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International Journal for Modern Trends in Science and Technology
Volume 11, Issue 01, pages 41-47.
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol11issue01.html
DOI: https://doi.org/10.46501/ijmtst.v11.i01.pp41-47

High-Gain Reboost Luo Converter with Advanced Soft-Switching for Increased Photovoltaic System Efficiency

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To Cite this Article
Uppalapati Veera Aravind, Chebrolu Akhil, Koppineedi Sanjay Sai Gopal and Vendoti Suresh, "High-Gain Reboost Luo Converter with Advanced Soft-Switching for Increased Photovoltaic System Efficiency", International Journal for Modern Trends in Science and Technology, 2024, 11(01), pages. 41-47. https://doi.org/10.46501/ijmtst.v11.i01.pp41-47

Article Info
Received: 04 January 2024; Accepted: 22 January 2025.; Published: 28 January 2025.

ABSTRACT

A unique Soft Switching High Gain Reboost Luo Converter is presented in this work with the goal of improving photovoltaic (PV) systems' performance and efficiency. Soft switching techniques are used in the proposed converter to lower switching losses and increase system efficiency, which is especially advantageous for PV applications that need high voltage gain. By incorporating the Reboost Luo Converter, the system's voltage conversion ratio is significantly increased, guaranteeing the best possible power extraction from PV panels in a range of environmental circumstances. The converter's capacity to deliver high gain, efficient energy conversion with decreased electromagnetic interference (EMI) and reduced stress on switching devices is demonstrated through modeling and analysis of its performance using the MATLAB/Simulink simulation environment. The outcomes demonstrate how well the converter works to increase the power output and dependability of PV systems, providing a viable way to develop renewable energy solutions.

KEYWORDS: Soft Switching, High Gain Converter, Reboost Luo Converter, Photovoltaic System, MATLAB/Simulink, Switching Losses, Voltage Conversion Ratio

1.INTRODUCTION

Due to the strain resulting from rapidly rising energy demands and decreasing fossil fuel resources, the globe is today facing a major problem. [1]. The global energy system must transition to a more efficient and long-term sustainable energy source in order to address this problem. [2] Alternative concepts and technologies with great potential for producing power are known as renewable energy. In addition to being more environmentally friendly than more traditional energy producing methods, solar power generation also delivers substantial financial benefits. Furthermore, the demand for solar PV arrays for the purpose of producing one's own electricity has increased due to a number of variables, including declining panel prices, rapid efficiency advances, and the effects of rising power bills [3–4]. As a result, the integration of renewable energy technologies into the current electrical infrastructure is being prioritized. The ability to generate value by supplying excess power to the grid and offsetting a portion of the building's daily electricity consumption are the two main advantages of using this technology [5].

The unpredictable and stochastic nature of solar photovoltaic panels' output power, however, is one of the biggest disadvantages of solar power generation. This makes the system vulnerable to fluctuations and intermittency. As a result, the system intended to reduce the erratic nature of PV power incorporates a battery energy storage system, commonly referred to as a BES system [6]. As long as the BES is running in islanding mode (IAM), which provides uninterruptible power to critical loads connected to the system in the case of a power outage, the additional expense is justified. Additionally, by smoothing out the electricity that is fed into the grid, the BES is able to supply the extra facilities in the grid-tied system. To maximize the size of BES for high utilization, numerous studies have generated a range of control techniques [7–10]. The goal of Jafari and his colleagues' [10] predictive energy management control was to administer BES's available capacity as efficiently as possible. Tran et al. provide a power management control for a PVBES linked grid interfaced system in the paper with the number [11]. By storing grid energy during off-peak demand hours and using that stored energy to satisfy peak demand during the day, BES is able to benefit from time-of-use (ToU) electricity pricing. Beniwal and the other scientists.

Micro distributed generation (DG) relies heavily on power electronics since solar energy sources provide low DC voltage that requires boosting and a high-quality tracking algorithm. The objectives include high useable life, power quality, and efficiency. It would be fantastic if solar inverters could last as long as the panels to which they are connected. These specifications might be economically necessary for the use of renewable energy sources like solar and wind both now and in the future because the most anticipated applications are connected to AC distribution networks, where energy storage technology is not required.

Popular non-isolated single-phase topologies for PV grid-tie applications, MPPT, island safeguards, and electrical safety will all be covered in this article. Experimental results for a structure that enhanced algorithm performance for this application are also presented and investigated. This useful framework was discussed.

2. PROPOSED SYSTEM

A VSI of one and a DC-DC REBOOST LUO converter work together to feed solar photovoltaic (PV) electricity into the grid. The converter power must be synchronized with the grid at the point of maximum power output for a solar array to operate correctly. A fuzzy logic controller is attached to the landsman converter to enable control. By examining the voltage and current extracted from the PV array, this controller keeps track of the maximum power that may be obtained from it. In order to match the power to the instantaneous power point, it is in charge of controlling both the duty cycle and the reference voltage. A fuzzy logic controller, which is non-linear and whose parameters vary over time, is used by the MPPT controller.

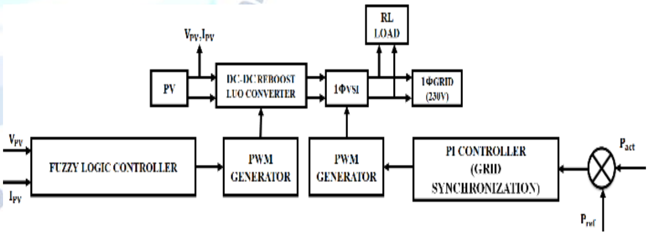

Figure1: Proposed System Block Diagram

A. *PVSystem*

The solar panel is the apparatus used to convert energy from sunlight into usable forms such as electricity or heat. A solar panel is a group of solar cells used to generate electricity via the photovoltaic (PV) effect. The system and solar cell type both affect the system's output of electricity (in volts or watts). The DC output power of each module varies from 100 to 365 watts under typical conditions. Most solar panels have solar cells arranged in a grid pattern on their surface. For this reason, it is sometimes described as a collection of modules attached to a larger framework. Assemblies of

6–10 PV cells are packaged and wired together to form a photovoltaic module. These panels have a good erosion resistance. In a year, solar panels lose only a small percentage of their efficiency. Crystalline silicon solar cells are the primary component of solar panels. Silicon, metal, and glass are the three basic materials used in manufacturing solar panels.

Each PV cell is part of a larger array that is housed in a metal frame within a solar panel or module. About 60, 72, or 96 photovoltaic cells make up a single solar panel. Numerous types of electronic devices, such as calculators, require solar panels to stay operational under bright light. Solar photovoltaics (PV) are among the most rapidly expanding, established, and competitively priced renewable energy technologies. There is little doubt that solar energy will remain a crucial renewable resource in the decades to come. Today, more and more people are opting to use renewable energy sources. Home solar panel installations mitigate the effects of global warming by cutting down on the release of dangerous greenhouse gases. Solar panels are the conventional power sources because they are clean and good for the environment.

B. DC-DC REBOOST LUO CONVERTER

The proposed converter is an evolution of the simple Super lift Luo converter and the more complex Fly back converter. The circuit uses one step-up isolation transformer, four capacitors, and four diodes. The transformer's coil is repurposed as an inductor. Figure 2 depicts the Re BoostLuo converter. The primary winding of the transformer is responsible for the continuous operation that is the main benefit of the proposed converter. Both modes of operation are broken down here, along with an examination of their respective on and off times. The diodes D1 through D4 are in their off states, and capacitors C1, C2, and C3 are in their discharging states, during the switch on period, when the magnetising inductance of the isolation transformer is being charged. Figures 3 and 4 show the polarity of the current flowing through the proposed converter when it is on and off, respectively.

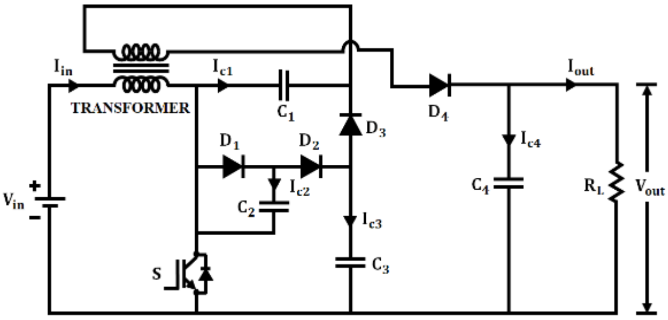

Figure 2:DC-DC Re-Boost Luo Converter

Mode 1 operation

As soon as Mode 1 is engaged, the Re-boost converter's On/Switch is activated. This charges the magnetising inductance of the isolation transformer's primary winding, while the secondary winding remains electrically isolated. Meanwhile, capacitor C1 is being charged by the charged capacitor Co. D3 has a tendency to lean towards the front side. When you turn off D2, the output capacitor Co is cut off from the rest of the circuit and discharges via the resistor RL.

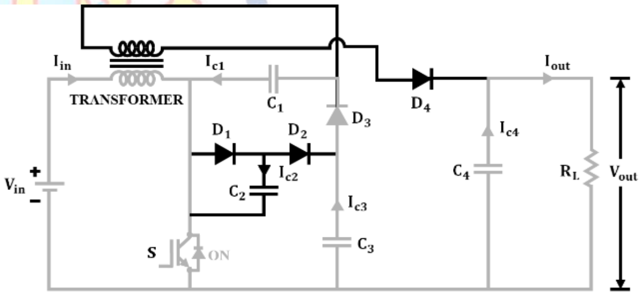

Figure 3:Switch On Mode Condition Flow Diagram

Mode 2 operation

In the second setting, S is turned off. Unlike other converters, the input current to a transformer is continuous because the direction of current flow across the transformer's primary does not change. With a forward bias, D1 turns on while D2 remains in its off state. The diodes D1 charge the second capacitor C2 while the charge from the first capacitor C1 is added to the charge in the main inductor and then travels to the output capacitor Co through the transformer's secondary winding, where it is amplified. Changing the duty cycle and the frequency may regulate this voltage..

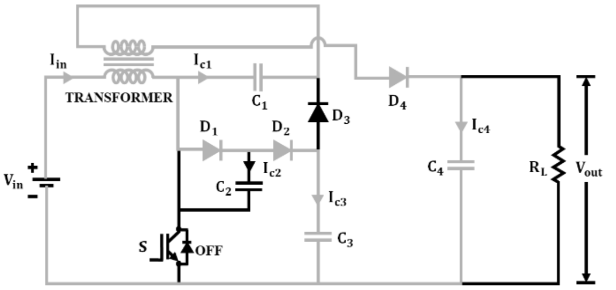

Figure 4: Switch Off Mode Condition Flow Diagram

Analysis of proposed Re Boost Luo converter

The output potential difference of the above elementary converter is,

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

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

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

When the main and secondary windings of the transformer are linked in a cascade, the device takes on the characteristics of an inductor. In order to do the necessary calculations, the proposed transformer is modelled as an inductor. The combined current from the inductor and capacitor is now the input current.

The electron flow rate at input, Iin, may be calculated as

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

The ripple currents present in the inductor is given a

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

in which T is the duration of the entire switching pulse The output voltage ripple is denoted by the expression,

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

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

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

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

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

From Eq. (1)

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

Input current,

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

Therefore,

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

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

We can derive the Re Boost-Luo Converter model from the above equations. Re Boost-Luo Converter uses flyback converters and super life Luo Converter. Proposed converter has three diodes and three capacitors. Transformers are used as inductors to boost output gain. In proposed converter, input voltage changes C1. Primary winding ripple current is,

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

L1 (N1) - Transformer primary winding inductance. C2 capacitor voltage is

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

Luo's secondary winding ripples.,

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

Capacitor C3 voltage,

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

C4 capacitor voltage is,

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

The proposed Re-Boost Luo Converter's output difference is,

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

where

N2 - No of turns in the secondary winding.

N1 - No of turns in the primary winding.

Number of turns and converter duty cycle affect output voltage.

C. PWM GENERATOR

PWM control swiftly switches motor power ON and OFF. The DC voltage is transformed to a square wave signal, oscillating between full power (almost 12v) and zero, to "kick" the motor. PWM may improve a motor's starting performance by controlling its speed. PWM controls motor speed similarly. Instead of variable voltage, a set voltage (such as 12v) starts a motor instantaneously. The motor "coasts" without power. Continuing this voltage on/off cycle with a variable duty cycle controls motor speed. DC motor speed control uses PWM or duty-cycle variation. Duty cycle is the ratio of digital high to low plus high during a PWM period.

At 0% duty cycle, the average DC Voltage is zero; at 25%, it's 1.25V (25% of 5V). 50% duty cycle averages 2.5V, 75% 3.75V, etc. 100% duty cycle equals a DC waveform. By adjusting the pulse-width, we can change the DC motor's average voltage and speed..

D. PI CONTROLLER

The closed loop PI Controller measures the deviation between actual output and the target value to provide an error signal. By deducting the incoming process variable from the controller's chosen reference input, an error value is generated. By adjusting the inputs, the error may be decreased and the process variable can be brought closer to the set point. Apply this technique whenever the mathematical model of the process is time-consuming. Fig. depicts the PI controller's block diagram.

Because of the connection between the PI controller and the reboost luo converter, the steady-state error is minimised, and the system is stabilised, without experiencing any oscillations. Better transient response with increased gain margin and phase margin is what these controllers are good at..

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 .

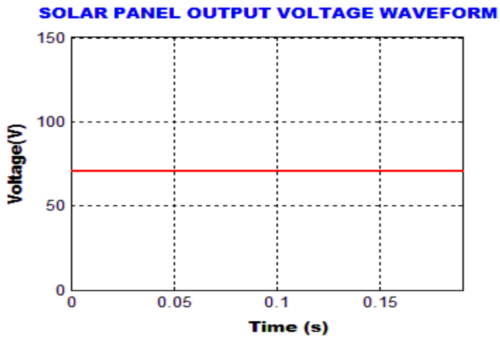

Figure5:Solar Panel Output Voltage Waveform

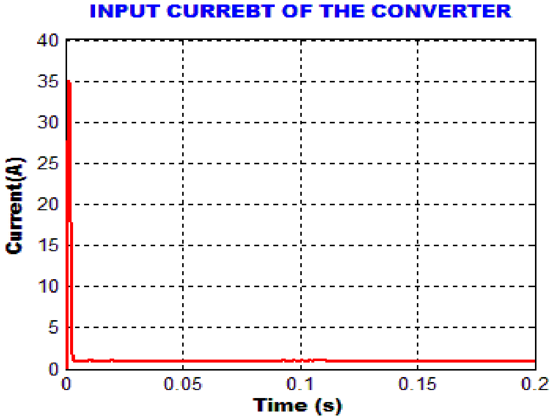

Figure 6: Input Current of the Converter

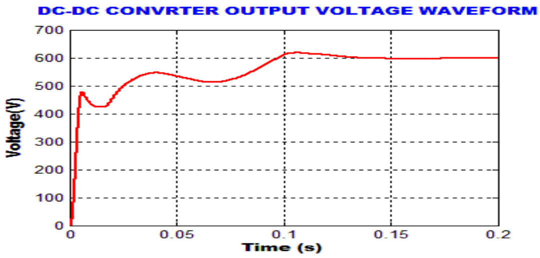

Figure 7:DC-DC Converter Output Voltage Waveform

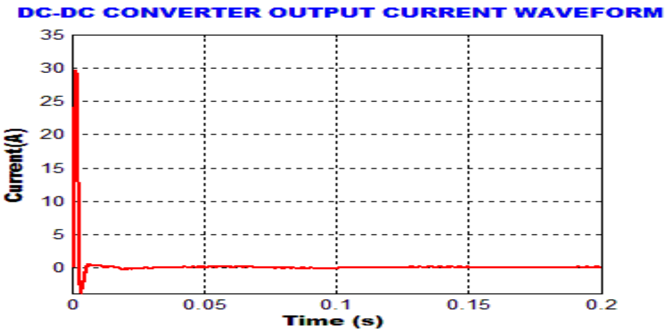

Figure 8: DC-DC Converter Output Current Waveform

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

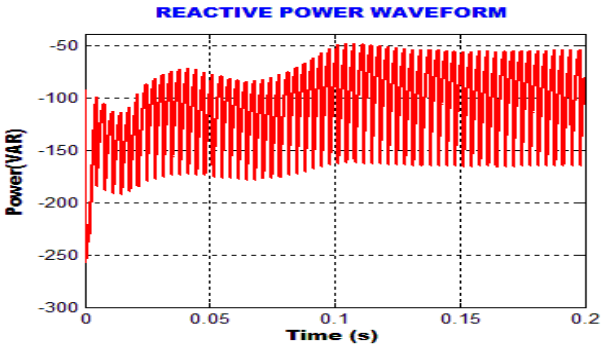

Figure 9:Reactive Power Waveform

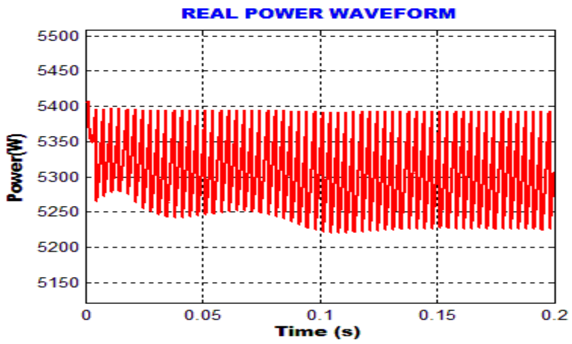

Figure 10: Real Power Waveform

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

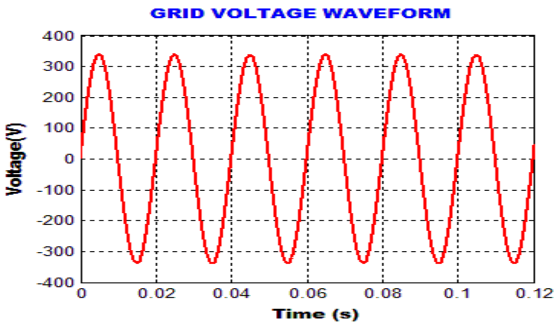

Figure 11:Grid Voltage Waveform

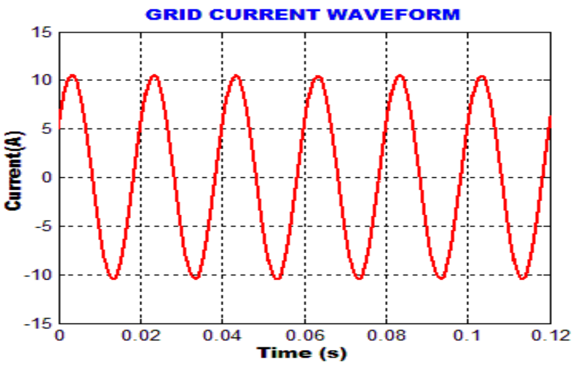

Figure 12: Grid Current Waveform

Figures 11 and 12 show grid voltage and current waveforms. PI-based grid synchronisation compensates reactive power..

4. CONCLUSION

The performance of a REBOOST LUO CONVERTER with FUZZY MPPT for a grid-connected solar system is predicted by this study. The PV system's inefficient output voltage is fed via a REBOOST LUO CONVERTER, which generates an output with a greater voltage and the same polarity as the input. This converter offers greater voltage gain with less switching losses and operates regardless of variations in light intensity. A 3 VSI is used to convert DC voltage into AC voltage with different frequencies. An LC filter is used to reduce the harmonics of the switching frequency. Consequently, by grid synchronization, the planned infrastructure guarantees improved power quality and lowers 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. DharmaianRetnam, A. G. NanjappaGounder and V. AmmasaiGounden, "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.