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SMART SOLAR POWERED CONTINUOUS AUTO EV CHARGING SYSTEM WITH INTEGRATED AUTO SWITCHING AND BILLING

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ABSTRACT
The increasing demand for electric vehicles (EVs) necessitates innovative solutions for seamless and efficient charging infrastructure. This project introduces a Continuous Auto EV Charging System, featuring a dedicated EV lane embedded with wireless charging technology. As the EV travels over the lane, charging is achieved inductively without the need for manual intervention. The system integrates an RFID-based vehicle identification mechanism to automatically initiate billing upon lane entry and estimate the total charging amount at exit, followed by an SMS notification to the vehicle owner. A novel auto charging source selection mechanism is incorporated to optimize energy utilization by prioritizing solar energy when adequate sunlight is available. In conditions of low light intensity, the system switches to alternative sources such as battery reserves or grid power. This approach promotes sustainable energy usage and offers a user-friendly, automated charging solution to enhance EV adoption.
Keywords: *Battery, Relay, RFID Reader, I2C Module, GSM Modem, ESP32, LCD Display.*

1. INTRODUCTION

The advent of electric vehicles (EVs) has revolutionized the transportation industry, paving the way for sustainable and eco-friendly alternatives to traditional fossil-fuel-powered vehicles. However, one of the significant challenges to EV adoption is the limited availability and convenience of charging infrastructure. Current EV charging systems often require drivers to locate charging stations and endure extended charging times, which can be inconvenient and deter widespread adoption. To address these challenges, this project proposes a novel Continuous Auto EV Charging System, designed to provide a seamless and efficient charging experience.

The core innovation of this system lies in the integration of wireless charging technology directly into dedicated EV lanes. As vehicles traverse these lanes, they are charged inductively without requiring the driver to stop or manually connect to a charging station. This solution not only enhances user convenience but also significantly reduces downtime associated with traditional charging methods.

A key feature of the system is its RFID-based vehicle identification mechanism, which automates the billing process. As an EV enters the charging lane, its unique ID is scanned, initiating the billing cycle. Upon exiting the lane, the total charging amount is calculated, and an SMS notification is sent to the vehicle owner, ensuring a transparent and user-friendly billing experience.

To promote sustainability, the system incorporates an auto charging source selection mechanism. This feature prioritizes the use of solar energy for charging when adequate sunlight is available, reducing dependency on non-renewable energy sources. In the absence of sufficient sunlight, the system seamlessly switches to alternative power sources, such as battery reserves or grid power, ensuring uninterrupted charging. This approach not only optimizes energy utilization but also supports the broader goal of transitioning to cleaner energy solutions.

This project aims to create a practical and scalable solution for continuous EV charging that aligns with the principles of environmental sustainability and technological innovation. By addressing the limitations of current EV charging systems, the proposed solution has the potential to significantly enhance the EV user experience and accelerate the adoption of electric mobility.

2. PROBLEM IDENTIFICATION-

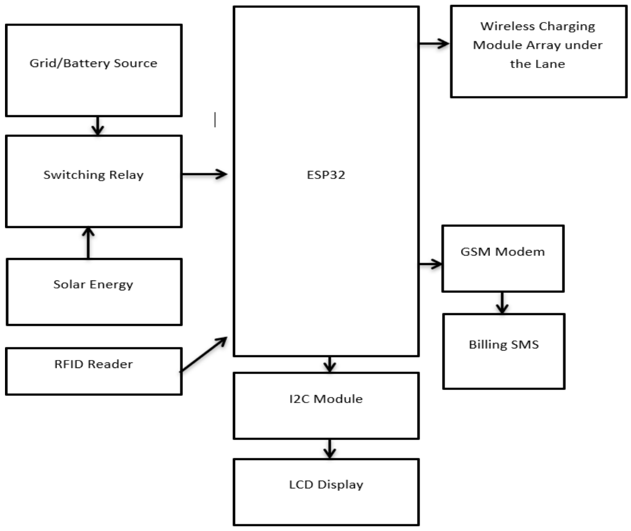
The adoption of electric vehicles (EVs) is hindered by several challenges related to charging infrastructure, energy efficiency, and user convenience. Key problems include:

1. Limited Charging Infrastructure
   - Existing EV charging systems often require vehicles to stop and connect to charging stations manually, leading to long waiting times and user inconvenience.
   - The availability of charging stations is sparse, especially on highways, limiting the feasibility of long-distance EV travel.
2. Dependency on Non-Renewable Energy
   - Many charging stations rely heavily on grid power, which is predominantly sourced from non-renewable energy, undermining the environmental goals of EV adoption.
3. Energy Utilization Inefficiency
   - Current systems lack smart energy management, often failing to prioritize renewable energy sources such as solar power when available.
   - There is limited integration of dynamic energy source switching to optimize energy usage based on real-time conditions.
4. Manual Billing and Tracking
   - Traditional systems require user intervention for payment and lack automated tracking mechanisms for usage and billing, resulting in inefficiencies and potential errors.
5. Inconvenience for Users
   - Stopping for charging interrupts travel, causing delays and reducing the overall efficiency of EV operation.
6. Scalability Challenges
   - Implementing scalable and sustainable charging systems in urban and highway scenarios remains a significant barrier due to high costs and technological limitations.

3. BLOCK DIAGRAM-

Part 1- The figure below shows the block diagram of the project.

The Road Part with Wireless Charging embedded inside the roads.



The Road Infrastructure (Wireless Charging Embedded in Roads):

* Grid/Battery Source: This represents the primary power source for the wireless charging system. It could be the main electrical grid or a dedicated battery bank, or a combination of both. This ensures a stable and reliable power supply to the charging system.

* Switching Relay: This component acts as a switch, controlling the flow of power from the grid/battery source to the wireless charging module. It's crucial for managing power delivery, ensuring safety, and potentially enabling features like scheduled charging or load balancing.

* Wireless Charging Module (under the road): This is the core of the road infrastructure. It generates the electromagnetic field required for wireless power transfer. This module is embedded within the road surface.

* GSM Modem: This module enables communication over cellular networks. It's used to send billing information to the vehicle owner via SMS.

* Billing SMS: This block represents the functionality of sending SMS messages with billing details to the vehicle owner after a charging session.

* ESP32: This is a microcontroller that acts as the "brain" of the road infrastructure. It controls various functions, including:

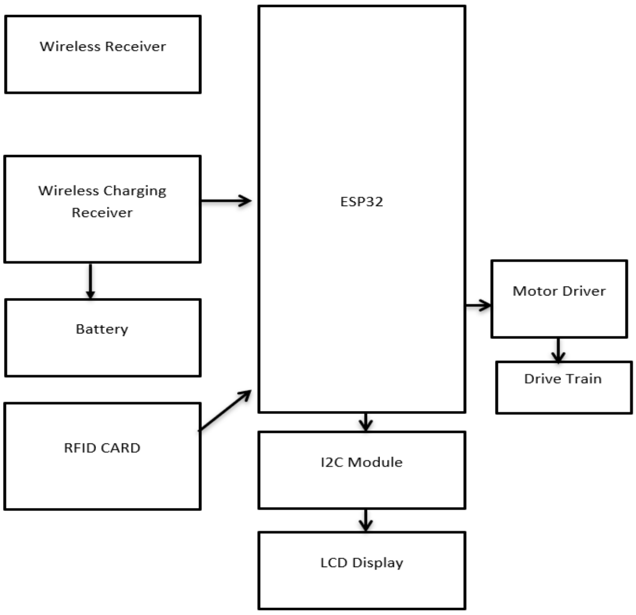
  * Managing the switching relay.
  * Communicating with the GSM modem.
  * Processing data from the RFID reader.
  * Controlling the LCD display.

* RFID Reader: This component is used for vehicle identification. When an RFID-equipped vehicle approaches, the reader detects its presence and triggers the charging process.

* I2C Module: This module facilitates communication between the ESP32 and other peripherals, such as the LCD display and potentially other sensors or modules.

* LCD Display: This displays information related to the charging process, such as charging status, billing information, or system diagnostics.

Part 2: The vehicle part



The Vehicle Integration:

* Wireless Receiver: This component is installed in the electric vehicle and is responsible for receiving the electromagnetic energy transmitted by the road's wireless charging module.
* Wireless Charging Receiver: This block represents the circuitry that converts the received electromagnetic energy into usable DC power to charge the vehicle's battery.
* Battery: This is the vehicle's main energy storage system. The received power from the wireless charging system replenishes the battery.
* Motor Driver: This component controls the electric motor that propels the vehicle. It receives signals from the ESP32 to regulate the motor's speed and direction.
* Drive Train: This represents the mechanical components that transfer power from the motor to the wheels, enabling the vehicle to move.
* ESP32 (Vehicle Side): Similar to the road side, this microcontroller manages various functions within the vehicle, including:
  * Receiving and processing data from the wireless receiver.
  * Controlling the motor driver.
  * Communicating with the I2C module.
  * Displaying information on the LCD.
* RFID Card: This card is used to identify the vehicle to the road infrastructure's RFID reader.
* I2C Module: Facilitates communication between the ESP32 and other peripherals within the vehicle.
* LCD Display: Displays information related to the charging process, battery status, and other vehicle-related data.

Key Project Considerations (for a Final Year Project):

* Efficiency of Wireless Power Transfer: Focus on optimizing the efficiency of the wireless charging system to minimize energy loss.

* Safety Measures: Implement safety features to prevent overheating, overcharging, and other potential hazards.

* Communication Protocol: Develop a robust communication protocol between the road infrastructure and the vehicle.

* Billing System: Design a secure and accurate billing system that integrates with the GSM modem.

* Real-World Testing: Conduct real-world testing to evaluate the performance and reliability of the system.

* Scalability and Cost-Effectiveness: Consider the scalability and cost-effectiveness of the system for future deployment.

* Impact on Road Infrastructure: Analyze the impact of embedding wireless charging modules on the road's structural integrity.

* Environmental Impact: Assess the environmental impact of the project, considering factors like energy consumption and electromagnetic radiation.

4. SYSTEM IMPLIMENTATION

The implementation of the Continuous Auto EV Charging System involves multiple interconnected components and technologies, integrated to provide a seamless and efficient charging experience. The system is implemented through the following steps:

1. Wireless Charging Infrastructure

- Road Embedded Charging Modules:
  Wireless charging pads are embedded into dedicated EV lanes, enabling inductive charging. As vehicles move over these lanes, power is transferred wirelessly to the vehicle's battery using inductive coupling technology.
- Vehicle-side Charging Receiver:
  The vehicle is equipped with a wireless charging receiver module that captures the energy from the embedded pads and transfers it to the battery.

2. RFID-Based Vehicle Identification

- RFID Tags:
  Each EV is assigned a unique RFID tag that identifies the vehicle for billing purposes.
- RFID Reader:
  Installed at the entry of the charging lane, the reader scans the vehicle's RFID tag to start the billing process.
- Data Transmission:
  The unique ID and charging details are stored and processed to calculate the total cost at the end of the charging session.

3. Smart Energy Management

- Auto Energy Source Selection:
  A controller monitors the availability of solar energy, battery reserves, and grid power to optimize

energy utilization.

- Solar Energy Priority: The system prioritizes solar energy when sufficient sunlight is available.
- Fallback Mechanisms: In low sunlight conditions, it switches to battery reserves or the grid.

- Switching Relays:
  Relays are used to dynamically transition between energy sources without disrupting the charging process.

4. Billing and Notification System

- Cost Calculation:
  The total energy consumed during the vehicle's transit over the charging lane is calculated based on energy usage and rates.
- GSM Module for Notifications:
  A GSM modem sends an SMS to the vehicle owner with details of the charging session, including energy consumed and the total cost.

5. System Control and Monitoring

- Microcontroller Integration:
  An ESP32 microcontroller is used to manage and monitor the various components, including wireless charging modules, energy sources, RFID systems, and relays.
- Display Module:
  An LCD with an I2C interface displays real-time data, such as energy source status, charging progress, and system alerts.

6. Vehicle Systems

- Battery and Drive Train:
  The vehicle's battery is integrated with the wireless receiver, while the drive train operates seamlessly during charging.
- Voltage Monitoring:
  A voltage measurement system monitors the battery's charging status and ensures stability.

5. METHODOLOGY

1. Requirement Analysis
   - Identify the challenges in current EV charging systems.
   - Define project objectives and scope.
   - Conduct a feasibility study on solar-powered EV charging.
   - Research existing wireless charging technologies and their limitations.
2. System Design & Planning
   - Design a wireless charging infrastructure with solar integration.
   - Develop a block diagram for system components and interactions.
   - Plan the integration of RFID-based vehicle identification and billing system.
   - Establish a framework for auto energy source selection.
3. Component Selection

- Choose microcontrollers (ESP32), RFID modules, relays, and sensors.
- Select solar panels, batteries, and wireless charging modules.
- Identify GSM module for real-time notifications.
- Opt for efficient energy storage and conversion devices.

4. Hardware Development

- Implement road-embedded wireless charging pads.
- Integrate the on-board charging receiver in EVs.
- Set up energy source switching mechanisms.
- Design and develop the RFID and GSM notification hardware.
- Assemble the control system with ESP32 and display modules.

5. Software Development

- Program ESP32 for energy management and source switching.
- Develop RFID-based vehicle identification and billing system.
- Implement real-time data monitoring and control algorithms.
- Configure GSM module for automated SMS notifications.
- Test and debug communication between components.

6. Integration & Testing

- Test seamless charging while EVs are in motion.
- Verify auto-switching between solar, battery, and grid power.
- Ensure correct RFID-based billing and SMS notifications.
- Conduct load testing on different energy sources.
- Perform safety and efficiency analysis for the system.

7. Performance Evaluation

- Measure system efficiency and charging speed.
- Optimize energy utilization for sustainability.
- Analyze energy consumption patterns and billing accuracy.
- Compare performance with conventional charging systems.
- Evaluate cost-effectiveness and potential improvements.

8. Final Deployment & Analysis

- Implement in a controlled environment for real-world validation.
- Assess scalability and user convenience.
- Gather feedback from users and stakeholders.
- Document findings and propose future enhancements.

Prepare a final report for project assessment and potential commercialization.

6. IMPLEMENTATION WORKFLOW

1. Vehicle Entry:

- When an EV enters the charging lane, its RFID tag is scanned, initiating the charging and billing process.

2. Wireless Charging:

- Power is transferred inductively as the vehicle moves along the lane, with charging managed dynamically by the energy source selection module.

3. Real-time Monitoring:

- The system tracks energy usage and battery status throughout the session.

4. Vehicle Exit:

- Upon exit, the billing module calculates the total cost and sends an SMS notification to the owner.

7. RESULTS

1. Seamless Wireless EV Charging – Enables dynamic charging without stopping, improving travel efficiency.
2. Efficient Energy Management – Intelligent switching between solar, battery, and grid power for optimal energy use.
3. Sustainable Energy Usage – Maximizes solar power utilization, reducing dependence on non-renewable sources.
4. Automated Billing System – RFID-based vehicle identification ensures accurate, hassle-free billing and payments.
5. User Convenience – Eliminates the need for frequent stops at charging stations, enhancing EV usability.
6. Improved EV Adoption – Encourages electric vehicle adoption by addressing charging infrastructure limitations.
7. Scalability & Smart City Integration – Can be implemented in highways, urban roads, and future smart city projects.
8. Cost-Effective Solution – Reduces operational costs by leveraging renewable energy sources.
9. Real-Time Monitoring & Notifications – Users receive SMS updates on charging status and billing.
10. Environmental Benefits – Reduces carbon footprint and reliance on fossil fuels for a greener transportation system.

8. CONCLUSION

The Smart Solar Powered Continuous Auto EV Charging System offers an innovative and sustainable solution to the challenges of electric vehicle charging infrastructure. By integrating wireless charging technology, automated RFID-based billing, and intelligent energy source switching, this system enhances convenience and efficiency for EV users. The prioritization of solar energy ensures reduced dependency on fossil fuels, promoting environmental sustainability. The proposed system not only optimizes energy utilization but also supports the broader adoption of electric mobility by making charging seamless and hassle-free. Future advancements in smart grid integration and energy storage optimization can further enhance the effectiveness and scalability of this system, making it a viable solution for urban, highway, and industrial EV applications.

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