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Dual-Input Non-Isolated Sepic Cuk Converter with Vehicle to Grid Tied System

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ABSTRACT

Worldwide energy consumption is rising, necessitating the search for an alternative source to address the looming power problem, which is most likely accomplished by means of a dual input power source. In this project, we use two input sources, a solar panel and a battery, and we also present a smart grid innovation called vehicle to grid technology, which enables energy exchange between electric vehicles and the grid. The combination of EVs and the grid has an impact on the entire power system, generating supply-demand, voltage, and frequency imbalances. In this project, workable optimization strategies are proposed to reduce these problems. Lithium-ion batteries are initially charged via smart grid, and their SOC is determined using CNN. In this study, the voltage is changed in both directions using a bidirectional Sepic-Cuk converter. With the help of PI, the calculated SOC is used to construct the gating sequence for the converter. When the SOC is less than 94%, the battery gets recharged by the grid through the Buck mode, and when it is greater than 94%, the battery gets depleted through the Boost mode. PI controllers are used to control both the active and reactive power. Through MATLAB simulation, the proposed tactic is verified.

Keywords: CNN-Convolutional Neural Network, PWM – Pulse Width Modulation, PI – Proportional and Integral, SOC-State of Charge, PV-Photovoltaic.

1 Introduction

Alternative sources of energy including solar, wind, ocean waves, fuel cells, and others are increasingly being used by energy planners today. It seems obvious that DC-DC converters will be used in such situations. Therefore, it is crucial to supply novel, inventive topologies with benefits like high voltage gain and dependability. A dual input DC-DC converter built on the Cuk and Sepic converter is provided in this work [1]. This converter can be used in a multivoltage DC grid to supply various needs. Additionally, electrical machines require multi-level voltage for motor drive and battery charging. Despite using transformers, this architecture is not isolated. Because of the similar input magnitudes, they cannot be controlled sequentially [2]. With the use of a transformers, the gain in voltage increased. However, using a transformer results in an increase in price and volume. By integrating a Sepic and a multilayer boost converter with high voltage, a dual input converter is created, although the input voltage level is also not independent in this converter [3]. In addition, as voltage gain improves, the number



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of elements grows as well. For instance, if the boost converter gain is increased by five times, we should employ four additional pairs of diodes and capacitance than under the preceding circumstance [4].

The introduction of a dual input converter is based on the Sepic and Cuk converters. A boost converter with several inputs and a diode clamp topology. In this conversion, input voltage is divided using a diode clamp topology among many inputs. As a result, input voltage is affected by the distribution of loads [5]. This reliance causes some restrictions when trying to get alternative voltages. We introduce a range of DC-DC converters with several inputs. The majority of this family's proposed topologies distribute voltage among their various inputs using active switches. A cutting-edge topology with the capacity to step up and down [6]. In this topology, clamp diodes are used to enhance the input voltage. Therefore, each input voltage level is lower, and inputs are dependent upon the fraction of loads. A single input that is taken from traditional boost and buck boost converters is introduced in a dual input system. In comparison to the converters stated earlier, this converter has a higher voltage gain [7]. An additional converter with a noteworthy voltage increase is obtained in accordance with the Sepic converter's extension. In this structure, the Sepic converter gain first switches to a conventional boost converter, and then it multiplies by an n-factor [8]. To put this theory into practice, a single diode and a capacitor were first added to the schematic circuit, followed by more diodes, capacitors, switches, inducers, and regulators to multiply the voltage gain. The reliability of this topology is decreased by the high number of applied elements in this converter. Though this converter uses bulk capacitors, it also only has a single input [9]. This study introduces a dual input converter using conventional Sepic and Cuk converters. Two synchronized switches and two diodes make up this architecture. This converter has both topological benefits, such as continuous current, as it is based on the Cuk and Sepic converters [10]. The contribution of the paper is implement to combine two energy sources at the input. Bi-Directional batteries converters and sepic-cuk converters in EV to create an energy administration system. Convolutional Neural Network will be utilised for tracking the State of Charge.

2 Proposed System Explanation

Due to the unpredictable nature of solar energy, the DC output voltage produced by the PV source in this proposed system is often low and erratic. A high gain converter called a SEPIC-CUK is used to increase the output voltage of a PV source. A control signal is produced when this error is fed to the CNN controller. The PWM generator generates PWM pulses based on this control signal, which in turn regulates the switching action of the converter and results in a controlled output without any distortion. For controlled DC applications, such as charging EV batteries, this output is employed. Using a PI controller, the single phase grid's operation and its synchronized. It is accomplished to have an energy management system and a battery



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storage system. The Convolutional Neural Network is used to monitor the State of charge. Figure 1 displays the proposed system's block diagram.

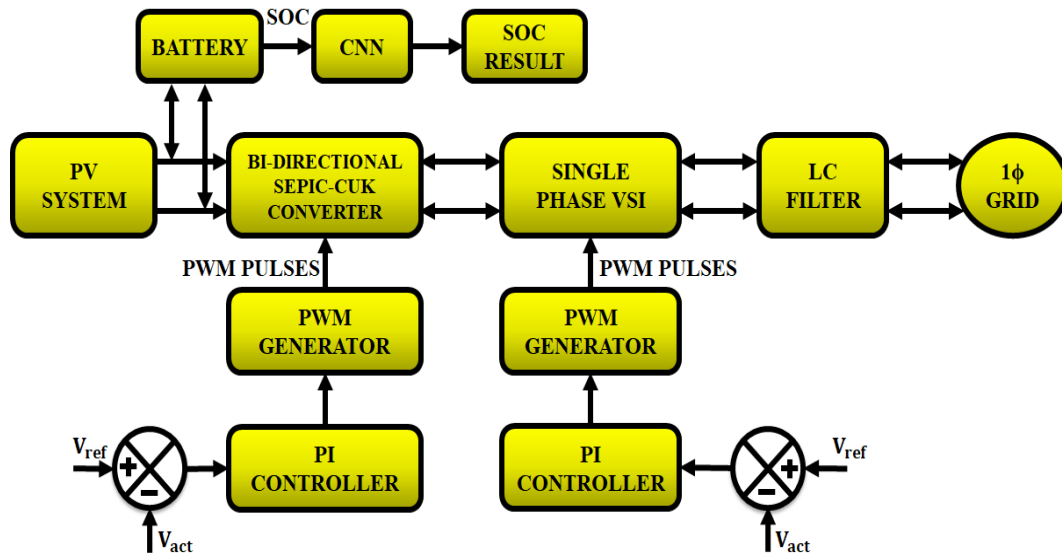


Figure 1: Proposed Diagram

Due to the intermittent nature of PV sources, Energy Storage Systems (ESS), such as batteries, play a crucial role in applications that rely on PV systems for supplying a dependable power supply and maintaining energy balance. In order to control the battery's charging and discharging processes with the help of a CNN controller, the SOC of the battery is tracked.

3 Proposed System Modelling

3.1 PV Panel

A semiconductor transistor that has been exposed to light is a solar cell. Few of the variously energetic particles 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.

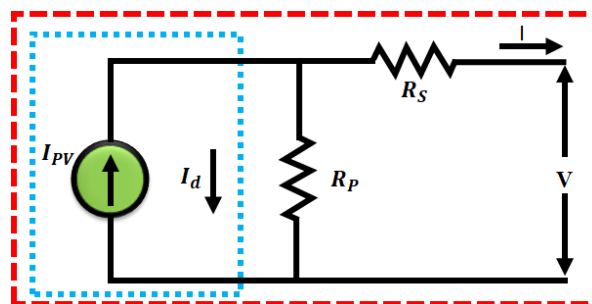


Figure 2: Corresponding circuit of PV cell



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The V-I characteristic equation is given by,

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

Thus the showing of PV classification is achieved and from (1), the yield voltage and the input voltage are assessed.

3.2 Bi-Directional Sepic-Cuk Converter

To change one DC voltage level to another DC voltage level, DC-DC converters of the Cuk and Sepic types are both employed. They mostly differ in how they convert voltage, which is the fundamental distinction. A particular kind of buck-boost converter called a Cuk converter can create an output voltage that is either greater or lower than the input voltage. The Cuk converter accomplishes this by utilizing an inductor, two capacitors, and an inverter to jointly produce a voltage inversion. With this inversion, depending on the converter's design, the output voltage might be either higher or lower than the input voltage. Dependent on the converter's architecture, this boost enables the output voltage to be either greater or lower than the input voltage. Solar system output is provided via the CUK-SEPIC converter, which then feeds it to the single phase grid system. It has the same input and output polarities as a buck-boost converter, but it also benefits from low ripple current at both the input and the output. A DC-DC converter topology that can step up or down depending on the input voltage and can function as both a boost and buck converter. The SEPIC is a positive output converter, whereas the CUK is a negative one.

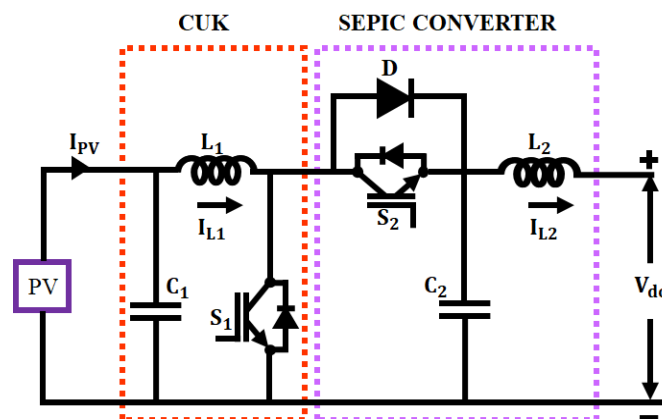


Figure 3: SEPIC-CUK converter

Both converters have the same voltage conversion ratio with opposite polarity when comparing the SEPIC-CUK arrangement, it is found. Two wires, one with positive polarity and the other with negative polarity, make up a bipolar DC link. The SEPIC converter operates in boost mode for discharging, whereas the Cuk converter operates in buck mode for charging the battery. Another choice for controlling an unregulated input-power source is the CUK converter.



3.3 CNN

CNNs, a subset of Deep Neural Networks (DNNs), are used to classify the input data sets related to the power system. As one of the fundamental components of an ISO AI decision system, CNNs can be used to analyse vast amounts of past data. The spatial relationship between the data points is preserved by CNNs. AI decision-making system that can replace or supplement human operators in the effective management of intricate power grids.

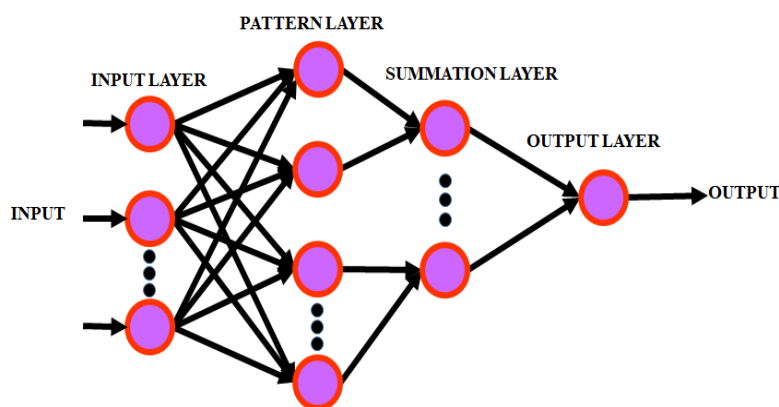


Figure 4: *CNN Structure*

The CNN model of machine learning enables us to extract more precise characterizations of the source images. CNN transports the model using the raw pixel data from the image, then instantly gathers the characteristics for more accurate classification. By comparison, conventional recognition software necessitates you to describe the picture characteristics oneself. CNNs are capable of effectively identifying features without human oversight.

4 Result and Discussions

The main topic of this research is the SOC monitoring methodology based on CNN. The CNN is utilised to operate the SEPIC converter in alongside measuring the SOC. With its dual step-up and step-down input voltage capabilities, the SEPIC is a powerful converter. Using MATLAB simulation, the operational performance of the proposed technique is examined.

Figure 5. (a) indicates the waveform for PV panel voltage and it represents DC voltage. Generally it remains constant during the presence of sufficient irradiance from sunlight. It is 28V Figure 5. (b) Indicates the PV panel current waveform and it is 80A.

The transformation of PV output to a necessary level is accomplished using a SEPIC converter, which is a high gain DC-DC converter with non-inverted output in addition to minimum losses. The SEPIC_CUK converter provides a voltage of 284.2V and a current of 23.66A as given in Figure 6.



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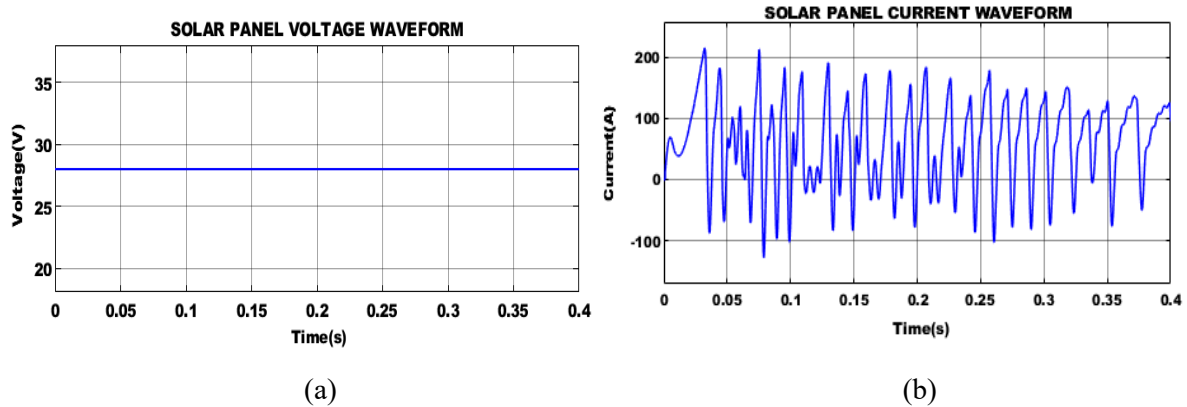


Figure 5: a) PV voltage waveform b) PV current waveform

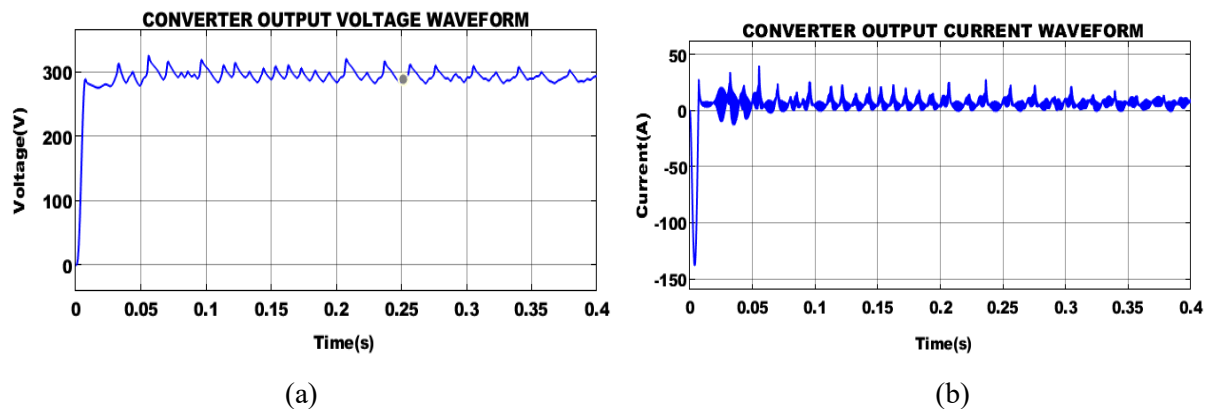


Figure 6: SEPIC-CUK converter (a) Output voltage and (b) Output current

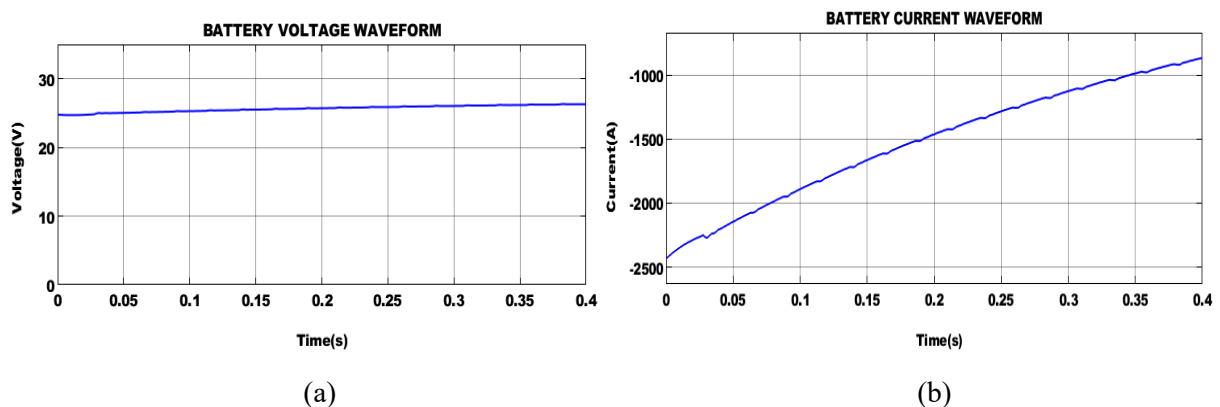


Figure 7: Waveforms of battery (a) Current and (b) Voltage

The waveforms that represents the level of current and voltage in the battery is given in Figure 7. The battery current and voltage is 1A and 28V respectively. The surplus power generated from the PV is stored in battery. During the unavailability of primary source of power supply, the battery, which acts as a secondary power source discharges and transfers power to the load.



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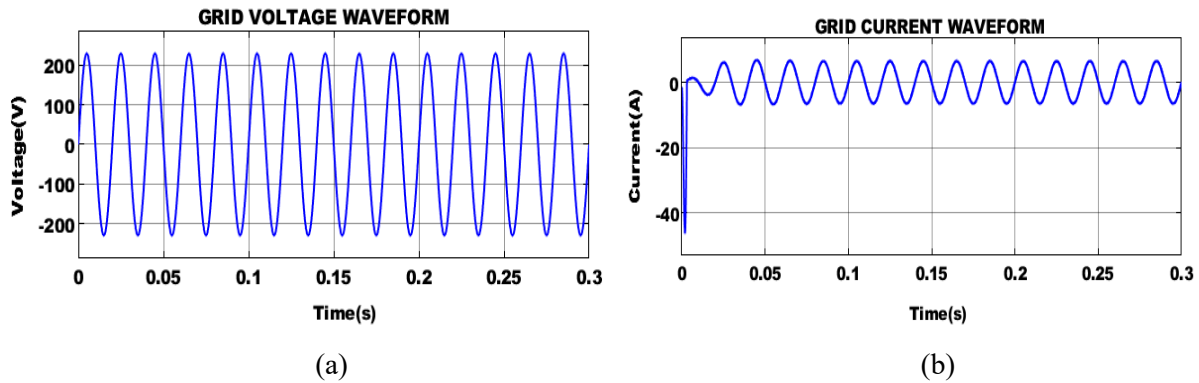


Figure 8: Waveforms representing (a) Grid voltage and (b) Grid current

The grid voltage and current waveforms are depicted in Figure 8. (a) and (b) respectively. Both the grid voltage and grid current are stable and steady without being affected by any variations. The voltage and current magnitude of 200V and 10A is observed.

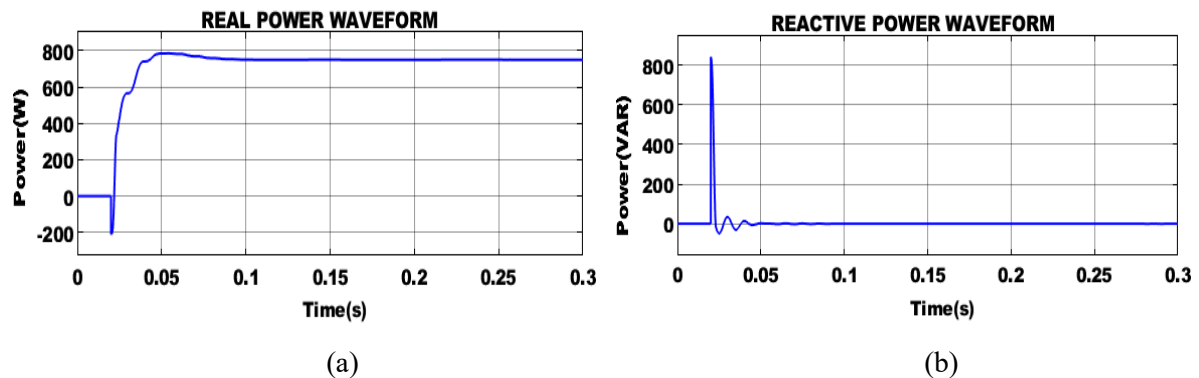


Figure 9: Waveforms of (a) Real power and (b) Reactive power

The value of real and reactive power, as illustrated in Figure9. 750W and -60VAR respectively.

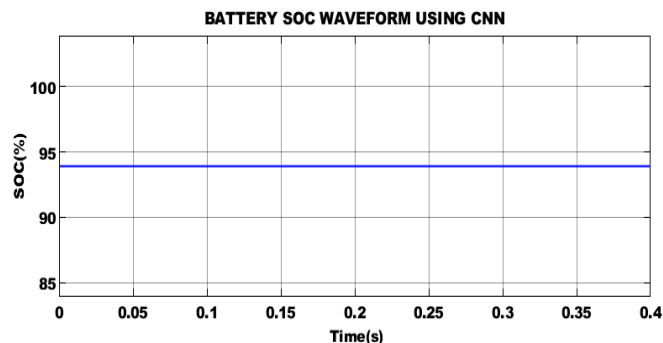


Figure 10: SOC of Battery

The waveforms for the SOC of the battery, which is 94% as depicted in Figure10. The SOC of the battery is effectively monitored using CNN.



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The assessment of the Efficiency Comparison of the converters are listed in Figure 11, in which they are listed as 97.6%, 98.4% and 99.6% as Sepic, Cuk and Sepic-Cuk Converters respectively.

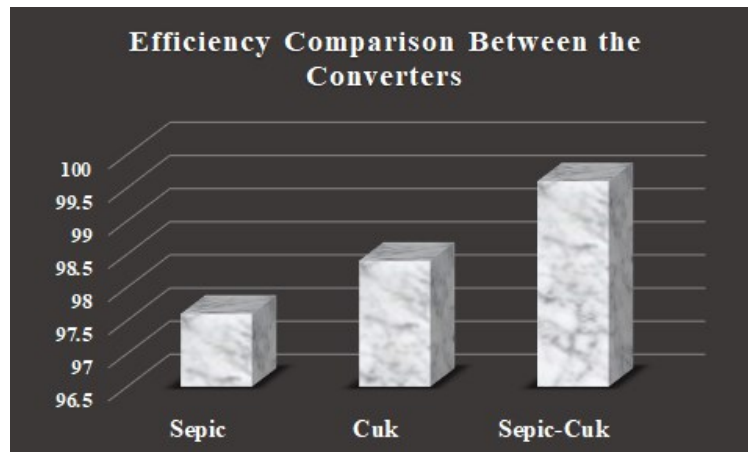


Figure 11: *Efficiency comparison Between the Converters*

5 Conclusion

This development's work focuses on a system having two input sources and one output. The power sources produced by the solar panel and batteries. A SEPIC-CUK converter, a DC-DC converter with high voltage gain and non-inverted output, is employed because the PV system needs a suitable converter to effectively convert the input voltage to the necessary voltage level. Using a PI controller, the single phase grid's operation and its synchronized. It is accomplished to have a system for energy management and a battery storage system. The CNN is used to monitor the State of charge. The PV system's integrated BESS serves as a backup power supply. The CNN controller keeps track of the battery's State of Charge (SOC) in order to regulate the charging and discharging processes.

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