A Review of Intelligent Smart Microgrids for Power Quality and Minimization of Power Loss

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Abstract- Loss of power during the generation of energy and distribution of energy is a major issue in the current decade. Minimization of power loss and quality of power increased by the removal of voltage distortion and fluctuation. Intelligent, smart grid technology gives for the better power generation and distribution for the energy sector world. The impact of intelligent, smart grid technology is increasing in the field of renewable energy plant and neural power plant. The smart grid technology is provided with versatile features. A technology that has let us dreamt about solution of the maximum power problem including generation to distributions ends. The intelligent, smart grid fills the all requirements of consumers and government agency on demand supply ratio. In this paper presents the review of smart grid technology and its advantage and limitation. Also discuss how to reduce the voltage distortion and fluctuation.

Keywords- Smart Grid, Power Quality, Distributed Grids.

I. INTRODUCTION

Microgrids are key elements to integrate renewable and distributed energy resources as well as distributed energy storage systems. Nowadays electrical and energy engineers have to face a new scenario in which small distributed power generators and dispersed energy storage devices have to be integrated together into the grid [9]. The new electrical grid, also named smart-grid (SG), will deliver electricity from suppliers to consumers using digital technology to control appliances at consumer's homes to save energy, reducing cost and increase reliability and transparency. In this sense, the expected whole energy system will be more interactive, intelligent, and distributed. The use of distributed generation (DG) makes no sense without using distributed storage (DS) systems to cope with the energy balances [1]. The microgrid control system follow the condition or some issues for the better purpose. Voltage and frequency management: The system acts like a voltage source, controlling power flow through voltage and frequency control loops adjusted and regulated as reference within acceptable limits. Supply and demand balancing**:** In grid-connected mode, the frequency of the DG units is fixed by the grid. Changing the setting frequency, new active power set points that will change the power angle between the main grid and the microgrid can be obtained. Power quality: The power quality can be established in two levels. The first is reactive power compensation and harmonic current sharing inside the microgrid and the second level is the reactive power and harmonic compensation at the PCC. Thus, the microgrid can support the power quality of the main grid [10]. A key feature of micro grids with distributed energy sources is that the sources are dispersed over a wide area The decentralized control of the individual interfaces should address the following basic issues. The interfaces should share the total load (linear or nonlinear) in a desired way. The decentralized control based on local measurement should guarantee stability on a global scale. The inverter control should prevent any dc voltage offsets on the microgrid. The inverter control should actively damp oscillations between the output filters [1]. Microsource controls need to insure that new microsources can be added to the system without modification of existing equipment, set points can be independently chosen, the microgrid can connect to or isolate itself from the grid in a rapid and seamless fashion, reactive and active power can be independently controlled, and can meet the dynamic needs of the loads. Each micro source controller must autonomously respond effectively to system changes without requiring data from the loads, the static switch or other sources [8]. Stability is a critical issue in a microgrid in which the source power electronic interfaces are controlled in a decentralized way. Each interface is controlled based only on local measurement, Stability analysis studies typically assume that frequency deviations are small even transiently, so that all impedances in the network can be assumed constant. This assumption results in a

significant simplification in the analytical formulation of microgrid stability [14]. Smarter distribution can be achieved through the fast control of hundreds of individual DER units. This would require real time information on each DER unit and key loads. The control complexity and reliability of such a system is greatly reduced using coupled microgrids. The basic smart distribution system objectives include improved reliability, self-healing, simplified controls and increased generation efficiencies through the use of waste heat. Improved reliability, simplified controls and increased efficiencies are imbedded in the basic microgrid concepts. Section-II gives the related work in the form of brief literature survey. In section III discuss the about problem formulation. In section IV discuss the overview about the topic. Finally, in section V conclusion and future scope.

II. RELATED WORK

In this section we discuss about an extended literature survey on the microgrid control model. we have studied various research and journal papers related to automatic microgrid control system. According to our research they have analyzed that many of the papers focuses on the problem of better controlling of microgrid and smartgrid technique for it. Few review of summary described here and implicated with their respective author.

Josep M, Mukul Chandorkar, Tzung-Lin Lee, Poh Chiang Loh Et.al. [1] Authors discuss on advanced control techniques for microgrids. This paper covers decentralized, distributed, and hierarchical control of grid connected and islanded microgrids. At first, decentralized control techniques for microgrids are reviewed. Then, the recent developments in the stability analysis of decentralized controlled microgrids are discussed. Finally, hierarchical control for microgrids that mimic the behavior of the mains grid is reviewed. micro grids are key elements to integrate renewable and distributed energy resources as well as distributed energy storage systems.

Robert H. Lasseter Et. al. [2] Authors describes Managing significant levels of distributed energy resources (DERs) with a wide and dynamic set of resources and control points can become overwhelming. The best way to manage such a system is to break the distribution system down into small clusters or microgrids, with distributed optimizing controls coordinating multimicrogrids. The Consortium for Electric Reliability Technology Solutions (CERTSs) concept views clustered generation and associated loads as a grid resource. The clustered sources and loads can operate in parallel to the grid or as an island. This grid resource can disconnect from the utility During events (i.e., faults, voltage collapses), but may also intentionally disconnect when the quality of power from the grid falls below certain standards.

Shafiee, Qobad, Guerrero, Josep M. Quintero, Juan Carlos Vasquez Et. al. [3] describes in this paper a novel approach to conceive the secondary control in droop-controlled Micro Grids. The conventional approach is based on restoring the frequency and amplitude deviations produced by the local droop controllers by using a Micro Grid Central Controller (MGCC). A distributed networked control system is used in order to implement a distributed secondary control (DSC) thus avoiding its implementation in MGCC. The proposed approach is not only able to restore frequency and voltage of the Micro Grid but also ensures reactive power sharing. The distributed secondary control does not rely on a central control, so that the failure of a single unit will not produce the fail down of the whole system. Experimental results are presented to show the feasibility of the DSC. The time latency and data drop-out limits of the communication systems are studied as well.

Florian Dorfler, John W. Simpson Porco, Francesco Bullo Et. al. [9] Authors discuss on control strategies for three layers and illuminate some possibly-unexpected connections and dependencies among them. Building from a first-principle analysis of decentralized primary droop control, they study centralized, decentralized, and distributed architectures for secondary frequency regulation. they find that averaging-based distributed controllers using communication among the generation units offer the best combination of flexibility and performance. They further leverage these results to study constrained AC economic dispatch in a tertiary control layer. Surprisingly, they show that the minimizers of the economic dispatch problem are in one-to-one correspondence with the set of steady-states reachable by droop control.

Ritwik Majumder, Balarko Chaudhuri, Arindam Ghosh, Rajat Majumder, Gerard Ledwich, Firuz Zare Et. al. [10] authors presents in this paper investigates the problem of appropriate load sharing in an autonomous microgrid. High gain angle droop control ensures proper load sharing, especially under weak system conditions. However it has a negative impact on overall stability. Frequency domain modeling, eigen value analysis and time domain simulations are used to demonstrate this conflict. A supplementary loop is proposed around a conventional droop control of each DG converter to stabilize the system while using high angle droop gains. Control loops are based on local power

measurement and modulation of the d-axis voltage reference of each converter. Coordinated design of supplementary control loops for each DG is formulated as a parameter optimization problem and solved using an evolutionary technique.

Ritwik Majumder, Arindam Ghosh, Gerard Ledwich, Firuz Zare Et.al. [11] authors in this paper describes control methods for proper load sharing between parallel converters connected in a microgrid and supplied by distributed generators (DGs). It is assumed that the microgrid spans a large area and it supplies loads in both in grid connected and islanded modes. A control strategy is proposed to improve power quality and proper load sharing in both islanded and grid connected modes. It is assumed that each of the DGs has a local load connected to it which can be unbalanced and/or nonlinear. The DGs compensate the effects of unbalance and nonlinearity of the local loads. Common loads are also connected to the microgrid, which are supplied by the utility grid under normal conditions. However during islanding, each of the DGs supplies its local load and shares the common load through droop characteristics. Both impedance and motor loads are considered to verify the system response.

Yun Wei Li, Ching-Nan Kao Et. al. [12] authors define, a power control strategy is proposed for a low-voltage microgrid, where the mainly resistive line impedance, the unequal impedance among distributed generation (DG) units, and the microgrid load locations make the conventional frequency and voltage droop method unpractical. The proposed power control strategy contains a virtual inductor at the interfacing inverter output and an accurate power control and sharing algorithm with consideration of both impedance voltage drop effect and DG local ,load effect. Specifically, the virtual inductance can effectively prevent the coupling between the real and reactive powers by introducing predominantly inductive impedance even in a low voltage network with resistive line impedances.

III. PROBLEM FORMULATION

In this section discuss the problem of voltage distortion and fluctuation in smart grid technology. In the process of review study finds some system and communication level problem identified in smart micro grids. The operation of smart grid not performed in well manner such types of problem is occurred. Some point is discussed related to the problem of smart grid technology.

1. In the grid-connected operation, the utility needs to balance power flow between sources and loads, and to maintain voltage quality. In contrast, inverter-based DGs must coordinate power requirements in the islanding networks. In order to maintain decent power quality as well as collect more energy from RESs, power conditioning equipment is definitely required.

2. Voltage distortion and voltage unbalance in islanding networks are severe due to high line impedance and uneven distribution of single-phase DGs/loads. Instead of installing power conditioning equipment, a preferable solution is to provide power-quality services by inverter-based DGs. That means, in addition to transferring fundamental power, the inverter needs to provide harmonic filtering as well as unbalanced suppression.

3. A harmonic power vs. voltage loop bandwidth droops to share the harmonic current among multiple inverters when sharing nonlinear loads. However, since this approach is based on increasing the gain of the voltage loop to reduce the bandwidth when the distortion increases, it can affect to the closed-loop system stability.

4. In case of paralleling inverters, the droop method consist of subtracting proportional parts of the output average active and reactive powers to the frequency and amplitude of each module to emulate virtual inertias. These control loops, also called P–f and Q–E droops, have been applied to parallel-connected uninterruptible power systems (UPS) in order to avoid mutual control wires while obtaining good power sharing [16].

5. Harmonic current sharing techniques have been proposed to avoid the circulating distortion power when sharing nonlinear loads. All of them consist in distorting the voltage to enhance the harmonic current sharing accuracy, resulting in a trade-off.

IV. OVERVIEW

The control of active power and reactive power exchange between grid connected converters and the utility grid is an important factor when considering the operation of ac power systems that employ distributed generation. The call for a sustainable society with renewable and distributed resources has driven the implementation of power electronic technology into ac power systems. Recently a power electronic converter called the static VAr compensator (STATCOM) has been employed to provide reactive power support to the ac power system. Active power support cannot be provided with the standard STATCOM due to the limited energy stored in the dc-link capacitor, nonetheless the real power capabilities of the STATCOM can be enhanced by the addition of energy storage to the dc-link. The exchange of active power and reactive power can be controlled by adjusting the amplitude and phase of the converter output voltage.

A. Grid Connected Converters

Power electronic converters have been predominantly employed in domestic and industrial applications. However, due to advancements in power semiconductor and microelectronics technologies, their application in power systems has gained more attention in recent times. Thus power electronic converters are increasingly employed in power conditioning, compensation and power filtering applications. Power electronic converters employed in power systems can be categorized into voltage source converters (VSC) and current source converters (CSC). In a VSC the dc-side is a DC-link voltage. CSC derives its terminal power from a current source e.g. a reactor. In comparison, a magnetized reactor is much lossier than a charged capacitor. The Voltage Source Converter (VSC) has several advantages over the Current Source Converter (CSC). Examples are unrestricted flow of reactive power in VSC and independent active and reactive power conversion. Based on the number of synthesized output voltage levels, VSCs can generally be categorized into two-level converters and multilevel converters. In recent times there has been a move towards increasing the voltage compatibility of IGBT voltage source converters. Diode–clamped multilevel converter, flying–capacitor multilevel converter, cascaded converter and mixed level hybrid cell converters are examples of multilevel converter topologies introduced to achieve this. These converter topologies allow recent semiconductor devices to be utilized in higher voltage applications without incurring voltage-sharing problems. However, in order to have multilevel converters operate safely and reliably, their complex configurations require more complicated control techniques. Therefore, for simplicity and economic reason, the two-level PWM converter has been chosen in this work. The switching technique used is based on the space vector PWM (SVPWM) modulation. Switching techniques are required for the purpose of synthesizing a close-approximation to a sinusoidal voltage.

B. Grid Current Control

Current controlled converters have the advantages of high accuracy control of instantaneous current, peak current protection, overload rejection and very good dynamics. They exhibit better safety, better stability and faster response. There are various possible strategies and structures for controlling the current in voltage source converters. These can be divided into two main groups, namely linear and non-linear controllers.

C. Linear Current Controllers

Linear current controllers have separate current control blocks and voltage modulation (PWM) blocks. Their structure enables them to exploit the advantages of modulators such as sinusoidal PWM and space vector modulation where constant switching frequency with a well-defined harmonic spectrum is employed. PI-Based controllers and deadbeat controllers are examples of linear current controllers. Classical PI control is commonly used for current-controlled grid connected converters. This approach exhibits two major drawbacks: The inability of the PI controller to track a sinusoidal reference without steady state error and a poor rejection capability. This is due to the poor performance of the integral action when the disturbance is a periodic signal. As discussed in the previous section (vector control), this limitation can be solved by implementing the PI control in a d-q rotating frame. The performance of a PI controller implemented in the rotating d-q frame can be improved by using cross coupling terms (ωL) and /or feed-forward grid voltage. The feed-forward grid voltage is used to improve the dynamics of the controller during grid voltage fluctuations. The cross-coupling terms are used to control the flow of active and reactive power through the active and reactive current components.

D. Non-Linear Current Controllers

Nonlinear current controllers can produce the switching signals required to control grid connected converters directly. They are employed in applications where the PWM modulators are negligible. Examples of non-linear current controllers are hysteresis controller, neural network controllers and fuzzy logic controllers. Non-linear

current controllers have excellent control response. With the exception of hysteresis controller, these controllers are difficult to implement in practical systems. Hysteresis control is simple and robust. The output of the hysteresis comparator is the state of the switches in the power converter. In the case of a two-level three phase grid connected converter, three hysteresis controllers are required (one for each leg of the converter). Three-phase output currents of the inverter are detected and compared with a corresponding phase current references individually. The switching signals are produced when the error exceeds an assigned tolerance band. Hysteresis control is insensitive to system parameters changes but it has unsatisfactory features. The main disadvantage of hysteresis control is the varying switching frequency it generates for the power converter. A number of proposals have been put forward to overcome variable switching frequency. A fixed modulation frequency has been achieved by varying the width of the hysteresis band as a function of instantaneous output voltage. This is achieved with the use of a feed forward action or a phase locked loop. Depending on the method used the complexity of the controller can be increased significantly, hence the advantage of the simplicity of the hysteresis controller is lost. The hysteresis controller has arguably the best performance of all the available controllers. However, its performance is significantly affected by switching frequency constraints enforced at high power levels. Amongst the linear controllers, the classical PI control implemented in the d-q rotating frame shows the most promise due to its excellent control performance and less dependence on plant parameters. Therefore, the PI based control implemented in the d-q rotating frame has been adopted for the control of grid current in this work.

V. CONCLUSION AND FUTURE WORK

In this paper presents the review of intelligent smart grid for the distributions of power and generation of power in different power sector unit. The advancement of intelligent smart grid technology improved the quality of power and minimization of loss due to system level and communication level. The distributions of load are also a major issue in grid technology. For the minimization of loss factor and improvement of quality of power various researcher suggested various technology in cooperation with modern trends. Also discuss in this paper the limitation and problem formulation of intelligent smart grid technology. Although smart grid enable power grid to be empowered with intelligent and advanced capabilities, it also opens up many new challenges and risks. Hence some challenges and risks in both topics are also briefly discussed, along with possible solution to overcome it. One important control task in power systems is to maintain balance between power production and consumption which means keeping the power system's frequency at an appropriate level. This process is becoming more and more challenging due to an increase in the penetration level of intermittent power production. In future design automatic intelligent smart grid technology for the improvement of power quality.

REFERENCES

[1] Josep M. , Mukul Chandorkar, Tzung Lin Lee, Poh Chiang Loh "Advanced Control Architectures for Intelligent Micro Grids. Part I: Decentralized and Hierarchical Control" IEEE,2011 PP1-17

[2] P. C. Loh and F. Blaabjerg, "Autonomous control of distributed storages in microgrids" IEEE-ICPE, 2011, PP. 536-542.

[3] Shafiee, Qobad, Guerrero, Josep M. Quintero, Juan Carlos Vasquez "Distributed Secondary Control for Islanded MicroGrids - A Novel Approach" IEEE 2014 PP 1-14.

[4] J. M. Guerrero, P. C. Loh, M. Chandorkar, T.-L. Lee, "Advanced Control Architectures for Intelligent MicroGrids – Part I: Decentralized and Hierarchical Control," IEEE Trans. Ind. Electron, 2012.

[5] F. Blaabjerg, R. Teodorescu, M. Liserre ,A. V. Timbus, "Overview of control and grid synchronization for distributed power generation systems," IEEE 2006 PP. 1398-1409.

[6] Y. Li, D. M. Vilathgamuwa, P. C. Loh, "A grid-interfacing power quality compensator for three-phase three-wire microgrid applications," IEEE, 2006 PP. 1021- 1031.

[7] S.-K. Kim, J.-H. Jeon, C.-H. Cho, J.-B. Ahn, S.-H. Kwon, "Dynamic modeling and control of a grid-connected hybrid generation system with versatile power transfer," IEEE 2008 PP. 1677–1688.

[8] M. Liserre, F. Blaabjerg, R. Teodorescu, "Grid impedance estimation via excitation of LCL-filter resonance," IEEE 2007 PP. 1401–1407.

[9] Florian Dorfler, John W. Simpson-Porco, Francesco Bullo "Breaking the Hierarchy: Distributed Control & Economic Optimality in Microgrids" MATH.OC 2014

[10] Ritwik Majumder, Balarko Chaudhuri, Arindam Ghosh, Rajat Majumder , Gerard Ledwich, Firuz Zare "Improvement of Stability and Load Sharing in an Autonomous Microgrid Using Supplementary Droop Control Loop" Institute of Electrical and Electronics Engineers Power & Energy Society 2010 .

[11] Ritwik Majumder, Arindam Ghosh, Gerard Ledwich , Firuz Zare "Load Sharing and Power Quality Enhanced Operation of a Distributed Microgrid" The Institution of Engineering and Technology 2009.

[12] Yun Wei Li, Ching Nan Kao "An Accurate Power Control Strategy for Power-Electronics-Interfaced Distributed Generation Units Operating in a Low-Voltage Multibus Microgrid" IEEE 2009 PP 2977-2988.

[13] Shivkumar V. Iyer, Madhu N. Belur, Mukul C. Chandorkar "A Generalized Computational Method to Determine Stability of a Multi-inverter Microgrid" IEEE 2010 PP 2420 -2432.

[14] Savaghebi, Mehdi , Jalilian, Alireza , Vasquez, Juan C. , Guerrero, Josep M., Lee, Tzung-Lin "Voltage Harmonic Compensation of a Microgrid Operating in Islanded and Grid- Connected Modes", ICEE 2011

[15] Savaghebi, Mehdi, Guerrero, Josep M., Jalilian, Alireza, Vasquez, Juan C. "Experimental evaluation of voltage unbalance compensation in an islanded microgrid" IEEE 2011
[16] Jin-Hong Jeon, Jong-Yul Kim , Hak-Man Kim, Seul-Ki Kim, Changhee Cho, Jang-Mok Kim, Jong-Bo Ahn, Kee-Young Nam "Development of Hardware In-the-Loop Simulation System for Testing Operation and Control Functions of Microgrid" IEEE 2010 PP 2919-2929.
[17] Joerg Dannehl, Marco Liserre, Friedrich Wilhelm Fuchs, "Filter-Based Active Damping of Voltage Source Converters With LCL Filter" IEEE 2011 PP 3623-3631.
[18] J.C. Vasquez, Josep M. Guerrero, Jaume Miret, "Hierarchical Control Of Intelligent Microgrid" IEEE 2011 PP 23-29.
[19] E. Barklund, Nagaraju Pogaku, Milan Prodanovic, C. Hernandez-Aramburo, Tim C. Green "Energy Management in AutonomousMicrogrid Using Stability Constrained Droop Control of Inverters" IEEE 2008.
[20] Paolo Piagi , Robert H. Lasseter "Autonomous Control of Microgrids" IEEE 2006.