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Standalone Solar Power Recharging Station with Auxiliary Device - Inverter

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Abstract- This project explores the design and implementation of a standalone solar inverter system integrated into electric vehicle (EV) recharging stations. The system is engineered to facilitate the charging of auxiliary devices such as mobile phones, laptops, and other electronics during the EV charging period. Because it can be seen that these devices are Buit for giving maximum output at rated voltage range that is 200~250V AC,50 Hz Supply, a solution that is economical, for the People Buying Electric vehicle for their Commutation from one place to Another. This Project Can be Implemented at Long Expressways where there is Lack of Facility of Charging. This Inverter can also help people living in remote location to access electricity.

Keywords: Electric Vehicle, Charging, Expressways

1. INTRODUCTION

In the present age of increased focus on sustainable and efficient energy solutions, the development of infrastructures driven by renewable sources has become a key objective. This academic paper discusses the design and implementation of a stand-alone solar-powered recharging station with an added inverter device. The novel system is designed to harness solar energy, directly converting it from a 12V DC source to a 220V AC output at 50Hz. This conversion is essential, as it allows the recharging station to charge electric vehicles (EVs) at a higher rate than traditional AC adapters when connected to a DC source, while also improving the charging efficiency of mobile phones and laptops, which operate best at 220V AC and 50Hz. By the addition of an inverter, the system avoids the inefficiencies of traditional charging methods, thereby offering a versatile solution to the diverse power requirements of modern electronic devices and EVs. The proposed recharging station represents a significant step in maximizing energy use from renewable sources, reducing dependence on traditional power grids, and promoting the use of green technology in daily practices.

2. ABBREVIATIONS AND ACRONYMS

EV: Electric Vehicle
AC: Alternating Current
DC: Direct Current
W: Wattage
PV: Photo Voltaic

3. UNITS

F = Farad, V = volts
H = Henry, Ω = Ohms

4. EQUATIONS

4.1 $V = v - Ir$
V: Voltage output of the PV module
v: Open-circuit voltage (the maximum voltage when no current is flowing)
I: Current
r: Series resistance

4.2 $I = I_{ph} - I_0(e^{\frac{V+IRs}{nV_t}} - 1)$
I_{ph}: Photo-generated current
I_0: Saturation current
V: Voltage across the PV module
R_s: Series resistance
n: Ideality factor (a factor that reflects the quality of the diode)
V_t: Thermal voltage, which depends on temperature

5. OVERVIEW OF THE RECHARGING STATION

Fig : EV(electric bike recharging using our system)

The standalone solar power recharging station is engineered to function as a multifaceted charging solution, exhibiting several key capabilities. It is capable of swiftly recharging electric vehicles when interfaced with a DC source, ensuring minimal downtime for EV users. Additionally, it facilitates efficient charging of mobile phones and laptops by providing a stable output of 220V AC at a frequency of 50Hz. The station incorporates an ammeter to offer real-time monitoring of the charging process, thereby enhancing user oversight and system performance. Furthermore, it employs diodes to safeguard against reverse current, effectively protecting the system components from potential damage. This comprehensive design ensures that the recharging station is both reliable and efficient, catering to a wide range of charging needs.

6.COMPONENTS AND SPECIFICATIONS

S. no	Component	Rating
1.	Solar Panel	50W,12~24V(as Available)
2.	Voltmeter	0~400V
3.	Diodes	
4.	Capacitor	5mF~50mF
5.	Ammeter	0~10A or 0~5A rating

Table 6.1

6.1 Solar Panels

We have installed 4 Solar Panel of 12V 50 W Rating which gives 48 V DC Voltage output which is greater than many of the Battery capacities present in small Ev like electric bicycles and E-Rickshaw The Solar panel were of Exide Company

6.2 Inverter

The DC to AC inverter is designed to convert 12V DC input from solar panels into a 220V AC output at 50Hz. It features high conversion efficiency to minimize energy loss. To ensure effective thermal management, the inverter is equipped with heat sinks and cooling fans that dissipate heat generated during operation. This design not only maximizes energy utilization but also enhances the overall reliability and performance of the system.

6.3 Ammeter

The device is designed to display the charging current in real-time, providing users with up-to-date information on the charging process. It is mounted in a prominent position for easy monitoring, allowing users to effortlessly check the status at a glance. Additionally, the indicator shows the decrease in current over time, effectively illustrating the progression of the battery charging process. This feature ensures users have a clear understanding of the charging status and can make informed decisions based on the displayed information.

6.3 Protective Diodes

The diodes are strategically arranged within the circuit to serve specific purposes. They prevent reverse current flow from the electric vehicle back to the solar panels or inverter, thereby safeguarding the system from potential damage. Additionally, these diodes protect sensitive components from voltage spikes and current surges. Schottky diodes are selected for their low forward voltage drop and fast switching capabilities, making them ideal for enhancing the circuit's overall efficiency and reliability

Solar Panels: The solar panels are rated to provide a 12V DC output. In this specific setup, four solar panels are used to generate a combined output of 48V, which is necessary for the 36V battery of the EV in question. The capacity of these panels is sufficient to supply a continuous power output of 200W. They are strategically positioned to maximize solar irradiance and energy capture.

Inverter: The inverter used is of the DC to AC type. An input of 12V DC is drawn from the solar panels and is converted to an output of 220V AC at 50Hz. This inverter is designed to ensure high conversion efficiency, thereby minimizing energy loss. Heat sinks and cooling fans are incorporated as cooling mechanisms to dissipate the heat generated during operation.

7. CIRCUIT DESIGN AND IMPLEMENTATION

7.1 Inverter Circuit

Inverter Circuit's Performance

Imagine an orchestra where each instrument plays a critical role in a harmonious symphony. Here, our inverter circuit takes center stage, converting a humble 12V DC input into a grand 220V AC output. The Oscillator Circuit is like the conductor, generating a rhythmic square wave signal at 50Hz, guiding the ensemble. Switching Devices such as MOSFETs or transistors act as skilled musicians, switching the DC input in perfect synchrony with the conductor's baton. The Transformer is the powerful brass section, stepping up the voltage from 12V AC to a resonant 220V AC, amplifying the melody. Finally, the Filtering Stage serves as the string section, smoothing the square wave output to approximate a melodious sine wave, ensuring every AC device can enjoy the refined performance. Together, these components create a masterpiece of electrical engineering, an efficient and reliable inverter circuit symphony.

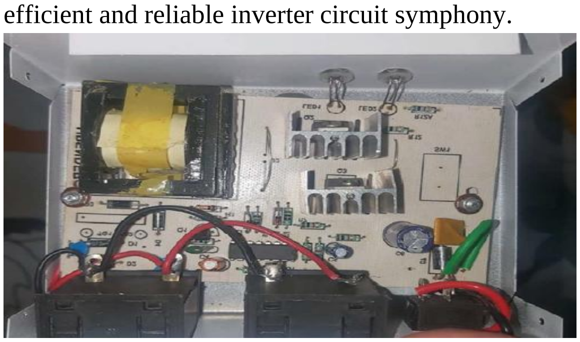

Fig 7.1 : Inverter Circuit Implemented

8. SYSTEM DESIGN, METHODOLOGY & OBSERVATION

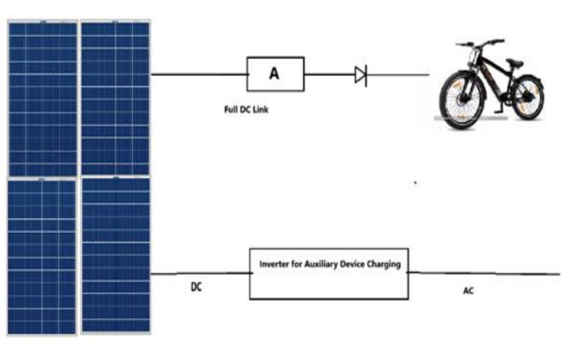

Fig 8.1 : System Design

With the installation of the solar panel and inverter setup, the setup demonstrated a highly efficient operation. The output was closely monitored through an ammeter in series with the load, which gave instantaneous readings in terms of the charging process. The electric vehicle was charged at a highly accelerated rate, with the battery level being raised from 50% to 90% in half an hour—15 minutes less than what would typically be achieved by a standard AC adapter. This significant reduction in charging time shows the efficiency of the system. The main function of the installed diodes was to block the flow of reverse current from the electric vehicle battery to the solar panel. This role is of particular significance in cases where shading by clouds or other atmospheric factors results in a voltage drop from the solar panels. By incorporating these diodes, the system ensures that the integrity of the charging process is maintained, while at the same time safeguarding the solar panels from possible damage caused by reverse current. In general, the design and execution of this setup not only maximize charging efficiency but also offer sturdy protection to the system components, thus improving reliability and performance. The application of AC (Alternating Current) rather than DC (Direct Current) for charging electronic devices has a number of technical benefits. AC is more efficient for the transmission of electricity over long distances, owing to less energy loss compared to DC, and therefore is well-suited for power distribution within electrical grids and charging systems. Furthermore, AC can be easily stepped up or down in voltage through transformers, thus enabling flexible and efficient power distribution. This facility is crucial in providing the appropriate voltage levels required for charging various electronic devices. The majority of modern electronic devices and appliances are designed to operate using alternating current (AC) power, which is the norm in homes and businesses. AC charging is used to offer compatibility with existing infrastructure. AC charging systems are also normally designed with safety features and conform to standardization across regions, thus the offer of secure and reliable operation. This reduces risk from electrical hazards during charging. AC is normally applied for charging electronic devices due to effective transmission, compatibility with transformers and devices, and standardized safety features. It has also been noted that the electronic device adapter generates less heat compared to direct current (DC) input.

9. CIRCUIT DESIGN AND IMPLEMENTATION

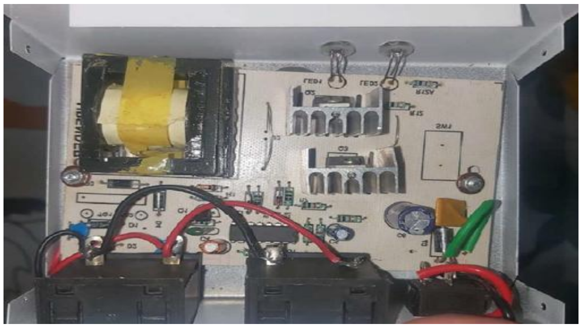

Fig 9.1 : Real Circuit Design

The inverter circuit is an essential component in converting a 12V DC input into a 220V AC output, enabling the use of standard AC devices with a DC power source. This process involves several key components working together in harmony to achieve the desired result. First, the oscillator circuit plays a crucial role by generating a square wave signal at a frequency of 50 Hz. This signal serves as the foundation for the AC output, providing the necessary timing for the subsequent stages of the circuit. Without this precise oscillation, the entire process would be ineffective, as the switching devices rely on this signal for synchronization. Next, the switching devices, which typically consist of MOSFETs or transistors, come into play. These components are responsible for switching the DC input on and off in synchronization with the oscillator output. This rapid switching action converts the steady 12V DC input into a pulsating waveform, which is essential for the transformation process that follows.

The transformer is another vital component in the inverter circuit. Its primary function is to step up the voltage from the initial 12V AC (resulting from the switching stage) to the desired 220V AC output. This significant increase in voltage is achieved through the transformer's winding ratios, which are carefully designed to provide the necessary voltage transformation while maintaining efficiency and stability.

Finally, the filtering stage ensures that the output waveform closely approximates a sine wave, which is the ideal form for AC devices. This stage smoothens the square wave output generated by the oscillator and switching stages, reducing harmonic distortion and improving the overall compatibility with AC devices. The filtering process typically involves the use of inductors and capacitors, which work together to eliminate unwanted high-frequency components and create a more stable and clean output signal.

In summary, the inverter circuit's ability to convert a 12V DC input into a 220V AC output relies on the precise coordination of its key components: the oscillator circuit, switching devices, transformer, and filtering stage. Each component plays a specific role in ensuring that the final output is both effective and compatible with standard AC devices.

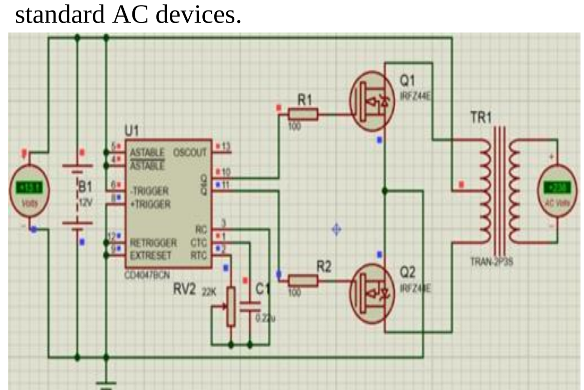

Fig 9.2: Inverter Circuit Diagram

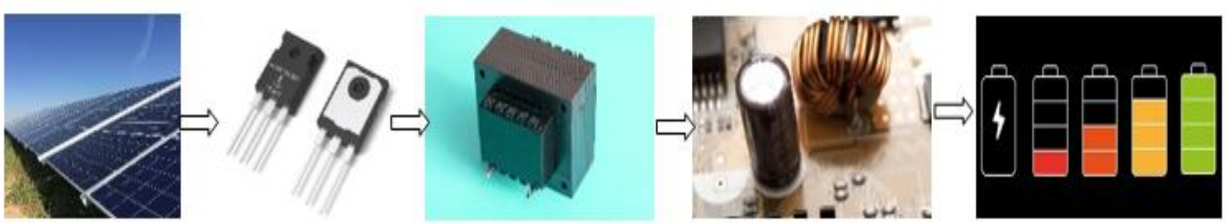

Fig 9.3: Working of Whole Project Chart

9.1 Ammeter Integration

The ammeter is connected in series with the load to measure the current flowing into the battery or device being charged. As the battery charges, its internal resistance increases, causing the charging current to decrease. This change is displayed on the ammeter, providing a visual representation of the charging progress.

9.2 Diode Protection Scheme

Within the circuit, diodes are strategically placed to prevent reverse current flow. A diode is positioned between the EV and the inverter to prevent current from flowing back into the inverter when the EV battery possesses a higher voltage than the inverter output. Similarly, a diode is located between the inverter and the solar panel to block reverse current that might potentially damage the solar panels during load fluctuations or when the inverter is off. The diodes are selected based on specific criteria: their voltage rating must be above the maximum expected voltage in the circuit, and their current rating must be adequate to handle the maximum possible current without overheating.

10. OBSERVATION

Fig 10.1 At Starting

Fig 10.2: After 30 Min

Based on our comprehensive project observations, we have identified several critical advancements in the field of electric vehicle (EV) technology. First and foremost, the speed of charging for electric vehicles has significantly increased. This enhancement is not merely incremental but represents a substantial leap forward, reducing the time required to charge EVs and thereby increasing their convenience and usability for everyday users. The implications of this improvement are vast, potentially leading to greater adoption of electric vehicles as the charging process becomes more efficient and user-friendly. Additionally, the performance of the inverter used for auxiliary device charging has shown remarkable improvements. The inverter, a key component responsible for converting direct current (DC) from the EV battery to alternating current (AC) for auxiliary devices, has exhibited enhanced efficiency. One of the most noteworthy observations is the substantial reduction in the heating of the adapter and power electronic components. In previous iterations, these components would often become excessively hot during operation, leading to potential risks and inefficiencies. However, in the latest observations, these components have remained relatively cool, indicating a significant improvement in thermal management. This reduction in heating not only enhances the safety and reliability of the system but also suggests improved energy efficiency, as less energy is lost as heat. This advancement in thermal management is crucial for the longevity and performance of the power electronics involved, ensuring that they operate within optimal temperature ranges and reducing the likelihood of thermal-related failures. In summary, the observations from our project indicate a dual advancement in electric vehicle technology: a marked increase in the speed of EV charging and a substantial improvement in the thermal management of power electronic components used for auxiliary device charging. These advancements collectively contribute to a more efficient, safe, and user-friendly electric vehicle ecosystem.

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12. AUTHORS' BIOGRAPHY

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