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Modeling and Analysis of Renewable Hybrid Energy Systems

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***Abstract*: In this paper, a novel DC-bus voltage control approach is proposed, which is able to demonstrate a very fast and reliable performance for a three-phase grid-connected VSI. The proposed control approach includes a new sensing technique for the dc-bus voltage that can effectively regulate the DC bus voltage, so harmonic distortion of the system will reduce and improves the bandwidth of the controller. This controller is design toward certain hybrid renewable energy applications, where a constant dc-bus voltage is required. This system minimizes the overall losses of the system and the simulation is carried out in MATLAB/SIMULINK to obtain the performance of the proposed scheme under supply-under hybrid renewable energy systems.**

***Keywords*: Hybrid system; hybrid inverter and controller; wind generator; power management; renewable energy.**

1. Introduction

Renewable energy sources are those energy sources which are abundantly available in nature. Various new control strategies are used for improving power quality and reliability obtained from renewable energy sources [1]. Power electronics technology works drastic role in small generation and for integrating non-conventional energy sources to grid. Recently solar, wind power generation has attracted special interest; the rapid growth of wind power worldwide has resulted in increasing media attention and public awareness of wind generation technology [2] the conventional energy sources are being depleted day by day and the cost of required fuel is increasing rapidly.

PV output is dc and then converted to ac by inverter. By approaching new strategy for multilevel inverter for reducing harmonic reduction [3]. Multilevel inverter is recently used for harmonic reduction. Demand of electricity is growing very rapidly for industrialization & urbanization of India. Renewable energy sources being available abundantly in nature can be considered as a better option over conventional energy sources [4]. Solar and wind energy are available in large amount and can be considered as reliable source of power generation. Hybrid solar and wind energy systems can be used for rural electrification and modernization of remote area. In this paper, a novel wind hybrid system based on PV is be designed which can supply electricity to a private house, farm house or a small company or an apartment house. The electrical power is provided based on the need at the site where used. The goal of this study is to introduce the local PV-wind hybrid system's [5] working principle system which is connected to the grid.

2. Literature survey

Wei Qiet al [6] focuses on the development of a supervisory model predictive control method for the optimal management and operation of hybrid standalone wind-solar energy generation systems. We design the supervisory control system via model predictive control which computes the power references for the wind and solar subsystems at each sampling time while minimizing a suitable cost function. The power references are sent to two local controllers which drive the two subsystems to the requested power references. We present several simulation case studies that demonstrate the applicability and effectiveness of the proposed supervisory predictive control architecture.

Sandeep Kumar and Vijay Kumar Garg [7] deals with the detailed of a hybrid model of a solar/wind in Simulink, which is using battery as its storage system. The simulation includes all realistic components of the system. This paper describes solar-wind hybrid system for supplying electricity to power grid. Work principle and specific working condition are presented in this paper.

Fernando Valenciaga and Paul F. Puleston [8] proposed a comprehensive supervisor control for a hybrid system that comprises wind and photovoltaic generation sub systems, a battery bank, and an AC load is developed in this paper. The objectives of the supervisor control are, primarily, to satisfy the load power demand and, second, to maintain the state of charge of the battery bank to prevent blackout and to extend the life of the batteries. For these purposes, the supervisor controller determines online the operation mode of both generation subsystems, switching from power regulation to maximum power conversion

Syed Zulqadar Hassan et al [9] Integration of different energy sources and power converters is required to meet the load demands adequately under various natural conditions. This research work focuses on the hybrid power system combining renewable energy sources, namely, a photovoltaic (PV) array and a solid oxide fuel cell (SOFC) and a hybrid energy storage system, i.e., a battery bank and hydrogen storage tanks in the proposed architecture. The complete layout is connected to the national grid via power electronics converters to enhance the continuity and reliability of power. In the proposed system, the

PV is taken as the primary energy source to satisfy the load demands.

MilanaTrifkovic et al [10] deals with system integration and a novel controller design in order to management the power of a stand-alone renewable energy (RE) hybrid system. The system consists of five main components: photovoltaic (PV) arrays, wind turbine, electrolyser, hydrogen storage tanks, and fuel cell. The model for each process component is developed and all the components of hybrid energy system are integrated in a MATLAB/Simulink environment.

Mr. Akshay Zade and Dr. Asha Gaikwad [11] mainly focused on power quality issue in distribution system. For improving the power quality of renewable energy generation the new approach of multilevel inverter is beneficial as total harmonics were reduced from system. Switches used in the proposed model are less hence switching losses are less. It is expected that total harmonic distortion in output voltage waveform of multilevel inverter will be reduced as the number of levels of output voltage waveforms will be increased. However, to carry out research work it is first necessary to analyze the smart grid system for various kinds of loads.

3. Proposed system

A novel DC-bus voltage control approach has been proposed in this paper, which is able to demonstrate a very fast and reliable performance for a three-phase grid-connected VSI. Block diagram of the proposed Renewable Hybrid energy system. A DC to DC converter is used to change the input resistance of the panel to match the load resistance (by varying the duty cycle). The converter such as Buck, Boost and Buck-Boost transferred energy between input and output using the inductor and analysis based on voltage balance across the inductor. Similarly, capacitive energy transfer and analysis is used by CUK converter based on current balance of the capacitor. The circuit in Fig. shown below is derived from DUALITY principle on the buck-boost converter.

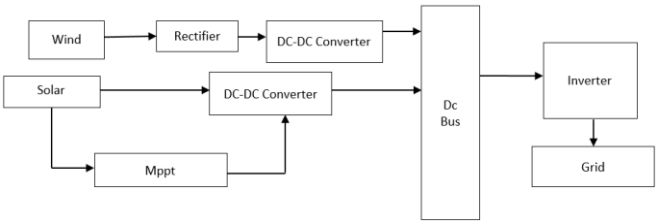

Fig 1. Block diagram of proposed renewable hybrid energy system

The hybrid solar wind energy system is modeled using MATLAB Simulink. The proposed block diagram of hybrid solar wind energy system is as shown in figure 1. The Wind energy is the renewable energy resources, which will provide the electrical energy with wind turbines coupled with generators. In this model the output of the wind is fed to the rectifier. Then the rectifier converts AC power to DC power. The DC power is fed to the DC-DC converters.

The solar energy radiated from the sun is directly fed to the DC-DC converters. Maximum power point tracking technique is used to improve the efficiency of the solar panel. P & O algorithm is used to track the maximum power and it is fed to the DC-DC converter. In this paper the analysis is done by using Boost converter and Cuk converter. The output of the DC-DC converter is fed to the common DC bus. The output is fed to the Inverter, which converts DC power to AC power. The AC power is then fed to the grid.

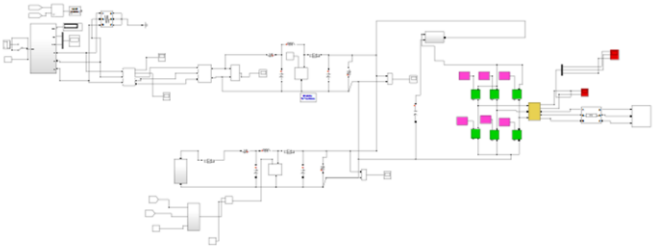

Fig. 2. Simulation circuit diagram with Boost Converter

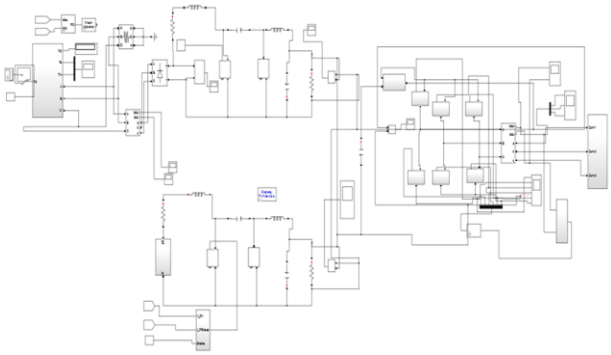

Fig. 3. Simulation circuit diagram with Cuk Converter

4. Result and discussion

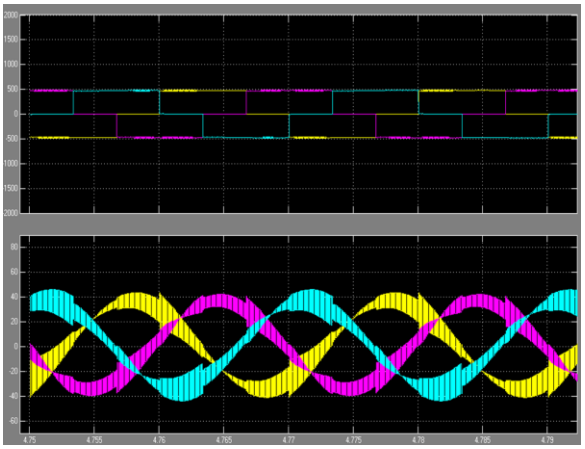

Fig. 4. Output voltage and current waveform using Boost converter

The proposed system model consisting of the previously described components was implemented using the MATLAB and Simulink software. Model testing was performed under

various conditions using historical wind data, irradiance, ambient temperature, as well as dynamic load demand data. The output of hybrid solar wind energy system using Boost Converter is as shown in figure.

The output of hybrid solar wind energy system using Cuk Converter is as shown in figure.

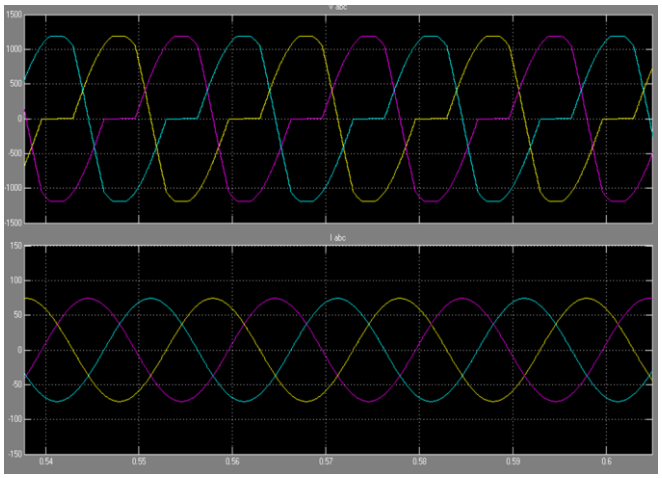

Fig. 5. Output voltage and current waveform using Cuk converter

5. Conclusion

A novel dc-bus voltage control approach has been proposed in this paper, which is able to demonstrate a very fast and reliable performance for a three-phase grid-connected VSI. The designed novel control approach contains a new sensing technique for the dc-bus voltage. This model can effectively regulate the DC bus voltage that reduces the harmonic distortion of the system and improves the bandwidth of the controller. This controller is well-suited toward certain hybrid renewable energy applications, where a constant DC-bus voltage is required. This system minimizes the overall losses of the system.

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