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Islanding Detection of Distributed Generation In The Presence Of Fault Events With Critical Load And Non-Critical Load

Kirti R. Waghare, N. R. Bhasme

Abstract: ***Incredible growth in demand for electricity with reliable, eco-friendly and efficient power has motivated the use of Distributed Generation (DG) all over the world. The problems associated with distributed generation system is unintentional islanding which causes power quality issues in the grid. During islanding operation, renewable energy sources such as solar, wind are used as distributed generation sources, supplies power to the local area. Islanding detection can be divided into remote and local methods; the later method is again classified into passive and active methods. In this paper, Passive technique is used for detecting the islanding condition which is carried out by controlling parameters like voltage and frequency. This is modeled and simulated in MATLAB/Simulink software.***

Keywords ***: Distributed resources, DG, Islanding operation, Islanding detection technique***

I. INTRODUCTION

The application of distributed generation (DG) in the distribution system is increasing rapidly to deliver power for the power system networks and local loads. DG provides economic, environmental and technical benefit for customers and utilities non-conventional energy resources such as solar power generation, micro turbine, wind power, hydro power generation, geothermal energy, fuel cell which are used for small scale power generation [1,2]. The utilization of DG has numerous advantages such as to improve voltage profile, to reduce transmission distribution losses and thereby improving the power quality of the power system [3].

However, there are various challenges associated with the DG source among which islanding detection is one of the most important protection issue and it should be isolated as quickly as possible. According to IEEE standard 1547, micro grid should be disconnected from main grid within 2 seconds to reduce damage occurring due to failure in the grid [4,5].

Islanding can be created by two types of modes which are unintentional and intentional islanding. Unintentional islanding is formed by sudden events such as sudden fault due to switching operations of various equipment's and sudden load changes while intentional islanding occurs for maintenance purpose [6]. Islanding can be classified into three types such as communication based techniques, active and passive techniques. Communication based method has guaranteed power quality of the power system and have very small blind area but this method is found to be very expensive because of the requirement of communication signals. Therefore, active and passive methods have been well established. Active method is used for recognition of islanding condition by introducing slight disturbances. Hence, there are significant changes in the measured value of voltage, frequency, phase at the point of common coupling (PCC) [1].

Also islanding can be detected using active method by power perturbation, frequency shift, Active frequency drift, Sandia frequency shift [7,8].

Active method has very small non-detection zone (NDZ) but its main drawback is that it has poor impact on power quality by introduction of harmonic contents in the power grid. On the other hand, Islanding condition is detected using passive method by several ways such as under/over voltage, under/over frequency, harmonic detection, wavelet based method, harmonic detection and phase jump detection [9].

Passive methods such as over/under voltage and over/under frequency are found to be very effective methods for isolating the islanding condition. This method has no impact on power quality hence it is found to be safe by controlling system parameter such as voltage and frequency at the PCC. This paper presents analysis of passive method for detection of islanding by controlling important parameter such as over/under voltage and over/under frequency. This method is implemented using MATLAB/Simulink model and all significant constraints and waveforms are observed and controlled at the PCC.

II. PASSIVE ISLANDING DETECTION METHOD

A. Over/Under Voltage and Over/Under Frequency

Overvoltage occur due to several reason such as sudden loss of load, lightning and switching impulse, insulation failure whereas under voltage occur due to overload phenomenon;

such variation of voltage beyond acceptable limits is responsible for identifying the islanding condition.

In this method, OUV and OUF relays are sited on distribution feeder to detect several abnormal conditions. During occurrence of islanding phenomenon, utility grid is disconnected from micro grid consisting of load and DG.

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Hence there is variation in the active and reactive power between DG and load which leads to deviation in parameter like voltage magnitude and the frequency which are measured to recognize isolated situation.

The behavior of the system can be determined by the value of ΔP and ΔQ during islanding occur. If $\Delta P \neq 0$, the deviation in the Frequency at the PCC is one of the factor for grid isolation.

such changes will be detected by UFP/OFP relays and trip the DG inverter source for supplying power to loads. If $\Delta Q \neq 0$, the magnitude of the voltage at the PCC will change and such changes will be detected by UVP/OVP relays and trip the DG source [6,10].

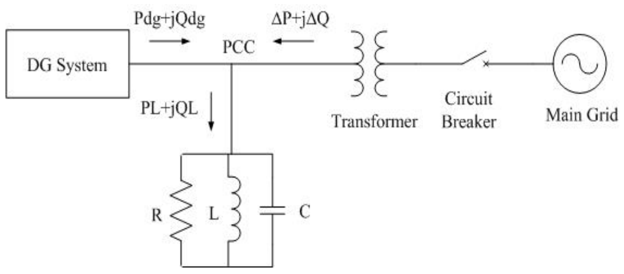

Fig. 1.DG system connected to Main Grid

$$P_L = P_{dg} + \Delta P \quad (1)$$

$$Q_L = Q_{dg} + \Delta Q \quad (2)$$

Active power at the PCC is given by

$$P_L = \frac{V_{pcc}^2}{R} \quad (3)$$

The main disadvantage of these passive method is large non-detection zone. As these method does not need disturbance signal hence it does not have any impact on the quality of the power system but this technique is not able to identify islanding condition when customer power demand is closely matches the DG power output. The implementation of these method is very easy as compared to active method [9].

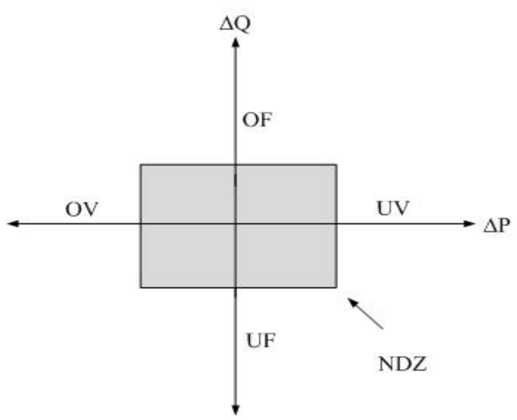

Fig. 2.Non-detection zone of passive method

The shaded area shown in Fig.2 indicate the NDZ of passive method. NDZ is defined as the area in which islanding detection techniques is not able to detect islanding.The effectiveness of various techniques is based on the area of NDZ. If this area is wide, failure of islanding detection increases [3].

III. SYSTEM DEVELOPMENT

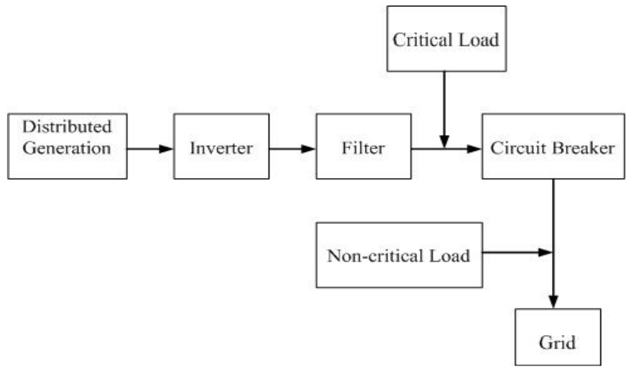

Fig. 3.Block Diagram of proposed scheme

Block diagram consist of three main components, they are main grid, distributed generation, load consist of heavy load and critical load which is shown in Fig.3.On distributed generation side, solar power generation is used as auxillury power source from which dc power is obtained. This dc power is converted into AC by three level bridge inverter, filter is used for conversion of DC to AC, RL filter is used for the elimination of higher order hormonics from the system and the transformer is required to change voltage level. There are two types of electrical loads, they are critical load and non-critical load. Critical load consists of emergency load which needs regular power supply under any disturbances hence voltage of critical load should be maintained constant. Critical loads include hospital, internet server, radar, digital communication load, industries etc. [11].

IV. CONTROL STRATEGY

This controller utilizes the concept of changing frequency and voltage when the islanding is formed in the grid connected solar power generation.

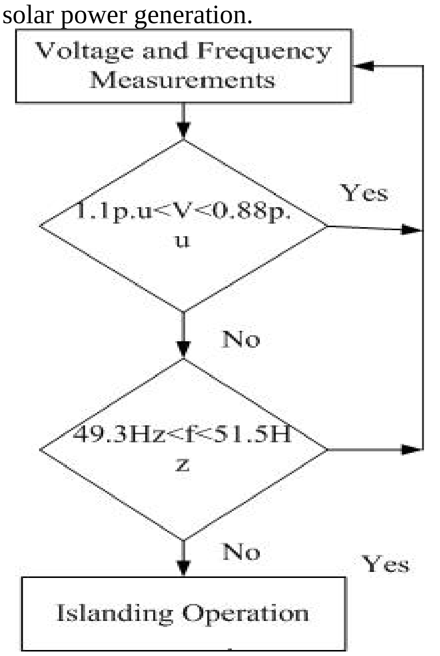

Fig. 4.Islanding detection algorithm

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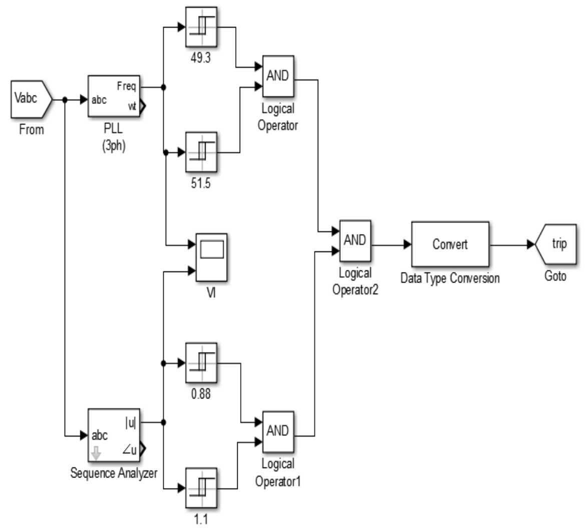

Fig. 5.OUV and OVF controller

The OUV and OVF Controller utilizes the grid voltage and grid frequency for detection of islanding. According to IEEE standard 1547, frequency limit should be deviated within 49.3Hz to 51.5Hz and voltage should be deviated within 0.88 pu to 1.11 pu. When islanding occur, loads get disconnected from main grid and switching operation take place from constant current mode to constant voltage mode. During such condition, parameter like frequency and voltage exceeds within permissible limits and trip will occur by AND gate operation. When voltage and frequency goes beyond 0.88pu to1.11 pu and 49.3Hz to 51.5Hz, the output of logical AND gate goes to high resulting in an islanding formation.

V. SIMULINK MODEL

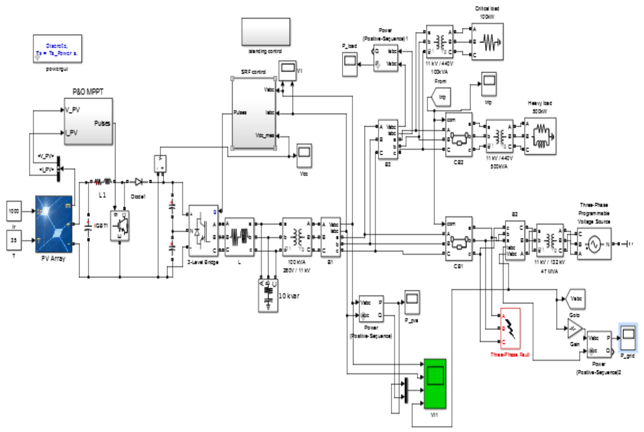

Fig. 6.Simulation Model for Islanding Detection

Passive technologies specifying OUF and OUV islanding detection algorithm are modeled in MATLAB/Simulink. This model consists of solar power generation as distributed power generation supplying 100 kW, 250V operated at unity power factor (UPF) operating in parallel with grid whose voltage and frequency rating is `132 kV and 50 Hz. This DC voltage increases to 260V by using DC-DC boost convereter. DG is coupled to the PCC through 260V/11kV step up transformer. DG, main grid, loads are connected at the PCC. The output voltage and frequency should be measured at the PCC for detection. Synchronous Reference Frames (SRF) Controller is used for synchronization of grid voltage V_{abc} and grid current $I_{abc}$with the inverter voltage and frequency by converting *dq0* components to *abc* components. It consists of Parks transformation, PI Controller, Phase Locked Loop (PLL).

Two types of electrical loads, critical load and noncritical loads are connected to the grid under normal operation. when fault occur on grid side, tripping of CB will occur and heavy loads should be disconnected along with grid and solar inverter will be actuated for supplying critical loads which is having capacity of 100 kVA at UPF.

Table- II: Parameters for modelling of Grid connected DG system

Parameters	Value
Grid Voltage	132 kV
Grid Frequecy	50 Hz
Solar Inverter power	100 kW
Critical Load	100 kW
Non-critical load	500 kW

VI. RESULT AND DISCUSSION

The performance of the model of grid connected DG system for detection of islanding is analysed using MATLAB/Simulink.

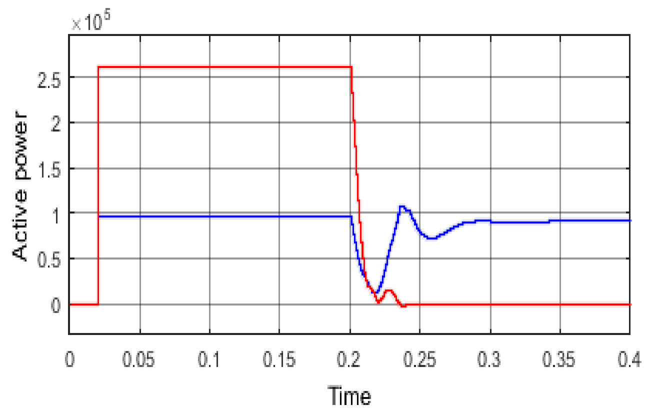

Fig. 7.Active power of critical and noncritical load

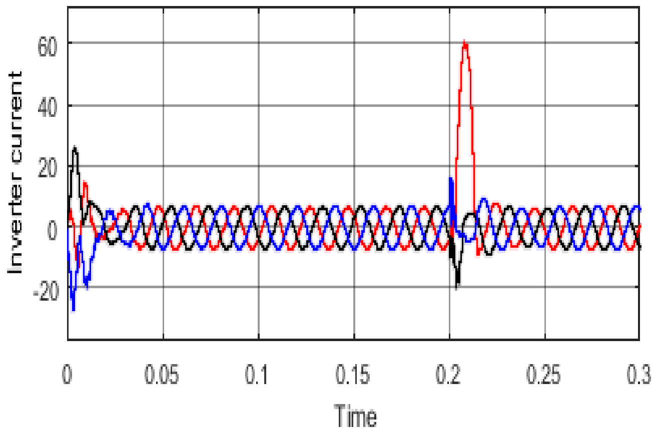

Fig. 8. Inverter voltage during normal and islanding connected operation

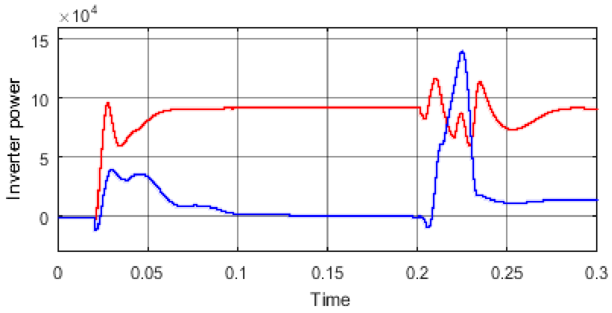

Fig. 9.Active and reactive power of inverter during normal and islanding operation

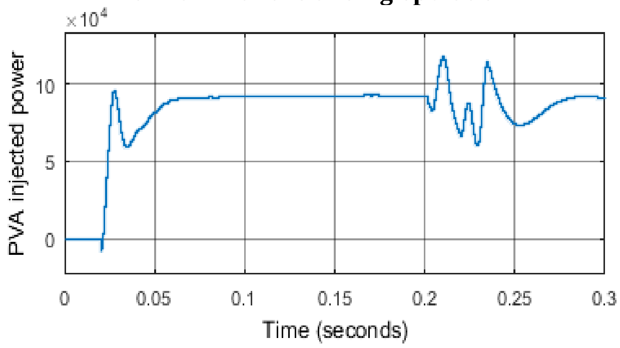

Fig. 10. Active power supplied by inverter to the load

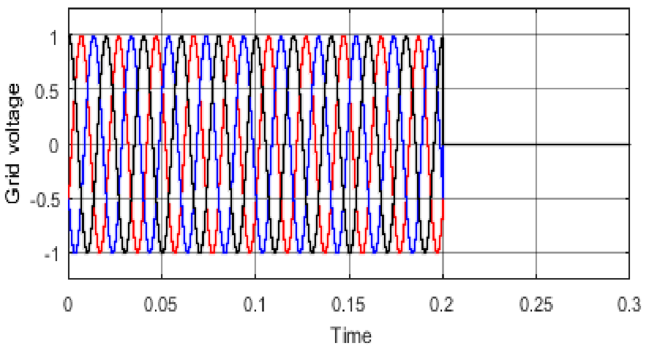

Fig. 11. Grid Voltage under normal and islanding operation

Table- II: Power supply to different loads in the presence of fault

Types of load	Critical load	Non-Critical load
Before fault	97 kW	270 kW
After fault	91 kW	0 kW

At t=0.2 seconds, islanding situation is created by simulating a three phase fault in the grid. Initially circuit breaker (CB) is closed during normal operation. Whenever the three phase fault occurs at 0.2seconds, the CB is trip and then grid is disconnected from the microgrid (island condition), where the DG remains to be operating and supplying power to the critical load.

Fig.7 shows the power supplying to critical and non-critical loads. It is observed that during normal operation, when load is connected to the main grid , both Main grid and solar power inverter is capable of supplying power to critical and non-critical loads but when islanding occurs, DG inverter should be capable to maintain its voltage and current which supplies 260V. DG will remain to be supplying power approximately 97 kW to critical loads as the reference Active power of DG is set to 100 kW.

Fig.10 shows the active and reactive power of solar inverter. It is observed that solar inverter is capable of supplying power even though the fault occurs at 0.2 seconds.

VII. CONCLUSION

In this paper, OUV and OUF passive controller are used for islanding and grid connected operation. The simulation results have been verified and shown the vigorous response of the control techniques which is proficient of retaining both the voltage and frequency within the standard allowable limits even though in islanding operating condition. In such cases, this control scheme could be used to supply solar power to the critical loads in the distribution system during islanded operation. This method is also capable to detect islanding situation within 0.025 seconds which meets the requirements of IEEE 1547 specification.

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AUTHORS PROFILE

Kirti Waghare received her Bachelor’s Degree from Government College of Engineering affiliated to Sant Gadge Baba University, Amravati, India in the year 2016, from Electrical and Power Engineering. She is currently working towards her Master’s Degree from Government college of Engineering, Aurangabad, India, in Electrical Power System specialization from department of Electrical Engineering, 2019. In the fulfillment of Bachelor’s degree, she done Islanding Detection. Her research interests in power electronics and drives.

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