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Modelling and Analysis of Microgrid by using Renewable Energy Sources

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Abstract: This paper presents a control of a micro-grid at an isolated location fed from wind and solar based hybrid energy sources. The machine used for wind energy conversion is Doubly Fed Induction Generator (DFIG) and a battery bank is connected to a common DC bus of them. A solar Photovoltaic (PV) array is used to convert solar power, which is evacuated at the common DC bus of DFIG using a DC-DC boost converter in a cost-effective way. The voltage and frequency are controlled through an indirect vector control of the line side converter, which is incorporated with droop characteristics. It alters the frequency set point based on the energy level of the battery, which slows down over charging or discharging of the battery. The system is also able to work when wind power source is unavailable. Both wind and solar energy blocks, have Maximum Power Point Tracking (MPPT) in their control algorithm. The system is designed for complete automatic operation taking consideration of all the practical conditions. The system is also provided with a provision of external power support for the battery charging without any additional requirement. A simulation model of system is developed in Matlab environment and simulation results are presented for various conditions e.g. unviability of wind or solar energies, unbalanced and nonlinear loads, low state of charge of the battery. Finally, a prototype of the system is implemented using a 5-kW solar PV array simulator and a 3.7 kW wound rotor induction machine and experimental results are produced to reaffirm the theoretical model and design.

Keywords: Photovoltaic, Maximum Power Point Tracking (MPPT), MATLAB, Boost Converter.

I. INTRODUCTION

There are many remote locations in the world, which don't have access to electricity. There are also many places, which are connected to the grid, however, they don't receive electricity for up to 10-12 hours in the day and as a result of it, economic activities of inhabitants suffer. Many of such places are rich in Renewable Energy (RE) sources such as wind, solar and bio-mass. An autonomous generation system utilising locally available RE sources, can greatly reduce the dependency on the grid power, which is predominantly fossil power. Wind and solar energy sources, are more favorited than bio-mass based system as latter is susceptible to supply chain issue. However, wind and solar energies suffer from high level of power variability, low capacity utilization factor combined with unpredictable nature.

As a result of these factors, firm power cannot be guaranteed for autonomous system. While the Battery Energy Storage (BES) can be helpful of lowering power fluctuation and increasing predictability, utilisation factor can be increased by operating each energy source at optimum operating point. The optimum operating point also called as Maximum Power Point Tracking (MPPT), requires regulation of the operating point of wind energy generator and solar PV (Photovoltaic) array in term of speed and voltage to extract maximum electrical energy from input resource. The MPPT can be achieved by Power Electronics (PE) based frequency based on state of charge of the battery and slows down deep discharge and over-charge of the battery.

II. EXISTING SYSTEM

DFIG may operate variable speed operation with lower power rated converters. However, to work the system as a micro-grid, the generated voltage should be balanced and THD (Total Harmonics Distortion), must be within requirement of IEEE-519 standard at no-load, unbalanced load as well as nonlinear load. Moreover, both the wind and solar energies sources should operate at MPPT. All these are the issues. In the proposed system performance parameters e.g. power quality, system efficiency etc under the different operating conditions are not mentioned. Moreover, they also lack experimental verification

III. PROPOSED METHOD

This project presents a control of a micro-grid at an isolated location fed from wind and solar based hybrid energy sources. The machine used for wind energy conversion is Doubly Fed Induction Generator (DFIG) and a battery bank is connected to a common DC bus of them.

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The system is also able to work when wind power source is unavailable. Both wind and solar energy blocks, have Maximum Power Point Tracking (MPPT)in their control algorithm. The system is designed for complete automatic operation taking consideration of all the practical conditions.

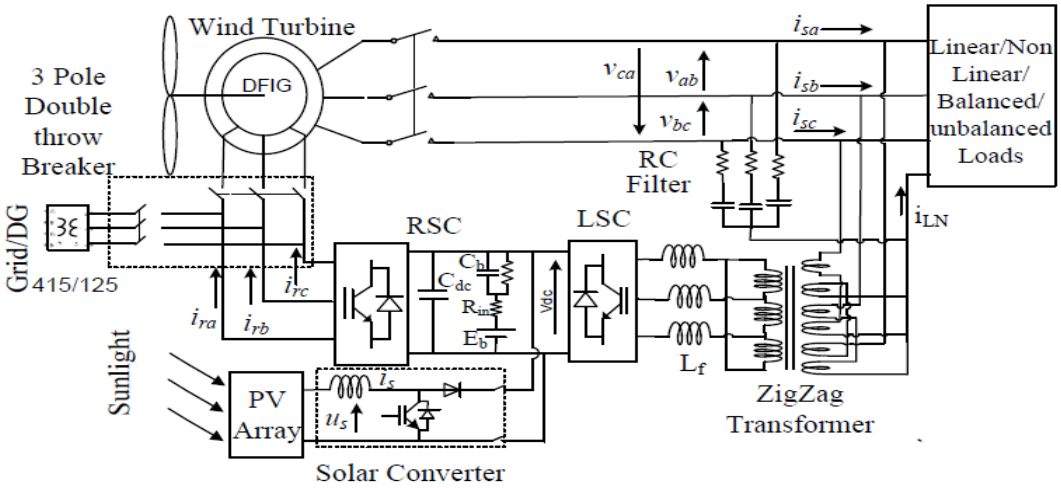

Fig: Schematic of isolated micro-grid network fed by renewable energy source using battery storage.

The system is also provided with a provision of external power support for the battery charging without any additional requirement. A simulation model of system is developed in Matlab environment and simulation results are presented for various conditions e.g. unreliability of wind or solar energies, unbalanced and nonlinear loads, low state of charge of the battery.

IV. RESULTS

The Simulink model of micro-grid fed by REGS is developed in Matlab. The solar panels and wind turbine are modelled using their functions. Fig. 1 shows the performance of the system when the wind generator is taken in an out of the system.

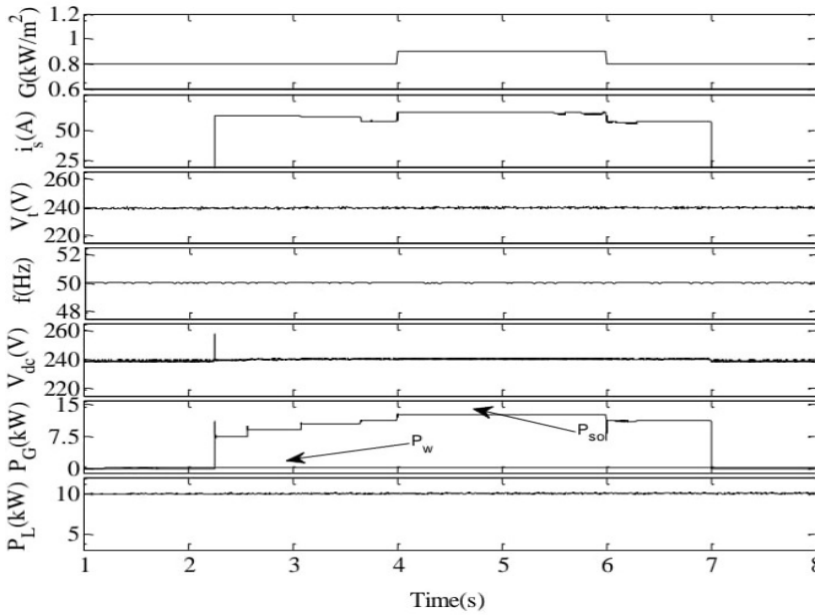

Fig. 1 Performance of REGS fed micro-grid with wind energy source

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Fig. 2 shows the performance of the system when solar PV system is taken in and taken out of the system.

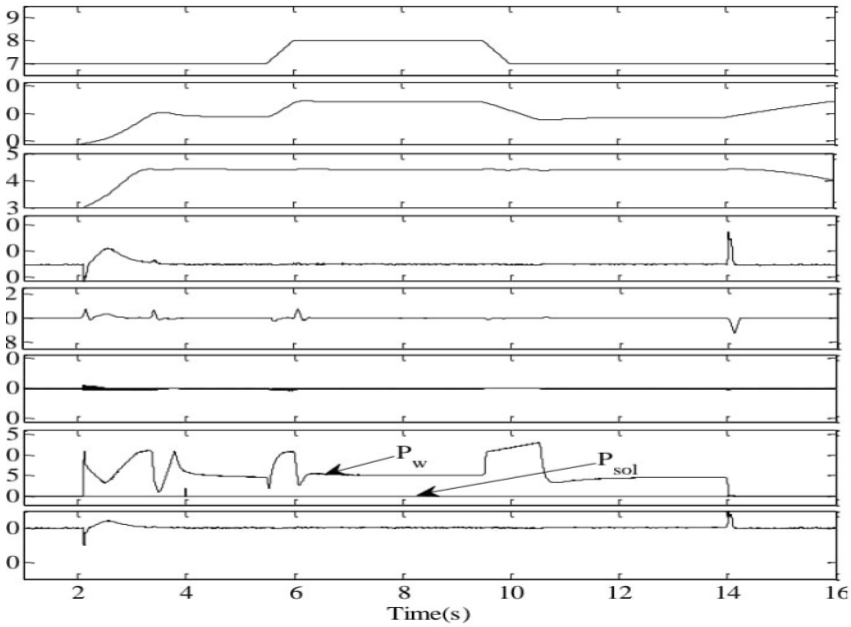

Fig. 2 Performance of the system without generating source and solar system

V. CONCLUSION

The proposed micro-grid system fed from REGS has been found suitable for meeting load requirement of a remote isolated location comprising few households. REGS comprises of wind and solar energy blocks, which are designed to extract the maximum power from the renewable energy sources and at the same time, it provides quality power to the consumers. The system has been designed for complete automated operation. This work also presents the sizing of the major components. The performance of the system has been presented for change in input conditions for different type of load profiles. Under all the conditions, the power quality at the load terminals, remains within acceptable limit. The effectiveness of the system is also presented with test results with prototype in the laboratory. The system has also envisaged the external battery charging by utilizing the rotor side converter and its sensors for achieving rectifier operation at unity power factor.

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