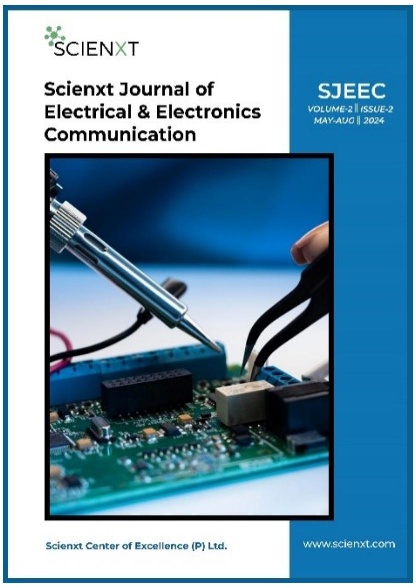

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Review paper of microgrid based on wind driven DFIG and boost converter with PV array for optimal fuel consumption

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Abstract:

In this Paper a micro grid is introduced with PVA and battery connected to DFIG for energy sharing. This paper presents a green energy solution to a microgrid for a location dependent on a diesel generator (DG) to meet its electricity requirement. This microgrid is powered by two renewable energy sources namely wind energy using doubly fed induction generator (DFIG) and solar photovoltaic (PV) array. The solar PV array is directly connected to common DC bus of back-back voltage source converters (VSCs), which are connected in the rotor side of DFIG. Moreover, battery energy storage (BES) is connected at same DC bus through a bidirectional buck/boost DC- DC converter to provide path for excess stator power of DFIG. The extraction of maximum power from both wind and solar, is achieved through rotor side VSC control and bidirectional buck/boost DC-DC converter control, respectively. Moreover, the control of load side VSC, is designed to optimize the fuel consumption of DG. A novel generalized concept is used to compute the reference DG power output for optimal fuel consumption. The microgrid is modelled and simulated using Sim Power Systems tool box of MATLAB, for various scenarios such as varying wind speeds, varying insolation, effect of load variation on a bidirectional converter and unbalanced nonlinear load connected at point of common coupling (PCC). The DFIG stator currents and DG currents, are found balanced and sinusoidal. The model is further updated with DC-DC boost converter connected to PVA for maximum power extraction controlled by MPPT algorithm. A comparative analysis is carried out with power delivered from the module to the grid for the two modules.

Keywords:

Wind Turbine, doubly fed induction generator (DFIG), diesel generator, solar photovoltaic array, bidirectional buck/boost DC-DC converter, battery energy storage, power quality.

1. Introduction:

Microgrids are emerging as an integral feature of the future power systems shaped by the various smart-grid initiatives. A microgrid is formed by integrating loads, distributed generators (DG) and energy storage devices. Microgrids can operate in parallel with the grid, as an autonomous power island or in transition between grid-connected mode and islanded mode of operation.

The microgrid concept, involving small transmission and distribution (T&D) networks, efficiently makes use of all the location specific distributed generations (DGs) and distributed energy resource (DERs). These are self-sustained power systems mainly based on loads fed through radial distribution systems and can operate either interconnected to the main distribution grid, or even in isolated mode.

The microgrids advantages are as follows: i) provide good solution to supply power in case of an emergency and power shortage during power interruption in the main grid, ii) plug and play functionality is the features for switching to suitable mode of operation either grid connected or islanded operation, provide voltage and frequency protection during islanded operation and capability to resynchronize safely connect microgrid to the grid , iii) can independently operate without connecting to the main distribution grid during islanding mode, all loads have to be supplied and shared by distributed generations. Microgrid allows integration of renewable energy generation such as photovoltaic, wind and fuel cell generations. After implementation, all the advantages of a microgrid may not become apparent right away because of higher cost of energy as compared to the cost of grid power.

2. Literature review:

(Shahgholian, 2021) Microgrid is an important and necessary component of smart grid development. It is a small-scale power system with distributed energy resources. To realize the distributed generation potential, adopting a system where the associated loads and generation are considered as a subsystem or a microgrid is essential. In this article, a literature review is made on microgrid technology. The studies run on microgrid are classified in the two topics of feasibility and economic studies and control and optimization. The applications and types of microgrid are introduced first, and next, the objective of microgrid control is explained. Microgrid control is of the coordinated control and local control categories. The small signal stability and methods in improving it are discussed. The load frequency control in microgrids is assessed.

(Tetuko, 2021) A solar power plant or photovoltaic (PV) is a generator that converts energy from light into pollution-free electrical energy. However, changes in the intensity of solar radiation and ambient temperature Photovoltaic (PV) which are not linear are the main problems of PV systems in efficient energy conversion that occurs. Control using the Maximum Power Point Tracker (MPPT) method based on the Perturb and Observe (P&O) algorithm which is applied to overcome these problems. Maximum Power Point Tracker (MPPT) itself is a technique for tracking the maximum output power point of the PV system. MPPT will change the working point so that the converter will force the work of the solar panels according to their ability to always reach the maximum power point. MPPT is not a mechanical system that makes the solar panel system move according to the direction of the sun's intensity, but an electronic system that works to optimize the power output from the solar panel. Meanwhile, Algorithm (P&O) works by detecting and disturbing the PV voltage periodically by varying its duty cycle, as well as observing the PV power to be able to increase and decrease the PV voltage in the next 3 cycles. This paper presents an analysis of the MPPT P&O performance with a standalone system implemented in the campus area. In this study, the applied PV system was able to produce a maximum power of 1626.087 Watts under optimal irradiation conditions and temperature. As well as testing the PV system under radiation and temperature conditions in the location study, namely FT UNNES. The maximum power of the PV system is

227.585 Watt.

3. Problem formulation:

This paper presents a green energy solution to a microgrid for a location dependent on a diesel generator (DG) to meet its electricity requirement. This microgrid is powered by two renewable energy sources namely wind energy using doubly fed induction generator (DFIG) and solar photovoltaic (PV) array. The solar PV array is directly connected to common DC bus of back-back voltage source converters (VSCs), which are connected in the rotor side of DFIG. Moreover, a battery energy storage (BES) is connected at same DC bus through a bidirectional buck/boost DC-DC converter to provide path for excess stator power of DFIG. The extraction of maximum power from both wind and solar, is achieved through rotor side

VSC control and bidirectional buck/boost DC- DC converter control, respectively. Moreover, the control of load side VSC is designed to optimize the fuel consumption of DG. A novel generalized concept is used to compute the reference DG power output for optimal fuel consumption. The microgrid is modelled and simulated using Sim Power Systems tool box of MATLAB, for various scenarios such as varying wind speeds, varying insolation, effect of load variation on a bidirectional converter and unbalanced nonlinear load connected at point of common coupling (PCC). The DFIG stator currents and DG currents are found balanced and sinusoidal. The model is further updated with DC-DC boost converter connected to PVA for maximum power extraction controlled by MPPT algorithm.

4. Proposed methodology:

Maximum power point tracking (MPPT) is a technique used with wind turbines and photovoltaic (PV) solar systems to maximize power output. To put it simply, they convert a higher voltage DC output from solar panels (and a few wind generators) down to the lower voltage needed to charge batteries. MPPT plays an important role in photovoltaic system because they maximize the power output from a PV system for a given set of conditions, and therefore maximize the array efficiency. Maximum power point is the voltage and current at which the PV module can produce maximum available power. The IPV- VPV characteristic is non-linear and varies with solar irradiation. Now, consider the power-voltage a characteristic of the PV panel. There is a unique point on the IPV- VPV or PV curve called the maximum power point (MPP) at which the entire PV system operates with maximum efficiency and produces its maximum output power. The location of MPP is not known, but it can be located either through calculation models or by search algorithms. There are many algorithms for implementing MPPT, among those Perturb and Observe method (P&O) & Incremental Conductance method (IC) are the most popular algorithms. The algorithm we use here is a modified version of incremental conductance method. In incremental conductance method the array terminal voltage is always adjusted according to the MPP voltage it is based on the incremental and instantaneous conductance of the PV module.

Among the MPPT algorithms implemented in TEG systems, perturb and observe (P&O) and open circuit voltage (OCV) methods are the most widely used. The P&O algorithm falls under the category of a hill climbing algorithm. Hill climbing algorithms are named so due to the algorithm taking steps over sampled data to reach a desired value, in the case of the P&O this takes steps towards the MPP by increasing or decreasing the duty cycle. A boost converter with variable output voltage and a new maximum power point tracking (MPPT) scheme is proposed which improves the efficiency by 10%. In this study, a modified P&O algorithm is proposed. Simulations and experiments are conducted to evaluate the tracking efficiency of the proposed system.

5. Expected result:

The microgrid based on wind turbine driven DFIG, DG and solar PV array with BES, is simulated using MATLAB. Various signals used to analyze the system performance, are rms value of phase voltage (Vr), system frequency (fL), DFIG rotor speed (ωr), DG power (PD), wind power from stator (Pw), solar PV power (Psol), load power (PL), LSC power (PLSC), DC link voltage (Vdc), battery current (Ib), battery voltage (Vb), wind speed (Vw), insolation (G), rotor power coefficient (Cp), a- phase stator current (isa), rotor currents (irabc), a-phase DG current (ida), a-phase PCC voltage (vLa), stator currents (isabc), DG currents (idabc), load currents (iLa, iLb and iLc), neutral current (iLn) and LSC currents (icabc). The parameters used for the simulation are mentioned in table.

6. Conclusion and future scope:

The microgrid based on wind turbine driven DFIG, DG and solar PV array with BES, with minimum number of converters, has been presented. The solar PV array is directly connected to DC link of back-back connected VSCs, whereas BES is connected through a bidirectional buck/boost DC-DC converter. The system has been simulated for various scenarios such as variable wind speeds, variable insolation and unbalanced nonlinear load connected at PCC. Moreover, the performance of bidirectional buck/boost DC-DC converter at change in the load has been investigated. Simulated results have shown the satisfactory performance of the system to achieve optimal fuel consumption. The DFIG stator voltages, currents and DG currents, are found balanced and sinusoidal, as per the IEEE 519 standard.

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