Solar Based Wireless Electric Vehicle Charging System

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Abstract:
The rapid growth of electric vehicles (EVs) has increased the need for efficient and eco-friendly charging systems. This project presents the design and successful implementation of a **Solar-Based Wireless Electric Vehicle Charging System**, which combines renewable solar energy with wireless power transfer technology. The system utilizes photovoltaic (PV) panels to generate electricity, which is stored in a battery and further used for charging the EV without any physical connection.The wireless charging mechanism is based on inductive coupling, where power is transferred from a transmitter coil to a receiver coil installed in the vehicle. The developed system includes power conditioning circuits, a battery storage unit, and control mechanisms to ensure stable and efficient energy transfer. Maximum Power Point Tracking (MPPT) techniques are incorporated to maximize solar energy utilization under varying environmental conditions.
The final project has been successfully tested and demonstrates reliable wireless power transmission with improved safety, reduced maintenance, and enhanced user convenience. This system minimizes dependency on conventional grid power and contributes to reducing environmental pollution. The developed model proves to be a cost-effective and sustainable solution for future electric vehicle charging infrastructure.

Introduction

The increasing demand for sustainable and environmentally friendly transportation has led to the rapid development and adoption of electric vehicles (EVs). Conventional EV charging methods mainly rely on wired connections and grid electricity, which may cause inconvenience, energy losses, and dependency on non-renewable energy sources. To overcome these challenges, there is a need for an innovative charging system that is efficient, user-friendly, and based on renewable energy.This project introduces a **Solar-Based Wireless Electric Vehicle Charging System**, which combines solar energy generation with wireless power transfer technology. Solar energy, being clean, abundant, and renewable, is harnessed using photovoltaic (PV) panels and stored in batteries for later use. The stored energy is then transferred wirelessly to the electric vehicle using inductive coupling, eliminating the need for physical cables.
Wireless charging offers several advantages such as improved safety, reduced wear and tear, ease of operation, and minimal maintenance. It also enhances the convenience of EV users by enabling contactless charging. The integration of Maximum Power Point Tracking (MPPT) ensures optimal utilization of solar energy under varying environmental conditions.
The primary aim of this project is to develop a cost-effective, efficient, and eco-friendly charging solution that reduces reliance on fossil fuels and supports the concept of smart and sustainable transportation systems. This technology has significant potential for future applications in smart cities, automated parking systems, and dynamic charging infrastructure.

Literature Review

A **2025 research paper** published in *Scientific Reports* presented a multiport DC–DC converter-based system integrating solar photovoltaic (PV), battery storage, and wireless power transfer. The study demonstrated improved efficiency and reliable EV charging using inductive coupling and advanced converter design.

In **2024**, a paper published in *Frontiers in Energy Research* introduced a solar EV charging station with improved power quality using intelligent optimization techniques. The research focused on reducing harmonics and improving system stability in renewable-based EV charging infrastructure.

Another **2024 study** in *E3S Web of Conferences* explored innovations in solar-driven wireless charging systems. It highlighted the integration of photovoltaic energy with wireless power transfer (WPT) to achieve efficient, contactless EV charging suitable for smart cities.

A **2024 review paper** published in *World Electric Vehicle Journal* analyzed modern wireless EV charging technologies, including inductive and resonant coupling methods. It emphasized improved efficiency, alignment techniques, and future trends like dynamic wireless charging.

In **2024**, another study in *Frontiers in Energy Research* discussed optimal planning strategies for wireless EV charging integrated with smart grids and vehicle-to-grid (V2G) systems, improving energy management and system performance.

Component Details

1.Battery

The battery is used to store electrical energy generated from the solar panel. It supplies power to the entire system when solar energy is unavailable. Rechargeable batteries such as lead-acid or lithium-ion are commonly used due to their reliability and efficiency.

2.ElectricVehicle(EV)

The electric vehicle acts as the load in the system. It receives electrical energy wirelessly and stores it in its internal battery for propulsion. EVs reduce dependency on fossil fuels and help in minimizing environmental pollution.

3. Introduction to Embedded System

An embedded system is a combination of hardware and software designed to perform a specific task. In this project, the embedded system is used to control and monitor the charging process. It ensures proper operation of components like PWM generation, display, and switching circuits.

4. PWM Generator (Pulse Width Modulation)

PWM is used to control the power supplied to the transmitter coil. By varying the duty cycle of the signal, the output power can be regulated efficiently. It helps in improving energy transfer efficiency and controlling voltage levels.

5. Transmitter Coil (Primary Coil)

The transmitter coil is responsible for generating a magnetic field when high-frequency AC current passes through it. This magnetic field is used to transfer energy wirelessly to the receiver coil through inductive coupling.

6. Receiver Coil (Secondary Coil)

The receiver coil is placed in the electric vehicle. It receives the magnetic field from the transmitter coil and converts it back into electrical energy. Proper alignment between coils is important for efficient power transfer.

7. Rectifier Circuit

The rectifier converts the AC output from the receiver coil into DC power. This DC power is suitable for charging the battery of the electric vehicle. Typically, a bridge rectifier is used for this purpose.

8. Motor

The motor represents the actual load in the electric vehicle. It converts electrical energy into mechanical energy to drive the vehicle. In prototype models, a DC motor is often used to demonstrate working.

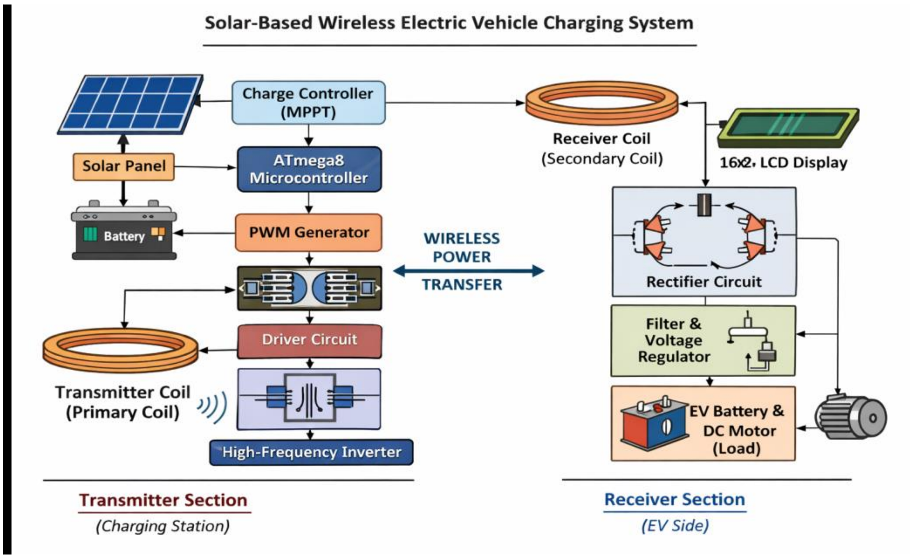
9. ATmega8 Microcontroller

The ATmega8 microcontroller is the main control unit of the system. It manages PWM generation, monitors system parameters, and controls the operation of different components. It ensures efficient and safe functioning of the charging system.

10. 16×2 LCD Display

The 16×2 LCD display is used to show system parameters such as voltage, charging status, and battery level. It provides a simple user interface for monitoring the system in real time.

Procedures



1. System Design and Planning

First, the overall system is designed by selecting suitable components such as solar panel, battery, microcontroller (ATmega8), coils, and other electronic circuits. The circuit diagram and block diagram are prepared.

2. Solar Energy Generation

The solar photovoltaic (PV) panel is installed to capture sunlight and convert it into DC electrical energy. The output is given to the battery through a charge controller.

3. Battery Charging and Storage

The generated solar energy is stored in the rechargeable battery. Proper regulation is ensured to avoid overcharging and maintain battery life.

4. Microcontroller Programming

The ATmega8 microcontroller is programmed using embedded C. It is configured to generate PWM signals, control system operations, and display system parameters on the LCD.

5. PWM Signal Generation

The PWM generator circuit produces high-frequency switching signals. These signals are used to drive the transmitter coil through a driver circuit.

6. Transmitter Coil Operation

The transmitter coil is energized with high-frequency AC current, producing an alternating magnetic field around it.

7. Wireless Power Transfer

When the receiver coil is placed near the transmitter coil, the magnetic field induces a current in the receiver coil through inductive coupling.

8. Rectification Process

The induced AC voltage in the receiver coil is converted into DC using a rectifier circuit.

9. Power Regulation

The rectified output is regulated to a suitable voltage level for safe charging of the EV battery.

10. Load Operation (Motor/EV Battery Charging)

The regulated DC power is supplied to the electric vehicle battery or a DC motor (in prototype), demonstrating wireless charging and utilization.

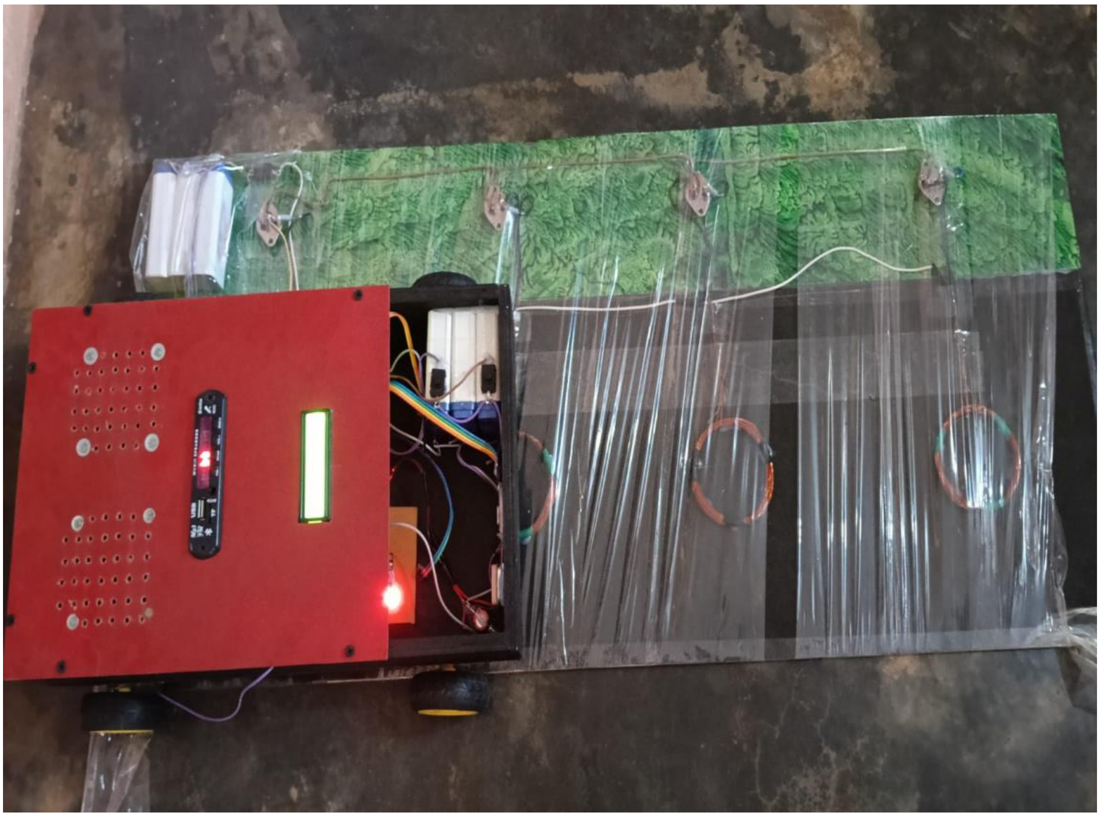
11. Display and Monitoring

The 16×2 LCD displays important parameters such as voltage level, charging status, and system condition for user monitoring.

12. Testing and Validation

Finally, the system is tested under different conditions to verify performance, efficiency, and proper functioning of wireless power transfer.

Final Project Image



Results

The **Solar-Based Wireless Electric Vehicle Charging System** was successfully designed, implemented, and tested. The system demonstrated effective generation, transmission, and utilization of electrical energy using solar power and wireless technology.

During testing, the solar panel was able to generate sufficient DC power under normal sunlight conditions. The energy was stored efficiently in the battery and supplied to the transmitter circuit without significant losses. The **ATmega8 microcontroller** successfully generated PWM signals to drive the transmitter coil through the driver circuit.

Wireless power transfer was achieved through inductive coupling between the transmitter and receiver coils. When both coils were properly aligned, a stable voltage was induced in the receiver coil. The rectifier circuit effectively converted the received AC signal into DC, and the voltage regulator provided a steady output suitable for charging.

The system was able to:

- Successfully transmit power wirelessly over a short distance
- Light a load (DC motor / battery charging) without physical connection
- Maintain stable output under proper alignment conditions
- Display system parameters such as voltage and charging status on the 16×2 LCD

Overall, the project proved that solar energy can be effectively combined with wireless power transfer to create an eco-friendly and convenient EV charging system. The developed model is reliable, safe, and suitable for small-scale applications and future development.

Conclusion

Solar-based wireless EV charging systems offer a sustainable, automated, and user-friendly method of powering electric vehicles. While challenges such as alignment precision, power transfer efficiency, and system cost remain, advancements in coil design, power electronics, and energy management can make this technology more practical. The integration of renewable energy further supports global clean mobility goals

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