A Novel Method For Islanding Detection Of Distribution System With Distributed Generator

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Abstract- Distributed Generator (DG) is a part of distribution network which is used to supply power both to the local loads and network. DG provides clean energy as it uses pollution free re-newable energy resources to generate power so interest in DG increases. Although DG provides many advantages such as improved reliability, efficiency etc it faces one technical issue called unwanted islanding phenomenon. Active and passive techniques are mainly used to detect islanding. Both active and passive techniques have its own advantages and disadvantages. This paper presents a novel islanding detection technique which is combination of both active and passive technique. MATLAB/SIMULINK platform is used for simulation and analysis of results.

Index Terms- Distributed Generation, Islanding detection, Active technique, Passive technique.

I. INTRODUCTION

Recently, the integration of DG with distribution system increases due to the DG's advantages. Some of the advantages of DG are reduction in transmission and distribution losses, no need of upgradation of transmission and distribution capacity, use of renewable energy resources etc [1]. One of the main technical issue related to DG is islanding. Islanding is the situation in which distribution system gets electrically separated from local load and DG fulfills the demand of load by supplying electrical power to the load [2]. Islanded mode of operation should be avoided for utility worker safety and power quality reasons of distributed lines [1]. Therefore DG should be disconnected as soon as islanding occurs. According to IEEE 1547-2003 and IEC 61727 standard stipulated time for islanding detection and disconnection in less than 2sec [3].

Islanding detection techniques are broadly classified into two main categories as remote and local. Remote techniques are based on communication between utilities and DG [4]. It uses Supervisory Control And Data Acquisition System (SCADA) or Power Line Signaling Scheme [4]. As these techniques are very expensive, local techniques are mostly used to detect islanding which are future classified as active and passive techniques. Passive method are based on continuous measuring and monitoring the system parameters (voltage, frequency etc).Passive techniques includes under/over frequency , under/over voltage,[5] rate of change of frequency(ROCOF) [6], rate of change of voltage(ROCOV) [7]. In case of load-generation balance, in islanded system it is difficult to detect islanding by using passive methods. Islanding is not detected in non detection zone (NDZ) by using passive methods.

Active techniques injects the distorted wave of current or voltage as a disturbance signal into the system and the monitors the response of the disturbance signal to detect islanding situation. Thus method can detect islanding under load-generation balance condition in islanded system [1]. It has smaller non detection zone.

In this paper, a novel hybrid islanding detection technique is proposed which integrates both the active and passive techniques to minimize their drawbacks. This method is based on measurement of rate of change of voltage and injection of disturbance current signal into the system. If rate of change of voltage exceeds threshold value, the disturbance current is applied to d-q current controller across direct axis which modulates the voltages and frequency at point of common coupling (PCC). If islanding is occurred, output voltage and frequency changes from their allowable limits and under/over frequency or voltage relays are used to detect islanding. MATLAB software is used to simulate test system under study to show the effectiveness of proposed methodology for different islanding and non-islanding conditions.

The flow of the paper is as follows: section II presents a model of radial distribution system with DG interface under study with proposed methodology. Section III Provides simulation results with different cases of islanding and non-islanding. Finally, the conclusion of the paper is given in section IV.

II. PROPOSED METHODOLOGY

The model consists of DG (PV panels) with current controlled VSC which is a dc voltage source and load is modeled as parallel RLC load. Main grid is connected to the DG and local load at PCC through the circuit breaker and step down transformer. Islanding is simulated by opening the circuit breaker at a particular time instant t.

Fig (1) shows power system model with DG in which proposed methodology is tested. Fig(1a) shows the system in grid connected mode. Active and reactive power consumed by the load in this mode is given by the following equ(1) and (2).,

$$P_{Load} = P_{DG} + P_{grid} \quad \text{Equ. (1)}$$

$$Q_{Load} = Q_{DG} + Q_{grid} \quad \text{Equ.(2)}$$

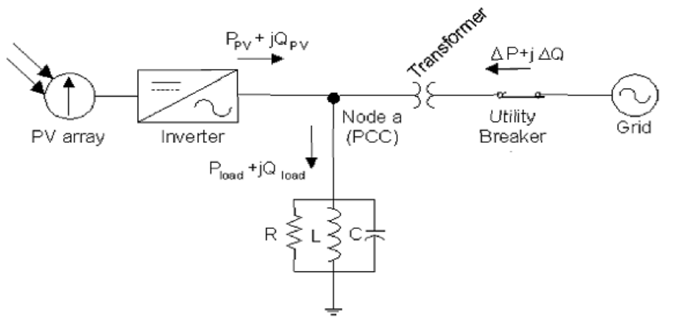

Figure 1a: Test system under study in grid connected mode

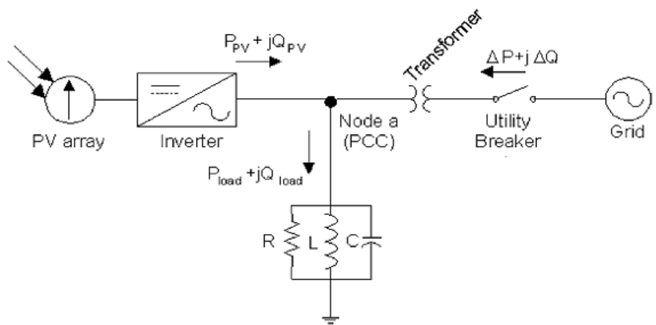

Figure 1b: Test system under study in islanded mode

Islanded mode of operation is shown in fig.(1b)

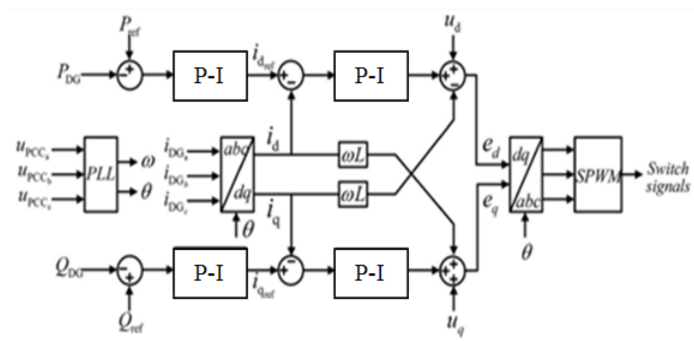

Figure 2: DG interface control

The block diagram of d-q current controller of the DG is shown in the fig.(2). Three important parts are phase-locked loop (PLL), outer power control loop and the inner current control loop. Active and reactive power of DG is independently control by using d-q synchronous reference frame. The Park's transformation is used for this purpose. Inverter switching signal is determined by the magnitude and angle of the modulating signal.

Specifications of the tested system are:

DG: 300 V,50 HZ
Transformer: 100 KW, 20/0.4 KV
RLC load: 80 KW, 70 KVAr, 78 KVAr
Main grid: 20 KV

When system is islanded, there may be active power mismatch (ΔP) between active power of DG and load. Hence, (ΔP = PLoad − PDG = PGrid) is not zero which results in increase or decrease in the value of PCC voltage. So continuous monitoring and measuring of instantaneous voltage and frequency is necessary. The amount of voltage deviation (ΔV) depends on the value of ΔP. According to IEEE Std.929 and IEEE Std.1547, the voltage thresholds are typically set at 88% and 110% of the rated voltage value [8]. After measuring the instantaneous voltage calculate rate of change of voltage by using equ. (3)

$$ROCOV = dV/dt \qquad \text{equ. (3)}$$

If this value is within threshold value, then system is grid connected but if it's value exceeds the threshold value, then third harmonic of output current is injected as a disturbance signal into the system through d-q current controller. If system is grid connected then disturbance signal flows into the low impedance path offered by utility and doesn't change the system parameter significantly. When system is islanded, disturbance signal affects the system parameter such as voltage and frequency. Their values exceeds from their allowable limits and islanding is easily and accurately detected by using over/under voltage or over/under frequency relays.

The flow chart of the proposed methodology is shown in fig. (3)

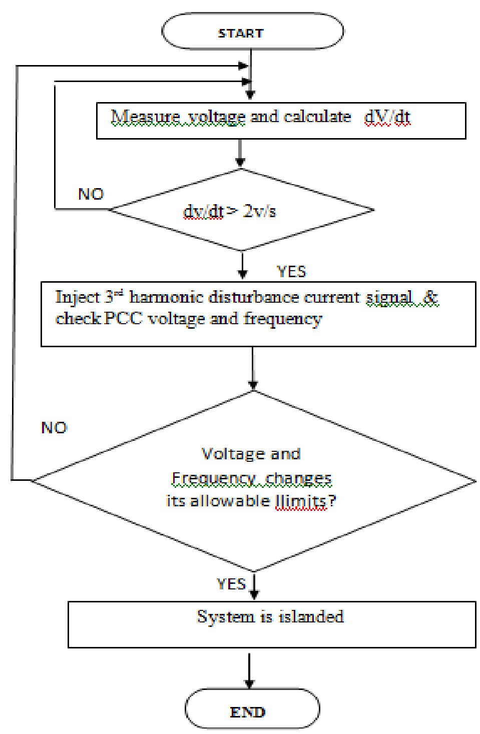

Figure 3: Flow chart of proposed methodology

III. SIMULATION RESULTS

To show effectiveness of the proposed methodology, different islanding non-islanding conditions are simulated in MATLAB software.

Case study No.1: Grid connected system

Circuit breaker connecting grid to the DG remain in close condition. As system is operated in grid connected mode system frequency remains constant at 50 HZ and system voltage is purely sinusoidal as seen in fig. (4b-4c). And rate of change of voltage is almost zero.

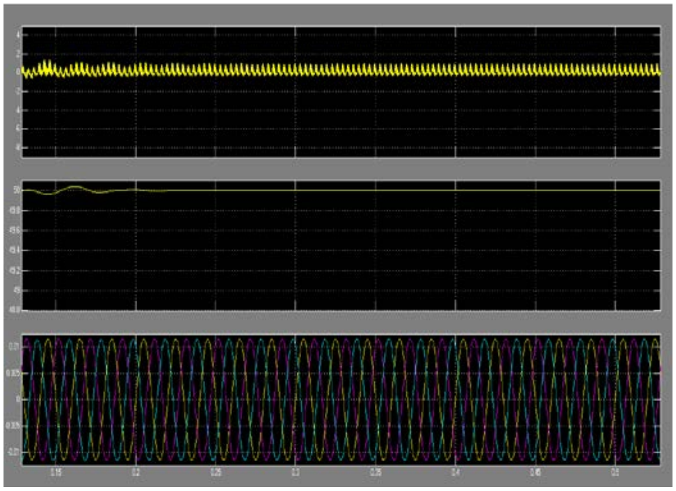

Figure 4: Simulation result of the system in grid connected mode a) rate of change of voltage, b) system frequency, c) System voltage

Case study No.2: Islanded system

Parallel R-L-C load with active of 80 KW and reactive power of inductance and capacitance 70 KVAr and 78 KVAr respectively is considered. Initially, circuit breaker is in close condition. At time t= 0.4 sec circuit breaker is opened and grid is islanded from the DG.

At time 0.4 sec rate of change of voltage goes above 2 V/Sec as shown in fig. (5a) and islanding is suspected so to detect islanding disturbance current signal is added through d-axis. Fig. (5b,5c) shows the change in system frequency and voltage respectively. System frequency drops down to 48.8 HZ after islanding and under frequency relay can easily detect the islanding.

Case study No.3: Non-Islanded system- Induction motor starting

There are some switching non-islanding situations which are not easily discriminated from islanding situation. Starting of induction motor is one of them. Here, Induction motor with active power 25 KW and reactive power 40 KVAr is started at time t=0.5 sec. Fig.(6a) shows that rate of change of voltage exceeds the value 2 V/Sec though it is not an islanding situation. But the islanding is suspected from the value of ROCOV. To confirm whether it is islanding or not, supply third harmonic disturbance signal of output of DG current. As it is not islanding, system voltage is purely sinusoidal and frequency remains within allowable limit upto 50.2 HZ. It is shown in fig (6b,6c)

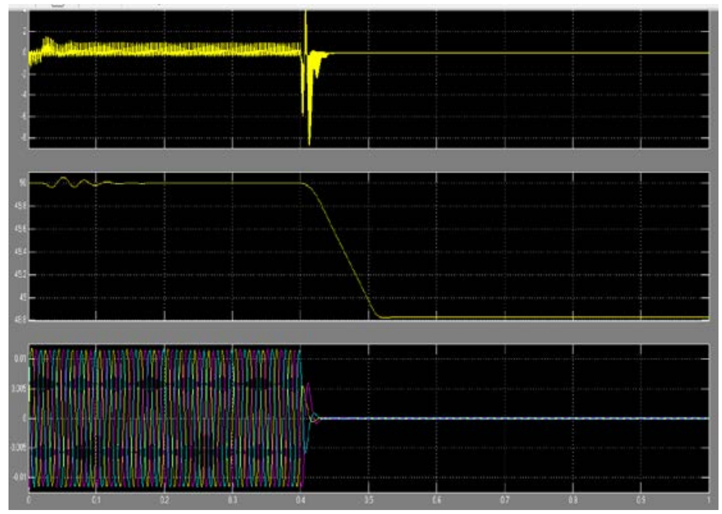

Figure 5: Simulation result of the system in islanded mode a) rate of change of voltage, b) system frequency, c) System voltage

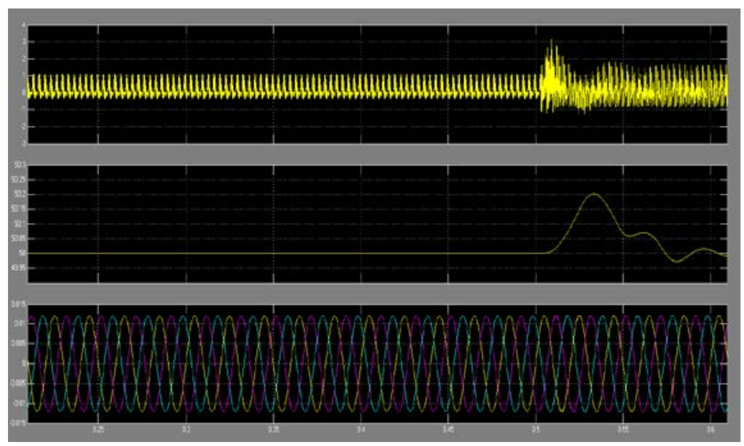

Figure 6: Simulation result of the system with induction motor starting a) rate of change of voltage, b) system frequency, c) System voltage

Case study No.4: Non-Islanded system- Switching off capacitor bank

A capacitor bank with 35 KVAr reactive power is switched off from the system at t=0.4 sec. Fig. (7a) shows that rate of change of voltage increases upto 5V/Sec at the instant 0.4 sec and islanding is suspected. Fig (7b, 7c) shows system frequency and voltage respectively. After adding disturbance signal system voltage and frequency does not increase above allowable limits. Therefore it is not an islanding situation.

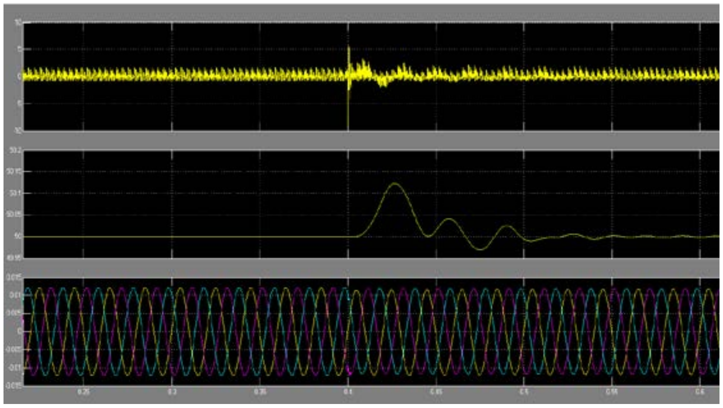

Figure 7: Simulation result of the system in capacitor switching off condition a) rate of change of voltage, b) system frequency, c) System voltage

IV. CONCLUSION

In this paper a new methodology is proposed for islanding detection. This is based on rate of change of voltage (passive) and injection of disturbance current signal through current controlled VSC (active).one test system is simulated in MATLAB/SIMULINK software with various loading conditions for islanding and non-islanding such as capacitor switching, I.M starting etc situations. This hybrid methodology integrates both the active and passive techniques and from the results drawn in MATLAB, we can say that this methodology can discriminate islanding and non-islanding situations effectively and accurately.

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