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INTEGRATED SOLAR WIRELESS INDUCTIVE CHARGING FOR ELECTRIC VEHICLE AND BATTERY MANAGEMENT SYSTEM USING IOT

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Abstract : *Electric vehicles (EVs) are reshaping transportation, but their widespread adoption demands innovative, sustainable, and convenient charging solutions. This project proposes a cutting-edge system combining solar-assisted wireless inductive charging with a high-performance Battery Management System (BMS) featuring Internet of Things (IoT) capabilities.*
The system begins with solar photovoltaic panels capturing sunlight to produce renewable energy, which is wirelessly transferred to a storage device. Using high-frequency resonant inductive coupling, this energy is delivered to the EV without physical connectors. This touchless charging minimizes wear and tear while achieving high power transfer efficiency over short distances.

The integrated BMS enhances battery safety and efficiency by monitoring key metrics such as State of Charge (SoC), State of Health (SoH), voltage, current, and temperature. Advanced fault detection algorithms mitigate risks like overcharging, deep discharging, thermal runaway, and short circuits, ensuring longevity and reliability.

IoT connectivity elevates the system further with real-time data monitoring and remote control via a cloud dashboard or mobile app. Users can track charging progress, assess battery health, and optimize energy use based on solar energy production statistics.

This intelligent solution promotes sustainable transportation by integrating renewable energy, wireless charging, and IoT-enabled battery management, paving the way for a cleaner and more efficient future globally.

Keywords: Electric Vehicle (EV), Solar Energy,Wireless Inductive Charging,Battery Management System (BMS),Internet of Things (IoT)

I. INTRODUCTION

The proposed system introduces a Solar Wireless EV Charging Station with RFID Authentication, combining renewable energy, wireless charging technology, and secure access control. The system harnesses solar power for EV charging, eliminating reliance on grid electricity and promoting sustainability. It employs RFID authentication for user verification, ensuring only authorized vehicles can access the station. Additionally, IR sensors detect vehicle presence to initiate charging.

Wireless charging operates through inductive coupling, transferring power between coils without physical connectors, minimizing wear and tear. Energy generated by solar panels is stored in batteries and used to wirelessly charge EVs via L298 coils, ensuring seamless and efficient energy transfer. Real-time updates on charging status and progress are displayed via an LCD screen, enhancing user convenience.

By integrating renewable energy and secure, wireless charging capabilities, this system overcomes challenges of traditional EV charging stations, such as cable management issues, grid dependency, and inefficiency. It represents an innovative and eco-friendly solution for advancing EV infrastructure, paving the way for a greener and more convenient future in transportation.

II. LITERATURE SURVEY

Electric vehicles (EVs) represent a pivotal shift towards sustainable transportation, but existing charging infrastructure faces challenges such as reliance on grid power, cable management issues, and inefficiency. To address these limitations, the proposed Solar Wireless EV Charging Station with RFID Authentication combines renewable energy, wireless charging technology, and secure access control. Solar panels generate eco-friendly power, which is stored in a battery and wirelessly transferred to EVs using high-frequency inductive coupling, eliminating the need for physical connectors and reducing wear and tear. RFID authentication ensures that only authorized vehicles can access the station, while IR sensors detect vehicle presence to initiate the charging process seamlessly. Real-time updates on charging progress and battery status are displayed on an LCD panel, enhancing user convenience. This innovative system resolves issues like cable damage and grid dependency, promotes renewable energy use, and offers a secure, touchless charging experience. By integrating cutting-edge technologies, it sets a new benchmark for efficient, user-friendly, and sustainable EV charging infrastructure, paving the way for cleaner transportation and a greener future.

III. PROPOSED WORK

The Proposed Work section outlines a novel approach for developing a Solar Wireless EV Charging Station with RFID Authentication. This system seamlessly integrates renewable energy generation, wireless charging technology, and secure access control to enhance user convenience and promote sustainability.

Solar panels are utilized to harness sunlight, producing eco-friendly energy stored in batteries for later use. A wireless charging mechanism based on high-frequency inductive coupling transfers energy efficiently between the transmitter coil in the station and the receiver coil in the EV, eliminating the need for cables and reducing wear-and-tear. The integration of an RFID module provides secure user authentication, allowing only authorized vehicles to access the charging station. An IR sensor detects the presence of a vehicle within the charging bay, automating the initiation of the charging process for a touchless experience.

The system further incorporates real-time monitoring capabilities, displaying updates on charging status, battery levels, and energy consumption through an LCD panel. LED indicators visually convey the charging progress, offering enhanced user feedback. By addressing the limitations of traditional EV charging stations, such as cable dependency, inefficiency, and reliance on grid power, this proposed work creates a sustainable and user-friendly charging infrastructure, paving the way for a greener transportation future.

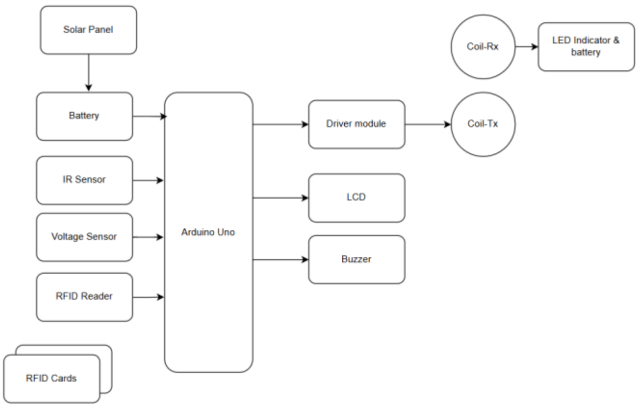


Fig 1: Block Diagram

IV. METHODOLOGY

The system begins with the deployment of solar panels to harness sunlight as a renewable energy source. The captured energy is stored in a battery management system, ensuring a steady power supply for wireless charging. The wireless charging mechanism utilizes high-frequency inductive coupling between a transmitter coil at the station and a receiver coil in the EV. This touchless energy transfer minimizes wear and tear associated with traditional cable-based systems and enhances user convenience.

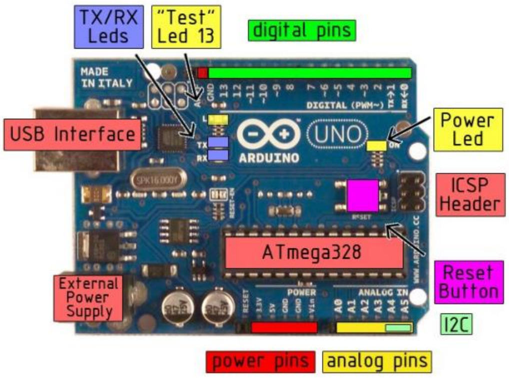
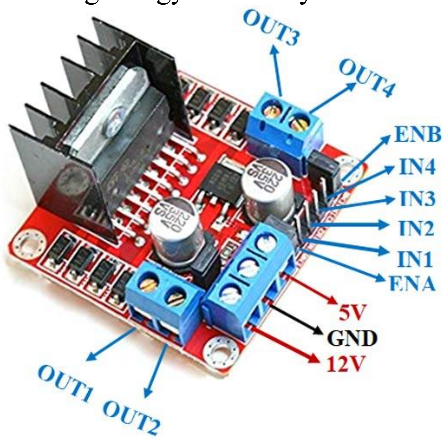


Fig 2: Arduino

Secure access is achieved using an RFID module, where users authenticate their credentials by tapping their RFID card. This ensures that only authorized users can access the station and initiate the charging process. An IR sensor is integrated to detect vehicle presence within the charging bay, enabling seamless automation. Once a vehicle is detected, the system activates the wireless charging coils, transferring energy efficiently from the battery to the EV.



L298 Motor Driver

The system is controlled by an Arduino-based embedded platform, which coordinates all hardware components, including RFID authentication, IR sensors, energy management, and wireless charging. Real-time updates on charging status, battery levels, and authentication are displayed on an LCD panel, while LED indicators provide visual feedback for user convenience. To further enhance functionality, IoT connectivity is implemented to enable remote monitoring, data visualization, and control through a cloud-based dashboard or smartphone application.

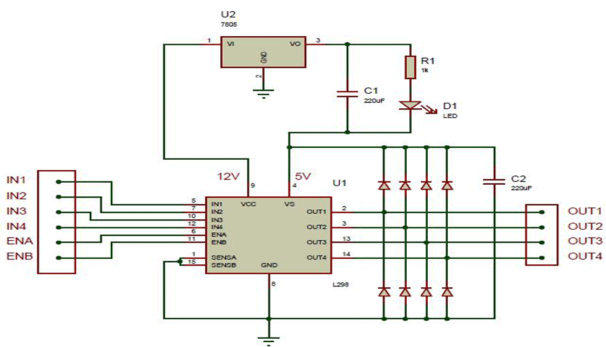


Fig 3: Internal circuit diagram of L298N

The software is developed using the Arduino IDE to integrate all components and manage their operations. Programming includes logic for authentication, vehicle detection, energy utilization, and wireless charging activation. The IoT framework facilitates real-time data monitoring, providing users with insights into solar energy production, battery health, and charging status.

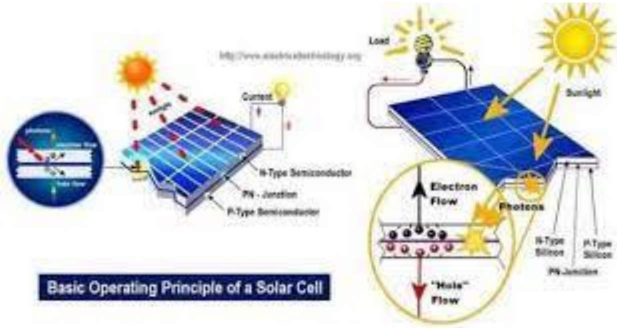


Fig 4: working

This detailed and systematic methodology ensures the efficient and sustainable operation of the EV charging station, addressing the limitations of existing systems while promoting eco-friendly transportation solutions. Let me know if you'd like me to create diagrams or expand on specific sections!

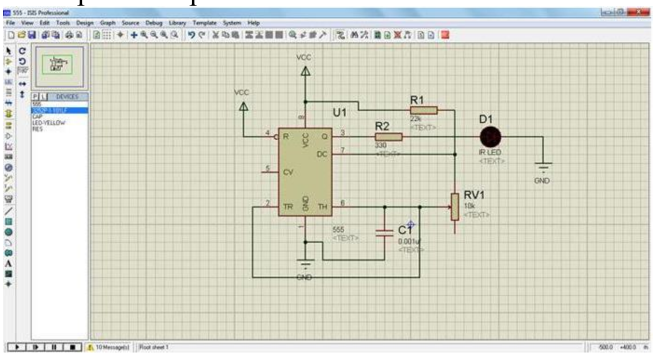


Fig 5: Proteus

V. RESULTS AND DISCUSSION

The **Results and Discussion** section encapsulates the outcomes of the Solar Wireless EV Charging Station with RFID Authentication and provides insights into the system's performance and implications for real-world applications.

Results

The system achieved several key objectives during testing and deployment:

- **RFID Authentication**: The RC522 RFID module demonstrated a high success rate in authenticating authorized users while denying access to unauthorized ones, ensuring secure charging operations.

Fig 6: RFID Authentication Success Rate

- **Vehicle Detection**: The IR sensor reliably detected the presence of vehicles in the charging bay, enabling automated activation of charging and preventing energy wastage when no vehicle was present.

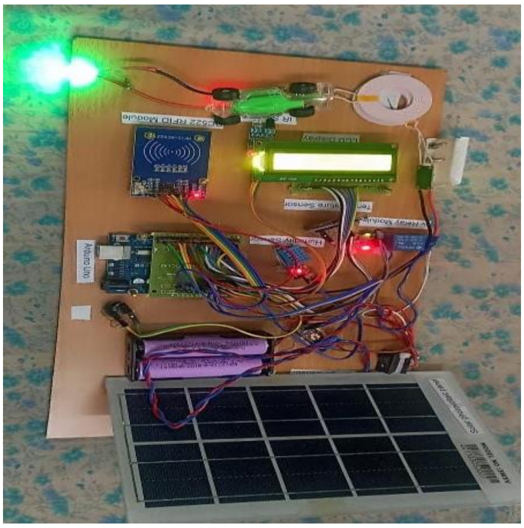


Fig 7: Vehicle Detection Accuracy

- **Wireless Charging Efficiency**: The L298 wireless charging coil efficiently transferred power to the EV's receiving coil with minimal energy loss, maintaining stable output throughout the process.
- **Solar Energy Utilization**: Solar panels performed efficiently, generating sufficient power to charge EVs and store surplus energy in the battery. Charging was sustained even in low sunlight conditions, highlighting the robustness of the energy management system.
- **Real-Time Monitoring**: LCD panels provided real-time updates, including charging status, battery levels, and authentication outcomes, while LED indicators enhanced user convenience by visually representing the charging process.

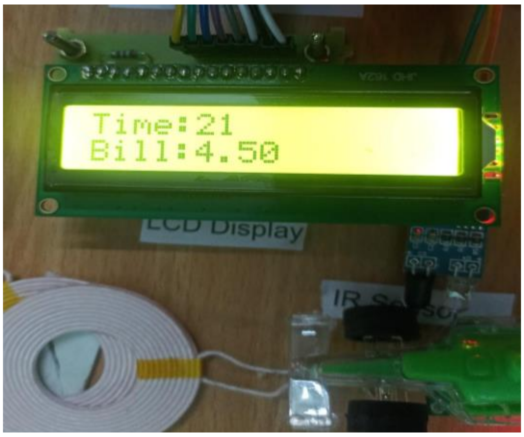


Fig 8: Real-Time Monitoring & User Interface

- **Automated Operation**: The system operated seamlessly without human intervention, with automated RFID-based authentication and vehicle detection ensuring a user-friendly experience.
- **Environmental Monitoring**: Voltage, temperature, and humidity were monitored effectively, with all values remaining within safe operational limits. Alerts were triggered at unsafe thresholds, such as when the temperature exceeded 40°C, demonstrating the system's safety mechanisms.

The successful deployment of the Solar Wireless EV Charging Station illustrates its potential as a sustainable and efficient solution for EV infrastructure. The use of solar panels aligns with global efforts to reduce dependence on non-renewable energy, while wireless charging eliminates the limitations of conventional wired systems, such as cable wear and user inconvenience. RFID authentication provides an additional layer of security, making the system suitable for both public and private applications.

The integration of real-time monitoring via LCD panels and IoT-enabled dashboards enhances usability and allows for effective management of charging operations. Environmental monitoring ensures safety and longevity for critical components, especially the battery. The system's ability to function in varying environmental conditions highlights its adaptability and potential for deployment in diverse geographic locations.

While the system demonstrates a high degree of functionality and efficiency, future improvements could focus on enhancing wireless charging range, integrating AI for predictive maintenance, and exploring hybrid renewable energy sources to further optimize performance. Overall, the results validate the feasibility of the proposed system as a smart, eco-friendly, and user-centric alternative to conventional EV charging solutions, paving the way for widespread adoption and global sustainability efforts.

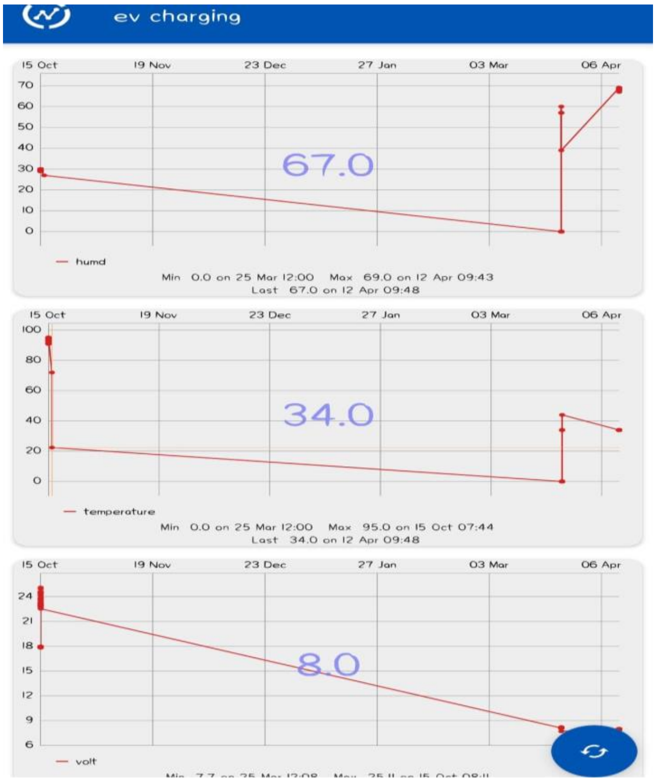


Fig 9: Monitoring the voltage,Temperature and Humidity

VI. CONCLUSION

For contemporary electric car charging infrastructure, the Solar Wireless EV Charging Station with RFID Authentication is a safe, effective, and environmentally responsible option. The solution gets around problems with conventional EV charging by utilizing solar energy, wireless power transfer, and RFID-based verification. It helps the global shift to sustainable transportation alternatives, encourages renewable energy, and improves convenience.

The integration of solar energy with wireless inductive charging and IoT-based Battery Management Systems presents a sustainable, smart, and efficient solution for electric vehicle (EV) charging. By harnessing clean solar power, the system eliminates dependency on the grid and reduces carbon emissions. Wireless charging ensures convenience, safety, and reduced mechanical wear, while the IoT-enabled BMS offers real-time monitoring and control over critical battery parameters. Together, these technologies create a reliable and future-ready EV charging infrastructure that promotes environmental sustainability and smarter energy usage.

This project successfully demonstrates the feasibility of combining renewable energy with modern charging techniques and intelligent monitoring systems, paving the way for next-generation EV charging solutions.

· **Voltage Monitoring** ensured that the battery operated within safe charging and discharging limits, helping to prevent overvoltage and undervoltage conditions that could affect performance or battery life.

· **Temperature Monitoring** provided real-time thermal data, allowing early detection of overheating during charging, which enhances safety and extends the overall lifespan of the battery system.

· **Humidity Monitoring** helped detect environmental moisture levels around the battery, reducing the risk of corrosion or short circuits due to excess humidity, especially in varying weather conditions.

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