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PV Tied Grid Connected Inverter Using High Gain Reboost Luo Converter

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ABSTRACT

This project proposes Reboost Luo converter based single phase three level voltage source inverter for PV system. The solar system provides voltage to the inverter through Reboost LUO converter. The MPPT fuzzy logic algorithm is used to extract the maximum power from the PV system. The solar PV energy generation system has been scrutinized as a most prominent energy system by power producers across the world as it uses renewable energy source for harnessing electricity. However, to the increase overall production, the grid connected PV system with DC – DC reboost luo converter has been employed as it boost up the low level DC voltage from the PV panel up to the level it matches the grid voltage. By assigning closed loop control strategy along with PI controller ensures the control performance and helps in extricating maximum possible power from the PV panel. The attained voltage is fed in to the grid through a VSI by assigning PI controller that eliminates the steady state error and helps in achieving the target grid voltage by analogizing actual power with the reference power. This single phase voltage source inverter converts DC voltage into AC voltage with grid synchronization. This project is implemented using Matlab simulation.

KEYWORDS — PV, PI CONTROLLER, DC-DC REBOOST LUO CONVERTER.

1.INTRODUCTION

Under the strain of rapidly rising energy demands and diminishing fossil fuel resources, the globe faces a tremendous problem. [1]. To address this problem, the global energy system must transition to a more efficient and long-term source of energy. Renewable energy are promising alternative ideas and technology for generating electricity [2]. When compared to traditional energy sources, solar panel generation is both environmentally friendly and cost effective. Furthermore, factors such as decreased panel prices, quick efficiency gains, and the consequences of rising power bills have all contributed to a growth in demand for solar PV arrays for generating their own electricity [3-4]. As a result, the focus is on connecting renewable energy systems to the local electrical grid. The offset sections of the premise daily electricity use and the possibility to generate value by transferring extra power to the grid are the main advantages of this technology [5].

However, one of the major problems with solar power generation is that the output power from solar PV panels is irregular and stochastic, resulting in operation intermittency and fluctuations. As a result, a battery energy storage (BES) system is equipped with the system for reducing the PV power's intermittency [6]. Operating BES in islanding mode (IAM), which provides uninterruptible power to key loads linked to the system during a power loss, justifies the increased expense. In addition, by smoothing the electricity sent into the grid, BES provides the additional facilities in the grid-tied system. Many studies have developed various control techniques [7-10] to optimise the size of BES for high use.

Jafari and his colleagues [10] presented a predictive energy management control to manage BES's available capacity best. A power management control for PVBES linked grid interfaced system was published by Tran et al. [11]. BES stores energy from the grid during off-peak periods and uses this stored energy at peak demand to take advantage of time-of-use (ToU) electricity prices. Beniwal and colleagues.

In this context, aiming for high efficiency, power quality and high average useful life, power electronics plays a fundamental role, considering that for micro distributed generation (DG) usually photovoltaic energy sources provide low DC voltage that requires boost, a high-quality tracking algorithm for maximum power extraction and low harmonic distortion for voltages and currents into the AC side. It would be desirable that the average useful life of a PV inverter could be at least equal to the lifetime of the panels to which they will be bound. These criteria may be economically critical to the current and future use of renewable energy such as solar and wind as the most awaited applications are connected to the AC distribution networks, where no energy storage system is required and all benefits of distributed generation can be reached.

Thus, it will be reviewed in this paper the main non-isolated single-phase topologies for PV grid-tie applications, with Maximum Power Point Tracking (MPPT), island and electrical protections. In addition, experimental results are presented and analyzed for a structure that presented greater benefits, as well as better performance for the algorithms required for this type of application.

2. PROPOSED SYSTEM

The solar PV power is applied to the grid along a DC-DC REBOOST LUO converter as well as a 1φ VSI. The point of functioning of PV array is at the maximum power point while the converter power is grid synchronized. For the controlling of landsman converter, an fuzzy logic controller is connected which tracks the maximum power by evaluating the current as well as voltage obtained from the PV array. It regulates the reference voltage or duty cycle for matching the power to instant power point. The MPPT controller exploits fuzzy logic controller and is non-linear and varies in accordance with time.

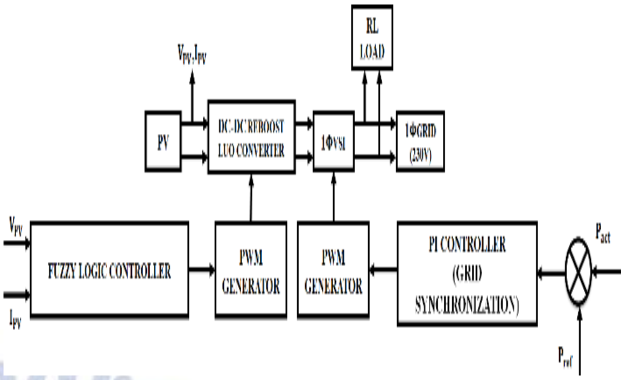

Figure 1: Proposed System Block Diagram

A. PV

The solar panel is the device that absorbs the sun rays and converts these rays into electricity or heat. With the help of the PV effect, electricity is generated whereas solar panel is a collection of solar cells. The amount of electricity produced, as measured in volts or watts, varies according to the system and the type of solar cell. Each module has its different DC output power depending upon the standard condition, and it has ranged from 100 to 365 watts. The arrangement of solar cells is mainly a grid-like pattern on the surface of the solar panels. That is why sometimes it may be called a set of modules, mounted on the structure supporting it. A photovoltaic module is packaged and connected assembly of 6×10 PV cells. When it comes to erosion,thesepanels are healthy. Solar panels wear out very slow once a year. Most of the solar panels are made up of crystalline silicon solar cells. Solar panels mainly made from these three key components which are silicon, metal, and glass.

Individual solar panel or module having an array which consists of PV cells packaged together in a metal frame. Single solar panel consist of around 60,72 or 96 photovoltaic cells. Solar panels are used in wide-ranging electronic equipment like calculators, which work as long as sunlightis available. Solar PV is a fast-growing, most mature, and costcompetitive renewable energy technologies.In the upcoming decades, solar power will clearly continue to be an essential renewables source. The popularity of green energy in today's era is increasing day by day Installation of solar panels reduces global warming by installing in homes and helps in the battle ofthe harmful emission of greenhouse gases. Solar panels are eco-friendly and are clean, solar panels are the traditional power sources.

B. DC-DC REBOOST LUO CONVERTER

This proposed converter is a combination of elementary Super lift Luo converter and Fly back converter. The circuit has four diodes, four capacitors and one step up isolation transformer. The coil from this transformer is used as an inductor. The Re BoostLuo converter is shown in Figure. 2. The main advantage of proposed converter is continuous input current operation; the transformer primary winding achieves this operation. The two mode of operation is explained here and also the switch on and switch off periods are analysed. During switch on period, magnetizing inductance of the isolation transformer gets charged, at that time, the diode D1 to D4 in off condition and also the capacitor C1, C2 and C3 in discharging condition. The Figures. 3 and 4 indicate the current direction of the proposed converter during on and off period.

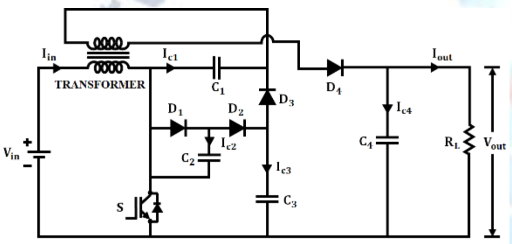

Figure 2: DC-DC Re-Boost Luo Converter

1.1. Mode 1 operation

During mode 1 the switch S of the Re-boost converter is turned ON. This causes the current to flow through the primary of the isolation transformer thus charging the magnetizing inductance of the transformer at this time the secondary winding is not in conduction. Meanwhile the capacitor C1 gets charged up by the capacitor Co which is in charged state due by the previous operations at this stage the diode D3 is at forward biased condition. Now the output capacitor Co gets disconnected from the remaining part of the circuit as the diodes D2 in off state and Co discharges through the output load resistor RL.

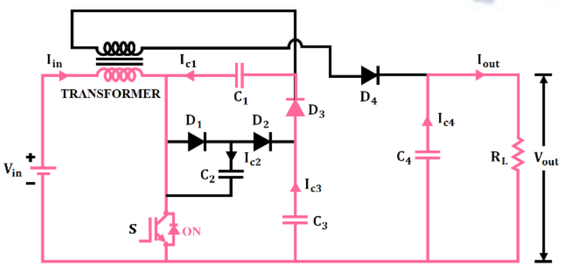

Figure 3: Switch On Mode Condition Flow Diagram

1.2. Mode 2 operation

In mode 2 the switch S is turned off. This time the current flow direction through the transformers primary doesn't get changed it follows the same direction as the in Mode 1 thus causing the input current to be continues in nature compared to other converters. At this mode the diodes D1 in forward bias that is turns on leaving diode D2 in off state. The capacitor C2 gets charged through the diodes D1 while the capacitor C1 which was charged by the previous mode gets added up with primary inductors charge and flows towards the output capacitor Co through the transformers secondary winding and charges the output capacitor to a higher voltage compared to the input voltage this voltage level can be controlled by increasing or decreasing the duty cycle and frequency.

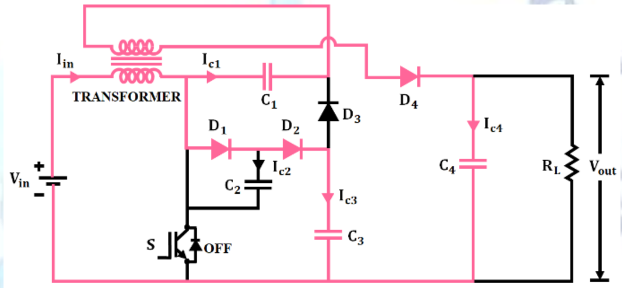

Figure 4: Switch Off Mode Condition Flow Diagram

1.3. Analysis of proposed Re Boost Luo converter

The output potential difference of the above elementary converter is,

$$V_0 = \left(\frac{2-\alpha}{1-\alpha}\right) V_{in} \quad (1)$$

where a is the duty cycle. From the Eq. (1),

$$G = \frac{(V_0)}{V_{in}} = \left(\frac{2-\alpha}{1-\alpha}\right) \quad (2)$$

The transformer will work as an inductor when its primary and secondary windings are connected in cascade. Hence for the purpose of analysis, the proposed transformer structure is viewed as an inductor. Now the input current will be the sum of current flowing through the inductor and capacitor.

The input rate of flow of electron, Iin is given by

$$I_{in} = I_{L1} + I_{C1} \quad (3)$$

The ripple currents present in the inductor is given a

$$\Delta T_{L1} = \frac{V_{in}.\alpha.T}{L_1} \quad (4)$$

where T - Total time of the switching pulse The ripple in the output voltage is expressed as,

$$\Delta V_0 = \frac{I_0(1-\alpha).T}{C_2} \quad (5)$$

$$T = \frac{1}{f} \quad (6)$$

$$I_0 = \frac{V_0}{R} \quad (7)$$

Sub (6) & (7) in Eq. (5),

$$\Delta V_0 = \frac{V_0(1-\alpha)}{fC2R} \quad (8)$$

From Eq. (1)

$$V_{in} = V_0\left(\frac{1-\alpha}{2-\alpha}\right) \quad (9)$$

Input current,

$$I_{in} = \frac{V_{in}}{R} = \frac{V_0}{R}\left(\frac{1-\alpha}{2-\alpha}\right) \quad (10)$$

Therefore,

$$\frac{V_{in}}{I_{in}} = \left(\frac{1-\alpha}{2-\alpha}\right)^2 . \frac{V_0}{V_0/R}$$

$$\frac{V_{in}}{I_{in}} = \left(\frac{1-\alpha}{2-\alpha}\right)^2 . R \quad (11)$$

From the above equations, we can derive the model for the proposed Re Boost-Luo Converter. Re Boost-Luo Converter is done with conventional fly back converters and elementary super life Luo Converter. An elementary Luo Converter with three diodes and three capacitor forms the proposed converter. In order to achieve high output gain, transformer is used as an Inductor. In proposed converter, the capacitor C1 is changed with input voltage. The ripple current of the primary winding of the transformer is,

$$\Delta I_{L1} = \frac{V_{in}.\alpha.T}{L1_{(N1)}} \quad (12)$$

where L1 (N1) - Inductance of the multi taped transformer primary winding. The potential difference in the capacitor C2 is

$$V_{C2} = \left(\frac{2-\alpha}{1-\alpha}\right)V_{in} \quad (13)$$

The ripple currents in the secondary winding of Luo transformer is,

$$\Delta I_{L2} = \frac{V_{C2}.\alpha.T}{L2_{(N2)}} \quad (14)$$

Voltage in the capacitor C3 is,

$$V_{C3} = \left(\frac{2-\alpha}{1-\alpha}\right)V_{in} \quad (15)$$

Voltage in the capacitor C4 is expressed as,

$$V_{C4} = V_0 \quad (16)$$

The potential difference at the output of the proposed Re-Boost Luo Converter is,

$$V_0 = \frac{N_2}{N_1}\left(\frac{2-\alpha}{1-\alpha}\right)V_{in} \quad (17)$$

where

N2 - No of turns in the secondary winding.

N1 - No of turns in the primary winding.

The potential difference at the output of converter depends on number of turns and duty cycle of the converter.

C. PWM GENERATOR

Pulse width modulation control works by switching the power supplied to the motor ON and OFF very rapidly. The DC voltage is converted to a square wave signal, alternating between fully on (nearly 12v) and zero, giving the motor a series of power "kicks". Pulse width modulation technique (PWM) is a technique for speed control which can overcome the problem of poor starting performance of a motor. PWM for motor speed control works in a very similar way. Instead of supplying a varying voltage to a motor, it is supplied with a fixed voltage value (such as 12v) which starts it spinning immediately. The voltage is then removed and the motor 'coasts'. By continuing this voltage on/off cycle with a varying duty cycle, the motor speed can be controlled. Pulse-width modulation (PWM) or duty-cycle variation methods are commonly used in speed control of DC motors. The duty cycle is defined as the percentage of digital'high'to digital 'low' plus digital 'high' pulse-width during a PWM period.

The average DC Voltage value for 0% duty cycle is zero; with 25% duty cycle the average value is 1.25V (25% of 5V). With 50% duty cycle the average value is 2.5V, and if the duty cycle is 75%, the average voltage is 3.75V and so on. The maximum duty cycle can be 100%, which is equivalent to a DC waveform. Thus by varying the pulse-width, we can vary the average voltage across a DC motor and hence its speed.

D. PI CONTROLLER

A closed loop PI Controller determines an error signal by finding the difference between the output and the set point of the system. The controller calculates an error value by subtracting the received process variable from the preferred reference input. The error is further reduced by adding or subtracting the inputs, bringing the process variable closer to the set point. This method is generally applicable when the mathematical model of the process is tedious. The block diagram of the PI controller is illustrated in Fig.

The PI controller is connected to the reboost luo converter which reduces the steady-state error making the system stable and stops the system from fluctuations. These controllers provide better transient response with improved gain margin and phase margin.

E. FUZZY LOGIC CONTROL

Fuzzy Logic requires some numerical parameters in order to operate such as what is considered significant error and significant rate-of-change-of-error, but exact values of these numbers are usually not critical unless very responsive performance is required in which case empirical tuning would determine them. For example, a simple temperature control system could use a single temperature feedback sensor whose data is subtracted from the command signal to compute "error" and then time-differentiated to yield the error slope or rate-ofchange-of-error, hereafter called "error-dot". Error might have units of degs F and a small error considered to be 2F while a large error is 5F. The "error-dot" might then have units of degs/min with a small error-dot being 5F/min and a large one being 15F/min. These values don't have to be symmetrical and can be "tweaked" once the system is operating in order to optimize performance. Generally, FL is so forgiving that the system will probably work the first time without any tweaking.

3. RESULT AND DISCUSSION

The proposed work is implemented in MATLAB simulation and the following outputs are obtained. Figure 5 shows the solar panel voltage representation of input AC, the source of output voltage is 70(V) attained. Figure 6 shows the input current waveform of Luo converter .

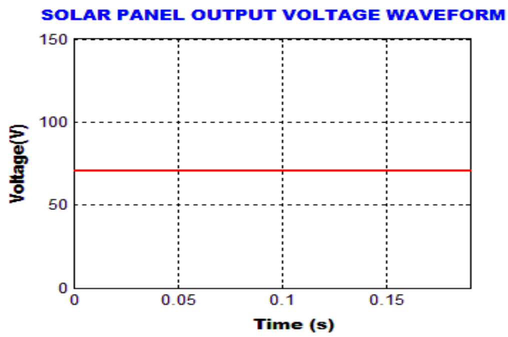

Figure 5: Solar Panel Output Voltage Waveform

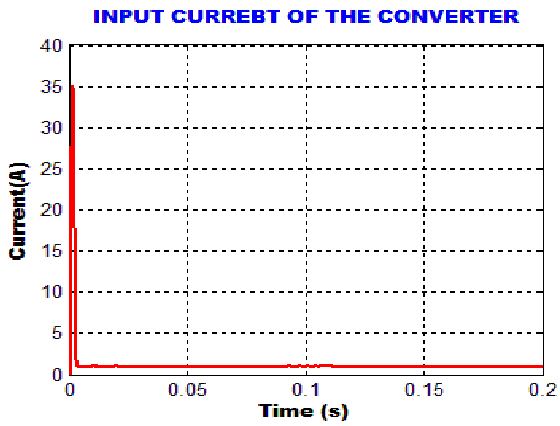

Figure 6: Input Current of the Converter

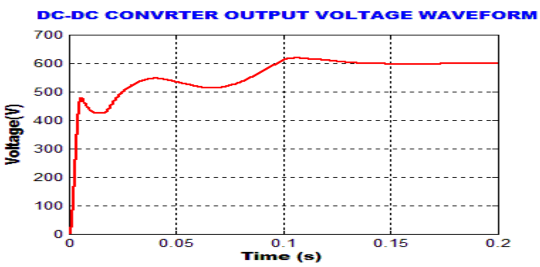

Figure 7: DC-DC Converter Output Voltage Waveform

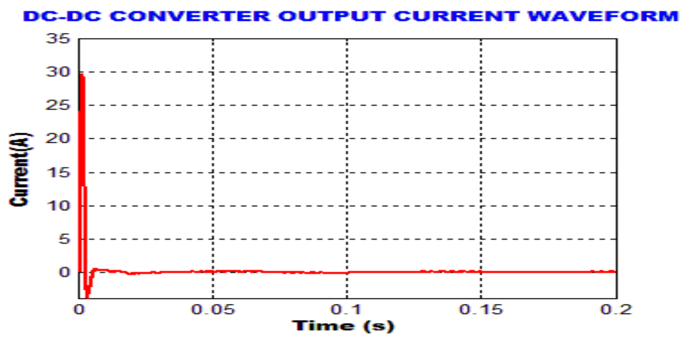

Figure 8: DC-DC Converter Output Current Waveform

The output of Luo converter voltage and current waveform are given in Figure 7 and 8 respectively.

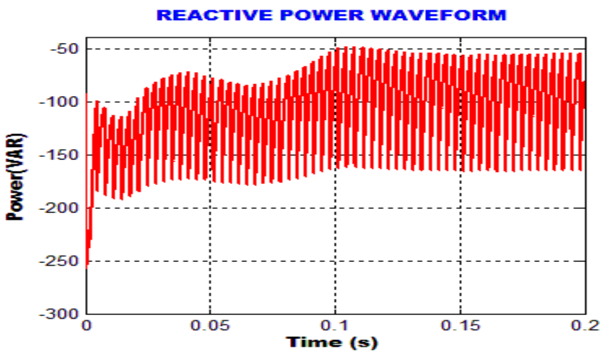

Figure 9: Reactive Power Waveform

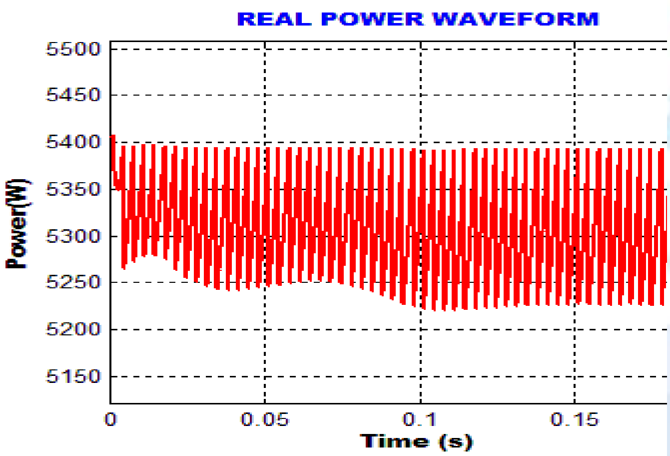

Figure 10: Real Power Waveform

The Figure 9 and 10 show the reactive power and real power waveforms of the proposed work.

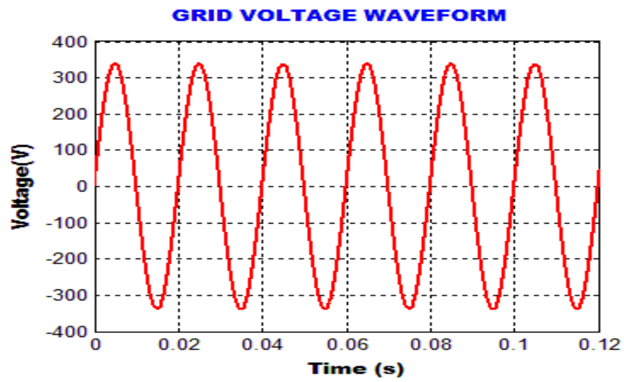

Figure 11: Grid Voltage Waveform

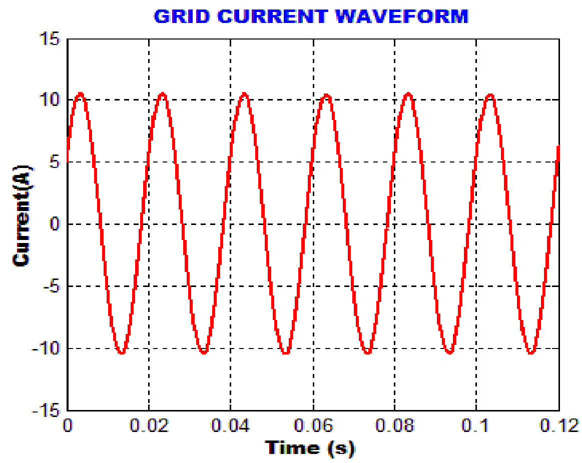

Figure 12: Grid Current Waveform

The output grid voltage and current waveform are given in Figure 11 and 12 respectively. The PI controller based grid synchronization achieves reactive power compensation.

4. CONCLUSION

In this work, an efficient REBOOST LUO CONVERTER with FUZZY MPPT is projected for a PV system utilizing grid. The output voltage generated by the PV system is not efficient hence it is fed to a REBOOST LUO CONVERTER which delivers a boosted output of similar polarity of the input voltage. The converter operates neglecting the variation of irradiance level and offers improved voltage gain with minimized switching losses. A 3φ VSI is exploited for converting fixed DC voltage to variable frequency AC voltage. An LC filter is employed for the attenuation of the harmonics of switching frequency. Thus, the projected system provides improved power quality with grid synchronization along with minimized distortion.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] J. T. Bialasiewicz, "Renewable Energy Systems with Photovoltaic Power Generators: Operation and Modeling," *IEEE Trans. Industrial Electronics*, vol. 55, no. 7, pp. 2752–2758, 2008,

[2] R. Panigrahi, S. Mishra, S. C. Srivastava, A. K. Srivastava and N. Schulz, "Grid Integration of Small-Scale Photovoltaic Systems in Secondary Distribution Network- A Review," *IEEE Trans. Industry Applications*, Early Access, 2020

[3] J. Krata and T. K. Saha, "Real-Time Coordinated Voltage Support with Battery Energy Storage in a Distribution Grid Equipped with Medium-Scale PV Generation," *IEEE Trans. Smart Grid*, vol. 10, no. 3, pp. 3486–3497, 2019.

[4] N. Liu, Q. Chen, X. Lu, J. Liu and J. Zhang, "A Charging Strategy for PV-Based Battery Switch Stations Considering Service Availability and Self-Consumption of PV Energy," *IEEE Trans. Ind. Elect*, vol. 62, no. 8, pp. 4878–4889, Aug. 2015.

[5] Y. Shan, J. Hu, K. W. Chan, Q. Fu and J. M. Guerrero, "Model Predictive Control of Bidirectional DC-DC Converters and AC/DC Interlinking Converters - A New Control Method for PV-Wind-Battery Microgrids," *IEEE Trans. Sust. Energy*, Early Excess 2018.

[6] V. Rallabandi, O. M. Akeyo, N. Jewell and D. M. Ionel, "Incorporating Battery Energy Storage Systems into Multi-MW Grid Connected PV Systems," *IEEE Trans. Ind. Appl*, vol. 55, no. 1, pp. 638–647, 2019.

[7] H. Myneni and G. Siva Kumar, "Energy Management and Control of Single-Stage Grid Connected Solar PV and BES System," *IEEE Trans. Sustainable Energy*, Early Access 2019.

[8] B. B. J. Dharmaian Retnam, A. G. Nanjappa Gounder and V. Ammasai Gounden, "Hybrid power electronic controller for combined operation of constant power and maximum power point tracking for single-phase grid-tied photovoltaic systems," *IET Power Electronics*, vol. 7, no. 12, pp. 3007–3016, 2014.

[9] Y. Yang, Q. Ye, L. J. Tung, M. Greenleaf and H. Li, "Integrated Size and Energy Management Design of Battery Storage to Enhance Grid Integration of Large-Scale PV Power Plants," *IEEE Trans. Industrial Electronics*, vol. 65, no. 1, pp. 394–402, 2018.

[10] M. Jafari, Z. Malekjamshidi, J. Zhu and M. Khooban, "Novel Predictive Fuzzy Logic-Based Energy Management System for Grid-connected and Off-grid Operation of Residential Smart Micro-grids," *IEEE Journal of Emerging and Selected Topics in Power Elect. in Early Excess*, 2018.

[11] V. T. Tran, K. M. Muttaqi and D. Sutanto, "A Robust Power Management Strategy with Multi-Mode Control Features for an Integrated PV and Energy Storage System to Take the Advantage of ToU Electricity Pricing," *IEEE Trans. Industry Applications*, vol. 55, no. 2, pp. 2110–2120, 2019.