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Auto synchronization of Microgrid with Main Grid after Islanding Operation - A REVIEW

PushprajsinhG.Jadeja,Dilip R. Moyal

Pursuing M.E Elect Engg. (Power System) , B.H.Gardi College of Engg.& Tech., Rajkot(GTU)
Assistant Professor (Elect.Engg.), B.H.Gardi College of Engg.& Tech., Rajkot(GTU)

Abstract: *This paper provides a review of research concerning thesynchronization technique for microgrid reclosing after islanding operation. It offers a brief review on some of the published work on control for grid connected and intentional islanding operations of microgrid.*
The future electric grid concept will cover some small parts to be disconnected and work in an autonomous way isolated from the main utility. Control of microgridscomposed by the couple distributed sources-local loads – with the competence of operating in grid-connected and island mode is a trending research area. The presence of an efficient algorithm for synchronizing the microgrid with the main grid every time the reclosure is allowed is crucial for assuring a safe operation.DG units are significantly and conceptually very different from conventional power system in terms of load characteristics, power quality constraints, market participation strategies and the control and operational strategies.

Keywords: *Distributed Generation (DG), Microgrid, Grid connected Mode, Islanding Mode, Islanding Detection, Synchronization*

I. INTRODUCTION

The classical concept of electric grid is based on the premise that generation and consumption are concentrated in geographically different points, being the grid itself the energy delivery mean between them.[10] However, the great development suffered in the recent years by distributed generation (DG) and renewable energies are provoking a challenging change on the electric grid structure. Technologies based on wind power and photovoltaic suppose a great part of the small front-end power converters microgrid forming. Besides, energy storage systems based on supercapacitors, flywheels energy storage (FES) and superconducting magnetic energy storage (SMES) supposes a usual part of a microgrid. The island operation of a microgrid can be very attractive: it satisfies the continuous supply of critical local loads as a power quality requirement and there is no need of stopping the power generation from DG sources. Working in both grid-connected and island operating modes set out several challenges to deal with. When grid-connected, DG systems must deliver some active and reactive power references while local voltage and frequency must be regulated and load sharing must be carried out when isolated of the main network. Besides, unintentional islanding events can compromise the integrity of the system. This can occur when the power supply from the main utility is interrupted but the DG keeps on energizing the distribution network.

Several anti-islanding techniques have been proposed based onpassive [11] and active [12] methods in order to detect theseundesirable events. That way it is possible to limit thegeneration to the local consumption and establish the islandcontrol strategy. An LC or LCL filter is usually employed asinterface between the power electronic converter and the areaelectric power system (EPS). Droop control has been deeplyemployed as high-level control in order to fulfill all theserequirements [13]. Although there are others options [14], it isgenerally disposed in cascade with a voltage controller, whichregulates the capacitor voltage. Hence, the filter and theconverter can be seen as a controllable voltage source forkeeping the microgrid's voltage magnitude and frequencywithin the desired ranges.
Nevertheless, the microgrid is not generally allowed tooperate in island mode [15]. The DG sources are forced to tripoff before the associated area EPS carries out the reclose.
There are two negative concerns when this statement is notfulfilled: (l) the automatic reclosing attempt can beunsuccessful if the fault arc has not been extinguish resultingin an extended restoration for the customers and (2) themicrogrid is likely loss the synchronism with the area EPSleading to an out-of-phase reclose.
In [16], the synchronization system is based on obtainingthe frequency of the system by means of a frequency-lockedloop (FLL). In [17], the phase is the variable under analysisworked out with a PLL. This system itself presents worsenbehavior in unbalanced and distorted grid conditions.The synchronization technique employed in this paperemploys the voltage

controller to make the voltage capacitortracks the point of common coupling (PCC) voltage. In orderto constitute the voltage reference, verify the performance anddecide the reconnection instant, a sequence detector and aSFR-PLL [18].
[19] are employed for monitoring the PCC andcapacitor voltages.

II. LITERATURE REVIEW

I.Balagur et al, "Control for Grid-Connected and Intentional Islanding Operations of Distributed Power Generation", discussed the new technique and control Strategy of microgrid connection and islanding operation for distributed generation system.In this paper Intentional islanding describes the condition in which a microgrid or a portion of the power grid, which consists of a load and a distributed generation (DG) system, is isolated from the remainder of the utility system. In this situation, it is important for the microgrid to continue to provide adequate power to the load. Under normal operation, each DG inverter system in the micro grid usually works in constant current control mode in order to provide a preset power to the main grid. When the microgrid is cut off from the main grid, each DG inverter system must detect this islanding situation and must switch to a voltage control mode. [1]

F. D. Kanellos et al. "Microgrid Simulation during Grid Connected and Islanded Modes of Operation", focused on the connection of microgrid with PV module and wind mill. In this paper the steady state and transient operation of a typical microgrid are studied. The models of two dispersed generation units (photovoltaic system, wind turbine) are presented. [2]

Sarina Adhikari, Fangxing Li, "Coordinated V-f and P-Q Control of Solar Photovoltaic Generators With MPPT and Battery Storage in Microgrids", proposes the control strategies of effective coordination between inverter V-f (or P-Q) control, MPPT control, and energy storage charging and discharging control. In this paper, proposes an approach of coordinated and integrated control of solar PV generators with the maximum power point tracking (MPPT) control and battery storage control to provide voltage and frequency (V-f) support to an islanded microgrid. Also, active and non-active/reactive power (P-Q) control with solar PV, MPPT and battery storage is proposed for the grid connected mode. [3]

Mario Rizo et al, "A Synchronization Technique for Microgrid Reclosing after Islanding Operation", idealizes that thevoltage control of the microgrid plays a great role in the synchronization system. Here they shown the control of microgrids composed by the couple distributed sources-local loads - with the competence of operating in grid-connected and island mode is a trending research area. The presence of an efficient algorithm for synchronizing the microgrid with the main grid every time the recourse is allowed is crucial for assuring a safe operation. The synchronization system presented in this work is compounded by two elements: Dual Second Order Generalized Integrator (DSOGI) and stationary reference frames phase locked loop (SRF-PLL).[4]

J. B. Almada et al, "Modeling and Simulation of a Microgrid with Multiple Energy Resources", modulates the modeling, control and operation of a microgrid with three power sources and a storage System. The objective of this work is to describe useful models of typical sources, the calculation of its parameters and control design of the power electronic converters of the energy sources. The modeling of the full system including all the stages of the converters is performed using PSCAD/EMTDC software package. The microgrid was designed to operate connected to the main network. [5]

Maher, G. M. Abdolrasol and SaadMekhilef, "Three phase grid connected anti islanding controller based on distributed generation Interconnection,covers detail on three phase grid connected anti-islanding controller based on distributed generation interconnection. In this paper active islanding detection generates disturbances at the output of the distributed generation by use of positive feedback and continuous feedback signal injection which is based on DQ implementation. Secondly, passive islanding detection method is based on measuring the system parameters such as voltage, frequency, active and reactive power and total harmonic distortion. This method use three phase RLC load and compares the performance of the technique with and without the anti-islanding controller [6]

Emanuel Serban, HelmineSerban, "A Control Strategy for a Distributed Power Generation Microgrid Application with Voltage and Current Controlled Source Converter," investigated performance of pseudo-droop control structure integrated within a microgrid system through Distributed Power Generation (DPG) modules capable to function in off-grid islanded, gen set-connected and grid-connected modes of operation. In this paper a control strategy is proposed in off grid islanded mode method based on the microgrid line frequency control as agent of communication for energy control between the DPG modules. A critical case is where the AC load demand could be lower than the available power from the photovoltaic solar array where the battery bank can be overcharged with unrecoverable damage consequences. The DPG voltage forming module controls the battery charge algorithm with a frequency generator function and the DPG current source module controls its output current through a frequency detection function. [7]

F. Katiraei et al, “Microgrid Autonomous Operation During and Subsequent to Islanding Process”discusses preplanned switching events and fault events that lead to islanding of a distribution subsystem and formation of a microgrid. The microgrid includes two distributed generation (DG) units. In this paper the power electronically interfaced DG unit can ensure stability of the microgrid and maintain voltage quality at designated buses, even during islanding transients. This paper concludes that presence of an electronically-interfaced DG unit makes the concept of micro grid a technically viable option for further investigations [8]

M. Dewadasa et al, “Islanded Operation and System Restoration with Converter Interfaced Distributed Generation“ demonstrates a protection scheme and an intelligent control strategy for converter interfaced DGs are proposed for a distribution network containing higher DG. In this the proposals can be used to maximize the DG benefits by maintaining as many DG connections as possible either in grid connected or islanded mode. The protection scheme is proposed using over current relays with the aid of communication to isolate the faults in the network. The intelligent control strategy for a converter interfaced DG will enable fault detection of relays, self-extinction of arc faults and automatic restoration of the network after a fault. These proposed strategies will prevent immediate DG disconnections from the network. The results are validated using MATLAB calculations. [9]

III. MICROGRID SYSTEM STRUCTURE DESCRIPTION

A) System configuration.

Fig.1 contains the interconnection scheme between ageneral microgrid and main network. The system is composed by a voltage source inverter (VSC) with an LC-filter. The local loads are connected in parallel with the filter capacitor Cf.The cable impedance is represented by the line impedance Z i. A circuit breaker (locally controlled by the microgrid) is connected for isolating the micro-grid when the anti-islanding system detects an unintentional islanding condition.

B) Control configuration.

There are two controllers disposed in cascade (droop and voltage controllers). The active and reactive power are calculated by means of the capacitor voltage Vcand the LCfilter output current i2, and then compared with their respective references - P* and Q*- in the droop controller for obtaining the capacitor voltage reference. Note that the droop controller is employed in both island and gridconnectedmode. The control provides a great performance tracking the active and reactive power reference when grid-connected. In island mode, the equivalent voltage source regulates the voltage magnitude and frequency keeping them within range near the rated values.

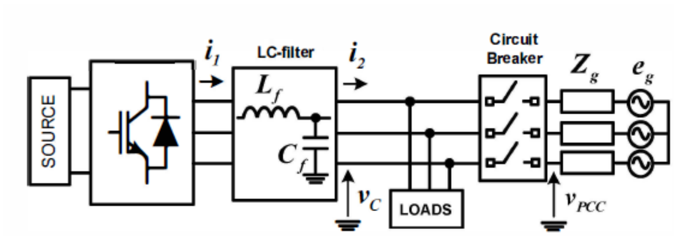

Fig. 1: Connection of the interface between microgrid and electric grid

C) Anti-islanding Algorithm.

The islanding detection is a delicate issue. The anti-islanding techniques present in the biography can be divided into two groups: passive and active. Passive algorithms are based on monitoring local values like voltage magnitude and frequency, current, etc. and analyze anomalous conditions caused by possible grid faults. There are some working conditions where the islanding events are not detected. The non-detection zone (NDZ) represents those values of the measured variables where the islanding is not detected even existing. Active algorithms consist on the perturbation of some system variables

D) Synchronization System

When the problem why the microgridstarted working in island mode disappears and hence, the main utility voltage isrestored in the PCC, the synchronization system is thenenabled. The capacitor voltage controller reference, which innormal conditions is supplied by the droop controller, is nowconfigured with the PCC voltage. Therefore, during thesynchronization process, the droop control is not employedand neither of its functions carried out. In such conditions, thecapacitor voltage starts tracking the PCC voltage.The synchronization system is compounded of threeelements: sequence detector, PLL andvoltage comparator.

1) **Sequence detector**

The purpose of the sequence detector is working out thefundamental frequency positive sequence (FFPS) (signal free of harmonics and unbalanced components) of the PCCvoltage.

2) **SRF-PLL**

The classical PLL is feedback system whose objective is the obtaining of constant amplitude sinusoidal signal in phase with the input signal. Its general structure covers: a phase detector, a low-pass filter and a voltage controlled oscillator.

3) **Voltage comparator**

The last element of the synchronization system has aprocessing purpose of the information supplied by the sequence detector and the PLL.

IV. CONCLUSION

Through the literature review of all the above paper reader comes to know different aspects of microgrid and its main two mode of operation i.e. islanded mode & grid connected mode. The papers included in this review introduces a different technique for re-synchronizing islanded micro-grid with the main utility when it is restored based on the monitoring on both systemsi.e DG and main grid. The paper by Mario Rizo and F. D. Kanelloshas rightly justified the importance of sequence detectors based on quadrature signal generation and PLL in power system synchronization tasks. Simulation and experimental results have been depicted assuring smooth transitions and unnoticeable transients.
Furthermore, the papers have also discussed that the stability of the microgrid is ensured during connection and disconnection to the grid. Through these papers, the control, islanding detection, load shedding, and reclosure algorithms have also discussed for the operation of grid-connected and intentional-islanding of DGs. The simulation results shown in all the papers have rightly justified their title and have proved the effectiveness in dealing with the microgrid.
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