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Islanding Detection Using Passive Technique

Navpreet Singh [1] and Akhil Gupta [2]
[1,2]Department of Electrical Engineering-UIE
Chandigarh University Mohali, India
navpreetsingh909@gmail.com
akhilgupta1977@gmail.com

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Abstract

The islanding is power flow between load, utility grid and distribution generation source when loss of gird is occurring. Now there is need of anti-islanding, it can be performed by using passive technique. Anti-islanding algorithm implements the scheme of disconnection of utility grid during fault through loss of grid protection system instantaneously from DG source. The main objective of anti-islanding algorithm is to detect the loss of grid and allow the DG source to behave as Power Island which supplies the power to load only.

Key Words : islanding technique; passive method; under/over voltage and frequency

1.1. Introduction

The distribution generation (DG) sources are time-honored from the renewable source of energy (wind energy, tidal energy, thermal energy, solar energy etc.). These sources of energy are pollution free and high energy efficiency. The DG source is manufactured

from low rated, online Distributed Energy Resources (DER) with the utility grid at distribution voltage level which is new approach in the electrical power system [1] - [4]. Mostly DG sources are uses the power electronic inverters for generation of alternate voltages and these inverters characteristically perform the function of fast current limiting for self-protection and may not be smashed by out-of-phase reclosing and provide passive monitoring for islanding detection. As the involvement of DG source in power system have extensive influence on operation, regulation, protection, reliability and degradation of power quality of the utility grid which is already implemented in system. These issues diminution the performance of DG source which have to be overcome for consuming the full potential of DG source [5] - [8]. When the DG source is interfaced with utility grid there is unintentional islanding is occur which constitute a great risk to personnel safety and stability of voltage and frequency [9]. Such type of islanding is not tolerable for power quality of the system [5].So that this islanding has to be detected, so that the anti-islanding algorithm has to be created. The anti-islanding algorithm is disconnect the DG source from utility side during the fault occur in utility grid and loss of grid is happened. The DG disconnection is compensated the system only if when the DG source is disconnected within two seconds after the disconnection of utility grid as per the IEEE 1547-2003 standard.

Basically two types of islanding detection techniques are possible namely remote and local. In remote techniques, Supervisory Control and Data Acquisition (SCADA), Trip Signal and Power Line Carrier Communication (PLCC) are the techniques which are installed on the side of utility grid. In the local techniques, active and passive methods are used, but these methods are implementing on DG source side. In local passive techniques the non-detection zone is large which is not suitable for high DG sources involvement [9] - [12]. The local active techniques are solution for reduction of the Non-Detection Zone (NDZ). The active methods for islanding detection are performing their action with help of agitation of injection of voltage, frequency or output power and the monitoring of the variation in electric parameter for confirmation of islanding condition [12] - [14]. These can detect islanding but fail when there is more DG sources are connected at point of common coupling because the effect of one source can be affected with other

DG source if there are issues are generated in synchronization between the multiple converters is not possible. However, the remote techniques are expensive and difficult to implement [15] - [16]. In Fig.1, it is depicted the classification of different types of islanding techniques.

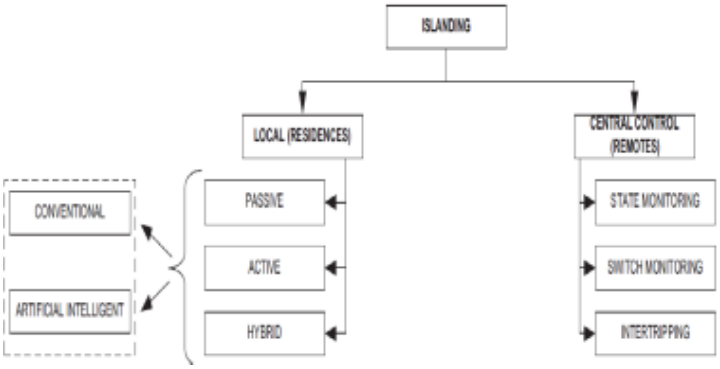

Fig.1.1. Classification of islanding technique

The circuit diagram of system which is proposed in this paper shown in Fig.2, it is demonstrate the PV array, power conditioning unit which is consist of inverter and converter that convert DC-AC, filtering unit consist of inductors and capacitor using π configuration, load at PCC, circuit breaker and utility grid. As shown in Fig.4 the controller is operating, manage and protect the DG system. In this model, the anti-islanding technique is used by controller so that islanding occur and Dg source is disconnected from the system for protection from damage and the load is protected by opening of circuit breaker so that system will become islanded [16] - [18] as depicted in Fig.3.The conversion of dc to ac inverting system is commonly used in renewable generation sources such as PV systems, fuel cell systems, wind turbines and modern tidal power systems. These DG sources are connected in parallel to the grid and supplying power to RLC load at the same time.

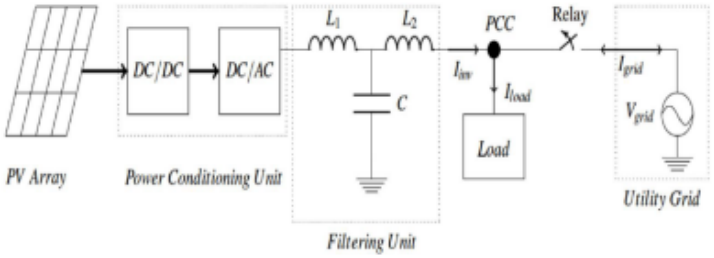

Fig.1.2. Circuit diagram of Photovoltaic system grid connected-normal model

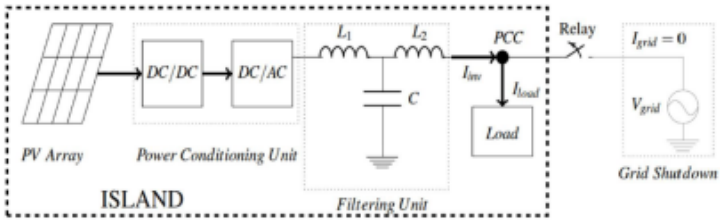

Fig.1.3. Circuit diagram of Photovoltaic system grid connected-island mode

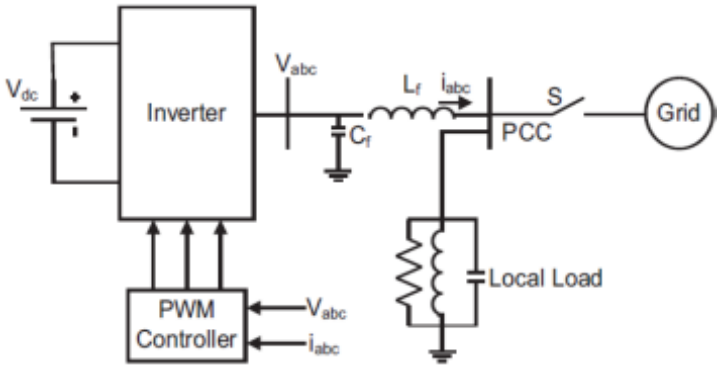

Fig.1.4. Block diagram of inverter connected grid

1.2. Loss Of Grid Protection

1.2.1. Objectives and Requirement

In the loss of grid (LOG) protection scheme the detection of situation has to be determined when the DG source is one sided or left sided connected to load of utility without any major source of power of utility. This phenomenon is referred as the LOG. The LOG is happen due to switching operation caused by fault clearance, load distribution which can be scheduled or unscheduled and equipment miscarriage. Mainly LOG protection scheme is detect the situation when the circuit has to be open, located between the DG source and utility network after any LOG occurrence in order to

(i) Permit the utility power has to be restored

(ii) The out of synchronism is removed so that damage to the reconnection of DG source and utility grid is avoided.

So that there are some necessities is described below for this type of protection:-

1) The system has to be operated in half a second

2) The specified limits of voltage and frequency have to be maintained by DG source.

For the determination of the LOG, There are some techniques are described below:

a) The limit of power ranges less than 200 kVA: In low ranges of DG units, the determination of LOG is processed with the reverse power relay. The reverse power relays are observing the flow of power in the inter-tie circuit. The LOG is also concluded with under/over voltage and frequency relays. After LOG occurring, obviously there is overloading to the DG unit which results to falling of voltage and frequency of utility grid. In these types of situation, the circuit breakers are operating to disconnect the DG source from utility grid.

b) The limit of power ranges more than 200 kVA: In higher ranges of DG units, the automatic voltage regulators are installed with it. So that after LOG these voltage regulators can be able to sustain the voltage and frequency at the load side within standard limits. Therefore for these types of DGs standard rating relays are needed for determination of LOG, hence it trip the inter-tie breaker.

1.2.2. Different techniques of LOG detection

For the detection of LOG s to observe the auxiliary connection on all circuit breakers which are connected to the utility system which installed between the main generation source and the DG source. When the LOG is occur due to switching operation, there is scheme is implemented named as transfer trip which is open circuited the CB installed between the both sources. When the power of utility grid is restored the DG source is again synchronized or connected with utility grid. Where all CBs are responsible for the LOG situation, there is transfer trip scheme is managed through an extensive SCADA system. The power from utility grid is superimposed on power on DG source which has to be removed with dead circuit pick-up supervision on the CBs of utility grid. This will hold the circuit breaker of utility from closing upto the extent of time to load-side circuit was de-energized and would start a transfer trip scheme to open the inter-tie circuit breaker between the DG source and the utility grid. LOG techniques are classified in two types named as active and passive. The active techniques have direct connection with operation of power system. These are

(i) Error detection in exported reactive power

(ii) Monitoring of the system up to extent of fault System

The determinations of LOG through Passive techniques, following are the techniques;

(i) under/over voltage and frequency

(ii) Rate of change of frequency

(iii) Monitoring of Phase displacement

(iv) The rate of change of power output of generator

There are following techniques which are neither active nor passive;

(i) ntertripping

(ii) Fault Thrower

(iii) Neutral Voltage Displacement

1.3. ISLANDING DETECTION METHOD

In the following subsections, the details of these methods are explained and evaluated.

1. Remote techniques

2. Local islanding detection techniques

The classification of various remote techniques is explained in following sub sections.

1.1 System state monitoring

System state monitoring is a method for determining system states from a model of the power system network with a reduced number of state measurements. This method is generally regarded as a function of the Distribution Management System (DMS), which is complementary tof SCADA systems. The method is also used to detect unintentional islanding by monitoring the parameters of the entire distribution system such as voltage and frequency. If the parameter can still be detected from the disconnected area, the occurrence of islanding is detected. This method is highly effective in detecting unintentional islanding if the system is properly instrumented and controlled. However, the cost of implementation is expensive because each inverter requires separate instrumentation and communication equipment. The survey shows that this technique was tested by the PV system. Therefore, other DG types, such as wind turbines and fuel cells, can be explored. The limitation of the high cost of implementation, particularly for small systems, can be addressed using other techniques.

The voltage sensitive devices embedded in the PV-based DG inverter are connected to SCADA system. The loss of mains is detected and notified to the central control system to inform the island mode operation. Real time monitoring of voltage for each generator in the distribution grid can be a cumbersome process with an increased number of DGs connected to the grid. SCADA is also used to monitor auxiliary contact on all circuit breakers between the main source of generation and the DG units.

1.2 Switch state monitoring

The SCADA system can be used to monitor the status of the circuit breakers and recloses that could island a distribution system. However, this method requires an improved interaction between the utility and DG units, which leads to extra costs for both utility and DG sides. Transfer trip detection schemes require all the circuit breakers that island the DG to be monitored and linked directly to the DG control, or through a central substation SCADA system. When a disconnection is detected at the substation, the transfer trip system determines which areas are islanded and send an appropriate signal to the DGs to remain in or discontinue operation.

The transfer trip scheme is incorporated with SCADA to observe the status of CBs and reclosers. The scheme allows for the additional control of DGs through the utility and increases the coordination between the DGs and utility. However, the method has a complexity cost because of the growth of the system complexity, where the transfer trip becomes outdated and requires relocation or updates.

1.3 Intertripping

Another method that can be used for islanding detection is intertripping, which is theoretically different from central control techniques. The method detects the opening of a contact at the points of disconnection and transmits the signal to all generation sites that support the respective island zones. Intertripping also generally relies on the communication between the sensors and generating units. These techniques have higher reliability and provide accurate solutions but are uneconomical.

The above three techniques are used because of their reliability. The review shows that central control techniques are preferable because these techniques can avoid Non Detection Zones (NDZ), where the power absorbed by the load almost perfectly matches the power generated by the DG.

2. Local islanding detection techniques

Local techniques are broadly used to detect islanding based on the measurement of the system parameters at the DG site such as voltage, frequency, current, and harmonic distortion. The local islanding techniques are classified into passive, active, and hybrid techniques. A literature overview on local islanding techniques was conducted. The statistic notably shows that active and passive techniques have rapidly increased throughout the years. The classification of various local islanding detection techniques are explained in following subsections.

2.1 Passive techniques

A passive islanding detection technique based on monitoring the ripple content in the instantaneous output voltage of the inverter at the PCC using time-domain spectral analysis is developed. Under steady state conditions, the output power of the PV inverter has small variations due to high switching frequencies, dead time, and DC link voltage ripple.

Passive techniques monitor the system parameters such as voltage, frequency, harmonic distortion, and current on the DG site at the Point of Common Coupling (PCC) with the utility grid. These parameters vary greatly when the distribution system is islanded. The parameters typically used to detect islanding conditions are frequency and voltage. Various traditional passive islanding detection techniques exist as follows:

2.1.1 Under/over voltage and under/over frequency

The Under/Over voltage (UVP/OVP) and Under/Over frequency (UFP/OFP) is the oldest technique modified to protect the distribution system. The Protection relays for this technique are placed on a distribution feeder. To determine the various types of abnormal conditions. UVP/OVP and UFP/OFP are used to monitor

of the grid voltage/frequency exist the limits imposed by the relevant standards. These protection methods are considered to be based on the power flow at the point of common coupling which is middle point of the grid power flow and PV inverter power flow, which refers to the active power (P) and reactive power (Q). Actually the main feebleness of UVP/OVP and UFP/OFP is the large NDZ as compared to other islanding detection techniques. Therefore, some improvement was made to overcome the large NDZ components. A technique is implemented to decrease the NDZ of UVP/OVP and UFP/OFP by relating the P-V and P-Q parameters of the controlled constant current inverters. The islanding detection based on the performance of the interface control, which is an additional parameter, was implemented in parallel to the UVP/OVP and UFP/OFP to reduce the NDZ. Both voltage and frequency parameters are studied which is benefit of this technique. This technique consider the upper limit & lower limit of 1.1 pu and 0.88 pu as voltage and that of 49.30 Hz and 51.50 Hz as frequency respectively. During the below and above the value of these limits of voltage and frequency, then there is a condition of islanding. In below figure 5 the proposed method is described by flow chart.

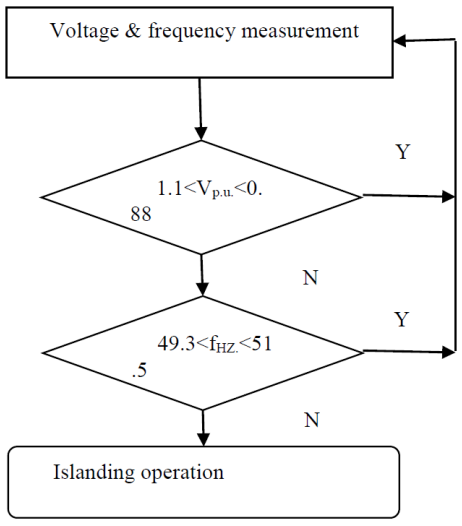

Fig.1.5. The algorithm of proposed method

The mathematical tool as named DQ-PLL comprises from mainly four components, Clark's transformation, Parks transformation, PI regulator and an integrator. The phase locked loop is that mathematical function which is mainly used to find out the frequency and angle at point of common coupling. Now there is concern about the transformation of two types namely Clark's transformation and parks transformation. If the dq0 to abc transformation is performed, then it is called as Clark's transformation and the other one is abc to dq0 transformation which is known as parks transformation. Both transformations are perform the function for transforming the two phase to three phase and vice versa. Three phase balanced waveform is produced by previously described transformation in DQ-PLL method with phase shift of 120o which is provided to the input of inverter.

Clarks & Parks transformation equations are below:

Parks transformation

$V_a = V_d Sin(wt) + V_q Cos(wt) + V_o$
$V_b = V_d Sin(wt = 2\pi/3) + V_q \cos(wt - 2\pi/3) + V_o$
$V_c = V_d Sin(wt + 2\pi/3) + V_q Cos(wt + 2\pi/3) + V_o$

Clark's transformation

$V_d = 2/3 V_a Sin(wt) + V_b Sin(wt - 2\pi/3) + V_c Sin(wt + 2\pi/3)$
$V_q = 2/3 V_a Cos(wt) + V_b Sin(wt - 2\pi/3) + V_c Cos(wt + 2\pi/3)$
$V_o = 1/3(V_a + V_b + V_o)$

2.2 Active techniques

Active techniques have recently been applied by introducing a small disturbance to grids, which is the response of the intern with the grid and deciding if the grid is in the islanding condition. Various active islanding detection with non-artificial intelligent techniques exist, some of which are described and discussed in detail below:

2.2.1 Impedance measurement

The impedance measurement method is continuing its performance same as the passive technique, which measures the variation in

impedance of the system occurring due to islanding condition. The assistance of shunt inductor is connected across the supply voltage source for particular time period from time to time in an active direct method. The short circuit through inductor and the decrement in value of supply voltage are used to determine the impedance of power system source. A large number of impedance detection methods have recently been proposed because of the belief that this method is well-suited for single inverter case because it has no NDZ for this scenario.

Therefore, the experimental study verifies the impedance Detection test based on the islanding detection in a single-Inverter case. The experiment reveals that the impedance detection method based on islanding detection don't have NDZ in the single-inverter system cases. During the connection of load type of parallel RLC however; mostly the issues are occurring due to high-Q for impedance detection such as with frequency-shifting islanding detection methods. Ensuring that the inverter maximum power point is enabled with impedance detection is important for the consistent anti-islanding which is only possible through the impedance detection method even for a small duty ratio value. The addition of time varying phase shift in impedance detection in single inverter system is shows the improved efficiency of impedance detection. This improvement comes with an additional cost from the small amounts of sub-harmonics in the PV inverter output. Therefore, other active techniques can be used to surpass the limitation of impedance measurement.

2.2.2 Slip-Mode Frequency Shift

Slip-Mode Frequency Shift (SMS) is that one method among the three methods which are defined in this study that uses that feedback which is rarely used for islanding detection, namely, amplitude, frequency, and phase. For shifting the phase of voltage, the positive feedback is applied to the phase of voltage as a method and, subsequently, the short-term frequency. The SMS is used to detect the islanding condition because of the easy implementation of the method caused by the involvement of only as light modification of a required component. SMS is well-suited for islanding prevention because of small NDZ as compared with other active techniques. However, SMS techniques decrease the power quality

at system-level which is further responsible for transient response problems at very high penetration levels and feedback loop gains. This is difficult to handle in all three methods that utilize positive feedback.

SMS also introduces a phase shift perturbation, which can lead to noise, measurement in accuracy, and quantization error in practice. This limitation can be answered by introducing an additional phase shift called the improved-SMS (IM-SMS). The IM-SMS was verified through digital simulation and experimentation, which result simplicity, easy implementation, and high reliability.

1.4. BLOCK DIAGRAM OF THE PROPOSED SYSTEM

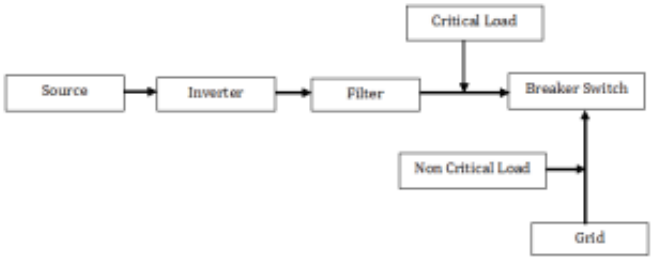

Fig1.6. Block Diagram of proposed Algorithm

Figure 1.6 depicts the block diagram of the proposed model. It consists of a DC micro voltage source, inverter, filter, non-critical loads and breaker switch. The DC voltage can be provided by a solar PV panels. Further, inverter is used for a conversion purpose of DC to AC voltage. AC voltage output from inverter is fed to the filter. Basically, filter is employing in order to eliminations of harmonics in AC output and makes it pure sine wave. Moreover, it is having a high attenuation and reduces the size and overall cost of the components.

Further, connected loads are classified into two types, critical load and non-critical load. Normally, the non-critical loads can be

switched off, when the emergency power is required for the critical loads. Electrical loads, such as hospital loads, industries load, digital communication systems, and internet servers are all comes under the critical loads. Interruption of power supply in these all equipments causes a major loss of money, wastage of equipments, production loss and sometime losses of man power. In such type of systems, there is a great demand of uninterruptable and losses free electrical power supply.

1.5. Simulation and Results

he analysis of the proposed model for the islanding detection in grid has validated by MATLAB 2010, simulink software. Simulation network of the proposed system has depicts in the figure 1.7. In the proposed network, supply is fed from AC grid and DC voltage source in both sides. At the mid of the network, circuit breaker is connected. The circuit breaker is operating only in the abnormal condition and fed the supply to the load from other supply source. It is detaching the micro grid from main grid on the basis of upper limit and lower limit of the voltage and limits of frequency. The upper limit and lower limit of the voltage is set to be 1.1 pu and 0.8 pu, respectively and frequency limits as a 49.30 Hz and 51.50 Hz. If frequency and voltage crosses these limits, islanding situation comes in operation. Load is connecting on the both micro and main grid side for the purpose of islanding detection. The voltage rating of the micro grid side is kept at 100 volts, as well as the voltage rating of grid side is also kept at 100 volts. Furthermore, the operating condition of the network is known as constant control mode. LC filter (inductance and capacitance) is employing for improves voltage profile and declined the ripples in output voltage. During the operating condition, islanding situation arises when the network is operating in the main grid connected mode. The micro grid detaches the supply from the main grid network and a switching action of the system takes place from current control mode to voltage control mode.

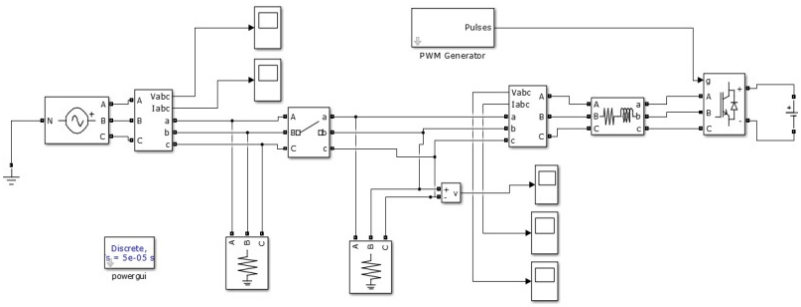

Fig.1.7. Simulation model of the proposed system

Figure 1.8 depicts the islanding detection in single phase of output load voltage. Load is fetching power from main grid, during abnormal condition it shut downs by circuit breaker and load takes supply from micro grid network. The change of supply source from main grid to micro grid represents an islanding detection technique. Figure 1.9 shows the islanding in three phases of output load voltage. Figure 1.10 depicts a line current waveform of proposed network. During the operation of inverter, maximum current rises up to 0.8 A and during the operation of main grid, it goes up to 1.5 A. Further, Figure 1.11 represents the grid voltage of main grid network.

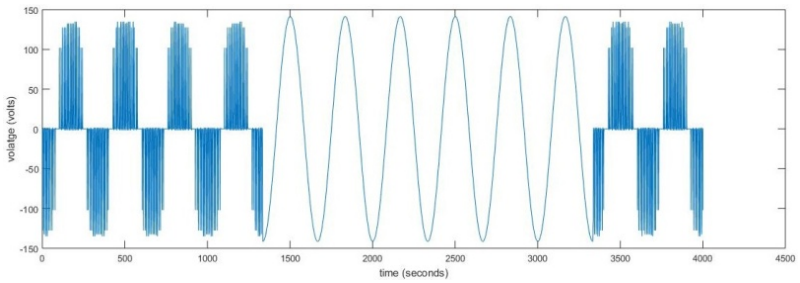

Fig.1.8. Waveform of load voltage

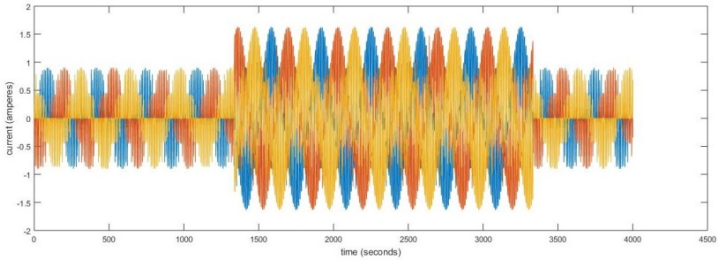

Fig. 1.9. Waveform of inverter current

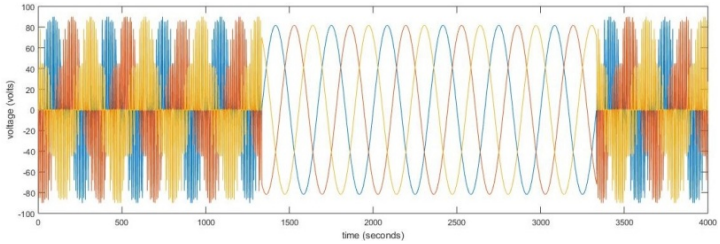

Fig.1.10. Waveform of inverter voltage

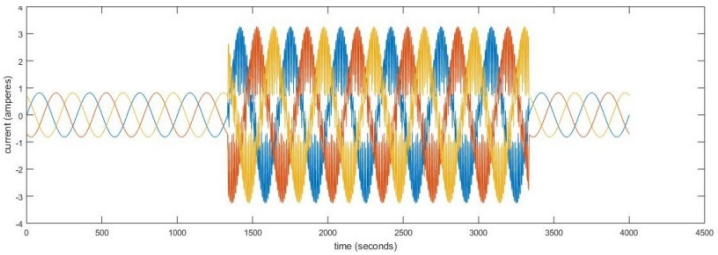

Fig.1.11. Waveform of grid current

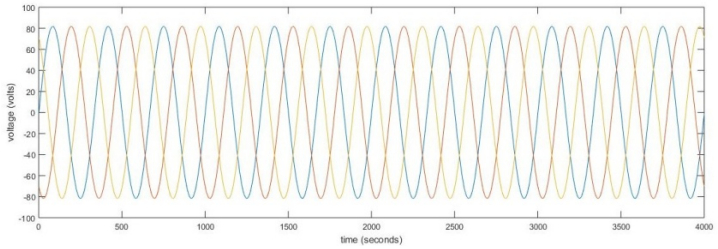

Fig.1.12. Waveform of grid voltage

1.6. Conclusion

Islanding detection is an important requirement for the modified power system scenario with increased perception of distribution sources. In this paper the passive techniques are used for islanding detection. The main purpose of the islanding detection is to continue the supply to load or providing an interruption free supply to the load. There are a many instruments or systems which required un-interrupted power supply. In such type of cases, islanding plays a significant role. Furthermore, it is easily integrates with the wind and solar power.

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