DESIGN AND ANALYSIS OF ISLANDING DETECTION TECHNIQUE WITH 5 LEVEL INVERTER DISTRIBUTION GENERATION SYSTEM

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ABSTRACT- *Islanding is the situation in which a distribution system becomes electrically isolated from the remainder of the power system, yet continues to be energized by DG connected to it. Islanding is a condition in which the micro grid is disconnected from the main grid which consists of loads and distribution generation. Islanding is required whenever there is a fault and whenever the maintenance is required. In this paper we are increasing the levels of inverter. If we increasing the level then the efficiency will be improved and also accuracy will be improved. Under normal condition or stable condition, the system works under constant current control mode. After islanding the system switched to voltage controlled mode. There are different methods that can be used to detect islanding situation such as active and passive methods. In this paper DQ-PLL detection technique used for detecting islanding condition is carried out. The major advantage is that the output waveform is more close to sinusoidal. Higher the number of the levels, more approximate is the waveform to sin wave. While increasing the number of levels in multilevel inverter THD value will get reduced. This paper also proposes the advantages of DQ-PLL method for islanding detection. The implementation is validated by using MATLAB/SIMULINK software.*

Keywords— *Islanding; Detection techniques; Active methods; Passive methods; 5 level inverter, DQ-PLL method*

INTRODUCTION

The advancement in new technology like fuel cell, wind turbine, customer demands for better power quality and reliability are forcing the power industry to shift for distributed generations. Hence distributed generation (DG) has recently gained a lot of momentum in the power industry due to market deregulations and environmental concerns. Islanding occurs when a portion of the distribution system becomes electrically isolated from the remainder of the power system yet continues to be energized by distributed generators. Islanding is the process of creating power island like a section of utility system in case of a wide spread disturbance in the main power grid.

Multilevel inverters (MLIs) are known as one of the most popular solutions to improve the performance of renewable energy systems, electric vehicles (EVs), and other innovative power electronic utilities in medium and high power applications [1], [2]. These converters can generate a staircase voltage waveform at the output with high quality and desired spectrum. The desired output voltage is synthesized by appropriate switching of several dc-voltage links, which leads to decrease voltage stresses on switches and total harmonic distortion (THD). In general, there are three conventional types of MLI configurations categorized into diode clamped (DCMLI) [5], flying capacitors (FCMLI) [6], [7], and cascade H-bridge (CHB) topologies, which can be divided into two entire divisions based on symmetric and asymmetric values of dc power supplies.

During islanding conditions uninterrupted power supply to critical load is maintained even in case of main grid failure. In case of disruption in main grid, sectionalization of grid happens automatically and the DG source energizes the critical load until the main grid is resynchronized with DG. Islanding can be two types, intentional islanding and unintentional islanding [1]. This paper mainly focusing on the working of islanding detection technique. The study of Islanding can be sub-divided into three sections:

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

A. Formation of Islanding

Figure 1 shows the schematic diagram for formation of islanding condition.

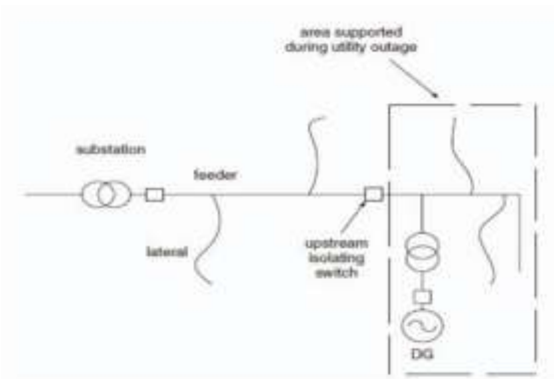

Fig.1. Islanding Condition

Based on the cause, formation of islanding can be classified into two:

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

In the case of fault, Islanding happens due to the fault in main distribution system. Here in this scenario, there will be a disruption of power for a small interval of time and the DG disconnects itself from the main grid and gradually reconnects to the critical load to form the island. To enhance the reliability islanding is initially formed by disconnecting the DG from the main grid and then gradually reconnecting loads to DG.

In the case of islanding by maintenance, the disconnection of parts from main grid is for the maintenance purpose. In this case also, the total remaining load should be nearly equal to the capacity of DG source, else, frequency difference will be high and generator's protective device operates. [2]

B. Operation during Islanding

It is the study on the performance of DG when Islanding occurs. The performance of DG is tested in the following aspects. [3]

i) Load Following –whenever a change in load occurs the generator should adjust the frequency and voltage to an appropriate level, so that the total load demand is met

ii) Large Load Rejection- When a sudden switching ON of a motor or the disconnection of a large load occurs from the main grid, the DG should be able to adjust system frequency and voltage to the desired level quickly.

iii) Fault- In case of a fault in the power system during an islanding condition, the fault should be isolated before the power system goes into an unstable state. That is, the DG must adjust system frequency and voltage to appropriate level after the fault gets cleared.

C. Resynchronization

It refers to transfer of load back to main grid from faulted parts. Before resynchronization of islanding part to the main grid, normally DG has to disconnect. At this time there will be de-energizing of islanded area for a while. If the loads are of critical nature where number of disruption affects the customer, Islanding cannot improve reliability of these customers. To mitigate this issue, we can use remote resynchronization of DG at the substation.

BLOCK DIAGRAM OF THE PROPOSED SYSTEM

Figure 2 represents the block diagram of the proposed system.

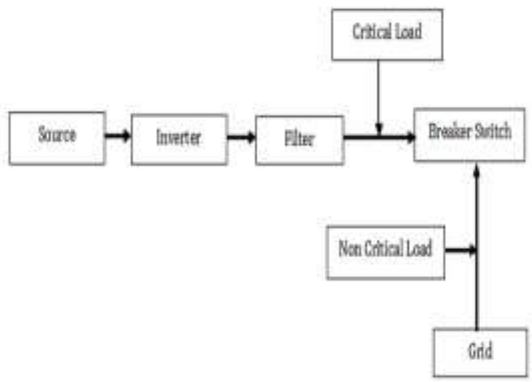

Fig. 2. Block Diagram

The block diagram has a dc micro voltage source, non-critical loads, inverter, filter, critical loads and breaker switch. Here the dc source which can be provided by solar PV panels, wind energy source etc. inverter is used for the conversion of dc to ac.

The filter used as LCL filter in order to eliminate the harmonics from the system. One of the main advantage of the LCL filter is it is having high attenuation and it reduces the size of the components and costs. Other function of LCL filter is it reduces the current injection to the utility grid. [5, 6]

Loads are classified into two types. Critical load and Non critical load. Normally the non-critical loads can be turned off when the emergency power is needed for the critical loads. Critical electrical loads include the hospital loads, radar loads, Factories, digital communication systems, internet servers etc. When this equipment fails, the losses will be very high in case of financial and may be this interruption leads to some hidden losses like man power, production losses, damaging of equipment. So these systems require great demand of uninterruptable electrical power supply. Noncritical loads is includes mainly domestic loads.[7]

There are two types of mode of operations: one is in grid connected mode and other one is in islanding mode. Based on these modes again there is two types of control modes. During the normal operation or in the grid connected mode, the DG in the microgrid will be working in constant current control mode. When the microgrid is detaching from the main grid, i.e. when the islanding occurs, the current control mode switched to voltage control mode.

ISLANDING DETECTION TECHNIQUES

Islanding detection techniques are mainly classified into two types as passive methods and active method. Under passive methods the islanding detection is carried out for Under/ Over voltage, Under/ Over Frequency, Voltage phase jump detection and Harmonic detection. Under active methods the islanding detection is carried out for Negative sequence current injection, Impedance measurement, Impedance measurement at specified frequency, Slip mode frequency shift. Passive method includes mainly the transient changes on the grid, based on the detailed probabilistic determination of whether grid has failed or not, or if there is any problem. Active methods is the detection of grid failure by active method is done by applying an external signal to the system and check whether the external signal has changed or not. Compared with passive method, active method is difficult. [8]

Compared with other detection methods, Under/Over voltage detection and Under/Over frequency detection are easy to implement. Because of this reason, majority of the inverters identify fault conditions using this method. The DQ-PLL is mainly designed for the detection of islanding situation. DQPLL used the concept of under voltage/Over voltage and under frequency/Over frequency for the detection purpose.

1. Under/Over voltage

The Under/Over Voltage and Under/Over frequency protection circuits are the fundamental detection schemes employed for terminating the inverter production into the utility grid. In grid interactive inverters, one of the best islanding detection technique is Under/Over voltage detection, because voltage is one of the main basic function of the inverter. If there is a change in load or a fault occurs, there will be a sudden change in voltage magnitude. So this voltage magnitude can be chosen as the input of the islanding detection.

2. Under/over frequency

Under or Over frequency is another scenario for the grid disconnection. Here the detection is done by checking the grid frequency, i.e. the grid frequency is within the limit or not. When there is fault happened or maintenance is required the grid get detached and the power frequency would fall to the natural resonant frequency in the island. [10]

One advantage of this method is that it considers, both voltage and frequency components. It takes the upper limit & lower limit of voltage as 1.1puand 0.88pu, and that of frequency as 49.30Hz and 51.50Hz respectively. If the grid frequency & voltage is below or above this limit, then the system goes to islanding condition. Figure 3 shows the flow chart for the proposed method.

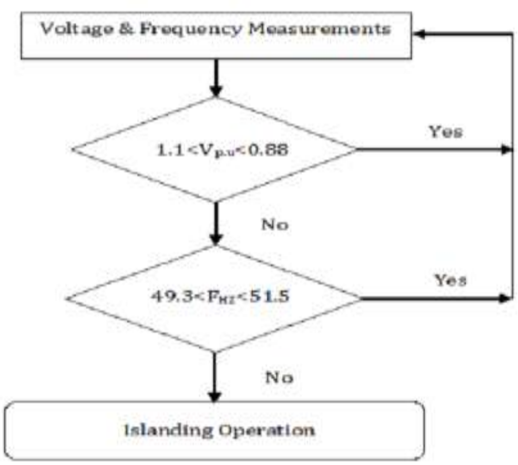

Fig.3 Flow chart

DQ-PLL consists of mainly four components, Clark's transformation, Parks transformation, PI regulator and an integrator. A phase locked loop (PLL) is mainly used for the determination of the frequency and angle reference at the point of common coupling. There are two types of transformations. One is dq0 to abc transformation which is also called as Clark's transformation and the other one is called as abc to dq0 transformation which is also called as parks transformation. [11]. These two transformations are helps in two phase to three phase transformation and vice versa. These transformations in the DQ-PLL method will produce a three phase balanced waveform with 120 degree phase shift which can be given as input to the inverter.

Clarks & Parks transformation equation are below:

Parks transformation

$$V_a = V_d \sin(\omega t) + V_q \cos(\omega t) + V_0 \qquad (1)$$

$$V_b = V_d \sin\left(\omega t - \frac{2\pi}{3}\right) + V_q \cos\left(\omega t - \frac{2\pi}{3}\right) + V_0 \qquad (2)$$

$$V_c = V_d \sin\left(\omega t + \frac{2\pi}{3}\right) + V_q \cos\left(\omega t + \frac{2\pi}{3}\right) + V_0 \qquad (3)$$

Clark's transformation

$$V_d = \frac{2}{3} V_a \sin(\omega t) + V_b \sin\left(\omega t - \frac{2\pi}{3}\right) + V_c \sin\left(\omega t + \frac{2\pi}{3}\right) \qquad (4)$$

$$V_q = \frac{2}{3} V_a \cos(\omega t) + V_b \cos\left(\omega t - \frac{2\pi}{3}\right) + V_c \cos\left(\omega t + \frac{2\pi}{3}\right) \qquad (5)$$

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

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

SIMULATION RESULTS

The performance of the proposed system for the islanding detection technique is validated. Figure 4 shows the simulated diagram of the system. This system was tested under the following conditions:

1) Switching frequency of the inverter fs: 10 kHz;

2) Output frequency of the inverter: 50 Hz;
3) filter inductor Li: 1 mH;
4) filter inductor LL: 1 mH;
5) filter capacitor Cf: 13F;
6) dc-link voltage Vdc: 400 V;

Initially, the operation is in grid connected mode which is also called as constant current control mode. Islanding situation arises when the system is operating in grid connected mode. When antislanding condition occurs, the micro grid detaches from the main grid and a switching of operation takes place from current control mode to voltage control mode. During the operation under voltage controlled mode the system supplies only the critical load. A breaker switch is used for detaching the micro grid from the main grid based on the limits of frequency and voltage of the main grid. The upper limit & lower limit of voltage is set to be 1.1pu and 0.88pu, and that of frequency is set as 49.30Hz and 51.50Hz respectively. If the grid frequency and voltage falls below or above this limit, then the system goes to an islanding condition with the help of breaker switch

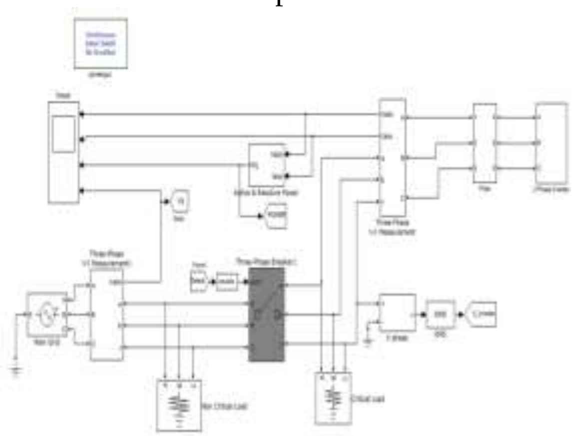

Fig.4: Block diagram of simulation

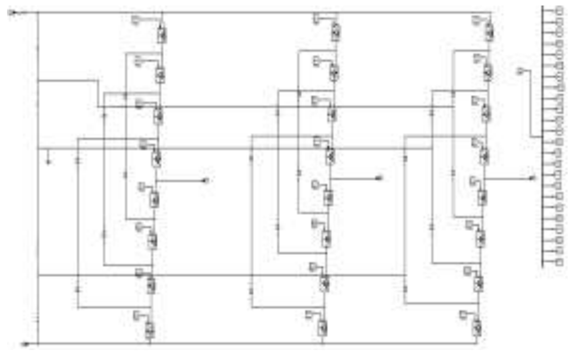

Fig.5 simulation diagram of 5 level inverter

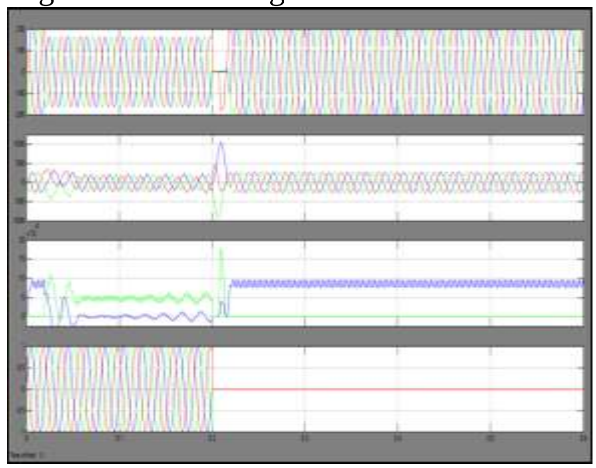

Fig.6: Islanding detection of the system

Fig.6 shows the voltage, current, active power and reactive power of the inverter and supply voltage of the main grid. Initially the system under grid connected mode. At 0.2sec there is a variation in the main grid by change the voltage. Correspondingly there is a change in inverter side which is representing the islanding. For the voltage change, intentionally creating a disturbance in the main grid which is connected with the micro grid.

CONCLUSION

This paper proposes the islanding detection and control the operation of the islanding mode of operation and grid conned mode of operation is validated by simulation results. If we increasing the level the major advantage is that the output waveform is more close to sinusoidal. Higher the number of the levels, more approximate is the waveform to sin wave. So for the motor, it is as good as a supply directly from grid. This reduces the stress on the insulation level of the motor. While increasing the number of levels in multilevel inverter THD value will get reduced. Here mainly controlling two modes of operations by the islanding detection technique. It is also supporting the switching of constant current controlled mode to constant voltage controlled mode. By using the simulation results we can analyze the proposed method.

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