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PV INTEGRATED WIRELESS CHARGING ARCHITECTURE FOR ELECTRIC VEHICLES UTILIZING MODIFIED TRANS QUASI Z-SOURCE BOOST CONVERTER

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Abstract:

The Photovoltaic (PV) systems harness solar energy by converting sunlight directly into electricity through semiconductor materials.This renewable energy technology offers a sustainable and eco-friendly alternative to fossil fuels, helping to reduce greenhouse gas emissions and dependence on non-renewable energy sources. This is a PV integrated wireless charging architecture for electric vehicles utilizing modified trans quasi z-source boost converter. The PV system integrated with advanced power electronics for efficient energy conversion and management. It begins with the photovoltaic cells generating voltage (Vpv) and current (Ipv), which are fed into a modified trans quasi Z-source boost converter. The Z-source boost converter utilizes PWM to enhance the output voltage, which is then processed by a high-frequency inverter.The output PWM signals are directed to an LC tank circuit, facilitating resonance and efficient energy transfer. A high-frequency isolation follows, ensuring safety and performance in the subsequent stages. The system includes an interleaved PWM rectifier to convert AC back to DC for charging an EV battery. The overall process is optimized by an Artificial Neural Network (ANN) Maximum Power Point Tracking (MPPT) algorithm, which maximizes energy harvest from the PV system. A Proportional-integral (PI) controller ensures that the output voltage (Vact) aligns with the reference voltage (Vref), enhancing system stability and efficiency. Finally the project is implemented by using a MATLAB 2021a simulink.

Keywords: Integration with PV Systems, Communication Protocols, Grid Interaction, Battery Management Systems.

1. INTRODUCTION

Due to the increasing demand for energy and the decrease in fossil fuels, solar and wind energy production as renewable energy sources have recently attracted great attention. Transformer less inverter (TI) is considered a promising technology to higher performance. In traditional transformer less photovoltaic systems, stray capacitors are connected to photovoltaic (PV) modules. This capacitor generates usable mode voltage and stray current, which are dangerous and cause electromagnetic interference (EMI). That is true. Preventing or protecting against current leakage is important because it can affect personal safety and cause negative energy. To solve this problem, many studies have been carried out that not only affect the leakage current, but also increase the electrical and thermal performance by reducing the number of components in the inverter topology scheme (power transformers, capacitors, inductors and diodes).

Most of these materials decrease the spillage current by: interfacing the lattice unbiased point to the unbiased point of the DC transport to create the voltage constant; photovoltaic cluster) associated. Utilizing the primary and moment arrangements, the spillage current can be constrained in a few ways, but these arrangements cannot be utilized to set the stream to zero.

Current MLIs can be isolated into three bunches: cascade H Bridge (CHB), neural point-clamped converter (NPC), and variable capacitor (FC) inverter. For such MLI, numerous semiconductor gadgets and isolated DC circuit are required, which increments control complexity, exchanging misfortunes, driver competition, and by and large fetched and measure. As arrangement to the inadequacies of conventional MLI, SC has received different adaptable photovoltaic interface line association frameworks. Compared with the MLI show, it makes numerous contrasts in control methodology, estimation voltage, moo control utilization, etc. The SC-based topology does not require extraordinary control to adjust capacitor voltages. So also, a few SC-based topologies can bolster DC voltage input in a certain way.In reality, SC charges the capacitor from the DC transport to make a virtual DC source, and the SC is associated in arrangement or parallel with the DC source in one phase. In this manner, SC-based inverters don't require extra control to adjust the capacitor voltage compared to conventional NPC and FC-based MLIs.

2. LITERATURE SURVEY

Technology-driven far reaching integration of housetop sun powered photovoltaics is causing major physical and specialized changes in dissemination control frameworks.

Yuming Liao *et al* [2023] have proposed a novel framework using the SIs connected to the three-phase four-wire weak grid under asymmetric faults. To make the 3∗3 permission demonstrate framework for the inverter subsystem whereas taking into consideration the stage and recurrence coupling impacts within the occasion of a kilter blame.

Udoka C. Nwaneto*et al* [2023] have developed the architecture using the dynamic phasor (DP) method to develop efficient simulation models for a single-phase two-stage grid-connected photovoltaic (PV) system. The two proposed DP models, DP-Full and DP-Simp, disentangle the DC side show of the inverter by combining the flow of the PV capacitor and boost inductor into a first-order work and computing the MPP (greatest control point) voltage and current systematically.

Liang-Rui Chen *et al* [2022] have proposed the architecture using the battery current-sharing power decoupling (BCSPD) method for hybrid photovoltaic (PV) power systems is proposed in this paper. The string PV module and the recommended BCSPD circuit are associated in parallel to form a single-stage engineering.

Josef Hrouda *et al* [2024] have proposed a novel framework using the newly designed reactive power control method for single-phase photovoltaic (PV) inverters. The control focuses on easy application and autonomous actions. With the help of voltage control and active loss optimization, the regulation is made to ensure efficient network operation and reactive power conservation.

Xianfeng DAI *et al* [2022] have proposed a novel framework using the traction power supply system (TPSS) of high-speed railways. A TPSS with a coordinates PV era framework is recommended in arrange to achieve NS remuneration and decrease vitality request. An NS compensating approach and a specific topology are given based on the auxiliary highlights of the PV framework and the TPSS.

Ganesh Moorthy Jagadeesan *et al* [2022] have developed the architecture using the two-stage single-phase grid-connected solar-PV (SPV) system with maximum power point (MPP) estimation. In arrange to assess the PV panel's real-time MPP and as it were work at the MPP or on the right-hand side (RHS) of the PV characteristics, it looks for to create and test a modern control framework.

Venkata R. Reddy *et al* [2022] have proposed a novel framework using the grid voltage sensor less protection scheme for OCC based single-phase inverter systems is proposed. The assessed voltage at the point of common coupling (VPCC) is utilized to disengage the lattice amid islanded circumstances, execute voltage ride through conditions, and secure the framework amid over/under voltage conditions of the lattice.

Sudipto Mondal *et al* [2023] have proposed a novel framework using the single-phase five-level SC based transformerless inverter is proposed for grid-tied PV systems. Since of their promising qualities, such as extended efficiency, light weight, sensible taken a toll, and sensible control thickness, transformerless grid-connected inverters have drawn a portion of ask approximately charmed in renewable essentialness interface applications.

AmirullahAmirullah*et al* [2024] have implemented the architecture using the Unified power quality conditioner (UPQC) is a power electronics device consisting of a series active filter (Se-AF) and a shunt active filter (Sh-AF) connected in parallel through a DC-link circuit to overcome power quality problems of voltage sag, voltage swell, and non-linear (NL) load.

Abdelbaset Laib *et al* [2022] have proposed a novel framework using the single-phase thirteen-level packed E-cell inverter (PEC13) for grid-tied photovoltaic (PV) systems. PEC13 topology contains six control switches, two four-quadrant switches and four DC capacitors.

3. MODELING AND CONFIGURATION OFPV INTEGRATED WIRELESS CHARGING ARCHITECTURE

In order to incorporate distributed generation (DG) and electric vehicle (EV) charging stations (CS), distribution systems have undergone significant improvements in recent years. By reducing load growth, the DG integration enhances system dependability and performance. EVs are regarded as a future form of transportation that will lessen reliance on fossil fuels and global warming. According to studies, charging EVs during off-peak hours raises greenhouse gas (GHG) emissions; yet, removing coal-based power generating lowers GHG emissions. The performance of the distribution system may be impacted by EV charging. To lessen the effects of EV charging and cut down on greenhouse gas emissions, charging stations could incorporate renewable energy sources (RES). The advantages of employing RES and EVs are increased when RES and EV charging stations are positioned correctly.

Concerns about increased grid load and greenhouse gas emissions from charging EVs using traditional power sources have led to a growing incorporation of RES into EV charging stations. By using wind farms, the effect of EV charging on the grid is negligible. However, it is not advised that wind farms be integrated with CSs since wind-powered charging stations are not practical to use in urban areas. As a result, a lot of academics are focused on CSs based on solar PV. Technical assessments of solar PV-grid based CSs and solar PV-based charging systems are available. There are a number of advantages to integrating solar PV systems with EV charging stations. The authors looked into installing PV-equipped EV charging stations on parking lot rooftops. By connecting the DGs to charging stations, energy losses are reduced. According to a study, a solar PV system and sophisticated energy management can significantly lessen the impact of EV charging. The advantages of employing solar PV integrated CS are examined from an economic and environmental perspective. The authors created a PV integrated CS with the capacity to compensate for reactive power.

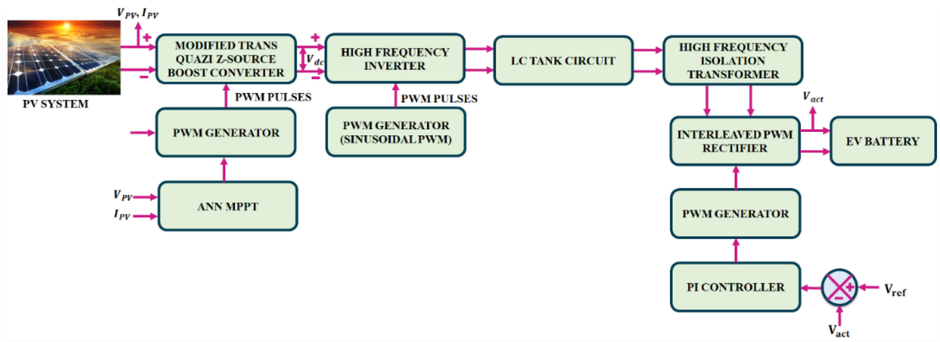

Figure 1: System-Block Diagram

This is a PV integrated wireless charging system for EVS using a modified Trans quasi Z-source boost converter. When PV cells first generate voltage (Vpv) and current (Ipv), the improved boost converter uses PWM to process the data and increase the output voltage. The PWM signals are routed to an LC tank circuit for effective energy transfer via resonance after this output is fed into a high-frequency inverter. To guarantee performance and safety, a high-frequency isolation transformer is employed. In order to convert the AC back to DC for EV battery charging, the system incorporates an interleaved PWM rectifier. An artificial neural network is used for MMPT in order to maximize energy harvesting from the PV system. By keeping the output voltage (Vact) steady and in line with the reference voltage (Vref), the proportional-integral (PI) controller improves the overall system performance and efficiency. Finally, the entire system is validated through a MATLAB simulation 2021a.

4. RESULTS AND DISCUSSIONS

The entire work is implemented in MATLAB simulation and the following results are obtained.

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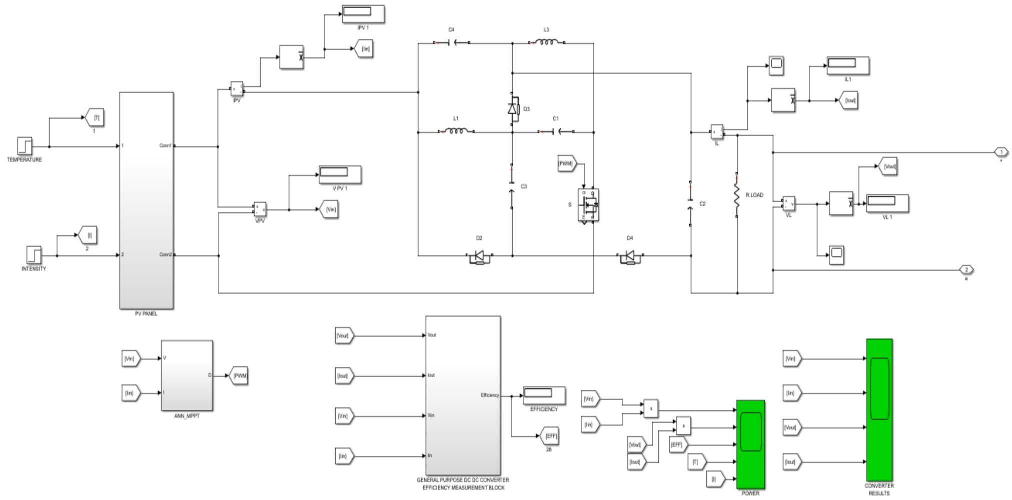

Figure 2 Overall Simulation Diagram

The fig 2 illustrates a overall simulation design, likely for a control system. It features various components, including sensors, relays, and microcontrollers, organized into distinct blocks for functionality. The top section appears to handle input signals, while the middle section processes these signals using operational amplifiers and logic gates. The output section, located at the bottom, shows connections for external devices or indicators. This structured layout emphasizes modularity, allowing for efficient troubleshooting and enhancements in the overall system design.

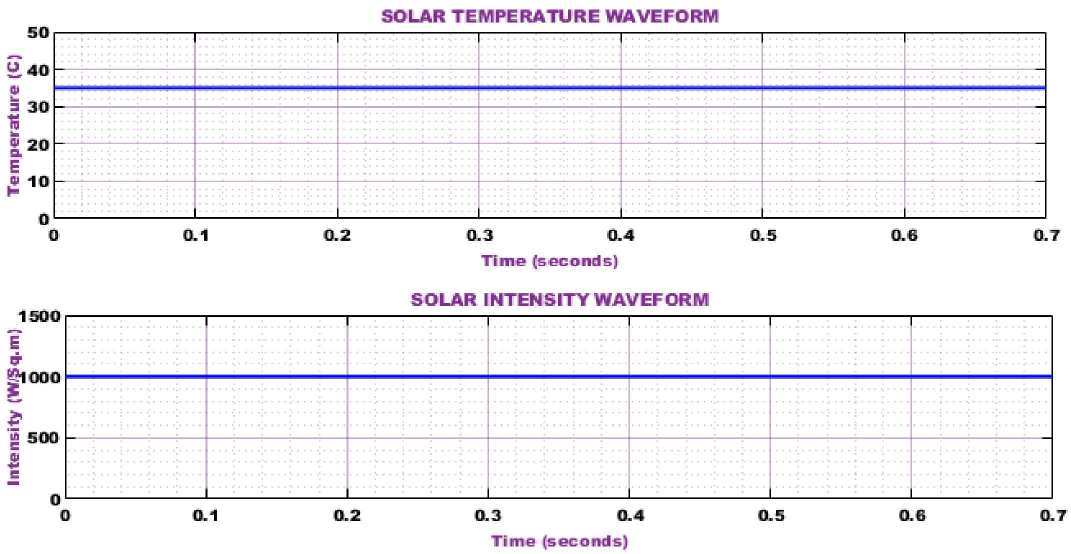

Figure 3 Solar Temperature And Intensity Waveform

The fig 3 displays two waveforms illustrating solar data over time. The upper graph represents the solar temperature, consistently maintaining a level of 40°C across the time span of 0 to 0.7 seconds, indicating stability in temperature measurements. The lower graph depicts solar intensity, measured in W/m², but shows a flat line, suggesting no variation or activity during the observed interval.Together, these waveforms provide insights into the solar conditions, highlighting the stable temperature and lack of intensity changes.

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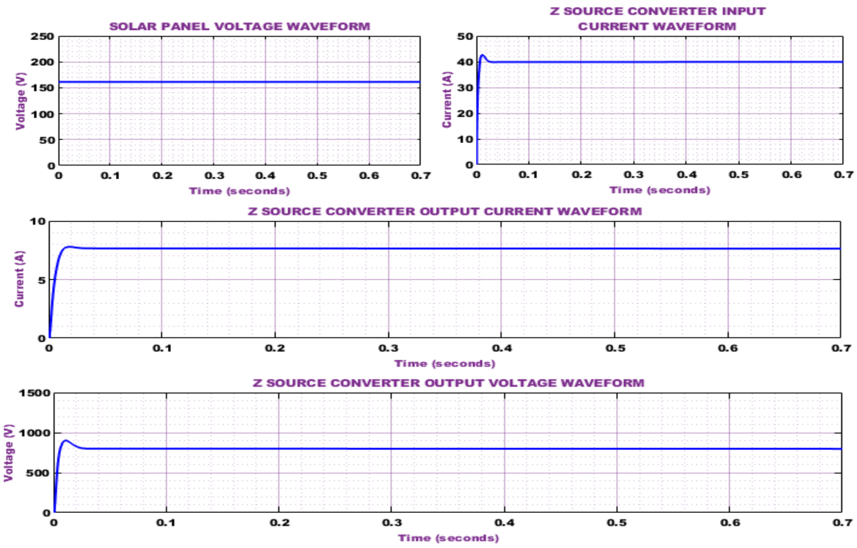
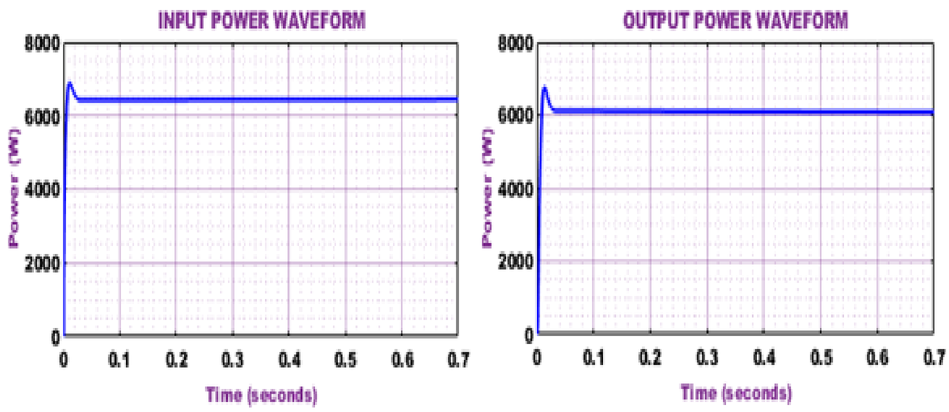


Figure 4 Solar Panel Voltage Waveform and Z Source Converter Input and Output Waveforms

The above multiple waveforms represent the performance of a solar energy system. The upper left graph shows the solar panel voltage, which remains steady at approximately 50 volts over the observed time of 0 to 0.7 seconds, indicating a consistent power output from the solar panel. The upper right graph depicts the input current to the Z-source converter, displaying a stable value of around 30 amps, suggesting efficient energy transfer. The lower two graphs illustrate the converter's output.

Figure 5 Input Power And Output Power Waveform

The fig 5 shows a two power waveforms: the input power on the left and the output power on the right. The input power remains steady at around 6000 watts throughout the time duration of 0 to 0.7 seconds, indicating a stable energy supply to the system. Conversely, the output power displays a slight dip but maintains a relatively constant level, suggesting efficient energy conversion. Together, these waveforms illustrate the system's effectiveness in processing and delivering energy consistently.



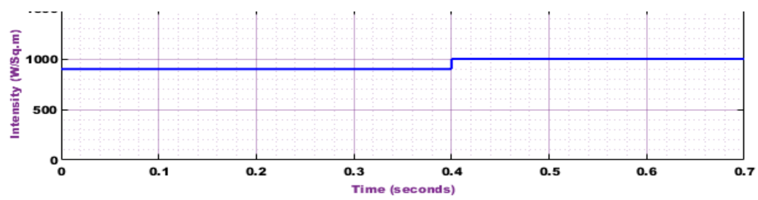


Figure 6 Solar Temperature And Intensity Waveform

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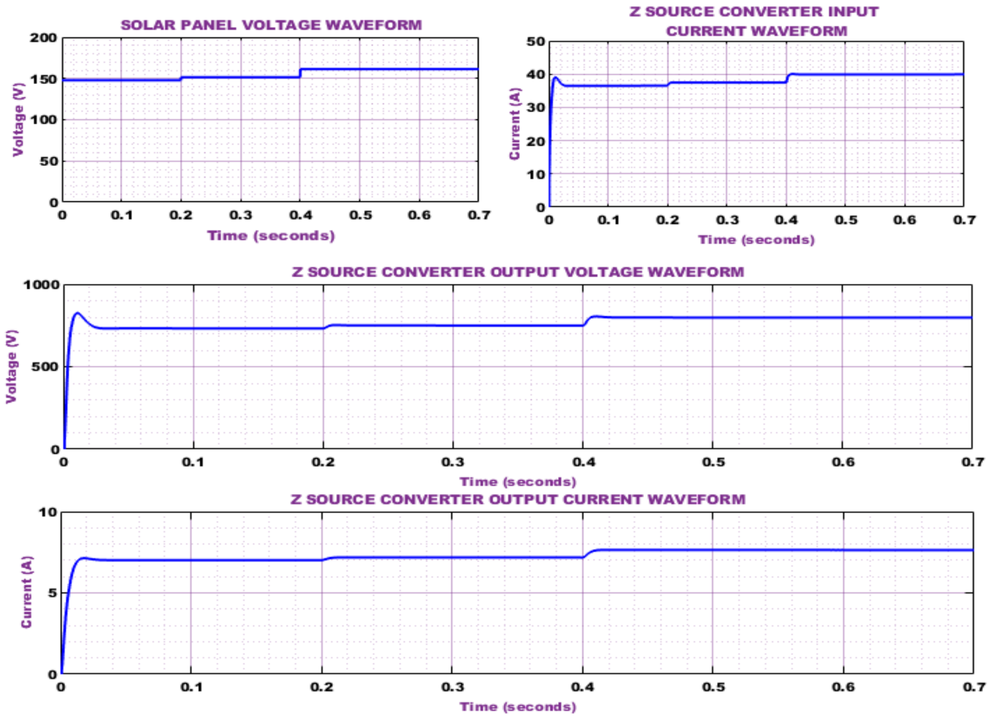
The fig 6 illustrates two waveforms: solar temperature and solar intensity. The upper graph shows the solar temperature, which remains steady at approximately 40°C across the time span of 0 to 0.7 seconds, indicating consistent thermal conditions. The lower graph represents solar intensity, holding stable at around 800 W/m² during the same period. This stability in both temperature and intensity suggests that the solar energy system operates under constant environmental conditions, crucial for optimal performance and energy generation.

Figure 7 Solar Panel Voltage Waveform and Z Source Converter Input and Output Waveforms

The fig 7 displays four waveforms related to a solar energy system, highlighting the performance of solar panel output and a Z-source converter. The upper section features the solar panel voltage waveform, which remains stable at approximately 48 volts throughout the 0 to 0.7 seconds time frame. Accompanying this, the Z-source converter input current waveform shows a consistent current of about 50 amps, indicating a steady flow of energy into the converter. Below, the Z-source converter output voltage waveform also maintains a stable level, suggesting efficient energy transformation.Finally, the output current waveform reflects a steady current, demonstrating the converter's effectiveness in delivering power. Overall, these waveforms illustrate the reliability



and efficiency of the solar energy system in converting and managing electrical output.

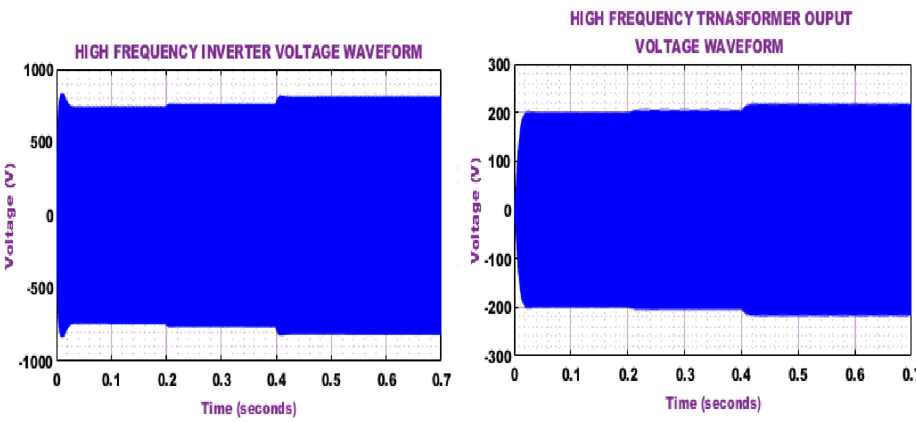


Figure 8 High Frequency Inverter And Transformer Output Voltage Waveform

The fig 8 illustrates two voltage waveforms: the high-frequency inverter voltage on the left and the high-frequency transformer output voltage on the right. The inverter voltage waveform fluctuates between approximately -500 volts and +500 volts, indicating the inverter's role in converting direct current to alternating

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current. In contrast, the transformer output voltage remains stable around -200 volts, demonstrating effective voltage transformation. These waveforms highlight the operational characteristics of the inverter and transformer, showcasing their importance in managing electrical energy in high-frequency applications.

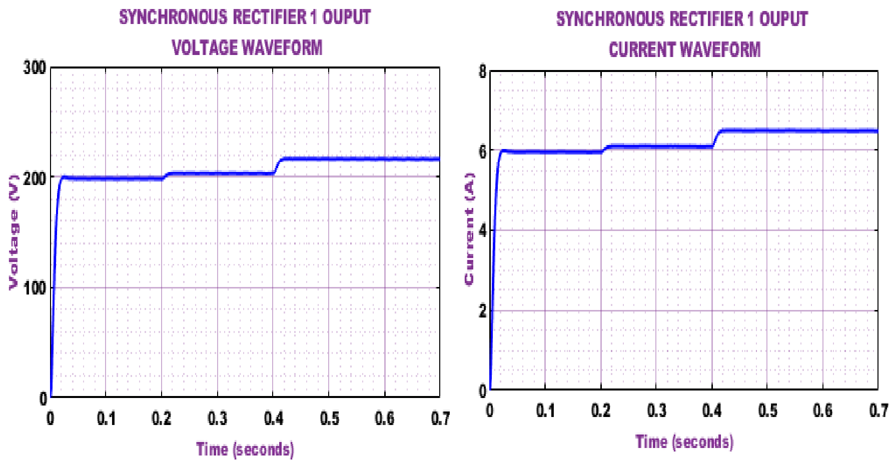

Figure 9 Synchronous Rectifier 1 Output Voltage and Current Waveform

The fig 9 displays the output characteristics of a synchronous rectifier, featuring two key waveforms: voltage on the left and current on the right. The voltage waveform stabilizes around 200 volts after a brief initial fluctuation, indicating consistent performance in converting AC to DC. Meanwhile, the current waveform reaches approximately 6 amperes, demonstrating effective current flow through the rectifier. Together, these waveforms reflect the synchronous rectifier's efficiency in providing stable voltage and current, essential for reliable power delivery in electronic circuits.

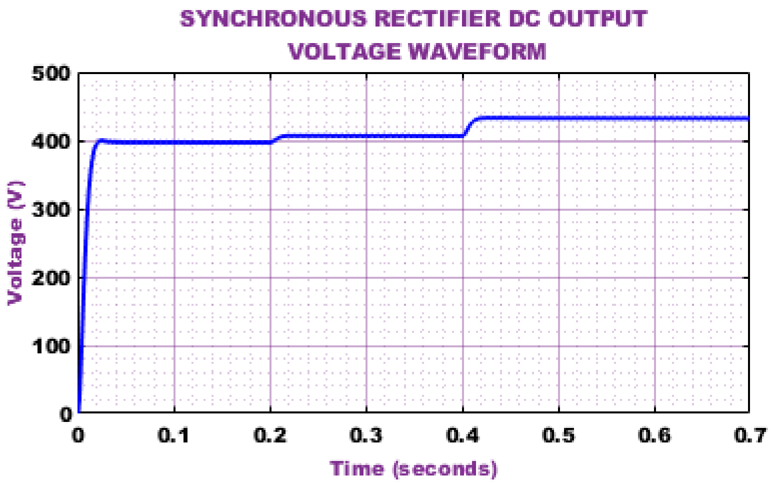

Figure 10 Synchronous Rectifier Dc Output Voltage Waveform

The fig 10 displays the voltage output of a synchronous rectifier over a time span of 0.7 seconds. Initially, the voltage increases rapidly, reaching a peak around 500 volts. After a brief transient phase, the voltage stabilizes near 400 volts, indicating a steady DC output. This stability is crucial for applications requiring consistent voltage levels. The waveform illustrates the rectifier's effectiveness in converting AC to DC, ensuring reliable performance in various electronic systems and enhancing overall energy efficiency.

5. CONCLUSION

This paper presents an innovative solution for electric vehicle (EV) wireless charging by integrating a photovoltaic (PV) system with a Modified Trans quasi Z-source boost converter. The prepared architecture

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efficiently converts solar energy into usable electrical power, optimizing energy management with advanced power electronics. The PV system generates voltage and current, which are processed by the modified Z-source boost converter, utilizing PWM to enhance the output voltage. The high-frequency inverter, LC tank circuit, and isolation transformer ensure efficient energy transfer and safety. The interleaved PWM rectifier converts AC back to DC for charging the EV battery, while the ANN and MPPT algorithm maximizes energy harvest from the PV system. The Proportional-Integral (PI) controller stabilizes the output voltage, maintaining it in line with the reference voltage for optimal performance. The system's design and implementation in MATLAB 2021a Simulink demonstrate the potential for high efficiency, reliability, and scalability in the wireless charging of electric vehicles. This approach promises to be a significant step forward in clean, sustainable energy solutions for electric mobility.

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