
SOLAR WIRELESS ELECTRIC VEHICLE CHARGING SYSTEM WITH TEMPERATURE-BASED BATTERY PROTECTION

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ABSTRACT:

Battery safety represents a critical challenge in electric vehicles, particularly when charging takes place. Extended charging periods can cause battery temperatures to rise, potentially shortening battery lifespan and creating hazardous conditions. Monitoring battery temperature and managing the charging cycle becomes essential to prevent excessive heat buildup. This paper presents a Solar Wireless EV Charging System that incorporates Temperature-Based Battery Protection to tackle these issues.

The system harnesses solar energy as its main power source, producing environmentally friendly electricity for vehicle charging. Power transmission occurs through wireless technology, eliminating the need for physical cable connections between the charging station and the vehicle. This approach enhances user convenience while minimizing complications related to traditional wired charging methods.

Temperature-based battery protection serves as the system's core safety feature. Real-time monitoring tracks the EV battery temperature throughout the charging cycle. When temperatures exceed predetermined safety thresholds, the system immediately halts the charging operation to prevent overheating and safeguard the battery against potential damage. Normal charging operations resume automatically once temperatures drop back within acceptable parameters.

Keywords: Solar Panel, Solar Charge Controller, Temperature Sensor (DHT11), Transmitter, Receiver, Relay Module, Arduino, Over Heating Protection.

1. INTRODUCTION:

This research developed and tested a static inductive charging system for electric vehicles using wireless technology. Wireless charging has gained popularity as a cable-free method for powering electric vehicles. The system works by transferring electrical energy from a transmitter coil to a receiver coil using magnetic coupling [1]. Current research efforts concentrate on creating renewable energy charging solutions for electric vehicles to promote sustainable transportation [2][3]. With growing environmental awareness, India has established an ambitious goal to switch entirely to electric vehicles by 2030. Yet the widespread adoption of EVs encounters obstacles including extended charging periods, insufficient infrastructure, and possible power grid instability. To tackle these problems, researchers have proposed a solar-powered wireless EV charging system that transforms solar energy into electrical power and stores it in a lead-acid battery [3][5]. The Solar Wireless Electric Vehicle Charging System represents an innovative approach designed to make EV charging straightforward, efficient, and eco-friendly. The system captures solar radiation using solar panels, converts DC electricity to AC power through an inverter, and wirelessly delivers it to the electric vehicle's receiver for battery charging. This removes the requirement for physical connections, providing a smooth and sustainable charging solution. When compared to traditional EV charging approaches, this system emerges as a cleaner, more environmentally sound, and more convenient option [4]. Recent studies examined the latest wireless charging technologies for EVs, including static and dynamic WPT systems, compensation configurations, obstacles and efficiency concerns. The research identifies technological limitations and future developments in EV charging infrastructure studies [6]. Additional research focuses on solar-integrated EV wireless charging systems, analyzing inductive and capacitive power transfer methods, photovoltaic integration, and control techniques to improve efficiency [7]. Studies have also explored dynamic wireless charging (DWC) systems that deliver power inductively to moving EVs, addressing smart grid connectivity,

continuous charging capabilities, and infrastructure requirements[8]. Designed and simulated a static inductive charging system for EVs using WPT coupled with MPPT solar input and converters to optimize wireless energy transfer without cables [9]. Developed a wireless power transfer model for charging deep-cycle lithium-ion EV batteries using resonant inductive coupling with PCB design, mathematical modeling and simulated performance analysis [10]. Proposed a solar-powered PV EV charging station using WPT technology to eliminate cables, enhancing convenience and sustainability in EV charging infrastructure [11]. It discusses Integrated solar PV with wireless power transfer using an ANFIS MPPT algorithm to maximize harvested solar energy and improve EV charging efficiency under variable irradiance conditions [12].

Considering the above issues, such as long charging time, dependency on conventional electricity sources, battery overheating, and power losses during charging, this work proposes an improved solar-based wireless EV charging system. The proposed system integrates Solar Energy with Wireless Power Transfer to provide an efficient and eco-friendly charging method for Electric Vehicles. In order to enhance battery safety, a temperature monitoring mechanism is implemented using a DHT11 Sensor, which continuously monitors the battery temperature during the charging process. The system is controlled using an Arduino, which manages sensor readings and controls the relay to protect the battery from overheating. By incorporating temperature monitoring and efficient wireless power transfer, the proposed system helps improve battery safety, reduce power loss, and provide a reliable and sustainable EV charging solution.

2. OBJECTIVES:

- To design a solar-powered EV charging system – To use Solar Energy for charging Electric Vehicles instead of depending completely on grid electricity.
- To integrate temperature detection for safety – To monitor battery temperature using a DHT11 Sensor and prevent overheating during charging.
- To enable automatic charging control – To automatically turn ON or OFF the charging process using a Relay Module based on system conditions.
- To reduce environmental pollution – To promote eco-friendly transportation by using renewable energy for EV charging.
- To create a safe and user-friendly system – To manage and control the whole system using an Arduino for reliable and simple operation.

3. LITERATURE SURVEY:

In recent years several studies have explored advanced charging systems for Electric Vehicles to improve convenience and efficiency. One study proposed an intelligent wireless charging station that automates the coil alignment process to reduce driver involvement and energy losses. The system uses wireless power transfer to overcome the limitations of traditional wired chargers and improve overall system usability [1]. Building on the concept of wireless power transfer, one study investigates a solar wireless EV charging system that integrates renewable energy with inductive charging technology. Solar panels are used to capture and store energy which is then utilized for wireless charging of EVs without relying on grid electricity. The system highlights the potential to reduce environmental impact while providing a flexible and convenient charging solution. The integration of solar energy addresses the growing need for greener transportation infrastructure [2][3]. This research reviews the latest wireless charging methods for electric vehicles covering both static and dynamic Wireless Power Transfer technologies, compensation topologies, efficiency issues and key challenges. It highlights the technological gaps and future trends in EV charging infrastructure research to guide further development in this field. The study provides a comprehensive understanding of current limitations in wireless power transfer and suggests improvements to enhance charging efficiency and reliability. This research serves as a valuable reference for designing better and more efficient wireless EV charging systems using advanced topologies and renewable energy

integration [6]. This research provides a comprehensive literature review on solar assisted EV wireless charging systems examining inductive and capacitive power transfer modes, photovoltaic integration and control methods to enhance efficiency. It also reviews dynamic wireless charging systems that transfer power inductively while electric vehicles are in motion discussing smart grid integration, continuous charging and infrastructure needs. Together these studies cover a wide range of wireless charging technologies and highlight the importance of integrating renewable energy sources with advanced power transfer methods to develop efficient, reliable and sustainable EV charging infrastructure [7][8]. This research designed and simulated a static inductive charging system for electric vehicles using Wireless Power Transfer coupled with MPPT solar input and converters to optimize wireless energy transfer without cables. Another study developed a wireless power transfer model for charging lithium-ion EV batteries using resonant inductive coupling with PCB design, mathematical modeling and simulated performance analysis. Both studies focus on improving wireless charging efficiency and providing a reliable cable free charging solution for electric vehicles using advanced inductive and resonant coupling techniques [9][10]. This research proposed a solar powered photovoltaic EV charging station using Wireless Power Transfer technology to eliminate cables and enhance convenience and sustainability in EV charging infrastructure. Another study integrated solar PV with wireless power transfer using an ANFIS MPPT algorithm to maximize harvested solar energy and improve EV charging efficiency under variable irradiance conditions. Both studies focus on combining solar energy with wireless charging technology to provide an efficient, cable free and sustainable charging solution for electric vehicles [11][12].

4. EXISTING SYSTEM:

- Grid-Based Wired Charging – Uses cables to supply electricity from the power grid, usually powered by conventional energy sources.
- Solar Wired Charging – Uses solar panels to generate electricity, but transfers power through cables to the vehicle.
- Battery-Backed Grid Wired Fast Charging – Uses a battery system with grid power to provide faster charging and reduce load spikes.
- Wireless Charging (Grid Powered) – Uses wireless power transfer (inductive/resonant) but is powered by grid electricity and often lacks integrated temperature monitoring of Battery.

5. METHODOLOGY:

A. System Overview

The proposed system is designed to implement a solar-powered wireless EV charging system with automatic temperature-based safety and battery charge control, ensuring safe and convenient charging without the need for physical cables. The system uses a solar panel along with a charge controller to generate and regulate electrical energy, which is then supplied to a transmitting coil for wireless power transfer. On the vehicle side, a receiving coil captures this energy and delivers it to charge a lithium-ion battery. An Arduino microcontroller acts as the main control unit, collecting data from a DHT11 sensor to monitor temperature and from the battery through sensing circuits to check its charge level. Based on these inputs, the Arduino controls a relay module to automatically switch the charging process ON or OFF when required, such as when the battery reaches a set limit or when the temperature becomes too high. This helps prevent overcharging and overheating. The main objective of the system is to provide efficient, cable-free solar charging for EVs while improving safety, reliability, and battery life through automatic control.

B. Block Diagram

The block diagram shown in Fig.1 represents the overall architecture of the proposed solar-powered wireless EV charging system. The system consists of key components such as a 12V solar panel, solar charge controller, switch, transmitter coil, receiver coil, relay modules, Arduino

microcontroller, LCD display, and a 3.7V lithium -ion battery. The solar panel generates electrical energy from sunlight, which is regulated by the solar charge controller to ensure a stable output. This regulated power passes through a switch and is supplied to the transmitter coil, which operates at 5V and 2A to enable wireless power transfer.

The receiver coil, placed on the vehicle side, captures the transmitted energy and delivers it to the charging circuit, which charges the 3.7V lithium -ion battery. Relay modules are used to control the charging process by switching the circuit ON or OFF based on control signals. The Arduino microcontroller acts as the central processing unit, monitoring battery status and controlling the relay modules accordingly. Additionally, the LCD display is used to show system parameters such as charging status and battery level.

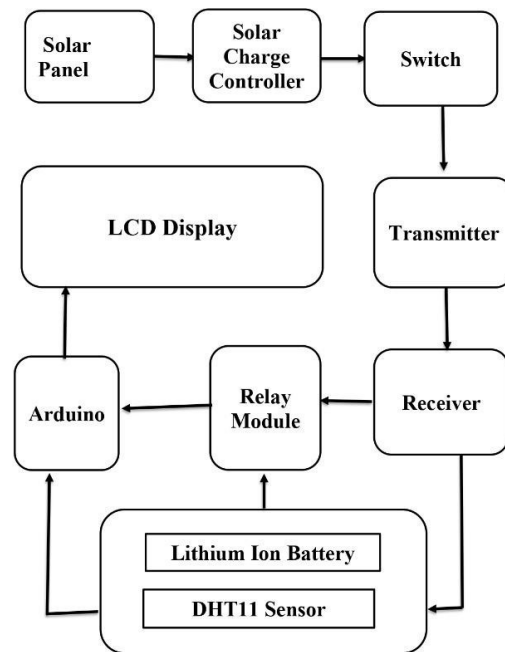


Fig .1 :Block diagram of Proposed System

C. Flow Chart

The flowchart in Fig.2 explains the working operation of the proposed solar-powered wireless EV charging system. The process begins with the solar panel capturing sunlight and converting it into electrical energy. This generated energy is passed to the solar charge controller, which regulates the voltage and current to provide a stable and safe power output. The regulated power is then supplied to the transmitter coil, which operates at 5V and 2A to create an electromagnetic field for wireless energy transfer. The receiver coil, placed on the vehicle side, captures this transmitted energy and converts it into electrical power suitable for charging. The received energy is directed through a relay module to the 3.7V lithium-ion battery. The relay acts as a switching device that controls whether the charging process is ON or OFF. An Arduino microcontroller serves as the central control unit of the system, continuously monitoring different parameters and controlling the relay accordingly. A temperature sensor is connected to the Arduino to measure the battery temperature in real time.

During operation, the system continuously compares the measured temperature with a predefined threshold value of 45°C. If the temperature remains within or below this limit, the Arduino keeps the relay in the ON state, allowing the battery to charge normally. However, if the temperature

exceeds 45°C, the Arduino immediately switches the relay OFF.

This monitoring and control process repeats continuously in a loop, ensuring automatic and safe operation. Once the temperature returns to a safe level, the system resumes charging by turning the relay back ON. Overall, the system provides efficient wireless power transfer, ensures battery safety through temperature - based control, and offers a convenient, eco-friendly charging solution using solar energy.

The system promotes sustainable and eco-friendly charging while reducing dependence on conventional electricity. The combination of the Arduino controller, relay module, and temperature sensing mechanism enhances system safety by preventing overcharging and overheating. Overall, this intelligent charging approach increases battery lifespan, ensures efficient energy utilization, and provides a modern solution for safe and convenient electric vehicle charging.

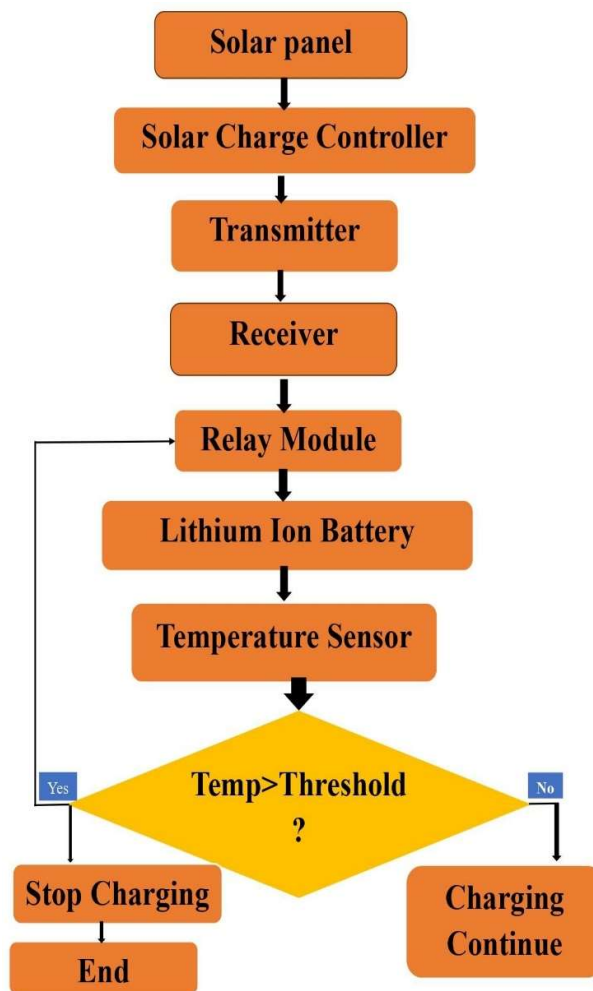


Fig.2: Flow Chart of proposed System

5.1 Hardware Components:

1. Solar Panel (12V):

Solar panel converts sunlight into DC electricity and supplies it to the charge controller as the main power source of the system.

2. Solar Charge Controller:

It regulates the voltage and current coming from the solar panel and sends controlled power to the battery, preventing overcharging and damage.

3. Lithium-ion Battery:

Battery stores the solar energy and supplies stable 12V DC power to the transmitter circuit whenever needed, even without sunlight.

4. Transmitter Coil:

It receives high frequency AC and produces an oscillating magnetic field around it. This magnetic field carries energy wirelessly through the air to the receiver coil. It is wound with 20 to 30 turns of 26–28 AWG copper wire on a 45–50 mm diameter former.

5. Receiver Coil:

It is placed on the EV side and captures the magnetic field produced by the transmitter through induction. This induced AC is rectified to DC and used to charge the EV battery. It also has 20 to 30 turns with same diameter as transmitter for proper coupling.

6. DHT11 Temperature Sensor:

It continuously monitors the temperature of the battery and charging area and sends the readings to Arduino. It detects if temperature crosses the 45°C safety limit.

7. Relay Module:

It acts as an automatic switch in the charging circuit. When temperature is below 45°C it stays closed and charging continues normally. When Arduino detects temperature at or above 45°C it opens the relay and charging stops automatically to protect the system.

5.2 Software requirements:

1. Arduino:

Arduino is programmed to read temperature data from DHT11 sensor continuously and compare it with the 45°C threshold value. If temperature exceeds the limit, Arduino sends a signal to the relay module to cut off charging automatically. It also reads the receiving voltage from the receiver coil side and controls the LCD display to show all system parameters.

2. Monitoring Software:

Monitoring software runs on the Arduino and continuously tracks the real time battery temperature, charging on or off status and receiving voltage of the system. It processes all these values and sends them to the LCD display so the user can monitor the complete system condition at any time.

3. User Interface — LCD Display:

A 16x2 LCD display is connected to the Arduino and shows three important parameters to the user in real time.

- Battery Temperature is shown on the display continuously. When temperature is below 45°C the system runs normally and when it reaches or crosses 45°C the display shows a high temperature

warning.

- Charging Status is displayed as Charging ON when the relay is closed and power is flowing normally. When temperature exceeds 45°C and relay opens, the display immediately changes to Charging OFF to inform the user that safety cutoff has occurred.
- Receiving Voltage from the receiver coil is also displayed on the screen so the user can monitor how much voltage is being received on the EV side during wireless power transfer.

6. RESULTS AND ANALYSIS:

The experimental results show that the solar wireless EV-charging system works properly under real-time conditions. The solar panel charges the battery through the charge controller, and wireless power is transferred using the transmitter and receiver coils. The DHT11 temperature sensor continuously monitors the battery temperature. When the temperature goes above or Equal to +45 °C, the relay automatically cuts off the charging to protect the battery. When the temperature falls below 45 °C, charging resumes automatically. This proves that the system is efficient, safe, and suitable for practical use.

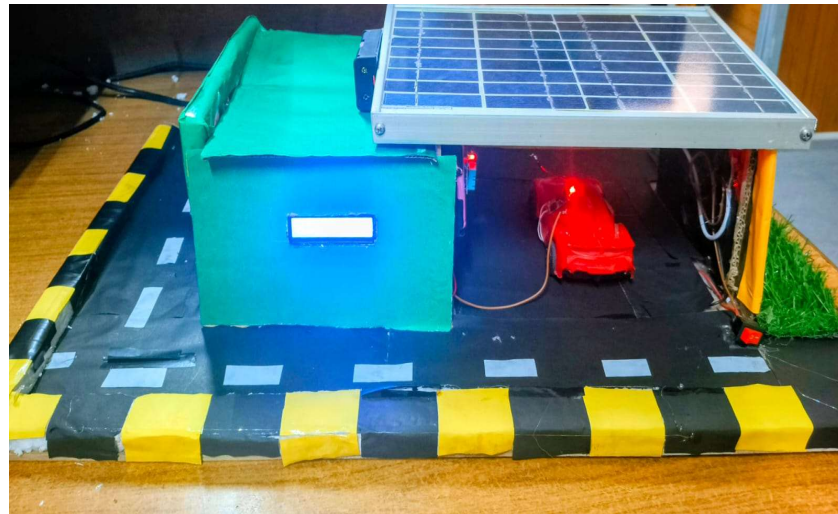


Fig .3: Hardware Prototype used for Experimental Evaluation

B. Experimental results

Test Case No.	Temperature Condition	Sensor	Charging Status
1	< 45°C		Charging ON
2	> 45°C		Charging OFF

Test Case 1: Charging ON

The Fig.4 shows that when the battery temperature is below 45°C the DHT11 sensor sends the safe

temperature value to Arduino. Arduino keeps the relay closed (ON) and charging continues normally. The transmitter coil wirelessly transfers energy to the receiver coil through inductive coupling and the EV battery gets charged. The LCD display shows the temperature, Charging ON status and the receiving voltage. As the temperature gradually increases towards 45°C the receiving voltage slowly decreases due to increase in internal resistance of the battery which can be observed on the LCD display in real time. This case represents the normal and safe operating condition of the system where EV battery charges efficiently as long as temperature remains below 45°C. Means as temperature rises the receiving voltage slowly decreases which can be clearly observed on the LCD display in real time.

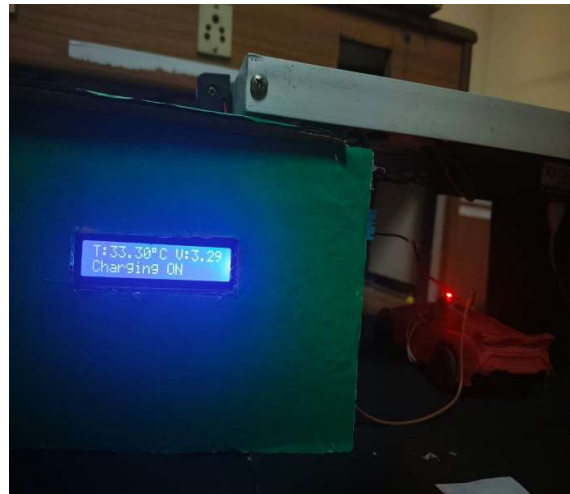


Fig .4: Charging ON Condition of EV vehicle

Test Case 2 : Charging OFF

The Fig.5 shows that when the battery temperature reaches or exceeds 45°C the DHT11 sensor sends the high temperature value to Arduino. Arduino immediately sends a HIGH signal to the relay module and the relay opens the circuit cutting off the power supply to the transmitter coil. The wireless energy transfer stops completely and the EV battery charging turns off automatically. The LCD display shows the high temperature, Charging OFF status and indicating that the safety cutoff has been triggered. Once the temperature drops back below 45°C the system automatically resumes charging without any manual reset ensuring complete protection of the system from heat damage.



Fig.4: Charging OFF Condition of EV Vehicle

CONCLUSION

This project successfully demonstrates a solar powered wireless EV charging system with automatic temperature based safety control. The system efficiently harvests solar energy and transfers it wirelessly to the EV battery through inductive coupling without any physical connection. The integration of DHT11 sensor and relay module ensures that charging is automatically stopped when temperature exceeds 45°C protecting the battery and system from heat damage. The LCD display provides real time monitoring of temperature, charging status and receiving voltage making the system user friendly and reliable.

FUTURE SCOPE

A more accurate temperature sensor can replace DHT11 for better and precise safety control. Charging efficiency can be improved by using better coil design and resonant coupling technique to transfer more power wirelessly. A mobile app can be added using Bluetooth or Wi-Fi module to monitor temperature, charging status and battery level remotely from a phone. MPPT charge controller can be used to extract maximum energy from solar panel even on cloudy days improving overall system efficiency. This system can be expanded and installed in public parking areas and EV charging stations to provide fully automatic contactless solar wireless charging supporting a cleaner and greener future.

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