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A New Approach for Islanding Detection; Using Combination of Active-Passive Techniques

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Abstract: During the last years, growing power demand and increasing concern about the use of fossil fuels in conventional power plants, the new paradigm of distributed generation is gaining greater commercial and technical importance in worldwide. Due to the DGs advantages, including using of Renewable Energy which not polluting environment and has endless nature, the application of DGs can potentially reduce the need for traditional system expansion, controlling a potentially huge number of DGs creates a daunting new challenge for operating and controlling the network safely and efficiently. One problem that encountered with it when using with DGs, is an unwanted Islanding phenomenon. In this study, a novel technique in order to detecting islanding conditions has been present and the proposed method based on combined of passive and active methods, its performance is much more appropriate than that of previous techniques. The simulation results performed in MATLAB clearly show improved operation of this method.

Keywords: Active technique, distributed generation, islanding, passive technique, switching

INTRODUCTION

Recently, the penetration of Distributed Generation (DG) at medium and low voltages in utility networks is increasing in developed countries and takes special place for them worldwide. Renewable distributed generation involves the interconnection of small-scale, on-site Distributed Energy Resources (DERs) with the main power utility at distribution voltage level Katiraei *et al*. (2005). DERs mainly combined from renewable energy sources like solar PV, wind turbines, fuel cells, small-scale hydro, tidal and wave generators, micro-turbines, Combined Heat Power (CHP) systems, etc.

Bulk of distributed generations in power system is from renewable energy. Depending on the distributed generations, their production can be AC or DC. But in all, most of these products are connected through electronic power converter to the network Shahabi *et al*. (2009). Most of inverters of DGs that produce DC voltage usually operate with current control system in order to control the output power of DG. But DGs will have affects in the network. One of these effects has become an islanding phenomenon.

An essential requirement of the grid interconnected DG system is the capability of islanding detection John *et al*. (2004). Islanding state happens when one or more DGs without connecting to the network are connected and supplied local loads. In most cases this phenomenon can occur unwanted. The islanding operation of DG may cause potential hazards to line-maintenance personnel, equipment damage due to instability in user voltage and frequency and risk the DG in being damaged by out of phase reconnection to the grid. The majority of utilities require that DG should be disconnected from the grid as soon as the islanding occurs. Therefore, according to IEEE1547 standard, islanding state should be detected and disconnected in less than 2 sec Sulaiman (2001) and Rohit and Wenzhong (2008).

So far many methods to detect Islanding condition have been proposed. These methods can be classified in two broad categories of active and passive classifications Chowdhury *et al*. (2009). In active techniques, disturbances are injected locally into the system and responses of these disturbances are used to detect islanding conditions. Including the active method we can point to the followings: Impedance measurement method Chowdhury *et al*. (2009), Sandia Frequency Shift (SFS) and Sandia Voltage Shift (SVS) John *et al*. (2004), Frequency domain analysis John *et al*. (2004), Changing voltage amplitude and reactive power method Kim and Hwang (2000), the mid-harmonic method Jou *et al*. (2007), Reactive power export error detection Redfern and Usta (1993).

And the passive techniques make decisions based on the local measurements of voltage and current signals. Passive techniques include:

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Table 1: Characteristic of studied power system

Parameters	Value
V_{dc}	800 V
L_f	2 mH
C_f	0.022 mF
Rated voltage	380 V
Grid voltage	20k V
R_L	1.8 ohm/phase
L_L	7.7 mH/phase
C_L	1.33 mF
Transformer Ratio	20/0.38 kV
Transformer Power	100 KW
Frequency	50 HZ

Under/over voltage and under/over frequency John *et al*. (2004), Rate of change of frequency relay (df/dt) Yuping *et al*. (2006), Phase displacement monitoring Chowdhury *et al*. (2009), Output power speed changing Yuping *et al*. (2006), Comparison of Rate of Change of Frequency (COROCOF) Bright (2001), Unbalanced voltage and Total current (or voltage) Harmonic Distortion (THD) Khalil *et al*. (2007).

The proposed method in this study is based on combined of active and passive techniques. At first the Rate of Change of Vq will be calculated and if its value exceeds the threshold value, in this case the disturbance current will be applied to dq-current controller across the d-axis. If the islanding situation was occurred, the output voltage and frequency become exceed from their allowable limits and over/under frequency or voltage relay can be detected the islanding condition. The performance of this method shows by simulation of test system in MATLAB software and applying the proposed algorithm in difference condition to test system.

System study: The study system in this study that the proposed algorithm applied to this system is shown in Fig. (1). As depicted, The DG unit is represented by a DC voltage source, a VSC that control with conventional dq-current controller, a series filter (Lf and Cf) and a transformer that join the DG to utility. The local load is represented by a three-phase parallel RLC network at the PCC. A step-up transformer is located between DGs local loads and utility grid. The utility grid simulated with ideal source and Rs ¬, Ls. connection between utility grid and DG is done with Circuit Breaker (CB). In order to convert the DC voltage to AC voltage, as can be seen, used of inverter with IGBT switches. The parameters of study system are given in Table 1.

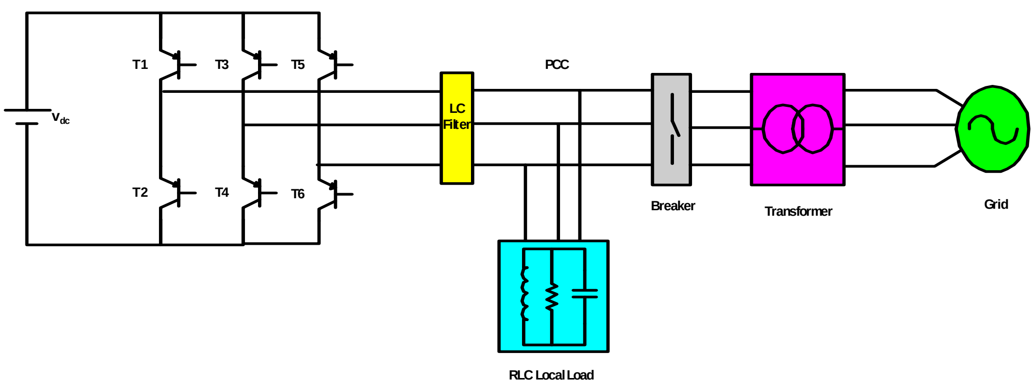


Fig. 1: Studied power system including DG and power grid

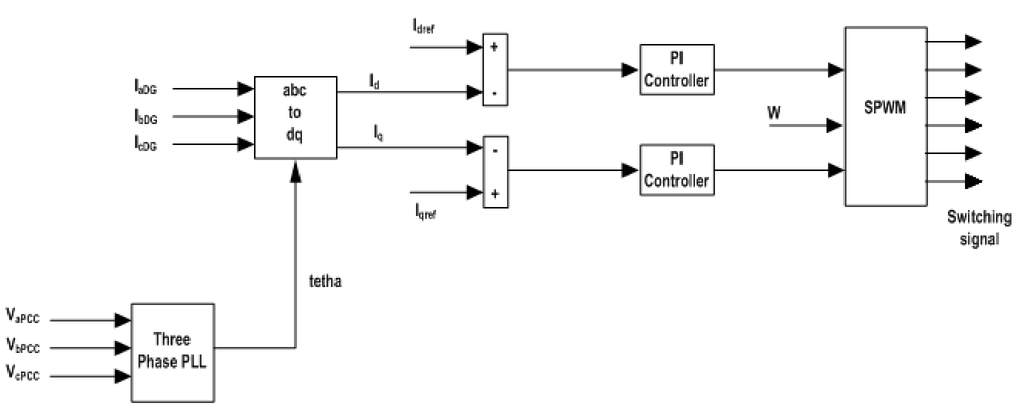


Fig. 2: Dq-current controller in order to control of active and reactive power of DG's output

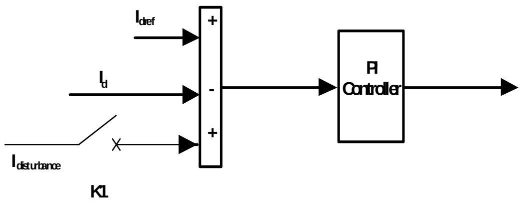


Fig. 3: 3th current harmonic injection across Id as a disturbance

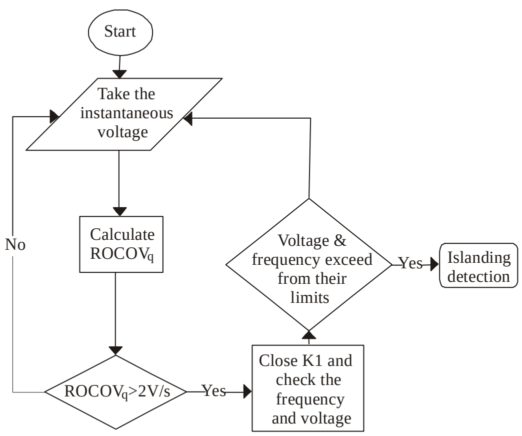


Fig. 4: Flowchart of the proposed algorithm in order to detection

When the CB as shown in the figure is closed, in this mode DG together with local load is connecting to power grids and power produced by DG is injected. But when the CB is opened, in this mode, islanding state occurs and DG along with a local load form an islanding condition which creates an independent power grid in which just DG supplies loads demand power. In these conditions, that should a case be detected islanding mode and power production is entirely disconnected from the power grid and after reconnection it starts to produce power again.

To detection the islanding condition, a measurement system installed at the head of a local load and output of the mentioned system ended in a central processor in which measured signals are being processed and in the Islanding state a fast decision made and command for disconnecting system will be exported.

PROPOSED METHODOLOGY

DG systems are connected to the distribution system through an inverter as shown in Fig. 1. The inverter performs two main functions:

- Controlling the active power output of the DG and, in some cases, injecting a suitable amount of reactive power to mitigate a power quality problem.
- According to the IEEE Standard 1547, the DG should be equipped with an anti-islanding detection algorithm, which could be performed using the inverter interface control (active methods).

In this study, these variables are controlled using the dq frame of reference Schauder and Mehta (1993). The VSC controls its output real and reactive power components. Figure 2 depicted the dq-current control strategy in order to control of active and reactive power of DG's output.

Under the test configuration of Fig. 1, the RLC tank draws the fundamental current component supplied by the VSC, at the unity power factor. If a disturbance signal at different frequency, different from the fundamental frequency, is injected into the system through the converter current controllers, the corresponding current disturbance flows into the low-impedance path offered by the utility, as shown in Fig. 3.

The proposed islanding detection method in this study is based on injecting an appropriate disturbance signal through the Id controller, Fig. 3, illustrate the proposed algorithm that inject the 3th harmonic of output current into the controller. When DG study in grid connected mode the value of 3th harmonic of current is small and doesn't has mostly influence in output power, but when DG become isolated from utility and islanding occurred, the amount of 3th harmonic increase and can affect on output current. This algorithm act such as positive feedback and finally islanding will be detected.

ROCOVq passive algorithm uses synchronous transformation based phasor estimation of the retrieved instantaneous voltage signals. The signal x(t) is represented as follows:

$$X(t) = \sum_{n=1}^{\infty} X_{\max} \cos\left(n\,\omega_0 t + \phi_n\right) \qquad (1)$$

where, $X_{\max}$ is amplitude and ϕ_n is angle of signal $X(t)$. Under balanced conditions, each three-phase variable x_{abc} of (1) can be transferred to a stationary αβ reference frame system by applying the following *abc* to αβ transformation:

$$x_{\alpha\beta} = x_a e^{j0} + x_b e^{j2\pi/3} + x_c e^{-j2\pi/3} \qquad (2)$$

where, $x_{\alpha\beta} = x_\alpha + jx_\beta$, in order to calculating dq parameters can be used of Eq. (3) Houshang *et al*. (2008):

$$x_d + jx_q = x_{\alpha\beta} e^{-j\theta} \qquad (3)$$

where, θ calculated by:

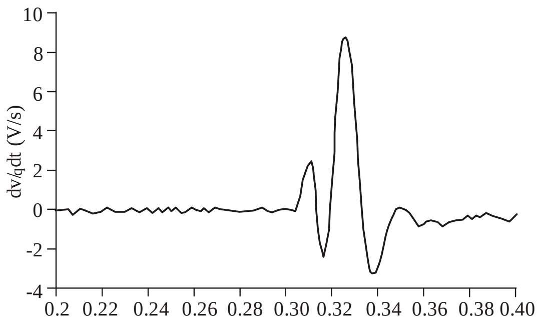
$$\theta = \arctan \frac{x_{\beta}^{ref}}{x_{\alpha}^{ref}} \tag{4}$$

$$ROCOV_q = \frac{dV_q}{dt} \tag{5}$$

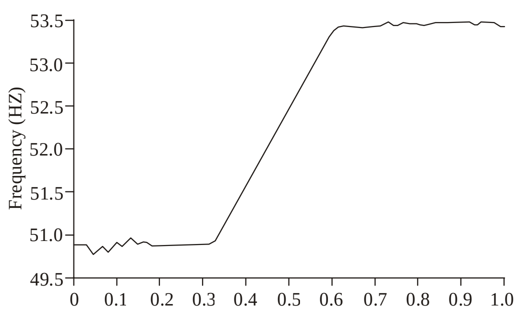
The proposed method in this study depicted in Fig. 4. At first, in this method, dq-component of voltage value will be calculated at determined range time, Then the value of $ROCOV_q$ will be calculated too with Eq. (5). If this value is less than the threshold value determined in this way continues working, but if its value exceeds the threshold value, in this case the K1 switch of dq-current controller that shows in Fig. 3 will be closed and disturbance current will be injected to system across the Id axis. If the islanding situation was occurred, the output voltage and frequency become exceed from their allowable limits and over/under frequency or voltage can be detected the islanding condition. In otherwise, the voltage and frequency doesn't have mostly changing and system continue to its working.

SIMULATION RESULTS

In this section of the study, the results of the proposed method to detection the islanding mode have carried out on different loads and the ability of proposed system for islanding detection have been shows.



(a)



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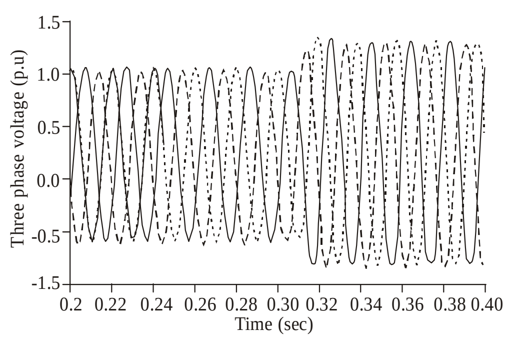
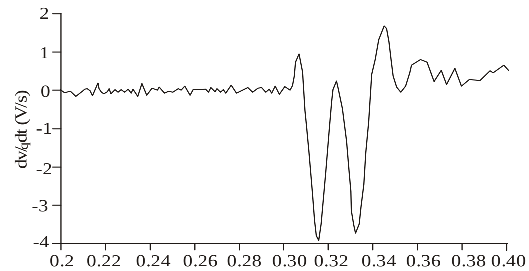
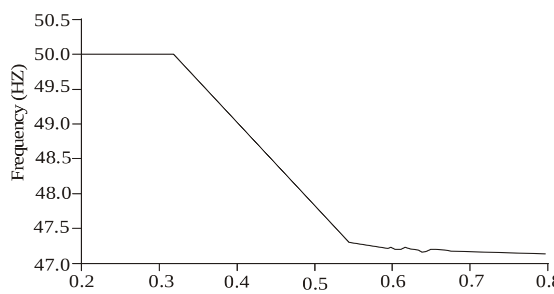


(c)

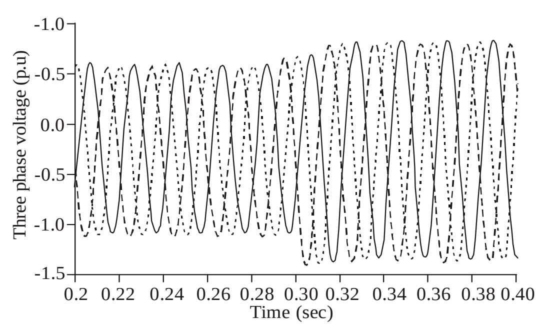
Fig. 5: The result of system in island mode with load condition 1 a) Rate of change of q-axis voltage b) frequency of system c) three phase voltage of local load in p.u



(a)



(b)



(c)

Fig. 6: The result of system in island mode with load condition 2 a) Rate of change of q-axis voltage b) frequency of system c) three phase voltage of local load in p.u

Load condition 1: In this case, local load is set to the nominal condition that given in Table 1, P = 80KW and Qc = QL = 60 KVAr, respectively. At the first CB is closed and system utilized in grid connected mode. At t = 0.3 sec, CB is opened and DG together with local load is separated from power grid and islanding condition occurs. Figure 5a, shows the rate of change of Vq of the output voltage. It is obvious from the figure that after islanding $ROCOV_q$ value increased and at t = 0.31 sec the value exceeded from 2V/sec. This case the probability of forming an is land is take places. At t = 0.31sec the K1 switch that is shown in Fig. 3 become closed and the disturbance will be applied in I axis. Figure 5b and c shows the voltage frequency and instantaneous value of three phase load voltage in (p.u) after that applying the disturbance. Before of island condition that is obvious the three phase voltage and frequency is in nominal condition but when islanding occurred the three phase voltage of Distributed Generation change from that nominal condition, therefore can be detect the island condition.

Load condition 2: In second condition, the active and reactive power of inductance and capacitor considers P = 80KW, QL = 70 KVAr and Qc = 78 KVAr, respectively. At the grid connected mode CB is closed. At t = 0.3 sec, CB is opened and DG together with local load is separated from power grid and islanding condition occurred again. Figure 6a, shows the rate of change of Vq

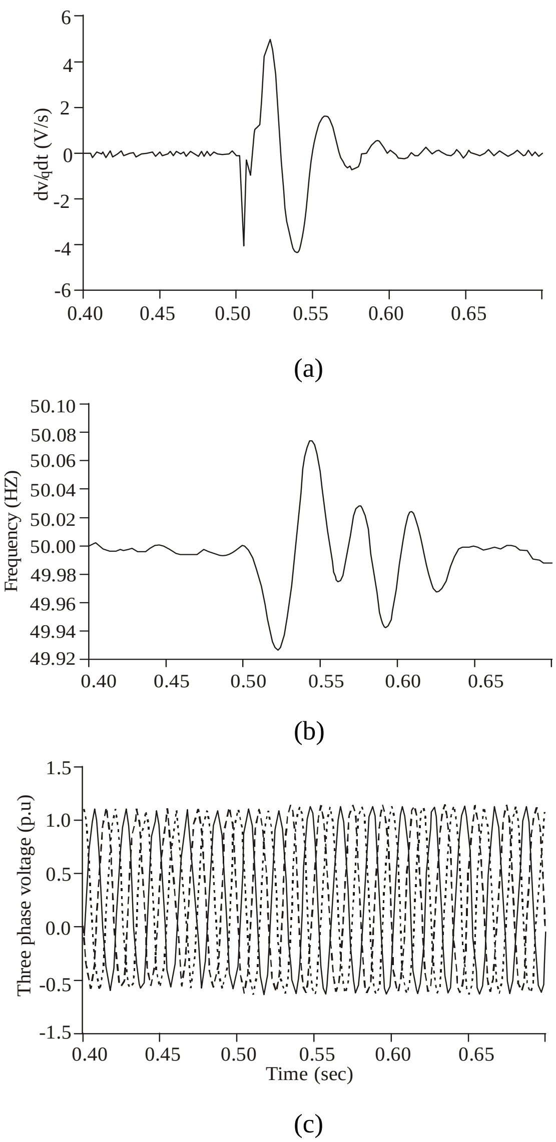


Fig. 7: The result of system in capacitor switching condition, (a) Rate of change of q-axis voltage, (b) frequency of system, (c) three phase voltage of local load in p.u

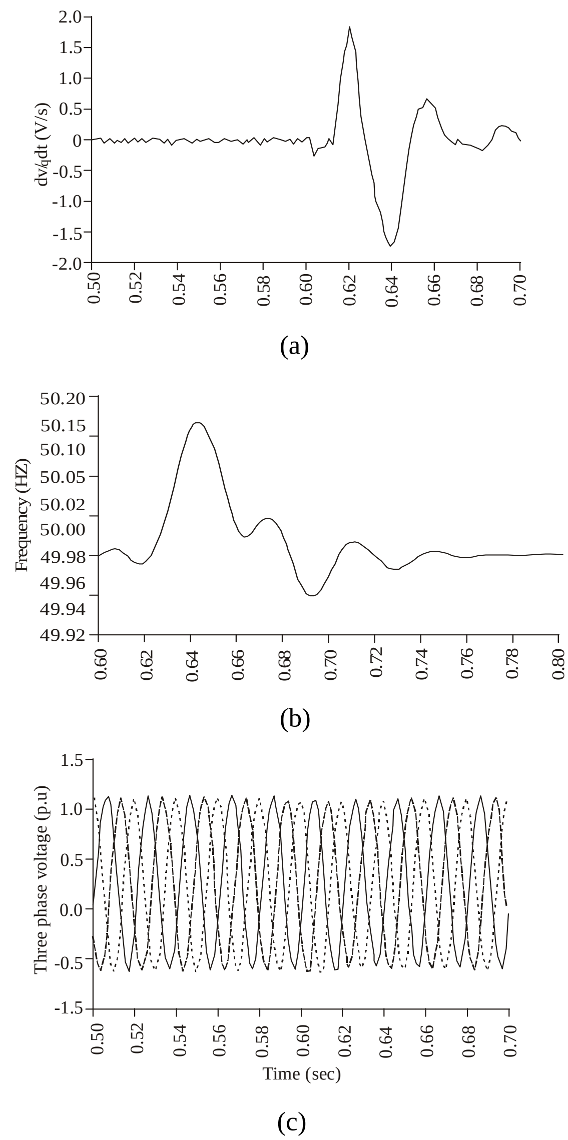


Fig. 8: The result of system in motor starting, (a) Rate of change of q-axis voltage, (b) frequency of system, (c) three phase voltage of local load in p.u

of the output voltage. It is obvious from the figure that after islanding ROCOVq value increased and at t = 0.315 sec the value exceeded from 2V/sec. This case the probability of forming an island is take places. Figure 5b depicted frequency of output voltage and instantaneous three phase voltage of load in (p.u) before and after islanding situation. As can be seen, after islanding situation the three phase voltage exceeds from that allowable limit and frequency fall down while, before islanding condition the three phase voltage of Distributed Generation and frequency was in nominal value. From of this voltage and frequency that can be detect the island condition.

Switch of capacitor bank: In this section, the performance of algorithm is studied for capacitor bank switching in grid connected mode to be shown that the proposed algorithm not mistaken in capacitor bank switching and detection properly the islanding state from capacitor bank switching conditions. Initially the system studies in nominal load condition that depicted in Table 1. At t = 0.5 sec a capacitor bank with 30KVAr reactive power switching and connect to system. Figure 7a, illustrate shows the rate of change of Vq of the output voltage. From of this figure can be seen that after switching ROCOVq value increased and at t = 0.505 sec the value exceeded from 2V/sec. the disturbance in d-axis apply at t = 0.51sec. From of Fig. 7b and c the frequency and voltage doesn't have mostly changing therefore can be said that islanding doesn't occur and system can be work without any problem.

Motor starting: One of the other switching condition that algorithm may be mistake is motor starting. Initially the system studies in a connecting to the network mode with nominal load situation. At t = 0.6 sec an induction motor with P = 20 kw and Q = 45 kVAr is started to work. Figure 8-a depicted the rate of change q-axis voltage and Fig. 8b and c, shows the frequency and three phase load voltage respectively. From Fig. 8a, the value of ROCOVq doesn't have mostly change and doesn't exceed from the allowable value therefore system continues to its working and doesn't mistake.

CONCLUSION

This study was proposed a new mixed passive and active technique based on rate of change of q-axis voltage and injection of disturbance across d-axis in dq-current controller of VSC. In order to detection of DGs islanding conditions. The results indicate that the performance of the proposed method is desirable because this proposed technique easily detect islanding conditions from of other switching situation without any mistake and making appropriate decision to disconnect the system. Simulation results are taken in MATLAB software and the results were shown for various loads were shown and from of results that is specified that this algorithm works well properly.

REFERENCES

Bright, C.G., 2001. Corocof: Comparison of rate of change of frequency protection: A solution to the detection of loss of mains, In: Proceedings of the Developments in Power System Protection Conference, Publication No. 479, IEE Press.

Chowdhury, S.P., S. Chowdhury and P.A. Crossley, 2009. Islanding protection of active distribution networks with renewable distributed generators: A comprehensive survey. Electric Power Syst. Res., 76(6): 984-992.

Houshang, K., N. Hassan and I. Reza, 2008. Control of an electronically-coupled distributed resource unit subsequent to an islanding event. IEEE T. Power Delivery, 23(1): 493-501.

John, V., Y. Zhihong and A. Kolwalkar, 2004. Investigation of anti-islanding protection of power converter based distributed generators using frequency domain analysis. Power Electronics IEEE, pp: 1177-1183.

Jou, H.L., W.J. Chiang and J.C. Wu, 2007. Virtual inductor-based islanding detection method for grid-connected power inverter of distributed power generation system. IET Renew. Power Genre., 1(3): 175-181.

Katiraei, F., M.R. Iravani and P.W. Lehn, 2005. Micro-grid autonomous operation during and subsequent to islanding process. IEEE T. Power Delivery, 20(1): 248-257.

Khalil, E.A., J. Géza, K. Innocent and T.M.G. Donald, 2007. Intelligent-Based Approach to Islanding Detection in Distributed Generation. IEEE T. Power Delivery, 22(2): 828-835.

Kim, J.E. and J.S. Hwang, 2000. Islanding Detection Method of Distributed Generation Units Connected To Power Distribution System. Power System Technology, Proceeding International power con2000, pp: 643-647.

Redfern, M.A., O. Usta and G. Fielding, 1993. Protection against loss of utility grid supply for a dispersed storage and generation unit. IEEE T. Power Delivery, 8(3): 948-954.

Rohit, S.K. and G. Wenzhong, 2008. Comparision and Review of Islanding Detection Techniques for Distributed Energy Resources Power Symposium, 40th North American, pp: 1-8.

Schauder, C. and H. Mehta, 1993. Vector analysis and control of advanced static VAR compensators. Proc. Inst. Elect. Eng., 140: 299-306.

Shahabi, M., M.R. Haghifam, M. Mohamadian and S.A. Nabavi-Niaki, 2009. Microgrid dynamic performance improvement using doubly fed induction wind generator. IEEE T. Energ. Conver., 24(1): 137-145.

Sulaiman, T.A., 2001. Using the real-time island detection and network colouring application in electrical systems: IEEE, Human Interfaces in Control Rooms, Cockpits and Command Centres, The Second International Conference on, pp: 234-239, 19-21 June.

Yuping, L., X. Yi, J. Wu and X. Lin, 2006. An Intelligent Islanding Technique Considering Load Balance for Distribution System with DGs. IEEE, pp: 567-573.