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DESIGN AND MODELLING OF PV BESS SYSTEM INTEGRATED WITH GRID UNDER DYNAMIC CONDITION

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ABSTRACT

The implementation of increasing distributed design topology design along with uncertainties that occurred due to PV systems intermittence and degradation in battery costs has shifted the direction of energy generation towards BESSs integrated with renewable microgrid systems. The fundamental advantages of the PV-BESS system integrated with grid are effective islanding operation, effective switching operation, and many more. The primary purpose of this research is to design and model PV-BESS system integrated with grid systems. On top of that, the secondary purpose of this study is to obtain optimal control by using DQ control technique and synchroconverter and compare them. g. In this research, the simulation of the grid system integrated with VSI has been carried out using the MATLAB Simulink tool. The performance of the system under different load conditions by varying the load variation, changing the solar insolation, and creating load unbalancing has been evaluated in order to compare system performance under different conditions.

Keywords –PV BESS, DQ, DERS, VSI, MPPT, GRID

1. INTRODUCTION

Alternative green energy sources are becoming more and more popular as a result of the rising need for electricity. One of the most promising renewable green energy technologies used as an alternative source of power is photovoltaic (PV) power generating. Power electronic converter assistance is necessary for the integration of PV to the load in order to improve performance. Power electronics converters are becoming increasingly complex as a result of their widespread use in standalone/grid-based systems. The point of discussion in this research is based on the design and model of the PV-BESS system integrated with grid in order to tackle the challenges of increasing power transmission losses and reducing carbon footprints.

1.1 PV-BESS AC GRID System

The formation of the "**Battery Energy Storage Systems (BESS)**", consists of numerous individual containers that have been arranged nearby next to the location of the substations. In this case, mainly rechargeable batteries have been used to store the energy 3om different sources and exhib6, June 2023ons in case of tJuneessity aspects . In case the same comprises more batteries then it can be used in providing efficient backup practices that automatically improve the stability of the attached grid. Effective adjustment can be done based on adjustment done in the microgrid voltages along with the subsequent frequency levels that maintain an enhanced set of equilibrium at the midpoint of the DC bus connected with "PV-BESS" systems.

1.2 Three-Phase VSI in PV-BESS AC GRID under Dynamic Conditions

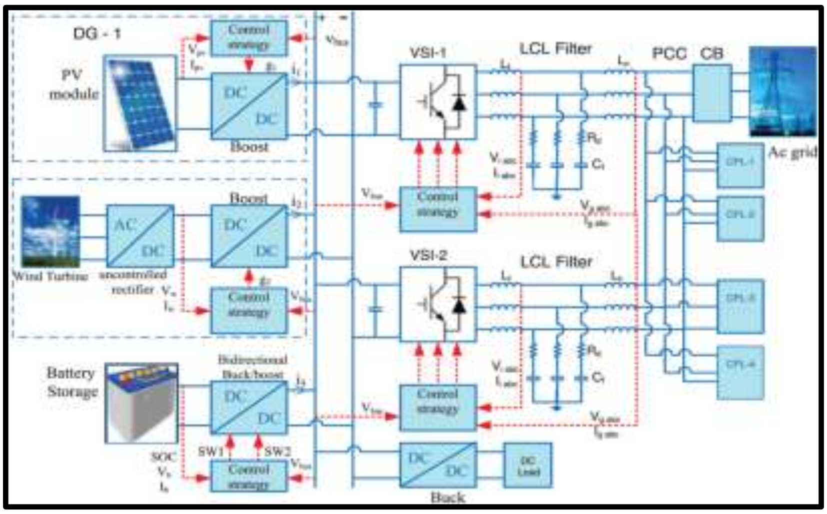

Fig 1 AC grid under dynamic condition

Within a AC Microgrid unified with multiple DERS and BESS, the intermittent output nature of the distributed energy resources due to the occurrence of fluctuation of input characteristics causes variation within the bus voltage and frequency. In order to overcome this issue, different control techniques such as P/Q Control, Voltage Control, and Frequency Droop control can be taken into consideration . The Battery Energy Storage System along with DER's interfacing VSI is associated with the autonomous control of the PV-BESS grid system without communication through the utilization of the bus voltage and frequency droop control.

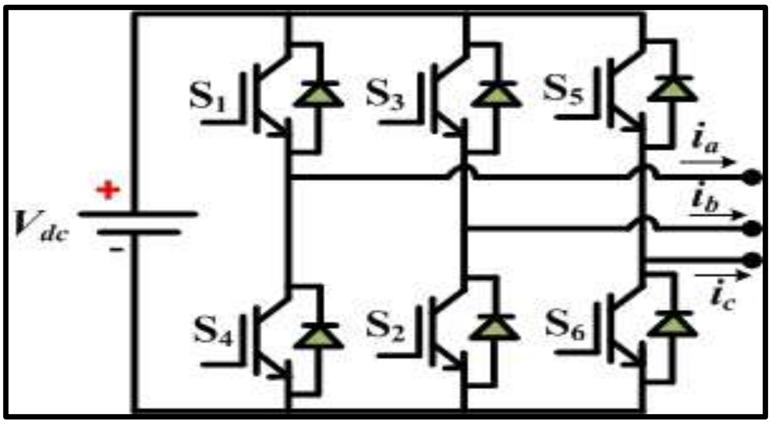

Fig 2 voltage source inverter

The Voltage Source Inverter (VSI) is used in this PV-BESS microgrid system in order to convert DC Voltage into AC Voltage in the presence of variable frequency and magnitude. Fig displays that the VSI is composed of six voltages, in which each phase output is connected to the middle of the inverter leg . 3 reference signals are compared with a high-frequency carrier waveform in order to fundamentally control the AC voltage (output) of the inverter.

According to A. K. Yadav et al IEEE(2017) (Transmission on power electronics) . the methods increase effectiveness by limiting the number of replacements made during the changeover interval. The analysis also demonstrates numerical methods for precisely determining switching losses and low-arrange harmonic regions for dual-VSI structures. In the lab, the exploratory setup—which includes a dual-VSI and an open-end induction engine—is gathered to evaluate how well the adopted method is being used. Finally, the simulations are observed to be closely in line with exploratory data after being finished in the MATLAB/Simulink environment. In the research study by H. Wang et al.IEEE 2016(transmission on power electronics), angular modulation list (AMI) actualized using a different space vector modulation is implemented for the dual voltage source inverters (VSI) with the primary goal of reducing switching losses. Through the application of the proper phase-point displacement between space vector references, the desired voltage across the load is blended. The method avoids the use of a dc/dc boost converter (which requires loss and weight/value punishment to reproduce the dc-connect voltage) and produces results that are particularly suitable for electrical/combination vehicle applications. The use of energy conservation to keep driving has been highlighted as a serious concern. Thus, the system to increase proficiency is the focus of this effort. According to H. Snani et al IEEE 2015(EEEIC)., a modulation method is used in this experiment to increase the yield power of the inverter and engine while reducing harmonic and loss. It is a hybrid modulation that combines pulse width and six-advance modulations. With strategy, efficiency and work area are increased, and the cost of the entire drive system is also decreased due to the removal of the dc-dc converter. Decryption is done for investigations, methodology, control plans, and simulation results. Trials with PMSM are conducted to verify that the created approach can be used. According to Bayhan et al. IECON 2015 IEEE INDUSTRIAL ELECTRONIC SOCIETY, a dual-inverter system with an open-end winding motor is an appealing way to give an engine a greater voltage for use in electric vehicle (EV) applications. To achieve the advantages of dependability and high voltage, a topology utilizing two isolated dc sources is suggested. Although this design might need two battery chargers, in this investigation, the use of just one charger to a basic battery was taken into consideration. The main challenge is to use the engine, whether it is operating or not, to transfer power from the primary battery to the auxiliary battery. The charging capacity is determined by the inverter voltage edge that remains after engine torque generation.

2. METHODOLOGY

This research work is fundamentally based on the designing and development of an AC Microgrid system based on the PV-BESS system under different dynamic conditions.

The grid integration PV-Solar and an intelligent controller-based Battery Energy Storage System have been developed in this work using MATLAB and Simulink. The AC grid system in this research has included two AC voltage distribution levels which are 13.8 kV for the primary level and 220 Volts for the secondary level. The AC Microgrid system operates at a supply frequency of 50 Hz.

The MATLAB/Simulink test system simulation has included the following aspects:

- Distributed generator
- PV-array
- Two battery energy storage system (PV-BESS),
- Multiple linear and non-linear loads.

3. PROPOSED SIMULINK MODEL

3.1 SOLAR PHOTOVOLTAIC SYSTEM

Two crucial processes are involved in photovoltaic energy conversion in solar cells. The initial one is light absorption, which results in an electron-hole pair. The design of the device keeps the electron and hole apart. The negative terminal is where the electrons go, while the positive terminal is where the holes go. Based on the division of holes and electrons, the electric potential is created.

3.2 MPPT: The maximum power point (MPP) designates the location on an I-V curve where a solar photovoltaic device produces the most output, or the location where the product of current intensity (I) and voltage (V) is greatest. The MPP may alter depending on environmental variables such temperature, lighting, and device performance.

3.3 PERTURB & OBSERVATION TECHNIQUE

In the perturb and observation (P&O) approach, the duty ratio, D, of the dc-dc converter is perturbed by a factor AJ after regular intervals, and the resulting output power is compared with that from the previous perturbation cycle. If a higher power is produced by increasing the duty ratio (D + D), it is increased further until the output power starts to decrease. In contrast, if a duty ratio increases results in less power than before, the duty ratio is reduced until power production stops rising and starts to fall.

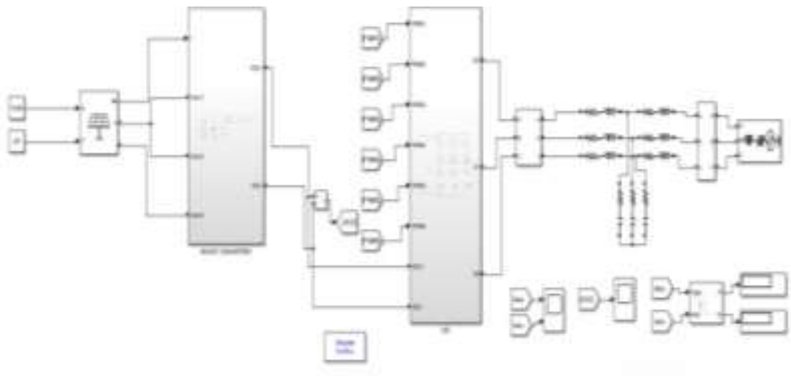

Fig. 3 shows overall Simulink model of proposed system of Grid connected PV Array with MPPT.

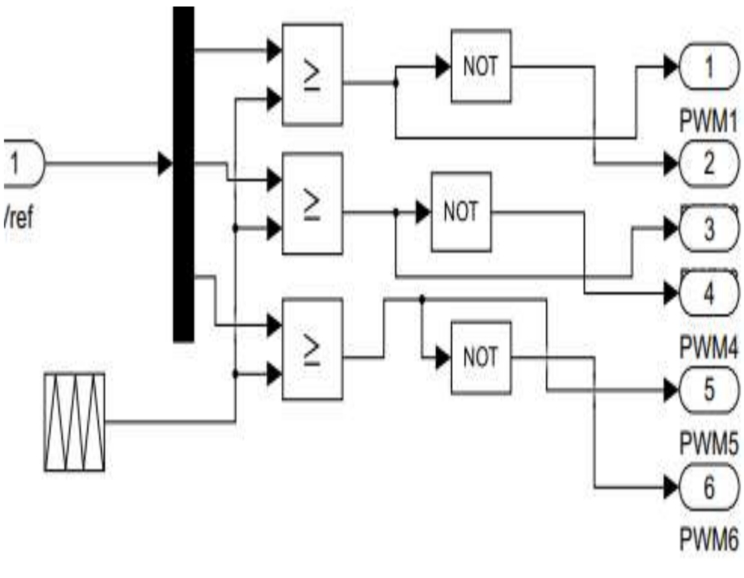

Fig 4 PWM control circuit

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4. SIMULATION RESULTS

The PV module's maximum PV output voltage is set at 290, and this voltage has a 50-volt peak to peak ripple. This large voltage ripple can harm a system, lower its efficiency, and increase its losses. Figure illustrates the DC voltage of the PV output.

A DC-DC boost converter was needed to reduce this ripple and raise the DC voltage. The output voltage of a DC-DC boost converter has a high voltage of 400V and is ripple-free, making it simple to connect it to a single-phase grid using an inverter. Additionally helpful for MPPT (Maximum Power Point Tracking), which is carried out using the perturb and observe method, is this DC-DC boost converter

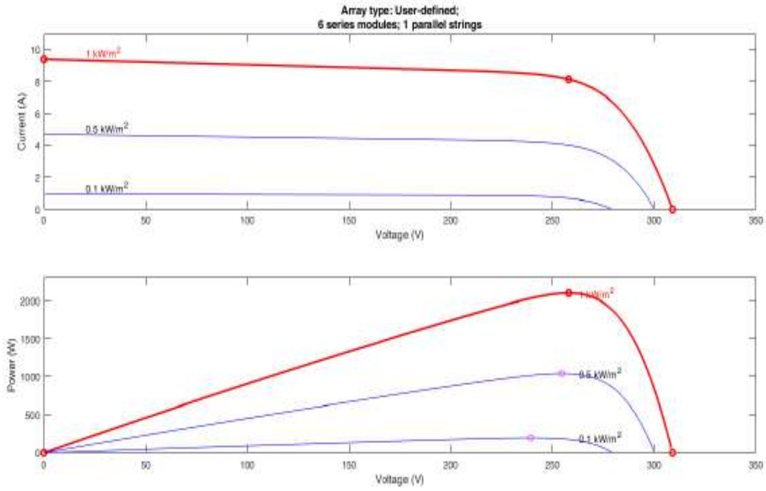

Fig 5 PV power and current w.r.t. voltage

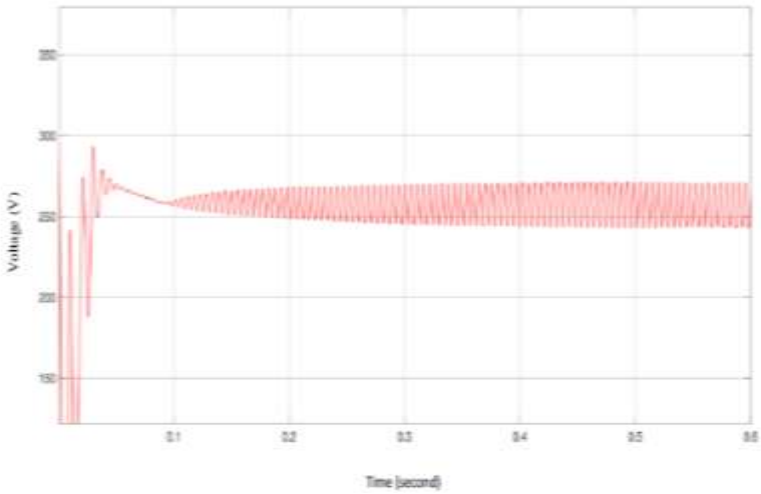

Fig 6 PV output DC voltage with 50 V ripple

The simulation results with DQ control under different cases are as under is shown in Fig. 7.

CASE 1 In case (I), the inverter is delivering only active power (i.e., Pref = 8 kW &Qref = 0) to the PCC from 0 to 0.6 sec

CASE 2 In case (II), the active power consumed by inverter while reactive power is zero (i.e., Pref = -8 kW &Qref = 0) to the PCC during 0.6 to 1.2 sec.

Case 3 In case (III), the inverter is injecting only reactive power (i.e., Pref = 0 kW &Qref = 6 kVAr) to the PCC during 1.2 to 1.8 sec.

CASE 4 In case (IV), the reactive power consumed by inverter while active power is zero (i.e., Pref = 0 kW &Qref = -6 kVAr) from the PCC during 1.8 to 2.4 sec

CASE 5 In case (V), the active and reactive power are injecting (i.e., Pref = 5 kW &Qref = 5 kVAr) to the PCC during 2.4 to 3.0 sec

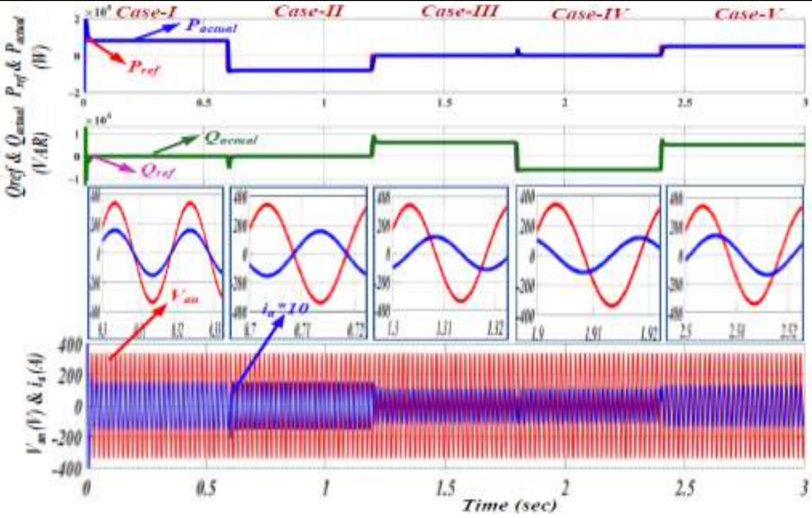

Fig. 7 Dynamic response of Pref, Qref, Pactual, Qactual, Van & Ia under case (I)-(V) with DQ-control.

The simulation results with synchro-converter control under different cases are as under is shown in Fig. 8.

CASE 1 In case (I), the inverter is delivering only active power (i.e., Pref = 8 kW &Qref = 0) to the PCC from 0 to 0.6 sec

CASE 2 In case (II), the active power consumed by inverter while reactive power is zero (i.e., Pref = -8 kW &Qref = 0) to the PCC during 0.6 to 1.2 sec.

Case 3 In case (III), the inverter is injecting only reactive power (i.e., Pref = 0 kW &Qref = 6 kVAr) to the PCC during 1.2 to 1.8 sec.

CASE 4 In case (IV), the reactive power consumed by inverter while active power is zero (i.e., Pref = 0 kW &Qref = -6 kVAr) from the PCC during 1.8 to 2.4 sec

CASE 5 In case (V), the active and reactive power are injecting (i.e., Pref = 5 kW &Qref = 5 kVAr) to the PCC during 2.4 to 3.0 sec

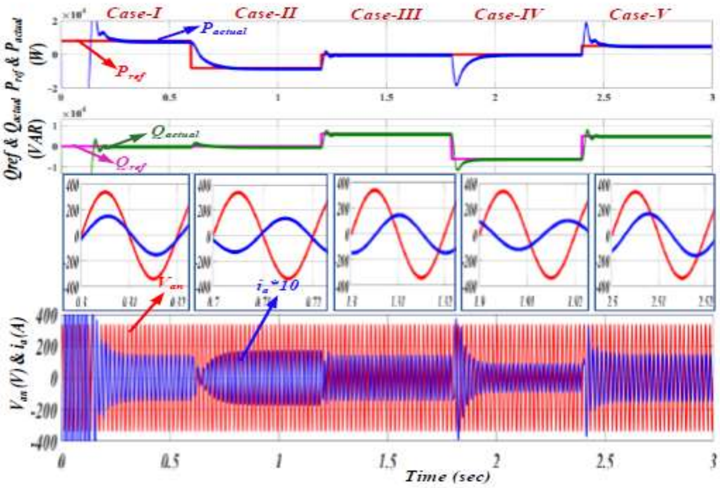

Fig.8 Dynamic response of Pref, Qref, Pactual, Qactual, Van and Ia under case (I)-(V) with synchro-converter control.

5. CONCLUSION

The point of discussion in this research work is based on the designing and development of an AC Microgrid system based on the PV-BESS system. The grid integration PV-Solar and an intelligent controller-based Battery Energy Storage System have been developed in this work using MATLAB. The analysis of the system performance of the AC Microgrid system integrated with 3-phase VSI has been executed under normal conditions. On the other hand, the same system is simulated and analysed under multiple fault conditions. The maximum power generated from the PV-BESS array is dependent on different factors such as compensation of reactive power, harmonic mitigation, grid current balancing, the effectiveness of transition from the grid-connected mode to autonomous mode, and many more. From the MATLAB simulation model, it has been found that whenever there occurs a failure within the microgrid system, the system starts to operate in autonomous mode without causing any interruption in the system. On the

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contrary, whenever the system is restored to its normal condition, the PV-BESS microgrid system automatically shifts to the grid-connected mode. The charging and discharging operation of the battery systems gets controlled by a Voltage Source Inverter. It helps in regulating the AC link voltage to the MPP voltage of the PV-BESS array.

The performance of a 3-grid connected VSI is examined in this work, and simulations using the same parameters for DQ control and synchro-converter controller are conducted. When compared to DQ-control, which requires less computing, s synchro-converter control's implementation is elegant. The s synchro-converter control's eloquence is translucent because the inverter is functioning like a synchronous generator. When the dynamic reaction is taken into account, DQ-control outperforms synchro-converter r control in terms of speed

6. REFERENCES

[1] L. Zhou and M. Preindl, "Hierarchical Software-Defined Control Architecture With MPC-Based Power Module to Interface Renewable Sources and Motor Drives," in IEEE Transactions on Sustainable Energy, vol. 14, no. 1, pp. 83-96, Jan. 2023, doi: 10.1109/TSTE.2022.3202957.

[2] L. Zhou and M. Preindl, "Hierarchical Software-Defined Control Architecture With MPC-Based Power Module to Interface Renewable Sources and Motor Drives," in IEEE Transactions on Sustainable Energy, vol. 14, no. 1, pp. 83-96, Jan. 2023, doi: 10.1109/TSTE.2022.3202957.

[3] S. Gaurav and C. Kumar, "Coordinated Control of EV Charging Stations in Smart Transformer based Microgrid," 2022 22nd National Power Systems Conference (NPSC), New Delhi, India, 2022, pp. 590-595, doi: 10.1109/NPSC57038.2022.10069390.

[4] M. Ahmed, R. Bhattarai, S. J. Hossain, S. Abdelrazek and S. Kamalasadan, "Coordinated Voltage Control Strategy for Voltage Regulators and Voltage Source Converters Integrated Distribution System," in IEEE Transactions on Industry Applications, vol. 55, no. 4, pp. 4235-4246, July-Aug. 2019, doi: 10.1109/TIA.2019.2902524.

[5] M. M. Gulzar, A. Iqbal, D. Sibtain and M. Khalid, "An Innovative Converterless Solar PV Control Strategy for a Grid Connected Hybrid PV/Wind/Fuel-Cell System Coupled With Battery Energy Storage," in IEEE Access, vol. 11, pp. 23245-23259, 2023, doi: 10.1109/ACCESS.2023.3252891.

[6] A. Yar Ali, A. Basit, T. Ahmad, A. Qamar and J. Iqbal, "Optimizing coordinated control of distributed energy storage system in the microgrid to improve battery life", Computers & Electrical Engineering, vol. 86, pp. 106741, September 2020, [online] Available: https://doi.org/10.1016/j.compeleceng.2020.106741.

[7] N. Mdini, S. Skander-Mustapha and I. Slama-Belkhodja, "Control with grid forming of a PV-BESS system for a 4-wire residential microgrid," 2021 12th International Renewable Energy Congress (IREC), Hammamet, Tunisia, 2021, pp. 1-6, doi: 10.1109/IREC52758.2021.9624926.

[8] A. Farooqi et al., “Dynamic Voltage Restorer (DVR) enhancement in power quality mitigation with an adverse impact of unsymmetrical faults,” Energy Reports, vol. 8, pp. 871–882, 2022. doi:10.1016/j.egyr.2021.11.147

[9] J. Khazaei and C. Schlauderaff, “Data on reducing carbon footprint in microgrids using Distributed Battery Energy Storage,” Data in Brief, vol. 27, p. 104679, 2019. doi:10.1016/j.dib.2019.104679

[10] A. Satapathy, N. Nayak, and T. Parida, “Real-time power quality enhancement in a hybrid micro-grid using nonlinear autoregressive neural network,” Energies, vol. 15, no. 23, p. 9081, 2022. doi:10.3390/en15239081

[11] B. Onar and Ş. e. Demirbaş, "A Survey on the Provision of Smooth Transition between Operation Modes in PV-BESS Microgrid," 2022 10th International Conference on Smart Grid (icSmartGrid), Istanbul, Turkey, 2022, pp. 203-207, doi: 10.1109/icSmartGrid55722.2022.9848664.

[12] S. A. Razzaq and V. Jayasankar, "Autonomous Power Management for Hybrid AC/DC Nano Grid Using ESS and DG," 2022 International Conference on Intelligent Controller and Computing for Smart Power (ICICCSP), Hyderabad, India, 2022, pp. 1-6, doi: 10.1109/ICICCSP53532.2022.9862413.

[13] D. P. Acharya, N. Nayak and S. Choudhury, "Active Power Management in an AC Microgrid Using Artificial Neural Network and DSTATCOM," 2021 International Conference in Advances in Power, Signal, and Information Technology (APSIT), Bhubaneswar, India, 2021, pp. 1-6, doi: 10.1109/APSIT52773.2021.9641304.

[14] B. Soudan and A. Masoud Darya, "Modular Hybrid Energy System for Refugee Camps," 2021 6th International Conference on Renewable Energy: Generation and Applications (ICREGA), Al Ain, United Arab Emirates, 2021, pp. 33-38, doi: 10.1109/ICREGA50506.2021.9388289.

[15] L. Tightiz and H. Yang, "Resilience Microgrid as Power System Integrity Protection Scheme Element With Reinforcement Learning Based Management," in IEEE Access, vol. 9, pp. 83963-83975, 2021, doi: 10.1109/ACCESS.2021.3087491.