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3.3 KVA Electric Vehicle Charger with RFID Security

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Abstract: The paper is all about designing a 3.3kVA electric vehicle (EV) charger with RFID (Radio Frequency Identification) technology that adds security and convenience to users. The use of RFID will only allow certified vehicles to connect and utilize the charger, hence a secure authentication process. When an EV with an RFID tag comes near the charging station, it is read to authenticate its identity and provide access if approved. The charger is made to provide a consistent and efficient charging experience, controlling the power provided to the vehicle for safe and effective charging. The system consists of real-time monitoring capabilities that monitor a number of charging parameters like voltage, current, and time, enabling accurate control and management. This real-time information also enables accurate billing according to the actual power usage during the charge process, which provides transparency to the consumers. In addition, the charger ensures improved energy management by maximizing the utilization of available power, minimizing power wastage, and enhancing grid efficiency overall. By integrating RFID technology with a strong EV charger, this system seeks to satisfy the increasing demand for safe, reliable, and easy-to-use charging infrastructure, making EV charging an easy and seamless part of daily life for EV drivers.
Keywords: EV Charger, RFID, Authentication, authorized, Real-time Monitoring, Energy Management, Grid Efficiency

I. INTRODUCTION

The requirement for a 3.3 kW EV charger with RFID security stems from the growing popularity of electric vehicles and the requirement for efficient, secure charging units. This Level 2 charger meets the demands of both fast charging and power efficiency, suited for residential and small business applications. The inclusion of RFID authentication guarantees that only approved users can utilize the charger, thereby avoiding unauthorized use and improving security. The objective of the paper is to design a working prototype with the main goals of secure access control, energy monitoring, and built-in safety measures, such as protection against overcharging, overheating, and short circuits This entails research into power specifications, proper choice of hardware components such as power modules and microcontrollers, writing firmware for charging and security protocol management, and implementing thorough testing for reliability. The design of the charger features a small, wall-mountable form factor with LED lights for easy user interaction and a safe RFID-based authentication system with encrypted data storage. By selecting components with care, integrating software, and rigorous testing, the project hopes to provide a secure, efficient, and scalable EV charging solution that facilitates the shift towards green transportation.

A. Objectives

The objective of this paper is to develop a simple, secure 3.3 kW EV charger with RFID-access control for residential and small business markets. The charger will possess an operational prototype with RFID authentication, safety aspects, and regulatory compliance to allow controlled use, clear status indication, and maximum charging efficiency. This will be done by power specification research, safety features, and relevant standards followed by careful hardware selection, e.g., power modules, RFID readers, and microcontrollers.

Software development will include firmware for power flow control, RFID authentication, and safety features to ensure protection against over-voltage, over-current, and thermal hazard. The system will include a wall-mountable, slim, compact physical shape with integral LED indicators for enabling user-friendly use and fault identification as well as secure encrypted RFID-based access control. Development will involve assembling a prototype, including firmware, and putting the assembly through comprehensive testing under a range of different conditions to establish performance and security. By the application of systematic design, component selection, and rigorous testing, this charger will provide a safe, efficient, and convenient solution to EV charging in controlled-access environments.

II. LITERATURE REVIEW

1) "A Comprehensive Review of AC Level 2 Charging Technologies" by Filizadeh et al. (2020) gives a detailed survey of AC Level 2 charging systems, concentrating on converter topologies including resonant, boost, and buck converters to improve efficiency and power handling. The research points out that some converters have the ability to convert energy with rates up to 95%, highlighting efficiency as an important parameter in EV charging. Further, it sees thermal management as a critical issue, as more power output increases the potential for overheating, necessitating efficient cooling strategies like air and liquid cooling. The research makes it clear that converter design needs further improvements to accommodate the increased demand for high-efficiency EV charging infrastructure, especially in city centers.
2) "Impact of Widespread Level 2 EV Charger Adoption on Local Distribution Grids" by Moura et al. (2018), published in IEEE Transactions on Transportation Electrification discusses the issues involved in large-scale integration of Level 2 EV chargers into local grids. The research points out important concerns like load management and voltage regulation, highlighting that peak EV charging hours coincide with peak residential energy usage. This intersection stretches the grid, causing voltage drops that contribute to deterioration of service quality and shortening the life of electrical equipment. In a bid to address these challenges, the study suggests solutions such as smart transformers, energy storage systems, and distributed energy resources like rooftop solar, which may improve grid resilience and efficiency.
3) "Design and Control of Single-Phase AC Chargers with Power Factor Correction" by Liu et al., appearing in IET Power Electronics, looks into the improvement of AC-DC conversion efficiency of household EV chargers by the use of Power Factor Correction (PFC) circuits. The research reveals how PFC circuits are critical to the mitigation of energy wastage through minimization of phase lag between voltage and current, leading to higher overall efficiency. Nonetheless, integrating PFC technology is challenging in terms of added expense and system complexity. Further, the study examines the efficiency and power factor trade-offs that can affect grid stability. Liu et al. promote ongoing improvement in PFC technology for greater efficiency, cost-effectiveness, and performance of EV chargers and encouraging their wider deployment.
4) "Enhancing Level 2 EV Charging Efficiency Through Smart Charging Strategies" by Li et al. (2019), published in Proceedings of the IEEE Conference on Industrial Electronics and Applications delves into how communication protocols and dynamic load control contribute to achieving optimal EV charging efficiency at low grid load levels. It calls attention to how protocols such as OCPP and ISO 15118 promote dynamic power modification and allow coordinated charging. Moreover, load management algorithms ensure that demand is shared among multiple chargers, enhancing overall grid stability. One of the main challenges identified is balancing user demand for rapid charging with grid constraints, which the study recommends overcoming through dynamic pricing models. Li et al. conclude that smart charging technologies are crucial to the sustainable growth of EV infrastructure, requiring continuous innovation to address future energy needs effectively.

III. THEIR ORIGIN AND IMPORTANCE

As electric vehicles (EVs) gain wider acceptance, the demand for effective, secure, and controlled charging systems has increased. The 3.3 kVA RFID-secured EV charger is intended to offer a safe and convenient charging experience, especially for domestic and small business use. The charger provides secure and efficient power supply while incorporating RFID authentication to limit access to approved users.

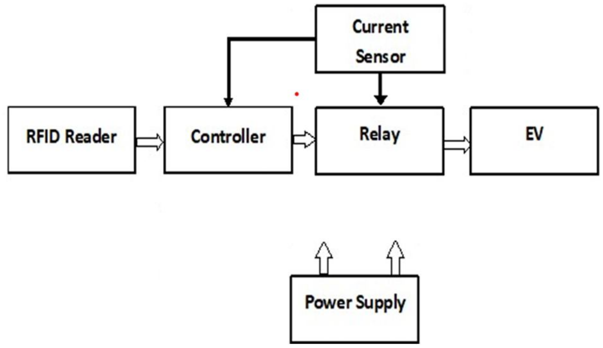
A. Origin

1) Designed to meet the increasing need for secure, low-power EV chargers for residential and shared environments.
2) Based on industry standards like IEC 62196, SAE J1772, and UL, for safety and compatibility.
3) Evolved from open-access chargers to incorporate RFID-based authentication for controlled access.
4) Motivated by the requirement to avoid electricity theft and unauthorized use of chargers in shared environments.

B. Importance

1) Improved Security: RFID authentication prevents unauthorized users from accessing the charger.
2) Compliance to Standards: Conforms to international safety and performance standards for sure operation.
3) User Convenience: Gives a quick and easy means of EV owners verifying and charging their cars.
4) Energy Efficiency: Optimizes the use of power to minimize wastage and facilitate renewable energy use.
5) Ideal for Shared Spaces: Designed for use in residential areas, office blocks, and public charging points.
6) Scalability: Upgradable to accommodate future software revisions and remote management.

IV. METHODOLOGY



3.1 Figure Block Diagram of EV-Charger

3.3 kW EV charging system with RFID security for restricted access and employing a microcontroller as the central control unit to manage operations. The system starts with an AC power supply that drives the microcontroller and other important components. The microcontroller is the key to managing the entire charging process, taking input from different sensors and control devices to ensure an efficient and secure operation. When a user reaches the charging station, they need to authenticate themselves with an RFID reader. This device reads the RFID tag (usually embedded in a card or key fob) held by the user. If the tag is the same as the stored information in the microcontroller's database, access is allowed, and the microcontroller starts the charging process. This security layer makes sure that only authorized

users can use the charging facility, avoiding unauthorized usage and improving overall safety. After the user verification, the microcontroller switches on a relay that connects the power supply to the charger. The relay works as an electrical switch, enabling current to flow and start charging the vehicle. This arrangement gives an efficient means of controlling the power supply, since the microcontroller can enable or disengage the relay according to the charging status or emergency situations.

A sensor is integrated into the system to track important parameters like voltage, current, and temperature during charging. This real-time information is fed back to the microcontroller, allowing it to modify operations if needed and avoid problems such as overheating or overcharging. Besides, a limit switch or magnetic switch can be included in order to provide correct physical connections between the charging plug and the EV. This safety feature prevents the system from running under dangerous conditions. The indicator lamp gives a visual indication of the status of the system. Various colors or patterns can indicate phases like 'charging in process, 'charging is complete,' or 'error.' The display displays important information like energy consumption, time left for complete charging, and user ID or session information, providing the user with clear, real-time feedback.

Finally, a buzzer is utilized to provide sound alerts, including the beginning of the charge session, the completion of charge, or alerting in case of an issue detected during the process. The overall integration of these devices with the microcontroller helps the system work efficiently, with provisions for user safety, process automation, and data monitoring. The RFID security with real-time monitoring via sensors and transparent feedback mechanisms renders this charging system secure and reliable for domestic or commercial use.

The approach provides safe and controlled EV charging through RFID authentication. The procedure begins with RFID card reading to authenticate user authorization. If the user is authorized, the system turns on the charging relay and initiates charging. Charging is always monitored for safety. In case of any fault, the system instantly disconnects the cable to avoid danger. This systematic approach provides efficient, secure, and reliable EV charging with fault protection automation.

1) Start – The system starts functioning once powered on, ready to manage user authentication and charging operations. It makes sure all the components, such as the RFID reader and charging control system, are in operational readiness
2) Reads the RFID Card – The RFID reader reads the submitted card to get the individual identification information. This is to prevent access to the charging system by unauthorized users
3) User Registration Check – The system checks the scanned RFID information against the registered database of users saved in the system.
a) If the user is not registered, access is denied by the system, thwarting unauthorized attempts to charge
b) If the user is registered, the system moves on to the next step, permitting access to the charger.

4) Charges Through Relay – After successful verification, the system energizes the relay to create a connection between the power supply and the EV. This ensures that charging is initiated only after successful verification, thus avoiding misuse or unauthorized usage.
5) Monitor Charging – The system constantly monitors the charging parameters, including voltage, current, and temperature. Real-time monitoring ensures that the charging process is safe and efficient.
6) Fault Detection – The system monitors for possible faults like overvoltage, overcurrent, overheat, or connection loss.
   a) If a fault is found, the system disconnects the charging cable instantly to avoid any damage to the EV or charger.
   b) If no fault is found, the charging operation proceeds normally until the session is finished.

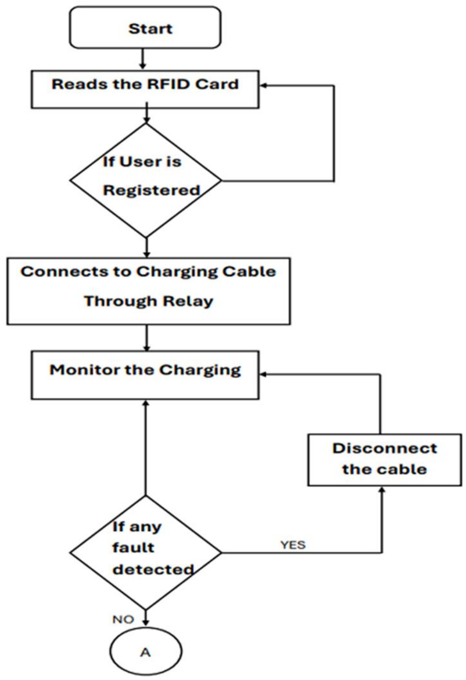


Figure 1. Process flow

7) End (A) – The process ends in accordance with successful completion of charging or identification of a fault. If all works well, the charging session finishes normally; else, the system safely disconnects the link.

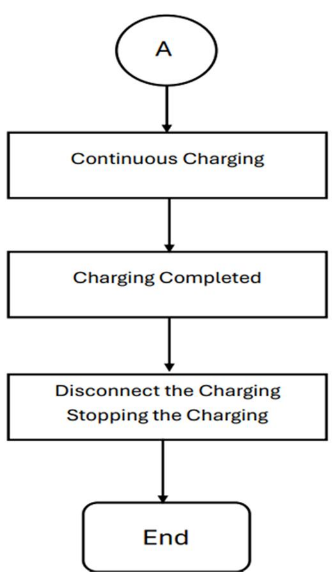


Figure 2. Process flow

8) Start from "A" – This stage follows the last flowchart, where charging continues if there are no faults. The system ensures that the charging process is stable.
9) Continuous Charging – The charger supplies a continuous supply of power to the EV battery while checking parameters such as voltage, current, and temperature. This helps in safe and efficient charging.
10) Charging Completed – When the EV battery is fully charged, the system identifies that the charging has been completed. It avoids overcharging, which might destroy the battery or present safety risks.
11) Disconnect the Charging / Stopping the Charging – Once the full charge is detected, the system automatically disengages the charging process. The relay is switched off, breaking the power supply to the EV.
12) End – The charging session is successfully executed, and the system returns to idle state for the next authorized charging session. This guarantees controlled power management and secure access to the EV charger.

V. KEY COMPONENTS

1) Power Supply and Conversion Unit: The system begins with an AC power source (usually from a 220V–240V grid). AC power is converted to DC using a power conversion circuit, consisting of an AC-DC converter and perhaps a DC-DC converter to manage the output. This conversion provides assurance that the power supplied to the EV is safe and suitable for its battery charging requirements.
2) Microcontroller: The microcontroller is the system's central control unit. It controls functions like RFID authentication, charging initiation, charging parameter monitoring (such as current, voltage, and temperature), and fault detection. The microcontroller also controls other elements, including the relay and display, and regulates the charging process to be done within safe and efficient parameters. Microcontrollers utilized in such applications is PIC32 microcontroller.
3) RFID Reader and Tags: The RFID reader provides secure access to the charging system. Authorized users are issued RFID cards or tags that have a unique ID. When a user holds up their RFID tag in front of the reader, the controller checks the tag's ID against an internal list of approved IDs. This function limits access to only authorized users who have been approved, so only authorized users can start a charging session.
4) Relay: The relay is a switch that regulates the flow of electricity between the charger and the EV. When a user is authenticated by the RFID system, the relay closes to enable power to be supplied to the EV. When the charging session is over or in case of a fault, the relay opens to disconnect the power. This ensures that power is supplied only when required and does not allow unauthorized charging. The relay employed is a 12V 40A T91 Relay. A T91 type relay with 12V DC control signal. It possesses very high current capacity of 40A.
5) Display and User Interface: The device usually has a display screen and LEDs that give feedback to the user. The display indicates crucial information, including charging status, energy usage, and system notifications. The I2C 16*2 LCD display is employed that can display 16 characters in each of its two lines, offering a total of 32 characters of information. The application will indicate the time and current and voltage consumed.
6) Safety Monitoring Sensors: The system incorporates the current sensor to track the charging process in real-time. These sensors feed information to the microcontroller, which can change the charging parameters if needed or terminate the charging process if it detects any unsafe conditions like overcurrent, overvoltage, or overheating. This tracking provides a secure charging experience for both the vehicle and the charger.

VI. CONCLUSION

The 3.3 kW RFID-secured EV charger is an important milestone in electric vehicle charging infrastructure that combines effective power transfer with robust user authentication. By integrating such features as power factor correction, microcontroller management, and simple-to-use interfaces, these chargers offer safe and efficient charging experience. The application of RFID technology is not only more secure in controlling access to rightful users but also simplifies users' interactions by making charging convenient and efficient. With the development of electric vehicles, the deployment and design of such innovative solutions will be integral in fostering cleaner transportation and capturing the evolving tastes of consumers.

VII. ACKNOWLEDGMENT

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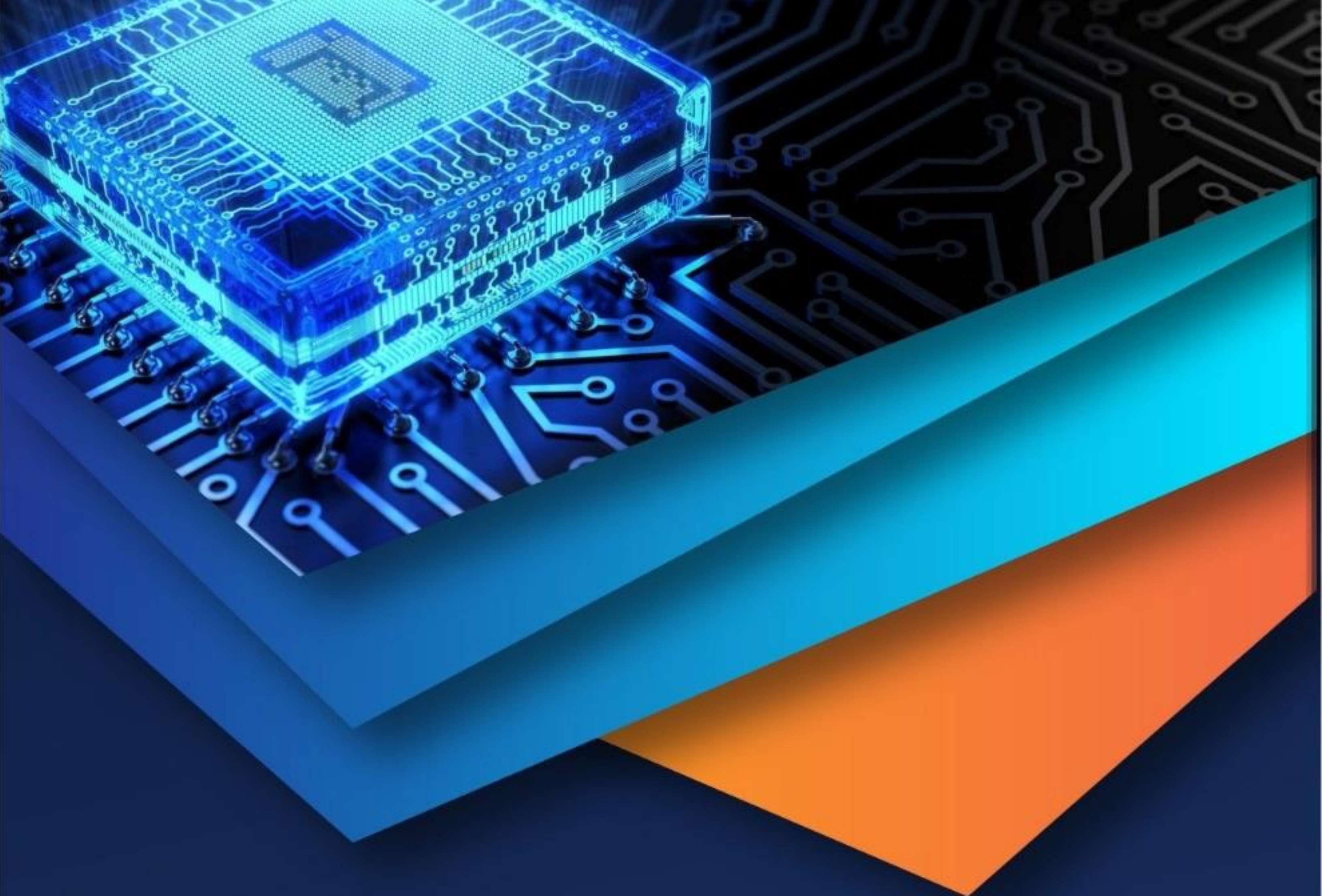

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