ADAPTIVE FUZZY LOGIC CONTROLLER-BASED EMS AND DYNAMIC PERFORMANCE OF GRID INTEGRATED MICROGRID.

K. Sai Sree Pooja[1], D. Krishna[2], T. Anil Kumar[3]

[1]PG-Scholar, Department of EEE, Anurag University, Hyderabad, India.

[2]Assistant Professor, Department of EEE, Anurag University, Hyderabad, India.

[3]Head of Department, Department of EEE, Anurag University, Hyderabad, India.

poojakosuri@gmail.com[1], krishnaeee@cvsr.ac.in[2], hodeee@cvsr.ac.in[3]

Abstract

An efficient energy management system for a small-scale hybrid wind-solar-batterybased microgrid is to be proposed in this paper. By the proposed control system, the battery energy storage system (BESS) participates in the microgrid energy management and plays a role in voltage regulation andcompensating for current harmonic, unbalance, and reactive power due to the presence of nonlinear loads. In this project, there is a proposal for a battery-aware energy management system based on adaptive fuzzy logic (SOC), voltage control, current control and dynamic performance improvement is also considered. To validate the application of the proposed control system, simulations need to be performed in MATLAB/Simulink software. The simulation results confirm and prove the efficiency of the proposed control system.

Keywords: Static voltage stability, Monte Carlo simulation, modal analysis, critical eigenvalue, QV curve method, reactive power reserve/margin, total line losses, PV penetration, stochastic loads.

DOI Number: 10.48047/NQ.2022.20.20.NQ109102 **NeuroQuantology2022;20(20): 1024-1033**

I. INTRODUCTION

With both energy demand and the negative effects of fossil fuels on the rise, renewable energy has become a focal point [1]. For ease of use and cost effectiveness, hybrid energy systems will be a key component of future energy storage innovations. When it comes to HRES (Hybrid"Renewable Energy" System), there are a few different approaches to addressing the issue of ES coupling [1]. Absolute 2-phase coupling at the entrance point leads to ineffective energy management, wasteful storage, and uncontrollable power flows [2]. The second tactic for designing a HESS's memory coupling architecture utilises a DC/DC bidirectional device (Hybrid "Energy" Storage Systems). It's an ideal neighbour for a high-speed RAM expansion. Protected against high-power surges and sudden changes in load [3,4]. Three conjugation designs exist, with the third using two DC/DC converters to great effect. An example of a typical shunt converter architecture is shown in Figure.1. An extra DC/DC converter connected to a "high power" storage facility regulates the DC bus voltage [5]. It makes it possible for "high power" storage to harvest energy from a broader range of voltages found in nature. Since RESs won't run out, the race to achieve the remotion's goals—increasing the cost and the environmental impact—will continue to be fraught with difficulty [7]. The use of hybrid RES to guarantee genuine and efficient electricity generation [3] is on the rise around the world. Microgrids help cut down on diesel use by allowing decentralised control over energy production. [8][9]. Energy is a constant that can neither be created nor destroyed. Energy is versatile; it can be transformed between many different forms. Energy and energy consumption are crucial to any nation's social, economic, and industrial development [10]. A photovoltaic array, battery, converter, network, and wind generator make up the previous system. In this study, we zero in on BEMS in domestic settings.[11] Options like DMS and EMS are among the many being considered. This paper proposes using MATLAB/Simulink to model, analyse, and regulate decentralised power generation and storage. The PI controller provides the optimal SoC for extending the runtime of rechargeable batteries. Based on the data, the system established a power balance and the battery's state of charge (SOC) was defended to preserve its desired value to use an AC/DC controller to increase its lifespan.

2. METHODOLOGY

With increasing demand for clean and alternative energy, DERs and hybrid systems have been installed. A HPS's generation profile is preferable to single-energy sources [2]. To link DERs to the power grid, PESs are employed [3]. Due to the intermittent nature of RES, a device is needed to store the energy until it can be utilised. This device must have at least one AC/DC/DC/AC converter. Voltage is used to determine how RES are linked to the grid. Microgrid distribution is linked to hybrid RES modelling in this work. To describe power flow, this model [10] addresses HPS and DER properties.

Solar power is environmentally friendly and cheap to implement, so it will likely become more important in the energy industry. Solar technology has advanced as a result. The technique's high cost has limited its use. Cheap price is crucial for commercialization, especially in residential electric power systems. This research aims to test the boost converter architecture at high power to advance solar inverter technology.

Due to the back topology's simple design, electricity can be flown and regulated easily while maintaining high quality at the grid interface. This converter requires the fewest parts of all isolated topologies, reducing its total cost. The back topology can integrate the energy-storage inductor and transformer. Separated transformer and inductor are used in another isolated topology. Inductors store energy while transformers transport it over galvanic isolation. Using a back topology with these two parts eliminates the costly and space-consuming energy storage inductor, resulting in a smaller, cheaper converter. Not all topologies result in a cheap converter, so this statement is true regardless of the topology. We will work toward a high-power, high-performance converter, which is our key research contribution, while maintaining the cost advantage throughout final implementation.

It's difficult to build a practical large transformer. High-power converters must have a large air gap to store energy. Inductance will be negligible. The problem is balancing a low leakage inductance with a tiny magnetizing inductance. High leakage flux and low coupling reduce a converter's energy transfer efficiency. High-power converters are therefore rare. The back architecture is therefore limited to low power solar microinverter applications [10,]. Each roof in this system has a PV panel. It has a micro inverter at the output terminals. "AC PV module application" describes it (for "alternating current PV module application"). This method links many AC PV modules in parallel to generate electricity.

2.1 Hybrid Wind and Solar Electric Systems

Experts in the field of renewable energy advocate a tiny "hybrid" electric system that utilises both home wind electric and house solar electric (photovoltaic or PV) technologies.

For the most part of the United States, wind speeds are quite modest during the summer, when the sun is at its highest and longest. Winter, with its shorter days and potential for high winds, is a time to take precautions. Since wind and solar systems each have their own peak working hours at different times of the day and year, hybrid systems are better able to produce power when it is required.

Many hybrid systems are not connected to a wider power grid but instead function independently. Most hybrid systems offer electricity through batteries and/or an engine generator run on conventional fuels, such as diesel, when the wind and solar system are not generating. In the event of a loss of power, the engine generator may be utilised to generate electricity and charge the batteries.

Complexity is increased by the engine generator but is mitigated by cutting-edge electronic controls that enable for hands-free operation. Using an engine generator allows us to reduce the overall footprint of the system. To ensure that electrical needs are met even when the system is not charging, a sufficiently enough storage capacity is necessary. The typical lifespan of a battery bank is between one and three days, providing grid power for that time.

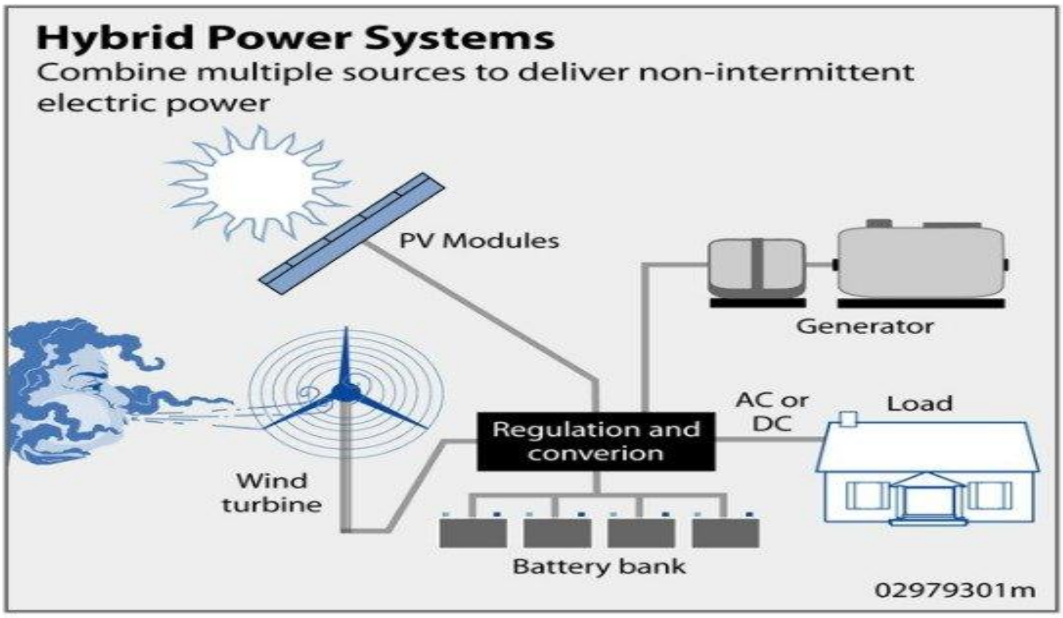

Fig. 1: Hybrid power system.

2.2 Maximum Power Point Tracker (MPPT)

The central type of inverter systems is less expensive overall, but this implementation is more expensive.

However, with the correct application of contemporary design methodologies, high-power single-stage flyback converters are feasible. Because of this property, filtering out the ripple components is simple and may be accomplished using very modest-sized filtering components. The ability to shrink passive components helps save costs and make the converter more compact.

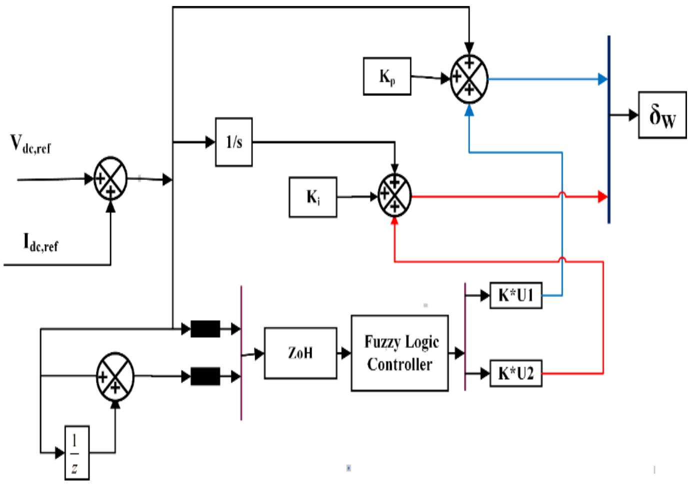

Fig. 2: Maximum power point tracker block diagram.

- It has a guaranteed stable operation under any and all environmental situations and a very rapid dynamic reaction.
- Secondly, there is no issue with a failed recovery in reverse.
- There are no power-on losses.
- Compact transformer.

- Controllable. No grid current feedback loop.

MPPT design

Flyback transformer design and execution are vital to the proposed inverter system's performance. During each switching cycle, magnetic coupling transfers flyback transformer energy to the output. It is imperative that the most efficient means of energy storage and transmission be given top consideration during the design process.

The MPPT algorithm is decided upon as the perturb and observe (P&O) strategy due to its simplicity of implementation. The figure's MPPT circuit.

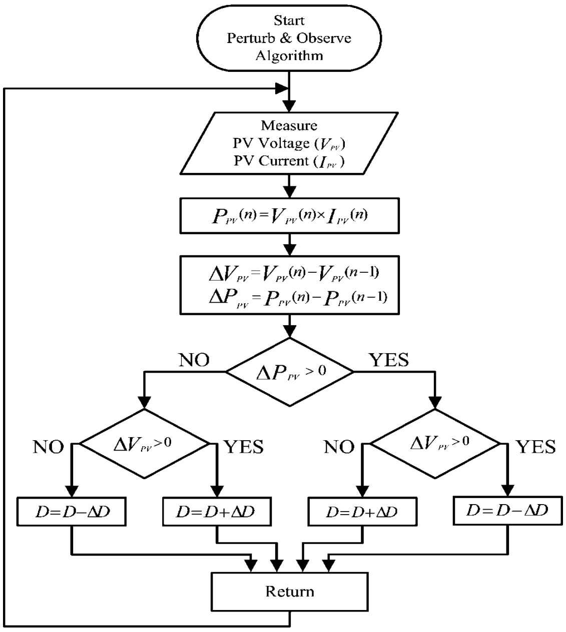

Fig.3: Perturb and observe algorithm implemented in the controller.

Produces the maximum value of the duty ratio data (Dpeak) for controlling grid current. In the same way that the voltage modulation ratio controls the output magnitude, frequency to voltage converter; the signal from the MPPT block determines how much current is taken from the grid. D, the symbol for disturbance in the figure, has a value of 0.0001 in this case.

2.3 DC to AC converter

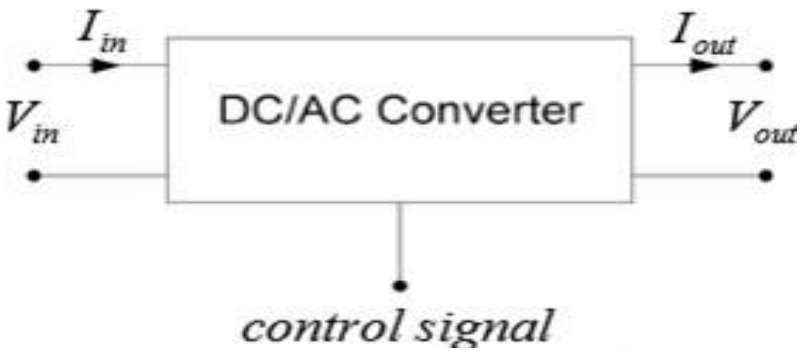

Fig. 4:DC/ACConverterblockdiagram

DC-to-AC inverters may be either single-phase or three-phase inverters. If a sinusoidal voltage or current with no DC component is to be output, then an alternating current (AC) source must be used as input. In this context, "load" might refer to either a passive R-L-C network or an active AC voltage or current sink. A signal's voltage or current may be used as a control parameter, but an angle can also be used. By opening and closing the diagonal switch pairs S1 and S4 or S2 and S3, the DC to AC conversion may be accomplished in a single phase. In this situation, neither the root-mean-square (RMS) value nor the amplitude of the fundamental component of the AC voltage are altered.

3. RESULTS & DISCUSSION

The goal of this paper is to present an efficient energy management system for a microgrid that utilises a mix of renewable energy sources (wind, solar, and batteries). By incorporating the battery energy storage system (BESS), the suggested control system enables the microgrid to perform voltage regulation, current harmonic, imbalance, and reactive power compensation with the help of nonlinear loads. The suggested Adaptive fuzzy logic-based energy management system takes into consideration the battery's state of charge (SOC), voltage control, current control, and dynamic performanceof system. Validating the efficacy of the suggested control system calls for simulations in MATLAB/Simulink. The simulation results verify the efficacy of the proposed control mechanism.

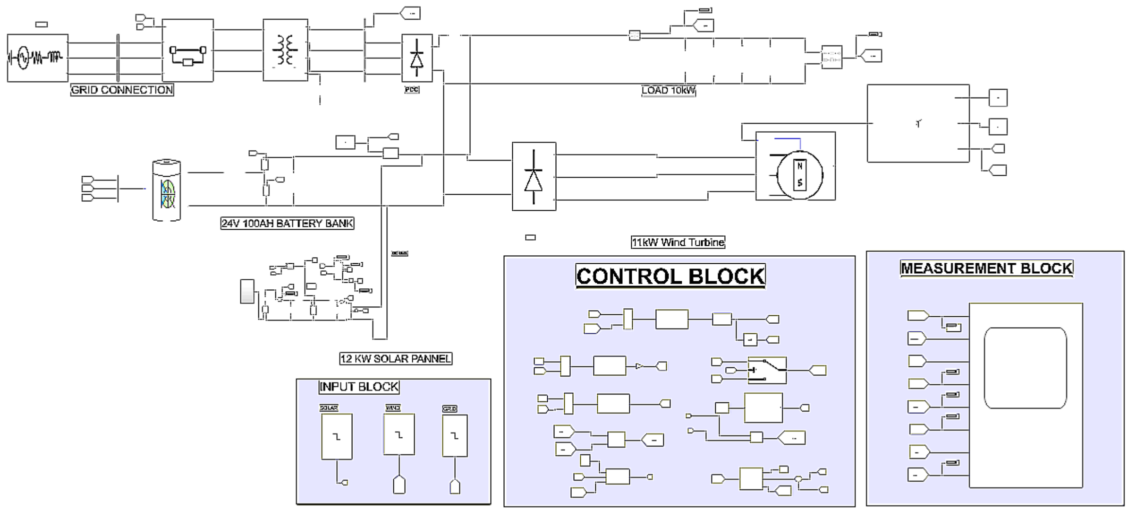

Fig.5: Proposed system Simulink,

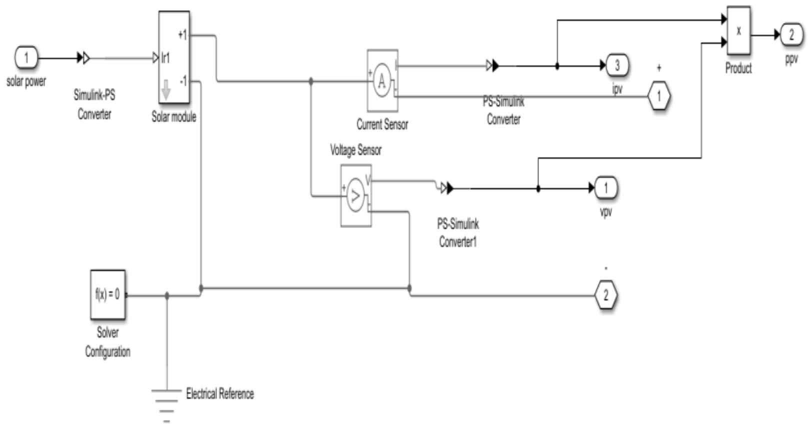

Fig.6: Proposed subsystem solar panel.

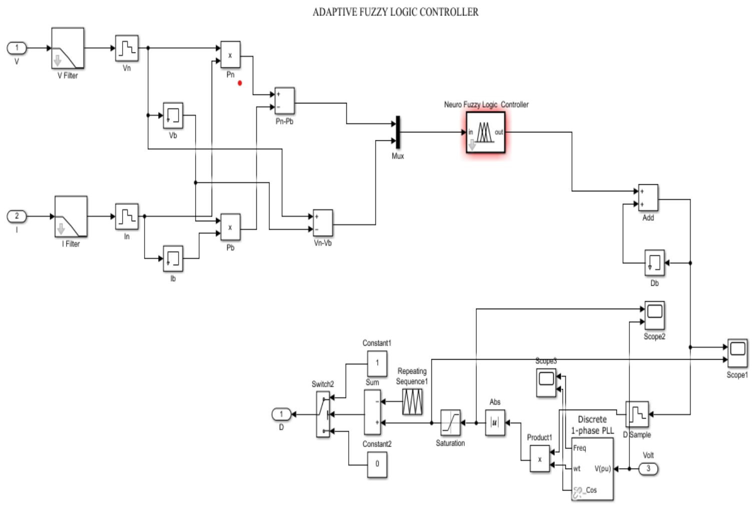

Fig.7:Proposed sub system fuzzysystem.

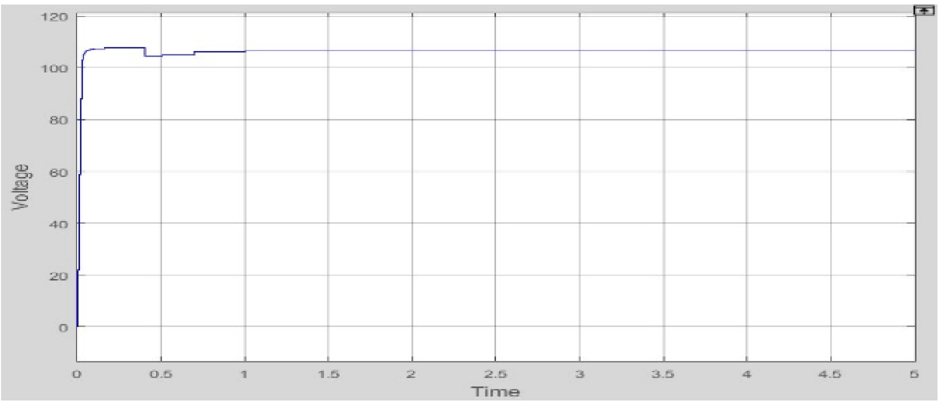

Fig. 8: Output response for Solar output voltage.

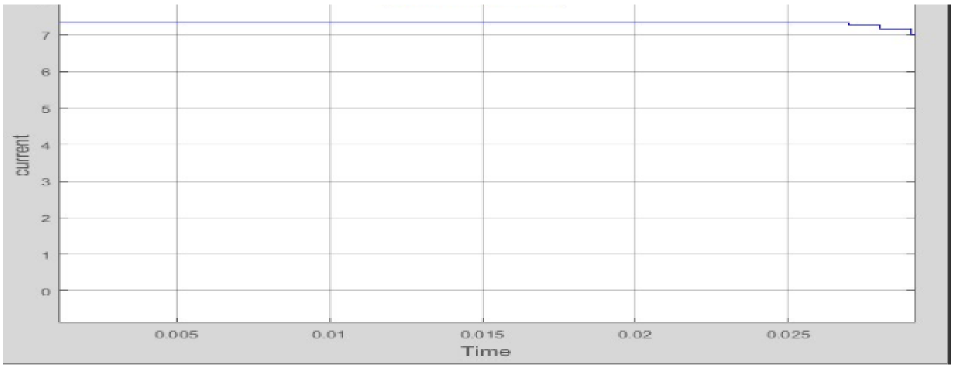

Fig. 9: Output response for Solar output current.

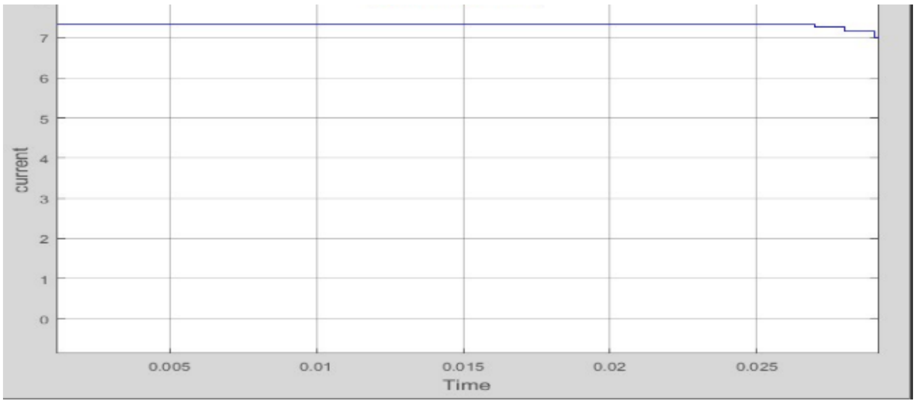

Fig. 10: Output response for MPPT with fuzzy.

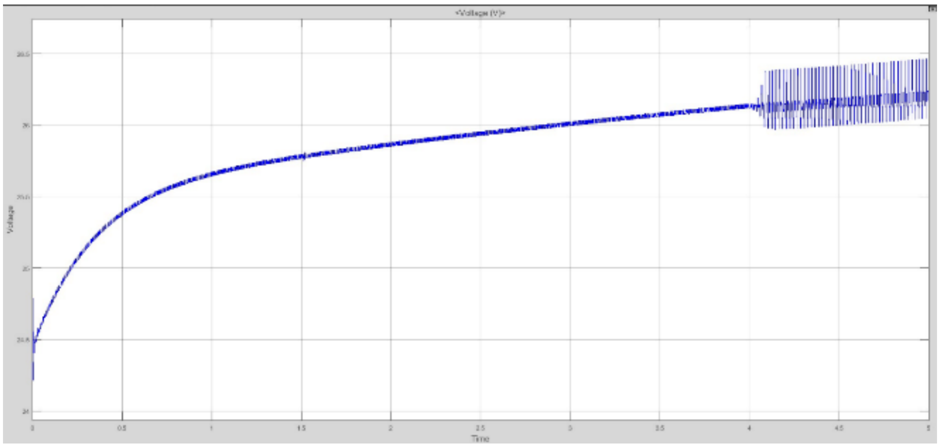

Fig. 11: Output response for battery output voltage.

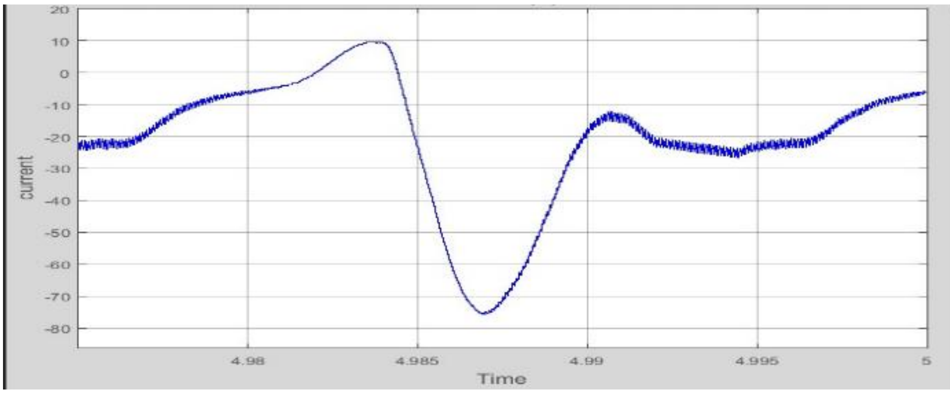

Fig. 12: Output response for battery output current.

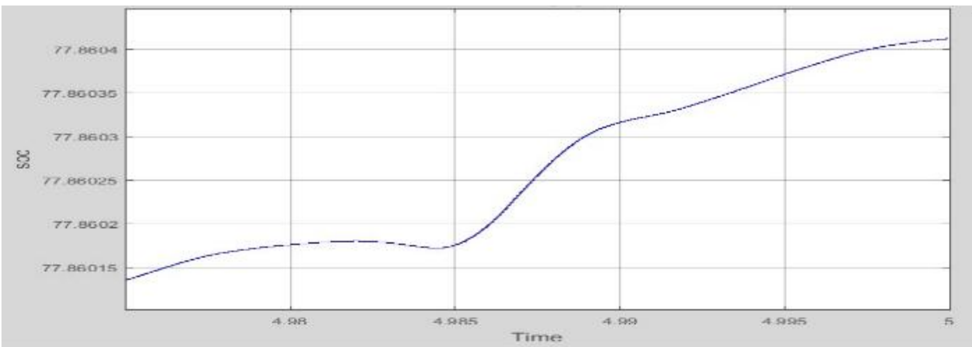

Fig. 13: Output response for SOC.

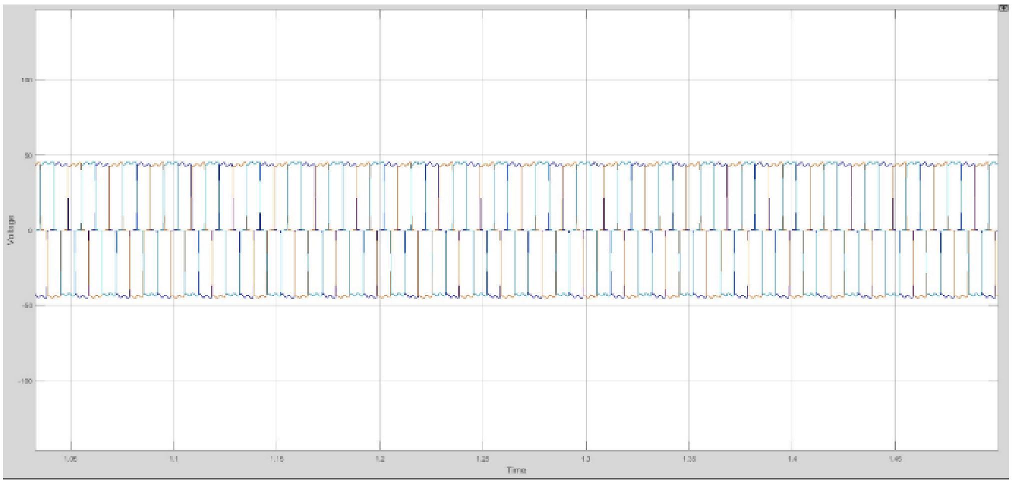

Fig. 14: Output response for Output Voltage grid.

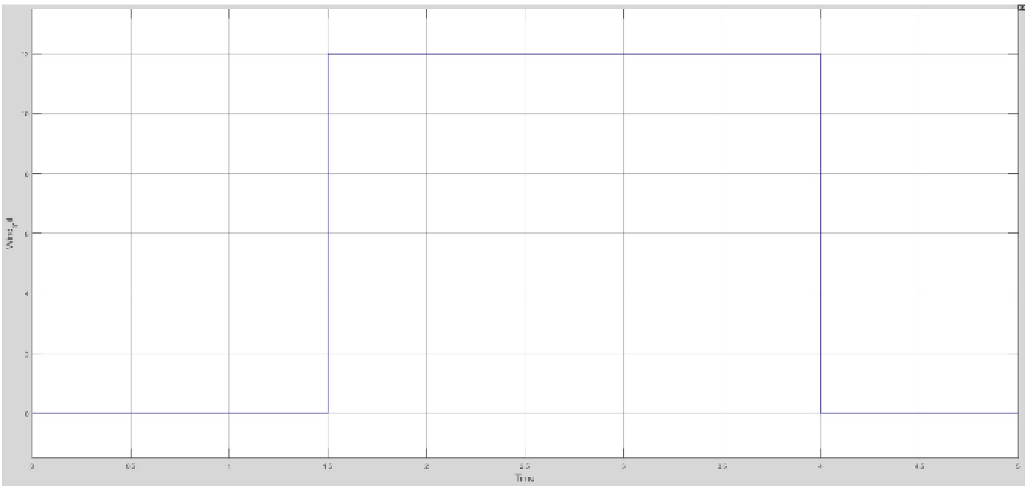

Fig. 15: Output response for wind speed.

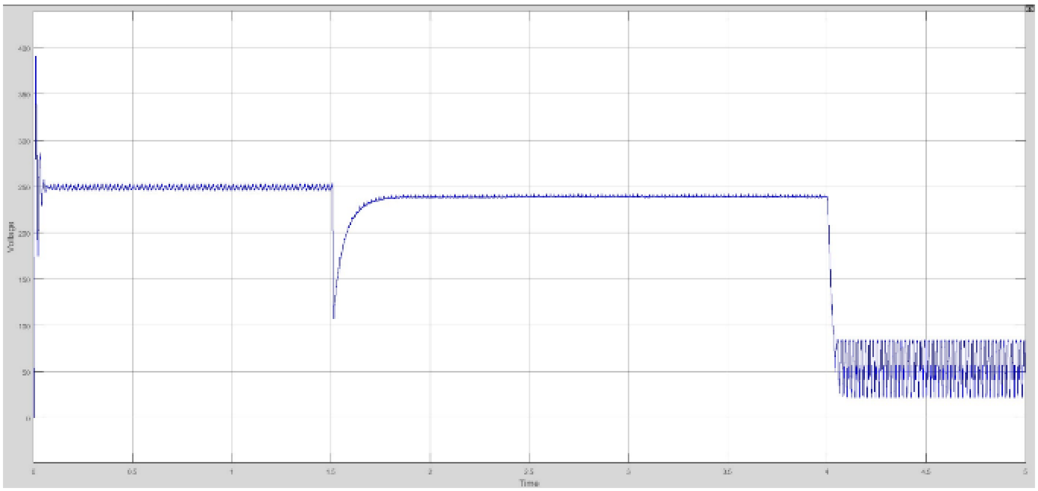

Fig. 16: Output response for Dc bus voltage.

Table. 1: Comparing dynamic performance with different control systems

Load Conditions		**PI**	**Fuzzy**	**Adaptive Fuzzy**
Constant Load	Overshoot	9.30%	0.80%	0%
	Settling time	0.8 sec	0.02 sec	0.016 sec
	Steady State	0	0	0
Change in Load Torque	Overshoot	9.33%	1.00%	0%
	Undershoot	8.67%	2.50%	1.66%
	Recovery time	0.15 sec	0.07 sec	0.02 sec
	Settling time	0.08 sec	0.02 sec	0.0012 sec

5. CONCLUSION

The proposed microgrid is modeled, controlled, and simulated in a MATLAB/Simulink environment, and it includes wind and solar power generation systems, a battery energy storage system, a variable load, and a nonlinear and unbalanced load. To provide voltage support, reactive power compensation, and imbalance reactive power minimization, this project involves the integration of BESS into a grid-connected microgrid. Aim of the project is to show the effective performance of the energy storage system and generation systems during participation in power management and simultaneously compensation of current harmonics, unbalance, and reactive power, and voltage support using fuzzy based controlled system.

REFERENCE

[1] E. Kabir, P. Kumar, S. Kumar, A. A. Adelodun, and K.-H. Kim, “Solar energy: Potential and future prospects,” Renewable and Sustainable Energy Reviews, vol. 82, pp. 894–900, 2018.

[2] V. Devabhaktuni, M. Alam, S. S. S. R. Depuru, R. C. Green II, D. Nims, and C. Near, “Solar energy: Trends and enabling technologies,” Renewable and Sustainable Energy Reviews, vol. 19, pp. 555–564, 2013.

[3] A. Q. Al-Shetwi, M. Z. Sujod, and N. L. Ramli, “A review of the fault ride through requirements in different grid codes concerning penetration of pv system to the electric power network,” ARPN journal of engineering and applied sciences, vol. 10, no. 21, pp. 9906–9912, 2015.

[4] Y. T. Tan and D. S. Kirschen, “Impact on the power system of a large penetration of photovoltaic generation,” in 2007 IEEE Power Engineering Society General Meeting. IEEE, 2007, pp. 1–8.

[5] M. M. Aly, M. Abdel-Akher, Z. Ziadi, and T. Senjyu, “Voltage stability assessment of photovoltaic energy systems with voltage control capabilities,” in 2012 International Conference on Renewable Energy Research and Applications (ICRERA). IEEE, 2012, pp. 1–6.

[6] Dr. P Bharat Kumar, D.Y. Kiran Kumar “Performance Enhancement of Large Scale Industrial Processes Using IMC-PI Controller Design”, ISSN: 0011-9342|Year 2021, DOI: https://doi.org/10.17762/de.vi.3031.

[7] S. Eftekharnejad, V. Vittal, G. T. Heydt, B. Keel, and J. Loehr, “Impact of increased penetration of photovoltaic generation on power systems,” IEEE transactions on power systems, vol. 28, no. 2, pp. 893–901, 2012.

[8] M. Alam, K. Muttaqi, and D. Sutanto, "An approach for online assessment of rooftop solar pv impacts on low-voltage distribution networks," IEEE Transactions on Sustainable Energy, vol. 5, no. 2, pp. 663–672, 2013.

[9] A. F. M. Nor, M. Sulaiman, A. F. A. Kadir, and R. Omar, "Voltage instability analysis for electrical power system using voltage stabilty margin and modal analysis," Indonesian Journal of Electrical Engineering and Computer Science, vol. 3, no. 3, pp. 655–662, 2016.

[10] S.S. Geethika, D Y Kiran Kumar, "Efficient Performance Analysis Of Adaptive Cruise Control System In Electrical Vehicle," e-ISSN: 2582-5208|Year 2021, Ref: IRJMETS/Certificate/Volume 3/Issue 10/31000039637.

[11] H. Nasiraghdam and S. Jadid, "Optimal hybrid pv/wt/fc sizing and distribution system reconfiguration using multi-objective artificial bee colony (moabc) algorithm," Solar Energy, vol. 86, no. 10, pp. 3057– 3071, 2012.K

[12] Krishna, D., M. Sasikala, and V. Ganesh. "Fractional order fuzzy logic based upqc for improvement of power quality in distribution power system." International Journal of Recent Technology and Engineering (IJRTE) 7, no. 6 (2019): 1405-1410.

[13] Krishna, D., M. Sasikala, and R. Kiranmayi. "FOPI and FOFL Controller Based UPQC for Mitigation of Power Quality Problems in Distribution Power System." Journal of Electrical Engineering & Technology 17, no. 3 (2022): 1543-1554.

[14] Himabindu, E., and M. Gopich Naik. "Energy management system for grid integrated microgrid using fuzzy logic controller." In 2020 IEEE 7th Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON), pp. 1-6. IEEE, 2020.