Modelling and Control of Hybrid Microgrid Based on Renewable Energy (PV and Wind Turbine) by Using Battery Management System with Help of Fuzzy Logic and PWM Inverter

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Abstract: ***Renewable energy-based distributed generators (DGs) presents an imperative role in electricity production, with the increase in global warming. Distributed generation based on wind, solar energy, biomass, mini-hydro, along with the use of fuel cells and micro-turbines, will give notable energy shortly. Advantages like environmental friendliness, expandability, and adaptability have made distributed generation powered by several renewable and nonconventional micro sources, an attractive option for configuring modern electrical grids. A microgrid consists of a cluster of loads and distributed generators that operate as a single controllable system. As an integrated energy delivery system, the microgrid can run in parallel with or isolated from the primary power grid. The microgrid concept proposes the reduction of multiple reverse conversions in an individual AC or DC grid and also expedites connections to variable renewable AC and DC sources and loads to power systems. The inter-connection of DGs to the utility/grid concluded power electronic converters have risen concerned about safe operation and protection of pieces of equipment. To the customer, the microgrid can be premeditated to meet their particular requirements, such as enhancement of local reliability, reduction of feeder losses, local voltages support, increased efficiency through the use of waste heat, improvement of voltage sag, or uninterruptible power supply. In the present scenario, the performance of a hybrid AC/DC microgrid system is analyzed in the grid-tied mode. Here photovoltaic system, wind turbine generator, and battery are used for the development of microgrid. Also, control tools are implemented for the converters to coordinate the AC sub-grid to DC sub-grid properly.***

Keywords: Pulse width Modulation (PWM),Hybrid microgrid, Solar Photovoltaic

1. Introduction

Since the growth in technology and change in the lifestyle of humanity, the power demand at the load center has enhanced to a greater extent. With the advancement of the economy and the increase of population, the consumption of energy resources is growing fast, resulting in a series of problems such as energy shortage, environmental pollution, and ecology deterioration. Making full use of renewable energy and achieving sustainable economic development has become a consensus among all countries in the world. In all sorts of renewable energy, wind power and solar energy are used most widely. Due to the instability of wind energy, it has a significant effect on the safe operation of the power grid. The microgrid concept acts as a solution to the problem of integrating large amounts of microgeneration without interrupting the operation of the utility network. With intelligent coordination of loads and micro-generation, the distribution network subsystem (or 'microgrid') would be less disquieting to the utility network, than conventional microgeneration. The net microgrid could even provide ancillary services such as local voltage control. In the cause of troubles on the leading system, microgrids could potentially disconnect and continue to operate separately.

2. Literature Review

In recent years, the power system has been an exciting topic and there have been many grids schemes proposed. The demand for renewable energy has risen significantly over the years due to the shortage of fossil fuels. Also, the need for pollution-free green energy has created a keen interest in renewable energy sources. Solar energy is the most natural and sufficient renewable energy source to meet the rapidly increasing energy requirements [1]. The maximum power from the solar PV array is to be tracked for its efficient implementation. Many algorithms are available in the literature for tracking maximum power from solar panels. In this paper, Perturbation and Observation, the algorithm is considered due to its simplicity. A boost converter is used to perform the maximum power point tracking algorithm [2]. The output power generated from the solar panels is periodically and transforms with the irradiance level. Hence to make the system more stable, a battery is included in the system. A bidirectional converter is also used to control the power flow from and into the battery [3]. Since the inverter is used in a PV system, a proportional-integral (PI) controller scheme is employed to preserve the output current sinusoidal and to control the power factor unity and to have a high dynamic appearance under rapidly changing atmospheric conditions. Simulation results are providing to verify the offered control system.

3. Proposed Methodology

The block diagram of the suggested architecture photovoltaic in Fig. 1. The output of the solar panel is given to the three-phase inverter through a boost converter. The switching pulse generated from the MPPT algorithm is given to the boost converter. The power from the battery is given to the single-phase inverter through a bidirectional dc-dc converter so that power flow through either direction can becontrolled. The grid voltage is sensed using a PLL, and thegrid current and the reference current are compared using acomparator, and the output of the comparator is fed to the PIcontroller. The PWM pulses to the single-phase inverter aregenerated by comparing the output of the SPVWM controller witha triangular wave.

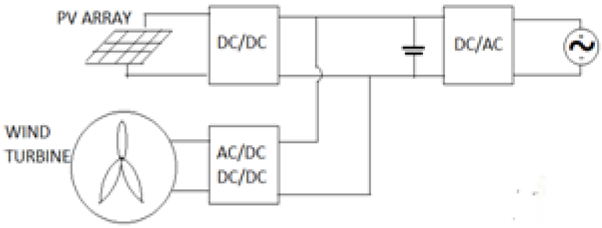

Figure 1: Hybrid grid basic structure

Here is a hybrid solar PV and wind system along with a battery bank that is connected to an AC Microgrid. The system can work in a grid-connected method or stand-alone method. The DC outputs' voltages from single solar PV and wind stream, through individual DC/AC and AC/DC-DC/AC units, are incorporated and combined in parallel on the AC side to produce the power to the grid/loads even with only one basis available. Therefore, in the grid-connected mode of operation, the renewable energy sources act as current sources and inject power directly into the AC bus. The battery system interfaced with a bi-directional converter and can be charged or discharged depending on the condition of the generation, load, and state of charge. However, in the stand-alone mode, the renewable energy sources act as current sources feeding the loads directly, and the battery bank works as a voltage source controlling the AC bus voltage by charging or discharging. The battery converter regulates the magnitude and frequency of the load voltage. The particular RES units can be operated for MPPT systems to have the determined power from the solar PV and wind systems in the grid-connected mode. The corresponding thing can be applied in the stand-alone mode provided that the battery bank endures as a voltage source to control the AC bus voltage by indicting or discharging.
A photovoltaic energy system is mainly powered by solar energy. The configuration of the PV system is manifested in the figure.

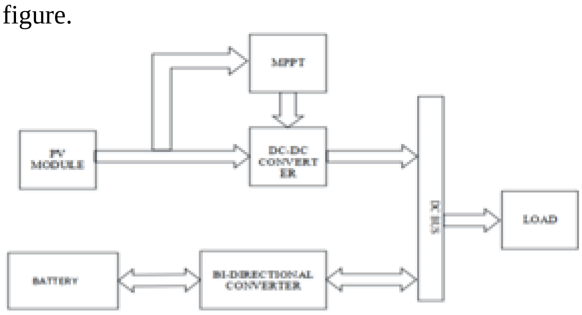

Figure 2: Overall block diagram of PV energy system

It contains PV modules or arrays, which transform solar energy into the usage of solar irradiation into electrical energy. The dc-dc converter alterations the level of the voltage to harmonize it with the electrical apparatuses that are supplied by this system. This DC-DC converter may be each buck or boost or buck-boost contingent on the essential and available voltage levels. The maximum power point tracking system coerces the maximum energy from the PV modules. A bi-directional converter that can supply the current in both directions is used to charge the battery when there is a power surplus, and the energy stored by the battery is discharged into the load when there is a power deficit.

This system comprises of a wind turbine which transforms wind's kinetic power into rotating movement, a gearbox to agree with the turbine speed to generator speed, a generator which converts mechanical energy into electrical energy, a rectifier which converts ac voltage to dc, a controllable dc-dc converter to trace the maximum power point, a battery is charged and discharged through bi-directional converter.

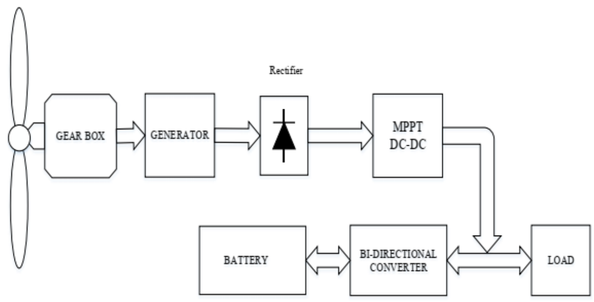

Figure 3: Wind turbine basic structure

A wind turbine converts the kinetic energy of air, i.e., wind power into production power, i.e., rotating motion of the turbine that can be used directly to run the machine or generator. Power obtained by wind turbine blade is a concomitant of the blade shape, the pitch angle, speed of rotation, the radius of the rotor.

a) Distribution Smart Solar

Distributed Smart Solar (DSS) technology combines anadvanced panel-level inverter with the smart grid sensors andcommunication technologies (Figure 1). A typical configuration is to provide each solar panel with a Smart Energy Module (SEM) connected to the low voltage utilitynetwork. All the SEMs form a secure meshed communicationnetwork that uploads their information to a data center viacommunication aggregators. Command and control centersand distribution management systems (DMS) access the datacenter to manage the solar portfolio as a virtual power plantand also to implement several smart grid functions.

This technology enables each solar panel to become a node in a smart grid and thus facilitates the implementation of manyutility applications such as demand response, conservationvoltage reduction (CVR) [6], Volt/VAR loss minimization,predictive maintenance, outage notification, theft detection,and street lighting controls. The financial benefits of thistechnology go beyond those of solar energy generation toThe Economic Opportunity of Distributed Smart Solar SystemsHisham .A. Othman, Ruba A. Amarinthose of the smart grid, and thus allow the utility to optimize the generation, the load, and the distribution assets in between.

Establishing the right solar energy policies andregulations in a country is crucial to the proper expansion ofthe various forms of solar energy technologies. In this respect,it is essential to understand who, along the electricity valuechain, benefits from the solar energy investments in order toallocate the costs to these beneficiaries in a proper fashion.The beneficiaries of a solar energy investment depend on themarket structure and subsidy system in a country.

b) Wind Power Integration

Speed, and they can generate electricity at both day andnight. While the power output of photovoltaic cells isdetermined by the light intensity and they can generateelectricity only at day. The differences of power outputfeature between wind power units and photovoltaic cellsrelated with time decide that the influences of both on the powergrid are different. The wind power units generate moreelectrieity usually at night. Thus the suitable wind powercapacity can be calculated by renewable energyconsumption at night in order to make full use of wind energy.While photovoltaic cells can generate electricity only at dayand it will make the actual power generation capacities of the power grid at day and night are different. This point shouldbe considered when deciding photovoltaic accommodationcapacity. The paper takes the result that the renewable energyeonsumption of power grid at day minus the consumption atnight as the ability to consume the photovoltaic power outputand deeides photovoltaie capacity according to the result.

c) Energy storage management

Battery energy storage systems are comprised of batteries,power electronics for conversion between alternating anddirect current, and the control system. The batteries transform the electrical energy into chemical energy for storage. Differenttypes of battery chemistries have various advantages andtradeoffs in terms of power and energy capabilities, size,weight, and cost. In large grid-tied applications, the mostcommon batteries are typically Sodium-sulfur, Lead-Acid, orLithium-Ion chemistries. Various other chemistries have beenused in pilot projects and laboratory tests, a reference discussing different electrochemistry is found in [2]Batteries are charged and discharged using DC power, which must be converted by a bi-directional power electronicinterface.

The power electronic interface is often referred to as apower conversion system (PCS). The PCS regulates the flowof power between batteries and the power grid and canrespond to a changing power command on sub-cycletimescales, far faster than typical peaking thermal plants. Thepower electronics are capable of taking independent controlsignals for real and reactive power on the AC side of the PCS,which enables the BESS to provide power factor and voltagesupport functions. This function is referred to as a four-quadrantoperation and can eliminate the need for such systemcomponents as capacitor banks at the point of interconnectionof the wind plant and the grid.

4. Discussion and Conclusion

This paper explores the relationship between DC bus voltage and system efficiency in a hybrid photovoltaic-grid power system. An optimal efficiency bus voltage value can be found by loss analysis within a specific voltage range. A new method of optimizing the efficiency of the hybrid photovoltaic-grid power system by changing the dc bus voltage is proposed. It provides an idea to improve the effectiveness of the hybrid photovoltaic-grid Power system. The optimal efficiency point of the system is different under different power states. So this paper proposes a new method to optimize the efficiency in a hybrid photovoltaic-grid power system by changing dc bus voltage.

5. Expected Outcomes

In this paper, the proposed hybrid wind-solar system will be modeled and simulated in MATLAB. Grid interconnection of Renewable System is done using DC-DC converter and grid interfacing inverter. An inverter is controlled in such a way that it acts as a grid interfacing unit as well as an active shunt filter. Nonlinear loads are connected at the point of universal coupling. Various Renewable Energy generation conditions with unbalanced and distorted grid conditions are simulated and found that the system works well for different conditions. Thus grid interfacing inverter with the additional functionality of shunt active power filter can be utilized in distribution systems for cost-effective distributed generation with power quality improvement features.

Hybrid generation systems that use more exceeding than a single power source can significantly improve the certainty of load demands all the time. Even higher generating capacities can be obtained by the hybrid system. In the stand-alone mode, we can able to provide independent fluctuation output to the load irrespective of climates condition. To perceive the energy output of the PV system converted to save energy, and consistent power performed by the wind turbine, an efficient energy storage device is challenged, which can be achieved by the battery bank.

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