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Designing & Controlling Of Micro Grid Fed From Wind And Solar Based Hybrid Energy Sources At An Isolation Point On Point Common Coupling

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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— DFIG, Vector Control, Wind Energy; Power Quality, Solar PV Energy, Micro-grid, Battery Energy Storage System, Renewable Energy System.

1. INTRODUCTION

Power systems at present suffer significant change in operating requirements essentially as a result of deregulation and due to rising the amount of Distributed Energy Resources (DER). In different cases DERs have various technologies that permit generation in small scale (micro-sources) and a couple of them take advantage of Renewable Energy Resources (RES) for instance solar, wind and bio-mass. Having micro-sources close to the load has the profit of lowering transmission losses as well as preventing system congestions.

Besides, the possibility prospect of having a power supply disturbance of end-customers connected with a Low Voltage (LV) distribution grid is reduced since adjacent microsources, controllable loads and energy storage systems can work in the islanded mode in case of extreme system disturbances.

The development of microgrids can make contributions to the reduction of emissions and the mitigation of climate changes. This is due to the availability and developing technologies for distributed generation units are based totally on renewable sources and micro resources that are characterized by very low emissions [1]. The renewable energy generating sources are mostly installed in remote locations. Renewable energy based Distributed Generators (DGs) play a important role in electricity production, with the development in the unnatural weather condition. Based on the climatic condition the power obtained from the solar photo voltaic and wind turbine generators.

Both the wind and solar system are non-reliable if there are inadequate capacity storage units like storage batteries. The microgrids stability increases when both the systems (wind-turbine and photo-voltaic) are combined with the storage devices. The batteries bank are needed to store the power and feed the power to the load demand in cloudy and non-windy days. So the optimal placing of the components assigns to the required parts of hybrid microgrid. It presents the modeling of the renewable energy resources with abundant methodologies and principles of the optimization for the hybrid networks.

The hybrid energy sources are gaining famous and fame in the environmental crises and current situation of energies. Based on this study, it has introduced a global survey on the present condition of optimization techniques especially that associated to the remote microgrid in the existing literature.

The present trend of optimization for hybrid renewable sources demonstrates that incremental conductance gives valuable optimization for the microgrid operations. A microgrid incorporates a group of loads and distributed generators that work as a single

controllable device [2]. A controlmethodology is utilized to increase the power quality and load sharing in both islanded and grid-connected modes. There are numerous remote locations in the world, which don't approach power. There are also many location, which are associated to the grid, however, they do not get power for up to 10-12 hours within the day and because of it, financial activities of inhabitants suffer. Many of such locations are wealthy in sustainable power sources. An independent generation system utilizing locally available RE sources, can greatly shrink the dependency on the grid power, which is mostly fossil power.

In any case, solar and wind energies specifically suffer from high degree of power variability, low capacity utilization factor combined with unpredictable nature [3]. As a result of these factors, company electricity can't be guaranteed for self sufficient system. While the Battery Energy Storage (BES) system may be helpful of decreasing the power fluctuation and improving the predictability, utilization factor can be improved through operating each energy source at optimum operating point. The optimum operating point is also known as Maximum Power Point Tracking (MPPT), the operating point of solar P-V (Photo-voltaic) array [4-5] and wind energy generator [6-7] in term of speed and voltage to extract maximum power from input resource. The MPPT can be obtained by Power Electronics (PE) primarily based control. PE based control can also helpful in energy management for Battery-energy-storage system.

The Doubly-Fed Induction Generator (DFIG), is broadly utilized in variable speed generation systems due to the advantages along with reduced converter length, improved efficiency, and economic benefits.

The DFIG is normally operated in grid-connected mode in which it is associated with the grid and helps the grid by providing active and reactive power. A lot of studies has been addressing the grid-connected mode, and several manage techniques had been developed together with vector

control, direct torque, direct power, and decoupled P-Q control [7-8]. The Permanent Magnet Synchronous Generator (P-M-S-G) is frequently used for small wind power application [11]. Some investigation has be done on the wind solar hybrid system with a Squirrel Cage Induction Generator (S-C-I-G) [12], however, the scheme does not have speed regulation required to achieve MPPT.

It is concluded that each of the D-Gs has a local-load connected to it, which can be unbalanced and/or non-linear. The D-Gs compensate the special effects of unbalance and non-linearity of the local loads. Common loads are associated with the microgrids that are provided by the utility grid under ordinary situations. The distributed generation located close to loads will decrease the flows in transmission and distribution system with two major effects: loss of reduction and ability to potentially substitute for community property. In addition, the presence of generation near to the demand could increase service quality seen by end customers. Mainly, the existence of energy storage systems permits microgrids to control their voltage and frequency and at the same time the system operates in various modes, while the microgrid is islanded from the utility grid.

2. LITERATURE SURVEY

Emmanouil A. Bakirtzis, et.al [1] had examined about a micro grid provided by renewable energy sources (photovoltaic's and wind generators) and a battery storage system. The battery converter controls the system frequency and acts as a control signal for battery converter and the RES. The system frequency is determined by the State Of Charge (SOC) of the battery converter while the voltage at the main bus is kept constant. It is shown that a micro grid with a PV station, a wind generating system and a battery storage system, canmaintain the voltage and frequency within the limits, evenunder large load or generating-power variations byimplementing a new control method which takes intoaccount the SOC of the battery.

P.Aravindan, et.al [2] proposed a control methodto improve the power quality and load sharing in each islanded and grid-connected modes. It is presumed that each and every

component of DGs has a local load which are associated with unbalanced and/or non-linear. The DGs balance the outcomes of unbalance and non-linearity of the local loads. Common loads are also associated with micro grid, which are provided by the utility grid under normal conditions.The efficacy of the controller has been confirmed through simulation for numerous operating conditions using the MATLAB/ SIMULINK.

M. Rezkallah, et.al [3] proposed the performance and control of a Hybrid-Standalone-Power-Generating-System (HSPGS) based on a W-T and a solar P-V array. A Squirrel-Cage-Induction-Generator (S-C-I-G) are used for wind energy conversion. The frequency and voltage at DC bus, as well as, power quality improvement at the PCC are attained by controlling the 3-phase VSC by using the decoupled nonlinear control algorithm. For acquiring the maximum power from a solar PV a DC-DC boost converter is controlled using P&O technique. The performance of HSPGS has been found suitable under change in generation and load perturbations.

Hongyu Zhu, et.al [4] discussed about PV Isolated Three-Port Converter and Energy Balancing Control Method for P-V-Battery Power Supply Applications. To decrease the cost and to enhance the power density of the power system, a P-V isolated Three-Ports-DC/DC-converter (TPC) was proposed. A PV primarily based stand-alone power system is frequently used to control the energy supplied from several power sources including (PV solar arrays and battery) and deliver a constant power to the users in an appropriate form.

Moumita Das, et.al [5] proposes a novel 3-phase stand-alone solar PV system configuration that makes use of excessive benefit, high efficiency (~96%) dc-dc converters. The high voltage gain converters permits the low voltage PV and battery sources. Series connection of a huge number of battery modules can stop the overcharging and discharging troubles that reduces the battery life. The proposed "Required Power Tracking (RPT)" of the PV source dependent on the load requirements eliminating the utilization of costly and hard to to manage dump loads.

Ahmad Bashar Ataji, et.al [6] presents Direct Voltage Control with Slip Angle Estimation to Extend the Range of Supported Asymmetric Loads for Stand-Alone DFIG. This paper shows the direct voltage control and uses negative-sequence compensation through Rotor Side Converter (RSC), to support "unbalanced" loads and demonstrates the control of the predictable direct voltage control to achieve the slip angle, and the resultant drawback of the negative-sequence compensation is to control the full range of unbalance loads. To control these drawbacks,proposes a new technique of the angle of the rotor current in the synchronous reference frame.

Natalia A. Orlando**,** et.al [7] aims to provide a complete overview about the primary control problems in small wind turbine systems. Looking at the source-side, it effect that the most critical problems are: sensor less operation of the generator and power limitation. Looking at the grid-side, a modern concept of “universal” wind turbine is stated. It relies on making sure that the wind turbine system can work grid-connected but also with the possibility to switch to island-operation and even support local loads during grid voltage variation.

Toshiro Hirose, et.al [8] proposes a totally unique stand-alone hybridpower generation system, applying power control techniques fed by four power sources: wind power, solarpower, storage battery, and diesel engine generator, and which isn't always related to a industrial power system. It is expected that this hybrid system to which natural energy is included, and which makes use of various power control techniques will be applicable in rural locations, even those with poor communications media.

S.K. Tiwari, et.al [9] explains about the design and control of adistributed-generation sources along with wind and solar P-V(Photo-voltaic) energy sources feeding to a three phase four wirenetwork. For wind energy conversion Double Fed Induction Generator is used andequipped with MPPT.Solar P-V system is connected to the DC bus usingDC-DC boost converter. The

system is performed under all the practical conditions e.g. varying wind speed and radiation, unbalanced and nonlinear load has been presented. The AHWSS has the capability to extract maximum energy from the input sources, voltage and frequency well within acceptable range under all conditions.

P.K. Goel, et.al [10] proposed micro-grid system consists of REGS feeding an isolated location. It has used the wind generator with DFIG having MPPT features. The solar photovoltaic system has also been equipped with S-MPPT to extract the maximum solar energy. The system has been designed for complete automatic operation. The overall performance of the system under all the practical conditions has been studied and presented. The system has been design for predicting the external battery charging by utilizing the rotor side converter and its sensors for achieving rectifier operation with unity power factor.

HenkPolinder, et.al [11] differentiates five dissimilargenerator systems for wind turbines, namely DFIG3G, DDSG,DDPMG, PMG1G,and DFIG1G. The comparison is mainly based on price and annual energyyield for a given wind climate. The D-F-I-G-3-G is a not expensive solutionusing standard components. The D-F-I-G-1-G appears the most attractive in terms of energy yield divided by cost. The D-D-P-M-G has the maximum energy yield, however despite the fact that it is less expensive than the D-D-S-G and it is more costly than the generator systems with gearbox.

Qi Zhiyuan, et.al [12] proposed a co-ordinate control method that adjusts the operation of power generation units according to the state of energy storage unit. The operating characteristics of wind-solar hybrid power system are examined for the purpose of improving energy conversion performance and device reliability. So, The proposed coordinated control method can guarantee the independent wind-solar hybrid power system optimizing operation.

Ab. Hamadi, et.al [13] offers with the layout and control of a connected wind hybrid generation system utilizing a Doubly-Fed-

Induction-Generator (D-F-I-G) drove by utilizing a variable-speed wind turbine and a variable-irradiation P-V solar feeding a three-phase four wire local loads. A M-P-P-T primarily based on rotor speed control is proposed. A nonlinear control is carried out to grid-side converter, which works as a shunt active power filter for adjusting the harmonics, unbalanced load currents and voltage regulation on the PCC. Another development strategy is proposed for modeling the Voltage- Source-Converter (V-S-C).

Prerna Gaur and Sunita Singh, et.al [14] presented a review of the issues in implementation of microgrid technology and introduces the activities and current progress in microgrid research. The three fundamental issues of technical difficulties that must be defeated for effective implementation of microgrid are voltage and frequency control, islanding and protection. In this context, integration of small-scale production in the form of microgrids, supported by the power electronic devices, could contribute enormous improvements inpower quality as seen by end users.

Zhou Xuesong , et.al [15] Proposed the photo-voltaic array is mainly used to track the maximum power point with the help of Incremental Conductance Method and firstly introduces a convenient model of photovoltaic cells, by which the photovoltaic array`s model is obtained. To get the maximum power point tracking the Incremental Conductance approach is used.

KanteVisweswara, et.al [16] presented MPPT technique with a simple algorithm for photovoltaic (PV) power generation systems. Maximum Power Point Tracking (MPPT) is utilized in photovoltaic (PV) systems to raise the output power, regardless of the temperature and radiation conditions and of the load. Due to the climatic conditions the output power of P-V arrays is continually varying, i.e., solar-irradiation and atmospheric temperature. The proposed method is an Incremental conductance method

for PV to determine an optimum operating point.

Ted Brekken, et.al [17] proposed a control technique for adjustable speed drives and reactive power control for a doubly fed induction generator.The proposed control method also includes an algorithm for greatly reducing the torque pulsations produced by the generator when operating with unbalanced voltages applied to the stator.

AnissiaBeainy, et.al [18] presented the comparison and benefits and the drawbacks of the most commonly used generators in WECS. D-F-I-G, S-C-I-G are the two forms of induction-generators generally used for geared operation in W-E-C-S in variable speeds and fixed speeds, while the P-M-S-G can operate gearless. Increasing demand of power for the wind energy, off shore installations is developing and new wind turbine designs are being estimated in the next future, with the expansion of the improved generators and converter designs.

Hemant Abuja, et.al [19] focuses in the improvement of variable speed WECS utilizing i) Doubly Fed Induction Generator with partial scale converters and ii) Permanent Magnet Synchronous Generator with full scale converters and their overall performance evaluation for similar ratings and with similar control strategies.DFIG is better when compared to PMSG especially at the low wind speeds. However, PMSG generates higher amount of power as compared to DFIG at higher wind speeds probably because of its inherently lower losses. The THDs of voltage and current are lower in the case of DFIG.

Joseph Kearney, et.al [20] describes a Control structure to improve and mitigate the detrimental effects of voltage unbalance on a DFIG rotor-side and grid-side converter. In particular modifications to the control structure of the grid-side converter was implemented to reduce the total power oscillations on the stator and the grid-side converter.

3. SIMULATION RESULTS

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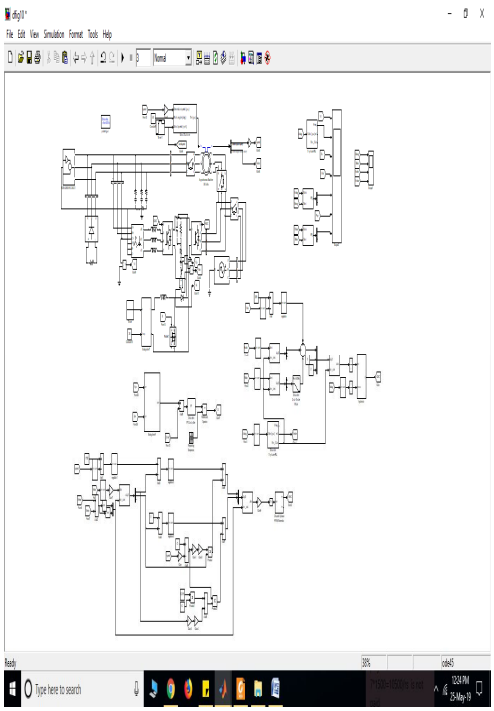

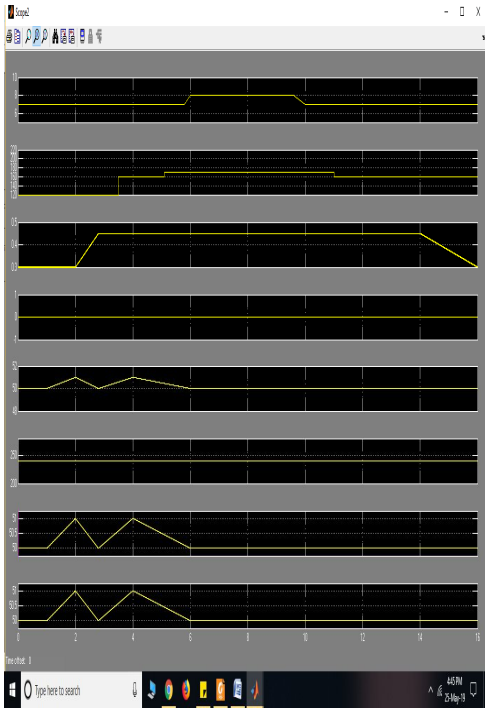

Fig. 1 Performance of REGS fed micro-grid with wind energy source

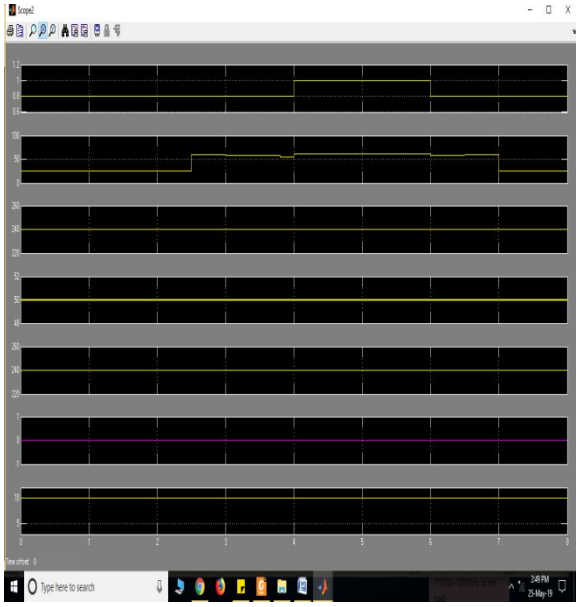

Fig. 2 Performance of the system without generating source and solar systemis taken in the service

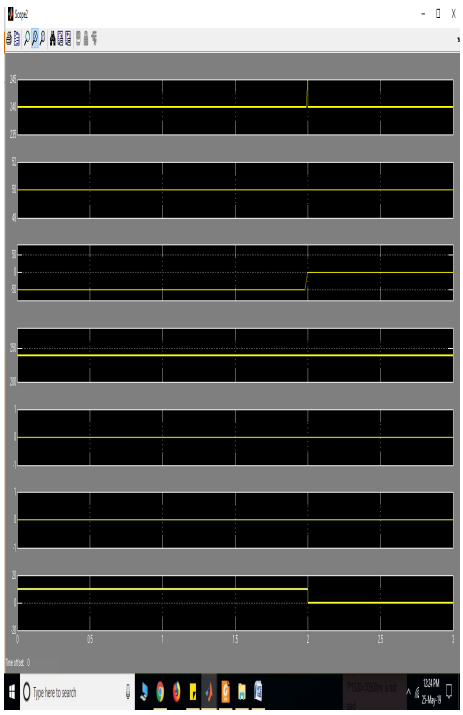

Fig.3 Performance of the system under loss of load at battery power

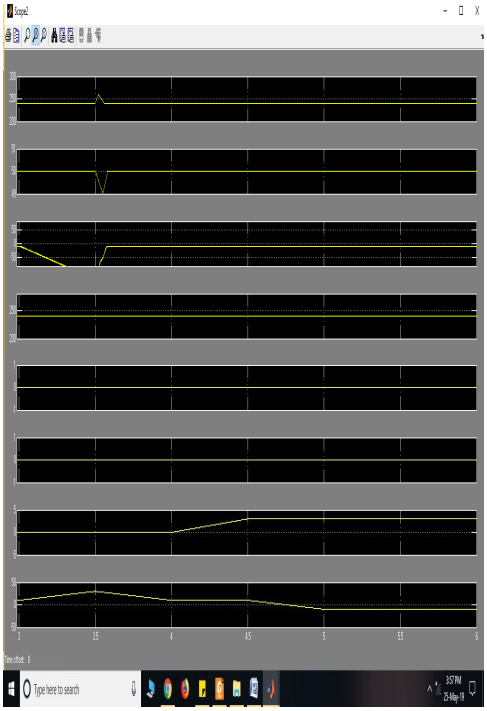

Fig. 4 Performance of system through external charging

4. CONCLUSION

Grid systems controlled by PI and Fuzzy Logic Controllers were designed, modeled and simulated by using MATLAB/SIMULINK. The simulation results of micro-grid fed renewable energy generating sources were presented. The proposed Microgrid fed by hybrid energy sources by using Fuzzy logic controller is suitable for meeting the load requirements of an isolated location. The PI controller is not reliable when compared with the Fuzzy Logic Controller (FLC) is proved by comparing the output response of the system.REGS involves 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 is designed for complete automated operation. The performance of the system is presented for change in input conditions for different types of loads. Under all the conditions, the power quality at the load terminals remains within the acceptable limit by the extensive use of fuzzy based modeling in renewable energy system. Fuzzy logic controller is being widely used in solar pv application for maximum power point tracking. From the simulation results, it is concluded that the load power is increased by using the Fuzzy logic controller when compared to the PI controller.

REFRENCES

[1] H. Zhu, D. Zhang, H. S. Athab, B. Wu and Y. Gu, “PV Isolated Three-Port Converter and Energy-Balancing Control Method for PV-Battery Power Supply Applications,” *IEEE Transactions on Industrial Electronics,*

vol. 62, no. 6, pp. 3595-3606, June 2015.

[2] M. Das and V. Agarwal, "Novel High-Performance Stand-Alone Solar PV System With High-Gain High-Efficiency DC–DC Converter Power Stages," *IEEE Transactions on Industry Applications*, vol. 51, no. 6, pp. 4718-4728, Nov.-Dec. 2015.

[3] A. B. Ataji, Y. Miura, T. Ise and H. Tanaka, "Direct Voltage Control With Slip Angle Estimation to Extend the Range of Supported Asymmetric Loads for Stand-Alone DFIG," *IEEE Transactions on Power Electronics*, vol. 31, no. 2, pp. 1015-1025, Feb. 2016.

[4] N.A. Orlando, M. Liserre, R.A. Mastromauro and A. Dell'Aquila, "A survey of control issues in PMSG-based small wind turbine system," *IEEE Trans. Industrial Informatics*, vol.9, no.3, pp 1211-1221, July 2013.

[5] T. Hirose and H. Matsuo, "Standalone Hybrid Wind-Solar Power Generation System Applying Dump Power Control Without Dump Load," *IEEE Trans. Industrial Electronics*, vol. 59, no. 2, pp. 988-997, Feb. 2012.

[6] Z. Qi, "Coordinated Control for Independent Wind-Solar Hybrid Power System," *2012 Asia-Pacific Power and Energy Engineering Conference*, Shanghai, 2012, pp. 1-4.

[7] M. Rezkallah, S. Sharma, A. Chandra and B. Singh, "Implementation and control of small-scale hybrid standalone power generation system employing wind and solar energy," *2016 IEEE Industry Applications Society Annual Meeting*, Portland, OR, 2016, pp. 1-7.

[8] A. Hamadi, S. Rahmani, K. Addoweesh and K. Al-Haddad, "A modeling and control of DFIG wind and PV solar energy source generation feeding four wire isolated load," *IECON 2013 - 39th Annual Conference of the IEEE Industrial Electronics Society*, Vienna, 2013, pp. 7778-7783.

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