IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 10, 2022

UPQC for Solar Photovoltaic-Small Hydro-Battery Based Microgrid

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Abstract

The paper addresses the topic of a microgrid. form involving decentralized power generation sources connected to three-phase loads exhibiting nonlinearity. The microgrid incorporates distributed generation sources, namely a self-excited induction generator-driven a mini-hydrosystem, battery and the solar PV panels. In the presence of nonlinear load situations, the Unified Power Quality Controller (UPQC) is intended to improve the power quality inside the microgrid system. This UPQC is built on a power electronics component based on a voltage source converter that simultaneously provides current and voltage into the microgrid. This action serves the purposes of eliminating harmonics, compensating reactive power, and regulating voltage. Furthermore, a bidirectional buck-boost controller connects the battery to regulate power flow within the microgrid, accounting for fluctuations in nonlinear load and solar radiation. A boost converter connects the solar photovoltaic (PV) system. The system also includes solar PV generating with MPPT capabilities, a battery supported by a buck-boost converter, and the UPQC. Additional components include a 3.2 kW, 230 V, 50 Hz Self-Excited Induction Generator (SEIG) and solar PV generation. MATLAB software was used to carefully design, develop, and simulate each of these parts.

Keywords:- Battery, Improved Power Quality, Microgrid Solar Photo Voltic Panel, UPQC

I. INTRODUCTION

In recent years, researchers have shown increasing fascination with microgrids. Microgrids take shape as networks of distributed energy sources linked to isolated systems, catering to localized power supply needs. Distributed power generation involves generating electricity at the utility's location, separate from the primary power grid. Small hydro and solar photovoltaic distributed power generation also fall under the category of renewable energy sources, holding significant potential to contribute towards curbing carbon emissions, which stands as one of the most pressing concerns in the present era The SEIG operates using an asynchronous machine that receives excitation from a distinct capacitor bank. This configuration brings about advantages including cost reduction, lowered maintenance needs, robust construction, and a brushless design.[1-3]. Furthermore, SEIG is used in the production of minor amounts of hydroelectric power, where the source voltage is maintained with constant power operation but the frequency varies depending on the load. Small hydro is a constant power drive that uses a dump load known as an electronic load controller (ELC) to maintain load power under different load conditions. [4-6]. For maximum power extraction, solar photovoltaic generating uses the incremental conductance approach. [7-11]

For the operation of the maximum power point tracking (MPPT) technique for SVP generation, the boost converter control is used. The suggested microgrid system consists of small hydro, solar photovoltaic (SVP), batteries, nonlinear loads, and a unified power quality controller (UPQC). In MATLAB software, the suggested system with UPQC to maintain constant voltage and frequency is built, modelled, and simulated. For solar power generation and bidirectional transmission of power through batteries under differing loads, buck-boost converter-based controls are used. For the operation of the maximum power point tracking (MPPT) technique for SVP generation, the boost converter control is used. [12]

The outlined study pertains to the introduced microgrid concept described in following context-

• A multipurpose converter, the shunt VSC adjusts for reactive power of load and its current of negative sequence as well as eliminates load harmonic currents and improves source current THDs.

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• In addition, the series controller is employed to maintain the voltage profile at load even when the SEIG source voltage is reduced, resulting in less stress on the SEIG core.

• When there are interruptions in the load, the buck-boost converter's controller can facilitate both the charging and draining of the battery.

• The boost converter's control system uses the Maximum Power Point Tracking (MPPT) technology to regulate solar photovoltaic (SPV) power while taking variable radiation levels into account.

II. SCHEMATIC OF MICROGRID

A three-phase capacitor bank used for excitation in an induction motor's self-excited induction generator (SEIG) provides the reactive power required to reach the no-load base voltage. The different reactive and active power components of the UPQC are controlled by a battery and a DC link capacitor, respectively. When the system is operating in a loaded state, this configuration enables the system's voltage, frequency, and overall power quality to be improved. The schematic representation of the battery unit, UPQC, nonlinear loads, SPV generation, SEIG-based small hydro generation, and SPV generation is shown in Figure 1

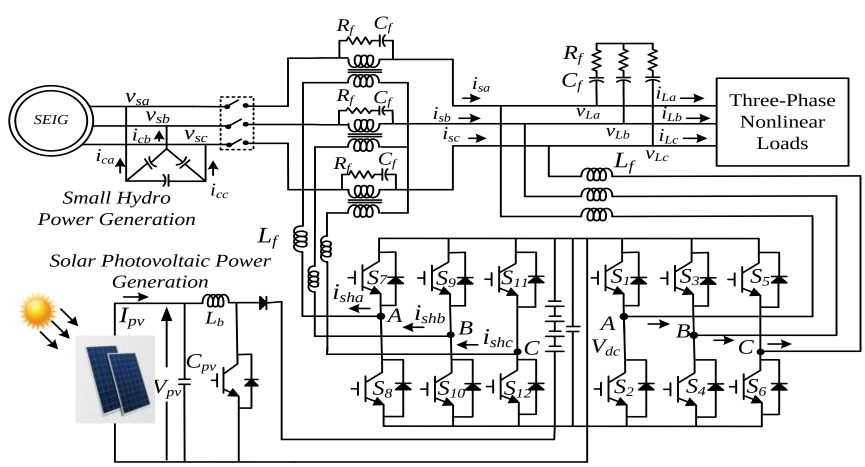

Fig. 1 System configuration of small hydro-solar photovoltaic-battery based microgrid system with UPQC

III. STRATEGIES FOR CONTROL

The control of shunt controller is shown in Fig. 2 and Fig. 3 shows the series VSC control

A. The Shunt Controller's Control Strategy

The power quality of the source current SEIG at the nonlinear load is enhanced using the shunt controller's control method. To create gate pulses, the shunt controller's control strategy extracted the basic components of the active load currents and the components which is in phase of the reference source current.

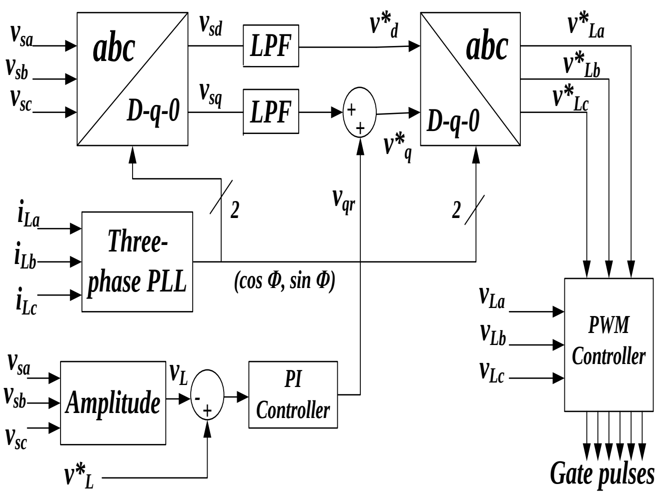

Fig. 2 Control of shunt VSC

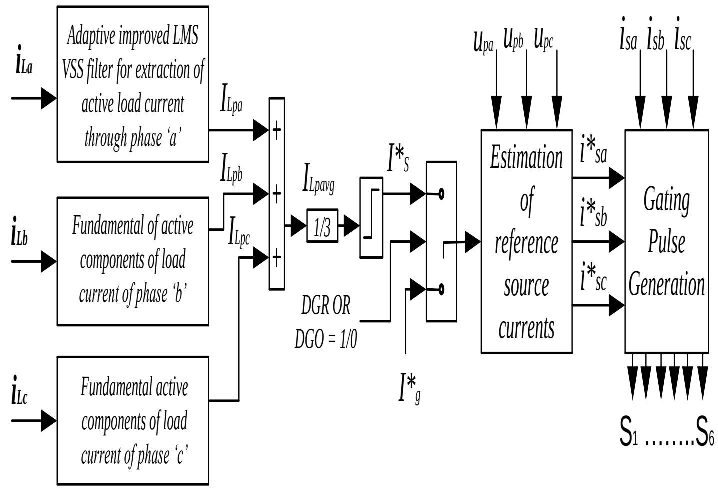

Fig. 3 Control of series VSC

B Series controller's control scheme

To enhance the power quality of SEIG at the nonlinear load, shunt controllers use synchronous reference frames (SRF) as the foundation of their control strategies. Park's transformation changes the three-phase SEIG source voltage in the d-q-0 reference frame. To synchronize signals, the 3-phase load currents flow via a PLL (Phase Locked Loop). only PI controller with the ability to control load voltage amplitude. The PWM controller produces the series converter pulses, as shown in Fig. 3.

C MPPT Control for Increasing Conductance

The maximum amount of electricity that can be extracted from a solar photovoltaic array employing an algorithm based on incremental conductance. The technique can also be used under a variety of sun irradiance conditions. The boost converter regulator is use to maximize solar photovoltaic power generation while keeping the necessary voltage and current.

D Battery control with bidirectional controller

The buck- boost type bi-directional convertar control is utilized for solar photovoltaic power and various loads when charging and discharging batteries. When under heavy load conditions, such as when the excess load demand is met by the battery and the load power required exceeds the supply power, the converter functions in boost mode. Under light load conditions, where the power to load is lower than the source power and battery absorption of excess power, the converter functions in buck mode.

IV. RESULTS AND DISCUSSION

Waveforms of the proposed microgrid's supply voltage (v_s), SEIG supply current (i_s), load voltage (v_L), load current (i_L), compensation voltage (V_{dvr}), compensation current (i_c), frequency (f), DC link voltage (V_{dc}), battery current (i_b), SPV current (Ipv)

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and SVP power (Ppv) are shown in Fig. 4. Fig. 4 (a) and (b) shown the performence of UPQC with proposed microgrid system at non-linear and unbalanced load condition respectively. Fig. 4 (c) shows the performance of UPQC with microgrid system under change in load and solar radiation.

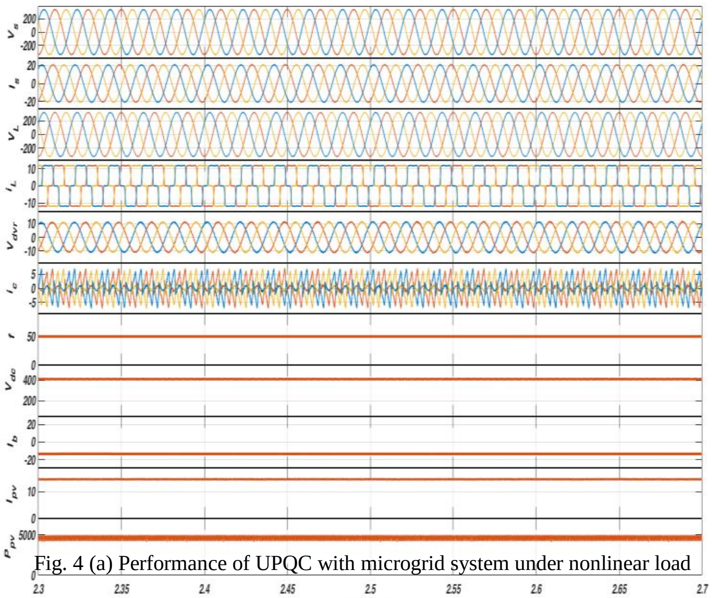

Fig. 4 (a) Performance of UPQC with microgrid system under nonlinear load

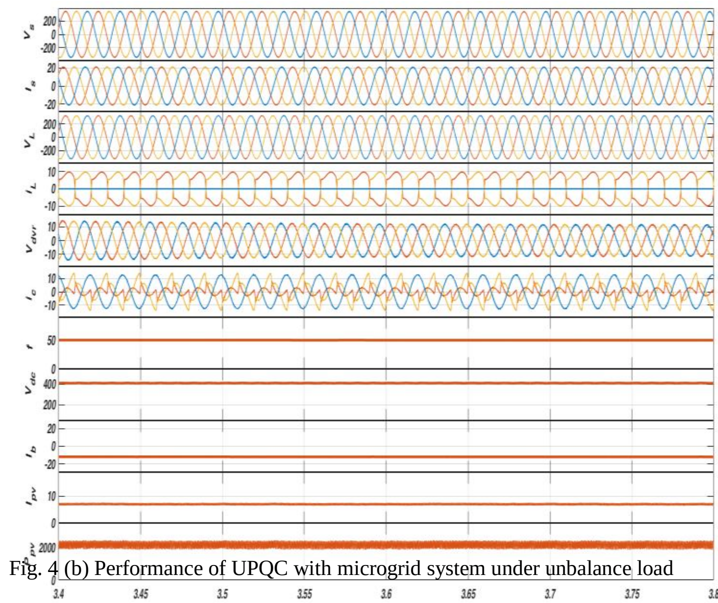

Fig. 4 (b) Performance of UPQC with microgrid system under unbalance load

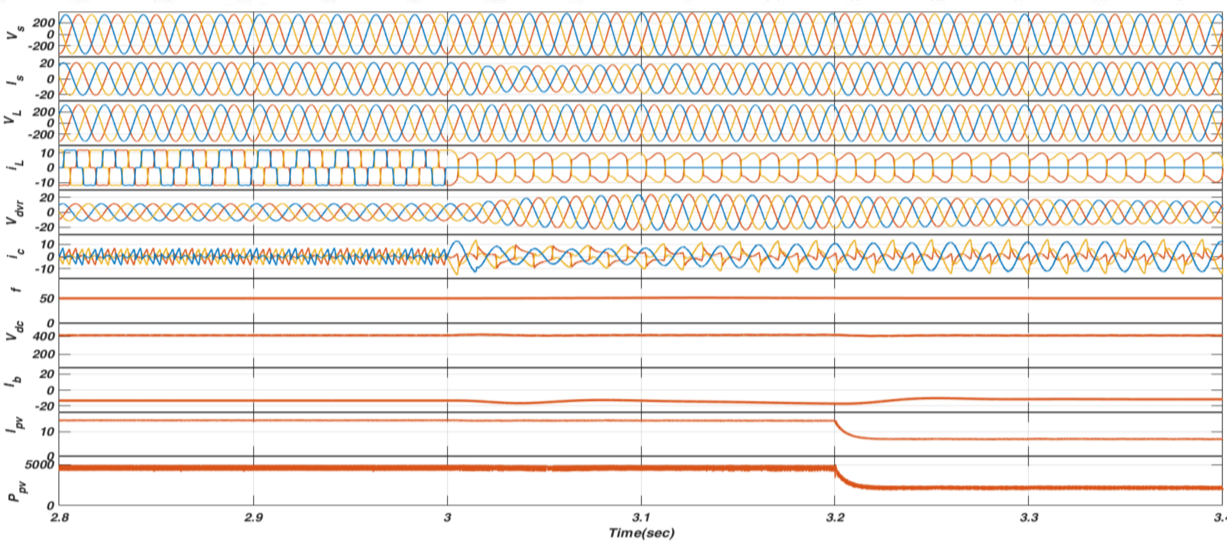

Fig. 4 (c) Performance of UPQC with microgrid system under variation in load and solar radiation

V. CONCLUSION

Under nonlinear load conditions, the UPQC can enhance the microgrid system's voltage, frequency, and power quality. A battery can be charged or discharged using a bidirectional buck-boost converter under variable loads and solar radiation. In order to extract the most power and draw from the microgrid in accordance with boost converter operation, the MPPT technique is performed with SPV. Additionally, even at lower rated SEIG voltages, the UPQC can maintain the load terminal voltage, putting less stress on the machine's magnetic core. The control strategy with nonlinear load, unbalanced load, and fluctuating solar radiation has been confirmed by the simulation results.

ISSN PRINT 2319 1775 Online 2320 7876
  UGC CARE Listed (Group -I) Journal Volume 11, Iss 10, 2022

REFERENCES

[1] Singh, S. P., Singh, B., Jain, M. P., 'Performance characteristics and optimum utilization of a cage machine as capacitor excited induction generator', IEEE Trans. Ener. Con., Dec. 1990, 5, (4), pp. 679 - 685.
[2] Singh, B., Shilpakar, L. B., 'Analysis of a novel solid state voltage regulator for a self-excited induction generator', IEE Proc.-Gener. Trans. Distrib., November 1998, 145, (6), pp. 647 - 655.
[3] Levi, E., Liao, Y. W., 'An experimental investigation of self-excitation in capacitor axcited induction generators', Electrical Power and Systen Research, 2000, 53, pp. 59-65.
[4] B. Singh, S. S. Murthy and S. Gupta, "An improved electronic load controller for self-excited induction generator in micro-Hydel applications", Proc. of 29th Annual Conf. of the IEEE Industrial Electronics Society, IECON '03, vol. 3, pp. 2741- 2746, 2-6 Nov. 2003.
[5] J.A. Barrado and R. Grino, "Voltage and frequency control for a self excited induction generator using a 3-phase 4-wire electronic converters," in Proc. 12th Int. IEEE Power Electronics Motion Control Conf., Aug. 2006, pp. 1419–1424.
[6] J.M. Ramirez Emmanuel and M Torres, "An electronic load controller for the self-excited induction generator", *IEEE Trans. Energy Convers.*, vol. 22, no. 2, pp. 546-548, Jun. 2007.
[7] B. Subudhi and R. Pradhan, "A comparative study on maximum power point tracking techniques for photovoltaic power systems," *IEEE Trans. Sustain. Energy*, vol. 4, no. 1, pp. 89–98, Jan. 2013.
[8] J. Zhao, N. Chen, C. Chen, Y. Cui and H. Ma, "Modeling and simulation of micro-grid based on small-hydro", *Proc. of International Conference on Power System Technology*, pp. 3257-3264, 2014.
[9] S. K. Khadem, M. Basu, and M. F. Conlon, "Intelligent islanding and seamless reconnection technique for microgrid with UPQC," IEEE J. Emerg. Sel. Topics Power Electron., vol. 3, no. 2, pp. 483–492, Jun. 2015.
[10] S. Kumar, A. K. Verma, I. Hussain, B. Singh, and C. Jain, "Better control for a solar energy system: Using improved enhanced phase-locked loop based control under variable solar intensity, "*IEEE Ind. Appl.Mag*.,vol.23, no. 2, pp. 24–36, Mar. 2017.
[11] A.M.Raufand V.Khadkikar, "Integrated photovoltaicand dynamic voltage restorer system configuration," *IEEE Trans. Sustain. Energy*, vol. 6, no. 2, pp. 400–410, Apr. 2015.
[12] S. Devassy and B. Singh, "Modified p-q theory based control of solar PV integrated UPQC-S," in IEEE Trans. Ind. Appl., vol. 53, no. 5, pp. 5031–5040, Sept./Oct. 2017.