International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

AN UNINTERRUPTABLE PV ARRAY- BATTERY BASED SYSTEM OPERATING IN DIFFERENT POWER MODES WITH ENHANCED POWER QUALITY

[1.]Dr. MEERA SHAREEF SHAIK, [2.]S.ANNE SANTHIPRIYA

1.Professor (EEE), PRAKASAM ENGINEERING COLLEGE, KANDUKUR, SPSR Nellore District (A.P)

2.PG Scholar (EEE), PRAKASAM ENGINEERING COLLEGE, KANDUKUR, SPSR Nellore District (A.P)

ABSTRACT

Battery energy storage stations are presently and usually used to smooth out variations in wind or solar power output. (BESS). These BESS-based hybrid power systems require a suitable management strategy that can effectively regulate power production levels and battery state of charge. (SOC). This study seeks to create a solar-battery energy storage (BES) based system that guarantees a continuous supply to loads regardless of the grid's availability. A solar photovoltaic (PV) field, a BES, the grid, and nearby household loads make up this system. A new control is put into place so that the electric grid, a BES unit, and a PV array all supply the active power consumption of domestic loads. With the incorporation of BES and extra power from the PV arrays that is sold back to the grid, the power management in this system works in various power modes to give advantages to the end users. For this, an efficient control algorithm for the grid-tied voltage source converter is created. (VSC). Additionally, this system addresses the problem of combining power quality improvement with the production of electricity from solar PV sources. For grid synchronization during the grid voltage disturbance, a phase locked loop (PLL) based on cascaded delayed signal cancellation (CDSC) is used. In order to improve the smoothing performance of wind/PV/BESS hybrid power generation and the effectiveness of battery SOC management, a modelling study of a wind/photovoltaic (PV)/BESS hybrid power system was carried out. The results are presented in this paper. The findings of the tests confirm how well the applied control performs under various working circumstances, including changing

solar power production, varying demand, and grid unavailability.

INTRODUCTION

Renewable energy sources (RES) such as Solar, Wind, Geothermal, Tidal, Hydro etc. are inexhaustible by nature. The RES have been found promising towards building sustainable and ecofriendly power generation. Due to the limitation of conventional resources of fossil fuels, it has compelled the evolution of hybrid power system. Therefore, new ways to balance the load demand is by integrating RES into the system. Hybrid system enables the incorporation of renewable energy sources and transferals the dependency on fossil fuels, while sustaining the balance between supply and demand. The significant characteristic of hybrid power system includes, system reliability, operational efficiency [1]. The hybrid power system enables to overcome the limitations in wind and photovoltaic resources since their performance characteristics depends upon the unfavorable changes in environmental conditions. It is probable to endorse that hybrid stand-alone electricity generation systems are usually more reliable and less costly than systems that depend on a single source of energy [2]. On other hand one environmental condition can make one type of RES more profitable than other. For example, Photovoltaic (PV) system is ideal for locations having more solar illumination levels and Wind power system is ideal for locations having better wind flow conditions [3]. For RES especially the variable speed wind energy conversion systems, Permanent Magnet Synchronous generator (PMSG) is gaining popularity. PMSG have a lossfree rotor, and the power losses are confined to the stator winding and stator core. A multi-pole PMSG connected to power converter can be used as direct driven PMSG in locations with low wind speed there by eliminating the gearbox which adds weight, losses, cost and maintenance [4]. A gearless construction of wind conversion system represents an efficient and reliable wind power conversion system. In a PV system, a solar cell alone can produce power of 1 to 2 watt [5]. The solar cell is modeled by two diode model [6]. The solar cells are connected in series and parallel to form a PV panel or module. The PV modules are connected in series and parallel to form a PV array in order to generate appropriate amount of power. Thus a PV system consisting of PV array, Maximum Power Point Tracking (MPPT) boost converters, and Wind power system

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

consisting of wind turbine, PMSG, rectifier and MPPT boost converter is integrated into Solar Wind hybrid power system (SWHPS). The efficiency and reliability of the SWHPS mainly depends upon the control strategy of the MPPT boost converter. The solar and wind power generation cannot operate at Maximum power point (MPP) without proper control logic in the MPPT boost converter. If the MPP is not tracked by the controller the power losses will occur in the system and in spite of wind and solar power availability, the output voltage of the hybrid system will not boost up to the required value [7]. The output voltage of the PV and Wind power generation are quite low as compared with the desired operating level. So, this output voltage is brought to desired operating value of 220V using Boost converter with MPPT controller at each source. The control logic of the MPPT controlled boost converter for the Wind power generation and PV based generation are selected on the basis of ease of implementation and robustness of the Hill Climb Search (HCS) and Perturb & Observe (P&O) algorithm respectively.

SOLAR PHOTOVOLTAICS

The conversion of solar radiation occurs by the photovoltaic effect which was first observed by Becquerel. It is quite generally defined as the emergence of an electric voltage between two electrodes attached to a solid or liquid system upon shining light onto this system. Energy conversion devices which are used to convert sunlight to electricity by the use of the photo- voltaic effect are called solar cells. Single converter cell is called a solar cell or more generally photovoltaic cell and combination of such cells designed to increase the electric power output is called a solar module or solar array and hence the name ‘Photovoltaic Arrays’. Solar cells can be arranged into large groupings called arrays. These arrays, composed of many thousands of individual cells, can function as central electric power stations, converting sunlight into electrical energy for distribution to industrial, commercial and residential users. Solar cells in much smaller configurations are commonly referred to as solar cell panels or simply panels. Practically, all photovoltaic devices incorporate a P-N junction in a semiconductor across which the photo voltage is developed. The solar panels consist mainly of semiconductor material, with Silicon being most commonly used.

According to the maximum power transfer theory, the power delivered to the load is maximum when the source internal impedance matches the load impedance. For the system to operate at or close to the MPP of the solar panel, the impedance seen from the input of the MPPT needs to match the internal impedance of the solar panel. Since the impedance seen by the MPPT is a function of voltage (V = I * R), the main function of the MPPT is to adjust the solar panel output voltage to a value at which the panel supplies the maximum energy to the load. However, maintaining the operating point at the maximum power point can be quite challenging as constantly changing ambient conditions such as irradiance and temperature will vary the maximum power operating point. Hence, there is a need to constantly track the power curve and keep the solar panel operating voltage at the point where the most power can be extracted.

Irradiance is a characteristic related to the amount of Sun energy reaching the ground, and under ideal conditions it is measured as 1000 W/m2 at the equator. The sun energy on the earth is highest around the equator when the sun is directly overhead. Some important magnitudes related to irradiance include the spectral irradiance, irradiance and radiation. Spectral irradiance is the power received by a unit surface area at a particular wavelength, while irradiance is the integral of the spectral irradiance extended to all wavelengths of interest. Radiation is the time integral of the irradiance extended over a given period of time.

SYSTEM CONFIGURATION

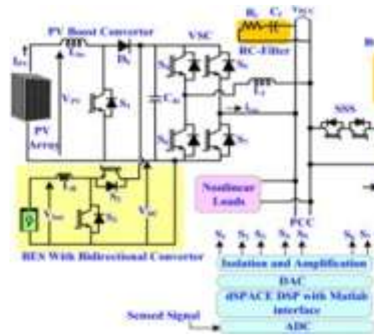
The configuration of a grid interfaced PV-BES system is illustrated in Fig. 1, which comprises of a utility grid, a solar PV array and the BES unit. A boost converter is used to achieve the maximum power extraction (MPE) and a DC-DC bidirectional converter (DBC) is used to couple the BES unit to the DC link. The real power transfer among the PV array, the battery and the grid, is achieved by the VSC. The ripple filter (R-C) is connected across the point of common coupling (PCC) of the system. This R-C filter is used to remove the high switching ripples generated by switching of VSC. This system is connected to the main grid via a controllable solid- state switch (SSS) for grid-on and grid-off controls. The SSS is closed during GCM. Conversely at off-grid condition, the grid is disconnected from PCC by opening SSS. The nonlinear loads are connected at PCC of the system.

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

DPM: During time interval t=0.15s to t=0.3s, this system operates in DPM. The load demand of the system is PL>PL_peak and extracted PPV is less than load demand. This deficient power is provided by the grid to feed the load. During this mode of operation, PPV is fed to the local loads via a VSC. The BES discharges to meet power losses of the system and to maintain power balance in the system. The deficient power for the load is drawn from grid assuming as positive value of the grid power from t=0.15 s to t=0.3 s.

SVPM: From t= 0.3s to 0.5s, the load demand of the system is PL>PL_peak and SOC of BES is SOC>SOCmin. Here, the load power is less than the generated PPV, thus the surplus power (PPV-PL) is delivered to the grid as Pg (assumed as negative value). At t=0.5s. the solar PV array irradiation is increased from 700W/m2 to 1000 W/m2 , which is also reflected in PPV. However, at the load remains same (t =0.3s to 0.5s), thus this excess PV array power is delivered to the grid after meeting the load demand.

CGPM- The load is decreased (PLSOCmax. In this mode, PPV is higher than PL available on the system. Thus, PPV and Pbat are used to supply constant power to the grid through VSC. Here, the PV array feeds a constant power (Pcgr) to the grid. At 0.7 s, the load is increased so that BES is discharging to maintain constant grid power mode. As result at 0.7 s, the BES charging current starts decreasing.



CONTROL STRATEGY

The functions of controller utilized in the system, include MPE from the solar panel, the power control for a different mode of operation in GCM, the voltage control for IAM of operation at the grid outage condition. The additional functionalities provided by VSC are harmonics mitigation, load compensation and power factor correction at the grid. The DBC adds a feature of charging and discharging of BES in the system. Details of utilized controls are provided in this section. A. MPE Control for PV Panel The PV array is interfaced to DC link of VSC with VDC through a boost converter. For MPE, a P&O-MPPT technique is used in the PV array. This technique generates the reference voltage (Vmpp) for generating the switching pulses of the boost converter. For this, a proportional integrator (PI) controller (with proportional gain KPB and integral gain KIB) is utilized toreduce the error between the PV array voltage, VPV and Vmpp for generating of gate pulse for the boost converter.

SIMULATION RESULTS

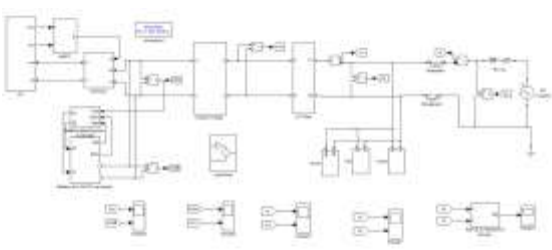


Fig 1. Simulation circuit

Fig2. Pv voltage current and power , inverter voltage, grid voltage, grid current, load voltage, load current, dc link voltage and current

CONCLUSION

The main contributions of this work are on the robustness of the system operating in different operating modes. The performance of a grid interfaced PV-BES system is validated through experimental results where the worst case of PV array insolation, load variation and grid unavailability are used for transition between modes. In addition, the system is operating in constant and variable power modes to provide power smoothening and a decrease the burden on the distribution grid during peak demand. This system is also found capable to work in an islanding mode to deliver the uninterruptable power to the load. The CDSC-PLL provides synchronization to the grid and MNSOGI-QSG-DQ control uses for current harmonics elimination and power quality improvement. The THD of ig and vL are achieved within limits of an IEEE-519-2014 standard

FUTURE SCOPE

Solar will have become the most important source of energy for electricity production in a large part of the world. This will also have a positive impact on the environment and climate change. technology improvements will ensure that solar becomes even cheaper. Pv array for generating their own electricity needs. Therefore, the focus is on the installations of renewable energy systems to the local electricity network. The key benefits based on this system are the offset portions of the premise daytime electricity use and the ability to add value by feeding excess power to the grid.

REFERENCES

1. J. T. Bialasiewicz, "Renewable Energy Systems with Photovoltaic Power Generators: Operation and Modeling," IEEE Trans. Industrial Electronics, vol. 55, no. 7, pp. 2752-2758, July 2008.
2. R. Panigrahi, S. Mishra, S. C. Srivastava, A. K. Srivastava and N. Schulz, "Grid Integration of Small-Scale Photovoltaic Systems in Secondary Distribution Network- A Review," IEEE Trans. Industry Applications, Early Access, 2020.
3. J. Krata and T. K. Saha, "Real-Time Coordinated Voltage Support with Battery Energy Storage in a Distribution Grid Equipped with MediumScale PV Generation," IEEE Trans. Smart Grid, vol. 10, no. 3, pp. 3486- 3497, May 2019.
4. N. Liu, Q. Chen, X. Lu, J. Liu and J. Zhang, "A Charging Strategy for PV-Based Battery Switch Stations Considering Service Availability and Self-Consumption of PV Energy," IEEE Trans. Ind. Elect., vol. 62, no. 8, pp. 4878-4889, Aug. 2015.
5. Y. Shan, J. Hu, K. W. Chan, Q. Fu and J. M. Guerrero, "Model Predictive Control of Bidirectional DC-DC Converters and AC/DC Interlinking Converters - A New Control Method for PV-Wind-Battery Microgrids," IEEE Trans. Sust. Energy, Early Excess 2018.
6. V. Rallabandi, O. M. Akeyo, N. Jewell and D. M. Ionel, "Incorporating Battery Energy Storage Systems into Multi-MW Grid Connected PV Systems," IEEE Trans. Ind. Appl., vol. 55, no. 1, pp. 638-647, Jan.-Feb. 2019.
7. Q. Zhou, M. Shahidehpour, et al, " Distributed Control and Communication Strategies in Networked Microgrids," IEEE Communications Surveys & Tutorials, vol. 22, no. 4, pp. 2586-2633, Fourth quarter 2020.
8. X. Zhao, J. M. Guerrero, et al, "Low-Voltage Ride-Through Operation of Power Converters in Grid-Interactive Microgrids by Using Negative-Sequence Droop Control," IEEE

Trans. Power Electron., vol. 32, no. 4, pp. 3128–3142, April 2017.

9. I. Sadeghkhani, M. E. H. Golshan, A. Mehrizi-Sani, J. M. Guerrero, "Low-voltage ride-through of a droop-based three-phase four-wire grid-connected microgrid," IET Gener. Transm. Distrib., vol. 12, no. 8, pp. 1906–1914, 2018.
10. Y. He, M. Wang and Z. Xu, "Coordinative Low- Voltage-Ride-Through Control for the Wind-Photovoltaic Hybrid Generation System," IEEE Journal of Emerging & Selected Topics in Power Electronics, vol. 8, no. 2, pp. 1503–1514, Jun. 2020.
11. Y. Yang, F. Blaabjerg, and Z. Zou, "Benchmarking of grid fault modes in single-phase grid-connected photovoltaic systems," IEEE Trans. Ind. Appl., vol. 49, no. 5, pp. 2167–2176, Sep./Oct. 2013.
12. N. Jelani and M. Molinas, "Asymmetrical fault ride through as ancillary service by constant power loads in grid-connected wind farm," IEEE Trans. Power Electron., vol. 30, no. 3, pp. 1704–1713, Mar. 2015.
13. P. P. Vergara, J. M. Rey, H. R. Shaker, J. M. Guerrero, et al, "Distributed Strategy for Optimal Dispatch of Unbalanced Three-Phase Islanded Microgrids," IEEE Trans. Smart Grid, vol. PP, no. 99, pp. 1-15, 2018.
14. A. Micallef, M. Apap, and J. M. Guerrero, "Singlephase microgrid with seamless transition capabilities between modesof operation," IEEE Trans. Smart Grid, vol. 6, no. 6, pp. 2736–2745, Nov. 2015.
15. J. Chan, J. Milanovic, and A. Delahunty, "Generic failure-risk assessment of industrial processes due to voltage sags," IEEE Trans. Power Del., vol. 24, no. 4, pp. 2405–2414, Oct. 2009.
16. P. Prasanna, E. Mohammad, K. G. Masoud, A. K. Sayed, "Fault Ride-Through Capability of Voltage-Controlled Inverters," IEEE Transactions on Ind. Electron., vol. 65, no. 10, pp. 7933- 7943, Oct. 2018.
17. J. A. Laghari, H. Mokhlis, M. Karimi, A. H. A. Bakar, and H. Mohamad, "Computational intelligence based techniques for

islanding detection of distributed generation in distribution network: A review," Energy Convers. Manag., vol. 88, pp. 139–152, Dec. 2014.