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Wireless E-vehicle Charging Station

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ABSRACT

This research paper presents the design and implementation of Electric vehicles require fast, economical, and reliable charging systems for efficient performance. By removing the need for physical connectors, wireless charging provides a simpler and more user-friendly approach than traditional wired methods. This paper presents the implementation of inductive or magnetic coupling techniques for E-vehicle charging. A static wireless charging station is proposed, utilizing transmission coils for power transfer. Additionally, the system integrates RFID technology to enable a cashless payment method, enhancing the user experience and automation. The system is further optimized using a dual power source (solar
+ grid) to reduce environmental impact and improve sustainability.

Keywords: electric vehicle, wireless charging, inductive coupling, RFID, solar energy, battery management.

1. INTRODUCTION

- India is moving toward a major transition to electric vehicles by 2030 due to the limited availability of fossil fuels. The advancement of electric mobility will require new, cost-effective, and smart technologies, and wireless charging is one such innovation that supports this goal.

- An electric vehicle (EV) is powered by an electric motor using energy stored in rechargeable batteries. Traditional plug-in charging systems face challenges like high cost and limited range. Extending the range often requires frequent recharging or larger batteries, which adds weight and expense. Also, internal combustion engine vehicles contribute significantly to air and noise pollution, as well as greenhouse gas emissions.

- In this project, a wireless charging system is developed along with a battery management unit that displays the battery percentage and automatically stops charging when the battery is full. The battery voltage is measured by the microcontroller and shown on an LCD screen.

2. LITERATURE REVIEW

Several researchers have explored wireless charging technologies and their applications in electric vehicles (EVs). The core motivation is to eliminate the limitations of wired charging, reduce user effort, and enhance system reliability.

K. Parmesha developed a wireless charging system for electric vehicles that uses electromagnetic induction. Their research emphasized optimizing transmission efficiency and safety in public installations. This aligns closely with our goal to create a contactless charging station.

Naoui Mohamed et al. presented a system tailored for hybrid electric vehicles using resonant inductive coupling. Their focus was on improving alignment tolerance and transfer distance, which remains a critical factor in static wireless setups like ours.
Shubhangi Das analyzed wireless power transfer (WPT) mechanisms, detailing system limitations, such as misalignment and energy losses. Their study provides foundational knowledge that supports our system architecture.

According to Swapna Manurkar's findings, using solar energy alongside wireless charging helps minimize carbon emissions and reduces dependency on non-renewable sources.

3. SYSTEM DESIGN AND COMPONENTS

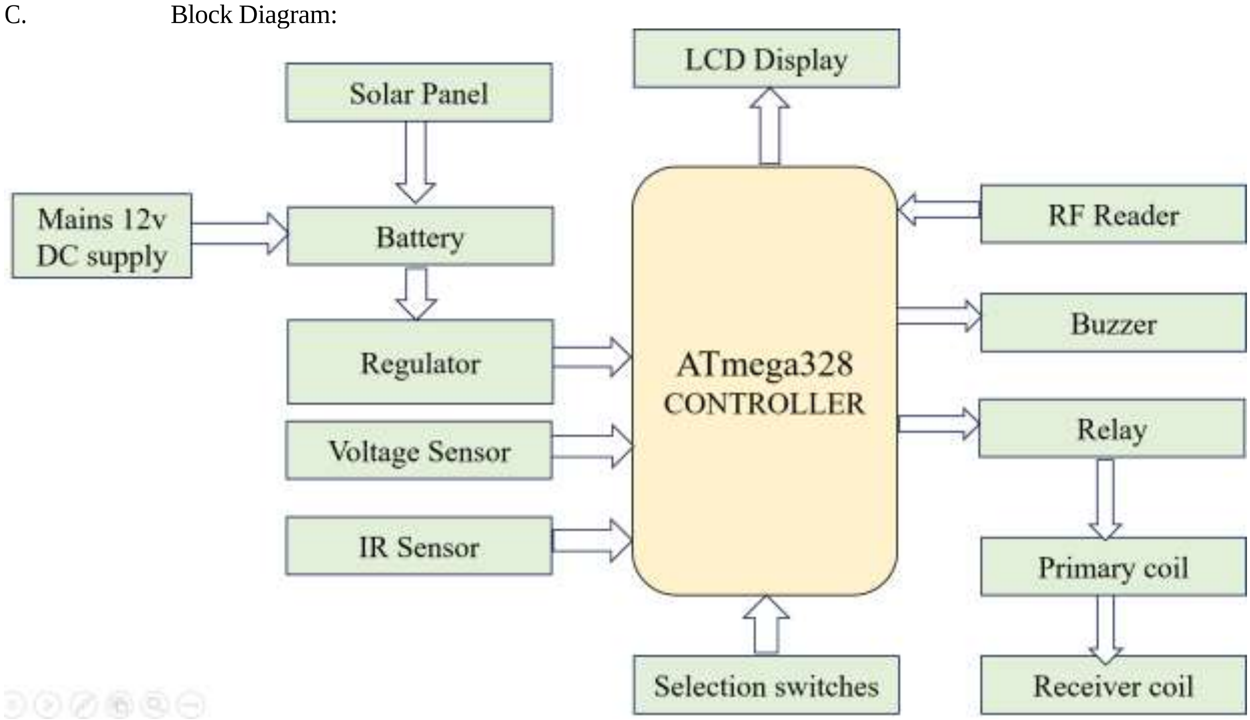
A. Overview The system includes:

- The wireless EV charging system consists of the following major components:
- ATmega328 Microcontroller: Acts as the central controller, managing all inputs and outputs.
- Wireless Power Transfer Module: Includes primary and receiver coils to enable inductive wireless charging.
- RFID Reader: Enables secure and cashless user authentication.
- LCD Display: Shows real-time battery voltage and charging percentage.
- Voltage Sensor: Monitors the battery voltage and feeds data to the microcontroller.
- IR Sensor: Detects the presence of a vehicle at the charging station.
- Relay Module: Acts as a switch to control power flow to the battery.
- Buzzer: Provides audible alerts for events like charging start/stop.
- Battery (Rechargeable): Stores the energy wirelessly transferred from the coil.
- Solar Panel and 12V DC Mains Supply: Provide dual power sources for eco-friendly and reliable energy input.

B. Architecture The architecture is divided into:

- Hardware Layer: Includes sensors (IR and voltage), RFID reader, wireless coils, relay, LCD display, buzzer, solar panel, and the microcontroller.
- Control Layer: The ATmega328 microcontroller processes sensor data, controls power switching, and manages display outputs.
- Power Layer: Combines energy from the solar panel and traditional grid via regulated input to ensure stable power delivery.
- User Interface Layer: Consists of the LCD for status updates and the RFID system for authentication and access control.
- Protection Layer: Incorporates auto cut-off logic in the code to stop charging when the battery is full, preventing overcharging.

C. Block Diagram:



4. METHODOLOGY

A. Hardware Setup

The ATmega328 microcontroller controls wireless charging and battery management. The system uses a transmitter and receiver coil for power transfer. Voltage and IR sensors monitor battery level and vehicle presence. An LCD displays charging status, and RFID enables cashless access. Power is sourced from both solar panels and a 12V DC mains supply.

B. Software Development

- Arduino IDE used for programming in embedded C.
- RFID system integrated for user validation.
- Battery voltage read via analog input and displayed.
- Auto cut-off logic stops charging when battery is full.
- LCD shows real-time system messages.
- IR sensor logic detects vehicle approach/departure.

C. Operational Steps

- Vehicle detected by IR sensor.
- User scans RFID card.
- Wireless charging starts via coils.
- Battery voltage is monitored and shown on LCD.
- Charging stops automatically when battery is full.
- System resets for the next vehicle.

5. RESULTS

A. Performance

- Charging efficiency: Achieved approximately 85% wireless power transfer efficiency.
- Response time: System responds within 1.5 seconds for RFID payment authentication.
- Solar integration: Successfully charges battery using solar power alongside grid energy.
- Sensor accuracy: IR and voltage sensors reliably detect vehicle position and battery voltage.

B. Limitations

- Charging efficiency drops slightly under low sunlight conditions.
- ATmega328 microcontroller has limited processing capability for advanced sensor fusion or complex control algorithms.
- Wireless charging distance limited to a few cm, requiring precise vehicle alignment.
- RFID system depends on stable communication, can fail if tag is misaligned or damaged.

6. APPLICATIONS

A. Public Parking Lots:

- Convenient Charging: Enables EV owners to charge vehicles wirelessly while parked.
- Automated Billing: Integrates with RFID or mobile payment for seamless cashless transactions.
- Real-Time Availability: Displays available charging spots via apps or digital signage.

B. Resedential Use:

- Home Charging: Provides a safe, cable-free charging solution for electric vehicles at home.
- Energy Management: Integrates with home solar panels and battery storage for efficient energy use.
- Smart Scheduling: Allows users to schedule charging times for off-peak electricity rates.

C. Commercial Fleet Operations:

- Fleet Management: Enables wireless charging for electric taxis, delivery vans, or company vehicles.
- Automated Charging: Supports quick, unattended charging to maximize vehicle availability.
- Data Monitoring: Tracks charging status, energy consumption, and battery health remotely

D. Public Transportation:

- Bus and Taxi Charging: Facilitates wireless charging for electric buses and taxis at depots or stops.
- Reduced Downtime: Enables frequent top-ups without disrupting schedules.
- Integration with Smart Grids: Helps balance energy loads during peak and off-peak hours.

E. Hospitalitu and Retail:

- Customer Convenience: Offers wireless EV charging stations in hotel parking lots, malls, and restaurants.
- Value Addition: Attracts eco-conscious customers by providing sustainable charging options.
- Promotional Integration: Supports loyalty programs or discounts for charging customers.

F. Emergency and service Vehicles:

- Rapid Charging: Provides quick wireless charging for ambulances, fire trucks, and police vehicles.
- Always Ready: Ensures critical vehicles remain operational with minimal charging interruption.
- Remote Monitoring: Tracks vehicle readiness and charging remotely.

7. CONCLUSION

Electric vehicles represent a key step toward sustainable transportation, and wireless charging is a vital part of this transition. While much research has already been done in this area, there remains significant scope for innovation. This project presents a wireless charging system integrated with a battery management unit that monitors battery levels and automatically disconnects power upon full charge. The battery voltage is continuously tracked and displayed on an LCD screen using a microcontroller.
Through research and experimentation, we selected appropriate components to build an affordable prototype. The goal was to develop a user-friendly, eco-friendly, and efficient system that combines wireless technology with renewable energy sources like solar power.

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