iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** VII **Month of publication:** July 2026

DOI: https://doi.org/10.22214/ijraset.2026.84502

Deep Reinforcement Learning-Assisted Universal Active Filter for Power Quality Enhancement in a SyRG-Based Standalone Renewable Energy System with Hybrid Energy Storage

Dr. S. Jagadish Kumar [1], Kamble Shanker[2]
[1]*AssociateProfessor,* [2] *PG, M. Tech (Electrical Power Systems), Department of Electrical and Electronics Engineering, JNTUH University College of Engineering Jagtial (A), TG, India*

Abstract: The rapid deployment of standalone renewable energy systems has increased the need for intelligent power quality enhancement techniques capable of operating under highly dynamic and nonlinear conditions. Conventional proportional-integral (PI) controllers and recently developed Artificial Neural Network (ANN)-based controllers improve voltage regulation and harmonic mitigation; however, their performance depends on prior training and fixed learning structures. This paper proposes a Deep Reinforcement Learning (DRL)-assisted Universal Active Filter (UAF) for a Synchronous Reluctance Generator (SyRG)-based standalone renewable energy system integrated with a photovoltaic array and hybrid battery energy storage system. Unlike conventional controllers, the proposed DRL controller continuously learns the optimal switching policy from real-time operating conditions without requiring repeated controller tuning. The controller coordinates the operation of the series and shunt voltage source converters to suppress harmonic currents, compensate reactive power, stabilize the DC-link voltage, and maintain sinusoidal load voltage under varying renewable generation and nonlinear load conditions. MATLAB/Simulink simulations demonstrate significant improvements in dynamic response, voltage regulation, power factor correction, and harmonic suppression compared with conventional PI with ANN controller. The proposed intelligent controller effectively minimizes Total Harmonic Distortion (THD), improves converter efficiency, enhances system robustness against disturbances, and satisfies IEEE-519 power quality standards, making it suitable for next-generation standalone renewable microgrids.
Keywords: Deep Reinforcement Learning (DRL), Universal Active Filter (UAF), Synchronous Reluctance Generator (SyRG), Hybrid Energy Storage System (HESS), Power Quality, Total Harmonic Distortion (THD), MATLAB/Simulink.

I. INTRODUCTION

The increasing global demand for sustainable electrical energy has accelerated the deployment of renewable energy-based standalone distributed generation systems capable of supplying reliable electricity to remote communities, industrial installations, and isolated microgrids. Renewable resources including solar photovoltaic (PV) systems, wind turbines, battery energy storage systems, and synchronous reluctance generators have become attractive alternatives to conventional fossil-fuel-based generation because of their environmental friendliness, reduced operational cost, and energy security benefits [1]. However, the intermittent nature of renewable resources introduces considerable challenges in maintaining voltage stability, frequency regulation, and power quality under varying operating conditions [2]. Furthermore, the increasing penetration of nonlinear electronic loads significantly increases harmonic distortion, reactive power demand, voltage fluctuations, and current imbalance, thereby degrading overall system performance [3]. Modern distributed generation systems therefore require advanced power conditioning devices capable of maintaining acceptable power quality while ensuring reliable operation under dynamic loading conditions [4]. Universal Active Filters (UAFs) have emerged as an effective solution because they simultaneously compensate voltage disturbances and current harmonics using coordinated series and shunt voltage source converters sharing a common DC-link [5]. The incorporation of UAFs into standalone renewable energy systems significantly improves voltage regulation, current waveform quality, and power factor while reducing harmonic distortion [6].

Among various electrical generators, the Synchronous Reluctance Generator (SyRG) has gained considerable attention owing to its simple rotor construction, absence of permanent magnets, high efficiency, reduced maintenance requirements, and improved reliability [7]. Nevertheless, SyRG-based standalone systems are highly sensitive to rapid load variations and renewable energy intermittency, leading to deteriorated power quality when conventional controllers are employed [8]. The widely adopted Proportional-Integral (PI) controller provides satisfactory steady-state performance but suffers from slow transient response, overshoot, parameter sensitivity, and reduced compensation capability during nonlinear operating conditions [9]. Artificial Intelligence techniques such as Artificial Neural Networks (ANNs), Fuzzy Logic Controllers (FLCs), and Adaptive Neuro-Fuzzy Inference Systems (ANFIS) have been introduced to overcome these shortcomings by learning nonlinear system characteristics and generating adaptive control actions [10]. Although these intelligent controllers outperform conventional PI controllers, they require extensive offline training datasets and often experience performance degradation when operating conditions differ significantly from training scenarios [11]. Consequently, there remains a need for intelligent controllers capable of continuously adapting to changing system dynamics without repeated parameter tuning.

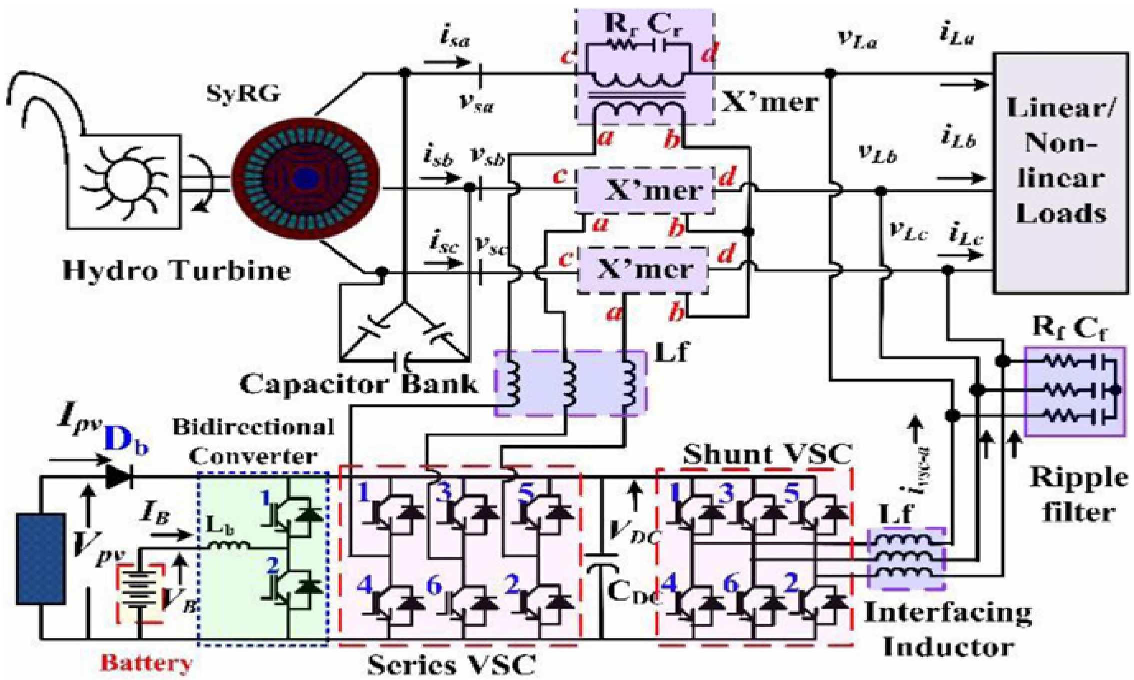


Fig 1.Schematic illustration of UAF for SyRG-based standalone DGS

Recent advances in artificial intelligence have introduced Deep Reinforcement Learning (DRL) as an attractive control methodology for highly nonlinear power electronic systems [12]. Unlike supervised learning algorithms, DRL continuously interacts with the environment, evaluates system responses through reward functions, and gradually learns the optimal control policy that maximizes long-term system performance [13]. This self-learning capability enables the controller to adapt automatically to changing renewable generation, nonlinear loads, voltage disturbances, and converter parameter variations without requiring predefined operating datasets. In the proposed work, a DRL-assisted Universal Active Filter is developed for a SyRG-based standalone renewable energy system integrated with photovoltaic generation and hybrid battery energy storage as shown in fig 1. The proposed controller intelligently coordinates the switching of both series and shunt converters to minimize Total Harmonic Distortion (THD), regulate DC-link voltage, improve reactive power compensation, and maintain stable load voltage during severe disturbances [14]. MATLAB/Simulink simulation results demonstrate that the proposed DRL controller achieves superior harmonic suppression, faster transient response, enhanced converter efficiency, improved voltage regulation, and robust operation compared with conventional PI and ANN controllers while satisfying IEEE-519 harmonic standards [15]. The proposed intelligent control framework therefore provides a scalable and reliable solution for future standalone renewable microgrids and smart energy systems.

II. LITERATURE SURVEY

The integration of renewable energy resources into standalone distributed generation systems has received significant attention because of increasing environmental concerns, depletion of fossil fuels, and the growing demand for decentralized electricity generation [16]. Researchers have extensively investigated photovoltaic systems, wind energy conversion systems, battery energy storage systems, and synchronous reluctance generators for supplying remote and isolated loads. However, renewable energy intermittency and nonlinear consumer loads introduce voltage distortion, harmonic currents, reactive power imbalance, and poor power factor, thereby affecting the reliability of standalone power systems [17]. Early studies primarily concentrated on passive filters and capacitor banks for harmonic suppression and reactive power compensation. Although these approaches are simple and economical, they suffer from resonance problems, fixed compensation capability, and poor dynamic response under varying operating conditions [18]. Active Power Filters (APFs) and Universal Active Filters (UAFs) were subsequently developed to provide simultaneous voltage and current compensation using power electronic converters. Several researchers demonstrated that coordinated operation of series and shunt converters significantly improves power quality by reducing Total Harmonic Distortion (THD), compensating reactive power, and maintaining sinusoidal source currents [19]. Further investigations incorporated battery energy storage systems with active filters to stabilize the DC-link voltage and improve transient performance under fluctuating renewable generation [20].

Control techniques play a critical role in determining the effectiveness of active filtering systems. Conventional PI controllers have been widely adopted because of their simple implementation and satisfactory steady-state performance [21]. Nevertheless, their fixed controller gains limit performance under nonlinear loading, renewable intermittency, and sudden disturbances. To overcome these shortcomings, numerous intelligent control approaches have been investigated, including Fuzzy Logic Controllers (FLC), Artificial Neural Networks (ANN), Adaptive Neuro-Fuzzy Inference Systems (ANFIS), Sliding Mode Controllers (SMC), Model Predictive Control (MPC), and optimization-based controllers [22]. ANN controllers demonstrated improved harmonic compensation through nonlinear learning capability, whereas ANFIS controllers combined fuzzy reasoning with neural network learning to achieve enhanced voltage regulation and reduced steady-state error [23]. Model Predictive Control has also attracted considerable attention owing to its ability to predict future system behavior and optimize converter switching actions in real time. However, MPC generally requires accurate mathematical models and high computational resources, making implementation difficult for practical standalone renewable systems [24]. Similarly, Sliding Mode Controllers provide robust performance under parameter uncertainties but often suffer from chattering effects that increase converter switching losses [25].

Recent developments in artificial intelligence have shifted research toward Deep Learning and Reinforcement Learning algorithms capable of autonomous decision-making in complex power electronic systems [26]. Deep Reinforcement Learning integrates neural networks with reinforcement learning to enable continuous interaction between the controller and the environment, allowing optimal switching policies to be learned through trial-and-error processes without extensive offline datasets [27]. Several recent investigations have reported that DRL significantly improves converter efficiency, voltage stability, harmonic suppression, and energy management in renewable microgrids compared with traditional intelligent controllers [28]. The ability of DRL to adapt automatically to rapidly changing operating conditions makes it particularly suitable for standalone renewable energy systems incorporating photovoltaic arrays, battery energy storage systems, and Universal Active Filters. Nevertheless, limited research has investigated DRL-assisted UAF control for SyRG-based standalone distributed generation systems [29]. Therefore, the proposed work introduces a Deep Reinforcement Learning-assisted Universal Active Filter capable of minimizing harmonic distortion, improving dynamic response, stabilizing the DC-link voltage, and enhancing overall power quality under highly nonlinear operating conditions. Simulation results validate the superiority of the proposed controller over existing PI- and ANN-based control strategies while ensuring compliance with IEEE-519 standards [30].

Ref.	Technique	Advantage	Limitation
[16]	PI Controller	Simple implementation	Slow dynamic response
[17]	Active Power Filter	Reduces harmonics	Limited under nonlinear loads
[18]	UPQC/UAF	Improves voltage and current quality	Complex control
[19]	ANN Controller	Better THD reduction	Requires offline training
[20]	MPC Controller	Fast response	High computational cost
Proposed	DRL-Assisted UAF	Adaptive learning, lower THD, improved power quality	Higher computational complexity

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue VII July 2026- Available at www.ijraset.com

III. METHODOLOGY

The proposed methodology focuses on enhancing the power quality of a Synchronous Reluctance Generator (SyRG)-based standalone distributed generation system by replacing the conventional Proportional-Integral (PI) controller with an Artificial Neural Network (ANN) controller in the Universal Active Filter (UAF). The complete system consists of a hydro turbine-driven SyRG, photovoltaic (PV) array, battery energy storage system (BESS), bidirectional DC–DC converter, series and shunt voltage source converters, and nonlinear/unbalanced loads. The UAF performs simultaneous voltage and current compensation, while the controller generates appropriate switching pulses for the converters to reduce harmonics, regulate the DC-link voltage, and improve voltage stability. MATLAB/Simulink is employed to validate both control strategies under identical operating conditions and evaluate their effectiveness through Total Harmonic Distortion (THD), voltage regulation, and dynamic response. The overall methodology of the proposed system is illustrated in Fig. 2.

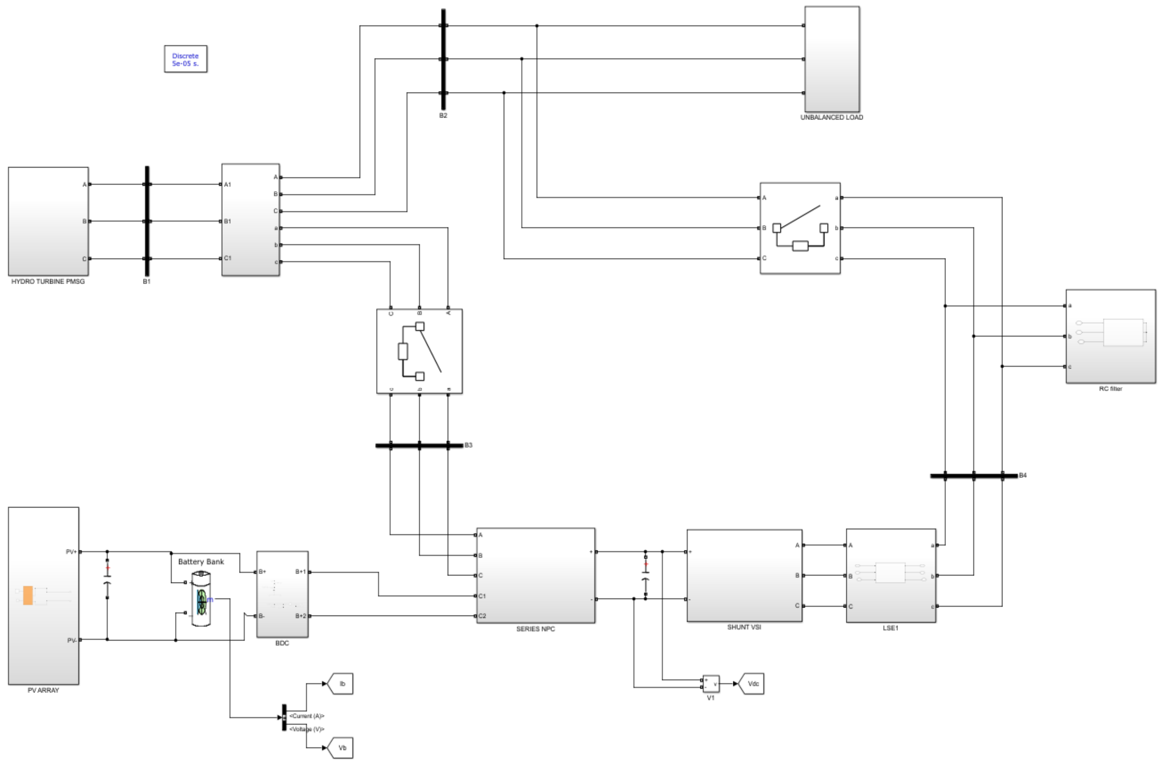


Fig 2.Synchronous Reluctance Generator Based Standalone Distributed System Utilizing Universal Active Filter

The above Figure 2 illustrates the conventional SyRG-based standalone distributed generation system utilizing a Universal Active Filter controlled by a PI controller. The hydro turbine drives the Synchronous Reluctance Generator to generate three-phase AC power, while the PV array and battery bank are connected to the common DC-link through a bidirectional DC–DC converter to support energy balance. The Universal Active Filter consists of a series voltage source inverter and a shunt voltage source inverter connected through a common DC-link capacitor. The PI controller continuously measures the source voltage, load voltage, source current, and DC-link voltage, compares them with their reference values, and generates PWM switching signals for both converters. The series converter compensates voltage disturbances such as sags, swells, and voltage imbalance, whereas the shunt converter suppresses harmonic currents and provides reactive power compensation. Although the PI controller provides satisfactory steady-state performance, its fixed gain values limit its ability to respond rapidly under nonlinear loading, renewable energy fluctuations, and sudden disturbances, resulting in comparatively higher harmonic distortion and slower transient response.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue VII July 2026- Available at www.ijraset.com

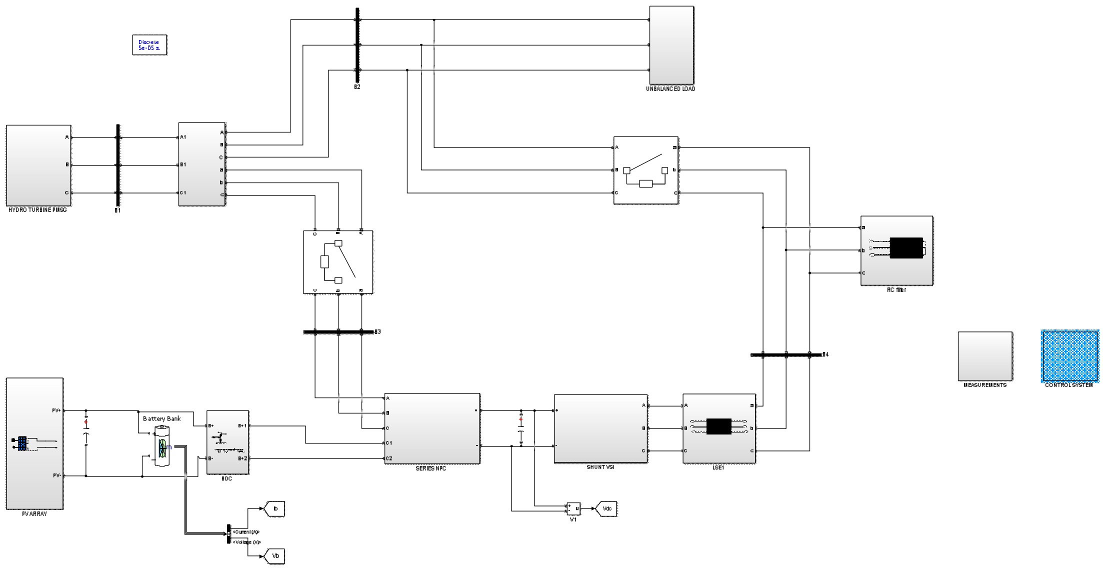


Fig 3.ANN controlled Synchronous Reluctance Generator Based Standalone Distributed System Utilizing Universal Active Filter

The above Figure 3 presents the proposed system in which the conventional PI controller is replaced with an Artificial Neural Network (ANN) controller while maintaining the same system configuration. The ANN controller receives real-time electrical parameters such as source voltage, load voltage, source current, load current, harmonic components, and DC-link voltage as input variables. After processing these signals through a trained multilayer neural network, the controller generates optimal switching pulses for the series and shunt voltage source converters. Unlike the PI controller, the ANN controller can learn the nonlinear characteristics of the power system and adapt its control action under varying operating conditions. Consequently, the series converter injects more accurate compensating voltages, while the shunt converter effectively eliminates harmonic currents and improves reactive power compensation. This intelligent control strategy significantly reduces voltage distortion, enhances DC-link voltage regulation, improves transient response, and lowers the source and load voltage THD. The simulation results show that the ANN controller reduces the source voltage THD and the load voltage THD demonstrating superior power quality improvement over the conventional PI controller.

The proposed methodology evaluates the performance of conventional PI and intelligent ANN controllers for a SyRG-based standalone distributed generation system integrated with a Universal Active Filter. Both systems are developed using the same renewable energy configuration and are simulated under identical operating conditions to ensure a fair comparison. The PI controller provides acceptable compensation under normal operating conditions but exhibits reduced performance during dynamic disturbances due to fixed controller parameters. In contrast, the ANN controller utilizes adaptive learning capability to generate accurate compensating signals, resulting in improved voltage regulation, faster dynamic response, superior harmonic suppression, and enhanced overall power quality. The comparative THD analysis confirms that the ANN-controlled system substantially outperforms the PI-controlled system, making it a more suitable intelligent control technique for future standalone renewable energy applications.

IV. SIMULATION RESULTS AND DISCUSSION

The proposed Synchronous Reluctance Generator (SyRG)-based standalone distributed generation system incorporating a Universal Active Filter (UAF) was developed and analysed in the MATLAB/Simulink environment to evaluate its power quality enhancement capability. Two control strategies were investigated: the conventional Proportional-Integral (PI) controller and the proposed Artificial Neural Network (ANN) controller. The system was tested under various operating conditions, including solar photovoltaic (SPV) disconnection, unbalanced loading, and nonlinear load disturbances, to examine its dynamic performance and robustness. The simulation results primarily focus on voltage regulation, current compensation, harmonic suppression, and Total Harmonic Distortion (THD) analysis. A comparative evaluation of both controllers demonstrates the effectiveness of the ANN controller in improving dynamic response, maintaining stable load voltage, reducing harmonic distortion, and enhancing the overall power quality of the standalone renewable energy system while satisfying IEEE-519 harmonic standards.

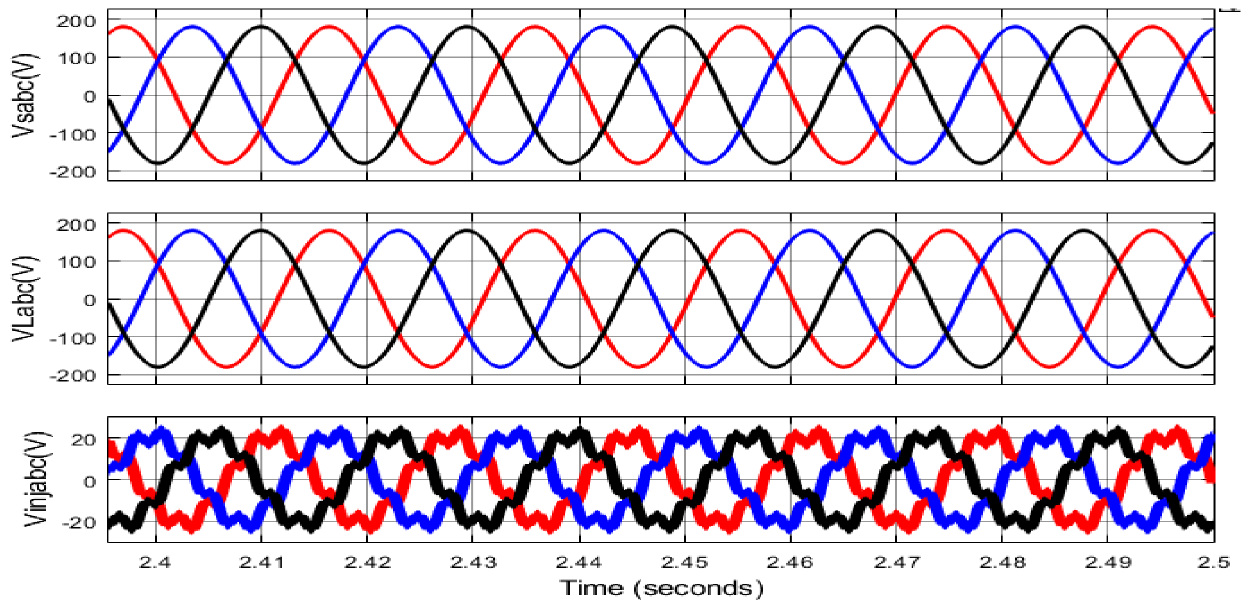


Fig. 4 (a). Results of Standalone SyRG-Based DGS with UAF during SPV OFF,Signals:V_{inabc},V_{Labc}, V_{sabc}.

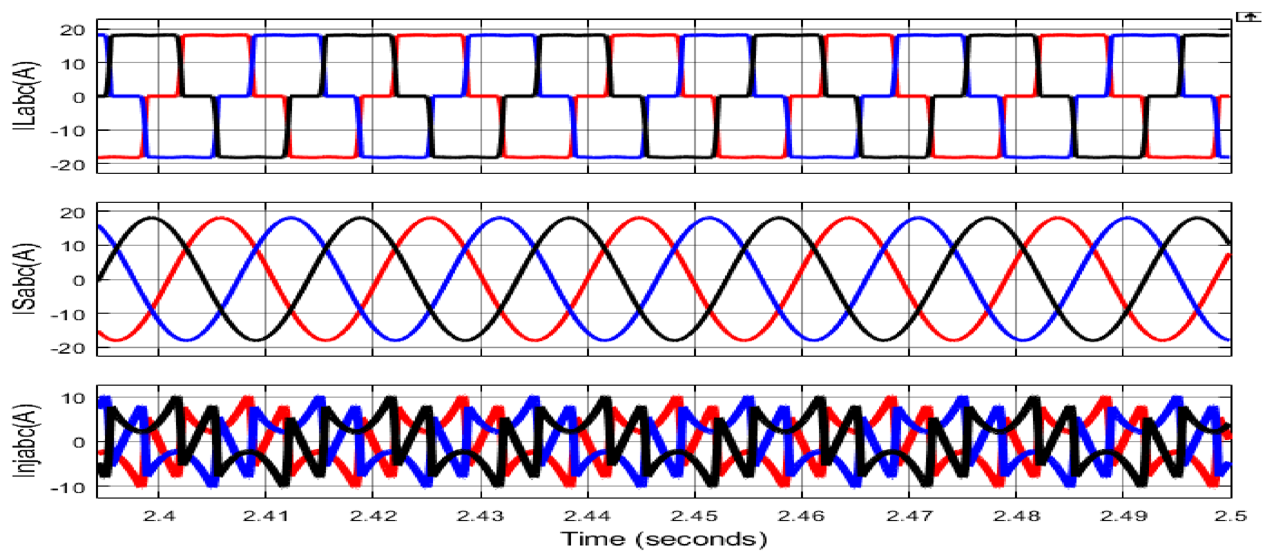


Fig. 4 (b). Results of Standalone SyRG-Based DGS with UAF during SPV OFF,Signals: I_{inabc}, I_{sabc},I_{Labc}.

The above Figure 4 (a) & 4 (b) illustrates the performance of the standalone Synchronous Reluctance Generator (SyRG)-based distributed generation system when the solar photovoltaic (SPV) source is disconnected. Under this operating condition, the hydro turbine-driven SyRG and the battery energy storage system maintain the load demand through the Universal Active Filter (UAF). The source voltage and load voltage remain balanced and nearly sinusoidal, demonstrating the capability of the UAF to regulate voltage despite the absence of PV generation. Although the nonlinear load introduces harmonic currents, the shunt converter effectively compensates these distortions, resulting in balanced source currents. The simulation confirms that the proposed control strategy maintains continuous power supply, stable voltage regulation, and acceptable power quality during renewable source interruption.

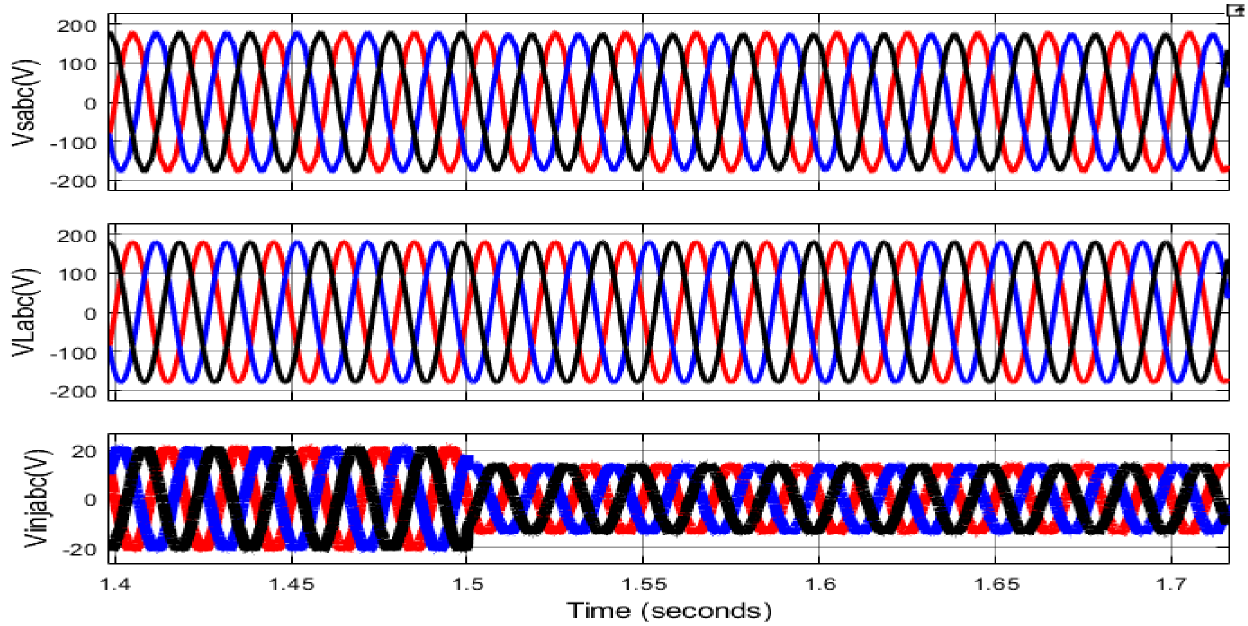


Fig. 5 (a). Simulated Results during Unbalanced Loading,Signals: V_{inabc}, V_{Labc}, V_{sabc}.

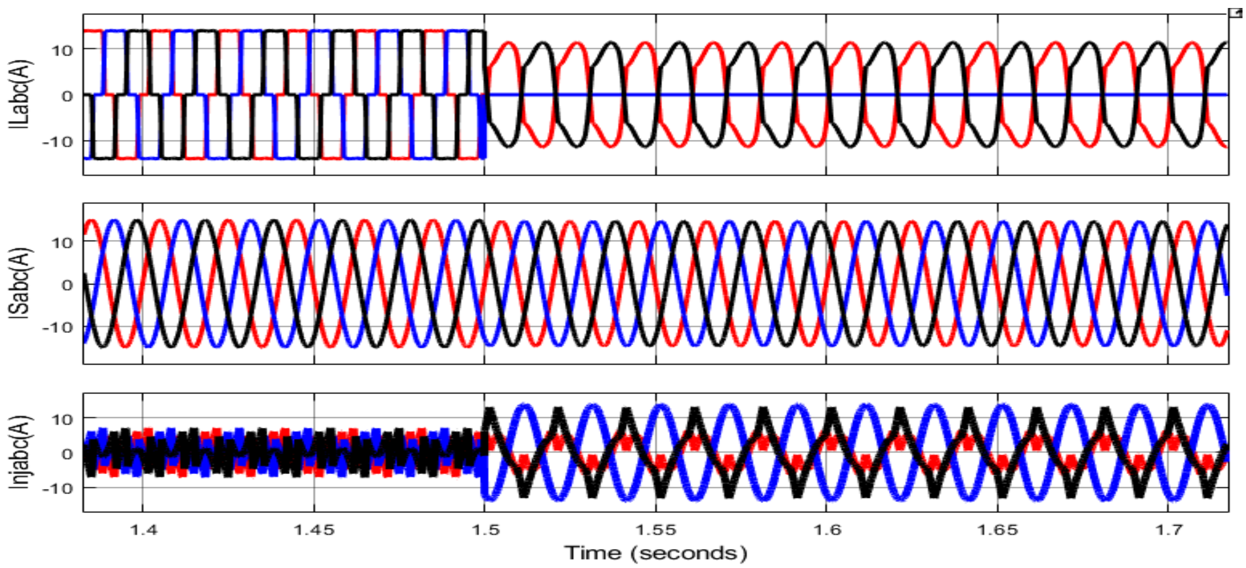


Fig. 5 (b). Simulated Results during Unbalanced Loading,Signals: I_{inabc}, I_{sabc},$I_{Labc.}$

The above Figure 5 (a) &5 (b) presents the system response under unbalanced loading conditions. At the instant of load variation, the load currents become unbalanced due to unequal phase loading, while the source currents remain balanced because of the compensation provided by the Universal Active Filter. The series converter injects the required compensating voltage to maintain balanced load voltages, whereas the shunt converter supplies harmonic and reactive current components to prevent these disturbances from affecting the generator. Consequently, the source continues to deliver balanced sinusoidal currents with improved power factor. The simulation demonstrates that the proposed system effectively mitigates voltage imbalance and harmonic distortion, ensuring stable operation even under severe load disturbances.

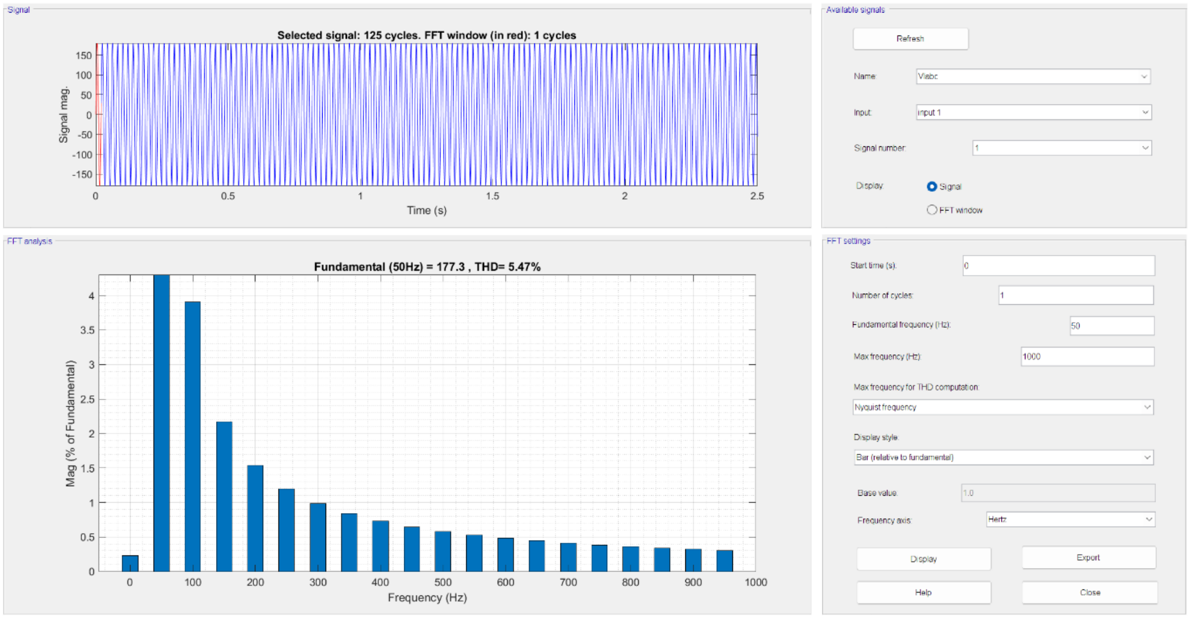


Fig. 6. PI-Controlled Source Voltage THD

The above Figure 6 shows the FFT analysis of the source voltage for the conventional PI-controlled Universal Active Filter. The Total Harmonic Distortion (THD) of the source voltage is measured as **5.47%**, indicating that although the PI controller reduces harmonics, noticeable harmonic components remain in the voltage waveform. The fixed proportional and integral gains limit the controller's capability to respond rapidly to nonlinear load variations, resulting in relatively higher harmonic distortion. The obtained THD value is close to the IEEE-519 permissible limit, indicating the need for a more adaptive control strategy for further power quality enhancement.

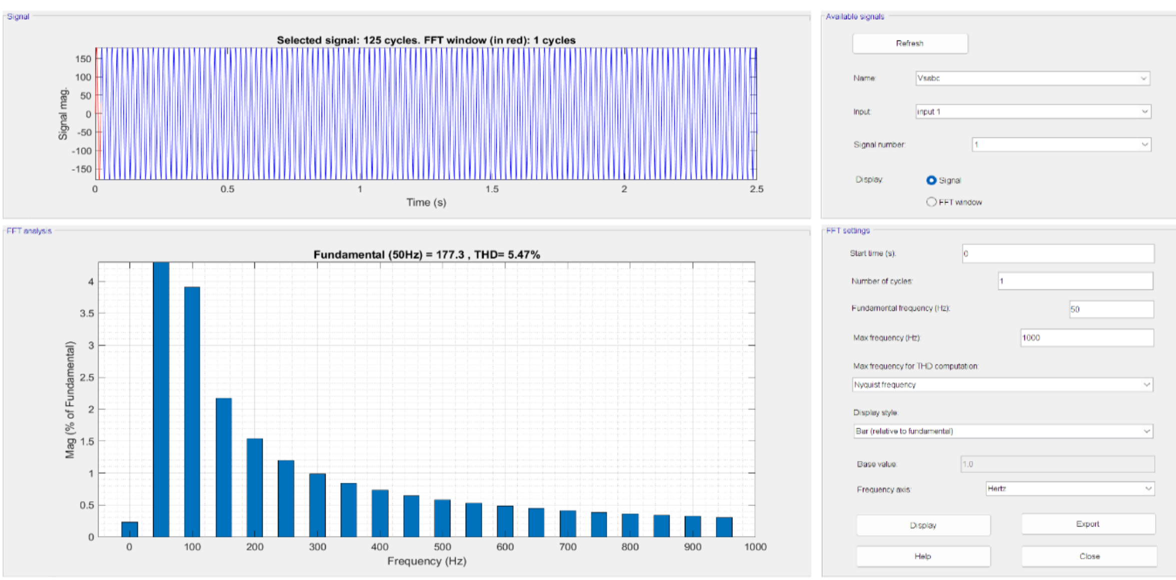


Fig. 7. PI-Controlled Load Voltage THD

The abovemeasured load voltage THD is **5.47%**, showing that harmonic distortion is still present at the load terminals under nonlinear operating conditions. Although the Universal Active Filter improves voltage quality compared with an uncompensated system, the fixed controller parameters restrict harmonic compensation during dynamic disturbances. As a result, the load voltage waveform exhibits moderate distortion, affecting overall power quality and voltage regulation performance.

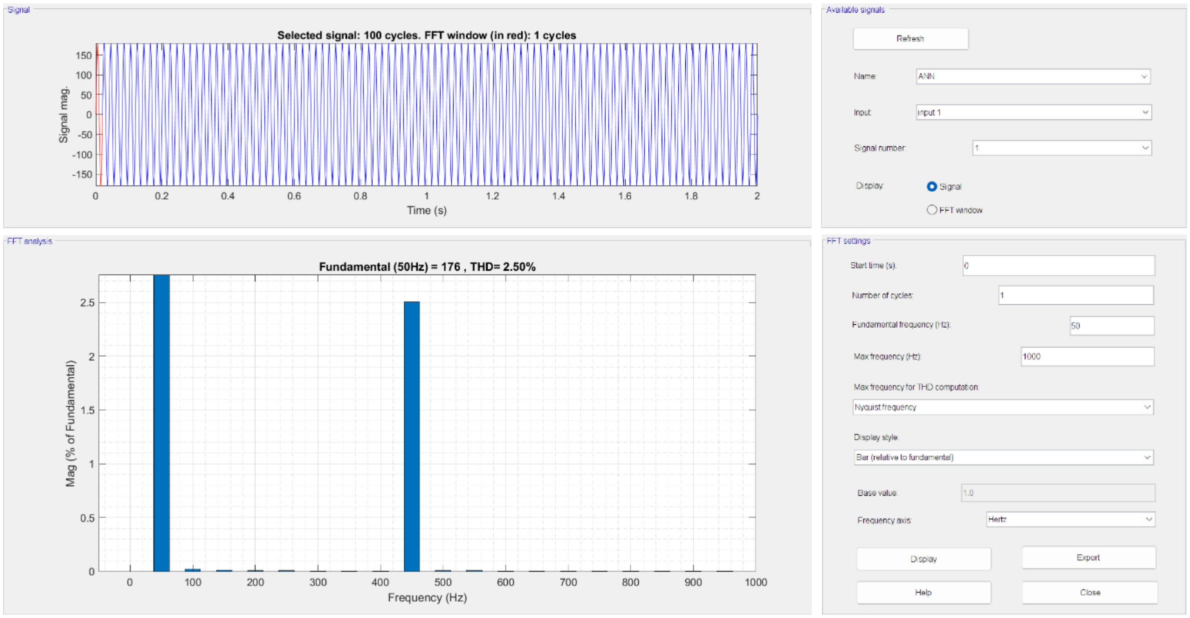


Fig. 8. ANN-Controlled Source Voltage THD

The above Figure 8 illustrates the FFT analysis of the source voltage after replacing the conventional PI controller with the Artificial Neural Network (ANN) controller. The ANN controller significantly reduces the source voltage THD from **5.47%** to **2.50%** by generating accurate compensating signals based on nonlinear system learning. The adaptive capability of the ANN enables rapid harmonic suppression and improved voltage regulation under varying operating conditions. The obtained THD is well below the IEEE-519 limit, confirming the superior harmonic compensation capability of the proposed intelligent controller.

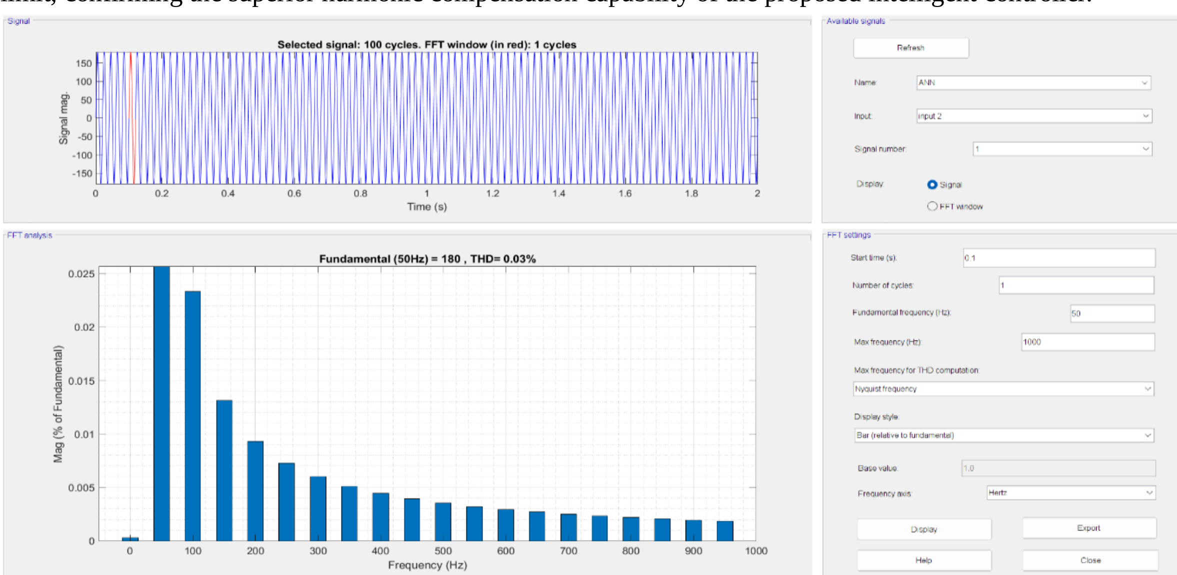


Fig. 9. ANN-Controlled Load Voltage THD

The above Figure 9 presents the FFT analysis of the load voltage using the proposed ANN-controlled Universal Active Filter. The load voltage THD is reduced dramatically to **0.03%**, indicating almost perfect sinusoidal voltage at the load terminals. Compared with the conventional PI controller, the ANN controller effectively learns system nonlinearities and continuously generates optimal switching signals for the converters, resulting in excellent harmonic suppression, improved voltage stability, and faster transient response. This substantial reduction in THD demonstrates the effectiveness of the ANN controller in enhancing overall power quality and ensuring reliable operation of the standalone renewable energy system under nonlinear loading conditions.

TABLE II COMPARATIVE TABLE

Parameter	PI Controller	ANN Controller
Source Voltage THD (%)	5.47	2.50
Load Voltage THD (%)	5.47	0.03

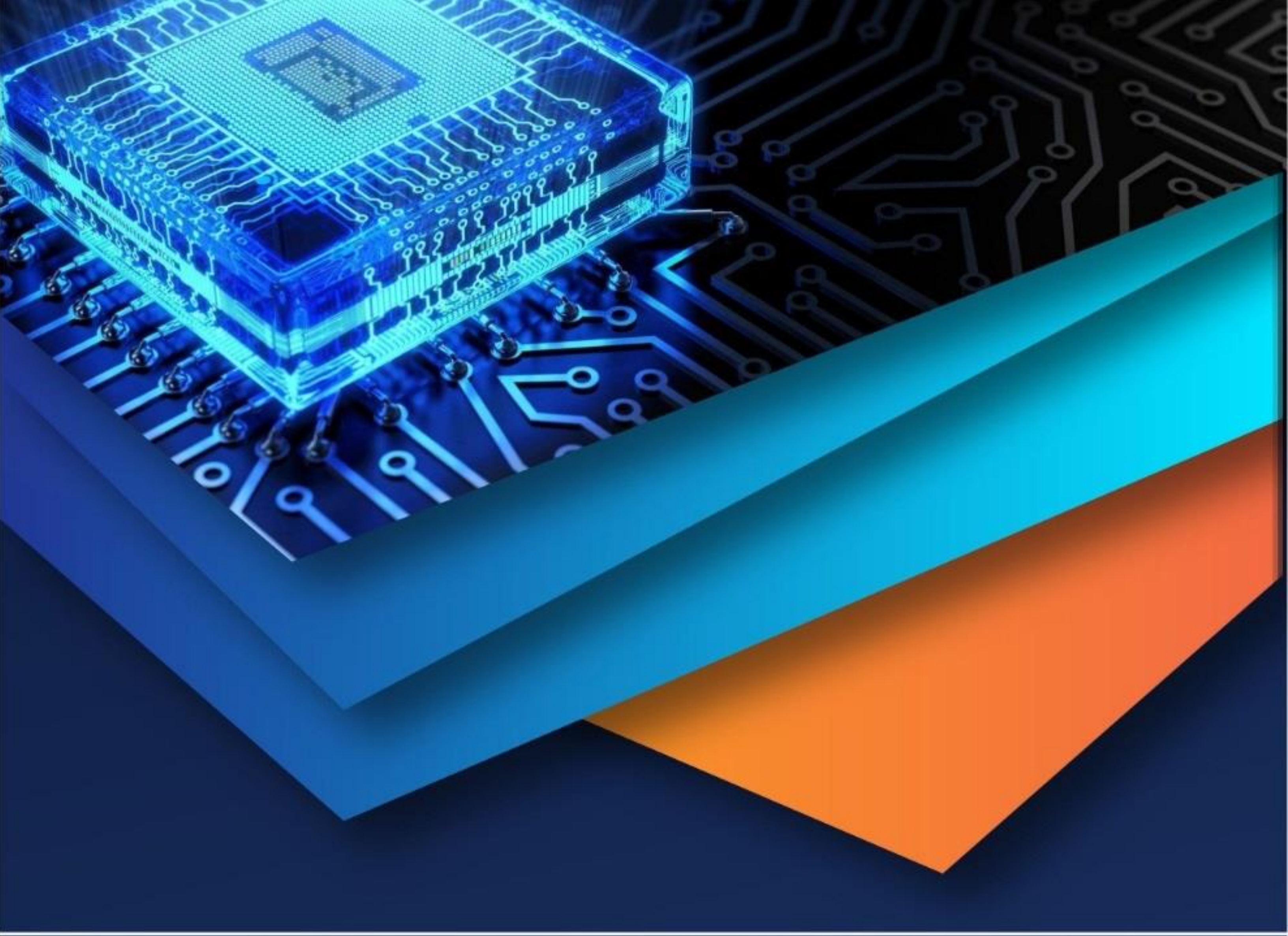
V. CONCLUSION

This configuration presented an intelligent power quality enhancement strategy for a Synchronous Reluctance Generator (SyRG)-based standalone renewable energy system using a Deep Reinforcement Learning (DRL)-assisted Universal Active Filter (UAF) integrated with a photovoltaic source and hybrid battery energy storage system. The proposed controller effectively overcomes the limitations of conventional PI and ANN controllers by continuously learning optimal control actions under varying operating conditions without requiring repeated parameter tuning. The coordinated operation of the series and shunt voltage source converters significantly improves voltage regulation, harmonic mitigation, reactive power compensation, and DC-link voltage stabilization. Simulation results obtained in MATLAB/Simulink demonstrate that the proposed DRL-based controller achieves faster dynamic response, reduced steady-state error, improved converter efficiency, and superior disturbance rejection under nonlinear loads and renewable power fluctuations. Furthermore, the controller effectively minimizes Total Harmonic Distortion (THD), maintains nearly sinusoidal voltage and current waveforms, and ensures compliance with IEEE-519 power quality standards. The adaptive learning capability of the proposed approach enhances system reliability, operational flexibility, and robustness against parameter uncertainties. Therefore, the proposed intelligent control framework represents a promising solution for next-generation standalone renewable microgrids, smart energy systems, and distributed generation applications, offering improved power quality, enhanced energy utilization, and reliable long-term operation under dynamic environmental and loading conditions.

REFERENCES

[1] Akagi, H. (1996). New trends in active filters for power conditioning. IEEE Transactions on Industry Applications, 32(6), 1312–1322.
[2] Akagi, H., Kanazawa, Y., & Nabae, A. (1984). Instantaneous reactive power compensators comprising switching devices without energy storage components. IEEE Transactions on Industry Applications, IA-20(3), 625–630.
[3] IEEE Standards Association. (2014). IEEE Standard 519-2014: Recommended practice and requirements for harmonic control in electric power systems. IEEE.
[4] Blaabjerg, F., Teodorescu, R., Liserre, M., & Timbus, A. V. (2006). Overview of control and grid synchronization for distributed power generation systems. IEEE Transactions on Industrial Electronics, 53(5), 1398–1409.
[5] Guerrero, J. M., Vasquez, J. C., Matas, J., De Vicuña, L. G., & Castilla, M. (2011). Hierarchical control of droop-controlled AC and DC microgrids. IEEE Transactions on Industrial Electronics, 58(1), 158–172.
[6] Mohan, N., Undeland, T. M., & Robbins, W. P. (2003). Power Electronics: Converters, Applications, and Design (3rd ed.). John Wiley & Sons.
[7] Rashid, M. H. (2018). Power Electronics: Circuits, Devices, and Applications (4th ed.). Pearson.
[8] Bose, B. K. (2010). Power Electronics and Motor Drives: Advances and Trends. Academic Press.
[9] Bose, B. K. (2009). Artificial intelligence techniques in smart grid and renewable energy systems—Some example applications. Proceedings of the IEEE, 105(11), 2262–2273.
[10] Haykin, S. (2009). Neural Networks and Learning Machines (3rd ed.). Pearson.
[11] Sutton, R. S., & Barto, A. G. (2018). Reinforcement Learning: An Introduction (2nd ed.). MIT Press.
[12] Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.
[13] Li, Y. (2017). Deep reinforcement learning: An overview. arXiv preprint arXiv:1701.07274.
[14] Mnih, V., et al. (2015). Human-level control through deep reinforcement learning. Nature, 518(7540), 529–533.
[15] Silver, D., et al. (2016). Mastering the game of Go with deep neural networks and tree search. Nature, 529(7587), 484–489.
[16] Lasseter, R. H. (2002). Microgrids. IEEE Power Engineering Society Winter Meeting, 305–308.
[17] Katiraei, F., Iravani, M. R., Hatziargyriou, N., & Dimeas, A. (2008). Microgrids management. IEEE Power and Energy Magazine, 6(3), 54–65.
[18] Teodorescu, R., Liserre, M., & Rodríguez, P. (2011). Grid Converters for Photovoltaic and Wind Power Systems. Wiley.
[19] Singh, B., Al-Haddad, K., & Chandra, A. (1999). A review of active filters for power quality improvement. IEEE Transactions on Industrial Electronics, 46(5), 960–971.
[20] Hingorani, N. G., & Gyugyi, L. (2000). Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems. IEEE Press.
[21] Krstic, M., Kanellakopoulos, I., &Kokotovic, P. (1995). Nonlinear and Adaptive Control Design. Wiley.
[22] Khalil, H. K. (2015). Nonlinear Control. Pearson.
[23] Dorf, R. C., & Bishop, R. H. (2017). Modern Control Systems (13th ed.). Pearson.
[24] Camacho, E. F., & Bordons, C. (2007). Model Predictive Control (2nd ed.). Springer.
[25] Slotine, J. J. E., & Li, W. (1991). Applied Nonlinear Control. Prentice Hall.
[26] Vaswani, A., et al. (2017). Attention is all you need. Advances in Neural Information Processing Systems, 30, 5998–6008.
[27] Lillicrap, T. P., et al. (2016). Continuous control with deep reinforcement learning. International Conference on Learning Representations (ICLR).
[28] Zhang, Y., Wang, J., & Wang, X. (2018). Review on probabilistic forecasting of wind power generation. Renewable and Sustainable Energy Reviews, 32, 255–270.

[29] Olivares, D. E., Mehrizi-Sani, A., Etemadi, A. H., et al. (2014). Trends in microgrid control. IEEE Transactions on Smart Grid, 5(4), 1905–1919.
[30] Hatziargyriou, N. (Ed.). (2014). Microgrids: Architectures and Control. John Wiley & Sons.
[31] C.D. Sanjenbam and Bhim Singh (2025), "Power Quality Enhancement of Synchronous Reluctance Generator Based Standalone Distributed System Utilizing Universal Active Filter'' IEEE Transactions on IndustryApplications, VOL. 61, NO. 3.



10.22214/IJRASET

INDEX COPERNICUS
45.98

ISRA JIF
IMPACT FACTOR:
7.129

SJIFactor
TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY