Journal of Advanced Research in Electrical Engineering and Technology
Volume 3, Issue 1 - 2020, Pg. No. 1-6
Peer Reviewed Journal

Article

A Review on Need of Integrated Distributed Energy Sources with Seamless Mode Transition In Perspective of Controlling, Protection, Equilibrium and Island Operation of Microgrids

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I N F O

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How to cite this article:
Gullapelli M, Hadpe S. A Review on Need of Integrated Distributed Energy Sources with Seamless Mode Transition In Perspective of Controlling, Protection, Equilibrium and Island Operation of Microgrids.
J Adv Res Electri Engg Tech 2020; 3(1): 1-6.

Date of Submission: 2019-12-26
Date of Acceptance: 2020-01-14

A B S T R A C T

Amalgamation or interconnection of distributed energy resources is evolving as an emerging power scenario for electric power generation, transmission and distribution infrastructure globally based on the significant issues, such as scarcity of fossil fuel in future, widespread disposition of advanced Distributed Energy Resources (DERs) technologies, deregulation of electric utility industries and public awareness on environmental impact of traditional electric power generation. These issues are changing the power generation concept worldwide and opening up new challenges in the generation and dispersal markets. Small non-conventional generation combined with Distributed Generation (DG) with an integrated power conditioning system (PCS) is rapidly becoming more attractive because it produces electrical power with less environmental impacts, easy to install, and highly efficient with increased reliability. It is important to have review and study observation of different system defined during the integration of these energy source for uninterrupted mode transition of microgrids

Keywords: Distributed Energy Resources, Distributed Generation, Power Conditioning System, Microgrid

As the awareness on conservational issues like worldwide warming is increasing; renewable energy sources are attractive most significant sources of energy in modern power scenario. Geographical, environmental, political and financial factors of different countries lead to increased use of renewable energy resources like wind–electric conversion system, photovoltaic system, biomass resources etc. Also, the low power generation capacity of DER has motivated the need for integration of different types of DERs and loads in the method of microgrid to enhance the power generation capacity, reliability and marketability of dispersed type of micro sources with a promising approach to reduce the load congestion on the conservative power system or utility grid and facilitating localized generation at customer ends. The effective integration of DERs depends on the versatile nature of DGs such as photovoltaic system, wind power, small hydro turbines, tidal, Combined Heat Power (CHP) based microturbines, biogas, geothermal,

fuel cells including battery packing facilities etc. that have the potential to support conventional power system with many issues involved with their interconnections. There are general interconnection necessities, e.g. response to irregular conditions as well as operation, power quality, and safety conditions including operation in utility grid connected and islanded mode.

Smart grid has been developed with microgrids which produce, store and utilize energy differently to the conventional centralized power supply system. The microgrid is a small-scaled power system, which comprises distributed energy resources such as renewable energy source and energy storage system, internal load, and additional power quality devices. The energy storage system has been necessary for flexibility in terms of power control and the renewable energy source has been general but important component for the green energy generation in the microgrid.

The microgrid control is divided into three hierarchical levels such as primary, secondary, and tertiary control. This control structure enhances the microgrid to be extra intelligent system. Because most interfaces of the distributed energy resources are based on the switching mode inverter for the controllability, it is appropriate that the interface of the microgrids is also based on the bidirectional inverter, which is able to transfer energy between the utility grid and internal resources. For the connection to the grid, the correct phase of the grid should be obtained by the Phase-Locked Loop (PLL) and the microgrid can be connected to the grid seamlessly through the state-of-the-art inverter controls. Thus, many microgrids can be associated together, making a bigger power system. In this paper, evolution of power conditioning system for the microgrid uninterrupted operations is discussed.

Literature Review

To obtain the results and review, study of various researchers we refer following papers:

Thomas S. Basso et al, (2003) In paper "IEEE P1547-Series of Standards For Interconnection", They have defined the effective integration of DERs depends on the versatile nature of DGs such as photovoltaic system, wind power, small hydro turbines, tidal, Combined Heat Power (CHP) based microturbines, biogas, geothermal, fuel cells including battery storage facilities etc. that have the potential to support conventional power system with many questions involved with their interconnections. In this standpoint, IEEE P1547- 2003 is a benchmark model for intersecting DERs with Conservative Electric Power System[1] which make availablestrategies to overall interconnection necessities, e.g. reply to abnormal conditions including operation, power quality, and safety conditions including operation in utility grid connected and islanded mode.

Tadao Ishikawa, et al, (2002) In Review report "Grid-connected photovoltaic power systems: survey of inverter and related protection equipment's" mentioned that Grid interconnection of PV power generation system has the advantage of more effective utilization of generated power. However, the technical requirements from both the utility power system grid side and the PV system side need to be satisfied to ensure the safety of the PV installer and the dependability of the utility grid. Clarifying the mechanicalnecessities for grid interconnection and resolving the problems such as islanding uncovering, harmonic distortion necessities and electromagnetic interfering are consequently very significantproblems for extensive application of PV systems.[2]

Eikelboom J. A., et al, (2000) "Classification of PV modules of new generations, results of tests and simulations" and Carr A. J., et al, (2004) "A contrast of the presentation of different PV module types in temperate climates" shows that the energy production of a grid-connected PV system depends on various factors. Among these we distinguish the rated characteristics of the components of the PV system, the installation configuration, the geographical siting of the PV system, its surrounding objects, and defects that occur during its operation. The need for PV arrays and inverters to be characterized has then become a more and more important aspect.[3-4]

J. A. P. Lopes et al, (2006) "Defining control strategies for microgrids islanded operation" This articledesignated and assessed the possibility of governor strategies which can be accepted for the process of a microgrid when it develops isolated. Commonly, the microgrid activates in interconnected method with the medium voltage network; nevertheless, scheduled or forced isolation can be substituted. In this case, the microgrid must have the ability to activate stably and self-sufficiently. An assessment of the essential of storage devices and load shedding strategies like single, Multi master and subordinate load control can be definite for islanded operations.[5]

A. Nasiri, et al., (2007) "Digital control of three-phase series-parallel uninterruptible power supply systems," paper familiarized a new digital organizer for a three-phase series-parallel Uninterruptible Power Supply (UPS) system. This UPS has advancedeffectiveness than online topology and it is accomplished to make available output voltage and input current acclimatizing in ordinary operation. The digital controller follows the voltage reference of the series converter with four sampling periods which also regulates the output current of the parallel converter with two-sampling delays. The comprehensiveexamination of the organizer has been on condition that in dissimilar operating modes of the system. The power flow examination of the system is also conversed with reverence to voltage and current harmonics.[6]

J. P. Lopes, et al, (2007) "Integrating distributed generation into electric power systems: A review of drivers, challenges and opportunities" In this paper key mattersconnected to the integration of distributed generation into electric power systems that are of most interest to power system planners and operators, policy makers and regulators, DG developers and customers in the electrical energy supply industry. And it's very mandatory to have more research in DG. An outline of the chief challenges that must be overwhelmed in the incorporation of DG into energy supply systems was also been obtainable. Researchers have mostlyattentive on specific emphasis was positioned on the need to shift network planning and functioning policies away from the fit and forget policy of connecting DG to electric power systems to a novel more suitable policy of integrating DG into power system preparation and operation though active management of distribution networks. Some of the opportunities that might be oppressed in support of the integration and hence superior penetration of DG into electric power systems were also traveled.[7]

R. Zamora et al, (2010) "Controls for microgrids with packing: Evaluation, tasks, and investigationrequirements," In this paper authors have mostlydeliberated on controlling of microgrids. To work in island operations two issuescarefullyconnected to these systems are microgrid controls and energy storage applications. The microgrid advancedependability of the distribution system by as long as power to the delicate loads when there is no source from the grid which are additionalrecognized as smart grid.[8]

Further research has been done on microgrids like M. A. Eltawil, et al., (2010) "Grid-connected photovoltaic power systems: technical and potential problems-a review," this smart grid has been developed with microgrids which are able to produce, store, and utilize energy differently to the conventional centralized power supply system. The renewable energy source and energy storage system, internal load, and additional power quality devices are known as microgrid which is a small-scaled power system, and comprised into Distributed Energy Resources (DER).[9]

P. Basak, et al., (2012) "A worksevaluation on integration of dispersed energy resources in the viewpoint of control, fortification and constancy of microgrid" in this paper it is experiential that possibility of microgrid process has many factors which are to be deliberatedcooperatively. For successful integration of DERs, due care to be taken for proper operation and control, protection and constancy issues. It is Stimulating to note that all these issues are to be concurrently and satisfactorily implemented during feasible operation of microgrid. The authors emphasized on technical aspects of microgrid the commercial issues are to be solved which may be different as per social, political and commercial policies of a particular country. Authors have realized that it is necessary to investigate the possibility of microgrid operation in the industrial fields and steady and dynamic state studies have been done in aherbalfortified with many induction machines. It is observed that there is a need of customer adoption of microgrid through recommending customer adoption modeling (DER-CAM). The submission of energy management system (EMS) is found as an important feature of microgrid operation and control for maximum utilization of generator and supply of heat to the consumers. In addition, authors have mentioned the scopes of power electronic based sophisticate application, specifically, static inverters with storage facilities provided with ''plug-and play'' functionality to provide compulsorysuppleness. The operation and control of CERTS microgrid in the form of integrated DERs in grid connected and islanded modes are found very useful with three-layer control using micro source controller, protection coordinator and energy manager. In the research activities in Europe on integration of DERs, the three factors namely security of energy supply, climate change and sustainable economic growth found significant found significant. The environment friendly and cost-effective technologies are needed to be industrialized in the universal research on DERs. In this paper it is also highlighted that the protection of microgrid system with fast solution of power quality issues along with stability of integrated dispersed DERs systems are essential factors to increase the acceptability of microgrid as an emerging power system is further needed.[10]

D. E. Olivares, et. al, (2014) "Trends in microgrid control" In this research paper the major issues and challenges in microgrid control were discussed, and a review of state-of-the-art control strategies and trends is presented; a general overview of the main control principles (e.g., droop control, model predictive control, multi-agent systems) is also included. This paper has classified the microgrid control strategies into three levels: primary, secondary, and tertiary, where primary and secondary levels are related with the operation of the microgrid itself, and tertiary level pertains to the synchronized operation of the microgrid and the host grid and discussed about the challenges, trending approaches and their need.[11]

J. C. Vasquez, et al., (2010) "Hierarchical Control of Intelligent Microgrids," this paper have mentioned key issues which helps in integration of microgrids, following are the observations. There is a need of improvement of not only the transient response of the DG and DS units but also of the microgrid, as well as virtual impedance: harmonic power sharing and hot-swapping of DG and DS units and adaptive droop control laws to increase the interactivity of the system. Also mentioned the hierarchical controls required for an microgrid; Primary control based on the sag method allows the connection of different ac sources acting like synchronous machines. Secondary control avoids the

amplitude and frequency deviation produced by the primary control. Only low-bandwidth communications are desirable to perform this control level. A synchronization loop can be added in this level to transfer from islanding to grid connected modes. Tertiary control allows import/ export active and reactive power to the grid, estimates the grid impedance, nonplanned islanding detection, and harmonic current injection to recompense for voltage harmonics in the PCC. Additional features are also required to the flexible microgrids: voltage ride-through and power quality in the PCC, black start operation, grid impedance estimation and islanding detection, storage energy management and control. These new features will permit microgrids more intellect and flexibility to participate DG and DS possessions into the future smart grid. This perception will be an instinct for the incorporation of clean energy resources, permitting a more maintainable electrical grid system in global terms.[12]

N. Pogaku, et al., (2007), "Modeling, Analysis and Testing of Autonomous Operation of an Inverter-Based Microgrid," In this paper, a small-signal state-space model of a microgrid is obtainable. The system comprises inverter low frequency dynamics, high frequency dynamics, network dynamics, and load dynamics. Altogether the submodules are individually modeled and are then combined on a shared reference frame to obtain the complete model of the microgrid. The model was examined in terms of the system eigenvalues and their sensitivity to different states. With the help of this analysis the relation between different modes and system parameters was established. It was experimental that the dominant low-frequency modes are extremely sensitive to the system configuration and the limitations of the power circulation controller of the micro sources. The high frequency modes are principally sensitive to the inverter inner loop controllers, network dynamics, and load dynamics. Through results It was experiential that the model positively predicts the complete microgrid dynamics both in the low and high frequency range. Small signal modeling has had a long history of use in conservative power systems. The inverter models (and the inclusion of network dynamics) allow microgrids to be intended to achieve the stability margin required of reliable power systems. This control structure improves the microgrid to be more intelligent system.[13]

Cho, et al., (2011) "Active Synchronizing Control of a Microgrid", The model planned here is an automatic synchronizing method for a microgrid, which can be applied to practical microgrid implementations. An active synchronizing control scheme that assumes the network-based control of multiple DGs to regulate the frequency and voltage of the microgrid is future in this research paper. Dynamic modeling and simulation are presented to show the system behavior underneath the prearrangedtechnique. And simulation results, which current how much the network delay has an effect on the synchronizing control performance. Concluded two experimental cases of a practical microgrid pilot plant, authors established the basic features of the planned controller and confirmed that a deterministic and dependable synchronization is attained using the planned controller even under the presence of power fluctuations in the renewable source.[14]

Z. Liu, et. al., (2014) "A unified control strategy for three-phase inverter in distributed generation," This paper presents a unified control strategy that permits both islanded and grid-tied processes of three-phase inverter in dispersed generation, with no indispensable for switching amid two compliant controllers or critical islanding detection. The planned control strategy comprises of an inner inductor current loop, and a novel voltage loop in the synchronous reference frame. The inverter is controlled as a current source just by the inner inductor current loop in grid-tied operation, and the voltage controller is mechanicallystimulated to control the load voltage upon the incidence of islanding. Additionally, the waveforms of the grid current in the grid-tied mode and the load voltage in the islanding mode are distorted under nonlinear local load with the conventional strategy. And this issue is addressed by suggesting a unified load current feedforward and it can advance the waveform quality of both the grid current in the grid-tied mode and the load voltage in the islanded mode. The planned unified control strategy was confirmed by the simulation and experimental results.[15]

C. L. Chen, et. al., (2010) "Design of parallel inverters for smooth mode transfer microgrid applications" In this paper, smooth mode transfers and precise current sharing are achieved in a multi-inverter-based microgrid system by the intendedscheme level controls with control area network communication. Controllers of individual inverters inside the microgrid in equally grid-tie and islanding modes are also considered to confirm high-quality output waveforms. The mode transfer tests are directed with an inverter-simulated grid to describe the proper transfer events. Investigational results demonstration that the inverters can make availableunchanging outputs in dissimilar basic microgrid operation modes. With the intended current sharing scheme, the output current is correspondingly shared among paralleled inverters deprived ofobvioussocializing current. Both the imitation and investigationalconsequences of mode transfer demonstration that the multi-inverter-based microgrid system is able to smoothly switch amid the grid-tie and islanding modes to guarantee ancontinuous power supply to the critical loads within the microgrid.[16]

Thus, many microgrids can be connected together, making a bigger power system using the inverter, Power Conditioning System (PCS).

Existing System Architecture

The existing system proposes an outline of intensity molding framework (PCS) and microgrid island tasks which depends on the PCS. The microgrid can be islanded from a utility framework and can be associated with the network consistently after stage identification and synchronization to the lattice through a stage bolted circle and a large number rate-controlled synchronizer, individually. There are three microgrid activities in view of the PCS. The microgrid distinguishes a lattice disappointment and changes quick to an island in the security mode. Then again, it changes the activity mode easily through an adjustment period in the auto-island mode. The microgrid can likewise be an island through coordinating the supply and load amid association with the network in the zero-vitality mode. In this system they had used two photovoltaic sources i.e. solar panel. In this one solar panel is connected to the PV inverter and another one is connected to the PV charger.[17] Purpose of developing the power conditioning system and the microgrid island operations using the PLL and synchronizer by the simulations of the three microgrid operation modes. Which is capable to operate all islands without power outages (seamless operation) during transitions between island and grid modes.

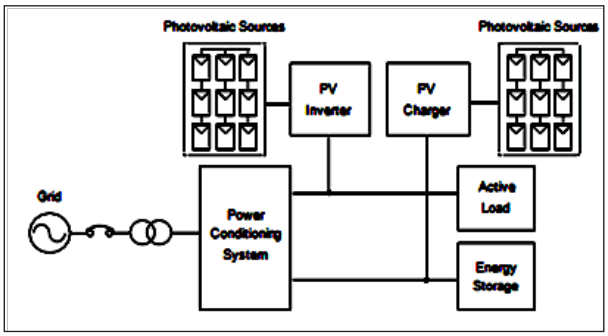

Figure 1.Microgrid Architecture Based on Power Conditioning System

In planned system the power conditioning system and the microgrid island operations. By means of the PLL and synchronizer, the phase of the grid was detected and the phase of the microgrid was familiar using the slew-rate control to the grid phase, correspondingly. The foremostmanagercontained of the voltage and current controller, and created on the seamless mode transition of the controller in the power conditioning system, the microgrid transformed its state amid the grid-connection and island state. The microgrid island operations were confirmed by the imitations of the three microgrid operation modes. The microgrid noticed the grid fault so initial, it altered mode effortlesslyseparately, and it acted like an island in spite of the connection to the grid conferring to the operation mode.

Conclusion

The latest research and development in the field of microgrid as a promising power system through a comprehensive literature review is presented in this paper. It is observed that from year 2000, the microgrid technology for the uninterrupted power supply is developed and many researchers have shown their interest to improve it for the mankind. Itsdemonstrations a comprehensive overview on the worldwide explorationtendency on microgrid which is most important topic at contemporary. This literature survey exposes that incorporation ofdispersed energy resources, operation, control, power excellencequestions and stability of microgrid system would be discovered to contrivance microgrid efficaciously in real power scenario. And there is wide scope to enterprise and progress the classifications to activate the microgrids in uninterrupted mode.

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