International Journal of Engineering and Techniques - Volume 10 Issue 4, August 2024

Simulation Analysis and Power Quality Enhancement in Grid- Connected Solar PV-Wind Hybrid System

Hariom Narware[1], Dr. E Vijay Kumar [2]

Department of Electrical Engineering,

RKDF IST, SRK University,Bhopal. M.P, India

---***---

Abstract- The current paper presents the various concerns regarding grid-connected solar PV-wind hybrid systems and improvements on those issues. For decades, the expansion of RERs (Renewable Energy Resources) has increased. As an adequate alternative to current energy sources, the RERs are very effective. The RERs include solar PV and wind as a global source of energy sources and their hybrid operation provides a continuous power generation source. The grid integration of these energy sources requires various control topologies based on power electronics control. The use of power electronics devices for controlling grid operation with multiple RERs creates power quality issues. The voltage regulation and voltage stability of the entire grid system require these power quality issues to be mitigated and enhanced the Power Quality (PQ) of the grid network. In this paper we represent the MATLAB simulation of the SPVWH (Solar PV-Wind Hybrid) system. The MATLAB simulation includes grid integration with PI-PWM control for grid parameter regulations. The simulation results confirm that the grid voltage and grid current THD level are below 5% This simulation also applies BESS (Battery Energy Storage System) as a power backup on power fluctuations due to uncertain wind and solar generation in the grid.

Keyword: Battery Energy Storage System, Power Quality, Renewable Energy Resources, Solar-Photo Voltaic Wind Hybrid System.

1. Introduction

In order to avoid a supply shortage, an international push to find alternative energy sources that can fulfil current demand is needed in light of the rapid depletion of global fossil fuel resources. Finding alternatives to satisfy the rising demand for energy, while reducing harm to the environment, is imperative. Recent research and development has centred on alternative energy sources. According to a 2002 calculation, one hour's worth of sunlight has more energy than what the world uses in a year. The examination of this source has taken years and is currently regarded as a prominent and significant issue in the modern era. A temperature of 25 degrees and a radiation of 1000 W/m2 are necessary to generate solar power. While at other hand wind power plant requires 12 m/s wind speed. These physical parameters must require for constant power generation in the system. When integrating these two sources in a hybrid operation the power fluctuates due to variable environmental conditions. Therefore MPPT (Maximum Power Point Tracking) and PWM based converters are used for grid integration of RERs and BESS is used as a power backup source.

2. Solar PV Array

For a long time, PV systems have been designed to extract as much power as attainable from their PV arrays and transfer that power to the AC grid. Therefore, concentrate on the maximization of conversion efficiency and maximum power point tracking (MPPT) of an evenly irradiated PV array.

It is explored for a Photovoltaic active power filter linked at PCC to the AC grid and a nonlinear load using the Fuzzy Hysteresis Band Current Control (Fuzzy-HBCC) technique. PV electricity production and power quality will both benefit from the link. [7]. There are specific considerations to make the PV plant is connected to the grid, and it is crucial to pay attention to the system's reliability, the implementation of protective measures, and synchronization functions, as well as power quality. To increase the amount of electricity they produce, modern power plants need to use the proper control strategies, such as proper shading controls and module tracking to take into account various module orientations. In addition, new policies on grid reactive power injection need the development of topologies and control algorithms. This system provides voltage support and harmonic distortion compensation for the common connection point of a single-phase PV system. A Capacity The incremental conductance method is commonly used in PowerPoint Tracking to change the phase of the PV inverter voltage, which regulates the power generated by the PV panels. [12].

Solar PV systems that are connected to the grid (known as grid-connected solar PV systems) can provide a constant stream of energy, even when the solar PV system is not able to supply all of the required energy. During times when consumer demand is low, the excess power generated by the solar power plant is fed into the grid. The energy generated close to the load has a higher value than grid power, which is transmitted from a longer distance. Also, the power generated during peak hours by the solar plant reduces the need for a grid during insulation hours that is when demand is higher.

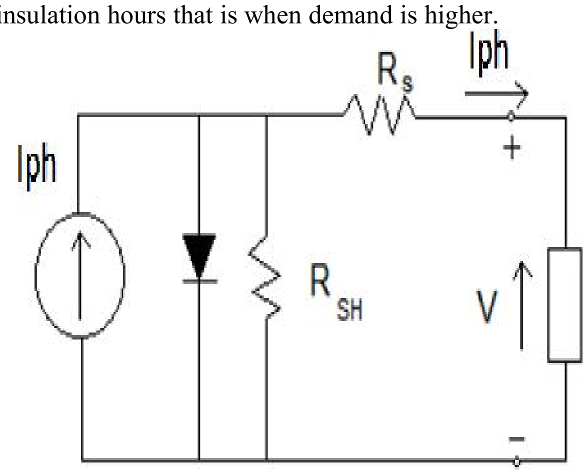


Fig. 2 Mathematical Modeling of PV Cell

The PV array is a build-up of the solar cell, which is a p-n semiconductor junction, shown in Fig.2. The characteristic of a solar array is given by the following equation. The main equation of the output module.

3. Wind Power Plant

Wind turbines are one way to generate clean, renewable energy. Wind power is the name given to the process by which wind energy is converted into electricity by wind turbines. In recent years, India's wind power producing capacity has grown significantly. By the end of the year, nearly 100 countries had commercial activity in them. It's at least a 24-country race, and half of the countries meet their electricity demand or better. A wind turbine turns the wind energy into mechanical energy, and then it generates electricity. The power needed by the loads is received from the distribution system at night and non-sunshine hours. In contrast, the inverter system solely provides reactive power adjustment and filters harmonic currents [9].

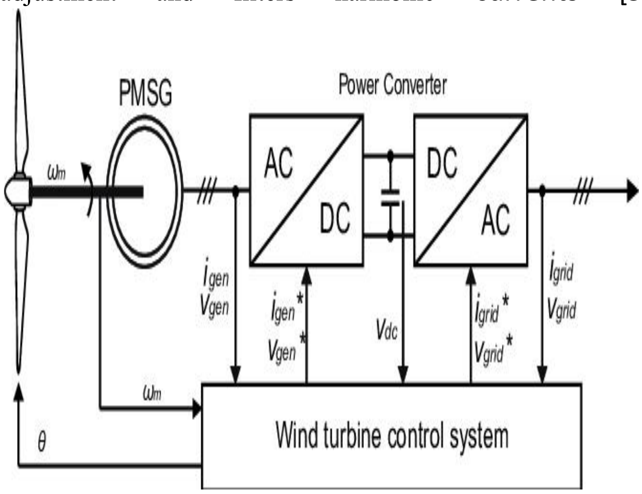


Fig.3 Grid-Connected PMSG based Wind Power Plant

4. Integration of PV-Wind in Hybrid system

Grid-connected hybrid wind/photovoltaic system is shown in this study. A hybrid system that is both off-grid and connected to the grid outperforms a single energy source. Power quality issues are also addressed in this paper, which could improve the economic attractiveness of SPVHW grid integration systems and user acceptance of these systems. VAR (voltage, current, frequency, and power quality) problems are the most common causes of equipment failures and malfunctions. Modern electronic devices consume electricity and power in different ways than older models. Problems with power quality can be traced back to an increase in nonlinear loads, sensitive loads, and switching devices. The combination of wind and solar energy creates issues such as voltage management, flicker, harmonic distortion, and stabilisation. Adherence to IEEE and IEC standards is required to tackle this issue of power quality. According to a recent study of papers from the last few years, studies done over multiple stages say power quality problems will show up in each of those stages. The hybrid system's use of several FACTS devices assists in the power quality improvement that comes with a grid connection. Many devices used for PQ enhancement in hybrid systems include things like STATCOM, UPQC, UPFC, DVR, D-STATCOM, and others

5. Inverter Controlling for SPVWH system

There are various kinds of controllers used in industry, though proportional-integral controller and hysteresis controller are the two types most often found. The PI controller is employed in this modeling. The figure illustrates how the control loop feedback works in the PI linear controller. When the output is regulated, the amount of error is controlled until it equals the reference value. Direct current control (DCC) governs the SAPF, which is a bridge inverter in its entirety. Controllers for both the external voltage and the internal current are integrated using a fractional order integral plus proportional controller (FO-IP). A boost converter, a P&O algorithm, and an emulator make up the PV generator. [10].

6. Simulation results & Discussion

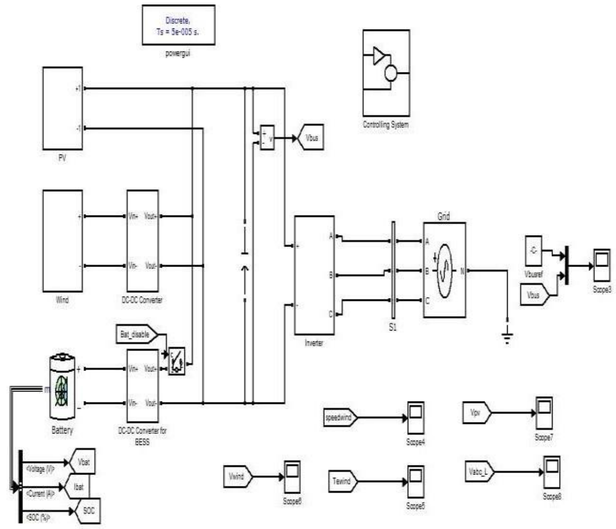


Fig 4- MATLAB Model of SPVWH system

Figure 4 depicts the MATLAB simulation of the SPVWH system, in which the wind power plant and BESS are the backup source for the Solar PV model. There are mathematical models for solar PV systems in section 2. All of the solar panels are connected to a boost converter and a maximum power point tracker (MPPT). The boost converter's duty cycle is programmed using the MPPT algorithm. Figure 5 shows a MATLAB model of a solar PV system incorporating MPPT.

Fig 5- MATLAB simulation of Solar PV with MPPT and Boost Converter

7. Simulation Results

The results obtained from the simulation results of the system are presented in the present section. The simulation results show the Solar PV output D.C. voltage and wind converter output D.C. voltage set up at 120 V D.C. for D.C. bus. The constant regulating D.C. output voltage for the D.C. bus of 120 V is shown in the simulation result. The grid side regulating A.C output voltage is also shown in this section.

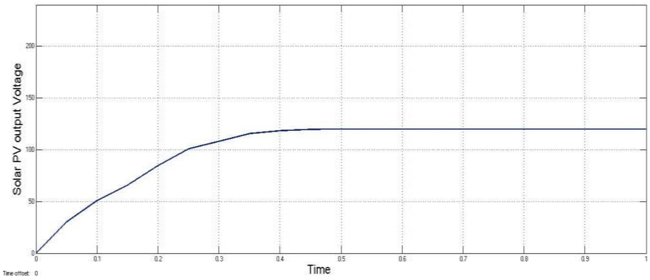


Fig.6 – Solar PV system controlled output D.C. voltage

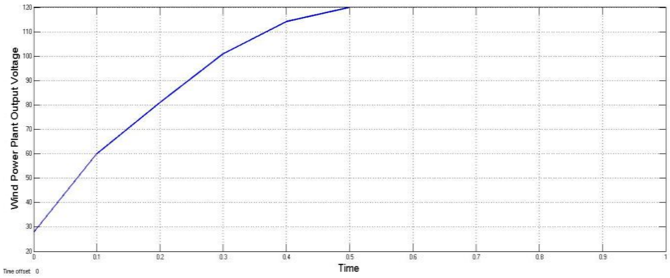
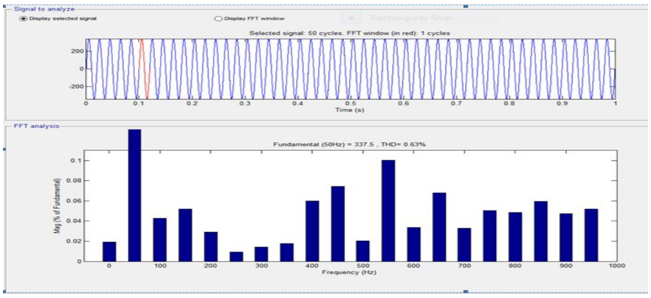


Fig.7-WindDC to DC Converter controlled output Voltage



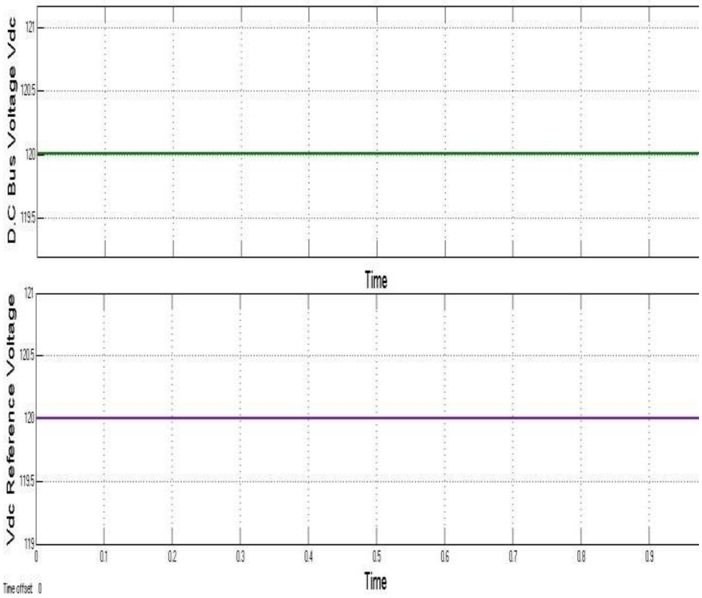


Fig.8 -D.C.Bus regulated output Voltage and reference Voltage comparison

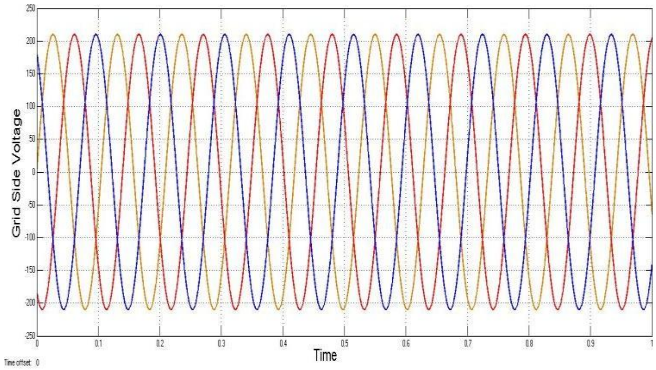


Fig.9-GridSide regulating the A.C output voltage

9. THD Analysis

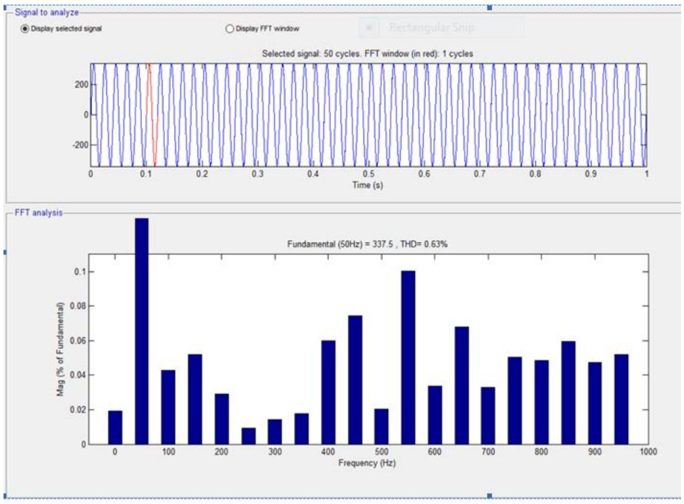


Fig 10- Grid Current THD Level

8. Conclusions

The aim of this document is to investigate the creation of hybrid solar-wind systems and the necessity of renewable energy sources. The system is described, with a focus on the way the system is controlled and the different parts of the system. This paper details the many problems arising from poor grid quality that have a bad effect on the Grid-connected hybrid system. Mathematical calculations were completed to perform modelling for both Solar PV and Wind systems. Also covered are the control system topologies used in inverters. To explore the design of the proposed hybrid system with Grid integration, the MATLAB-Simulink simulation is run on MATLAB. The results of the simulation show that the grid voltage and grid current THD level are 0.08 % and 2.90% respectively which is within limit of international standards. We can tell just how well the hybrid system is working by looking at the grid side regulating parameters. In the new system, this research can proceed with the use of FACTS devices for combating various types of power quality issues. References

10. References

1. Akshay S. Shirbhate, and Prof. Suhas D. Jawale, "Power Quality Improvement in PV grid Connected system by using Active Filter", 978-1-4673-9925-8/16/©2016 IEEE.

2. Yashi Singh, Ikhlaq Hussain, and Bhim Singh, Sukumar Mishra, "Power Quality Improvement in Single Phase Grid Tied Solar PV-APF Based System using Improved LTI-EPLL Based Control Algorithm" 2017 7th International Conference on Power Systems (ICPS) College of Engineering Pune, India. Dec 21-23, 2017, 978-1-5386-1789-2/17/©2017 IEEE.

3. Sachin Devassy, and Bhim Singh, "Implementation of Solar Photovoltaic System with Universal Active Filtering Capability" IEEE Transactions on Industry Applications, 0093-9994 (c) 2018 IEEE.

4. Satyavarta Kumar Prince, Kaibalya Prasad Panda, Moushumi Patowary, and Gayadhar Panda, "FPA tuned Extended Kalman Filter for Power Quality Enhancement in PV integrated Shunt Active Power Filter", 2019 International Conference on Computing, Power and Communication Technologies (GUCON) Galgotias University, Greater Noida, UP, India. Sep 27-28, 2019, 978-93-5351-098-5/19/2019 Galgotias University.

5. Nagaraj C, K Manjunatha Sharma, "Improvement of Harmonic Current Compensation for Grid Integrated PV and Wind Hybrid Renewable Energy System" 978-1-5090-0128-6/16/$31.00 ©2016 IEEE.

6. M T L Gayatri, Alivelu M Parimi, "Power Quality Improvement of PV-WECS Microgrid Using Active Power Filter in Real time", 978-1-5386-2910-9/18/2018 IEEE.

7. Asmae Azzam-Jai and Mohammed Ouassaid, "Power Quality Improvement of a Photovoltaic Active Power Filter using A Fuzzy Hysteresis Band Current Controller", 978-1-7281-5152-6/19/ ©2019 IEEE.

8. Krishna kumar S, Ranga J, Ch.S.K.B.Pradeep Kumar and Jayalakshmi S, "PV based Shunt Active Power Filter for harmonics mitigation using Decoupled DSRF theory", 2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS 2019), 978-1-5386-9533-3/19/©2019 IEEE.

9. Rachid Belaidi, Mohamed Fathi, Mohamed Mghezzi Larafi, Gunia Mohand Kaci, Rachid Belaidi, A. Haddouche, "Power Quality Improvement Based on Shunt Active Power Filter Connected to a Photovoltaic Array", 978-1-4673-7894-9/15/ ©2015 IEEE.

10. Hamza Afghoul, Fateh Krim, Antar Beddar, Badreddine Babes, "Real time Implementation of Robust Controller for PV Emulator Supplied Shunt Active Power Filter", 978-1-7281-1182-7/18/ ©2018 IEEE.