AN ACTIVE ISLANDING DETECTION TECHNIQUE FOR CURRENT CONTROLLED INVERTERS

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Abstract- This paper presents an active islanding detection technique are using hysteresis current controlled inverter. This paper are also refer single inverter as well as multiple inverter for single phase grid. Islanding occurs when a portion of distributed power system becomes electrically isolated from the rest of the power system yet continues to be energized by distributed generators. In this method, all such occurrences are needed to be detected as early as possible in order to safely shut down the distributed generators. So the simple and fast responses the current controlled inverter circuit is to disconnect all distributed generators immediately after the occurrence of islands. Typically, a distributed generator should be disconnected within 100 to 300 ms after loss of main supply. Each distributed generator must be equipped with an islanding detection device which is also called anti islanding devices. An active islanding detection technique is proposed for grid connected single phase hysteresis current controlled inverters. Active method are better at sensing islanding disturbances and reducing or eliminating the Non Detection Zones (NDZs). Feasibility of the proposed technique is performing by MATLAB Simulink.

Keywords- distributed generators, inverters, islanding protection, islanding detection techniques method -active methods, hysteresis current controller.

I. INTRODUCTION

In advance technologies are under development or implemented to satisfy the variable load demand. The main function of the installed Distribution Generation (DG) can make a contribution to improve quality of power, minimize peak loads and eliminate the need for reserve margin. The Distributed Generation (DG) system is one of the most possible solutions to deal with the aforementioned problems. The DG is in the renewable energy sources like as solar power, tidal power, wave power, hydroelectric power, geothermal power, radiant energy, biomass, nuclear power, natural gas etc. The most of distributed resources may be connected in parallel and supply power to the power grids as well as local loads. Therefore, DG must be operated in such an inherently safe manner that the DG should supply the generated power to the network loads only if the utility power supply is present. Integration of distributed generations (DGs) in the distribution network is expected to play an increasingly important role in the electric power system infrastructure and market. DG system is an increased safety hazard for domastic purpose, industrial purpose, commercial purpose, the quality problems of electric service to the utility customers, and an increased risk of damage to the power system and the serious damages to DG if utility power is wrongly restored. An islanding operation is said to when the DG continues supplying power into the network after power from the main utility is interrupted. If islanding occurs, the entire distribution network becomes out of the utility's control. The occurrence of islanding, detection and protection against islanding for Distributed Generators (DG) becomes an important and emerging issue in power system and networks since the distributed resource installations are increasing rapidly and most of the newly installed systems are interconnected with distribution

network. An inbuilt control system should provide the islanding detection in addition to its normal function of protection and control of the DG.
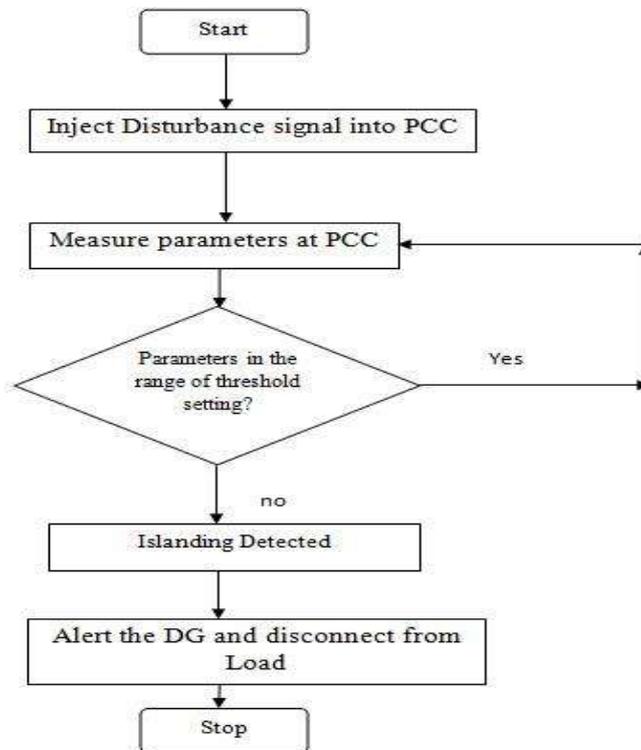
ACTIVE ISLANDING DETECTION METHOD

Active methods try to overcome the shortcomings of passive methods by introducing perturbation in the inverter output. Active methods could detect islanding in almost every situation; however they have the disadvantage to generate instability in the grid, during normal operation, especially if more inverters are connected in parallel. Other active methods can be implemented in external devices like SCADA, PLCC (methods not resident in the inverter). They rely on a transmission of data between the inverter and the grid, but extra hardware is needed with an increment in the cost. The idea of an active detection method is that this small perturbation will result in a significant change in system parameters when the DG is islanded, whereas the change will be negligible when the DG is connected to the grid. Active schemes are better at sensing islanding disturbances and reducing/eliminating the Non Detection Zones (NDZs) that the passive ones cannot, but at the cost of system performance. Common types of active detection methods involve injecting harmonics into the output of the system to sense for islanding events and depending on the perturbation and power mismatch. These schemes will drive the voltage and/or frequency away from the nominal values and out of the NDZs; however, this usually degrades the power quality of the output to the load. The perturbations usually inject harmonics or distort the power factor angle into the system, thus increasing the THD delivered to the grid. In active detection methods involve perturbations of the Active and Reactive Power/Current and/or Voltage level. These methods have the drawback that they perturb the system continuously and though these perturbations can be absorbed with only a handful of sources in a relatively strong grid producing such effects, when system penetration is high and/or the grid system is weak, then these perturbations could cause system-wide instabilities in the voltage and frequency Other active methods involve creating perturbations in the frequency such as Active Frequency Drift (AFD), Sandia Frequency Shift (SFS) and Slip Mode Frequency Shift(SMS). Voltage/Under Voltage protection methods (OVP/UVP). These are the classical active islanding methods that are widely used.

FLOWCHART OF ACTIVE ISLANDING DETECTION METHOD

Figure 1 shows flowchart of active islanding detection methods. The parameters at PCC (voltage, frequency etc) are measured and compared with the threshold values continuously. If the threshold limit is crossed then islanding is detected subsequently the DG is alerted and is shut down. As can be seen a disturbance signal is injected into PCC continuously or periodically depending on the working principle of particular method. Then the parameter variation is observed and if the threshold for voltage/frequency is crossed, islanding flag is raised which alerts the DG and disconnects it from the load. Figure1. shows flowchart of active islanding detection methods. As can be seen a disturbance signal is injected into PCC continuously or periodically depending on the working principle of particular method.

Then the parameter variation is observed and if the threshold for voltage/frequency is crossed, islanding flag is raised which alerts the DG and disconnects it from the load.

All grid-connected PV inverters are required to have Over Frequency/Under Frequency Protection methods (OFP/UFP) and Over Voltage/Under Voltage protection methods (OVP/UVP) that cause the PV inverter to stop supplying power to the utility grid if the frequency or amplitude of the voltage at the Point of Common Coupling (PCC) strays outside of prescribed limits. These active islanding protection methods protect consumer's equipment and also serve as islanding detection methods.

**Figure 1: Flowchart of Active Islanding Detection Methods.**

HYSTERESIS CURRENT CONTROL

The hysteresis current control technique is to be most suitable solutions for current control and high performance converters. The harmonic performance of a hysteresis current controller can be substantially improved by varying the hysteresis band over each fundamental cycle to maintain a constant switching frequency. The purpose of a current controller is to control the load currents by forcing them to follow the reference currents. They provided switching frequency is constant between two adjacent switched output voltage, simple control and flexible implementation. The actual current signal is compared with the given current signal of the inverter by hysteresis current control. The below waveform shows that comparison between reference current and actual current. If the actual current signal exceeds the given current signal a certain range, we can change the switching state of the inverter to control the change of the actual current signal in order to track the given current signal.
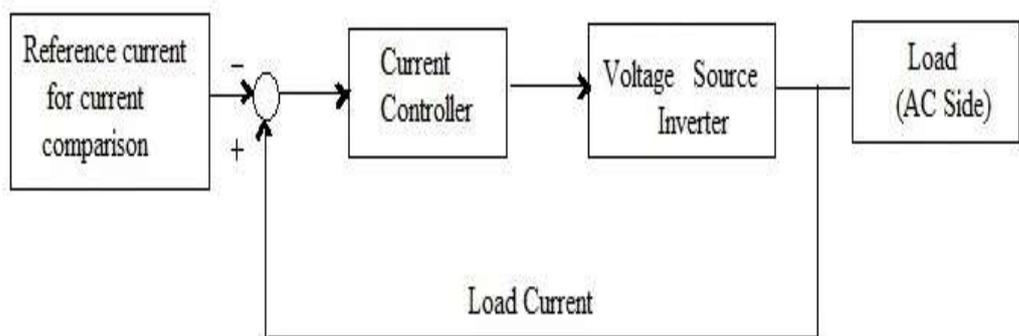
Figure 2: Block diagram of Hysteresis current controller

Hysteresis current control has a series of advantages such as quick response, internal current limiting capacity and stability. Based on the above advantages, hysteresis current control is widely used in power inverter, AC drive and active power filter and so on.
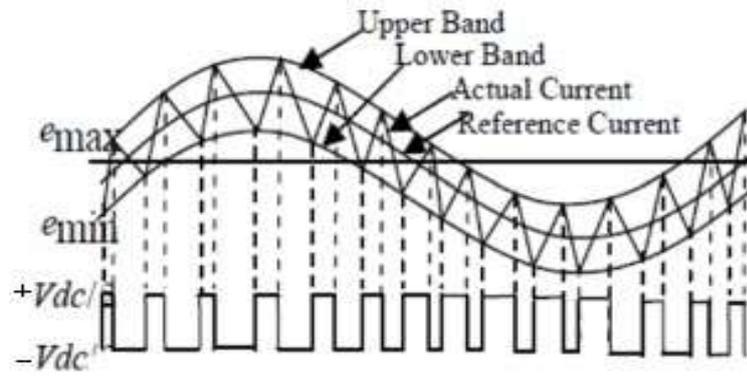
Figure 3: Waveform of pulse and reference current with hysteresis control

The hysteresis current control scheme for the converter to achieve in both rectifier and inverter modes of operation and also describes the proposed scheme for islanding detection. The basis of the control scheme for power flow control is presented.

PROPOSED SCHEME

The hysteresis current control scheme for single phase converter is presented in detail. The converter output voltage is positive when S_1 and S_4 are ON and this duration is treated as ON time. (T_{ON}) The converter output voltage is negative when S_2 and S_3 are ON and this duration is treated as OFF-time (T_{OFF}).

The following nomenclature is adopted in developing the expression for the average switching frequency.
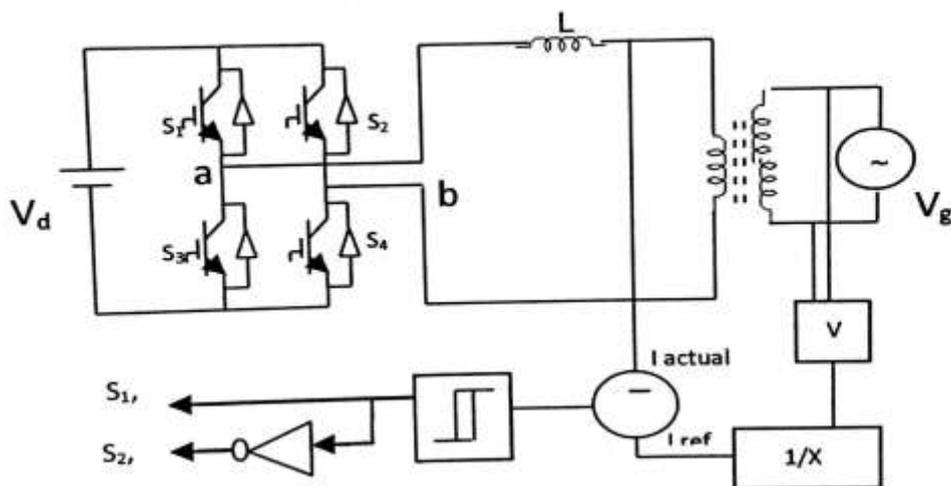
V_d = DC voltage source.

$V_{conv} = V_{ab}$ = Converter output voltage

V_g = Grid Voltage

I_r = Reference current

I_0 = Output current

Figure 4: Schematic for proposed system (single phase)

The system consists of grid connected current controlled inverters and a parallel RLC circuit to represent the load. the parallel RLC circuit is tuned at the resonant frequency of the grid (i.e. 50Hz±0.1Hz) and the quality factor Q≤2.5. Consequently the resonant tank appears as a purely resistive load at the line frequency of 50 Hz. Resistance is

adjusted to dissipate the output power of the DG unit at the rated voltage. This results in the absence of the fundamental current component flow to/from the utility during the steady state operation, when DG unit operates at unity power factor. This is the worst case scenario of islanding since no noticeable change in either voltage or frequency occurs at PCC when the utility is disconnected from the load. In this case switch S2 in the Fig.4. In the system shown in Fig.4 the current control of inverter (DG) is achieved using a hysteresis current controller and the reference current for the controller is obtained using circuit. In case of grid failure the switch S2 is opened, the voltage at PCC is equal to,

$V_L = I_{INV} \times R$

For particular load and inverter current the load voltage is equal to grid voltage. Under this condition no noticeable change in voltage at PCC point is detected under grid failure. Hence islanding detection is very difficult. To incorporate the anti islanding scheme to the existing system, the reference current I_c of the hysteresis controller is modified periodically. The current disturbance is created by reducing magnitude of the reference current to 80% of I_c for 2 cycles and the voltage at PCC is monitored and this process is repeated for every 20 cycles. Since the grid is relatively stronger compared to DG, this small change in the inverter current does not significantly affect the load voltage under normal conditions. But when the grid fails even the small change in the inverter current causes a large change in the voltage at the PCC. Hence islanding will be detected and DG will be disconnected from the utility.

Islanding Detection

To detect the islanding effectively the change in the PCC voltage is monitored. When this change in the voltage exceeds a certain threshold, a signal is generated to shut down the inverter. This voltage threshold is chosen so as to make it independent of the load.
For an inverter current of I A, the voltage at PCC is $(V_P) = I \times R$
Where, R is equivalent resistive load.
The inverter current reduced by X (in %) of I, the change in voltage is DV.
Hence, $V_P \pm DV = (I \pm XI) \times R$
$V_P \pm DV = (I \times R) \pm (X \times I \times R)$
$V_P \pm DV = V_P \pm X \times V_P$
therefore
$DV = X \times V_P$

For example let the grid voltage be 100V and inverter supplying a current of 1A for a load of 100W. Almost the same voltage is maintained across the load even if grid fails. During the disturbance in the inverter current (80% of 1A) the load voltage reduces to 80V. In case the inverter is supplying 5A and the load is 20W if the grid fails the voltage at load becomes 100V same as grid voltage. During the disturbance in the inverter current (80% of 5A) the load voltage reduces to 80V.Therefore threshold value is independent of load. The same scheme has been extended to multiple inverter topologies. where the current disturbance is produced by only one inverter while other inverters always supply the rated current.

II. RESULTS

Introduction

The proposed active islanding technique is verified by conducting simulation studies on MATLAB/ Simulink environment. The inverter current is measured using current transducer and PCC voltage is sensed using voltage transducers. The control algorithm including the hysteresis current control. The simulation performance for detecting islanding can be a single inverter and extended to multiple inverters case.
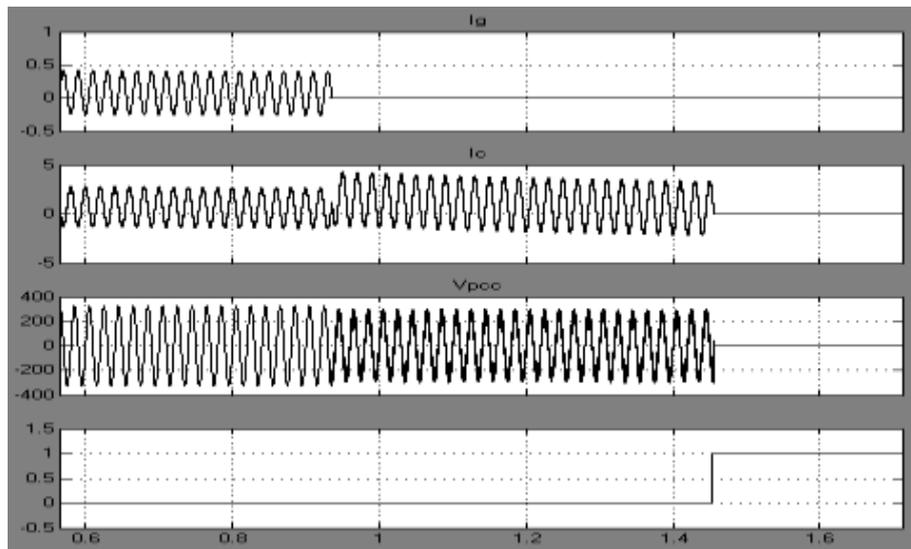
Case 1: Simulation Results of Single Inverter-
Figure 5. shows the simulation results of a single inverter (DG) connected to grid while supplying 2A with parallel RLC load.
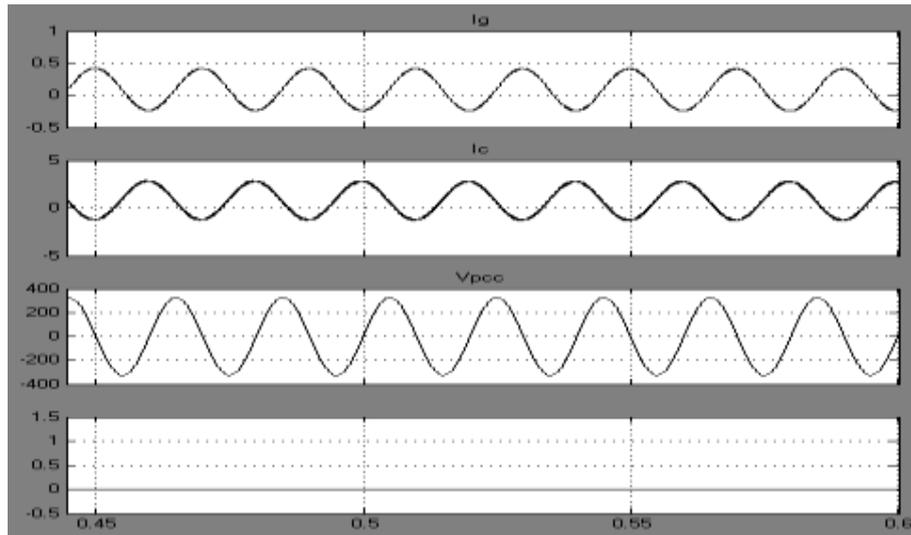
Figure 5. Simulation Performance single inverter under RLC load

Figure 6. shows the simulation performance of a single inverter (DG) connected to grid for islanding detection.
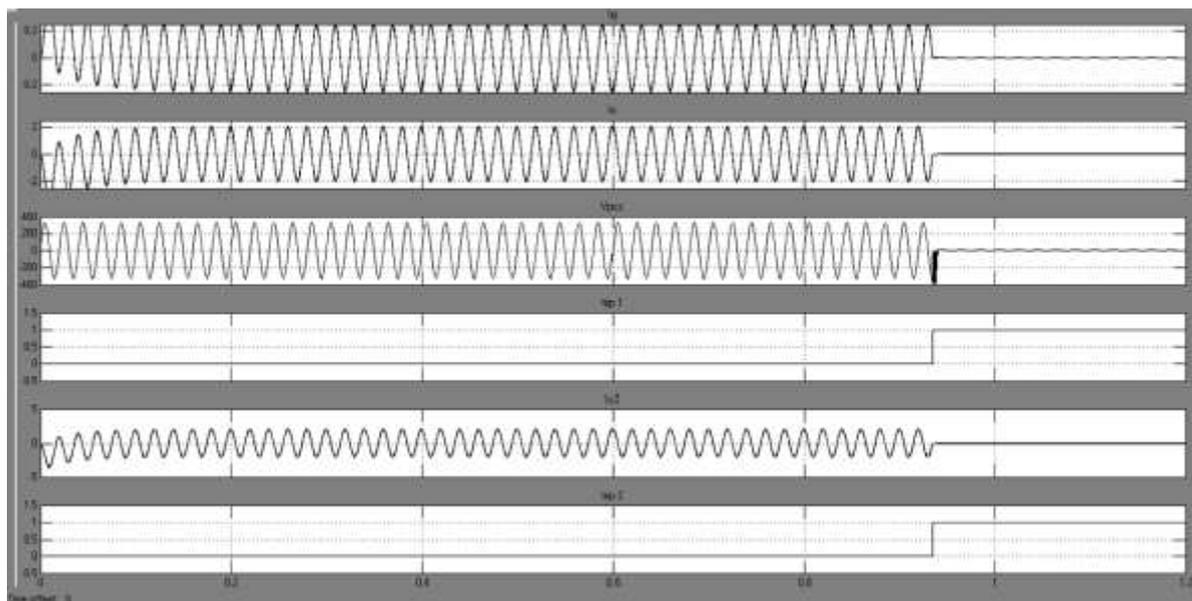

Figure 6. Simulation performance for Islanding detection to a single inverter

Case 2: Simulation Results of Multiple Inverters-
The simulation performance for detecting islanding can be extended to multiple inverters case. In this case the current perturbation is done by the control circuit of only one inverter while other inverter supplies the rated current at all the instants. Similar to single inverter case to generate the trip signal change a in PCC voltage the criterion. If this change in voltage crosses the predefined threshold then the trip signal is generated which leads to shutdown of all the DGs. In this case simulations carried out with two inverters which can be extended to any number.

Figure 7. shows the operation of two grid connected inverters supplying 4A load. The load is a parallel RLC with resonant frequency 50Hz.

Figure 7. Simulation performance for detecting islanding to multiple inverters

III. CONCLUSIONS

The paper presents an active islanding detection technique suitable for grid connected inverters in DG system. Both single inverter (DG) as well as multiple inverters(DGs) configurations are considered for investigations. The method is based on changing the magnitude of the injected current and monitoring the voltage at the point of common coupling(PCC). Under grid failure, the change in voltage at the PCC exceeds the allowable range and islanding is detected. The perturbations caused by this method does not affect the zero crossing of the converter current nor introduce any disturbance as in case of other active anti islanding techniques.The salient features of the proposed method are simple control circuit incorporated in inverter control and faster response without degrading the power quality. The performance of the proposed technique applied to grid connected inverters is simulated using MATLAB Simulink environment.

IV. FUTURE SCOPE

More studies are required to meet the problems caused due to sudden load changes which may create false alarm in the islanding detection process. To verify the feasibility of the proposed technique under different grid conditions, the performance of the system can be studied by varying the R/X ratio of the grid.

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