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"Next-Generation Four-Port Isolated Pv Ev Charger with Integrated Ac and Dc Charging Solutions"

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ABSTRACT

This research introduces a pioneering 4-port isolated photovoltaic (PV) based electric vehicle (EV) charger designed to support both alternating current (AC) and direct current (DC) charging. The integration of four ports enhances charging flexibility and efficiency, catering to the evolving needs of electric vehicle users. The system harnesses solar energy through photovoltaic panels, ensuring a sustainable and eco-friendly charging solution. The isolation mechanism ensures safe and reliable charging by preventing ground loops and minimizing electrical hazards. By accommodating both AC and DC charging, the charger adapts to various EV models, offering a versatile and future-proof solution. This research contributes to the advancement of renewable energy integration into transportation infrastructure, promoting cleaner and more resilient mobility options in the growing electric vehicle market.

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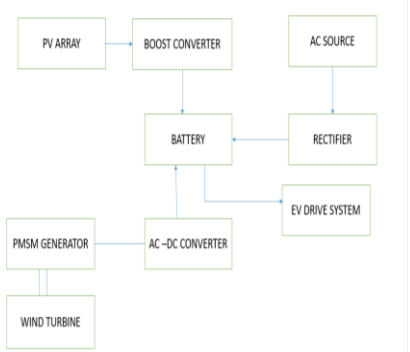
INTRODUCTION

In the wake of the accelerating global transition towards sustainable transportation, this research presents a ground breaking development in electric vehicle (EV) charging infrastructure 4-port isolated photovoltaic (PV) based EV charger. As concerns over environmental impact and energy sustainability continue to drive the paradigm shift toward electric mobility, the need for versatile and efficient charging solutions becomes increasingly imperative. This innovative charger not only taps into renewable energy through PV panels but also offers a dual charging capability, supporting both alternating current (AC) and direct current (DC) charging. The integration of photovoltaic technology sets this EV charger apart as a sustainable and environmentally conscious solution .The charger's ability to support both AC and DC charging standards further positions it at the forefront of adaptability, accommodating various EV models and user preferences. As electric vehicles become increasingly prevalent, this research aims to address the evolving needs of the market by presenting a comprehensive and [1] forward-looking charging solution that aligns with the principles of renewable energy integration. Crucially, the incorporation of isolation in the charger design emphasizes safety and reliability. This feature mitigates potential risks associated with ground loops and electrical hazards, ensuring secure charging operations for both the vehicles and the grid. This research not only responds to the immediate challenges of electric mobility but also anticipates and accommodates the future complexities of an evolving market, making substantial contributions to the sustainable integration of renewable energy in the transportation sector.

BLOCK DIAGRAM



Block diagram

A proposed system integrating photovoltaic (PV) arrays, a boost converter, an AC source, a battery, rectifier, electric vehicle (EV) drive system, AC-DC converter battery, permanent magnet synchronous motor (PMSM) generator, and a wind turbine can create a comprehensive renewable energy solution. The PV array and wind turbine act as primary

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renewable energy sources, capturing solar and wind energy, respectively. The collected energy is then fed into a boost converter to optimize voltage levels [2] before being stored in a battery. To enhance the efficiency of the system, an AC-DC converter connected to the battery can convert stored DC energy into AC for broader compatibility with various applications. The rectifier helps in converting AC from the grid to DC for battery charging or supplying power to the EV drive system. The EV drive system, powered by the integrated energy sources, provides a clean and sustainable solution for electric transportation. Additionally, the PMSM generator can be employed to harvest energy from the vehicle's motion and feed it back into the system, increasing overall efficiency and sustainability. The proposed system offers a holistic approach to renewable energy utilization, combining solar and wind power, energy storage, and electric transportation [3] in an interconnected and efficient manner. The integration of these components creates a resilient and sustainable energy ecosystem that contributes to reducing reliance on conventional energy sources and mitigating environmental impacts.

COMPONENTS EXPLANATION

PV Array (Photo voltaic Array):

A collection of solar panels that convert sunlight into electrical energy using photovoltaic cells. The generated DC (direct current) electricity is typically used to charge batteries or fed [4] into an inverter for conversion to AC (alternating current).

Boost Converter:

A boost converter is an electronic circuit that increases the voltage of a DC power source. It's often used in solar power systems to efficiently step up the low voltage generated by the PV array to a higher level for charging batteries or other applications.

AC Source:

In the context of renewable energy systems, this could refer to an external AC power source that can supplement the energy supply or serve as a backup. It might be [5] connected to the system through an inverter.

Rectifier:

A rectifier is a device that converts AC to DC. In the context of your description, it may be used to convert AC power from the grid (or other AC sources) to DC, which can be utilized by the system.

Battery:

Energy storage devices that store electrical energy in chemical form. Batteries are crucial for storing excess energy generated by renewable sources like solar panels or wind turbines [6] , allowing for a consistent power supply when the primary source is unavailable.

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EV Drive System:

The electric vehicle drive system is the mechanism that propels an electric vehicle. It includes components like the electric motor, power electronics (inverters, converters), and the controller responsible for managing [7] power distribution and optimizing efficiency.

AC-DC Converter:

This component converts alternating current (AC) to direct current (DC). It may be used to convert the AC power from the grid or other sources into DC power suitable for charging batteries or powering DC loads.

PMSM Generator (Permanent Magnet Synchronous Generator):

A type of generator that converts mechanical energy into electrical energy using a permanent magnet to create a rotating magnetic field. PMSM [8] generators are commonly used in wind turbines for power generation.

Wind Turbine:

A device that converts the kinetic energy of the wind into electrical energy through the rotation of blades connected to a generator. Wind turbines are a common source of renewable energy.

SMPS (Switched-Mode Power Supply):

The SMPS is responsible for regulating and converting the variable output voltage from the PV array into a stable and reliable DC voltage suitable for charging the battery and powering the system's electronics.

Arduino Controller:

The Arduino controller serves as the central processing unit of the system, controlling and coordinating the operation of various components based on input from sensors and user commands.

HARDWARE DESCRIPTION

PV PANNEL

PV panels convert sunlight into electrical energy through the photovoltaic effect, generating direct current (DC) electricity .Photovoltaic (PV) technology harnesses sunlight to generate electricity, offering a sustainable and renewable energy source. PV systems consist of solar cells, typically made of semiconductor materials like silicon, which absorb photons from sunlight. As sunlight strikes the solar cells, it liberates electrons, creating a flow of electric current. These cells are interconnected in a panel to enhance power output. The basic building block of a solar panel is a solar cell, where sunlight stimulates the movement of electrons, generating a direct current (DC) voltage [9] . Multiple solar cells are connected in series and parallel to form a solar module, and these modules are combined to create a solar array. To optimize power generation, the solar array is often installed at an angle or tracking system to align with the sun's position throughout the day. The generated DC power is then converted

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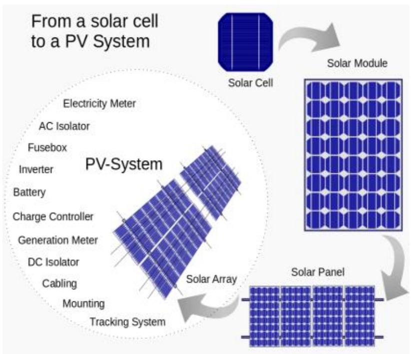
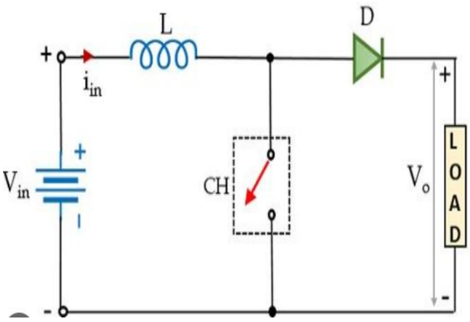
into usable alternating current (AC) electricity through inverters for integration into the electrical grid or for direct use in various applications. The importance of photovoltaic (PV) technology lies in its capacity to provide a clean and sustainable energy source, mitigating environmental impact and reducing dependence on finite fossil fuels. The primary objective of PV systems is to convert sunlight into electricity, offering a decentralized and renewable energy solution [10]. By harnessing solar power, PV technology contributes to a more resilient and diversified energy grid, fostering energy independence and security. Additionally, the widespread adoption of PV systems aligns with global efforts to combat climate change, as solar energy generation produces minimal greenhouse gas emissions.



PV System

In a simplified diagram, solar cells within a solar panel absorb sunlight and produce DC electricity. The solar panels are organized into modules, and these modules are connected to form a solar array. The DC output from the solar array is then directed to an inverter, which converts it into AC electricity [18] suitable for use in homes, businesses, or integration into the power grid [11]. This diagram illustrates the fundamental components of a PV system, highlighting the role of solar cells, panels, inverters, and the solar array in the generation and conversion of solar energy.

BOOST CONVERTER



Boost Converter

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The emergence of electric vehicles (EVs) has significantly influenced the development of charging infrastructure. This paper presents the design and implementation of a 4-port isolated PV-based EV charger capable of supporting both AC and DC charging. The charger integrates boost converters to efficiently harness solar energy [12] and deliver it to EVs, ensuring compatibility with various charging standards. This solution addresses the growing need for sustainable transportation and renewable energy integration. The rapid adoption of EVs necessitates versatile charging solutions that can accommodate different power sources and charging standards. Traditional charging infrastructure relies heavily on grid electricity, which may not always be sustainable or environmentally friendly. To address these challenges, integrating photovoltaic (PV) [13] technology into EV chargers presents a compelling solution. By leveraging solar energy, EV charging becomes more sustainable and decentralized. However, designing an efficient and versatile charger that can handle both AC and DC charging while incorporating PV technology requires careful consideration of various components, including [17] boost converter. The primary objective of this study is to design and implement a 4-port isolated PV-based EV charger capable of supporting both AC and DC charging. The charger aims to maximize the utilization of solar energy, minimize grid dependency, and ensure compatibility with different EV models and charging standards. By integrating boost converters, the system aims to efficiently manage [19] power flow from PV panels to EVs, optimizing charging performance and energy utilization. Additionally, the charger seeks to provide isolation between the grid, PV array, and EVs for enhanced safety and reliability [14] .The proposed 4-port isolated PV-based EV charger offers several advantages over conventional charging solutions. Firstly, by harnessing solar energy, it reduces reliance on grid electricity, leading to lower operational costs and reduced environmental impact. Secondly, the integration of boost converters enhances energy efficiency by optimizing power conversion and delivery to EVs. Additionally, the charger's ability to support both AC and DC charging enables flexibility and compatibility with a wide range of EV models and charging standards. Furthermore, the isolation provided by the system ensures safety and reliability [15], protecting against electrical faults and ensuring uninterrupted charging. The versatile nature of the 4-port isolated PV-based EV charger makes it suitable for various applications across residential, commercial, and public charging infrastructure. By efficiently harnessing solar energy and supporting both AC and DC charging, the charger offers versatility, energy efficiency [16], and compatibility with various EV models and charging standards. Its applications span across residential, commercial, and public charging infrastructure, contributing to the widespread adoption of electric vehicles and renewable energy [20] integration.

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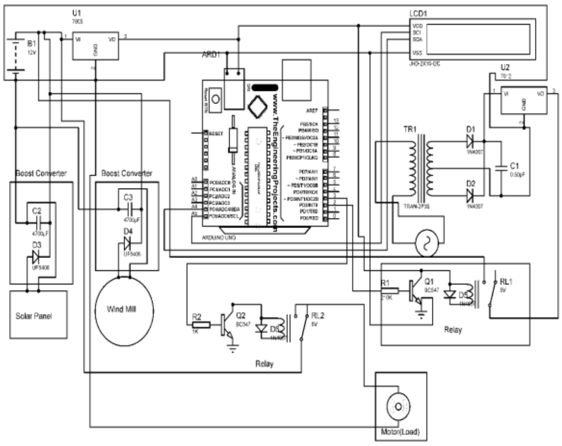
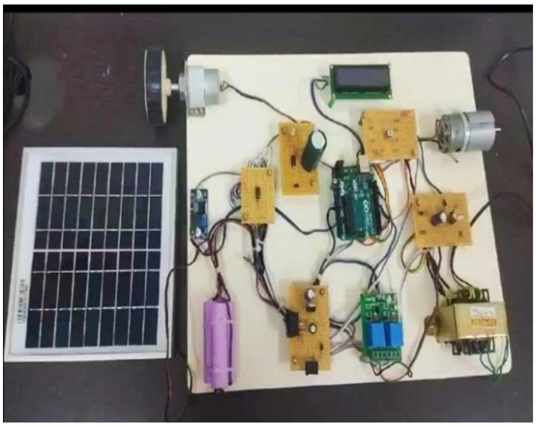
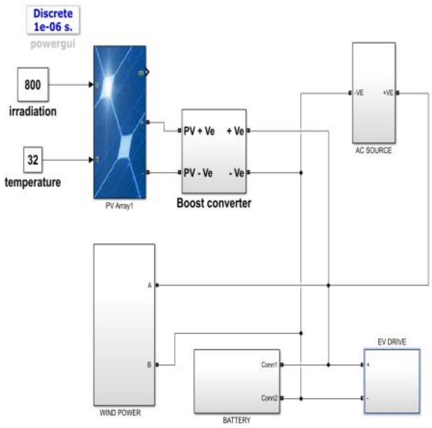
HARDWARE KIT&CIRCUIT DIAGRAM



Circuit diagram



Hardware Circuit diagram



Four port System.

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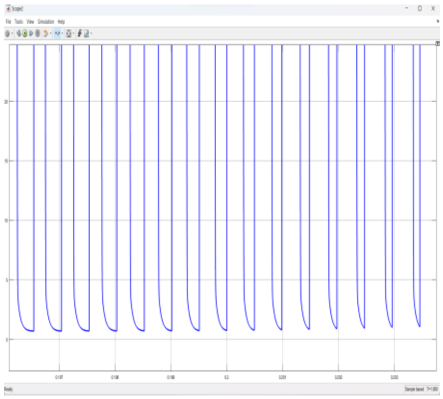
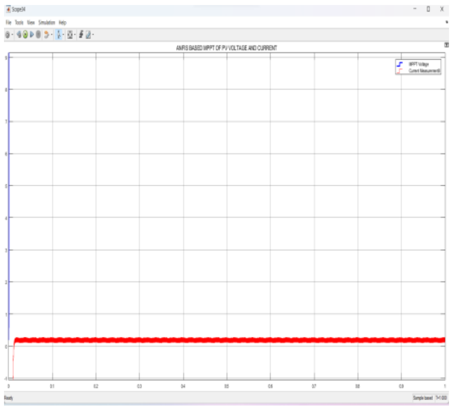


Simulation wave form.



Waveform of ANFIS Based MPPT of PV Voltage and Current

CONCLUSION

The development of a 4-port isolated PV-based EV charger with support for both AC and DC charging represents a significant stride towards sustainable and efficient electric vehicle infrastructure. The integration of photovoltaic (PV) technology ensures a cleaner and more environmentally friendly energy source for charging, leveraging solar power to reduce dependence on traditional grid electricity. The isolated design enhances safety by minimizing the risk of electrical hazards and ensuring reliable performance across all four charging ports. Furthermore, the dual support for AC and DC charging enhances the versatility and compatibility of the EV charger, catering to a wide range of electric vehicle models with varying charging requirements. This flexibility is crucial for accommodating the diverse needs of electric vehicle users and fostering widespread adoption. The 4-port configuration not only allows for concurrent charging of multiple vehicles but also contributes to more efficient utilization of charging infrastructure, potentially reducing wait times and promoting the accessibility of electric mobility.the 4-port isolated PV-based EV charger, equipped with AC and DC charging capabilities, signifies a robust and sustainable solution for the growing

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electric vehicle market. Its technological advancements not only address environmental concerns but also offer practical benefits such as safety, compatibility, and enhanced charging efficiency, contributing to the promotion and integration of electric vehicles in the broader transportation landscape.

FUTURE SCOPE

Looking ahead, the future scopes for a 4-port isolated PV-based EV charger with support for AC and DC charging are promising and aligned with the ongoing trends in renewable energy and electric vehicle (EV) technology. One significant avenue for development lies in the optimization of energy storage solutions, allowing the charger to store excess solar energy during periods of low demand and supply it during peak charging times. This approach not only enhances grid stability but also ensures a continuous and reliable power supply for electric vehicles, reducing dependence on external power sources. Another exciting future scope involves the integration of smart grid technologies and advanced communication systems. Implementing intelligent charging algorithms and real-time data exchange can enable the charger to dynamically adjust its charging rates based on grid conditions, energy prices, and the availability of renewable energy. This smart functionality would contribute to a more efficient use of resources, cost savings for EV users, and a reduced environmental impact by optimizing the utilization of renewable energy sources. Furthermore, on-going research and development efforts could focus on enhancing the scalability and modularity of the 4-port EV charger. This would grid (V2G) systems and bidirectional charging, enabling electric vehicles to not only consume energy but also contribute back to the grid during peak demand, creating a more interactive and sustainable energy ecosystem. In summary, the future scopes for a 4-port isolated PV-based EV charger encompass advancements in energy storage, smart grid integration, and modular design to further enhance its efficiency, sustainability, and adaptability in the evolving landscape of electric mobility and renewable energy.

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