An Extensive Review Sliding Mode Control of Standalone Microgrid using Hydro, Wind or Solar PV Array based Generation

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Abstracts- Recently year, distributed generation has picked up loads of fascination due to the naturally amicable nature of renewable energy, the attachment and-play activity of new generation units, and its capacity to offer low establishment cost to address the difficulties of the power showcase. The capability of renewable energy sources is tremendous and they can take care of the world's energy demand various occasions. Renewable energy sources, for example, biomass, wind, sunlight based and hydropower can give feasible energy. In the previous three decades, sun oriented and wind frameworks have encountered declining capital expenses and quick deals development. The expense of power created has likewise diminished with increments in efficiencies of change. The requirement for manageability has prompted increasingly looks into in the region of renewable energy.

Keywords-Microgrid, Renewable energy source, Single Phase microgrid , sliding mode control.

I. INTRODUCTION

When electricity was first introduced in the late 19th century, the major resource that was used to produce electricity was non-renewable. Humans kept using these limited resources inefficiently without realizing that these resources will deplete to a small amount sometime in the future. With the ever growing economy of the world, it is nearly impossible to rely solely on these resources for a long-term duration, the reason being these resources are depleting rapidly.

Power systems currently undergo considerable change in operating requirements mainly as a study of deregulation and due to an increasing amount of distributed energy resources (DER). In many cases DERs include different technologies that allow generation in small scale (micro sources) and some of them take advantage of renewable energy resources (RES) such as solar, wind or hydro energy. Having micro sources close to the load has the advantage of reducing transmission losses as well as preventing network congestions. Moreover, the possibility of having a power supply interruption of end-customers connected to a low voltage (LV) distribution grid (in Europe 230 V and in the USA 110 V) is diminished since adjacent micro sources, controllable loads and energy storage systems can operate in the islanded mode in case of severe system disturbances.

Solar energy can be converted to useful energy forms through a variety of demonstrated technologies. One way to convert the sunlight into heat is by using solar thermal technologies. Heat collected can be used for space heating or can be stored in a thermal medium such as water or molten salt. Need for electricity generating capacity can be reduced when solar energy replaces electricity in such applications. Another way of using solar energy is through solar photovoltaic (PV) technologies. Solar photovoltaic technologies directly absorb incident photons (particles of light that acting as individual units of energy) without complete conversion to heat. It is either converted to dc electricity as in a photovoltaic [PV] cell or stored as chemical energy through a chemical reaction such as dissociation of water into hydrogen and oxygen.

Wind is air in motion in simple terms. Uneven heating of the Earth's surface causes it by radiant energy from the sun. People have harnessed wind energy since ancient times. Ancient Egyptians used wind to sail ships on the Nile River as early as 5000 B.C. Later, people built windmills to grind wheat and other grains. Early windmills looked like paddle wheels. Water has always been one of the most indispensible and extensively used resource for humankind. Hydropower is a renewable energy source where power is obtained from the potential energy of water in higher elevations that flows and gets converted to kinetic energy at lower elevations. It is a proven, fully developed, anticipated, highly efficient and a price-competitive technology.

By coupling water turbines to generators with belts and gears, a constant source of electricity was generated that could be used to power residences, commercial establishments and industries. Large supply of rivers and streams around the globe became readily available sources of energy which were quickly exploited. By using water for power generation, people have utilized nature to achieve a better lifestyle.

Photovoltaic Array

A photovoltaic array (PV system) is an interconnection of modules which in turn is made up of many PV cells in series or parallel. The power produced by single module is not enough to meet the requirements of commercial applications, so modules are connected to form array to supply the load. In an array the connection of the modules is same as that of cells in a module. The modules in a PV array are usually first connected in series to obtain the desired voltages; the individual modules are then connected in parallel to allow the system to produce more current. In urban uses, generally the arrays are mounted on a rooftop. PV array output can directly feed to a DC motor in agricultural applications.

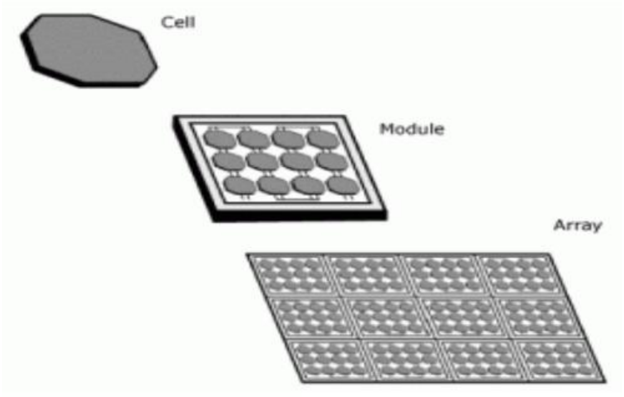

Fig.1.1 Photovoltaic System.

II. SYSTEM MODEL

As electric distribution technology steps into the next century, many trends are becoming noticeable that will change the requirements of energy delivery. These modifications are being driven from both the demand side where higher energy availability and efficiency are desired and from the supply side where the integration of distributed generation and peak shaving technologies must be accommodated.

Micro grid is an important and necessary part of the development of smart grid. The micro grid is characterized as the "building block of smart grid". It comprises low voltage (LV) system with distributed energy resources (DERs) together with storage devices and flexible loads. The DERs such as micro-turbines such as, fuel cells, wind generator, photovoltaic (PV) and storage devices such as flywheels, energy capacitor and batteries are used in a micro grid. The micro grid can benefit both the grid and the customer.

The single phase grid interactive inverter system is shown in Fig. 2.1. It comprises of a dc supply voltage E, a full bridge VSI, an LCL filter with local loads and a utility grid of voltage vg. The LCL filter composes of the inverter side inductor L1, capacitor C, and a grid interfacing inductor L2 connected through a static transfer switch (STS). The local sensitive loads are generally connected with the filter capacitor in a parallel manner. The switches of the bridge inverter are controlled by the FFHC control logic, which is implemented by means of a cascaded feedback controller. The currents i1 and i2 are called the filter inductor current and grid interfacing current (termed as grid current in this paper) respectively.

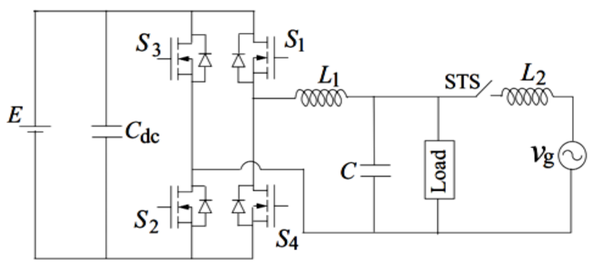

Fig. 2.1 Single phase Micro grid system.

Sliding Mode Control (SMC) is a nonlinear control method, belonging to the framework of Variable Structure Control (VSC), that adjusts the dynamics of systems by the application of a switching control The basic concept is the design of a controller ensuring finite-time arrival of the state space trajectory to a suitable surface in both its sides. This implies the generation of the so-called "sliding motion" on that surface. The latter is named switching surface and the sliding motion can occur on one or more than one surfaces defined in the state space of the controlled system. When the sliding motion is contemporarily enforced on all the defined surfaces, the controlled system is said to be in "sliding mode".

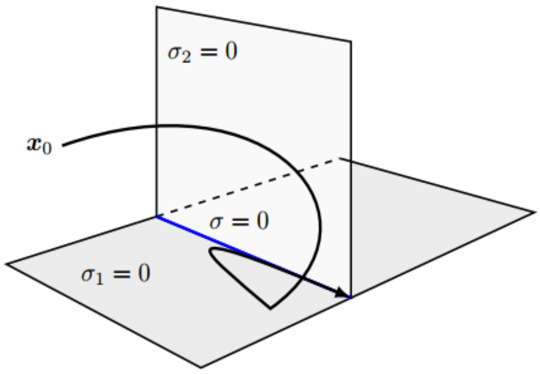

Fig. 2.2 Basic Structure of Sliding Mode Control.

Given some initial conditions x0 = x(t0), the goal of SMC is to steer the state trajectories of the controlled system to the so-called sliding subspace or sliding manifold, i.e., the intersection of the switching surfaces, in order to enforce a sliding mode. If this is the case, the states belong to the sliding subspace, and the controlled equivalent system features an order reduction. Moreover, the dynamic performance can be arbitrarily specified by suitably selecting the sliding manifold, and it is invariant with respect to a significant class of parameter uncertainties and disturbances.

III. LITERATURE SURVEY

U. K. Kalla, B. Singh, S. S. Murthy, C. Jain and K. Kant, [1] This paper presents an adaptive sliding mode control (ASMC) of an improved power quality standalone single phase microgrid system. The proposed micro grid system integrates a governor-less micro-hydro turbine driven single-phase two winding self-excited induction generator (SEIG) with a wind driven permanent magnet brushless DC (PMBLDC) generator, solar photo-voltaic (PV) array and a battery energy storage system (BESS). These renewable energy sources are integrated using only one single-phase voltage source converter (VSC). The ASMC based control algorithm is used to estimate the reference source current which controls the single-phase VSC and regulates the voltage and frequency of the microgrid in addition to harmonics current mitigation. The proposed ASMC estimates the reference real and reactive powers of the system, which is adaptive to the fluctuating loads. The sliding mode control is used to estimate the reference real power of the system to maintain the energy balance among wind, micro-hydro, solar PV power and BESS, which controls the frequency of standalone microgrid. The proposed microgrid is implemented in real time using a DSP (Digital Signal Processor) controller. Test studys of proposed microgrid shows that the grid voltage and frequency are maintained constant while the system is following a sudden change in loads and under intermittent penetration of wind and solar energy sources.

S. Heo, W. Park and I. Lee [2] This paper proposes single-phase power conditioning system which is capable of connecting a microgrid to an utility grid seamlessly through slew-rate control. The power conditioning system is composed of a single-phase phase-locked loop using an inverse Park transformation to detect the grid phase, a phase synchronizer using the slew-rate control, and isolated bidirectional inverter which transfers power among the utility grid, energy storage, and load. The inverter is controlled by the voltage and current controllers for the island and grid-connected operation, respectively. The power conditioning system operates using the inverter controlled by a mode controller according to the microgrid operation mode and state of charge of the energy storage. The stable operation of the power conditioning system was verified in three microgrid operation modes through simulations using the MATLAB/Simulink tool.

S. Heo, W. Park and I. Lee [3] This paper proposes a single-phase microgrid based on a power conditioning system with dual photovoltaic array and an energy storage. A grid-connected inverter and battery charger are adopted for energy conversion from the two arrays of different construction. The power conditioning system based on a bidirectional inverter delivers power among grid, load, and storage using the grid-connected mode and island mode. The performance of the microgrid was verified by simulation of three microgrid operations.

G. Oriti and A. L. Julian [4] This paper presents a novel control strategy to achieve unity power factor with an energy management system (EMS) in an AC microgrid. The digitally controlled, power electronics based EMS controls the microgrid in both grid-connected and islanding mode by making sure that energy is harvested from distributed resources, stored in batteries, and available at all times for critical loads. In this paper a new EMS prototype is presented which offers reactive power compensation as an auxiliary service. Modeling and simulations are presented and verified experimentally on a laboratory prototype.

Q. Sun, J. Zhou, J. M. Guerrero and H. Zhang [5] With the fast proliferation of single-phase distributed generation (DG) units and loads integrated into residential microgrids, independent power sharing per phase and full use of the energy generated by DGs have become crucial. To address these issues, this paper proposes a hybrid microgrid architecture and its power management strategy. In this microgrid structure, a power sharing unit (PSU), composed of three single-phase back-to-back (SPBTB) converters, is proposed to be installed at the point of common coupling. The aim of the PSU is mainly to realize the power exchange and coordinated control of load power sharing among phases, as well as to allow full utilization of the energy generated by DGs. Meanwhile, the method combining the modified adaptive backstepping-sliding mode control approach and droop control is also proposed to design the SPBTB system controllers. With the application of the proposed PSU and its power management strategy, the loads among different phases can be properly supplied and the energy can be fully utilized, as well as obtaining better load sharing. Simulation and experimental results are provided to demonstrate the validity of the proposed hybrid microgrid structure and control.

K. Singh, P. Swathi and M. U. Reddy [6] As the power demand is increasing, the PV based microgrid has the important role to full fill the demand of energy today. In PV based microgrid, PV inverter is used to convert dc to ac with novel pulse width modulate control. A PWM is well known and powerful control technique for analog circuits. In this paper, we are discussing about inverter with neural network control to convert dc to 3-Phase ac in PV based microgrid. The neural network control is implementing by two layer network to produce the optimise switching signals for controlling voltage and current harmonics of dc to ac bridge inverter. The neural network keeps the current injected into the grid sinusoidal and improves the performance of the bridge inverter. The proposed system is verified though MATLAB simulation and the experimental results are compared with single phase three level grid connected PWM inverter.

IV. PROBLEM FORMULATION

The popularity of distributed generation systems is growing faster from last few years because of their higher operating efficiency and low emission levels. Distributed generators make use of several micro sources for their operation like photovoltaic cells, batteries, micro turbines and fuel cells. During peak load hours DGs provide peak generation when the energy cost is high and stand by generation during system outages. Micro grid is built up by combining cluster of loads and parallel distributed generation systems in a certain local area. Micro grids have large power capacity and more control flexibility which accomplishes the reliability of the system as well as the requirement of power quality.

V. CONCLUSION

In this survey paper study of Adaptive Sliding Mode Control of Standalone Single-Phase Micro grid Using Hydro, Wind and Solar PV Array Based Generation. In the coming years, it is conceivable that the development in the energy part will be transcendently in the region of renewable energy and not in traditional advancements. These advancements are offering ascend to showcase chances to plan new thoughts and endeavor developing markets to energize renewable energy frameworks. The development and usage of renewable energy can without a doubt enhance the assortment in the energy supply showcases and can be instrumental in increasing broadened period and continuous and maintainable energy supplies. Notwithstanding energy can without a doubt enhances the assortment in the energy supply advertise and can be instrumental in increasing broadened time of a continuous and reasonable energy supplies.

REFERENCES

[1]. U. K. Kalla, B. Singh, S. S. Murthy, C. Jain and K. Kant, "Adaptive Sliding Mode Control of Standalone Single-Phase Microgrid Using Hydro, Wind and Solar PV Array Based Generation," in IEEE Transactions on Smart Grid.

[2]. S. Heo, W. Park and I. Lee, "Single-phase power conditioning system with slew-rate controlled synchronizer for renewable energy system in microgrid," 2016 IEEE International Conference on Renewable Energy Research and Applications (ICRERA), Birmingham, 2016, pp. 550-555.

[3]. S. Heo, W. Park and I. Lee, "Single-phase microgrid with dual photovoltaic array for efficient power balance based on power conditioning system," 2016 IEEE 43rd Photovoltaic Specialists Conference (PVSC), Portland, OR, 2016, pp. 3225-3229.

[4]. G. Oriti and A. L. Julian, "Reactive power control with an energy management system in single phase AC microgrids," 2015 IEEE Energy Conversion Congress and Exposition (ECCE), Montreal, QC, 2015, pp. 753-759.

[5]. Q. Sun, J. Zhou, J. M. Guerrero and H. Zhang, "Hybrid Three-Phase/Single-Phase Microgrid Architecture With Power Management Capabilities," in IEEE Transactions on Power Electronics, vol. 30, no. 10, pp. 5964-5977, Oct. 2015.

[6]. K. Singh, P. Swathi and M. U. Reddy, "Performance analysis of PV inverter in microgrid connected with PV system employing ANN control," 2014 International Conference on Green Computing Communication and Electrical Engineering (ICGCCEE), Coimbatore, 2014, pp. 1-6.

[7]. S. de Freitas, M. C. Meira, Z. M. Gomes, A. A. de Melo, C. C. Azevedo and F. Salvadori, "Applied control strategy in a micro system interconnected between a renewable energy source and a single-phase electric power," 2013 Brazilian Power Electronics Conference, Gramado, 2013, pp. 1029-1033.

[8]. Stefan Gsanger et al. “World Wind Energy Report 2012” World Wind Energy Conferences, Havana/Cuba, June 2013

[9]. Sean Pool et al. “Fulfilling the Promise of Concentrating Solar Power” Centre for American progress, May 2013.

[10]. Klaus Rave et al. “GLOBAL Wind Energy Outlook 2012” Global wind energy council, November.

[11]. White paper on “Electrical Energy Storage”, International Electro technical Commission, December 2011.

[12]. Wei Zhou et al. “Current status of research on optimum sizing of stand-alone hybrid solar-wind power generation systems” Applied Energy (2010) pp. 380-389.

[13]. Jose L. Bernal-Agusti n, “Simulation and optimization of stand-alone hybrid renewable energy systems” Renewable and Sustainable Energy Reviews (2009) pp.2111-2118.