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Article Title: An Intelligent Control Technique for Grid Tied PV with Hybrid Storage System

An Intelligent Control Technique for Grid Tied PV with Hybrid Storage System

S. Rajakumar[1], C. Shonic Regan[2]

[1]PG Student of Electrical Engineering, Marthandam College of Engineering and Technology, Kuttakuzhi, Tamilnadu, India. strajakumar1997@gmail.com

[2]Assistant Professor, Department of Electrical and Electronics Engineering, Marthandam College of Engineering and Technology, Kuttakuzhi, Tamilnadu, India. shonicreegan@macet.edu.in

ABSTRACT

An intelligent control method for a grid-tied system made up of photovoltaic panels, a grid connection, and technologies to convert solar energy into electricity is presented in this study. The DC/DC Z source SEPIC (Single-Ended Primary Inductor Converter) converter controller is included into the hybrid storage system to manage battery charging and discharging. In order to reduce stress on the power components and provide intrinsic short-circuit protection, the Z-source system serves as a safeguard between the input and output stages also it increases the dependability of the converter. The primary innovation is the use of artificial neural networks (ANN) for both the bidirectional converter's control and the assessment of the battery's state of charge is monitored by Recurrent Neural Network (RNN).The gating categorization for the converter is produced by incomes of PI, which be contingent on the projected SOC. The performance and robustness of the proposed control strategy are explained by the simulation results produced in the MATLAB/Simulink environment and the voltage gain comparison of the Z source Sepic converter has 10V also the comparative analysis are carried out in this study.

Keywords: Recurrent Neural Network, PWM – Pulse Width Modulation, Photovoltaic System, Artificial Neural Networks, PI – Proportional Integral Controller.

1 Introduction

Due to the use of renewable energy sources, storage devices, and advanced control algorithms on power converters, the development of generation technology-based hybrid renewable/storage systems has recently been touted as one of the biggest successes in the power sector. Due to technological advancement, PV systems are among the most promising RESs. By lowering the possibility of RESs having inconsistent power supply, SSs ensure that the load demand is continually satisfied [1-2]. A coordinated smart charging control system in a PV-BESS integrated EV charging station to manage BESS operation and prevent overloading of the grid connection transformer. Additionally, BESS is controlled to minimize the intermittent impact of PV by regulating the output of PV power according to the transformer's loading and PV availability [3]. The power management between the PV-battery unit and other generating

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units is the major emphasis of both of these techniques, despite the fact that they both successfully control power demand and output. Furthermore, systems with DC buses and loads are not taken into account by these approaches. A hybrid PV-battery-diesel system employs a hierarchical control algorithm that regulates the AC bus voltage by the hydropower generator and manages the active and reactive power by the PV-battery unit in a PV-battery-hydropower system. However, in the event that the hydropower or diesel generator is not operational, neither of these methods takes the voltage regulation into account [4-5].

The peak demand, overall demand, total generation, and SOC of storage solutions are taken into account while developing the recommended management plan. In general, the adaptive droop control is created for the best regulation of battery storages' charging and discharging to maintain the system's lifespan with changes in power output. Techniques for controlling and managing power are addressed in order to track the power converters' working point more quickly for improved dynamic responsiveness and a decrease in the battery's charging and discharging rate [6-7]. In this study, a centralised control system that efficiently and flexibly manages power flows between power sources, loads, and utility grid is proposed as a control and power management system for PV-battery systems. The proposed approach is successful in seamless transitions between grid-connected and islanded operating modes, voltage regulation on both DC and AC buses, and rapid power balancing in the hybrid PV-battery system [8-9]. The single phase inverter used to feed the link voltage to the grid helps with the DC-AC conversion, and the PI controller then synchronizes the grid. In this work, the voltage is either increased or lowered using a Z source Sepic converter. With the help of PI, the calculated SOC is used to construct the gating sequence for the converter [10]. The contribution of the paper is to design a Z Source Sepic converter for hybrid vigor storing scheme such as Battery and Perfect Capacitor and to control the Z Source Sepic converter using ANN Controller and to monitor the battery SOC and current by using RNN Controller also to reduce the switching losses and increase the power transfer ratio.

2 Proposed System Explanation

This smart battery will have a DC-DC bidirectional converter as well as its own battery monitoring unit. This converter will be utilized for charging as well as for discharge. In this work, a Z source Sepic translator is used to boost or reduce the voltage. The gated pattern for the converters is created using ANN and is determined by the predicted SOC. With a Non-isolated Bidirectional DC-DC converter, the power supply and super capacitor function as a means of storing electricity.

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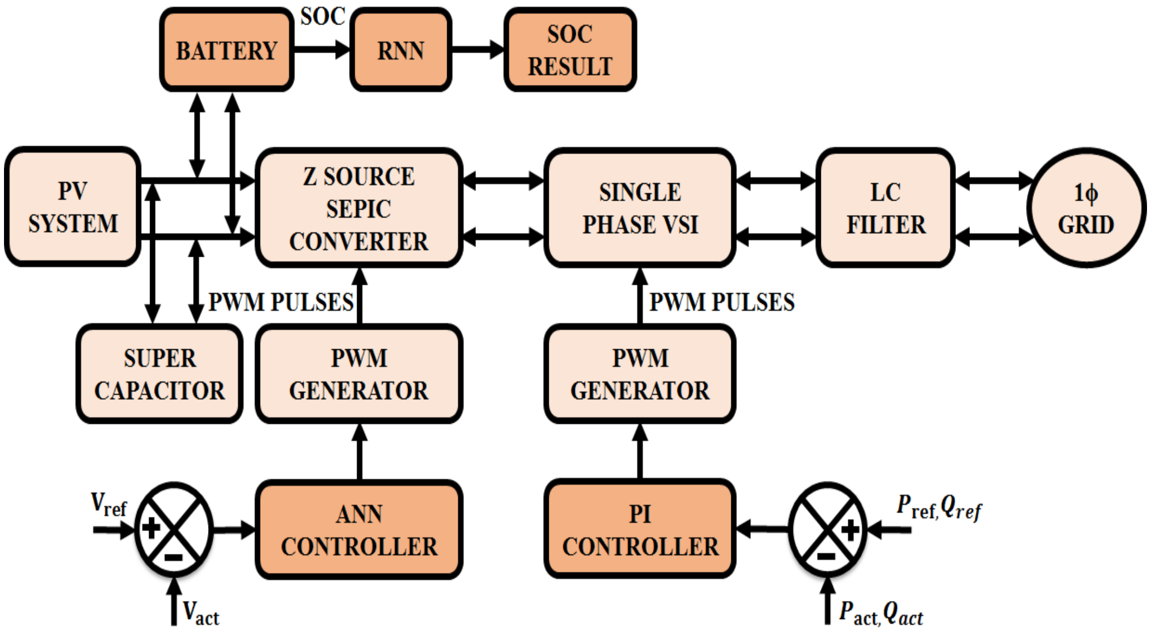

Figure 1: *Proposed Diagram*

The suggested system employs Z source Sepic converters to provide a hybrid energy storage system that blends grid-connected PV installations with battery SOC. A switched Z source Sepic converter is a high gain conversion used to boost the output voltage of a PV source. It is linked to a photovoltaic (PV) system. The resultant signal is sent to the LC filter's single phase VSI connector. When the voltage that the converter generates is compared to the referencing voltage, an error is created. When this mistake is sent into the ANN administrator, the signal for control is created. The PWM generator creates PWM pulses based on this control signal, which regulates the conversion action of the converter and produces a regulated output with no distortion. With the assistance of an RNN controller, the sequence's State SOC is followed in order to achieve both its accusing and clearing procedures.

3 Proposed System Modelling

3.1 PV panel

A semiconductor transistor that has been unprotected to light is a solar cell. Insufficient of the variously energetic subdivisions in this solar output are caught at the p-n contact. In contrast to band gap, this sector employs the greatest energy rays. A single diode is utilized to construct comparable devices that are frequently used to represent PV cells, which offers a better balance between accuracy and usability. In Figure 2, the equivalent schematic is shown.

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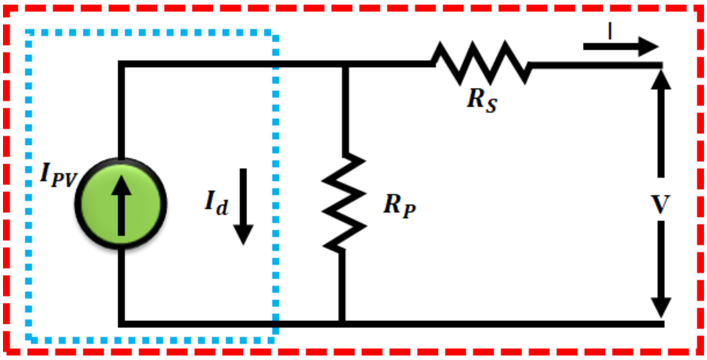

Figure 2: *Consistent path of PV cell*

The V-I characteristic equation is given by,

$$I_{out} = I_{Sh} - I_{sat}\left[exp\left(\frac{V_{out}+I_{out}.R_S}{V_{th}}\right) - 1\right] - \left(\frac{V_{out}+I_{out}.R_S}{R_{sh}}\right) \quad (1)$$

Thus the presentation of PV organization is attained and from (1), the produce voltage and the input voltage are measured.

3.2 Z-Source Sepic Converter

A hybrid DC-DC converter which combines the advantages of the Z-source and Sepic topology is known as a Z-source Sepic converter. The Sepic converter is well recognized for its capacity to deliver non-isolated voltage step up or step down conversions, whereas the Z-source converter is renowned for its distinctive shoot-through capabilities, which enables it to handle voltage boost and voltage buck activities with a comparable circuit design. In order to reduce stress on the electrical components and provide intrinsic short-circuit security, the Z-source network serves as a buffer between the input and output stages. This increases the converters dependability. Due to its distinct shoot-through function, the Z-source network can aid in lowering EMI outputs and improving electrical compatibility.

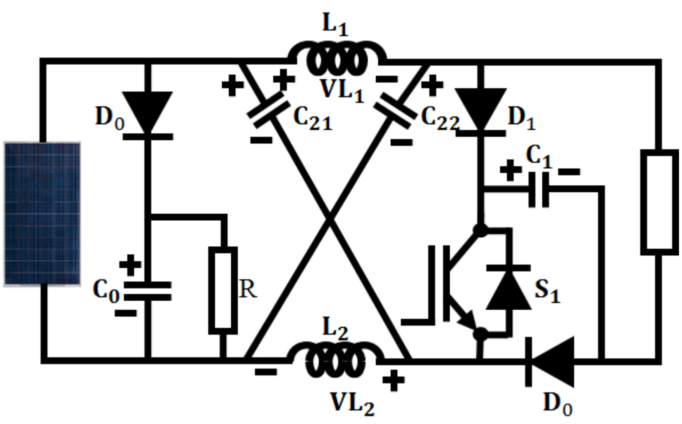

Figure 3: *Z-Source Sepic converter*

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3.3 ANN Controller

The degree of difficulty of the control problem determines the amount of coatings and neurons in each layer. The ANN controller is constructed as a neural network with feed forward operations, where data travels from the input layer to the output layer in a single direction. The inputs that are used in this DC-DC converter scenario comprise the voltage at the output and load current of the conversion as well as potential additional system settings or return signals. By introducing non-linearity, the activation function enables the ANN to recognize intricate connections between both inputs and outputs. The proposed converter is controlled in real-time to provide the required output voltage once the ANN controller has been taught and its biases and weighs have been determined.

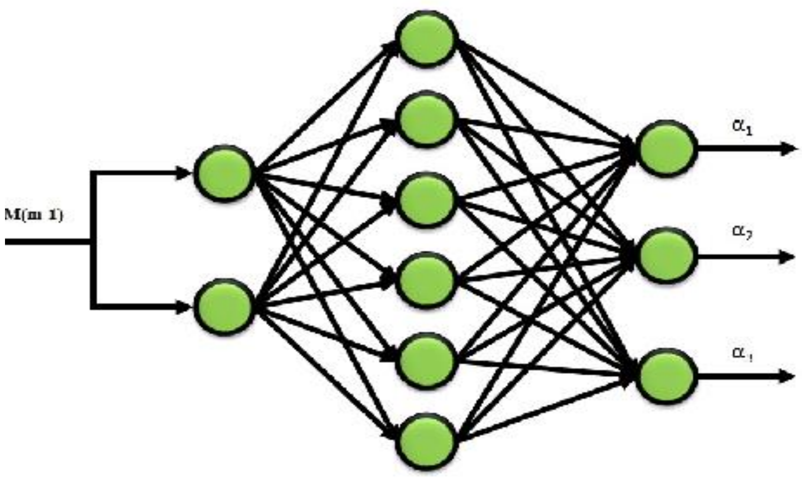

Figure 4: *ANN controller*

3.4 RNN Controller

RNNs include connections that enable them to display temporal dynamics and preserve a kind of memory of previous inputs, in contrast to standard feed forward neural networks, which handle information in a single forward pass. This makes applications requiring sequences, including time series data, machine learning for detection of speech, and even more suitable for RNNs. An RNN's fundamental design incorporates a hidden state that stores data on previous inputs. The RNN accepts an input vector at each time step, and depending on the input and the prior hidden state, changes its hidden state. The battery's charging time is shortened and its life is lengthened by employing the RNN controller.

4 Result and Discussions

The following outcomes are attained as a result of implementing the planned work in MATLAB simulation.

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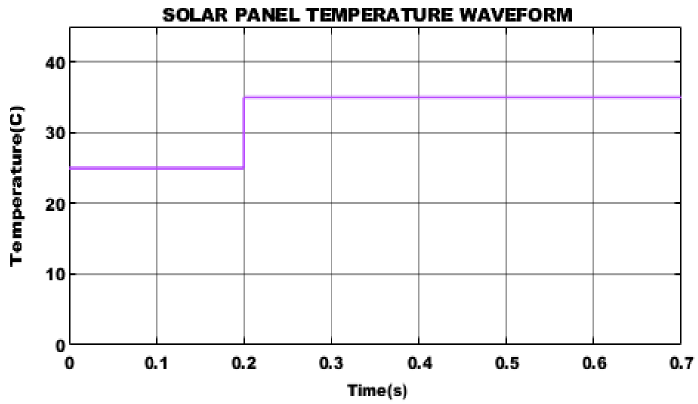

Figure 5: *Solar Panel Temperature amplitude*

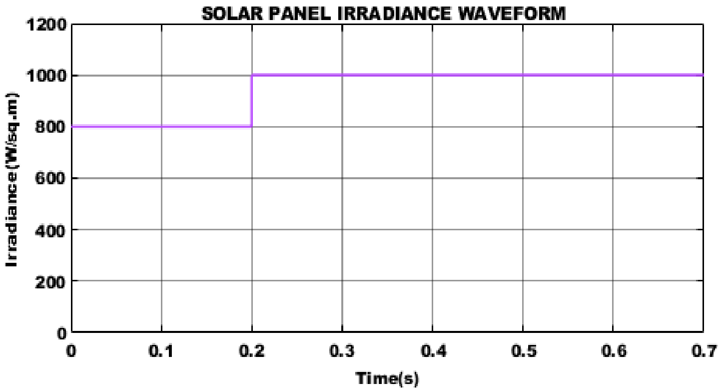

Figure 6: *Solar Panel Irradiation Waveform*

The solar board contamination and irradiation waveform exposed in Figure 5 and 6 produces a step response at 0.1 seconds after it reaches the highest possible temperature and intensity.

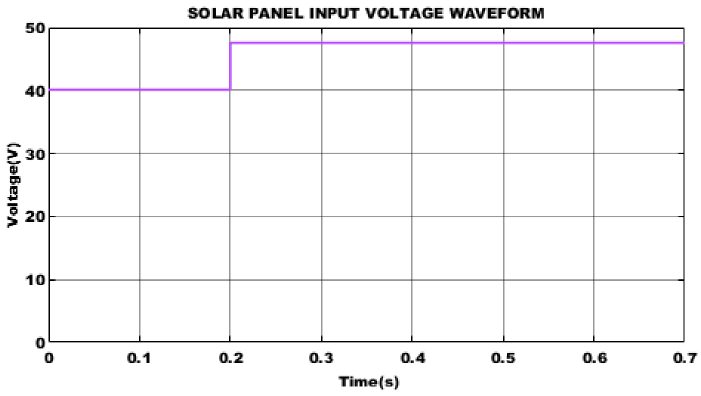

Figure 7: *PV voltage waveform*

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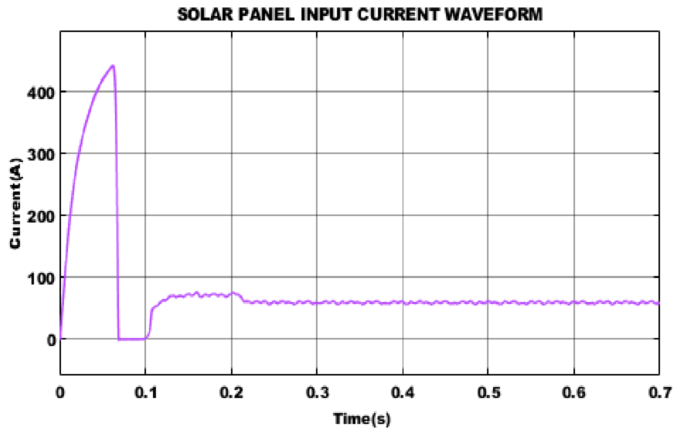

Figure 8: PV current waveform

PV panel voltage is shown as a waveform in Figure 7, and it shows a constant DC voltage. When sunlight is present in adequate amounts, it often stays constant. It is 48 V. The PV panel current waveform, seen in Figure 8, is 68A.

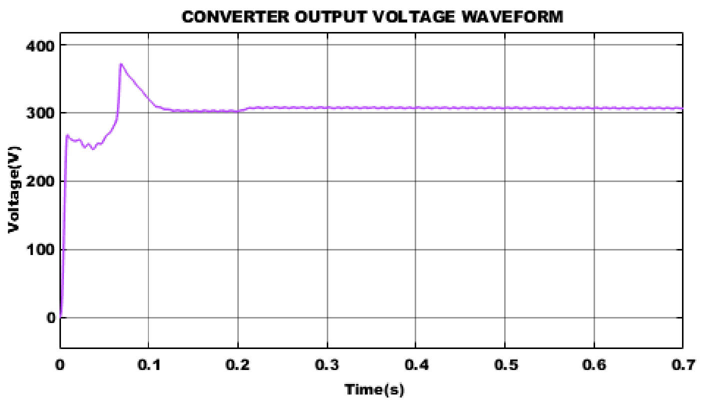

Figure 9: *Z Source Sepic converter Yield voltage waveform*

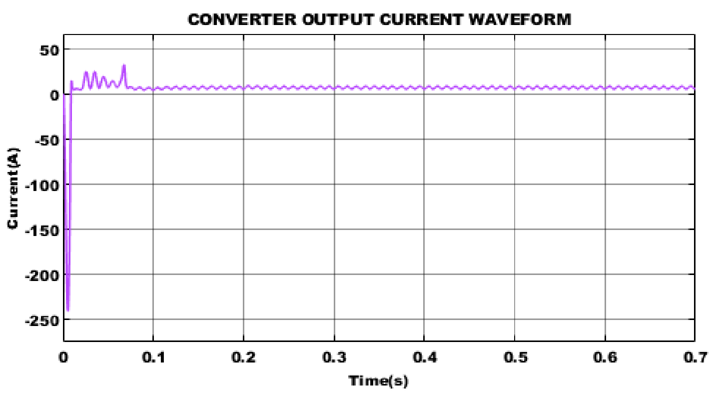

Figure 10: *Converter Output Current Amplitude*

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A Z Source Sepic converter which is a great improvement in DC to DC converter with non inverted output and little losses, is used to transform PV output to the required level. As seen in Figures 9 and 10, the converter delivers a voltage of and a current waveform.

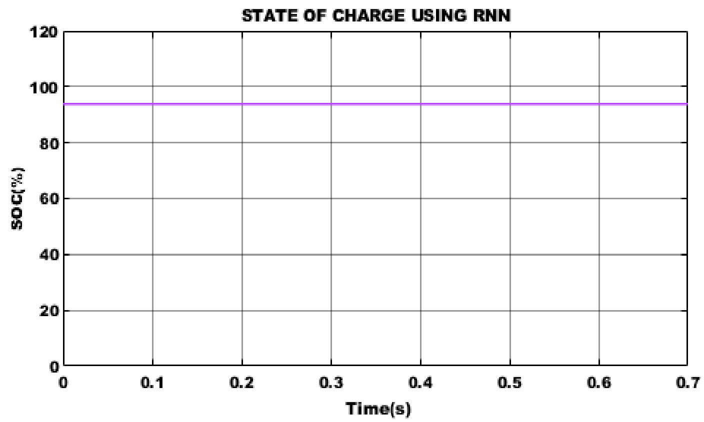

Figure 11: *SOC of Battery*

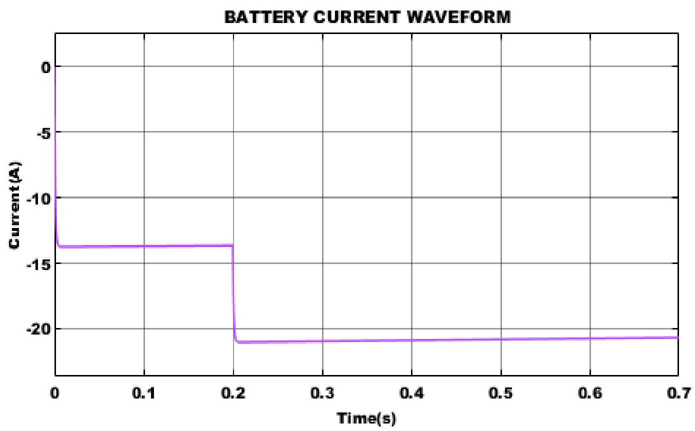

Figure 12: *Battery Current Waveform*

Figure 11 has the constant value of 100% SOC and Figure 12 has the reverse battery direction after 0.2A it maintains the constant value.

Figure 13 and 14. Represent the waveforms for battery voltage has the constant value of 25 V and super capacitor voltage waveform has fallen from 100 V.

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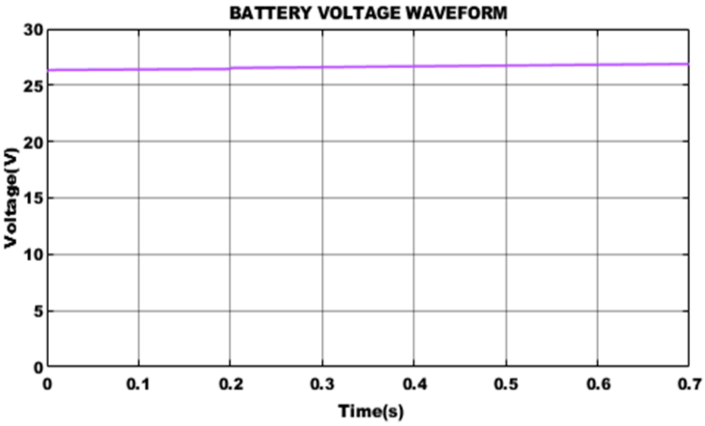

Figure 13: *Battery Voltage waveform*

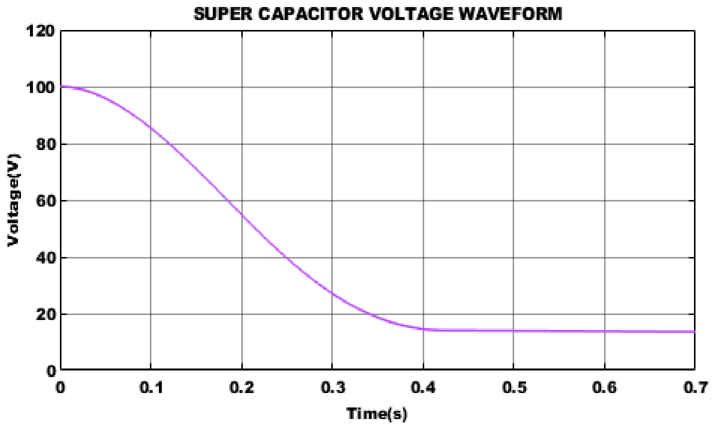

Figure 14: *Super capacitor voltage waveform*

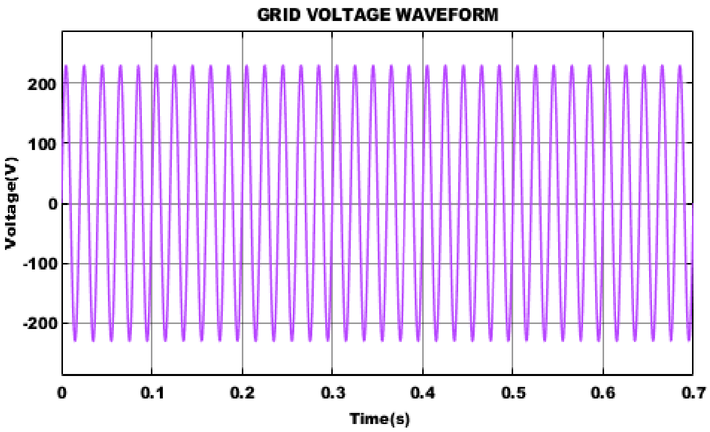

Figure 15: *Network voltage waveform*

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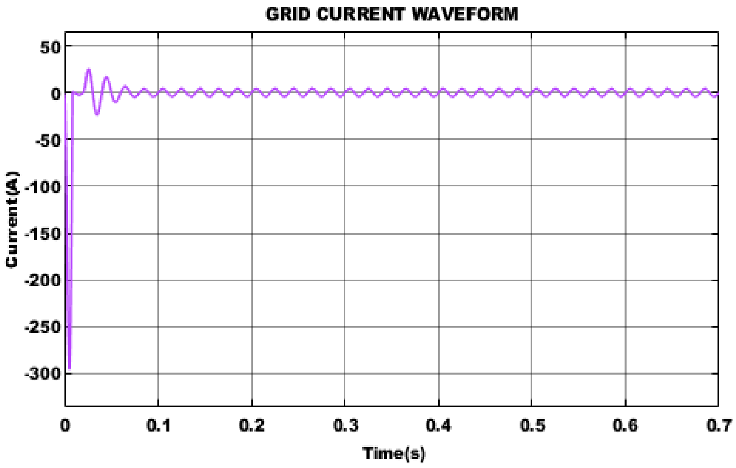

Figure 16: *Lattice current waveform*

Figure 15 and 16 indicates the output voltage and current waveform for grid which is sinusoidal in nature with constant voltage and frequency.

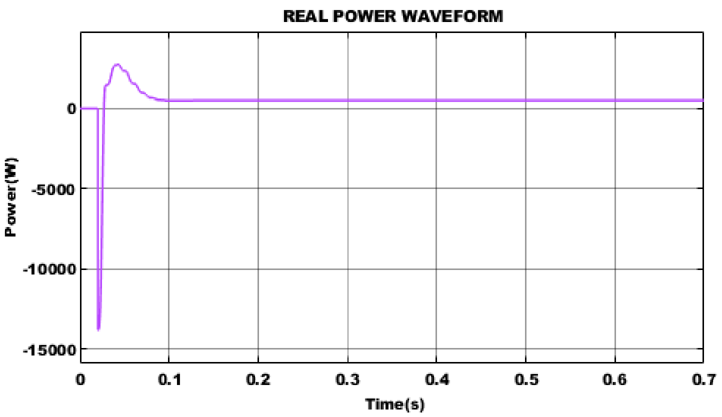

Figure 17: *Real Power waveform*

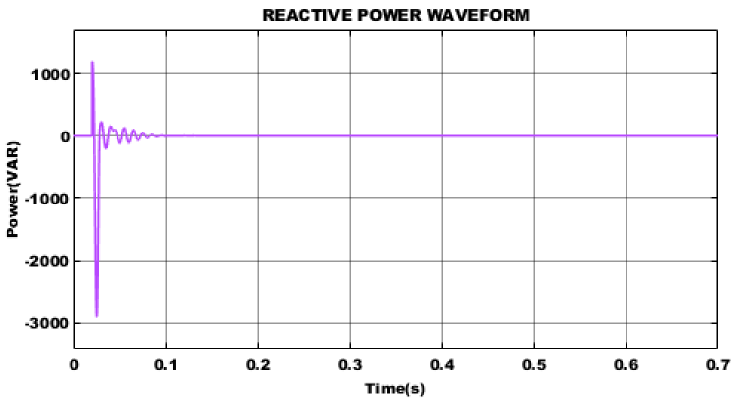

Figure 18: *Reactive Power Waveform*

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Figure 17 and 18 demonstrations the real and reactive power waveform of this work, the real power attained is 500W and reactive power has 0 VAR constant value.
The calculation of the voltage gain value comparison of the converters are registered in Figure 19, in which they are enumerated as 4.5 V, 5.3 V,6.2 V, 7V and 10V as Boost, Buck-Boost, Cuk, Sepic and Z Source- Sepic Converters correspondingly.

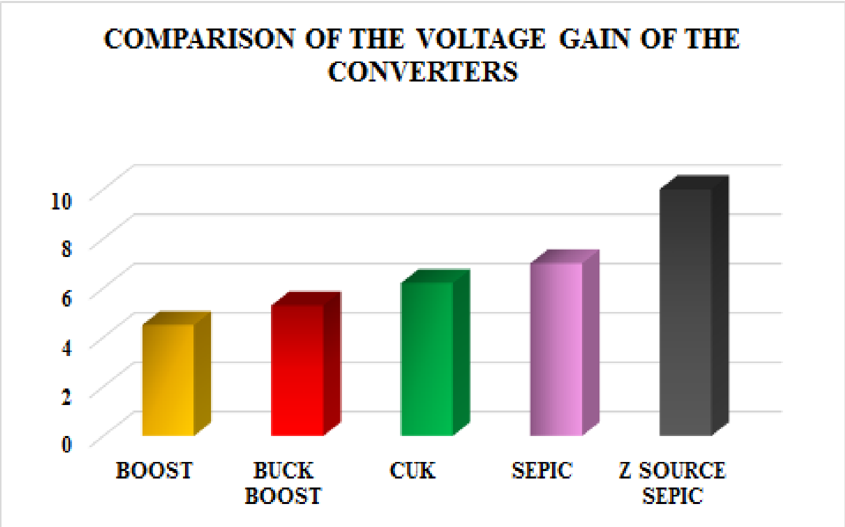

Figure 19: *Voltage gain assessment*

5 Conclusion

A grid system control technique has been put out in this study. Whereas the battery and grid backup scheme steady the system, the photovoltaic system serves as the primary source of power. In this work, the voltage is raised or lowered using a Z source Sepic converter. With the help of PI, the calculated SOC is used to construct the gating sequence for the converter. After the SOC is fewer than 80%, the battery is charged by the network finished the Buck style, PI controllers are used to regulate both the active and reactive power. The proposed strategy is validated through simulation using MATLAB and the voltage gain of z source converter has 10V and the comparative analysis are carried out in this paper.

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