Designing of a Inverter with Islanding Detection

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Abstract— Photovoltaic (PV) and other sources of renewable energy are being used increasingly in grid-connected systems, for which stronger power quality requirements are being issued. Continuous grid monitoring should be considered so as to provide safe connections and disconnections from the grid. One problem with Distributed Generators (DG) is an unwanted islanding phenomenon. This condition can be dangerous to grid workers who may not realize that the load is still powered even though there is no power from the grid. This paper proposes a new active islanding detection method based on impedance measurement which is a cost effective, simple, and effective method to prevent islanding of grid-connected inverters. Emphasis is placed on a method based on the injection of a non characteristic harmonic in the grid. Some of the injection parameters are tuned in order to get an accurate measurement of line impedance.

Key words: Grid Monitoring, Islanding, Distributed Generators, Line Impedance, Impedance Measurement

I. INTRODUCTION

The advancement in new technology like fuel cell, wind turbine, photo voltaic and new innovation in power electronics, 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.

The integration of Distributed Generation (DG) into the main electricity networks is currently changing the paradigm we used to live with, where the electric power industry was generated in large power plants, sent to the consumption areas through transmission lines, and delivered to the consumers through a passive distribution infrastructure. While numerous benefits are associated with this change and Distributed Generation is gaining interest in worldwide, such a transition also represents many challenges for all stakeholders (Utilities, independent power producers, manufacturers, researchers, governments and regulators).

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. An important requirement to interconnect a DG to power distributed system is the capability of the DG to detect islanding detection. Failure to trip islanded generators can lead to a number of problems to the generators and the connected loads.

The current industry practice 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. To achieve such a goal, each distributed generator must be equipped with an islanding detection device, which is also called anti islanding devices like vector surge relay and ROCOF relay.

II. ADVANTAGES OF DISTRIBUTED GENERATORS

1) Flexibility - DG resources can be located at numerous locations within a utility's service area. This aspect of DG equipment provides a utility tremendous flexibility to match generation resources to system needs.
2) Improved Reliability - DG facilities can improve grid reliability by placing additional generation capacity closer to the load, thereby minimizing impacts from transmission and distribution (T&D) system disturbances, and reducing peak-period congestion on the local grid. Furthermore, multiple units at a site can increase reliability by dispersing the capacity across several units instead of a single large central plant.
3) Improved Security - The utility can be served by a local delivery point. This significantly decreases the vulnerability to interrupted service from imported electricity supplies due to natural disasters, supplier deficiencies or interruptio6ns, or acts of terrorism.
4) Reduced Loading of T&D Equipment - By locating generating units on the low-voltage bus of existing distribution substations, DG will reduce loadings on substation power transformers during peak hours, thereby extending the useful life of this equipment and deferring planned substation upgrades
5) Reduces the necessity to build new transmission and distribution lines or upgrade existing ones.
6) Reduce transmission and distribution line losses.
7) Improve power quality and voltage profile of the system.

In fact, many utilities around the world already have a significant penetration of DG in their system. But there are many issues to be taken into account with the DG and one of the main issues is islanding.

III. DIFFERENT TECHNICAL CHALLENGES FOR DISTRIBUTED GENERATIONS

1) Voltage Regulation and Losses
2) Voltage Flicker
3) DG Shaft Over-Torque During Faults
4) Harmonic Control and Harmonic Injection
5) Increased Short Circuit Levels
6) Grounding and Transformer Interface
7) Transient Stability
8) Sensitivity of Existing Protection Schemes
9) Coordination of Multiple Generators
10) High Penetration Impacts are Unclear Islanding Control

IV. ISLANDING

Islanding refers to the condition in which a distributed generator (DG) continues to power a location even though electrical grid power from the electric utility is no longer present. Islanding can be dangerous to utility workers, who may not realize that a circuit is still powered, and it may prevent automatic re-connection of devices. For that reason, distributed generators must detect islanding and immediately stop producing power; this is referred to as anti-islanding.

The common example of islanding is a grid supply line that has solar panels attached to it. In the case of a blackout, the solar panels will continue to deliver power as long as irradiance is sufficient. In this case, the supply line becomes an "island" with power surrounded by a "sea" of unpowered lines. For this reason, solar inverters that are designed to supply power to the grid are generally required to have some sort of automatic anti-islanding circuitry in them.

V. ANTI-ISLANDING PROTECTION

Anti-islanding protection is a US-required safety feature that is built into all grid-tied and hybrid grid-tie inverters that operate in the US. It may not be built into some inverters meant to operate in different countries. Anti-islanding protection is a way for the inverter to sense when there is a problem with the power grid, such as a power outage, and shut itself off to stop feeding power back to the grid. This is because when problems arise with the power grid it is assumed that workers will be dispatched to deal with the issue, and they want the power lines to be completely safe, and not have electricity flowing from all the nearby PV grid-tie systems.

An important product of anti-islanding protection is that a purely grid-tied PV system will only operate when the power grid is active. If there is a power outage the inverter will shut off and although the solar panels may still be generating power it will not be sent to your house. A hybrid grid-tie system ensures that you will still have a useable power source in the batteries even if the power is out.

Photovoltaic inverter manufacturers are obliged to meet power quality regulations for connecting inverters to the grid. Some technical regulations have a requirement for the inverter's anti-islanding protection. The anti-islanding protection has two main objectives. One is to prevent dangerous voltage presence in parts of the network disconnected from the rest of the grid for maintenance or other reasons. The other is to prevent the inverter to supply an islanded part of the network (together with other distributed generators) with voltage which doesn't meet local power quality requirements.

Numerous anti-islanding methods are developed. They are shown in Fig. 1. Globally, they are distinguished as passive, active, and methods which are not resident in the inverter. Passive methods are non-invasive, and use only monitoring of voltage and frequency. Active methods deliberately inject disturbances into the grid, and then monitor its response. This paper aims one of the active methods – the impedance measurement method.

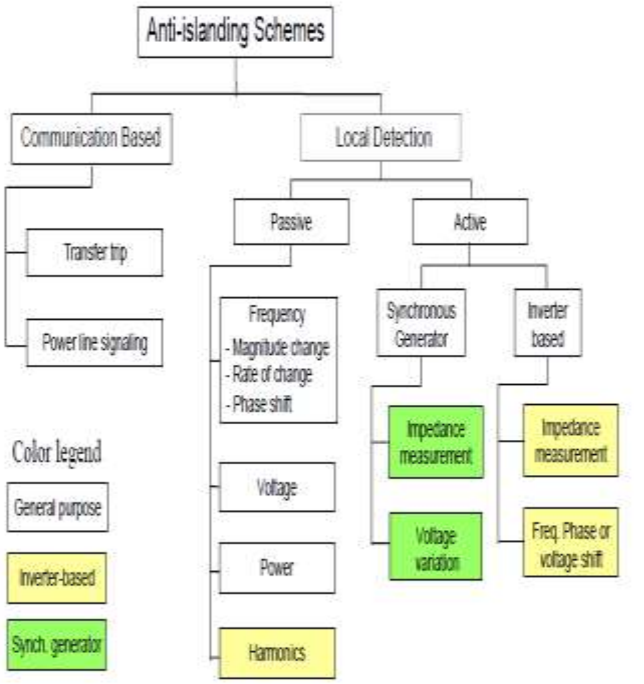

Fig. 1: Classification of Anti-Islanding Schemes

VI. IMPEDANCE MEASUREMENT METHOD

One of the widely used active methods for anti-islanding detection is impedance measurement. This method is suggested by DIN VDE 0126 and EN 50330-1 standards. Requirements for this type of protection is that it detects a change in the network impedance equal or higher than 0.5 Ω, and that it reacts within 5 s. Impedance measurement can be done with power shifting or injection of non-characteristic harmonics or inter-harmonics. Injection of harmonics or inter-harmonics is a widely used variant of this method. It uses a deliberate disturbance which will produce a current at the desired frequency. Simultaneously, voltage and current are measured and their (inter)harmonic components are derived. Impedance is then calculated by dividing the values of voltage and current (and scaled to 50 Hz) which is shown in equ 1.1, 1.2. To reduce measurement errors, averaging of impedance results is often used.

One of the problems mutual for both variants of impedance measurement is inaccurate measurement caused by parallel operation of several devices. In case of power shifting, impedance measurement suffers from lower sensitivity due to unsynchronized power shifts. In case of harmonic or inter-harmonic injection, false tripping is possible because injection of harmonic currents of several devices will increase the overall harmonic voltage.

To reduce the erroneous effect caused by parallel injection, altered injection methods are developed to desynchronize the peaks of inter-harmonic currents. So it is possible to reduce the effect of deliberate disturbances, but the method is not always immune to uncontrolled disturbances, such as inrush transients. Their impact is not large when the voltage is not distorted, but when the voltage is distorted, higher and longer (inter)harmonic bursts are created during a transient. This was the motivation to explore their impact on impedance measurement.

$$V = IR \quad (1.1)$$

$$Z = VI \quad (1.2)$$

If a DG is connected to the main grid, the system impedance seen by the DG will be very small. On the other hand, if it loses connection with the system, the impedance will be large. A possible way to detect an islanding condition, therefore, is to monitor the impedance on a continuous basis. Determining system impedance is not an easy task. It requires injecting disturbance into the system. One obvious choice is to inject low frequency inter harmonic current. Impedance is calculated from the voltage and current responses. Since there is a large difference between impedances with and without the supply system, accurate impedance measurement is not necessary for this scheme. One significant advantage of this scheme is that the power mismatch level in the island will not affect its performance.

VII. HARDWARE DESCRIPTION

Hardware of this can be done using a DC source, Inverter circuit, arduino UNO board, LCD display, relay and DC gear motor shown in Fig. 2.

DC supply can be generated using 12V power supply and this can be given to simple inverter circuit. The DC supply can be converted into AC by using inverter circuit. The output of the inverter is given to arduino UNO board. The output voltage and current of inverter will be measured using atmel processor present in the arduino board. Then impedance value of the source can be is connected to a DC Gear motor through a relay and pot calculated using the measured voltage and current values and this can be displayed in the LCD display. Here Inverter circuit. DC gear motor is considered here as load instead of grid. If we vary the resistance value then based on that grid voltage and impedance will vary. Calculated impedance value is interfaced with another arduino board for control purpose. Calculated source impedance value will be compared with the grid impedance value and based on that islanding can be detected and anti islanding can be implemented. Here external injection of some signals is done by POT variation.

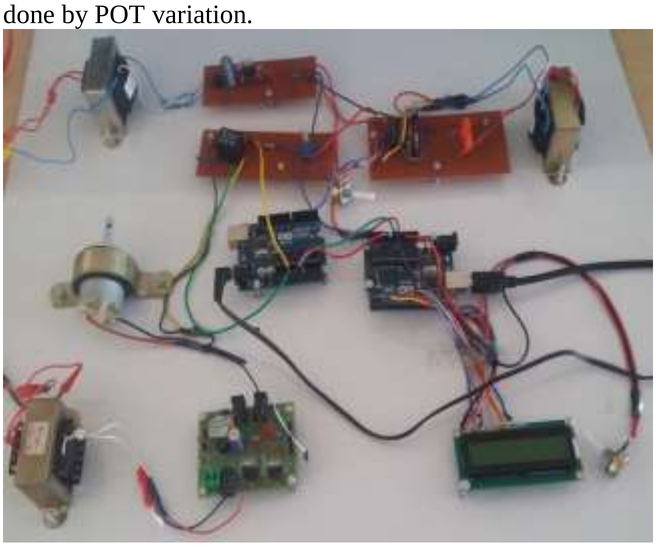

Fig. 2: Hardware Snapshot

In the modern part of the grid, the value of impedance is usually around 0.175Ω.

If the impedance value of source is greater than the grid then the grid will be in connection with the inverter otherwise if it is lower than the grid impedance grid was disconnected from source. From this we can find whether the grid is connected or not. By Continuous monitoring of impedance islanding can be identified and protection can be made easily.

VIII. OUTPUT AND RESULTS

The outputs are displayed in LCD. Grid imedance will lie between 0.175 -.85Ω. If the calculated impedance value lies between this limit DC motor will run. Grid is connected to source in between these values which is shown in Fig. 3, 4, 5, 6 . And if the source voltage and impedance

Fig. 3: Output 1

Fig. 4: Output 2

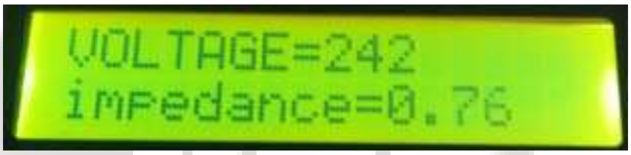

Fig. 5: Output 3

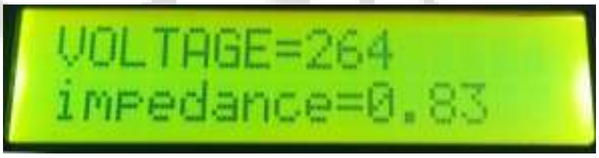

Fig. 6: Output 4

Fig. 7: Output 5

Fig. 8: Output 6

Value are higher then the motor will not run which are shown in Fig. 7, 8. By this we can identify that islanding is occurred and anti islanding can be performed and human safety is ensured. This calculated values can be transmitted to computer and it can be monitored through online for current variations. islanding can be identified in few seconds after it's occurance.

IX. CONCLUSION

In this paper, a new active method to identify islanding mode for DGs was proposed. It describes a digital implemented PV-inverter application grid impedance estimation. Injecting of inter harmonic current into the grid and measuring the voltage response can be used to estimate the grid impedance. This method has less NDZ zones. In a context of practical use into a PV-inverter, this method has the advantages of low cost and easy implementation. Equipments protection and Safety of persons working over transmission lines were ensured by using this islanding detection.

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