM Module

ENERGY METER: An analog energy meter measures electrical energy consumption and consists of a rotating disc driven by electric current. With features like voltage rating, current rating, and communication interface, it records cumulative energy consumption over time, providing essential data for billing and resource planning.

Figure 10: Energy Meter

C. SOFTWARE IMPLEMENTATION



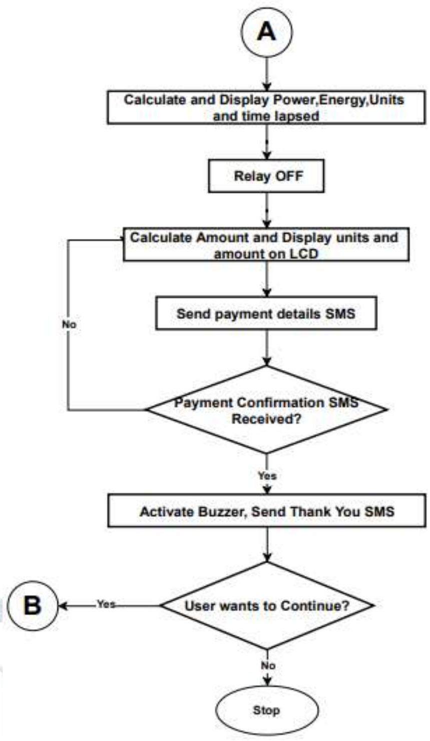


Figure 11: Flowchart of the Code

For the software implementation, we utilized the Arduino Integrated Development Environment (IDE) to develop and program the code for our project. The flowchart provided outlines the sequential steps involved in executing this code, which manages the RFID-based smart electric vehicle charging system. Initially, the system initializes essential components including the LCD, GSM module, ACS712 sensor, RFID reader, relay, and buzzer to ensure they are ready for operation. Following initialization, the Setup () function is executed, displaying a welcome message on the LCD and sending an SMS notification to users. Subsequently, the Loop () function continuously measures current and voltage, enabling the system to calculate power consumption and energy usage accurately. During charging, the LCD displays relevant information such as power consumption and elapsed time, while the system checks for payment confirmation SMS, activating the buzzer upon confirmation. Additionally, the system detects RFID tags, verifies authorization, and toggles the relay state for charging control. Upon relay deactivation, it calculates the payment amount and displays "Access Granted" or "Access Denied" on the LCD accordingly. Throughout this process, the system effectively manages access control, electric vehicle charging, and payment notifications via SMS, ensuring the efficient and secure operation of the charging system.

V. RESULTS AND DISCUSSION

The implementation and testing of the RFID-based smart electric vehicle charging system followed a systematic approach to validate functionality and reliability. Individual hardware components such as RFID readers, voltage and current sensors, and the relay for power regulation underwent rigorous testing protocols to ensure compatibility and performance. Through simulated charging scenarios with various devices, the system demonstrated accurate user authentication, real-time power monitoring, and effective charging regulation. Comprehensive tests across diverse charging loads validated the system's versatility and adaptability. Overall, the project achieved its objectives and showcased robust functionality, reliability, and effectiveness in providing efficient and secure charging solutions for electric vehicles. User feedback during testing highlighted the system's ease of use and readiness for real-world deployment, emphasizing its potential contribute to sustainable transportation and environmental conservation.

Figure 11: Prototype Model of RFID Based Smart Electric Vehicle Charging System

Figure 12: SMS sent to the Consumer regarding total units Consumed and Amount to be paid.

VI. CONCLUSION

The implementation of the RFID-based smart electric vehicle charging system represents a significant advancement in sustainable transportation. Its efficiency, reliability, versatility, and user-friendliness mark a promising milestone in electric vehicle charging infrastructure. Through rigorous testing, the system has proven its ability to meet diverse charging needs, adapt to varying loads, and ensure transparent and secure charging operations. Safety features enhance its appeal, prioritizing user safety and promoting battery longevity. Looking ahead, this system has the potential to drive widespread electric vehicle adoption, reduce emissions, and create a cleaner environment. Continued innovation in charging technologies will further enhance accessibility, affordability, and sustainability in transportation. This project demonstrates technology's role in addressing environmental challenges and shaping a greener future.

VII. FUTURE SCOPE

The RFID-based smart electric vehicle charging system represents the foundation for future advancements in electric bike charging infrastructure. As we progress, our focus will be on enhancing its capacity to charge multiple bikes simultaneously and enabling its deployment in diverse locations, including those powered by renewable energy sources like solar power. Additionally, we aim to integrate smart technology to optimize charging schedules for maximum efficiency and sustainability. Our vision extends beyond merely charging bikes; it's about revolutionizing transportation to be cleaner and more sustainable for all, beginning with two-wheelers.

REFERENCES

[1]. “Smart E-Vehicle Charging System Using RFID,” A. Ajithkumar, M. Ajithkumar, S. Gopi, V.G. Balajisabarinathan, Mr. C. Gowrishankar.

[2]. “RFID BASED SMART ELECTRICITY BILL PAYMENT AND ENERGY SHARING SYSTEM THROUGH IOT,” Kanpath Karan.M, Maha Ramya.S, Mailesh.B, Sham Kumar.K, Santhosh Kumar.T, International Research Journal of Engineering and Technology (IRJET) 2020.

[3]. J. Joyce Jacob, Abinaya.S, Divya Priya.R, Ms. Poonam Khatarkar, Abdullaeva Barno, Sathish kumar- "ELECTRIC VEHICLE WIRELESS CHARGING USING RFID,"- International Conference on Newer Engineering Concepts and Technology, Volume: 399,2023.

[4]. “RFID Based Vehicle Monitoring System,” Nadeer Mohamed, Vijayakumar Adaickalam, International Journal of Science, Engineering and Technology-2022

[5]. “Design And Implementation of a Smart Energy Meter." G. Harish and V. Preethi, International Conference on Inventive Computation Technologies, 2016.

[6]. M. Padmapriya, T.A. Raghavendiran, S. Gomath, “Smart Energy Meter for Electric Vehicle” International Conference on Artificial Intelligence and Smart Systems (ICAIS), 2021.

[7]. Niloy Mondal, Mahdi Mohammed, Hashem Shake, Husam Ali Mahdi, Ch. Ravisankar: “Design of A Smart Energy Meter,” International journal of current science an international open access peer-reviewed refereed (IJCSPUB), Volume 12, May 2022.

[8]. “Smart Energy Meter Using GSM,” S.P. Karthi, T. Monisha, S. Prathana, and T. Radha.

[9]. “Design And Development of GSM Based Energy Meter,” Abhinandan Jain, Dilip Kumar, Jyoti Kedia, International Journal of Computer Applications, Volume 47 - No.12, June 2012.

[10]. “Microcontroller Based Single Phase Digital Prepaid Energy Meter for Improved Metering and Billing System,” Md. Mejbaul Haque, Md. Kamal Hossain, Md. Mortuza Ali, Md. Rafiqul Islam Sheikh, IJPEDS.

[11]. “IoT Based Smart Energy Meter”, Birendra Kumar Sahani, Tejashree Ravi, Akibjaved Tamboli, Ranjeet Pisal.

[12]. "Design And Simulation of Smart Prepaid-Postpaid Energy Meter with Alarm and Theft Control," Kumar Ask, Navneet Kumar Singh, Asheesh Kumar Singh, Dinesh Kumar Singh, Kundan Anand.

[13]. "Smart Energy Meter Based on Arduino and Internet of Things", N M Yoeseph, M A Safi'ie, and F A Purnomo, Teknik Informa tika Sebelas Maret University, Indonesia

[14]. "EXPERIMENTAL STUDY AND DESIGN OF SMART ENERGY METER FOR THE SMART GRID," Anmar Arif, Muhannad Al-Hussain, Nawaf Al-Mutairi, Essam Al-Ammar, Yasin Khan and Nazar Malik, Department of Electrical Engineering, King Saud University, Saudi Arabia.