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Design & Simulation of PV-Wind Energy Based Hybrid Power System with Sepic Converter

Gangadara B N, Dr. S. Vasudevamurthy

Abstract: ***In this paper, the proposed Microgrid consists two Distributed generations namely Wind power and Photovoltaic energy. Here these DG's are connected in the form of a small power system network and interlinked with the main grid. Whenever two or more DG's are interconnected in the power system network the power quality problems are increased and voltage profiles are reduced. The stability of the system is affected due to the above mentioned phenomenon. The voltage can be controlled using sepic converter and it is subjected to P&O based mppt for extraction of maximum power. The proposed system is simulated in MATLAB/ Simulink software.***

Keywords: PMSG, MPPT, PV system, 3-phase inverter

1. Introduction

Continuous and accelerating energy demand across the globe has stimulated opportunity for renewable energy sources (RES) in energy market. In near future, RES will dominate the market due to lack of any other sustainable alternative. Among the available RES, fuel cell footprints are gaining prominence and growing at rapid pace. Higher efficiency, low emissions, less noise and high modularity are some of lucrative attributes of fuel cell. Based on the concept and components, FC is segmented into Solid Oxide Fuel Cells (SOFC), Molten Carbonate Fuel Cells and Proton Exchange Membrane. SOFC is a viable technology alternative for power production in the range of few kW to hundreds of kW due to availability of wide range of hydrocarbon based fuels, higher operating temperature and higher power conversion efficiency. In a grid connected fuel cell (GCFC) system, the integration of FC stacks to the grid has to meet performance parameters related to power quality, reliability and safety aspects. These functional requirements related to integration and control requires power conditioning unit (PCU) to maintain defined performance parameters. Different topologies for the PCU are given. DC-DC boost converter and current controlled VSC are used as PCU in this paper and control of VSC is based on PBCT. Different types of control methods have been discussed in the literature viz. p-q theory, Fryzes theory, synchronous d-q reference frame theory (SRFT) etc. These methods require several transformations for conversion from to αβ to dq frame of reference and back. Adaptive control algorithm has been also applied for power quality improvement. PBCT has been applied for DSTATCOM, and gives satisfactory response when used for active filtering and load compensation. A definite advantage of this algorithm is that it does not need PLL for grid synchronization, less computational complexity is required and gives better performance under variety of load conditions. Grid integration has necessary requirement of a filter at the output for effective interface. The design of filter plays an important role and is a critical issue in grid connected topology for stability of the system and to reduce the ripples. L, LC, LCL filter may be used as filter configurations. The LC filter configuration involves computation of only two parameters making it less complex but has inferior filtering effect. Improper output in this configuration is due to uncertainty of network impedance and also becomes very costly for higher and medium power network. Ripple attenuation at high frequencies can be effectively attained using LCL filter which also has advantage of better decoupling between the filter and the grid impedance. Presence of filter capacitor reduces current ripple across grid side inductor. Further, Due to sudden change of load, a disturbance in DC link voltage results, which needs to be damped rapidly to ensure reliable and steady operation. Hence, it is necessary to incorporate a DC link voltage controller which can maintain constant voltage level under major disturbances such as a sudden change in load. Which is subject of concern in various researches such as adaptive neuro fuzzy controller, adaptive PI controller etc. In this paper, hybrid energy sources are combined to create a micro grid system. A three leg VSC is used to connect the WECS and PV system with the grid. Sepic converter is used as dc-dc converter which process the combined input of wind and solar energy and provides to the inverter. P&O based mppt algorithm is used for extracting the maximum power from the hybrid sources and provides to the load.

2. System Description

This hybrid system having three distributed generation units and those are Wind power and Photovoltaic energy. Wind and PV are the major energy sources and these two DG's are connected with small power system network and interlinked with main grid. Here P-V cells supplier 20 KW load and wind generator supplies 20 KW load.

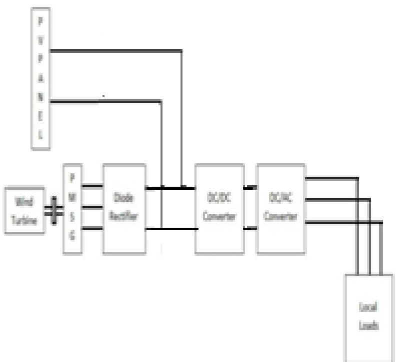

Figure 1: Proposed system Block diagram

In wind energy conversion system, PMSG is used as generator. as the generator power rating is medium. In this, all the DG units are coupled and form a DC bus. A Sepic converter provides the dc/dc operation for the DG units.

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Then a three phase inverter is used to convert the DC quantities to three phase AC quantities which is provided to loads. As there is no storage devices, when the power generation exceeds or insufficient to satisfy the loads, power quality issues such as voltage sag and harmonics arises. To rectify these issues, a P&O based mppt algorithm is used in the system to extract the maximum power from the hybrid energy sources.

A. Photovoltaic Energy Conversion System (PVECS):

In this, the proposed system consists of the PV array which generates DC power directly proportional to the solar radiation. The power generated by the PV array is provided below:

$$P_{PV} = W_{PV} f_{PV}\left[\frac{G_T}{G_{STC}}\right]\left[1 - \alpha_p (T_c - T_{C,STC})\right]$$

where W_{PV} is the rated power of the PV array (kW), α_p and f_{PV} are coefficients of temperature and PV derating factor in percentage, G_T is the actual irradiation (kW/m2), G_{STC} is the standard irradiation (1 kW/m2 at 25), Tc is the actual temperature of PV panel and $T_{C,\ STC}$ is the standard temperature of the PV panel.

B. Wind Energy Conversion System (WECS):

In this, the proposed system consists of the WECS as one of the renewable sources in which the wind turbine translates the kinetic energy from the wind to AC or DC power. The mechanical power generated by an ideal turbine is provided below:

$$P_m = \frac{1}{2} C_p \rho A v^3$$

where ρ represents the thickness of air, Cp denotes coefficient of power, A represents wind turbine coverage area, and v denotes wind speed (m/s).

3. SEPIC Converter

The circuit for the sepic converter is given in Fig.2 as follows:

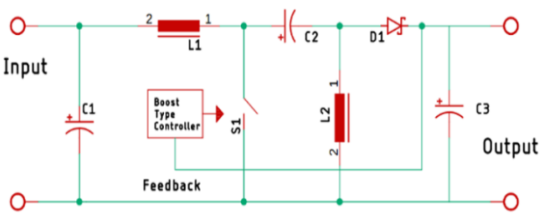

Figure 2: Sepic Converter Circuit

SEPIC converter is a buck-boost topology**,** unlike the classic buck-boost that is an inverting topology. A SEPIC converter is characterized by using two inductors, one is at the input and another one is connected to the ground and these two inductors are connected by a coupling capacitor, which effectively puts the L1 and L2 in parallel when a switching signal is applied. When the switch is ON, the inductors L1 and L2 get charged and the capacitor C2 gets discharged. When the Switch is OFF, the inductors starts discharging and the capacitor C2 gets charged.

The pulse width relation with the input and output voltage of sepic converter is given below as

$$D = \frac{V_{OUT} + V_D}{V_{IN} + V_{OUT} + V_D}$$

The calculation of inductance is performed by the following relation:

$$L1 = L2 = L = \frac{V_{IN\,(min)}}{\Delta I_L \times f_{sw}} \times D_{max}$$

The calculation of ripple current of boost inductance is performed by the following relation:

$$\Delta I_L = 0.2 * \frac{Vo}{V_{in}} * I_o$$

The coupling capacitance value of sepic converter is provided by the following relation:

$$\Delta V_{Cs} = \frac{I_{OUT} \times D_{max}}{Cs \times f_{sw}}$$

The capacitance value at the load side is provided by the following relation:

$$Cout \geq \frac{I_{OUT} \times D}{V_{ripple} \times 0.5 \times f_{sw}}$$

The ripple output voltage is calculated with the following equation:

$$\Delta Voc = 2\%\ of\ Vo$$

4. Control Strategy of Proposed System

MPPT Control

The Perturb and Observe algorithm based MPPT controller will provide the change in duty ratio (ΔD) which will be added with initial duty ratio and provided for pwm pulse generation unit. The pulse generated is given to the gate terminal of the boost converter switch. The P&O mppt operates under the following conditions:

1. If ΔP/ΔV > 0, ΔD is +ve,
2. If ΔP/ΔV < 0, ΔD is –ve.

The flowchart of the P&O algorithm basedmppt is provided below in Fig 3:

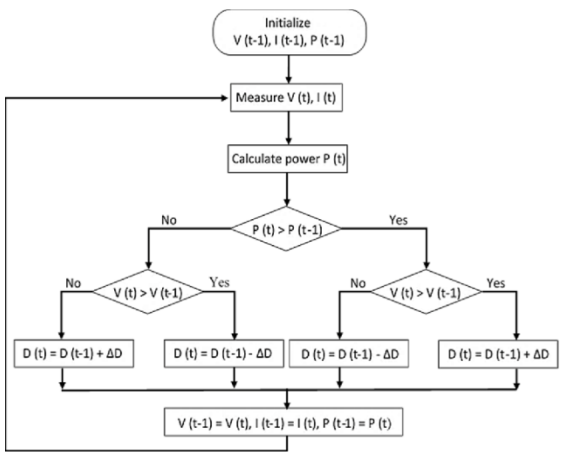

Figure 3: P&O Algorithm based MPPT control

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5. Simulation Results

The simulation circuit of the proposed system without filter is provided below in Fig 4:

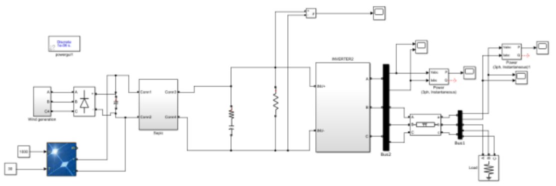

Figure 4: Proposed system without filter

In this, PV, wind energy and fuel cell are the three sources used for power generation. The PV voltage is 300V and power is 20KW and Wind energy conversion system voltage is around 400V and power is 20KW. Each source is connected with single sepic converter in order to get boosted dc voltage, so that it can be provided to for inverter. It is connected to inverter and then provided to load.

The dc voltage and current in the input side of sepic converter is provided in Fig 5.

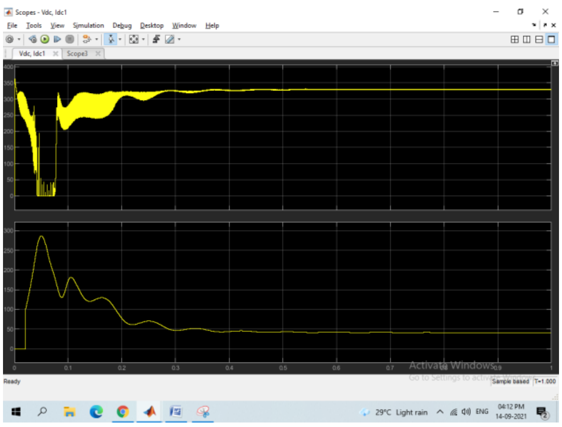

Figure 5: Input DC voltage and current of sepic converter

In this, the voltage is around 340V and current is around50A. It is provided to sepic converter which converts the dc voltage according to the pulses generated from mppt. The output voltage and current of sepic converter is provided below in Fig 6:

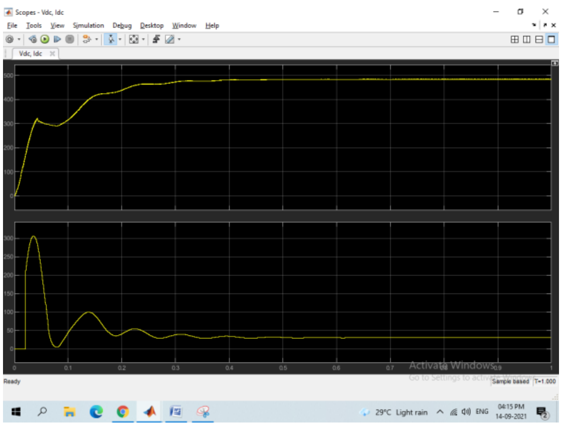

Figure 6: DC output Voltage and current of sepic converter

The dc voltage is around 480V and current is around 30A and it is provided to inverter. The inverter is connected to the R load and the load voltage and current waveforms as shown in Fig 7:

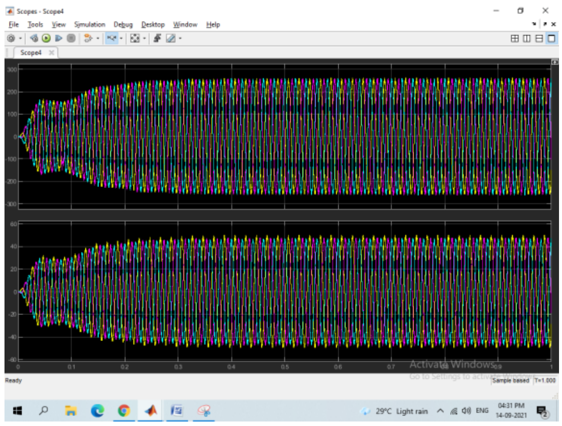

Figure 7: Load voltage and current with filter

Here, the load voltage is around 230V and the current is around 40A. A low pass filter is added to the inverter circuit and hence the ripples are reduced in the voltage and current waveforms. The load power is shown below in Fig 8:

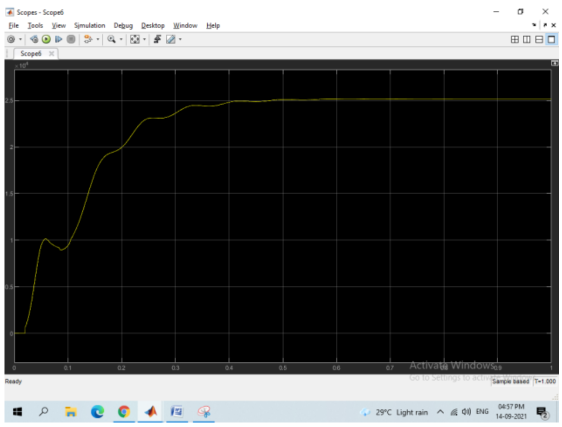

Figure 8: Load Power without filter

The %THD of the proposed system without filter is provided below in Fig 11:

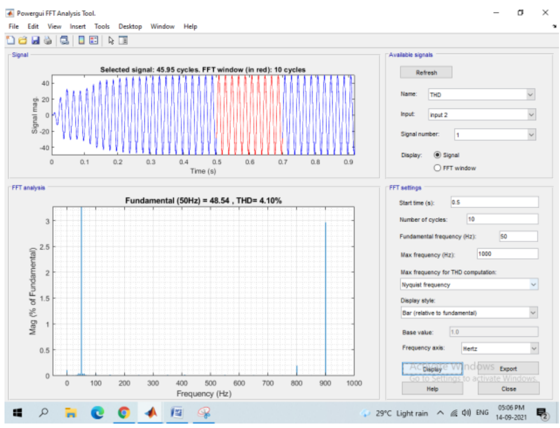

Figure 11: %THD of load current without filter

The %THD of load current with filter is around 4.1%.

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6. Conclusion

In this paper, hybrid energy sources are combined and a micro grid system is formed. A sepic converter is designed for dc voltage regulation and P&O algorithm based mppt is used to extract maximum power from the hybrid energy sources. A voltage source inverter is used for dc-three phase ac voltage conversion and provided to the load. The harmonic content of the load current is measured using the %THD measurement and provided.

References

[1] Y. Joka, H. Sasaki, "Protection coordination scheme for distribution networks with high penetration of photovoltaic generators, " in IET Generation, Transmission & Distribution vol.12, April 2018, pp.1802–1814.

[2] M. Uma Maheshwara Rao, K. Mercy Rosalina, "Modeling of a Microgrid Connected Hybrid System using Solar, Wind and Fuel cell", Jour of Adv Research in Dynamical & Control Systems, vol.10, July 2018, pp.1908-1915.

[3] K. Walled, A. Najy, " Optimal Protection Coordination for Microgrids with Grid-Connected and Islanded Capability", IEEE transactions onindustrial electronics, vol.60, 2013, pp.1968-1977.

[4] D Q Hung, N. Mithulanandham, "Multiple distributed generators placement in primary distribution networks for loss reduction", IEEE Trans. Ind. Electron, vol.60 no.4, April 2018, pp.1700-1708.

[5] P. S. Shete, N. S. Maurya, R. M. Moharil and A. A. Dutta, "Analysis of Micro-grid under Different Loading Conditions, " International Conf. on Industrial Instrumentation and Control, 2015, pp.1120-1124.

[6] Z. Kai-Hui and X. Ming-Chao, "Impacts of Microgrid on Protection of Distribution Networks and Protection Strategy of Microgrid," IEEE Conf. on Advanced Power Sys. Automation and Protection, Vol.1, 2011, pp.356-359.

[7] R. Enio, Ribeiro and Ivo Barbi, "Harmonic Voltage Reduction Using aSeries Active Filter Under Different Load Conditions", IEEE Transactions on Power Electronics, vol.21, no.5, September 2006, pp-1394-1402.

[8] Z. Kai-Hui and X. Ming-Chao, "Average Modeling and Hybrid Control of a Three-Phase Series Hybrid Power Filter, " IEEE International Symposium on Industrial Electronics, vol.2, July 2016, pp.919-924.

[9] M. Uma Maheshwara Rao, K. Mercy Rosalina, "Microgrid protection by using resistive type superconducting fault current limiter, "Modelling, Measurement, and Control A, Vol.91, no.2, June2018, pp.89-93.

[10] P. Salmerón, S. P. Litrán, "Improvement of the Electric Power Quality Using Series Active and Shunt Passive Filters", IEEE Transactions on Power Delivery, vol.25, no.2, April 2010, pp-1058-1067.

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