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A New Islanding Detection Method For Inverter-Based Distribution Generation Power System Using Impedance Unbalancing And Total Harmonic Distortion Of Current

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ABSTRACT: One of the important protection characteristics in online distributed generation is to identify the islanding operation. And in accordance with standards of distribution network, this identification must take in less Than 2 seconds. A novel islanding detection method for an inverter-based distribution generation power system is proposed in this paper. The inverter-based distribution generation power system includes a dc power source and a grid-connected DC/AC inverter. The grid-connected DC/AC inverter acts as a virtual capacitor as the frequency is slightly lower than the fundamental frequency of utility voltage. Hence, the proposed method can immediately detect the islanding operation. This method is combination of previous methods therefore its operation is more suitable. The results of simulation done by MATLAB program, shows the suitable operation of this method well. It is observed that method is highly effective in islanding detection, including different islanding and non-islanding conditions in the initial test system and standard inverter-based distribution generation power system with wide variations in operating parameters.

KEYWORDS: Islanding Detection Method, Inverter-Based Distribution Generation Power System, Impedance Unbalancing, Harmonic Distortion, Current.

1 INTRODUCTION

Nowadays, in most of the countries, most of the energy is supplied by fossil fuels. But in this way, we are faced with many problems such as environmental pollution and finite fossil energy. Countries use renewable energy for supply needed energy to solve these problems. Renewable energies mostly include solar energy, wind energy, energy from waste, biomass and flowing water. At the present time the goal of Europe is to supply 12% energy consumption through renewable energy in 2012. Most of distributed generations in power systems are renewable energy. Depending on the type of distributed generation, they are can be either AC or DC. But in general, most of these distributed generations are connected to the network by power electronic converters [1, 2].However, distributed generations have effects in the network; one of these effects is islanding phenomenon. Islanding mode occurs when one or more DG separately and without connection to the network, supplies local loads. This phenomenon often is unwanted. This phenomenon will cause problems such as risk for maintenance crew, damaging consumers' devices because of unstable voltage and frequency and happening imbalance while reconnecting to the network. Therefore according to the IEEE1547 standard, islanding operation must be recognized and disconnected in 2 seconds [3-5]. So far many methods have been proposed to detect the islanding state. These methods can be divided into two main groups: active and passive [4]. Active methods include:

- Impedance measurement method [6]
- Analysis of the frequency range [7]
- Methods of changes in voltage and reactive power level [8]
- Interharmonic method [9]

And the passive methods can be highlighted:

- Voltage and frequency relays [10]
- frequency changing rate relays($^{df}/_{dt}$)
- rate of output power changes[10]
- imbalanced voltage and total harmonic distortion of current(voltage)[9]

THD method may go wrong in some cases that start-stop mode occurs in network but islanding mode haven't happened therefore disconnect the network. In impedance measurement method the decision will be made very quickly because only measuring the impedance is done and sometimes may be wrongly diagnosed. In this paper, a new method based on a combination of the previous methods is proposed to detect an islanding condition and this method has a high speed because it uses the passive and active methods based on measurements. Also it prevents misdiagnosis from islanding state and system disconnection mistake. This paper is organized as follows. In the next section discussed case will be studied. An algorithm will be proposed in third section to detect the islanding state. The result are presented and analyzed in the fourth section. Finally, the conclusions are presented in fifth section.

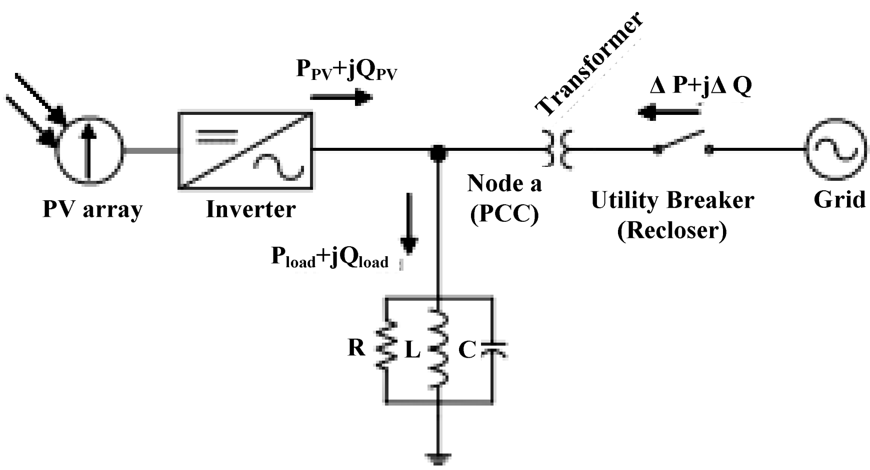

Fig 1:sketch of distributed generation system for detecting anti Islanding

2 MODEL DEVELOPMENT

Single-line diagram of the system being studied is shown in Fig 2. In this system, DG is shown by a DC source and a voltage source converter (VSC) which is connected to power system and local load through a low-pass filter. The total impedance of the low-pass filter is displayed by R_t and L_t . The system parameters are described in Table 1.

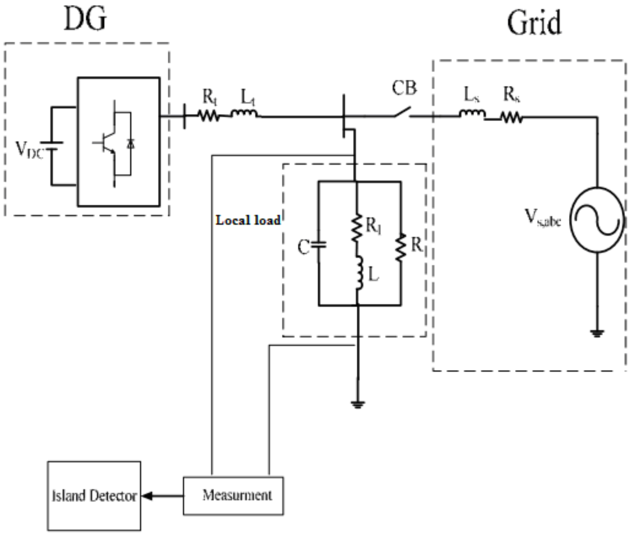

Fig 2: The power system being studied including distributed generation and network

Table 1. System 's parameters

PARAMETER	VALUE
R	76.176 Ω
L	111.9 mH
C	62.855
R_s	1 Ω
L_s	10
R_t	1.5
L_t	300
F_0	60
PWM carrier frequency	1980
DC voltage	1500
Nominal gird frequency	60

When the circuit breaker is closed as shown in the figure, distributed generation with local load is connected to the power system and generation power is injected into the system by DG. But when the circuit breaker is opened, islanding conditions occur and DG with local load creates an islanding state and independently of national network, requisite power of local load will be provided by distributed generation. In this situation islanding state must be recognized and generation must entirely be cut off and after connection to the network, generation is restarted. A measurement device is located in both side of local load to distinguish the islanding condition. The output of the measurement device ends in a central processor so measured signals are processed and in islanding state, decision is quickly made to cut off the system

3 PROPOSED ALGORITHM TO DETECT THE ISLANDING STATE

In changing rate method, we measure impedance of load. When changing of measured impedance in one period is greater than its set value, trip signal is sent to circuit breaker. Relay setting is done based on independent performance of distributed generation units and without the presence of network. Presence of network doesn't affect relay setting. The problem of this method is wrong operation in some situation such as switching mode. And because decision in this method is very fast, as a result relay operates and system is disconnected wrongly. Loading Changes in islanding mode leads to changes in current (voltage) harmonics. So, the total harmonic distortion (THD) can be used as a parameter to determine the islanding state. The current THD in moment t is obtained from equation (1).

$$THD_t = \frac{\sqrt{\sum_{h=2}^{H} I_h^2}}{I_1} \times 100$$

I_h is rms value of hth harmonic and I_1 is the main component of measured current at time t. In this paper, a new method based on the two previous methods is proposed to detect an islanding condition. Fig 3 shows the flowchart of the proposed method. In this paper, first the THD of current is measured any moment. If the measured value is less than the determined threshold value, system continues to operate. But if the measured value goes above this threshold value, the value of dz/dt is checked. And if its value exceeds of the set threshold value, islanding mode is diagnosed and stop command is sent.

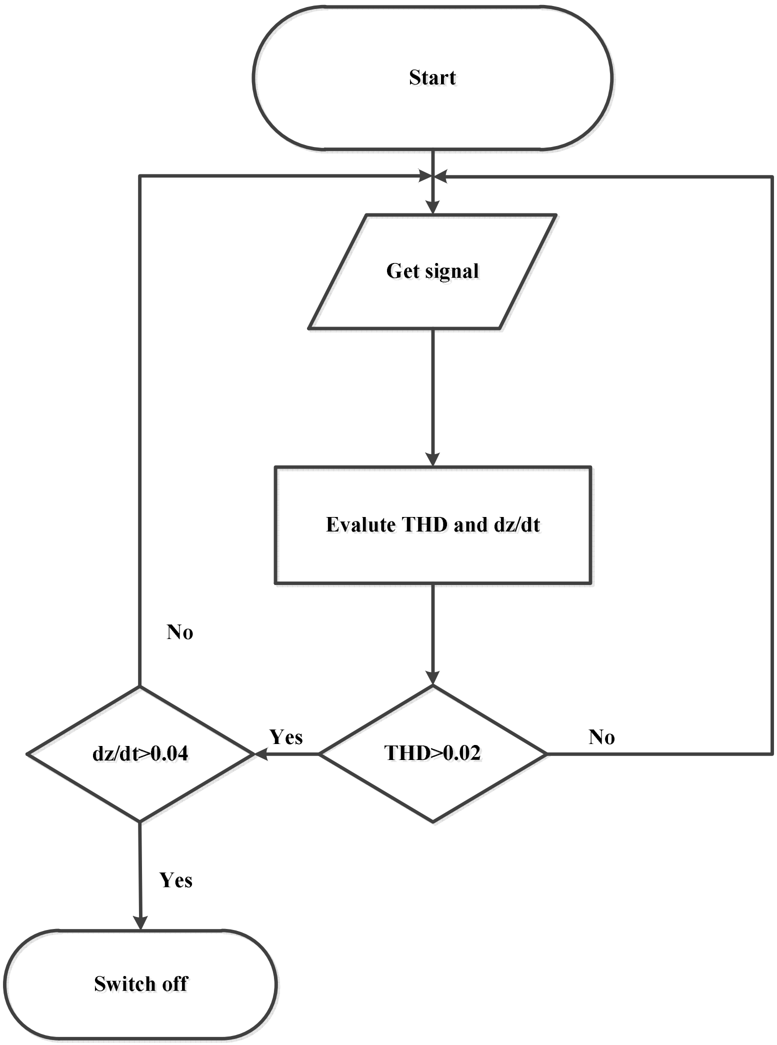

Fig 3: The flowchart of the proposed algorithm for detecting Islanding

4 SIMULATION RESULTS

In this section the results of proposed method are presented for various loads.

4.1 NON-NOMINAL LOAD

In this case, local load have non-nominal values. In connection (to network) state, network absorbs 910kw (0.5Pu) active power from distributed generation and absorbs 400Kvar (0.16Pu) reactive power from load as well.

At the first circuit breaker is closed and the system is connected to the network. At t = 1.2 sec, CB is opened and distributed generation and local load are isolated from the network and islanding state is created. Figure 4 shows the voltage waveform of phase A, which has remained relatively constant. Fig 5 and Fig 6 display THD of voltage and THD of current respectively. According to the figures, it is clear that at t = 1.2 seconds THD values are increased rapidly and their value is greater than 0.025. In this situation it is possible for islanding state to occur therefore $dz/_{dt}$ should be checked. Fig 7 shows $dz/_{dt}$ of signal. According to waveform, it is determined that the size of the waveform $dz/_{dt}$ is higher than 0.04. Therefore islanding state is diagnosed and system should be shut down and generation should be stopped. In Fig 8, the impedance and Phasor of the system in accordance with frequency are shown in terms of the non-nominal load.

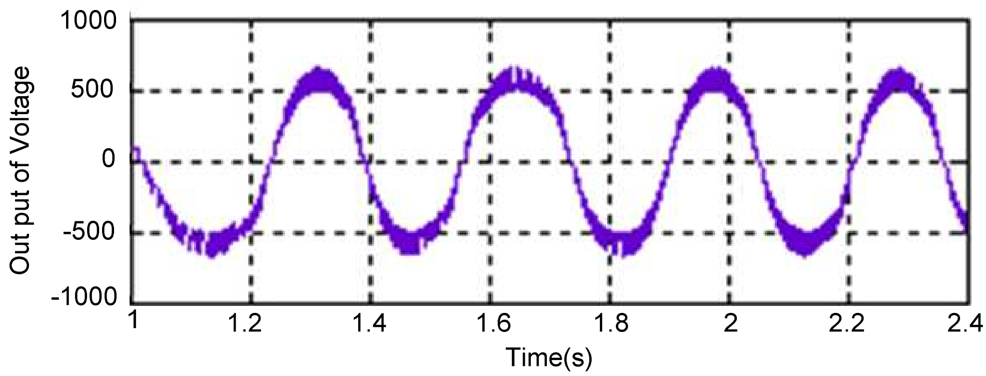

Fig 4: voltage waveform of phase A at the non-nominal state

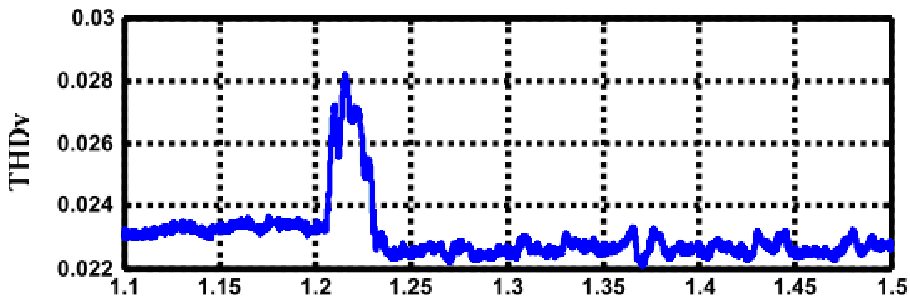

Fig 5: Changes of THD of voltage at non-nominal load on the islanding conditions

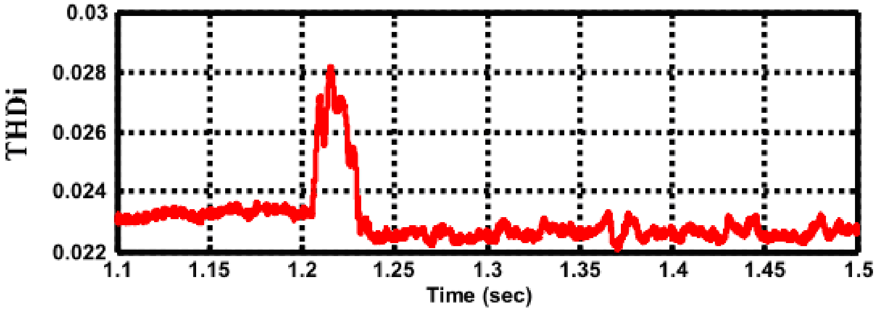

Fig 6: Changes of THD of current at non-nominal load on the islanding conditions

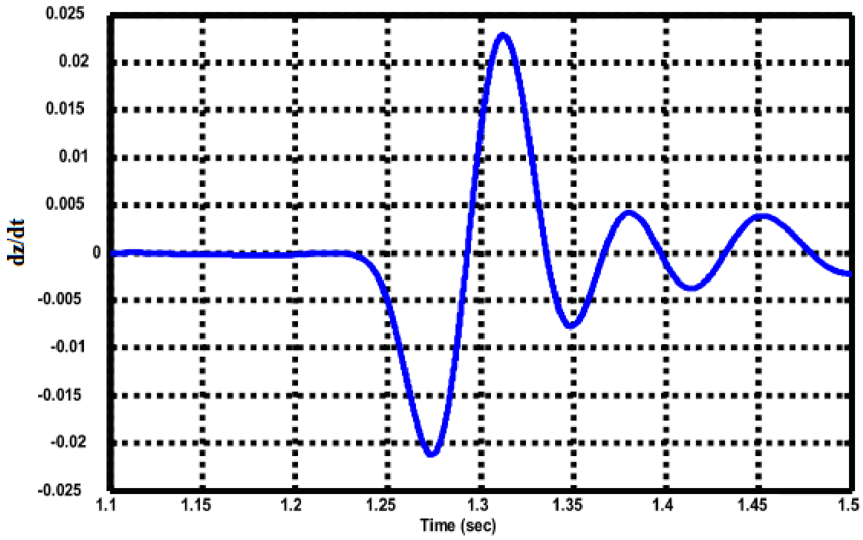

Fig 7: The rate of impedance changes in non-nominal conditions

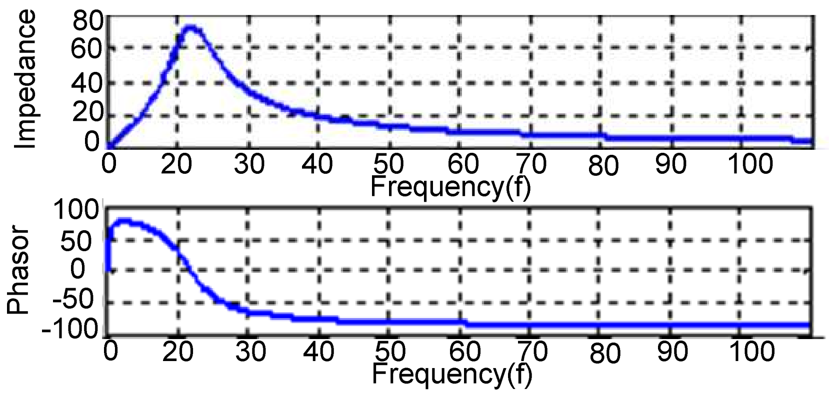

Fig 8: changes of impedance and phasor in accordance with frequency

4.2 NOMINAL LOAD

In this section, the local load values are nominal values of load and power cannot be exchanged between the network and distributed generation. At t = 1.0 sec, CB is open and the system turns to an islanding state. Fig 9 and Fig 10 display THD of voltage and THD of current respectively. THD values go higher than 0.025 at islanding moment and changing rate of impedance must be evaluated then must be decided about the islanding situation. Fig 11 shows the changing rate of impedance. According to the figure, $dz/_{dt}$ at t = 1.09 s is higher than 0.04. So it can be claimed that the islanding has happened.

The IEEE standard is considered like the previous section, and the islanding has been diagnosed before 2 seconds.

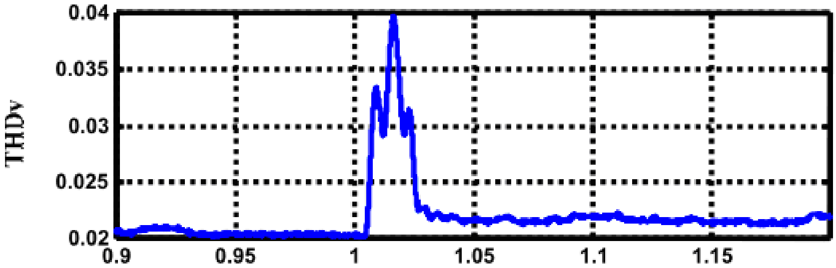

Fig 9: Changes of THD of voltage at nominal load on the islanding conditions

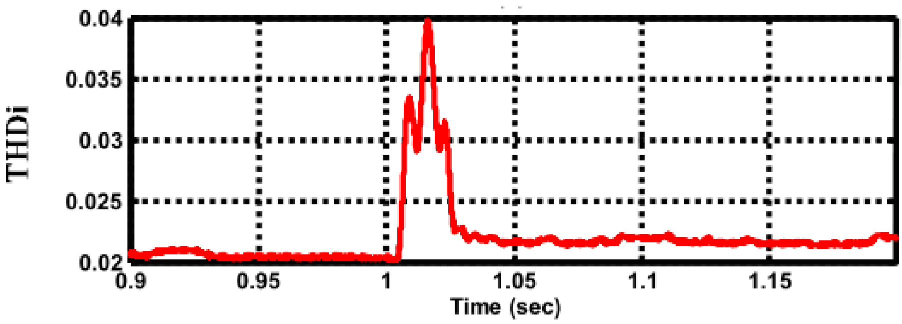

Fig 10: Changes of THD of current at nominal load on the islanding conditions

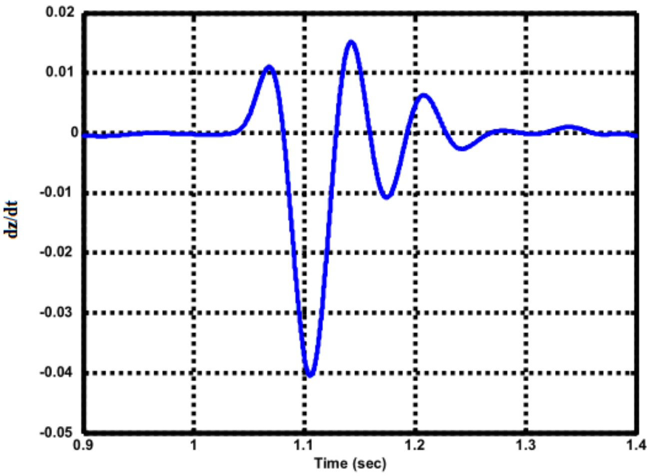

Fig 11: The rate of impedance changes in terms of the nominal

4.3 STARTING THE ENGINE AND SWITCHING THE CAPACITOR BANK

In this section, the performance of the algorithm is evaluated for different switching modes, to demonstrate that the proposed algorithm cannot be wrong at switching times and islanding is recognized well. At first the system works in the state of connected to the network. At t=1.5 sec an induction motor with (P=1.5 KW and P.F=0.75, lag) starts. At t=1.8 sec a capacitor bank with reactive power Q=1 MVAR is switched and connected to the network. And at t = 2.2 sec islanding state occurs and the system is isolated from the network. Fig 12 shows the voltage phase A in this case. According to the voltage waveform it is clear that voltage has changed a little. Fig 13 and Fig 14 show THD of voltage and THD of current in this state. As shown in Fig 14, at t=1.5, t=1.8 and t=2.2 sec THD values are higher than 0.025. Then in these moments, it should be examined whether an islanding state or switching state is done

According to Fig 15 showing the changing rate of impedance, it is determined that the value of $dz/_{dt}$ is higher than 0.02 just at t = 2.2sec. So we can understand that the islanding state is at t=2.2 sec and other events except islanding state have happened in other moments (t=1.5 and t=1.8).

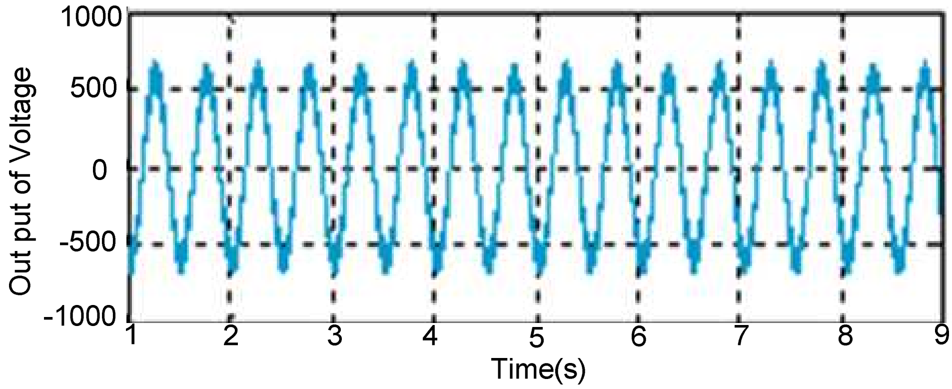

Fig 12: Voltage waveform at the switching conditions

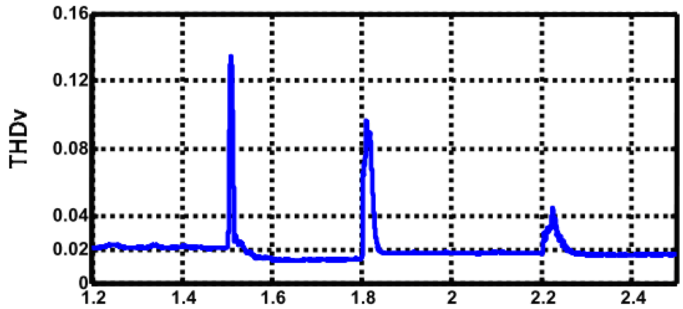

Fig 13: Changes of THD of voltage in islanding and switching state

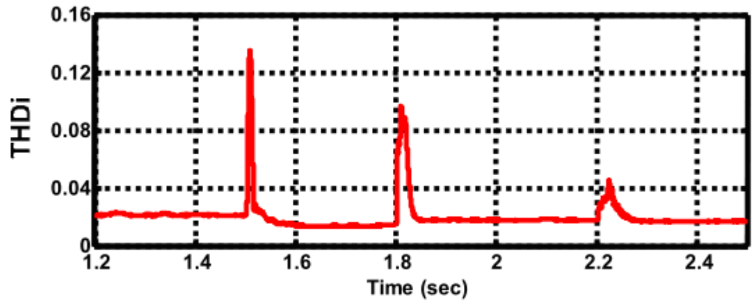

Fig 14: THD waveforms for current in the switching conditions

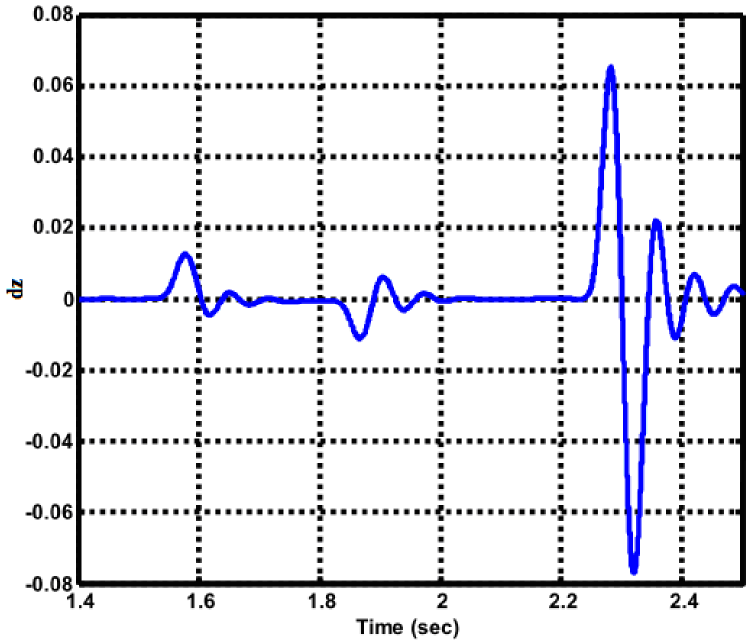

Fig 15: The rate of impedance changes in accordance with time for switching condition

5 CONCLUSION

In this article a new combined method was proposed for detecting islanding conditions for distributed generation. The results shown in this paper indicate that the proposed method has good performance. Because, in situations that previous methods go wrong, new method simply detects the situation and adopts more appropriate decision to disconnect systems.

Following results have been performed based on simulation:

1. In this method, there is no injection in inverter current so there is no unwanted reactive power.
2. The proposed islanding detection method is having a high speed.
3. Simulations have been performed using MATLAB software in real environment.
4. In this method we do not have non detection zone (NDZ).
5. Studied system is similar to standard with the difference that is used local loads are assumed to be unbalanced.

Conventional active detection methods are not able to detect the island with the aim to keep it stable. Because they try to leave electrical parameters such as voltage and frequency from their rating value. So in micro grids, island should be detected by using passive or remote methods. We should note that the detection time of 2 seconds which is referred to in standard is not appropriate and detection time must be less than this value. The proposed method which is in group of active methods is capable for use in micro grids.

REFERENCES

[1] Karrari, M. Rosehart, W,Malik.O.P,. "Nonlinear Modeling and Simulation Of a Wind Generation Unit For Transient and Stability Analysis", Technical Report University of Calgary, March 2003.

[2] Hassan Nikkhajoei, Reza Iravani ”Steady-State Model and Power Flow Analysis of ElectronicallyCoupled Distributed Resource Units” IEEE TRANSACTIONS ON POWER DELIVERY, VOL.NO 1. .2007.

[3] Xu, Wilsun, Mauch, Konrad, Martel, Sylvain; An Assessment of DG Islanding Detection Methods and Issues for Canada CETC-Varennes 2004-074.INVERT,July,2004.

[4] John, V. Zhihong, Y. and Kolwalkar,A Investigation of anti-islanding protection of powerconverter based distributed generators using frequency domain analysis,” Power Electronics IEEE, pp. 1177 Sept., 2004

[5] Vinod John, Zhihong Ye, Amol Kolwalkar ,Investigation of Anti-Islanding Protection of Power Converter Based Distributed Generators Using Frequency Domain Analysis" IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 19, NO. 5 ,SEPTEMBER,2004.

[6] Kim.J.E, Hwang.J.S,"Islanding Detection Method of Distributed Generation Units Connected To Power Distribution System.

[7] Jou, H.-L. Chiang, W.-J. and Wu, J.-C." Virtual inductor-based islanding detection method for grid-connected power inverter of distributed power generation system" IET Renew. Power Gener., 2007. pp. 175–181.

[8] Chowdhury,S.P.Chowdhury,S. Crossle P.A,."Islanding protection of active distribution networks with renewable distributed generators: A comprehensive survey" Electric Power Systems Research,2009.

[9] Yuping Lu, Xin Yi, Ji'an Wu, Xia Lin, An Intelligent Islanding Technique Considering Load Balance for Distribution System with DGs, IEEE , pp.567-573,2006.

[10] Rani B I, Srikanth M et al. (2013). An active islanding detec-tion technique for current controlled inverter, Renewable Energy, vol 51, 189–196.

[11] Hashemi F, Kazemi A et al. (2012). A new algorithm to detection of anti-islanding based on dqo transform, Energy Procedia, vol 14, 81–86.

[12] Lee J, Min B et al. (2011). Active frequency with a positive feedback anti-islanding method based on a Robust PLL algorithm for grid-connected PV PCS, Journal of Power Electronics, vol 11, No. 3, 360–368.

[13] Yazdani A, and Iravani R (2010). Voltage-sourced converters in power systems, Modeling, Control, and Applications Chapter 3, 8, Wiley/IEEE Press.