Islanding Detection Technique of Distribution Generation System

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Abstract— There is a condition known as islanding, which occurs when the micro grid is detached from the main grid, which is comprised of loads and distribution generation. In the event that there is a problem or anytime maintenance is required, islanding is a necessary procedure. The mode of constant current control is the mode that the system operates in when it is in normal conditions or stable conditions. Following islanding, the system transitioned into a mode that was controlled by voltage. Procedures such as active and passive procedures are two examples of the several approaches that can be utilized to identify situations involving islanding. This research takes a look at the DQ-PLL detection approach, which is utilized for the purpose of identifying islanding conditions. This paper also provides a comprehensive explanation of the benefits that the DQ-PLL method offers for the detection of islanding. MATLAB/SIMULINK software is utilized in order to achieve validation of the implementation.

Keywords— Islanding; Detection techniques; Active methods; Passive methods; DQ-PLL method

I. Introduction

In the event of a widespread disruption in the primary power grid, islanding is the act of establishing a power island akin to a segment of the utility system. Even in the event that the main grid fails, a continuous power supply to key loads is maintained during islanding conditions. When the main grid is disrupted, the DG source automatically sections the grid and energises the important load until the main grid and DG are synchronised again. There are two forms of islanding: deliberate islanding and accidental islanding [1]. The primary topic of this research is the operation of the islanding detection approach. Three divisions can be used to further separate the subject of islanding:

A. Formation of Islanding.
B. Operations during Islanding.
C. Resynchronization.

A. Formation of Islanding

The schematic diagram for the establishment of the islanding state is displayed in Figure 1. Two categories can be distinguished according to the cause of islanding formation:

i) Islanding due to fault
ii) Islanding due to maintenance

When there is a problem, the main distribution system's fault causes islanding to occur. In this scenario, there will be a brief power outage when the distributed generator (DG) separates from the main grid and then progressively reconnects to the important load to create the island. Here, the primary cause of the island formation problem is the discrepancy between the required load and the DG source's capacity. An island may occur if the DG's capacity is almost equal to the overall load. This is often an extremely uncommon occurrence. Assume that in the event that an islanding does not occur during a faulty state, the affected portion will be cut off from the main grid and left without power. As a result, the power supply is less reliable. Islanding is first created by severing the DG from the main grid and then progressively reconnecting loads to the DG in order to increase reliability.

When maintenance causes islanding, the parts are disconnected from the main grid specifically for that reason. In this instance as well, the total residual load must be almost equal to the DG source's capacity; otherwise, there will be a significant frequency differential, triggering the generator's protection mechanism. [2].

B. Operation during Islanding

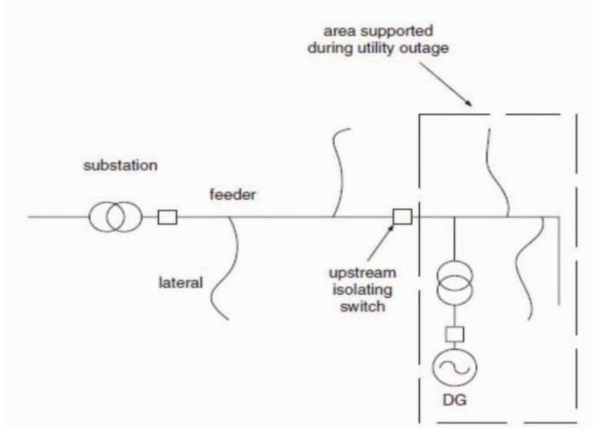

Fig.1. Islanding Condition

It is a research on how well DG performs when islanding happens. The following criteria are used to assess DG's performance. [3].

i) i) Load Following: In order to meet the entire load requirement, the generator should modify the frequency and voltage whenever there is a change in load.

ii) ii) Large Load Rejection: The DG should be able to swiftly modify system frequency and voltage to the appropriate level in the event of a sudden motor ON or large load separation from the main grid.

iii) iii) defect: Should a defect arise during an islanding scenario, it should be isolated to prevent the power system from becoming unstable. That is, once the problem is cleared, the DG needs to set the system voltage and frequency to the proper levels.

C. Resynchronization

It describes the process of returning the load from malfunctioning areas to the main grid. DG often has to disconnect before the islanding portion resynchronizes with the main grid. The islanded area will now experience a temporary de-energizing. Islanding cannot increase the dependability of these customers if the loads are of a crucial kind where many disruptions impact the client. We can employ remote DG resynchronization at the substation to lessen this problem. [4]

II. Block Diagram of the Proposed System

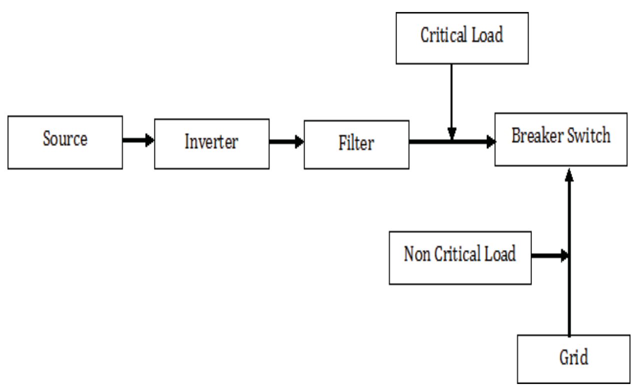

Fig. 2. Block Diagram

The proposed system's block diagram is shown in Figure 2. The block diagram includes a breaker switch, inverter, filter, critical loads, non-critical loads, and dc micro voltage supply. Here, the DC supply is supplied by renewable energy sources like solar PV panels and wind power. To convert DC to AC, an inverter is utilised.

The filter is employed as an LCL filter to remove harmonics from the system.The LCL filter's strong attenuation and ability to lower prices and component sizes are two of its primary advantages. The LCL filter also lessens the amount of current that is injected into the power grid. [5, 6]

There are two categories for loads. loads that are critical and non-critical. Typically, non-critical loads can be disabled.

when the essential loads require emergency power. Hospital loads, radar loads, factory loads, digital communication systems, internet servers, etc. are examples of critical electrical loads. When this equipment malfunctions, there will likely be significant financial losses, and there's also a chance that this disruption may result in unanticipated costs like lost labour, decreased output, or equipment damage. Thus, there is a high need for an uninterrupted electrical power supply to power these systems. Domestic loads are the majority of noncritical loads.[7]

The modes of operation are divided into two categories: islanding mode and grid linked mode. There are two different kinds of control modes based on these modes once more. The microgrid's distributed generation will operate in constant current control mode during regular operations or when linked to the grid. Voltage control mode replaced current control mode when the microgrid disconnected from the main grid, or when islanding happened.

III. ISLANDING DETECTION TECHNIQUES

Techniques for detecting islanding are mostly divided into two categories: passive methods and active methods. Islanding detection is done using passive methods for voltage phase jump detection, harmonic detection, under/over voltage, and frequency. Active approaches include negative sequence current injection, slip mode frequency shift, and impedance measurement at a given frequency for the purpose of islanding detection. The grid's temporary modifications are mostly included in the passive technique, which is based on a thorough probabilistic analysis to determine whether the grid has failed or not and whether there is a problem. Active approaches involve providing an external signal to the system and determining whether or not the external signal has changed in order to detect grid failure. It is more difficult to use the active method than the passive one. [8]

Under/Over voltage detection and Under/Over frequency detection are simple to use in comparison to other detection techniques. For this reason, this method is used by most inverters to determine fault states. The primary purpose of the DQ-PLL is to identify islanding situations. For the purpose of detection, DQ-PLL employed the concepts of undervoltage/overvoltage and under frequency/over frequency. [9]

1. *Under/Over voltage*

Under/Over voltage detection is one of the finest islanding detection techniques for grid interactive inverters because voltage is one of the inverter's primary core functions. There will be an abrupt shift in voltage magnitude if there is a malfunction or a change in load. Therefore, the input of the islanding detecting system can be selected with this voltage magnitude.

2. *Under/over frequency*

Another possibility for the grid to disconnect is when the frequency is over or below. In this case, the grid is checked in order to detect.

frequency, that is, whether or not the grid frequency is within the limit. The grid disconnects when a problem arises or maintenance is necessary, allowing the island's natural resonant frequency to become the source of power. [10]

This method's consideration of both voltage and frequency components is one of its advantages. It uses 1.1pu and 0.88pu for the highest and lower limits of voltage, and 49.30Hz and 51.50Hz for the frequency, respectively. Should the grid frequency and voltage fall or rise beyond this threshold, the system enters an islanding state. The suggested method's flow chart is displayed in Figure 3.

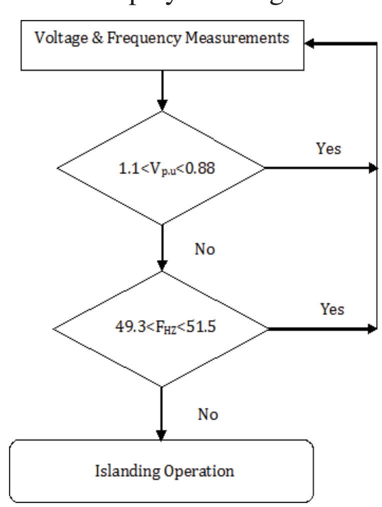

Fig.3 Flow chart

The four primary parts of DQ-PLL are an integrator, a PI regulator, a Parks transformation, and a Clark transformation. The primary application of a phase locked loop (PLL) is the determination of the frequency and angle reference at the common coupling point. Two categories of transformations exist. There are two types of transformations: the dq0 to abc transformation, also known as Clark's transformation, and the abc to dq0 transformation, also known as Parks transformation. [11]. The two phase to three phase transformation and vice versa are aided by these two transformations. A three-phase balanced waveform with a 120-degree phase shift will be produced by these DQ-PLL technique transformations, which can be used as an input for an inverter

Clarks & Parks transformation equation are below: Parks transformation

$$V_a = V_d \,\mathrm{Sin}(\omega t) + V_q Cos(\omega t) + V_0 \quad (1)$$

$$V_b = V_d Sin(\omega t - {}^{2\pi}/_{3}) + V_q Cos(\omega t - {}^{2\pi}/_{3}) + V_0 \quad (2)$$

$$V_c = V_d Sin\,(\omega t + {}^{2\pi}/_{3}) + V_q Cos(\omega t + {}^{2\pi}/_{3}) + V_0 \quad (3)$$

Clark's transformation

$$V_d = \frac{2}{3} V_a \,\mathrm{Sin}(\omega t) + V_b Sin(\omega t - {}^{2\pi}/_{3}) + V_c Sin\,(\omega t + {}^{2\pi}/_{3}) \quad (4)$$

$$V_q = \frac{2}{3} V_a \,\mathrm{Cos}(\omega t) + V_b Cos(\omega t - {}^{2\pi}/_{3}) + V_c Cos\,(\omega t + {}^{2\pi}/_{3}) \quad (5)$$

$$V_0 = \frac{1}{3}(V_a + V_b + V_0) \quad (6)$$

In this technique,Vqis set to zero at first. PI regulators are used for controlling the errors in the output of the grid frequency and grid voltage magnitude. [12]

IV. SIMULATION RESULTS

The performance of the proposed system for the islanding detection technique is validated by MATLAB Simulink software. Figure 4 shows the simulated diagram of the system.

This system was tested under the following conditions:

1) Switching frequency of the inverterf_s: 10 kHz;

2) Output frequency of the inverter: 50 Hz;

3) filter inductor L_i: 1 mH;

4) filter inductor L_L: 1 mH;

5) filter capacitor C_f: 1μF;

6) dc-link voltage Vdc: 400 V;

Loads are connected to the main grid side and the micro grid side in order to verify the islanding situation. The system is designed so that the load can have a capacity of 8 KW and the inverter's maximum capacity is 60 KW. At first, grid connected mode—also known as constant current control mode—is used for the operation. When the system is in grid connected mode, an islanding issue occurs. A situation known as anislanding causes the micro grid to separate from the main grid and a transition from current control mode to voltage control mode occurs in the operation. The system only serves the critical load when operating in voltage regulated mode.The micro grid can be disconnected from the main grid using a breaker switch in accordance with the main grid's frequency and voltage limitations. The frequency is set to 51.50Hz and 49.30Hz, and the highest and lower limits of voltage are set to 1.1pu and 0.88pu, respectively. This limit is reached by the system using a breaker switch to send it into an islanding condition if the grid frequency and voltage drop or rise.

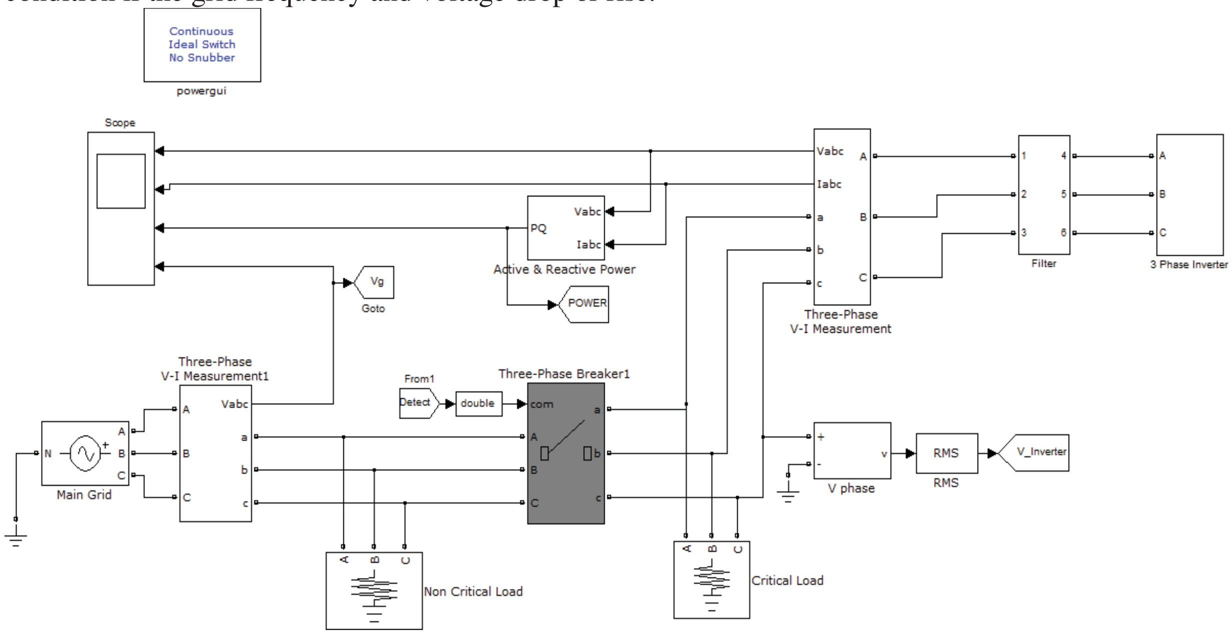

Fig.4: Simulated diagram

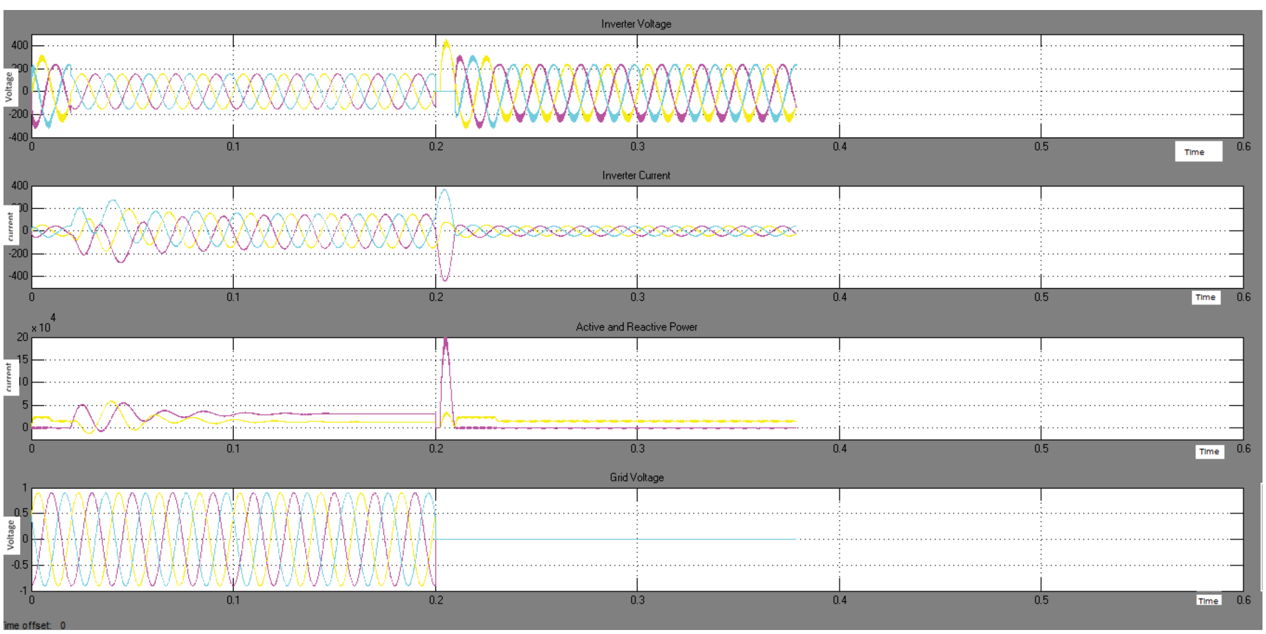

Fig.5: Islanding detection of the system

Figure 5 displays the main grid's supply voltage along with the inverter's voltage, current, active power, and reactive power. The system was initially in grid-connected mode. A voltage shift causes a fluctuation in the main grid at 0.2 seconds. The islanding is represented by a corresponding change in the inverter side. In order to alter the voltage, deliberately disrupt the main grid that is linked to the micro grid. With the aid of an interval test on the inverter side that measures the primary grid voltage and frequency, the breaker switch is able to detect this disturbance. At 0.2 seconds, the voltage exceeds its limitations. Thus, the microgrid is being disconnected from the main grid by the breaker switch. All of the system's properties, including voltage, current, and power, will vary. When operating in the islanding mode, the DG system helps to balance this variance in voltage, current, and power.

V. CONCLUSION

In this study, control is discussed, islanding detection is suggested for the islanding mode of operation, and MATLAB Simulink software is used to validate the grid connected mode of operation. Here, two basic modes of operation are controlled using the islanding detection technique. Additionally, it facilitates the transition from constant voltage controlled mode to constant current controlled mode. The simulated diagram's output makes the islanding problem and its detection quite evident.

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