

SOLAR-BASED WIRELESS CHARGING IN ELECTRIC VEHICLES

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ABSTRACT

The rapid growth of electric vehicles (EVs) has increased the demand for efficient and sustainable charging technologies. This project focuses on the development of a **solar-based wireless charging system for electric vehicles**, which combines renewable energy with wireless power transfer technology. The system uses solar panels to capture sunlight and convert it into electrical energy. The generated power is stored in a battery and then transferred wirelessly to the electric vehicle through inductive coupling.

The proposed system consists of major components such as solar panels, a charge controller, battery storage, an inverter,

transmitter coil, receiver coil, and power conditioning circuits. The transmitter coil generates a magnetic field when alternating current flows through it, and the receiver coil placed in the vehicle captures this magnetic field to produce electrical energy, which is then used to charge the EV battery.

This technology reduces dependency on conventional wired charging infrastructure and minimizes energy losses caused by cables and connectors. It also promotes the use of renewable energy, thereby reducing carbon emissions and supporting environmentally friendly transportation. The system provides convenience, safety, and efficiency by enabling automatic charging when the vehicle is parked

over the charging pad. The solar-based wireless charging system is a promising solution for future smart transportation systems, offering clean energy utilization, reduced operational costs, and improved charging convenience for electric vehicles.

Keywords: Solar-based wireless charging, electric vehicles (EV), wireless power transfer (WPT), electromagnetic induction, inductive coupling, resonant inductive coupling, photovoltaic panel, MPPT charge controller, DC-AC inverter, transmitter coil, receiver coil, rectifier circuit, lithium-ion battery, renewable energy, contactless charging, static wireless charging, dynamic wireless charging, sustainable transportation, green energy, EV battery charging.

1. INTRODUCTION

1.1 Introduction

The rapid depletion of fossil fuel reserves and the worsening effects of vehicular greenhouse gas emissions have made the development of sustainable transportation systems one of the most pressing technological priorities of the twenty-first century. Electric vehicles (EVs) have emerged as the most commercially viable and environmentally responsible alternative to conventional internal combustion engine vehicles, offering zero tailpipe emissions, higher energy conversion efficiency, and compatibility with renewable energy sources [1]. The global adoption of EVs is accelerating rapidly, driven by government incentives, declining battery costs, and increasing public awareness of climate change. However, the widespread deployment of EVs continues to be constrained by a significant infrastructure challenge — the availability of efficient, convenient, and safe charging systems that

can meet the diverse needs of EV users across residential, commercial, and public environments.

Conventional wired charging systems require physical cable connections between the charging station and the vehicle. While functional, this approach introduces several practical limitations. Cables and connectors are subject to mechanical wear and tear over repeated use, creating maintenance costs and potential failure points [2]. Exposed electrical connectors pose electric shock hazards, particularly in wet or outdoor environments. The requirement for a physical connection also imposes a manual step on the user — the vehicle must be plugged in and unplugged at every charging session — reducing the convenience that should characterize a mature EV ecosystem. These limitations have motivated extensive research into wireless power transfer (WPT) technology as a contactless alternative for EV charging [9].

Wireless power transfer technology enables electrical energy to be transmitted from a stationary charging pad to the vehicle without any physical connectors, using the principle of electromagnetic induction. A high-frequency alternating current drives a transmitter coil embedded in the charging pad, generating a time-varying magnetic field. A receiver coil mounted on the underside of the vehicle intercepts this magnetic field and induces an AC voltage that is rectified and regulated to charge the EV battery. Among the various WPT techniques explored in research — including inductive coupling, resonant inductive coupling, and capacitive coupling — resonant inductive coupling has emerged as the preferred approach for EV applications due to its ability to achieve efficient power transfer over practical air gap distances with acceptable coil misalignment tolerance [4][5].

The sustainability and energy independence of wireless EV charging systems are further enhanced by integrating solar photovoltaic (PV) energy generation as the primary power source. Solar energy is clean, abundant, and renewable — capable of powering EV charging infrastructure without grid dependency, carbon emissions, or fuel costs [3][6]. The solar-based wireless charging system proposed in this project combines a photovoltaic panel, MPPT charge controller, lithium-ion battery storage, DC-AC inverter, transmitter coil, receiver coil, and rectifier circuit into a unified, off-grid EV charging platform. By eliminating both the physical cable and the dependence on grid electricity, the proposed system represents a significant advancement toward safe, convenient, and fully sustainable electric vehicle charging [7][8].

1.2 Problem Statement

Despite the rapid growth of the EV market, the charging infrastructure available to EV users remains inadequate, inconvenient, and heavily dependent on conventional grid electricity. Wired charging stations require the user to manually connect and disconnect a charging cable at every session — an inconvenience that becomes a practical barrier in high-traffic public parking areas, shared parking facilities, and automated or autonomous vehicle environments where human intervention for cable connection is not feasible [2]. The mechanical components of wired connectors — plugs, sockets, cable insulation, and locking mechanisms — degrade progressively under repeated use and outdoor weathering, increasing maintenance costs and creating reliability concerns for charging infrastructure operators [1].

Grid-powered EV charging stations impose a significant new electrical load on distribution networks that are already operating near capacity in many urban areas. During peak EV

charging periods — typically evening hours when residents return home — this concentrated demand creates voltage sag, increased transformer loading, and power quality degradation in residential distribution feeders [7]. The carbon intensity of grid electricity also varies significantly by region and time of day — in countries where the grid is predominantly coal-powered, EV charging from the grid produces substantial indirect carbon emissions that undermine the environmental case for electric vehicle adoption. The absence of integrated renewable energy generation at existing charging stations means that the environmental benefit of switching from combustion vehicles to EVs is substantially diluted by the fossil-fuel origin of the charging electricity [3][6].

Wireless power transfer technology for EVs, while technically promising, has not yet been widely deployed due to persistent challenges around charging efficiency, coil alignment sensitivity, electromagnetic interference, and system cost. Coil misalignment between the ground-mounted transmitter and the vehicle-mounted receiver reduces power transfer efficiency significantly — a critical limitation in real parking environments where vehicle positioning is imprecise [4][5]. The conversion chain from DC solar or battery power through a DC-AC inverter to the transmitter coil, across the air gap to the receiver coil, and back through a rectifier to the EV battery involves multiple energy conversion stages, each introducing losses that cumulatively reduce overall system efficiency. Addressing these combined challenges — contactless charging convenience, renewable energy integration, coil alignment tolerance, and end-to-end efficiency — within a single cost-effective system is the central engineering problem that this research aims to solve [9][10].

1.3 Scope of the Research

This research focuses on the design, hardware implementation, and functional validation of a Solar-Based Wireless Charging System for Electric Vehicles that integrates photovoltaic energy generation with inductive wireless power transfer technology. The scope encompasses the complete energy flow path from solar energy capture through to EV battery charging — including solar panel sizing, MPPT charge controller regulation, lithium-ion battery storage, DC-AC inverter operation, transmitter coil design, wireless power transfer through electromagnetic induction, receiver coil energy capture, rectifier-based AC-to-DC conversion, and final EV battery charging [1][2].

The solar energy subsystem uses a photovoltaic panel as the primary renewable power source. The MPPT charge controller ensures that maximum available power is extracted from the solar panel at all irradiation levels by dynamically adjusting the operating point to match the panel's maximum power point. Harvested solar energy is stored in a rechargeable lithium-ion battery, which serves as the energy buffer — supplying power to the wireless charging circuit continuously, including during periods of reduced sunlight or nighttime operation [3][8]. The wireless power transfer subsystem converts the DC battery voltage to high-frequency AC through an inverter or oscillator circuit, drives the transmitter coil to generate an alternating magnetic field, and relies on inductive coupling to transfer power across the air gap to the receiver coil mounted on the underside of the electric vehicle. The induced AC voltage at the receiver coil is rectified and conditioned by a charging controller circuit before being delivered to the EV battery at the appropriate charging voltage and current [4][5].

The scope of this research includes circuit design, component selection and interfacing, prototype assembly, and experimental testing of the complete system — evaluating solar panel output voltage, battery charging voltage, wireless power transfer distance, charging efficiency, charging time, and system stability under varying operating conditions. The research does not extend to dynamic wireless charging of moving vehicles, bidirectional vehicle-to-grid (V2G) energy flow, or large-scale commercial charging station deployment — these are identified as future research directions [6][7]. The proposed system is designed as a prototype-scale demonstration of the integrated solar-wireless EV charging concept, suitable for academic validation and as a foundation for future scaling toward practical deployment in residential parking and solar EV charging stations.

2.LITERATURE SURVEY

1. Bidirectional Battery Charger for Electric Vehicles Author: Kang Miao et al. Description: This paper presents a bidirectional battery charger architecture for electric vehicles focusing on efficient energy conversion between the grid and the EV battery. The authors analyze the power electronics topology required for controlled charging and discharging operations. The study establishes foundational understanding of EV battery charging requirements and power conditioning circuits that directly inform the rectifier and charging controller design in the proposed solar wireless charging system [1].
2. Bidirectional Battery Charger with Grid-to-Vehicle and Vehicle-to-Grid Technologies Author: Pinto, J. G. et al. Description: This work examines bidirectional EV charging systems

incorporating Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) power flow capabilities. The authors evaluate the power electronics interface required for seamless transition between charging and discharging modes and analyze the impact of EV charging loads on distribution network power quality. The findings provide important context for understanding the grid dependency limitations of conventional wired charging infrastructure that the proposed solar-based wireless system aims to overcome [2].

3. Solar Powered Motor Drive Systems for Sustainable Applications Author: Bugatha Ram Vara Prasad et al. Description: This paper investigates solar PV-powered drive systems using MPPT-controlled converters for efficient energy extraction from photovoltaic panels under varying solar irradiation conditions. The authors validate that MPPT-based charge controllers maximize the power harvested from PV panels across a wide range of operating conditions. The MPPT control methodology and solar panel interfacing techniques described are directly applied in the solar energy collection subsystem of the proposed wireless EV charging system [3].

4. Three-Phase Bidirectional Battery Charger for Smart Electric Vehicles Author: Gallardo-Lozano, Milanes-Monster, and Guerrero-Martinez Description: The authors propose a three-phase bidirectional charging architecture for smart EVs with enhanced power factor correction and harmonic mitigation. The study evaluates the power conditioning requirements for efficient EV battery charging and highlights the importance of controlled AC-to-DC conversion at the vehicle side. These power conditioning and rectification principles are

applied in the receiver-side rectifier and charging controller circuit of the proposed wireless system [4].

5. Vehicle-to-Grid Reactive Power Operation Analysis Author: M. C. Kisacikoglu Description: This doctoral dissertation provides a comprehensive analysis of bidirectional EV charger operation including reactive power management and power factor control in V2G systems. The author establishes detailed models of EV battery charging behavior and inverter-based power conversion that are applicable to understanding the DC-AC inversion stage required to drive the transmitter coil in the proposed wireless charging system [5].

6. Smart Electric Vehicle — Integrated System Design Author: Bugatha Ram Vara Prasad, C. Prasanthi et al. Description: This paper presents an integrated smart electric vehicle system design incorporating solar energy, power electronics, and embedded control. The authors demonstrate how solar PV panels can be effectively integrated with EV power systems to reduce grid dependency and improve energy sustainability. This integrated design approach directly supports the solar-plus-wireless charging architecture proposed in the current system [6].

7. Grid-Connected Converter Design for Plug-in Hybrid Electric Vehicles Author: X. Zhou, S. Lukic, S. Bhattacharya, and A. Huang Description: The authors design and analyze a grid-connected bidirectional converter for plug-in hybrid EV charging applications, evaluating control strategies for stable charging operation under varying grid conditions. The study highlights the technical and operational limitations of grid-

dependent wired charging infrastructure, reinforcing the motivation for developing off-grid solar-powered wireless charging alternatives as proposed in this project [7].

8. Wireless Transmission of Electrical Power — Overview of Research and Development Author: Seglem Kripa Chariya Singh, T. S. Hasarmani, and R. M. Helmke

Description: This paper provides a comprehensive review of wireless electrical power transmission technologies, including inductive coupling, resonant inductive coupling, and microwave-based methods. The authors evaluate the efficiency, transfer distance, and practical applicability of each technique for EV charging applications. The review confirms that resonant inductive coupling offers the best balance of efficiency and air gap tolerance for practical EV wireless charging — the approach adopted in the proposed system [9].

3.EXISTING SYSTEM

Conventional electric vehicle charging infrastructure relies entirely on wired conductive charging — a method in which physical cables terminate in standardized plugs that must be manually inserted into the vehicle's charging port at every session. This physical connection requirement creates a range of practical inconveniences and technical limitations that constrain the user experience and infrastructure scalability of wired EV charging. The charging cables themselves represent significant material and maintenance costs — subject to progressive insulation degradation, connector pin wear, and mechanical damage from repeated plug-and-unplug cycles in outdoor environments exposed to temperature cycling, moisture, and ultraviolet radiation [1]. Damaged cables and connectors create electrical

shock hazards and fire risks, particularly in unattended public charging environments.

Existing wired charging stations draw power exclusively from the utility grid — either through AC Level 1 (standard household outlet), AC Level 2 (dedicated 240V circuit), or DC fast charging connections. This complete grid dependency means that the carbon emissions associated with EV charging are directly tied to the generation mix of the local electricity grid — which remains predominantly fossil fuel-based in most countries [3][6]. No energy storage buffer exists at conventional charging stations — power is drawn from the grid in real time as vehicles are charged, imposing concentrated demand peaks on distribution feeders during evening hours when EV owners typically return home and initiate charging simultaneously. This peak demand concentration causes voltage sag, transformer overloading, and power quality deterioration in residential distribution networks [7]. Furthermore, conventional wired chargers are entirely dependent on continuous grid availability — a power outage renders the charging station inoperable, leaving EV users without charging access precisely when grid stress events are most likely to coincide with high charging demand.

The wired charging interface also represents a fundamental barrier to future autonomous and robotic vehicle operation. Autonomous EVs — vehicles that operate without human drivers — cannot self-connect to wired charging stations without robotic cable-handling systems that add significant cost and mechanical complexity to the charging infrastructure [2]. The absence of self-initiating, contactless charging capability is therefore not merely a convenience limitation in the current EV ecosystem but a structural barrier to the

next generation of autonomous electric transportation. Additionally, existing charging stations provide no integration with renewable energy sources at the point of use — the connection between solar or wind generation and EV charging is mediated entirely through the grid, introducing transmission losses, grid scheduling constraints, and the full carbon intensity of grid electricity into every charging transaction [5][9].

Disadvantages of Existing System

Wired charging connectors and cables are mechanical components subject to wear, corrosion, and insulation degradation under repeated use and outdoor weathering conditions. As documented in [1] and [2], connector damage creates electrical safety hazards including shock risk and fire potential in unattended public charging environments, while cable replacement imposes recurring maintenance costs on charging station operators that reduce the economic viability of widespread deployment.

The complete dependence of existing charging stations on grid electricity ties the environmental performance of EV charging to the carbon intensity of the local grid — which remains substantially fossil fuel-based in most regions. As established in [3] and [6], grid-powered EV charging in coal-heavy electricity systems produces indirect carbon emissions that significantly reduce the net environmental benefit of switching from combustion vehicles to EVs, undermining the primary environmental justification for EV adoption.

The concentration of EV charging demand during evening peak hours imposes severe stress on residential distribution networks — causing voltage sag, transformer overloading, and harmonic distortion as demonstrated in [7]. Without integrated

energy storage or renewable generation at the charging point, conventional wired stations have no mechanism to smooth this demand peak or shift charging to periods of lower grid stress and higher renewable generation fraction.

The manual cable connection requirement makes existing wired charging systems fundamentally incompatible with autonomous vehicle operation and impractical for high-throughput public charging environments where users expect seamless, self-initiating charging without physical interaction [4][5]. The absence of contactless charging capability represents a structural limitation that cannot be resolved through improvements to wired connector technology — requiring a fundamentally different charging approach such as the solar-based wireless system proposed in this research [9].

4. PROPOSED SYSTEM

The proposed Solar-Based Wireless Charging System for Electric Vehicles presents a fully integrated, renewable energy-powered, and contactless EV charging solution that simultaneously eliminates the physical cable interface, removes grid dependency, and enables automatic self-initiating charging when the vehicle is parked over the charging pad. The system combines a photovoltaic solar panel as the primary energy source, a lithium-ion battery as the energy storage buffer, an MPPT charge controller for maximum solar energy harvesting, a DC-AC inverter to generate high-frequency AC for wireless power transmission, a transmitter coil embedded in the charging pad, a receiver coil mounted under the vehicle, and a rectifier-based power conditioning circuit that delivers regulated DC to the EV battery [1][3].

The solar energy collection stage forms the foundational power supply of the entire system. The photovoltaic panel continuously converts incident solar irradiation into DC electrical energy throughout the daylight hours. The MPPT charge controller dynamically adjusts the operating voltage of the solar panel to maintain operation at its maximum power point — ensuring that the maximum available power is extracted from the panel regardless of variations in solar irradiation intensity or ambient temperature [3][8]. This MPPT-regulated power is used to charge the lithium-ion battery storage system, which serves as the energy reservoir that powers the wireless charging circuit continuously — including during nighttime operation and periods of cloud cover when direct solar generation is insufficient. The charge controller also protects the battery from overcharging and over-discharging, extending battery service life and maintaining system reliability [6].

The wireless power transfer stage converts the stored DC battery energy into a high-frequency alternating current through a DC-AC inverter or oscillator circuit. This high-frequency AC — typically in the range of tens to hundreds of kilohertz — drives the transmitter coil embedded in the ground-level charging pad, generating a time-varying alternating magnetic field in the region above the pad surface. When the electric vehicle is parked with its receiver coil positioned directly above the transmitter coil, electromagnetic induction couples the magnetic field from the transmitter to the receiver, inducing an AC voltage in the receiver coil. The efficiency of this power transfer is governed by the mutual inductance between the two coils, which depends on coil geometry, number of turns, core material, and the air gap distance between them [4][5]. Resonant inductive coupling — achieved by tuning both

transmitter and receiver coil circuits to the same resonant frequency — enhances the effective coupling coefficient and improves power transfer efficiency and tolerance to coil misalignment compared to basic inductive coupling [9].

The power conditioning stage on the vehicle side converts the AC voltage induced in the receiver coil back into regulated DC using a rectifier circuit — typically a bridge rectifier followed by a filter capacitor. A charging controller circuit regulates the output voltage and current to the levels required for safe lithium-ion battery charging — implementing constant-current constant-voltage (CC-CV) charging protocols to protect the EV battery from overcharging while maximizing charging speed [2][7]. The final regulated DC output is delivered directly to the EV battery pack, completing the energy transfer chain from solar irradiation through to stored vehicle energy without any physical electrical connection at any point in the system. The complete system operates automatically — charging initiates when the vehicle parks over the pad and terminates when the EV battery reaches full charge, requiring no manual intervention from the user [10].

Advantages of Proposed System

The elimination of physical cable connections removes all the mechanical wear, connector degradation, and electrical safety hazards associated with conventional wired charging infrastructure. As established in [1] and [2], contactless charging significantly reduces maintenance requirements and eliminates shock and fire risks at unattended public charging locations, improving both the reliability and safety profile of the charging infrastructure.

Solar energy integration provides a fully off-grid, zero-carbon power source for EV charging — decoupling the environmental performance of the charging system from the carbon intensity of the local electricity grid. As validated in [3] and [6], solar-powered EV charging eliminates indirect carbon emissions entirely during periods of direct solar generation, making the proposed system genuinely zero-emission from energy source to vehicle wheel. The lithium-ion battery storage buffer ensures continuous charging capability through nighttime and cloudy periods, providing operational continuity that solar-only systems without storage cannot achieve.

The self-initiating automatic charging capability — activated simply by parking the vehicle over the charging pad — is fundamentally compatible with autonomous vehicle operation and reduces the user effort associated with EV charging to zero [4][5]. This represents a qualitative improvement in user experience over wired charging that addresses one of the most frequently cited practical deterrents to EV adoption among potential new users. The absence of grid dependency also means the proposed system is immune to power outage events and can be deployed in remote locations without grid access — extending the geographic reach of EV charging infrastructure far beyond what wired grid-connected stations can serve [7][9].

Circuit Diagram Explanation

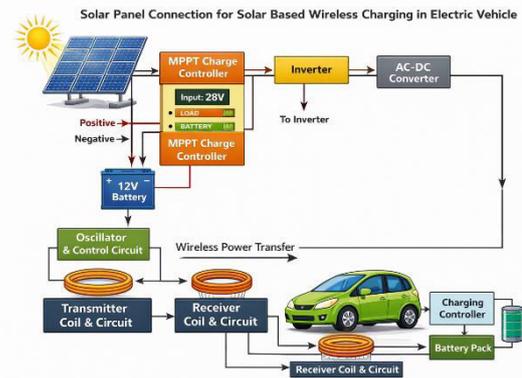


Fig1: Circuit Diagram

The complete circuit diagram of the Solar-Based Wireless EV Charging System illustrates the sequential energy conversion and transfer path from the photovoltaic source to the EV battery through nine interconnected functional blocks.

The **Solar Panel** at the input stage converts incident sunlight into DC electrical energy through the photovoltaic effect. The panel's output voltage and current vary with solar irradiation intensity and temperature, requiring active regulation before use.

The **MPPT Charge Controller** receives the variable DC output of the solar panel and continuously adjusts the electrical operating point to maintain the panel at its maximum power point — the voltage-current combination that delivers the highest instantaneous power output. The regulated output from the charge controller flows to the battery storage and simultaneously prevents overcharging by limiting charging current as the battery approaches full capacity.

The **Battery Storage** block — a lithium-ion or lead-acid rechargeable battery — accumulates solar energy during generation periods and supplies it to the wireless charging circuit on demand. It serves as the energy buffer that decouples solar generation timing from charging demand

timing, enabling nighttime and cloudy-weather charging operation.

The **DC-AC Inverter** converts the battery's DC voltage to a high-frequency alternating current. The frequency of this AC signal is tuned to match the resonant frequency of the transmitter coil circuit, maximizing power transfer efficiency through resonant inductive coupling.

The **Transmitter Coil** is driven by the high-frequency AC from the inverter. The

Solar Panel Rating	Typical Output Voltage	Application
Small PV Panel	12 V – 18 V DC	Small EV or prototype systems
Medium PV Panel	24 V – 36 V DC	Medium wireless charging setups
Large Solar Array	48 V DC or higher	High-power EV charging stations

alternating current flowing through the coil windings generates a time-varying alternating magnetic field that extends into the space above the charging pad surface. This coil is embedded in the ground-level charging pad platform.

The **Wireless Power Transfer** stage represents the contactless energy coupling zone between the transmitter and receiver coils. When the EV is positioned over the pad, the alternating magnetic field generated by the transmitter coil threads through the receiver coil windings,

inducing an AC voltage by Faraday's law of electromagnetic induction. The strength of the induced voltage depends on the mutual inductance between the coils and the operating frequency.

The **Receiver Coil**, mounted on the underside of the electric vehicle directly above the charging pad, captures the transmitted magnetic field and produces AC electrical output. This coil is connected to the vehicle-side power conditioning circuit.

The **Rectifier and Charging Controller** converts the AC output of the receiver coil to regulated DC using a bridge rectifier and filter circuit. The charging controller then conditions this DC output — regulating voltage and current — to safely deliver power to the EV battery at the appropriate charging profile.

The **EV Battery Pack** receives the regulated DC charging current and stores it as electrochemical energy — completing the full energy chain from photon to stored vehicle charge, entirely without physical electrical contact between the charging infrastructure and the vehicle.

5. RESULTS

1.Solar Panel Output Voltage

The solar panel output voltage is the electrical voltage generated by photovoltaic (PV) panels when sunlight strikes the solar cells. In a solar-based wireless charging system for electric vehicles, this voltage acts as the primary power source that supplies energy to the wireless charging circuit.

Working of Solar Panel Output Voltage

When sunlight falls on the solar panel, the

photovoltaic cells convert solar energy into direct current (DC) electricity. This DC voltage is then used to power the wireless charging system. The output voltage depends on factors such as solar radiation, temperature, and panel capacity.

Typical Output Voltage Levels

Common solar panel voltage ratings used in EV wireless charging systems include:

Voltage Regulation in the System

The voltage generated by the solar panel is not constant. Therefore, it passes through a charge controller or DC-DC converter to regulate the voltage before it is supplied to the battery storage system and the wireless power transfer circuit.

Role in Wireless Charging

The regulated solar voltage powers the inverter and transmitter coil of the wireless charging system. The transmitter coil produces an alternating magnetic field, which transfers energy wirelessly to the receiver coil installed in the EV.

Example

For example, a 100 W solar panel may produce around 18 V DC output under standard sunlight conditions. This voltage is regulated by a charge controller and stored in a 12 V battery, which then supplies power to the wireless charging transmitter circuit.

2. Typical Battery Charging Voltage

In a **solar-based wireless charging system for electric vehicles (EVs)**, the battery charging voltage depends mainly on the **battery type and number of cells connected in series**. The solar panel energy is regulated by a charge controller and then supplied to the EV battery through the wireless charging system.

Most EVs use **lithium-ion batteries**, where each cell has:

- Nominal voltage: **3.6–3.7 V**
- Fully charged voltage: **about 4.2 V per cell**

If many cells are connected in series, the total battery charging voltage increases.

Example:

- $96 \text{ cells} \times 4.2 \text{ V} = 403 \text{ V}$ full charging voltage for a typical EV battery pack

Thus, many EV battery systems operate around:

- **Nominal voltage:** ~350–400 V
- **Maximum charging voltage:** ~400–420 V

➤ Battery Charging Voltage in Solar Wireless Charging System

In a solar-based wireless EV charging system, the charging voltage flow is typically:

Solar Panel Output → 18–48 V
(depending on panel array)

Charge Controller / DC-DC Converter

→ regulates voltage

Wireless Power Transfer System →

transmits power inductively

Receiver & Rectifier → converts AC to DC

EV Battery Charging Voltage → about 350–420 V for a 400-V EV system

➤ **Example Calculation**

If an EV battery pack has 96 lithium-ion cells in series:

- Voltage per cell (full charge) = **4.2 V**
- Total charging voltage =
 $96 \times 4.2 = 403.2 \text{ V}$

So, the **battery charging voltage** \approx **400 V**.

Battery charging voltage in a solar-based wireless EV charging system depends on the EV battery configuration. Lithium-ion batteries typically require about **4.2 V per cell for full charging**. When many cells are connected in series, the total pack voltage becomes around **350–420 V in most EVs**. The solar energy collected by panels is regulated by a charge controller and converted through the wireless power transfer system before being applied to the EV battery at the required charging voltage.

3. Wireless Power Transfer Distance

Wireless power transfer (WPT) is used in a **solar-based wireless charging system** to

transfer electrical energy from a **transmitter coil (charging pad)** to a **receiver coil installed in the electric vehicle** through **electromagnetic induction**. The transfer distance is an important factor that affects the efficiency and charging speed.

In most EV wireless charging systems, the distance between the transmitter and receiver coils is usually small.

- **Typical distance: 5 cm – 20 cm**
- **Optimal operating distance: 10 cm – 15 cm**

Keeping the coils close together improves the **magnetic coupling** and increases the charging efficiency.

➤ **Distance in Solar-Based Wireless EV Charging**

In a solar-based wireless charging setup:

- **Solar panels** generate electrical energy.
- The energy is regulated using a **charge controller and inverter**.
- Power is supplied to the **transmitter coil embedded in the charging pad**.
- The **receiver coil in the EV** receives the energy wirelessly.

air gap between the coils (transfer distance) is normally **10–15 cm**, which

allows efficient energy transfer while maintaining safe vehicle clearance.

➤ **Factors Affecting Wireless Power Transfer Distance**

Several factors influence the effective transfer distance:

- **Coil size and design**
- **Operating frequency**
- **Alignment between transmitter and receiver coils**
- **Power rating of the system**
- **Magnetic coupling efficiency**

If the distance increases beyond the designed range, **power transfer efficiency decreases significantly.**

➤ **Example**

If the **transmitter coil is installed on the ground** and the **receiver coil is mounted under the EV**, the gap between them may be:

- Ground clearance of vehicle: **12 cm**
- Effective wireless charging distance: **≈12 cm**

4. Typical Charging Efficiency

Charging efficiency refers to the **ratio of useful electrical energy stored in the EV battery to the total energy generated by the solar panel.** In a solar-based wireless charging system, some energy is lost during **power conversion, wireless transmission, and battery charging**, which reduces overall efficiency.

The overall efficiency of a solar wireless EV charging system depends on several stages:

Overall system efficiency:

Approximately **60% – 75%** depending on system design and operating conditions.

Working Explanation

Solar panels convert sunlight into DC electricity.

A **charge controller** regulates the voltage and current.

The power is supplied to the **transmitter coil** which generates a magnetic field.

The **receiver coil in the EV** captures the magnetic energy and converts it back to electrical energy.

A **rectifier and battery management system (BMS)** charge the EV battery.

During each stage, **small power losses occur**, which reduce the final charging efficiency.

6. CONCLUSION

The solar-based wireless charging system for electric vehicles (EVs) provides an innovative and sustainable solution for future transportation. By integrating solar energy generation with wireless power transfer technology, the system enables electric vehicles to charge without physical cables while using renewable energy. This approach helps reduce dependence on conventional electricity sources and support environmentally friendly mobility. The project demonstrates that solar panels can effectively generate electrical energy, which

can be stored and transferred wirelessly through inductive coupling between transmitter and receiver coils. The experimental setup shows that wireless charging is convenient, safe, and reduces the wear and tear associated with traditional plug-in charging systems. Although the efficiency of wireless power transfer is slightly lower than wired charging and depends on proper coil alignment and distance, the technology has strong potential for improvement. With advancements in power electronics, better coil design, and improved energy storage systems, solar wireless charging can become more efficient and widely adopted. In conclusion, solar-based wireless charging for electric vehicles is a promising technology that promotes clean energy utilization, enhances user convenience, and contributes to the development of smart and sustainable transportation systems. Future work can focus on improving charging efficiency, increasing power transfer range, and implementing dynamic wireless charging on roads for continuous EV charging. The integration of solar-based wireless electric vehicle charging stands as a beacon of sustainable innovation in the realm of transportation. This system not only taps into the abundant potential of renewable energy through solar panels but also revolutionizes the charging process with wireless technology. By sidestepping conventional power sources, it ushers in a new era of eco-conscious mobility, drastically curtailing carbon emissions and lessening the burden on our environment. This represents a pivotal stride towards a cleaner, more convenient, and ultimately more sustainable transportation landscape. The solar based wireless electric vehicle charging system exemplifies the kind of transformative solutions needed to address the urgent challenges of our time and pave the way for a

greener future. Solar-based wireless charging is a clean and innovative solution for EV charging. It uses renewable solar energy and eliminates the need for cables. The system reduces carbon emissions and dependency on grid power. It supports sustainable and smart transportation for the future.

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