Certain investigations on performance analysis of different converter designs for smart micro-grid systems

N. Krishnamoorthy[1], Sudheer Hanumanthakari[2], Gobimohan Sivasubramanian[3], A. Prabha[4], P. Hemachandu[5], P. Veeramanikandan[6], Nageswara Rao Medikondu[7], R. Gopinathan[8], L. Anbarasu[9]

[1]Department of Computer Science and Applications (MCA), Faculty of Science and Humanities, SRM Institute of Science and Technology, Ramapuram, India
[2]Department Electronics and Communication Engineering, Faculty of Science and Technology, ICFAI Foundation for Higher Education, Hyderabad, India
[3]Department of Electrical Engineering, College of Engineering and Technology, UTAS NIZWA, Oman
[4]Department of Electrical and Electronics Engineering, S. A. Engineering College, Chennai, India
[5]Department of EEE, Sasi Institute of Technology and Engineering, Tadepalligudem, India
[6]Department of Electrical and Electronics Engineering, Dhanalakshmi Srinivasan College of Engineering and Technology, Chennai, India
[7]Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, India
[8]Department of Mechatronics Engineering, Sri Krishna College of Engineering and Technology, Coimbatore, India
[9]Department of Electrical and Electronics Engineering, Erode Sengunthar Engineering College, Erode, India

Article Info

Article history:

Received Aug 22, 2023
Revised Nov 9, 2024
Accepted Nov 28, 2024

Keywords:

ABC-PI controller
DC-DC
Grid
MPPT
SEPIC-Luo converter

ABSTRACT

This paper proposes a grid-connected hybrid renewable power system. A LUO converter driven by ABC-PI controller is used to produce stable DC-link voltage. To enhance the voltage, a LUO converter is used, and the boosted voltage is regulated by an ABC-PI controller. Using the suggested optimization approach, the power fluctuation is kept at a low value. The execution of the proposed optimization is efficient, as it is simple and robust. It has a limited number of control parameters as compared to other approaches. The suggested method is described in complete detail, together with its converter and control mechanisms. The modeling and experimental results are validated to ensure that the system is feasible. The HRES is analyzed through simulation in MATLAB with converters like boost, SEPIC, and LUO. The results reveal that the LUO converter performs better with a minimum settling time of 0.175 seconds with a source current THD of 1.29%. From the modeling and the simulation results, it has been revealed that the proposed technology provides more reliable and steady power.

Corresponding Author:

L. Anbarasu
Department of Electrical and Electronics Engineering, Erode Sengunthar Engineering College
Perundurai, Erode, Tamilnadu, India
Email: lanbarasu78@gmail.com

1. INTRODUCTION

Energy is a basic need for all human activities like agriculture, transportation, manufacturing, and generating electricity. The accessibility of energy is directly related to the growth and development of the country; as there is a limited availability of fossil fuels, its usage leads to many environmental consequences. Also, developing nations and industries are in an urge to improve their living standards. Hence a non-polluting clean energy resource is needed, which satisfies the growing energy demand and also assists in achieving better living standards. Some of the available renewable energy sources (RES) are wind, solar, geothermal and hydropower. When analogized to other energy sources, the HES provides higher performance. Because of climatic conditions, the output attained from these two energy sources is uncertain, i.e. one system provides more power, whereas the other system provides less power or no power. As a result, this system's output voltage needed to be stabilized. These two energy sources are linked in parallel, if one energy system is unavailable, then another energy system balances the control system. Therefore, these two energy sources operate individually and simultaneously. A LUO converter is proposed, which overcomes the drawbacks of SEPIC and boost converters, and also the THD has been further minimized.

2. PROPOSED METHODOLOGY

The renewable energy-based smart micro-grid is proposed. PV and wind turbines is integrated with the grid through three-phase inverters. The retrieved power from PV and wind turbines is to be regulated at a stable mode. To regulate a DC-link voltage, an LUO converter controlled by an optimized PI controller is used. LUO converter maximizes the voltage retrieved from renewable sources and to provide a steady state DC voltage to the grid, an optimized PI controller is used. To perform optimization, the Artificial Bee colony algorithm is used. It's a robust and facile algorithm and it requires few control parameters when analogized with other algorithms. To minimize the intermittent distribution of power from renewable resources, the battery is coupled with PCC to generate power at the time of lack of renewable sources [1]-[5]. The resulting voltage of DC-DC LUO converter is fed to the PI controller and analogized with the reference voltage which is fixed to 600 V. The fault that is observed is given to the comparator and it is utilized to produce manipulating pulses for LUO converter. The power from a wind turbine is obtained as AC electrical power. It is transformed to DC by making use of a PWM rectifier. The battery acts as a secondary storage device. When the voltage of the battery exaggerates above 560 V, the power from the battery will start released out to the inverter, and finally by using three-phase inverters, the DC voltage is transformed to AC and it is fed to the grid. The grid synchronization is carried out by using DQ theory [6]-[10]. The proposed system performs effectively in generating reliable and sufficient power to the grid displayed in Figure 1.

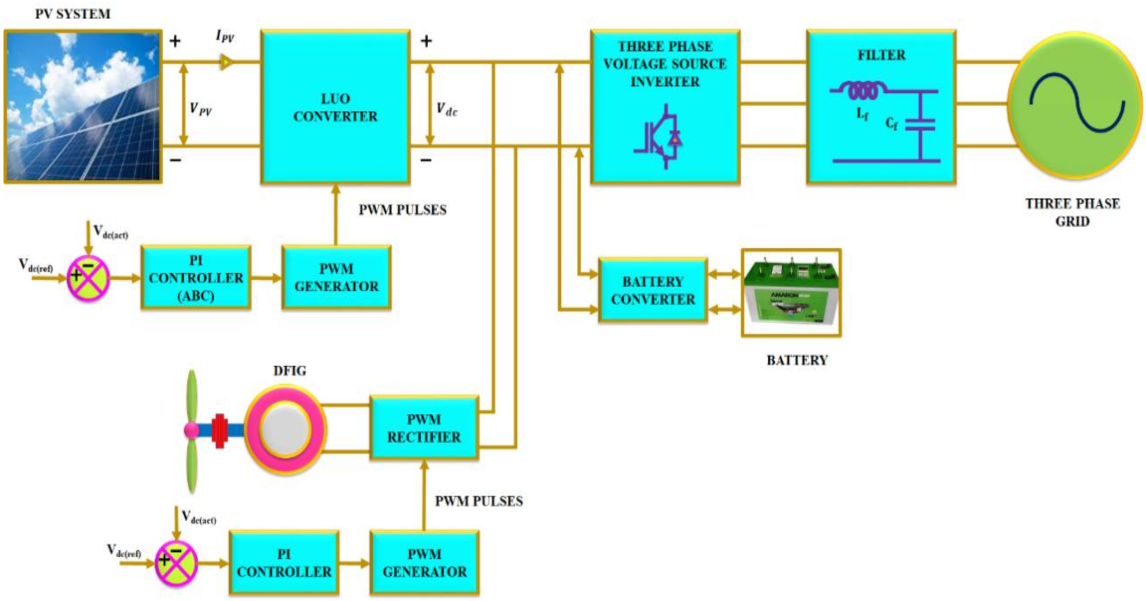

Figure 1. Control approach of HRES with LUO converter

3. MODELLING METHOD

LUO converter assists to lift the voltage retrieved from PV and wind turbine. The impact of circuit elements minimizes the resulting voltage and transfer efficiency of power. LUO converter acquires maximum output voltage with minimized ripples along with good efficiency. The positive LUO converter circuit diagram is represented in Figure 2. From source to capacitor, the inductor L_1 transfer energy during turn off mode and after that, accumulated energy is fed to load when it is switched on. Therefore, if the voltage Vc is found to be higher than the resulting voltage Vo, the resulting voltage also gets maximized. When the switch S is turned to be in mode off position, the power starts flowing via diode D. If the power not reaches zero before turning on the switch again.

This operating state is said to be in CC mode and if it becomes zero, then it is to be in discontinuous mode. The inductor and capacitor play a significant role and its computation is performed as follows:
The inductor current IL2 is computed by using the (1).

$$IL_2 = \frac{(1-a)}{a} IL_1 \quad (1)$$

The resulting voltage equation as shown in (2).

$$V_o = \frac{a}{1-a} V_{in} \quad (2)$$

The average voltage across the capacitor is (3).

$$V_c = \frac{a}{1-a} V_{in} \quad (3)$$

The peak-to-peak inductor current is computed by (4).

$$\nabla IL_1 = \frac{aTV_{in}}{L_1} \quad (4)$$

From (4), inductor L1 value and L2 value are calculated as (5) and (6).

$$L_1 = \frac{aTV_{in}}{\nabla IL_2} \quad (5)$$

$$L_2 = \frac{aTV_{in}}{\nabla IL_2} \quad (6)$$

The charge that is present in the capacitor exaggerates during off mode by IL2 and minimizes during on mode by IL1. The voltage across the capacitor is given by (7).

$$C = \frac{1-a}{\nabla VC_1} T_1 \quad (7)$$

The negative output LUO converter is shown in Figure 3. In the negative output LUO converter, the inductor L2 accumulates energy from PV and wind during switch-on mode and it carries out the accumulated energy to the condenser at the time of off mode.

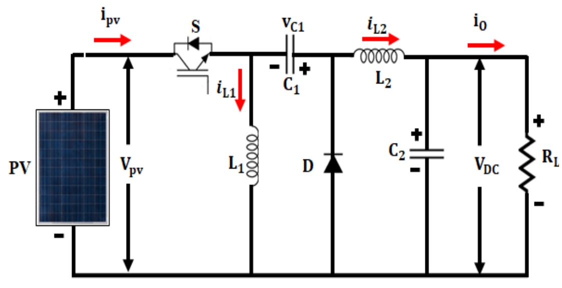

Figure 2. Positive output LUO converter

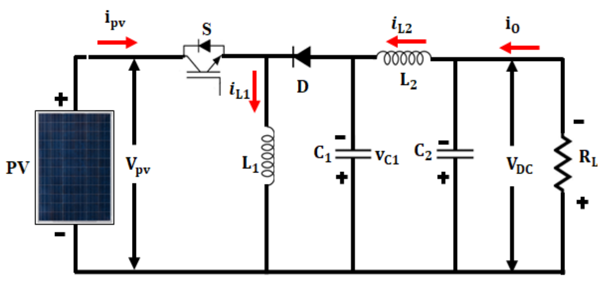

Figure 3. Negative output LUO converter

4. RESULTS AND DISCUSSION

A simulation model for PV-wind battery based HRES with a LUO converter is instigated in MATLAB software to examine the system's effectiveness. This main goal of this approach is to provide the grid with stable power. Due to temperature changes, the power obtained is not retrieved in a balanced state. To overcome this, a LUO converter is utilized in this proposed control methodology, which provides a constant output and this converter is controlled with the aid of a PI controller. The specifications for LUO converter is represented in following Table 1. The DC-link voltage waveform with LUO converter using ABC is displayed in Figure 4. The DC-link voltage with LUO converter by utilizing PI, fuzzy and ABC are $600\ V$, but the settling time is different. By utilizing PI controller, the DC link is settled after the time of $0.29s$, for Fuzzy controller, the DC link is settled after the time of $0.26\ s$ and for ABC [11]-[15], the DC link is settled after the time of $0.175\ s$. The output voltage of PWM rectifier by utilizing LUO converter is displayed in Figure 5. The output attained from the WECS based DFIG is AC voltage, which is transformed in to DC voltage by utilizing a PWM rectifier [16]-[20].

The output voltage of PWM rectifier is noted as $600\ V$, which is highlighted in the above waveform and this output is similar to LUO converter's output. In the initial stage, the voltage shows fluctuations and after the time period of $0.11\ s$, it goes to steady state. The battery voltage and current waveforms by utilizing LUO converter are displayed in Figures 6 and 7. For the analysis of HRES, the battery plays an essential role in storing the excess energy, whereas the charging and discharging is carried out by utilizing a bidirectional buck-boost converter. The battery voltage of $183\ V$ is attained after a time period of $0.132\ s$. The voltage fluctuations occurs in the initial stage and after $0.132\ s$, it goes to steady state. In the current waveform, the current increases in the initial stage and then decreases to zero at a time period of $0.1s$, which again slightly increases to $12.5\ A$ as observed in the current waveform. The battery SOC waveform by utilizing LUO converter is displayed in Figure 8. From this waveform, it is noted that the battery's SOC is observed as 80%. The grid voltage and current waveforms by utilizing LUO converter are displayed in Figures 9 and 10. The HRES based PV-wind-battery system with a LUO converter is given to the grid through a 3ϕ VSI. The grid voltage is ranges from $+370\ V\ to - 370\ V$, whereas the grid current is ranges from $+10\ A\ to - 10\ A$ are observed, which are highlighted in the above waveforms. The real and reactive power waveforms by utilizing LUO converter are displayed in Figures 11 and 12. The real power is noted as $5600\ W$ with some distortions, whereas from the reactive power waveform, it is noted that the reactive power varies between $-165\ to - 45\ VAR$. The power factor waveform by utilizing LUO converter is displayed in Figure 13. The unity power factor is observed in this waveform with the aid of a HRES based PV-wind-battery system along with a LUO converter. The grid current THD by utilizing HRES based PV-wind-battery system along with LUO converter power factor are displayed in Figure 14. The system's performance is assessed on the basis of THD observed [21]-[26]. If the THD is high, the system shows more harmonics; therefore, lower the THD, the performance becomes better. With the utilization of LUO converter, the THD attained is 1.29%.

Table 1. Specifications of LUO converter

Specifications	Values
Inductances (L_1, L_2)	$4\ mH, 6\ mH$
Capacitances (C_1, C_2)	$220\ \mu F, 100\ \mu F$
Switching Frequency (f_s)	$25\ KHz$
Resistive Load (R_L)	$15\ \Omega$

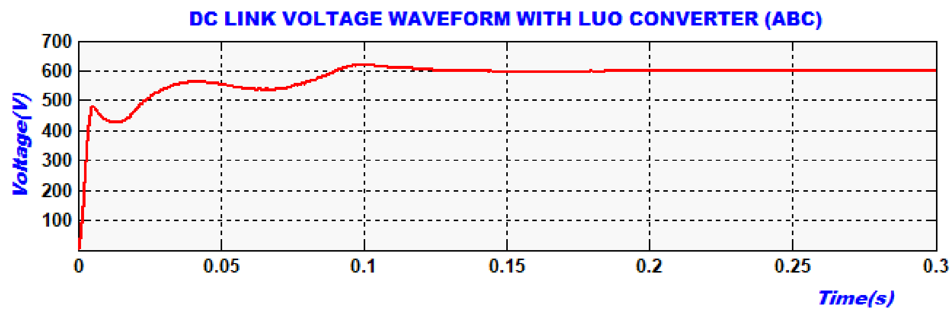

Figure 4. DC-link voltage with LUO converter (ABC algorithm)

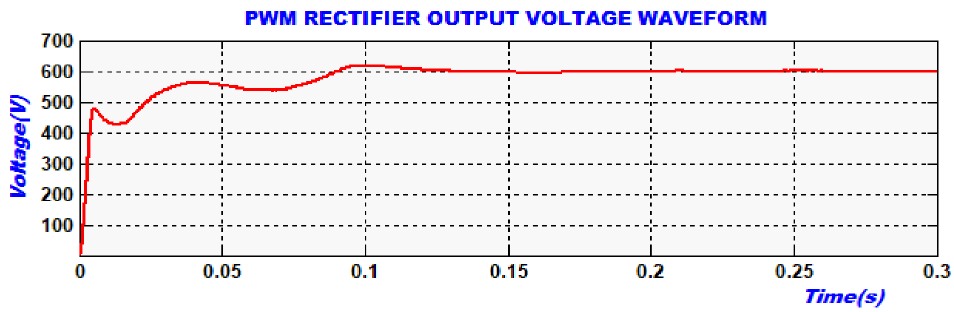

Figure 5. Output voltage of PWM rectifier by utilizing LUO converter

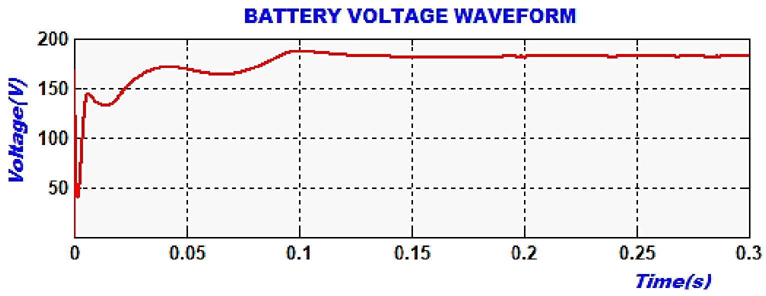

Figure 6. Battery voltage waveform by utilizing LUO converter

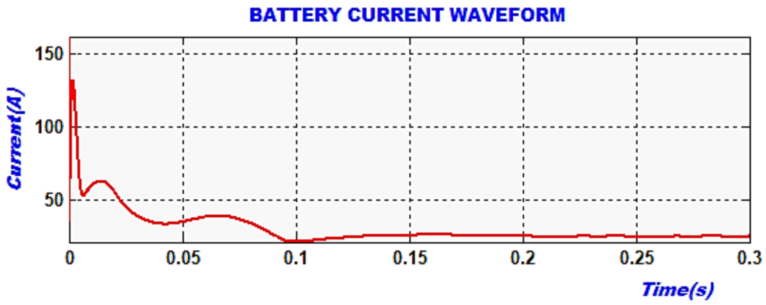

Figure 7. Battery current waveform by utilizing LUO converter

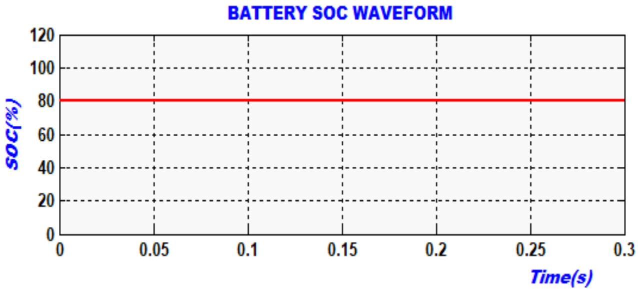

Figure 8. Battery SOC waveform by utilizing LUO converter

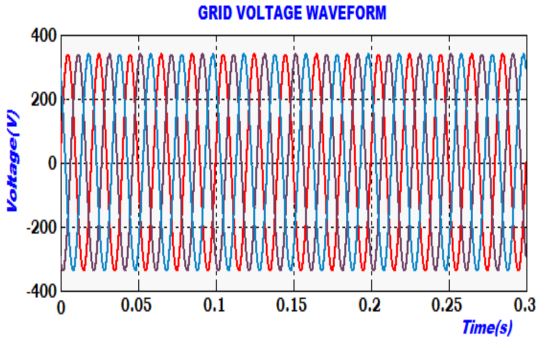

Figure 9. Grid voltage waveform by utilizing LUO converter

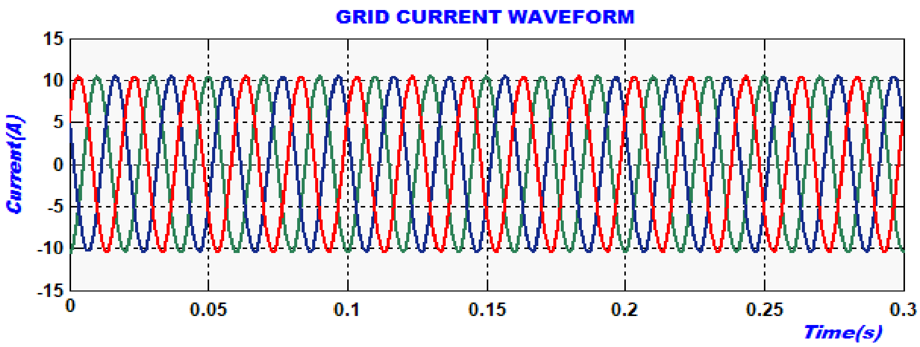

Figure 10. Grid current waveform by utilizing LUO converter

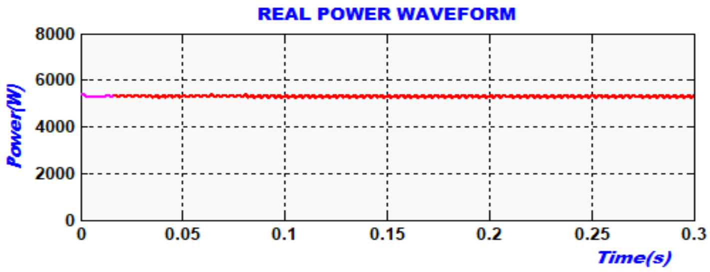

Figure 11. Real power waveform by utilizing LUO converter

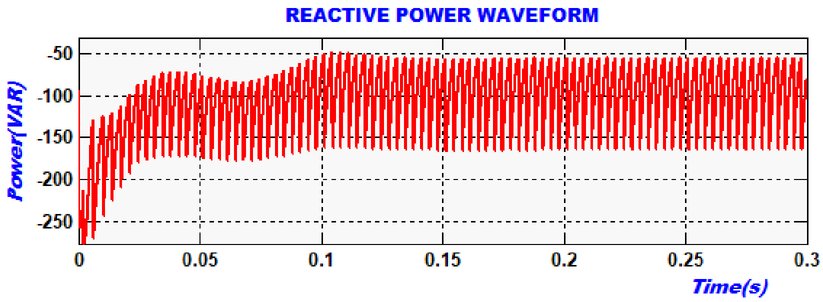

Figure 12. Reactive power waveform by utilizing LUO converter

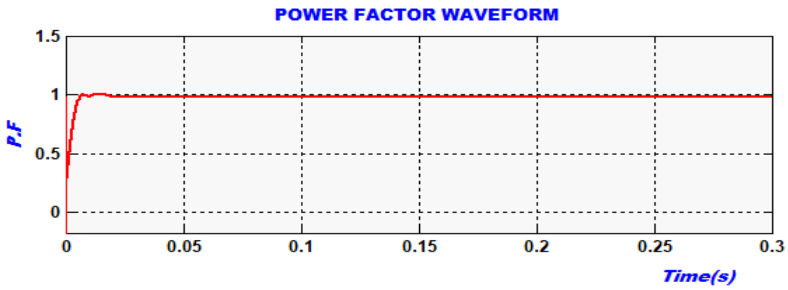

Figure 13. Power factor waveform by utilizing LUO converter

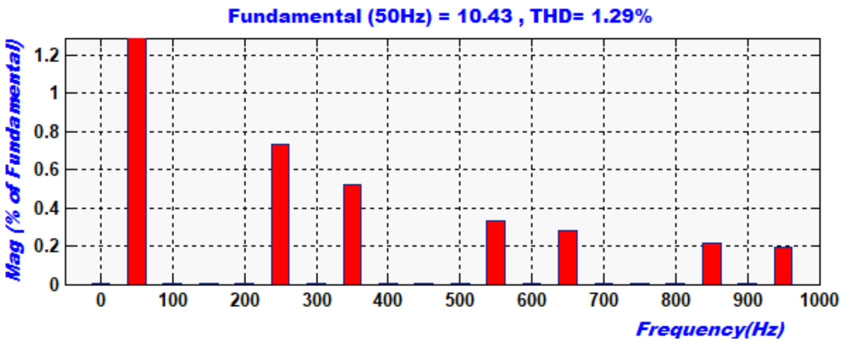

Figure 14. Grid current THD by utilizing LUO converter

5. CONCLUSION

A micro-grid-based HRES (PV-wind-battery) is presented in this research. The output power of solar panels and wind turbines is managed to obtain stable power. A LUO converter driven by ABC ABC-based PI controller is utilized to regulate the DC-link voltage. The power collected from renewable sources is increased by LUO converter and a steady-state DC voltage is supplied to the inverter by using the ABC-PI controller.

When compared with several optimization algorithms, ABC is a reliable and simple approach with minimal control parameters. In order to tackle the intermittence in power obtained from renewable resources, a battery is incorporated to maintain the power availability when the RES are unavailable. Through a three-phase inverter, the renewable sources PV and wind turbines are connected to the grid. In WECS, the ac output from wind turbine is converted into DC with the assistance of the PWM rectifier and the battery serves as a backup storage device. The link voltage is fed to the grid via three-phase inverters, which assist in DC-AC conversion and finally, grid synchronization is achieved through DQ theory. A simulation model is created in MATLAB for the hybrid system to examine its effectiveness. SIM power system toolkit was used to implement the overall model. The goal of this technology is to provide the grid with stable power.

REFERENCES

[1] J. R. Albert and A. A. Stonier, "Design and development of symmetrical super-lift DC-AC converter using firefly algorithm for solar-photovoltaic applications," *IET Circuits, Devices and Systems*, vol. 14, no. 3, pp. 261–269, 2020, doi: 10.1049/iet-cds.2018.5292.

[2] K. Saravanan and J. R. Albert, "Optimizing Energy Utilization in the Weaving Industry: Advanced Electrokinetic Solutions with Modified Piezo Matrix and Super Lift Luo Converter," *Electric Power Components and Systems*, 2023, doi: 10.1080/15325008.2023.2262458.

[3] T. Kaliannan, J. R. Albert, D. M. Begam, and P. Madhumathi, "Power Quality Improvement in Modular Multilevel Inverter Using for Different Multicarrier PWM," *European Journal of Electrical Engineering and Computer Science*, vol. 5, no. 2, pp. 19–27, 2021, doi: 10.24018/ejece.2021.5.2.315.

[4] J. R. Albert *et al.*, "Investigation on load harmonic reduction through solar-power utilization in intermittent SSFI using particle swarm, genetic, and modified firefly optimization algorithms," *Journal of Intelligent and Fuzzy Systems*, vol. 42, no. 4, pp. 4117–4133, 2022, doi: 10.3233/JIFS-212559.

[5] K. Santhiya, M. Devimuppudathi, D. S. Kumar, and A. J. Renold, "Real Time Speed Control of Three Phase Induction Motor by Using Lab View with Fuzzy Logic," *Journal on Science Engineering and Technology*, vol. 5, no. 2, pp. 22–27, 2018.

[6] K. Vanchinathan, K. T. R. Valluvan, C. Gnanavel, C. Gokul, and R. A. Renold, "An improved incipient whale optimization algorithm based robust fault detection and diagnosis for sensorless brushless DC motor drive under external disturbances," *International Transactions on Electrical Energy Systems*, vol. 31, no. 12, 2021, doi: 10.1002/2050-7038.13251.

[7] S. K. Ramaraju *et al.*, "Design and experimental investigation on VL-MLI intended for half height (H-H) method to improve power quality using modified particle swarm optimization (MPSO) algorithm," *Journal of Intelligent and Fuzzy Systems*, vol. 42, no. 6, pp. 5939–5956, 2022, doi: 10.3233/JIFS-212583.

[8] L. Thangamuthu, J. R. Albert, K. Chinnanan, and B. Gnanavel, "Design and development of extract maximum power from single-double diode PV model for different environmental condition using BAT optimization algorithm," *Journal of Intelligent and Fuzzy Systems*, vol. 43, no. 1, pp. 1091–1102, 2022, doi: 10.3233/JIFS-213241.

[9] R. Palanisamy, V. Govindaraj, S. Siddhan, and J. R. Albert, "Experimental investigation and comparative harmonic optimization of AMLI incorporate modified genetic algorithm using for power quality improvement," *Journal of Intelligent and Fuzzy Systems*, vol. 43, no. 1, pp. 1163–1176, 2022, doi: 10.3233/JIFS-212668.

[10] J. R. Albert, "Design and Investigation of Solar PV Fed Single-Source Voltage-Lift Multilevel Inverter Using Intelligent Controllers," *Journal of Control, Automation and Electrical Systems*, vol. 33, no. 5, pp. 1537–1562, Oct. 2022, doi: 10.1007/s40313-021-00892-w.

[11] A. J. Renoald and M. S. Keerthana, "Design and Implementation of Super-Lift Multilevel Inverter using Renewable Photovoltaic Energy for AC Module Application," *IJSTE - International Journal of Science Technology and Engineering*, vol. 2, no. 11, 2016.

[12] C. Gnanavel, P. Muruganantham, K. Vanchinathan, and A. Johny Renoald, "Experimental Validation and Integration of Solar PV Fed Modular Multilevel Inverter (MMI) and Flywheel Storage System," in *2021 IEEE Mysore Sub Section International Conference, MysuruCon 2021*, 2021, pp. 147–153, doi: 10.1109/MysuruCon52639.2021.9641650.

[13] C. Gnanavel, A. J. Renoald, S. Saravanan, K. Vanchinathan, and P. Sathishkhanna, "An experimental investigation of fuzzy-based voltage-lift multilevel inverter using solar photovoltaic application," *Smart Grids and Green Energy Systems*, pp. 59–74, 2022, doi: 10.1002/9781119872061.ch5.

[14] M. Dhivya and A. J. Renoald, "Fuzzy Grammar Based Hybrid Split-Capacitors and Split Inductors Applied In Positive Output Luo-Converters," vol. 3, no. 1, pp. 327–332, 2017.

[15] J. R. Albert, A. A. Stonier, and K. Vanchinathan, "Testing and performance evaluation of water pump irrigation system using voltage-lift multilevel inverter," *International Journal of Ambient Energy*, vol. 43, no. 1, pp. 8162–8175, 2022, doi: 10.1080/01430750.2022.2092773.

[16] M. A. J. Renoald, V. Hemalatha, R. Punitha, and M. Sasikala, "Solar Roadways-The Future Rebuilding Infrastructure and Economy," *International Journal of Electrical and Electronics Research*, vol. 4, no. 2, pp. 14–19, 2016, [Online]. Available: www.researchpublish.com

[17] J. R. Albert, P. Selvan, P. Sivakumar, and R. Rajalakshmi, "An advanced electrical vehicle charging station using adaptive hybrid particle swarm optimization intended for renewable energy system for simultaneous distributions," *Journal of Intelligent and Fuzzy Systems*, vol. 43, no. 4, pp. 4395–4407, 2022, doi: 10.3233/JIFS-220089.

[18] B. Babypriya, A. J. Renoald, M. Shyamalagowri, and R. Kannan, "An experimental simulation testing of single-diode PV integrated mppt grid-tied optimized control using grey wolf algorithm," *Journal of Intelligent and Fuzzy Systems*, vol. 43, no. 5, pp. 5877–5896, 2022, doi: 10.3233/JIFS-213259.

[19] A. J. Renoald, R. Kannan, S. Karthick, P. Selvan, A. Sivakumar, and C. Gnanavel, "An Experimental and Investigation on Asymmetric Modular Multilevel Inverter an Approach with Reduced Number of Semiconductor Devices," *Journal of Electrical Systems*, vol. 18, no. 3, pp. 318–330, 2022.

[20] J. Renoald Albert and D. Shunmugham Vanaja, "Solar Energy Assessment in Various Regions of Indian Sub-continent," *Solar Cells - Theory, Materials and Recent Advances*, 2021, doi: 10.5772/intechopen.95118.

[21] M. Periasamy, T. Kaliannan, S. Selvaraj, V. Manickam, S. A. Joseph, and J. R. Albert, "Various PSO methods investigation in renewable and nonrenewable sources," *International Journal of Power Electronics and Drive Systems*, vol. 13, no. 4, pp. 2498–2505, 2022, doi: 10.11591/ijpeds.v13.i4.pp2498-2505.

[22] J. R. Albert, K. Ramasamy, V. Joseph Michael Jerard, R. Boddepalli, G. Singaram, and A. Loganathan, "A Symmetric Solar Photovoltaic Inverter to Improve Power Quality Using Digital Pulsewidth Modulation Approach," *Wireless Personal Communications*, vol. 130, no. 3, pp. 2059–2097, 2023, doi: 10.1007/s11277-023-10372-w.

[23] J. R. Albert, T. Kaliannan, G. Singaram, F. I. R. E. Sehar, M. Periasamy, and S. Kuppusamy, "A Remote Diagnosis Using Variable Fractional Order with Reinforcement Controller for Solar-MPPT Intelligent System," *Photovoltaic Systems*, pp. 45–64, 2022, doi: 10.1201/9781003202288-3.

[24] S. Hemalatha, R. A. Johny, G. Banu, and K. Indirajith, "Design and investigation of PV string/central architecture for bayesian fusion technique using grey wolf optimization and flower pollination optimized algorithm," *Energy Conversion and Management*, vol. 286, 2023, doi: 10.1016/j.enconman.2023.117078.

[25] J. R. Albert, K. Premkumar, K. Vanchinathan, A. N. Ali, R. Sagayaraj, and T. S. Saravanan, "Investigation of super-lift multilevel inverter using water pump irrigation system," *Smart Grids and Green Energy Systems*, pp. 247–262, 2022, doi: 10.1002/9781119872061.ch16.

[26] R. Dineshkumar *et al.*, "A novel hyperparameter tuned deep learning model for power quality disturbance prediction in microgrids with attention based feature learning mechanism," *Journal of Intelligent and Fuzzy Systems*, vol. 46, no. 1, pp. 2911–2927, 2024, doi: 10.3233/JIFS-233263.

BIOGRAPHIES OF AUTHORS

Dr. N. Krishnamoorthy received his B.Sc. degree in Physics from Bishop Heber College, Tiruchirappalli, affiliated with Bharathidasan University in 1994. M.Sc. (Applied Physics Computer Electronics) from Urumu Dhanalakshmi College, Tiruchirappalli, affiliated to Bharathidasan University in 1996 with University III Rank. He completed MCA in the year 2000 and his M.Phil. (computer science) from Bharathidasan University in 2008. He completed his Ph.D. (computer science) from SRM Institute of Science and Technology, Chennai in 2024. He can be contacted at email: Krishnan@srmist.edu.in.

Dr. Sudheer Hanumanthakari received his B.Tech, (EEE) degree from JNTU Hyderabad, M.Tech (power electronics) from JNTU Hyderabad and PhD in the area of Application of AI & Fuzzy controllers for Power Electronics Drives. He has teaching experience of 20 years in Engineering college and Universities. He is currently an Associate Professor in the Department of Electronics and Communication Engineering, Faculty of Science and Technology, ICFAI Foundation for Higher Education, Hyderabad, India. He can be contacted at email: hsudheer@ifheindia.org.

Dr. Gobimohan Sivasubramanian is an Indian, Lecturer, Department of Electrical Engineering, University of Technology and Applied Sciences Nizwa, Oman. He was born in 1975 in Tiruchirappalli, Tamil Nadu, India. He received a B.E. degree from Bharathidasan University (1996), M. E., degree from MIT campus, Anna University (2000) and PhD in the area of application of soft computing techniques for microgrid modelling. He can be contacted at email: sgm2kx@gmail.com.

A. Prabha received her B.E degree in Electrical and Electronics Engineering, M.E degree in Energy Engineering from the College of Engineering, Guindy. She is currently working as an associate professor in the EEE Department, S. A. Engineering College, Chennai. She can be contacted at email: prabhaa@saec.ac.in.

Dr. P. Hemachandu is currently working as a professor at Sasi Institute of Technology and Engineering, Tadepalligudem, and is an alumnus of Sri Venkateswara University, Tirupati. He has 17+ years of experience in teaching and research. He has published more than 25 research papers in international journals and conferences with 9 SCI-indexed journals. He can be contacted at email: hemachandu@ieee.org.

P. Veeramanikandan was born in Ramanathapuram, Tamilnadu, India. Tamilnadu, India. He received B.E degree in Electrical and Electronics Engineering and M.E. degree in Power Electronics and Drives both from Anna University, Chennai in 2010 and 2012. respectively and the Ph.D. degree in Electrical Engineering from Anna University, Chennai. He can be contacted at email: veerarmd@gmail.com.

Nageswara Rao Medikondu is an associate professor in, K L E F University, Guntur AP -522302, India. He earned his bachelor's from Andhra University, master's from Andhra University, and Ph.D. in Artificial Intelligence task scheduling from the Jawaharlal Nehru Technological University, Kakinada. He has 15 years of experience in teaching. He can be contacted at email: medikondu1979@gmail.com.

Dr. R. Gopinathan completed my undergraduate degree in Mechatronics Engineering and post-graduate degree in Manufacturing Engineering. I did my Ph.D. in Mechanical Engineering from PSG College of Technology (Anna University Chennai). Currently serving as associate professor in the Department of Mechatronics Engineering at Sri Krishna College of Engineering and Technology, Coimbatore. He can be contacted at email: gopinathanr@skcet.ac.in.

Dr. L. Anbarasu received his AMIE degree in Electrical Engineering from The Institution of Engineers (India), Kolkata, in 2004 and his ME degree in Power Electronics and Drives from Anna University, Chennai, in 2007. He did his Doctorate at Anna University, Chennai in the year 2022. He is currently working as an Associate Professor in the Department of Electrical and Electronics Engineering at Erode Sengunthar Engineering College from June 2013. He can be contacted at email: lanbarasu78@gmail.com.