An Extensive Review on Controlling of Different Non Conventional Power Generation Systems

Deepika Soni[1], Prof. Pallavi Bondriya[2]

[1]*Mtech Scholar*, [2]*Research Guide*

Department of Electrical Engineering, TIT-S, Bhopal

Abstract- The rapid depletion (hence, increase of cost) of fossil fuels, rising demand of electricity, and ever tightening government policies on reduction of greenhouse gas emissions, together with the inability and inefficiency of the existing electricity grid, are driving major changes in electricity generation, distribution, and consumption patterns all around the world. Technical challenges linked with the operation and controls of microgrids are immense. Ensuring stable operation during network disturbances, maintaining stability and power quality in the islanding mode of operation necessitates the improvement of sophisticated control strategies for microgrid's inverters in order to provide stable frequency and voltage in the presence of arbitrarily varying loads. No matter how the DG sources are connected to the grid or to a local load, the essentials of this power conversion process are the power electronics, which provides the flexible interface between the energy sources and the power customers. This work presents an extensive survey of literature on adaptive sliding mode control of standalone single-phase microgrid using hydro, wind and solar PV array based generation.

Keywords- Microgrid, Hydro, Wind and Solar PV Array based generation, battery energy storage system (BESS), renewable energy source.

I. INTRODUCTION

Because of increasing demand of economy, the world energy consumption is in- creasing year by year with depletion of fossil fuel resources. There also have been concerns on accompanying global climate change and its related harmful effects, such as environmental pollution, global warming and extreme climate. These severe impacts endanger not only the balance of the ecosystem but also the stability of human society. In order to mitigate these challenges, renewable energy is developing rapidly. This blend includes wind, solar, hydro-power, bio-energy, geothermal and nuclear energy. Both developing and developed countries have put forward and implemented some successful policies to promote and encourage the smart grids with utilization of renewable energy generation

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.

Power systems currently undergo considerable change in operating requirements mainly as a result 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 (microsources) and some of them take advantage of renewable energy resources (RES) such as solar, wind or hydro energy. Having microsources close to the load has the advantage of reducing transmission losses as well as preventing network congestions.

Combined win-PV hybrid generation system utilizes the solar and wind resources for electric power generation. Individual wind and solar renewable sources have unpredictable random behavior. As throughout the day solar energy is present but due to the sun intensity and unpredictable shadows by the clouds, birds, trees etc the solar irradiation levels varies. Due to this cause solar energy is unreliable and less used.

Wind is a form of solar energy. Due to the uneven heating of the atmosphere by the sun wind flow. Due to the earth terrains, bodies of water and vegetation the wind flow patterns are modified. Wind turbine converts the kinetic energy in the wind in to mechanical then to electrical by rotating the generator which are connected internally. Wind is highly unpredictable in nature as it can be here one moment and gone in another moment but it is capable of supplying large amount of power. Due to this concept of wind energy it is an unreliable one and less used.

So it is better to use hybrid generation system which is better than individual wind or individual PV generation system. So it is overcome the demerits of individual system. Grid interface of hybrid generation system improves the system reliability.

In this system there is a wind turbine, the output of the wind turbine goes to permanent magnet synchronous generator. The output of the wind system is in ac so we need ac to dc converter to convert the ac output in to dc .Similarly in the PV side the output of the PV array is connected with a dc-dc boost converter to rise the output voltage up to a desire level. And the output of PV and wind are connected with a common DC link voltage. The common DC link voltage will be connected with the DC to AC converter and the output of the inverter is synchronizing with grid. This inverter changes DC power from PV array and the wind turbine into AC power and it maintain the voltage and frequency is equal to the grid voltage and frequency.

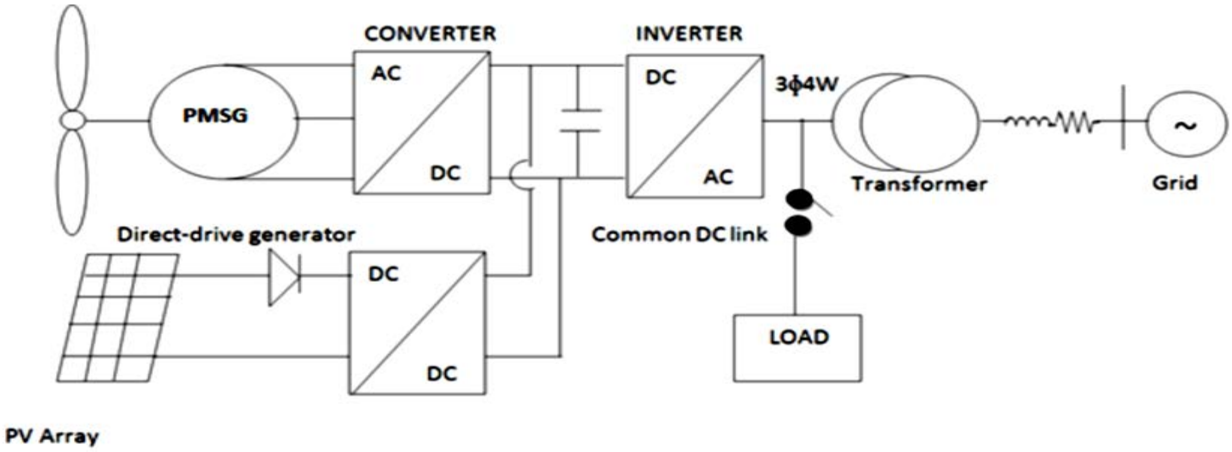

Figure 1.1 System representing Grid-Connected hybrid wind PV.

II. SLIDING MODE CONTROL

A non-linear control scheme, namely, sliding mode control (SMC) strategy has been reported in inverter control since these are well known for their robustness, guaranteed stability and good dynamic response under the wide range of operating conditions. The SMC utilizes a switching control law to drive the state trajectory from any initial positions to a specified surface in the state space called sliding or switching surface and maintain it on this surface for all subsequent time. However, SMC operates at variable switching frequency at which an undesirable chattering phenomenon may occur. In order to compensate the above drawback partially, the SMC are realized by means of a hysteresis comparator, which also provides a variable switching frequency. Several authors have reported constant frequency SMC by means of a variable width hysteresis controller, which can however lead to a complex analog implementation, thereby involve more cost. Moreover, the width of hysteresis band depends on the converter parameters. Alternatively, fixed frequency SMC can also be achieved by comparing an external ramp signal to the switching surface. Hence in these controllers, the switching instant does not depend on the switching surface behavior.

Over the past decades, many efforts have been devoted to this research area and references therein. A discrete-time sliding mode control technique has developed for 1-φ inverters in both voltage and current loops. In this technique, the control variable in each sampling period is calculated based on the plant model and feedback quantities. The control is continuous and the chattering problem does not exist. The presented results show good performances under both linear and nonlinear loads. However implementation of this controller is quite complex, and involve more cost. Another SMC control technique using deadbeat current control and proportional voltage control was reported. The deadbeat control concept is suitable when the plant model parameters are known. The presented result is reasonably good. However, its dependence on knowledge of plant parameters limits its application as an outer loop controller in multi-loop feedback systems.

Based on the above discussion, SMC is suitable for improving both steady-state and dynamic performance of an inverter system. More details, including SMC design.

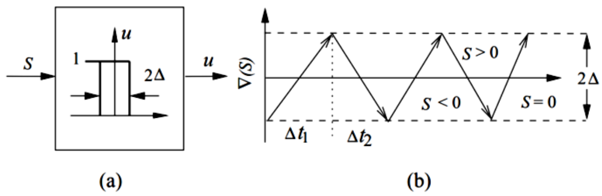

Figure 2.1 Schematic diagram of (a) a hysteresis function (b) the state trajectory in the vicinity of sliding surface S = 0.

Normally, SMC is considered as a good alternative to the control of switching converters. The main advantages of such control scheme over classical one are its robustness and high dynamics performances under parameter fluctuations. However, in order to achieve these advantages the power electronics practitioners usually design and implement the SMC on the basis of hysteresis controller with a band Δ. The hysteresis band Δ essentially forms the boundary layers of the switching surface. Within these boundaries the trajectory (i.e., current and voltage) of the systems jitters and travel along the switching surface guided by boundary layers. In figure 2.1 Schematic has reported where Δt_1 is the conduction time of the switches S_1, S_2 and Δt_2 is the conduction time of S_3, S_4 respectively.

III. LITERATURE REVIEW

SR. NO.	TITLE	AUTHORS	YEAR	APPROACH
1	Adaptive Sliding Mode Control of Standalone Single-Phase Microgrid Using Hydro, Wind and Solar PV Array Based Generation	U. K. Kalla, B. Singh, S. S. Murthy, C. Jain and K. Kant,	2017	Adaptive sliding mode control (ASMC) of an improved power quality standalone single phase microgrid system
2	Slide mode control of microgrid using small hydro driven single-phase SEIG integrated with solar PV array	U. K. Kalla, B. Singh and S. S. Murthy,	2017	A susceptance theory-based sliding mode control (STSMC) algorithm for an improved power quality voltage and frequency control
3	Single-phase microgrid with dual photovoltaic array for efficient power balance based on power conditioning system,	S. Heo, W. K. Park and I. Lee,	2016	A single-phase microgrid based on a power conditioning system with dual photovoltaic array and an energy storage
4	Design and control of single phase photovoltaic systems for AC MicroGrid,	E. h. Margoum, N. Krami, F. Z. Harmouch, H. Al montaser, L. Seca and C. Moreira	2016	The PVSs should be able also to operate below the MPP in order to participate to the MG regulation such as grid frequency stabilization
5	Hybrid Three-Phase/Single-Phase Microgrid Architecture With Power Management Capabilities	Q. Sun, J. Zhou, J. M. Guerrero and H. Zhang,	2015	A hybrid microgrid architecture and its power management strategy to address full use of the energy generated by DGs.
6	Lower gain adaptive Sliding Mode Control of DFIG stator powers,	A. Djoudi, H. Chekireb, S. Bacha and E. M. Berouk,	2014	A lower gain adaptive Sliding Mode Control (SMC) method, of Doubly Fed Induction Generator (DFIG)
7	Design of High-Performance Stand-Alone and Grid-Connected Inverter for Distributed Generation Applications	R. J. Wai, C. Y. Lin, Y. C. Huang and Y. R. Chang,	2013	A high-performance inverter, including the functions of stand-alone and grid-connected power supplies

U. K. Kalla, B. Singh, S. S. Murthy, C. Jain and K. Kant, [1] This exploration presents an adaptive sliding mode control (ASMC) of an improved power quality standalone single phase microgrid system. The reported microgrid 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 reported 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 results 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.

U. K. Kalla, B. Singh and S. S. Murthy,[2] This study presents a susceptance theory-based sliding mode control (STSMC) algorithm for an improved power quality voltage and frequency control of a single-phase microgrid. The proposed microgrid includes a governor-free small hydro turbine-driven single-phase two winding self-excited induction generator (SEIG), a solar PV array and a battery energy storage system (BESS). The non-linear relationship among magnetising reactance, frequency and speed of SEIG along with random fluctuation in active power output of the solar PV array create the major challenge in frequency and voltage control of such renewable energy-based microgrid. The STSMC algorithm is found suitable to control frequency and voltage of such non-linear and complex system. In this proposed control, the system frequency control in dynamics and steady-state conditions and balance of power among various energy sources and BESS are achieved using the sliding mode control. The STSMC eliminates all possibilities of overshoot and undershoot problem in DC-link voltage of the VSC, which in turn reduces the required size of DC-link capacitor and BESS.

S. Heo, W. K. Park and I. Lee, [3] This exploration reported 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.

E. h. Margoum, N. Krami, F. Z. Harmouch, H. Al montaser, L. Seca and C. Moreira, [4] Photovoltaic systems (PVS) based MicroGrid (MG) should be able to operate at the maximum power point (MPP) in order to extract the maximum available power during atmospheric conditions changes. In addition to this, the PVSs should be able also to operate below the MPP in order to participate to the MG regulation such as grid frequency stabilization, voltage profile control and grid management support. This exploration discusses the state of the art of operation and control of PVS in MG. Design and control of a single stage single phase PVS connected to a low voltage AC MG are presented and analyzed. A comparison between two current control methods, Proportional integral with grid voltage feed forward (PI+FF) and proportional resonant with selective harmonics compensation (PR+HC) is also made. The control structures are validated through dynamic simulation.

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 exploration reported 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 reported 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.

A. Djoudi, H. Chekireb, S. Bacha and E. M. Berouk, [6] Reported in the present exploration a lower gain adaptive Sliding Mode Control (SMC) method, of Doubly Fed Induction Generator (DFIG) stator powers. This allows eliminating some problems caused by high gain SMC. The main idea is to put the DFIG model under state space presentation using as states the stator and rotor currents with rotor speed. Using Euler method, the DFIG model can be rewritten as ARMA model, which used to online identification of DFIG resistances and inductances based on Recursive Least Square (RLS) algorithm and Low-Pass Filter (LPF). These identified parameters are used to calculate the stator power control law. In this case, we demonstrated using Lyapunov function that a lower gain satisfied to achieve the control objectives. The viability of our approach is verified by simulation results in the case of DFIG rating at 1.5 MW.

R. J. Wai, C. Y. Lin, Y. C. Huang and Y. R. Chang, [7] In this study, a high-performance inverter, including the functions of stand-alone and grid-connected power supplies, is developed so that distributed generation units can operate individually or in a microgrid mode. In the stand-alone power-supply mode, the output ac voltage can supply to ac loads. In the grid-connected power-supply mode, the goal of power management can be achieved by controlling the amplitude and direction of the output current in the inverter. An adaptive total sliding-mode control (ATSMC) scheme is designed for the proposed high-performance inverter with a full-bridge framework. As a result, the reported high-performance inverter with the ATSMC scheme has the output voltage with a low total harmonic distortion in the stand-alone power-supply mode and the output current with a high power factor in the grid-connected power-supply mode to provide an ac output with high-performance power quality. The effectiveness of the proposed high-performance inverter with the ATSMC is verified by experimental results of a 5-kW prototype, and the merit of the reported ATSMC scheme is indicated in comparison with conventional proportional-integral and proportional-resonant control strategies.

IV. PROBLEM FORMULATION

Protection system is one of the major challenges for microgrid which must react to both main grid and microgrid faults. The protection system should cut off the microgrid from the main grid as rapidly as necessary to protect the microgrid loads for the first case and for the second case the protection system should isolate the smallest part of the microgrid when clears the fault. A segmentation of microgrid, i.e. a design of multiple islands or sub-microgrids must be supported by microsource and load controllers. In these conditions problems related to selectivity (false, unnecessary tripping) and sensitivity (undetected faults or delayed tripping) of protection system may arise. Mainly, there are two main issues concerning the protection of microgrids, first is related to a number of installed DER units in the microgrid and second is related to an availability of a sufficient level of short-circuit current in the islanded operating mode of microgrid since this level may substantially drop down after a disconnection from a stiff main grid.

V. CONCLUSION

In this work an extensive survey of literature based on recent work on adaptive sliding mode control of standalone single-phase microgrid using hydro, wind and solar PV array based generation has reported. Over the past few decades, distributed generation (DG) has gained lots of attraction due to the environmentally-friendly nature of renewable energy, the plug-and-play operation of new generation units, and its ability to offer low installation cost to meet the challenges of the electricity market. DG units provide power at the point of the load center, which minimizes the losses during power transmission and improves the power quality to the loads. Furthermore, it can also be used as a backup source under the absence of grid. There are some advantages and drawback of DG system and microrids are reported in this work based on the findings of recent work.

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]. U. K. Kalla, B. Singh and S. S. Murthy, "Slide mode control of microgrid using small hydro driven single-phase SEIG integrated with solar PV array," in IET Renewable Power Generation, vol. 11.

[3]. S. Heo, W. K. 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]. E. h. Margoum, N. Krami, F. Z. Harmouch, H. Al montaser, L. Seca and C. Moreira, "Design and control of single phase photovoltaic systems for AC MicroGrid," 2016 International Renewable and Sustainable Energy Conference (IRSEC), Marrakech, 2016, pp. 1188-1193.

[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]. A. Djoudi, H. Chekireb, S. Bacha and E. M. Berouk, "Lower gain adaptive Sliding Mode Control of DFIG stator powers," 3rd Renewable Power Generation Conference (RPG 2014), Naples, 2014, pp. 1-6.

[7]. R. J. Wai, C. Y. Lin, Y. C. Huang and Y. R. Chang, "Design of High-Performance Stand-Alone and Grid-Connected Inverter for Distributed Generation Applications," in IEEE Transactions on Industrial Electronics, vol. 60, no. 4, pp. 1542-1555, April 2013.

[8]. P. Dondi, D. Bayoumi, C. Haederli, D. Julian, and M. Suter, “Network integration of distributed power generation,” J. of Power Sources, vol.106, no. 1–2, pp. 1–9, 2002.

[9]. J. P. Lopes, N. Hatziargyriou, J. Mutale, P. Djapic, and N. Jenkins, “Integrating distributed generation into electric power systems: A review of drivers, challenges and opportunities,” Electric Power Syst. Research, vol. 77, no. 9, pp. 1189–1203, 2007.

[10]. N. Hatziargyriou, H. Asano, R. Iravani, and C. Marnay, “Microgrids, “IEEE Power Energy Mag.,” vol. 5, no. 4, pp. 78–94, Jul./Aug. 2007.

[11]. N. Ruiz, I. Cobelo, and J. Oyarzabal, “A direct load control model for virtual power plant management,” IEEE Trans. Power Syst., vol. 24,no. 2, pp. 959–966, May 2009.

[12]. H. Morais, P. Kádár, M. Cardoso, Z. A. Vale, and H. Khodr, “VPP operating in the isolated grid,” in Proc. IEEE Power and Energy Soc. General Meet., 2008, pp. 1–6.