Power Quality Gain of Self-Lift Luo Converter used for Hybrid Renewable Power System with Battery Grid Integration

E. RAJENDRAN, V. SURESH, V. K. DINESH PRABU, M. KARUNAKARAN
Department of Electrical and Electronics Engineering,
S. K .P. Engineering College, Tiruvannamalai, Tamil Nadu,
INDIA

Abstract: - The renewable power sources such as wind as well as photovoltaic (PV) energy are fashionable for residential and commercial applications. For the reason, that eco friendlessness plus expenditure are effective. This paper intends a Self-Lift Luo converter integrated with solar photovoltaic system to the utility grid along with its Adaptive Neuro-Fuzzy Inference System (ANFIS) and Recurrent Neural Network (RNN) control strategies are proposed. By achieve an energy management for the proposed system using Bidirectional Battery converter along with battery system. Power supervision move towards is suggested to control the DC bus voltage by way of Self-Lift Luo converter. The wind power with Doubly Fed Induction Generator (DFIG) based grid integration with a PI controller. Under this work, DSTATCOM has been used to improve the quality of power under different load conditions. The obtained results designate that the proposed approach delivers recovered performance with enhanced efficiency and nominal harmonics. The intact system is validated through a MATLAB simulation.

Key-Words: - Recurrent Neural Network (RNN), Adaptive Neuro-Fuzzy Inference System (ANFIS), Doubly Fed Induction Generator (DFIG), Photovoltaic (PV), Storage System (ESS), Voltage Source Inverter (VSI).

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1 Introduction

In the early time of power transmission due to reactive control unbalances, the problems comparable to voltage deviation during load changes as well as power transfer limitation are observed. The widely held of the AC loads are consuming reactive control due to the occurrence of reactance. The power value is getting reduced due to serious utilization of reactive power. The growth of power semiconductors devices (GTO and IGBT) allowed modern power electronic configurations to be introduced to the responsibilities of power transmission and load flow control. In excess of the transmission parameters, the FACTS devices suggest a fast and dependable control. The widely used custom power devices are IPC, TCPST, DVR, UPFC, TCSC, SVC, STATCOM, and DSTATCOM. In the centre of them DSTATCOM is very well known and can provide price valuable clarification for the reparation of reactive power as well as unbalance loading in distribution system. Here the DSTATCOM competent to inject a current into the system to correct the power factor along with reactive power compensation and harmonics lessening.

This message proposes a technique for choosing the trade-off orientation value of the DC-side voltage of a D-STATCOM to decrease the switching losses moreover the harmonic content of its output current without compromising its lively performance, [1]. The increasing saturation of distributed production as well as regular power loads complicates the trade for the electric utilities on the way to deliver high-quality electrical power. Conventionally, electrical energy source converters supply Power Quality compensation; the strength of character of these converters. However, the huge electrolytic capacitors (e-caps), which that contain well-known not success rate, [2]. The algorithm shows high lively performance to organizing the CHB STATCOM with several numbers of cells. Here, FCS-MPC needs high sampling frequency to make certain good control act, because of unpredictable switching frequency, requiring an often unnecessary computational time, [3]. The changed case studies are planned to make known the hardiness of the obtainable ASFC on

harmonic mitigation, active voltage stabilization, and reactive power recompense in addition to power factor development considering the variety of RESs such as variations of wind speed, solar PV irradiation along with provisional fault situation, [4].

The DVS systems capitalize on the active power sustain from PV units subsequent an unforeseen event make use of the maximum permissible current of the PV inverters. Additionally, the inverter plan margin is taken into description in designing the proposed idea to limit the injected grid current contained by the maximum acceptable inverter current, [5]. Surveys on the combined achieve of Voltage Source Converter (VSC)-based sources along with synchronous condensers in grid unbalanced fault. VSC is suffers from high switching losses as it normally requires a high switching frequency to function, [6]. The entire signals in the closed-loop plan are certain to be semi-globally surrounded, along with the productivity of the system converges to a little neighbourhood of the source, [7]. The accurate strength of the closed-loop arrangement with the earlier period control method is reputable in mild assumptions, and it is demonstrated that the relative position and the virtual attitude converge to a tiny locality of nought, [8].

The multiple powers interactive power system through power quality perfection function to moderate the unreliability of power supply. It gets better power value of power supply used for load. The Total Harmonic Distortion (THD) is comparatively high, [9]. The model outcome is incompatible with the abstract analysis in PV balanced case. The presence of ripple current in night operation is high comparatively, [10]. The system's performance is huge in unusual functioning conditions. It is not tested in noisy environments. It has an upper sum of THD comparatively, [11]. An innovative PWM clamping strategy to put into practice the zero sequence voltage calculation in the converter. It helps in the line voltage by way of active and reactive power swap in the grid through situation fault condition. PV has unevenly distributed solar irradiance, [12]. The D-STATCOM becomes an option device for civilizing the power quality of the MG is customized to be self-tuned along with more valuable.Total Harmonic Distortion (THD) is high reasonably, [13]. A new PWM approach based on state changeover for cascaded H-Bridge inverter by way of unbalanced DC sources to reach high quality line-to-line output voltages. In additionally, to capitalize the linear modulation ranges. The control capacity of Power Control Algorithm (PCA) will reduce when the modulation index is unmitigated, [14].

An intentional applies of a Static Synchronous Compensator (STATCOM) for provided that active reactive power management of a hot rolling mill plant along by way of active alleviation of harmonics is proposed. The topology chosen for the converter did not fine the possible of the control algorithm, [15]. The MCCF is carrying out to eliminate the voltage harmonics beginning decidedly polluted grid voltages. It is not tested in noisy environments, [16]. Based on the above mentioned survey, the proposed Self-lift Luo converter through Adaptive Neuro Fuzzy Inference System (ANFIS) algorithm used PV system and PI controller-based wind power systems as well as RNN controller based VSI system are integrated with grid network. The voltage and supplying the reactive power, power quality issues are overcome for grid. The role of the manuscript is mentioned below:

- To extract maximum power from PV system using Self-lift Luo converter with MPPT Neuro Fuzzy Logic algorithm.
- To achieve high gain output DC voltage with Proposed MPPT and Self Lift Luo converter.
- To achieve energy management for the proposed system using Bidirectional Battery converter along with battery system.
- To achieve the grid synchronization using D-Q theory and RNN controller.
- To demonstrate the characteristics of the PV along with Wind and the battery systems is analysed using MATLAB Simulink environment and experimental model.

2 Materials and Methods

In this proposed system implementing a recent DC-DC multi-source converter construction supported grid-interactive microgrid consists of Photovoltaic (PV), wind and Energy Storage System (ESS), and Self-Lift Luo converter is proposed as shown in Figure 1. The intended system design makes use of solar and wind power, as well as batteries for an efficient storage system. The grid synchronization of renewable energy source applications like PV source is performed. The PV voltage is partial by the impacts of climate variations including irradiation and temperature.

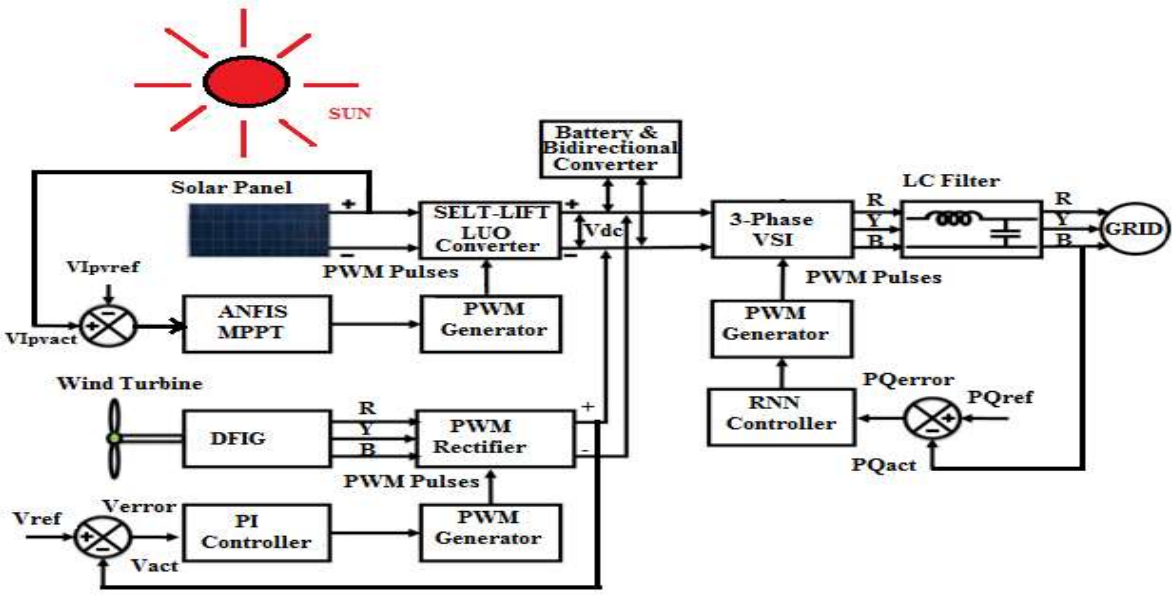

Fig. 1: Proposed System Block Diagram

The aim of PV array to produces maximum power, whereas the converter power is to grid coordinated. Here, SELF-LIFT LUO converter, an ANFIS MPPT regulator is connected to follow the maximum power near evaluating the current via voltage obtained from the PV array. This situation is voltage if not duty cycle for similar the power to immediate power point tracking. The MPPT checker exploits ANFIS along by way of non-linear moreover varies with accordance with time. A DFIG based Wind energy conversion provides the necessary DC supply through a PWM rectifier. To achieve energy management for the proposed system is uses using Bidirectional Battery converter along with battery system. The optimal DC voltage extracted from the PV panel via ANFIS MPPT is injected into a proposed converter, which helps to manage the DC voltage. A power output obtained from a PV panel with self-lift Luo converter and WECS PWM rectifier outputs are added and fed into the three phases Voltage Source Inverter (VSI). The inverter output is injected to the grid after proper synchronization process. When the RNN controller is implemented to retain the unvarying voltage of the DC link and increase the grid's performance. The PWM pulse generator is working in this study to generate the proper PWM pulses. The harmonic present in VSI is rectified using LC filter, in that way the real and reactive power has been safely injected into the grid.

2.1 Solar Power with Analysis of Self Lift Luo Converter

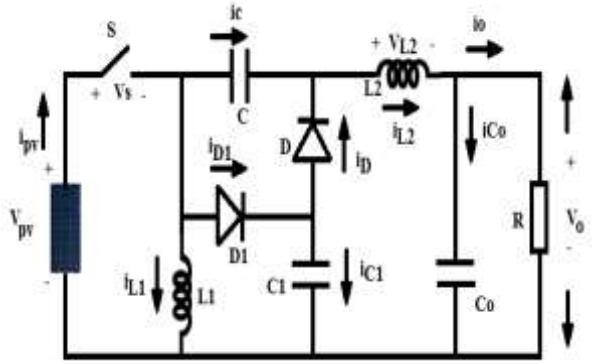

Fig. 2: Self Lift Luo Converter Diagram

The Self Lift Luo converter is shown in Figure 2. In this path, S is the power switch down with D is the freewheeling diode. Here, the energy storage submissive elements are inductors L_1, L_2 along by way of capacitors C_1, C_0, and R be the load resistance. To consider the process of the Self Lift Luo converter, the circuit can be divided keen on two modes. While the switch is ON, the inductor L_1 is charged through the solar panel supply voltage V_{pv}. At the same time, the inductor L_2 absorbs the energy from source moreover the capacitor C_1. When the load is supply via the capacitor C_0. During switch is in OFF state, the current is drawn from the source befall zero. The inductor current iL_1 flows during the freewheeling diode towards charge the capacitor C_1. The current iL_2 flows through C_0 –R circuit as well as the freewheeling diode D to continue it. If adding together additional

filter components parallel to inductor and capacitor to decrease the harmonic levels of the output voltage.

Here inductor current is i*L2*:

$$\mathrm{iL2} = \frac{1-\alpha}{\alpha}\mathrm{iL1} \quad (1)$$

Switch duty cycle:

$$\alpha = \frac{\mathrm{Ton}}{\mathrm{T}} \quad (2)$$

Output voltage is,

$$\mathrm{Vo} = \frac{\alpha}{1-\alpha}\mathrm{Vpv} \quad (3)$$

Standard Voltage crosswise the capacitor C_1 is:

$$\mathrm{Vc1} = \frac{\alpha}{1-\alpha}\mathrm{Vpv} \quad (4)$$

Peak to peak inductor current is:

$$\mathrm{VTL1} = \frac{1\alpha\mathrm{TVpv}}{\mathrm{L1}} \quad (5)$$

Equation (5) inductor L_1 value is:

$$\mathrm{L1} = \frac{\alpha\mathrm{TVpv}}{\Delta\mathrm{iL1}} \quad (6)$$

Peak to peak inductor current L_2 is:

$$\Delta\mathrm{iL2} = \frac{\alpha\mathrm{Vpv}}{\mathrm{L2}} \quad (7)$$

Equation (7) inductor L2 value is:

$$\mathrm{L2} = \frac{\alpha\mathrm{TVpv}}{\Delta\mathrm{iL2}} \quad (8)$$

The charging on this series capacitor (C1) increases all through off period by iL_2 (=io) as well as decreases through on period by iL_1. The modify in charge on C_1 must be zero and Peak to peak ripple voltage across the capacitor C_1 is:

$$\Delta\mathrm{Vc1} = \frac{1-\alpha}{\mathrm{c1}}\mathrm{Ti1} \quad (9)$$

Equation (9) C_1 value is to find:

$$\mathrm{C1} = \frac{1-\alpha}{\Delta\mathrm{Vc1}}\mathrm{Ti2} \quad (10)$$

2.2 ANFIS Supported MPPT

An innovative ANFIS support MPPT technique is proposed to attain the highest power of the PV module under changing the typical weather conditions. The planned input variables are the PV voltage ($Vpv_)$ as well as PV current (Ipv) in totalling to the PV cell temperature (Tpv). The unpredictable is the duty cycle, which is used to control the DC-DC switched Self Lift Luo converter to order to preserve tracking maximum power. As the modelling of the conservative FLC is support on trial and error, the chance of obtaining the finest recital is low. For that reason, obtaining membership functions as well as fuzzy rules can be done in ANFIS. The qualified data should be collected initially. To attain the qualified data, the steps concerned are as follows,

- The scheme is to be under different solar radiation in addition to temperature conditions.
- The data to be composed along with manipulated using a MATLAB code, which built for this utility to get the needed data.
- The manipulated data to be subsequently shuffled. The results data are then filtered once more to attain only the exclusive rows surrounded by collecting data.

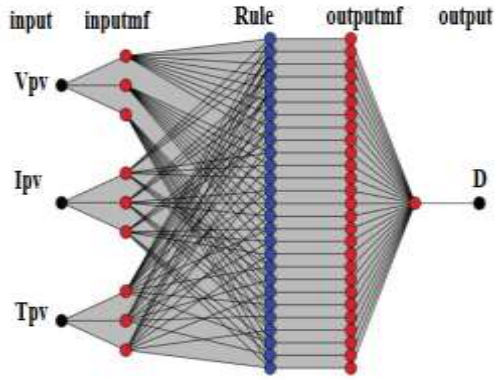

Fig. 3: ANFIS Model Structure

The current as well as power of the PV mode in addition to the duty cycle relation of the converter is obtained the outputs via ANFIS controller as shown in Figure 3. The input labels give permission the ANFIS for produce the converter command which is further feed to the converter for ensuring power modification.

2.3 RNN Supported Reference Current Generation by 3-Phase Inverter

The improved tradition of non-linear loads to leads distortions in current moreover voltage; conversely,

there be a number of methods to mitigate harmonics. The insertion of incompatible harmonics in the PCC (Point of Common Coupling) is one of the expensive methods. Intended for this, precise reference current generation is needed in addition to this is talented in this work near RNN. The plan of RNN is specified in Figure 4.

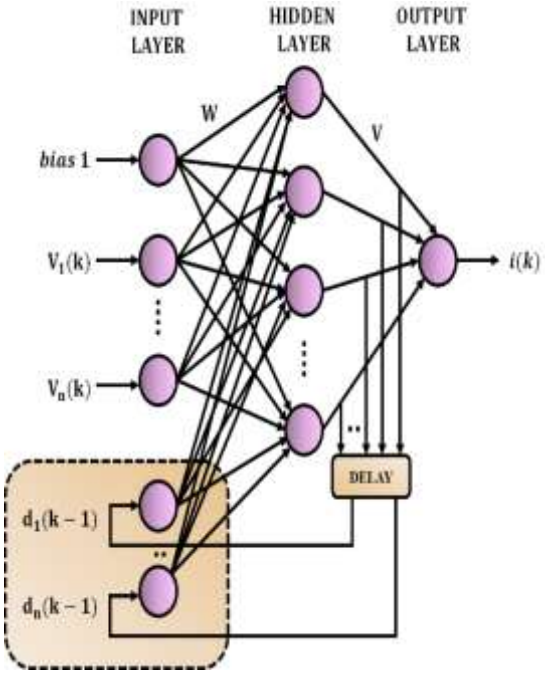

Fig. 4: Structure of RNN

3 Simulation Result and Discussion

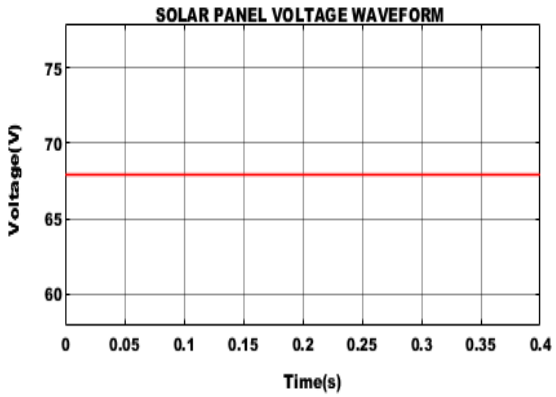

Fig. 5: Solar Output Voltage

Figure 5 shows the solar output voltage 68V. To facilitate the 68V fed to the Self Lift Luo Converter. Figure 6 shows the Self Lift Luo Converter output voltage attains a maximum voltage of 600V.

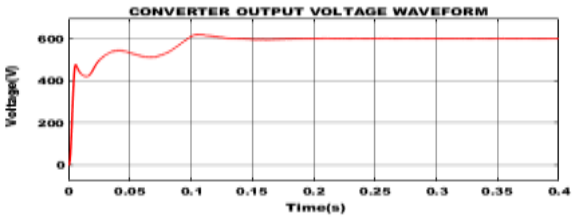

Fig. 6: Output voltage to the converter

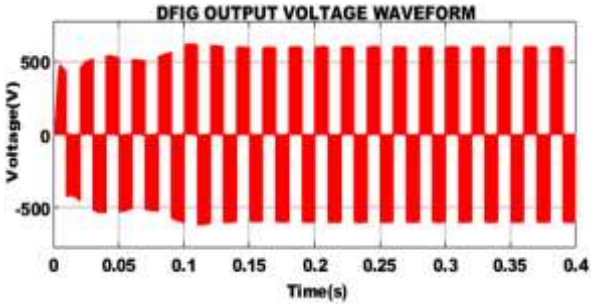

Fig. 7: DFIG output voltage

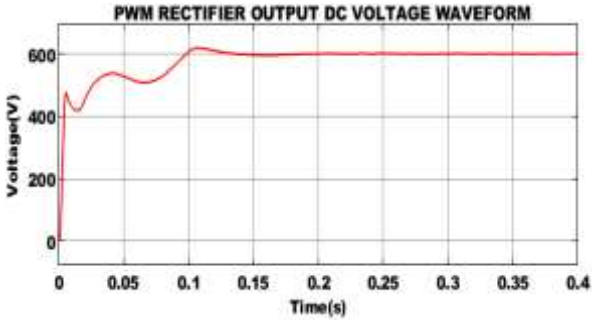

Fig. 8: PWM Rectifier Output Voltage

Figure 7 shows the DFIG based WECS output voltage of the proposed system, the Voltage value is attained 540 V AC. In this 540V AC convert to the 600VDC using PWM rectifier as shown in Figure 8. Figure 9 represents battery state of charge which attained a value around 80%.

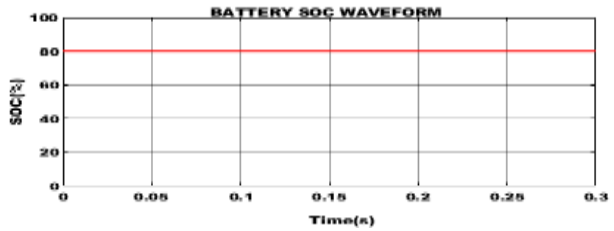

Fig. 9: Battery SOC Waveform

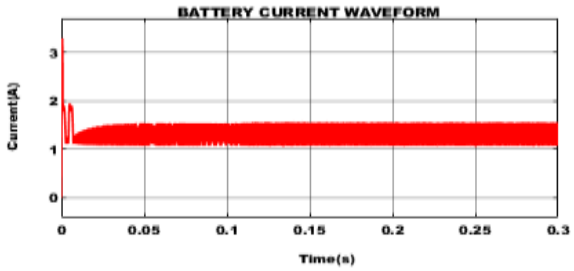

Fig. 10: Battery Current

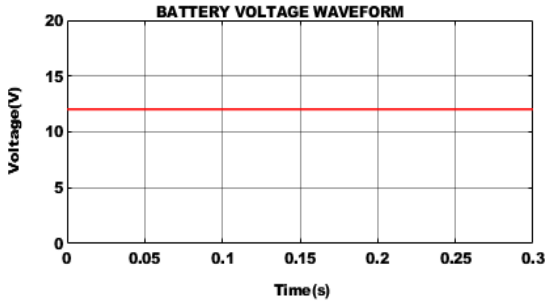

Fig. 11: Battery Voltage

Figure 10 and Figure 11 represent the waveforms for battery current and voltage parameter.

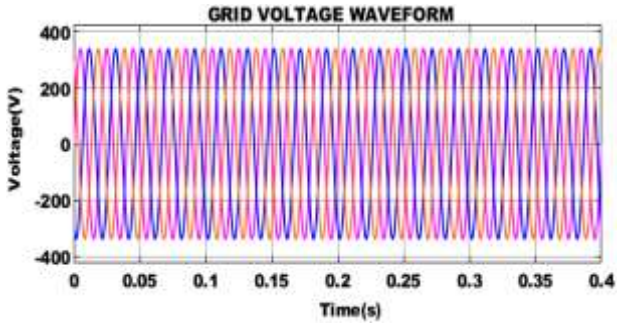

Fig. 12: Grid Voltage

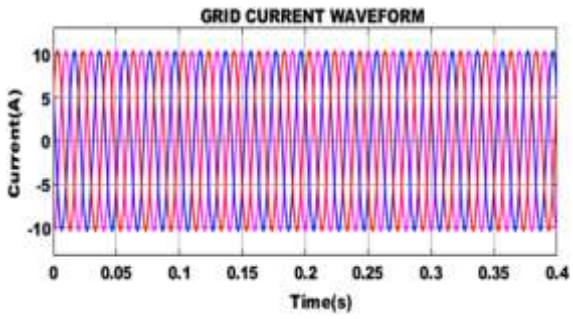

Fig. 13: Grid Current

Figure 12 and Figure 13 illustrate that the grid voltage as well as grid current of the statcom inverter. Mutually the grid voltage moreover grid current are stable and steady without being affected by any variations. The voltage and current magnitude of 300V and 10A is observed. Figure 14 represents the total harmonic distortion. The grid current THD obtained with the proposed work is 1.24%, as can be seen from the graph.

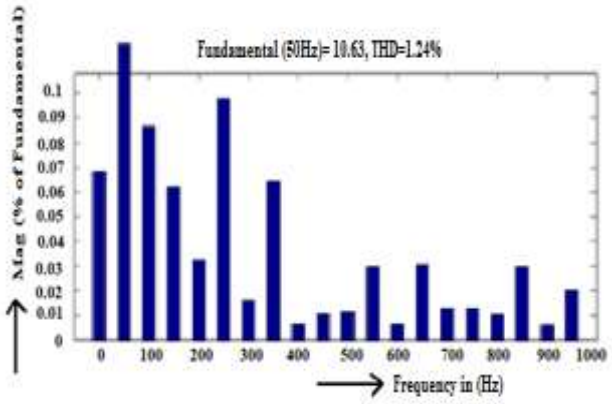

Fig. 14: Total Harmonics Distortion

4 Conclusion

In this document, a professional way of flexible voltage stability moreover justifying harmonics is addressed by using a PV fed DSTATCOM. The DSTATCOM is essentially shunt connected, which is provide reactive power recompense as well as voltage stability. The DC-DC converters is integrated with PV systems and self-lift LUO converter has been utilized in this document, along with ANFIS MPPT for tracking the maximum power beginning the PV, along by way of dc-link voltage regulation. The energy supervision for the proposed system is achieved using Bidirectional Battery converter along with battery system. A battery converter is included with the PV system and WECS system to meet the growing power demand in addition to provide an uninterruptible supply to the system. The selected converter provides well again efficiency moreover voltage-gain ratio, as soon as compared with other converters. The RNN supported in the making of reference signal, therefore the harmonic is minimized the method to be effectively mitigated. The justification of the proposed work is conceded out through MATLAB simulation.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

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Conflict of Interest

The authors have no conflicts of interest to declare.