International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

September 2014 Issue 20 Volume 6 Number 3 Pages 145-152

USING TV-ACPSO FOR ISLANDING DETECTION AND CONTROLLING BASED MICROTURBINE NETWORK SYSTEM

M.S. Dincer S.S. Tezcan S. Korjani

Department of Electrical and Electronics Engineering, Gazi University, Ankara, Turkey
sedincer@gazi.edu.tr, stezcan@gazi.edu.tr, saman@gazi.edu.tr

Abstract- Nowadays, distributed generations (DGs) have taken a special role in power systems. Distributed generations have received significant attention as a means to improve the performance of the electrical power system, provide low cost energy, and increase overall energy efficiency. A problem with such generators is the unwanted islanding phenomenon. Islanding detection an important and challenging issue to power engineers. Several methods based on passive and active detection scheme have been proposed in the literature. While passive schemes have a large non detection zone (NDZ), concern has been raised on active method due to its degrading power quality effect. In this paper, a new technique based Time Varying Acceleration Coefficients (TV-ACPSO) to detect islanding conditions has been proposed for microturbine (MT) as distributed generation. The performance of the proposed method based on passive methods is much more appropriate than that of previous methods. The simulation results performed in Simulink-MATLAB, clearly show improved operation of this method.

Keywords: Microturbine, Distributed Generation, Islanding Phenomenon, Non-Detection Zone.

I. INTRODUCTION

Distributed generations have been broadly used and are expected to be an important element in the future power systems. These generation systems have characteristics which are different from those of conventional large capacity fossil and nuclear generation systems. Distributed generation (DG) with its various distributed resource (DR) technologies has many advantages when connected to the power system [1]. DGs are energy sources that are located near the load. By locating sources near the load, transmission and distribution costs are decreased and delivery problems mitigated. DGs application can relieve transmission and distribution assets, reduce constraints, and improve power quality and reliability [1].

DGs are constituted by a variety of small, modular distributed generation (DG) technologies that can be combined with energy management and storage systems. DG devices enable renewable energies utilization and more efficient utilization of waste heat in combined heat and power (CHP) applications and lowering emissions. [2]. Deregulation of the electric utility industry, environmental concerns associated with central electric power plants, volatility of electric energy cost, and rapid technological developments of DG systems all support the proliferation of DG units in electric utility systems. When the distributed generation systems are operated in parallel with utility power systems, especially with reverse power flow, the power quality problems become significant.

Power quality problems include frequency deviation, voltage fluctuation, harmonics and reliability of the power system. In addition, most important problem is an islanding protection. Islanding happens when one or more DGs supply local loads without getting connected to a power grid [2]. In most cases, this phenomenon can occur unintentionally, which causes problems due to the instability in consumer voltage and frequency and inconsistency in the reconnection to the power system such as creating the hazard for line repair technicians and equipment damages. Therefore, according to IEEE-1547 standard, islanding state should be identified and distributed generations disconnected within 2 seconds [3, 4].

To detect Islanding state many methods have been proposed so far. These methods can be classified in two broad categories of active and passive classifications [5]. The following techniques can be mentioned as the active methods: Impedance measurement method [6], Frequency domain analysis [7], Changing voltage amplitude and reactive power method [8]. The mid-harmonic method [9]. And, the techniques which can be mentioned as the passive methods: Voltage and frequency relays [10], Rate of change of frequency relay (df/dt) [11], Output power speed changes [10], Unbalanced voltage and total current (or voltage) harmonic distortion (THD) [12].

Passive methods do have a NDZ and active methods reduce the NDZ close to zero but making a compromise with the output power quality. The main emphasis of the proposed scheme is to reduce the NDZ to as close as possible and to keep the output power quality unchanged. In this paper a new method has been proposed for islanding detection that the performance of the method is based on instantaneous measurement of the Micro turbine rotor speed changes and measurement phase of angle voltage at the point of common coupling (PCC).

As regards, parameters that can be changed in islanding mode are rotor speed of microturbine and phase angle of the voltages at PCC. This new method will help to reduce the NDZ without any perturbation that deteriorates the output power quality.

II. MICROTURBINE MODEL

Microturbines are very small gas combustion turbines, featuring a single shaft structure with no gearboxes and rotating at very high speed, typically between 50,000 and 120,000 rpm/min; as a consequence these machines are always equipped with permanent magnet synchronous generators to produce electricity. The designs of micro-turbines are composed of the following parts [13, 14]:

(a) *Turbine*: There are two kinds of turbines, high speed single shaft turbines and split shaft turbines. All are small gas turbines.

(b) *Alternator*: In the single shaft design, an alternator is directly coupled to the single shaft turbine. The rotor is either a two or four pole permanent design, and the stator is a conventional copper wound design. In the split shaft design, a conventional induction or synchronous machine is mounted on the power turbine via gearbox.

(c) *Power Electronics*: In the single shaft design, the alternator generates a very high frequency three phase signal ranging from 1500 to 4000 Hz. The high frequency voltage is first rectified and then inverted to a normal 50 or 60 Hz voltage. In the split shaft design, the power inverters are not required.

(d) *Recuperator*: The recuperator is a heat exchanger which transfers heat from the exhaust gas to the discharge air before it enters the combustor. This reduces the amount of fuel required to raise the discharge air temperature to that required by the turbine.

(e) *Control and Communication*: Control and communication systems include full control of the turbine, power inverter and start-up electronics as well as instrumentation, signal conditioning, data logging, diagnostics, and user control communications.

The microturbine model considered is based on the following assumptions:

(a) The recuperator is not included in this model as it is mainly used to raise the efficiency of the system.

(b) The temperature control and acceleration control have no impact on the normal operating conditions; therefore, they can be omitted in the turbine model.

(c) The micro turbine does not use any governor, so, the model is not included in the model [13, 14].

For load following analysis purposes a simplified block diagram for the microturbine can be represented as shown in Figure 1. The real power control is described as conventional PI control function as illustrated in Figure 2.

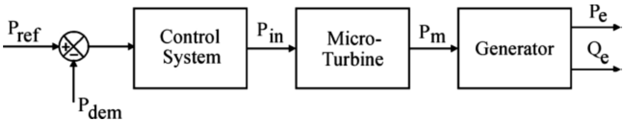

Figure 1. Micro-turbine model

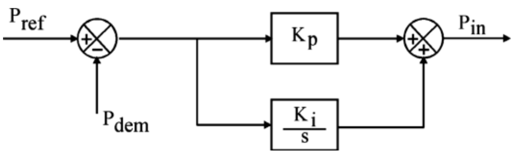

Figure 2. Control system model

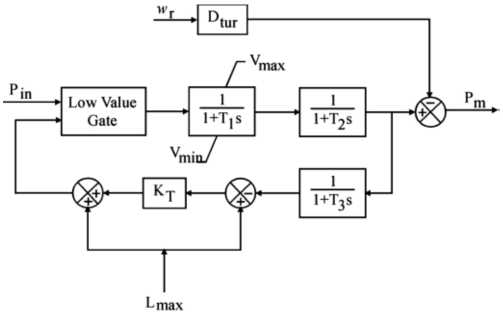

Figure 3. Turbine model

The real power control variable P_{in} is then applied to the input of the micro-turbine. In control system of the micro-turbine, P_{dem} is the demanded power, P_{ref} is the reference power, P_{in} is the power control variable to be applied to the input of the micro-turbine, K_p is the proportional gain and K_i is the integral gain of the proportional-integral controller. For turbine model GAST model is used which is most commonly used dynamic models of gas turbines [13, 14]. This model is simple and follows typical guidelines as shown in Figure 3.

III. STUDY SYSTEM

The system studied in this paper is shown in Figure .4. The synchronous machine used in the simulations is based on Matlab-Simulink synchronous machine block set. The parameters related to the machine are given in Table 2. The distribution network is of 11 KV rating and modeled by a simple R-L equivalent source of short circuit level 500 KVA. It has a wye-delta connected transformer with voltage ratio of 11 KV/440 V. Other related parameters of the distribution system are shown in Table 3. The MT-generator system can be connected/disconnected to distribution system by closing/opening a circuit breaker (CB).

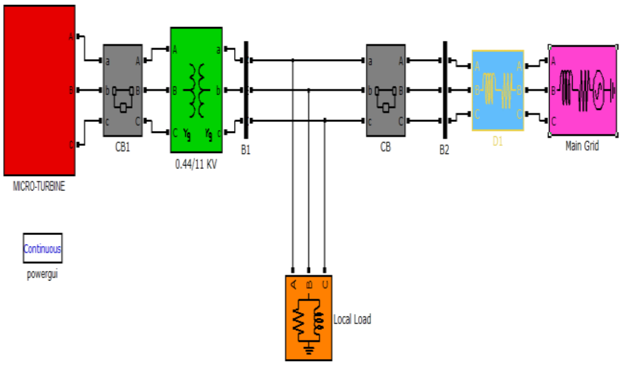

Figure 4. System study

IV. MODEL PARAMETERS

The parameters used for simulations of MT-generator system and distribution system are based on [14] and adopted as illustrated in Tables 1, 2 and 3, respectively.

Table 1. Microturbine parameters [14]

Parameter	Value
Rated power, P_{rate}	150 KW
Real power reference, P_{ref}	1.0
Proportional gain, K_p	0.1
Integral gain, K_i	1.0
Damping of turbine, D_{tur}	0.03
Fuel system lag time constant 1, T_1	10.0 S
Fuel system lag time constant 2, T_2	0.1 S
Load limit time constant, T_3	3.0 S
Load limit, $L_{\max}$	1.2
Maximum value position, $V_{\max}$	1.2
Minimum value position, $V_{\min}$	-0.1
Temperature control loop gain, K_T	1.0

Table 2. Synchronous generator parameters [14]

Parameter	Value
Rated Power, P_{rate}	150 KW
Rated Voltage, V_{rate}	440 V
Frequency, f	60 Hz
No. of poles , P	2
Damping factor, K_D	60 p u
Inertia constant, H	0.822 s
Internal resistance, R	0.02 pu
Internal reactance, X	0.3 pu

Table 3. Distribution system parameters [14]

Parameter	Value
3-ph source base voltage	11 KV
3-ph source S.C. level	500 KVA
3-ph source X/R ratio	6
Dist. trans. nominal power	200 KVA
Frequency	60 Hz
Dist. trans. primary voltage	11 KV
Dist. trans. Secondary voltage	440 V

To detect the islanding state, a measuring system is 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 a fast decision should be made in the islanding state and a command to disconnect the system will be exported.

V. CONTROLLER DESIGN

A. Classic PSO

Classic PSO (CPSO) is one of the optimization techniques and a kind of PSOTVAC computation technique which is launched by the Aberhart Rasel [14]. The method has been found to be robust in solving problems featuring nonlinearity and non-differentiability, multiple optima, and high dimensionality through adaptation, which is derived from the social-psychological theory. The features of the method are as follows:

- The method is developed from research on swarm such as fish schooling and bird flocking.
- It is based on a simple concept. Therefore, the computation time is short and requires few memories.
- It was originally developed for nonlinear optimization problems with continuous variables. It is easily expanded to treat a problem with discrete variables.

CPSO is improved through simulation of bird flocking in two-dimension space. The position of each agent is defined by XY axis position and also the velocity is expressed by VX (the velocity of *X* axis) and *VY* (the velocity of Y axis). Modification of the agent position is notified by the position and velocity information. Bird flocking optimizes a certain objective function. Each agent knows its best value so far (*pbest*) and its *XY* position. This information is comparison of personal experiences of each agent. Moreover, each agent knows the best amount so far in the group (*gbest*) among *pbest*. This information is comparison of knowledge of how the other agents around them have performed. Namely, each agent tries to update its position using the following information:

- The current positions (x, y),
- The current velocities (V_X, V_Y),
- The distance between the current position and *pbest*
- The distance between the current position and *gbest*
- This modification can be represented by the concept of velocity and the place of particle. Velocity of each agent can be modified by the following equation:

$$x_i(t+1)=x_i(t)+v_i(t+1) \tag{1}$$

$$\begin{aligned} V_i(t+1) &= \omega v_i(t)+c_1 r_1(t)[pbest_i(t)-x_i(t)]+ \\ &+c_2 r_2(t)[leader_i(t)-x_i(t)] \end{aligned} \tag{2}$$

where,

- x_i: position of agent i at iteration k
- v_i: velocity of agent i at iteration k
- w: inertia weighting
- $c_{1,2}$: tilt coefficient
- $r_{1,2}$: rand random number between 0 and 1

leader: archive of unconquerable particles
pbesti: pbest of agent *i*
gbest: gbest of the group

Convergence of the PSO strongly depended on w, c_1 and c_2. While $c_{1,2}$ are between 1.5 till 2, however the best choice to these factors is 2.05. Also, $0 \le w < 1$; this value is really an important factor to the system convergence and it is better that this factor is defined dynamically. It should be between 0.2 and 0.9 and should decrease linear through evolution process of population. Being extra value of w at first, provides appropriate answers and small value of that help the algorithm to convergence at the end.

B. PSO with Time-Varying Inertia Weight

The PSOTVIW method is capable of locating a good solution at a significantly faster rate, when compared with other meta-heuristic techniques; its ability to fine tune the optimum solution is comparatively weak, mainly due to the lack of diversity at the end of the search. Also, in PSO, problem-based tuning of parameters is a key factor to find the optimum solution accurately and efficiently. The main concept of PSOTVIW is similar to CPSO in which the Equations (7) and (8) are used. However, for PSOTVIW the velocity update equation is modified by the constriction factor C and the inertia weight w is linearly decreasing as iteration grows.

$$\begin{aligned}V_i(t+1)=C\{\omega v_i(t)+c_1r_1(t)[pbest_i(t)-x_i(t)]+\\ +c_2r_2(t)[leader_i(t)-x_i(t)]\}\end{aligned} \qquad (3)$$

$$\omega=(\omega_{\max}-\omega_{\min}).\frac{(k_{\max}-k)}{k_{\max}}+\omega_{\min} \qquad (4)$$

$$C=\frac{2}{\left|2-\phi-\sqrt{\phi^2-4\phi}\right|}\text{ , where } 4.1\le\phi\le 4.2 \qquad (5)$$

C. PSO with Time-Varying Acceleration Coefficients (PSO-TVAC)

Consequently, PSO-TVAC is extended from the PSO-TVIW [15]. All coefficients including inertia weight and acceleration coefficients are varied with iterations. The equation of PSO-TVAC for velocity updating can be expressed as:

$$\begin{aligned}&V_i(t+1)=C\{\omega v_i(t)+((c_{1f}-c_{1i})\frac{k}{k_{\max}}+c_{1i}).\\ &.r_1(t)[pbest_i(t)-x_i(t)]+((c_{2f}-c_{2i})\frac{k}{k_{\max}}+c_{2i}).\\ &.r_2(t)[leader_i(t)-x_i(t)]\}\end{aligned} \qquad (6)$$

D. Using PSO-TVAC to Tune Controller Parameters

With so much development in controlling systems and making applicable of these controllers, in power system, simple controllers are still considered desirable controllers. In most cases in the power systems, compensators are PID controllers. And these controllers can be implemented easily in analog and digital systems. In this paper, PID controller is used to control voltage of load voltage of micro-turbine in island condition.

Controller general form is expressed in Equation (3). The controller parameters must be optimized include: k_p, k_i, k_d. It is clear that the transient mode of the system in the load variations depends on the controller coefficients. Controller design methods are not viable to be implemented because this system is an absolute nonlinear system. So these methods would have not efficient performance in the system.

$$G_c(s)=k_p+\frac{k_i}{s}+k_d s \qquad (7)$$

In order to design controller using PSOTVAC algorithm for the micro-turbine from the load power curve, we consider the worst condition for load design controllers for these conditions. Figure 6 displays the worst condition for load power in the system.

Now, problem should be written as an optimization problem and then be solved. Selecting objective function is the most important part of this optimization problem. Because, choosing different objective functions may completely change the particles variation state. In optimization problem here, we use error signal.

$$J=\int_0^{t=tsim}\left|P_{ref}-P_{load}\right|dt \qquad (8)$$

where, *tsim* is the simulation time in which objective function is calculated. We are reminded that whatever the objective function is a small amount in this case the answer will be more optimized. Each optimizing problem is optimized under a number of constraints. At this problem constraints should be expressed as [7].

minimize J subject to

$$\begin{aligned}&k_p^{\min}<k_p<k_p^{\max}\\ &k_i^{\min}<k_i<k_i^{\max}\\ &k_d^{\min}<k_d<k_d^{\max}\end{aligned} \qquad (9)$$

where, k_p, k_i are in the interval [0.01 300] and k_d in the interval [0.001, 20]. In this problem, the number of particles, dimension of the particles, and the number of repetitions are selected 20, 3 and 40, respectively. After optimization, results are determined as below:

$$k_p=151.4319 \;\; k_i=115.6443, k_d=0.018957 \qquad (10)$$

VI. TEST RESULTS

In this section, the results of the proposed method to detect islanding conditions and different modes of the network are shown. Bay the way, the ability of the method to detect the islanding conditions as well as the other cases with these results are represented.

A. Load Condition 1

In this case, the MT with 30KW local load works in a connecting to the network mode (CB is closed). At *t*=18 s, the another local load with active and reactive powers 100KW and 120KVAR respectively, are switched and connected to the system. Figure 5 shows three phase continuous voltage at PCC. Figure 6 the rotor speed change of microturbine is depicted. It is obvious from the figure that after connection load the rotor speed changes value has been increased. In this case, the probability of forming an island takes place. To make sure, the phase angle of the voltage at PCC is calculated. It is obvious from the figure that after connection load the value phase angle of the voltage-(A) at PCC has not significant changes before and after connecting load. Figure 7 shows angel of phase voltage-A at PCC. Thus, the system is not interrupted and is utilized continuously.

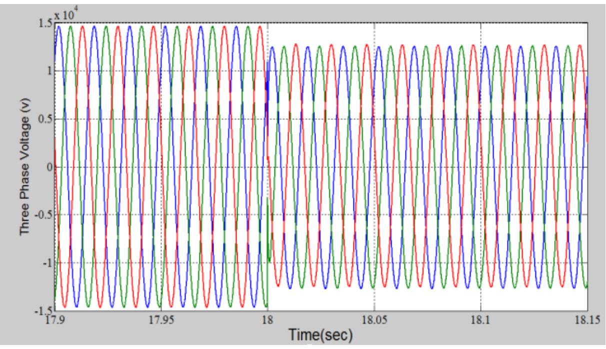

Figure 5. Three phase voltage at pcc for load condition1

B. Load Condition 2

In the second condition, the active and reactive powers of local load1 are being considered as 30KW and 20KVAR respectively, and active and reactive powers of local load2 are being considered as 60KW and 90KVAR respectively. At *t*=18 s, local load 2 separate from network. Figures 8 shows three phase continuous voltage at PCC.

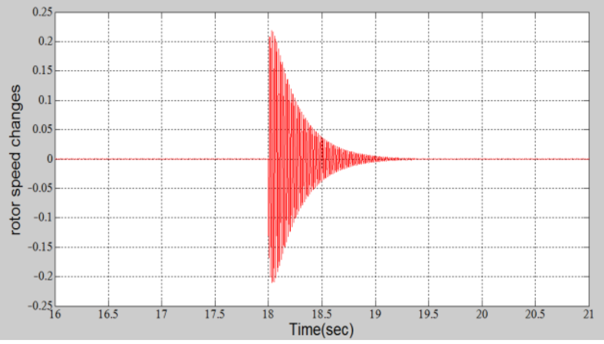

Figure 6. Rotor speed changes for load condition 1

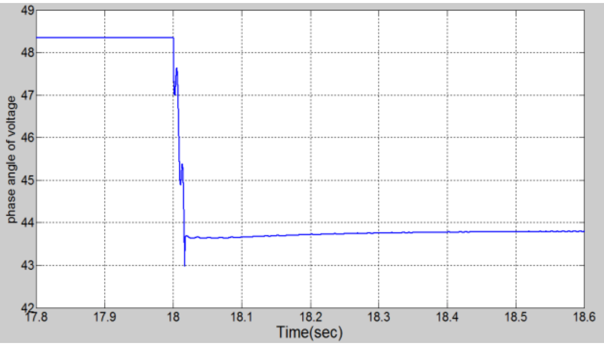

Figure 7. Phase angle of voltage-a for load condition 1

Figure 9 the rotor speed change of microturbine is depicted. It is obvious from the figure that after connection load the rotor speed changes value has been increased. In this case, the probability of forming an island takes place. To make sure, the phase angle of the voltage at PCC is calculated. It is obvious from the figure that after disconnection local load 2 the value phase angle of the voltage-(A) at PCC has not significant changes before and after disconnecting local load 2. Figure.10 shows angel of phase voltage-A at PCC. Thus, the system is not interrupted and is utilized continuously.

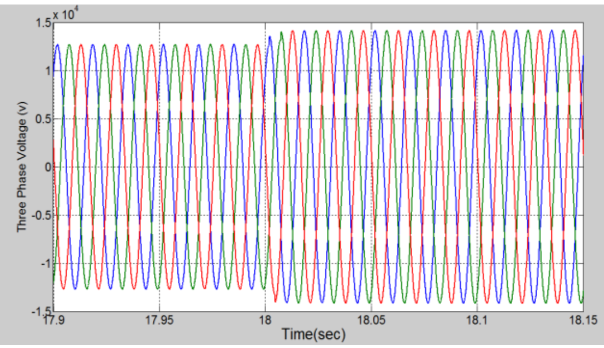

Figure 8. Three phase voltage at pcc for load condition 2

C. Switching of Capacitor Bank

In this section, the performance of the algorithm is studied for capacitor bank switching in grid connected mode to show that the proposed algorithm does not wrong in capacitor bank switching, and detect properly the islanding state from capacitor bank switching conditions.

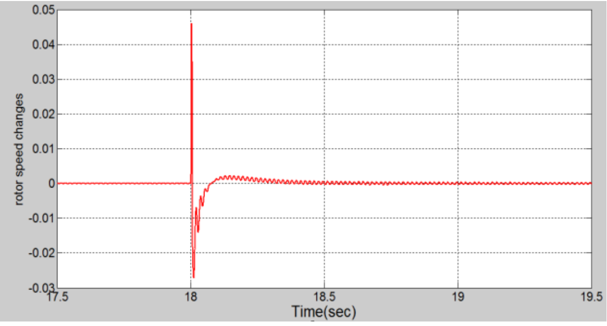

Figure 9. Rotor speed changes for load condition 2

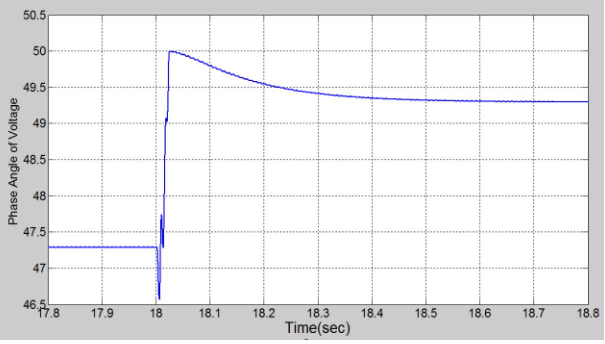

Figure 10. Phase angle of voltage-a for load condition 2

Initially, the system with local load 30KW and 45KVAR works in a connecting to the network mode. At *t*=18 s a capacitor bank with 30KVAR reactive power is switched and connected to the system. Figure 11 shows three phase continuous voltage at PCC. Figure 12 the rotor speed change of microturbine is depicted. It is obvious from the figure that after connection load the rotor speed changes value has been increased. In this case, the probability of forming an island takes place. To make sure, the phase angle of the voltage at PCC is calculated. It is obvious from the figure that after connection capacitor bank the value phase angle of the voltage-(A) at PCC has not significant changes before and after connecting capacitor bank.

Figure 13 shows angel of phase voltage-A at PCC. Thus, the system is not interrupted and is utilized continuously. Figure 15 shows Rotor speed changes for motor starting and Figure 16. Phase angle of voltage-a for motor starting.

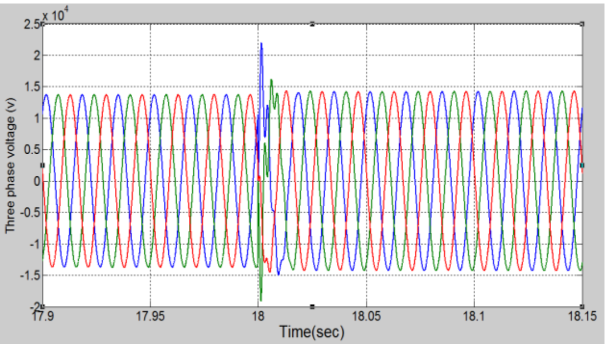

Figure. 11. Three phase voltage at pcc for capacitor bank switching

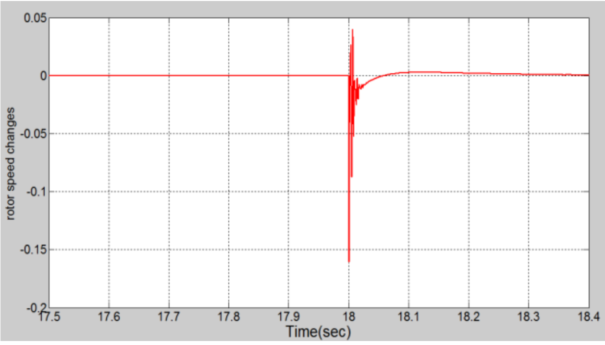

Figure 12. Rotor speed changes for capacitor bank switching

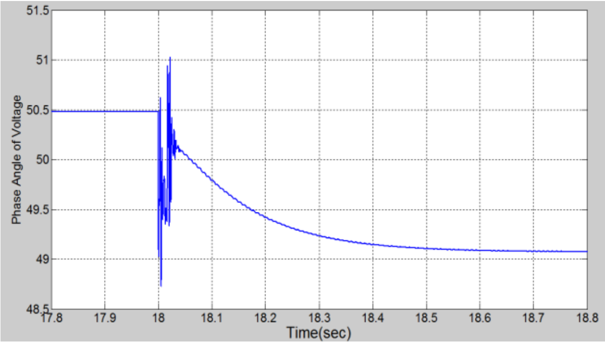

Figure 13. Phase angle of voltage-a for capacitor bank switching

D. Motor Starting

The other switching condition that method may be does wrong motor starting. Initially, the system power works connecting to the network mode. The active and reactive powers of local load are being considered as 30KW and 45KVAR respectively. At *t* = 18 s an induction motor with nominal power 50 horsepower (HP) is starting and connected to the system. Figure 14 shows three phase continuous voltage at PCC. Figure 15 the rotor speed change of microturbine is depicted. It is obvious from the figure that after connection load the rotor speed changes value has been increased.

In this case, the probability of forming an island takes place. To make sure, the phase angle of the voltage at PCC is calculated. It is obvious from the figure that after motor starting the value phase angle of the voltage-(A) at PCC has not significant changes before and after motor starting. Thus, the system is not interrupted and is utilized continuously. Figure16 shows angel of phase voltage-A at PCC.

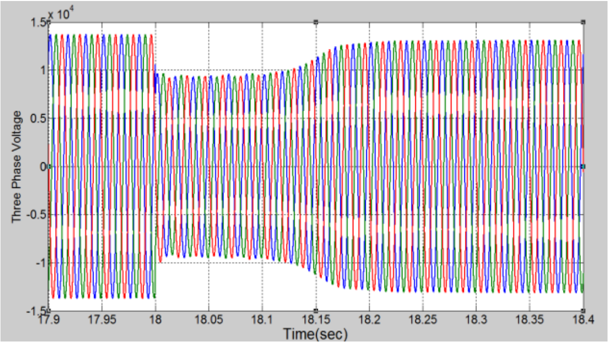

Figure. 14. Three phase voltage at pcc for motor starting

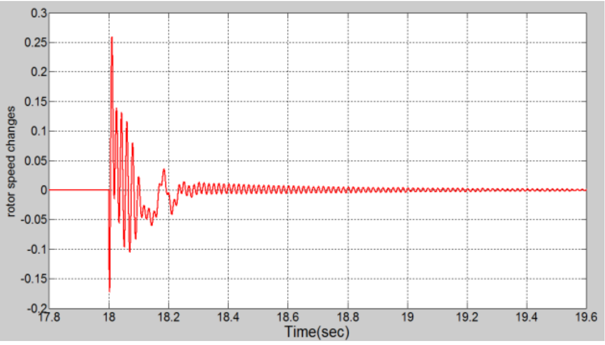

Figure 15. Rotor speed changes for motor starting

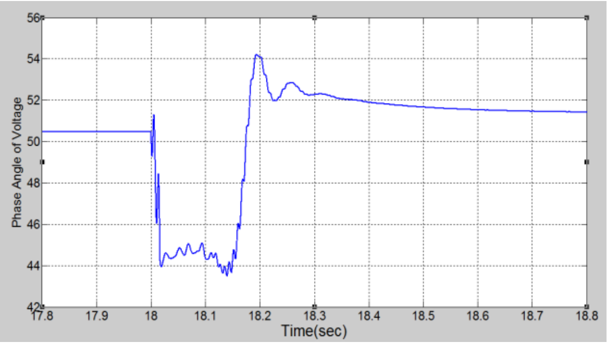

Figure 16. Phase angle of voltage-a for motor starting

E. Island Condition

In this case, the active and reactive power of local load is 90KW and 120KVAR respectively. Firstly CB is closed and the system is utilized in grid connected mode. At *t*=18 s, the CB is opened and the DG with local load is separated from the power grid and islanding condition occurs. Figure 17 shows three phase continuous voltage at PCC. Figure 18 the rotor speed change of microturbine is depicted. It is obvious from the figure that after connection load the rotor speed changes value has been increased.

In this case, the probability of forming an island takes place. To make sure, the phase angle of the voltage at PCC is calculated. It is obvious from the figure that after open CB the value phase angle of the voltage-(A) at PCC has significant changes before and after open CB and islanding condition has been detected. Figure 18 shows Rotor speed changes for islanding condition and Figure 19 shows angel of phase voltage-A at PCC.

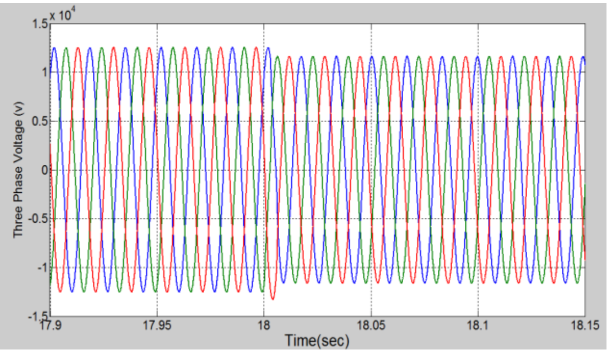

Figure 17. Three phase voltage at pcc for islanding condition

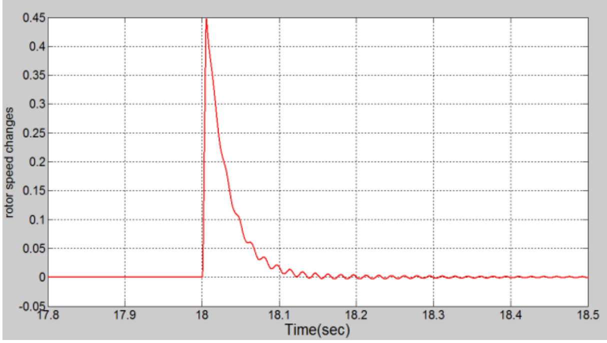

Figure 18. Rotor speed changes for islanding condition

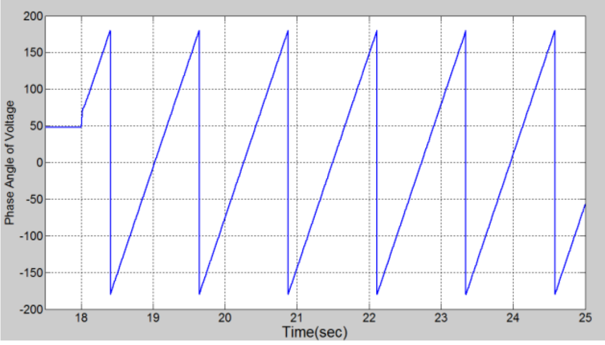

Figure 19. Phase angle of voltage-a for islanding condition

VII. RESULTS AND DISCUSSION

Fast and accurate detection of islanding is one of the major challenges in today’s power system with many distribution systems already having significant penetration of DGs as there are few issues yet to be resolved with islanding. Islanding detection is also important as islanding operation of distributed system is seen a viable option in the future to improve the reliability and quality of the supply.

The islanding situation needs to be prevented with distributed generation due to safety reasons and to maintain quality of power supplied to the customers. In this paper, a new passive method for detecting DGs islanding conditions has been represented. Also, in this paper, a new controller based on PSO-TVAC and PID controller to control the micro-turbine output power in island mode was proposed.

This controller is chosen because of its simplicity and because the implementation of this controller is simple and it could obviate the problem of the previous controller and its efficiency is higher than previous controllers.

PSOTVAC algorithm was utilized to design the PID controller to have the most optimized state. The results indicate that the this method works properly because when the previous method does wrong, the new method will easily diagnoses conditions and make an appropriate decision to disconnect the system. Simulation result has been represented in MATLAB software for various types of loads and although the older passive method performs it by error, this algorithm works properly.

REFERENCES

[1] P. Ebrahimi Fard Zanjan, K. Mazlumi, F. Merrikh Bayat, “Optimal Protection Coordination for Micro Grids with Grid Connected and Islanded Capability”, International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 18, Vol. 6, No. 1, pp. 209-204, 2014

[2] M. Bakhshi, R. Noroozian, “Reactive Power Based Anti-Islanding Scheme for Synchronous Distributed Generators”, International Journal on Technical and Physical Problems of Engineering (IJTPE), Vol. 4, No. 4, pp. 30-37, December 2012.

[3] V. John, Y. Zhihong, and A. Kolwalkar, “Investigation of Anti-Islanding Protection of Power Converter Based Distributed Generators Using Frequency Domain Analysis”, IEEE Power Electronics, pp. 1177-1183, Sept. 2004.

[4] T.A. Sulaiman, “Using the Real-Time Island Detection and Network Colouring Application in Electrical Systems”, IEEE 2nd International Conference on Human Interfaces in Control Rooms, Cockpits and Command Centres, pp. 234-239, 19-21 June 2001.

[5] S. Rohit, Kunte, G. Wenzhong “Comparision and Review of Islanding Detection Techniques for Distributed Energy Resources” Power Symposium, 40th North American, pp1-8, 2008.

[6] N. Ghadimi S. Behrooz, "Adaptive Neuro-Fuzzy Inference System (ANFIS) Islanding Detection Based on Wind Turbine Simulator”, Int. J. Phys. Sci., Vol. 8, No. 27, pp. 1424-1436, 2013.

[7] J. Vinod, Y. Zhihong, A. 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.

[8] H.M.Trafdar, N. Ghadimi, F. Hashemi, S.J. Zebardast, “New Islanding Detection Algorithm for Wind Turbine”, 10th International Conference on Environment and Electrical Engineering (EEEIC), 8-11 May 2011.

[9] H.L. Jou, W.J. Chiang, and J.C. Wu, “Virtual Inductor Based Islanding Detection Method for Grid Connected Power Inverter of Distributed Power Generation System”, IET Renew. Power Gener., Vol. 1, No. 3, pp. 175-181, 2007.

[10] S.P. Chowdhury, S. Chowdhury, P.A. Crossley, “Islanding Protection of Active Distribution Networks with Renewable Distributed Generators: A Comprehensive Survey”, Electric Power Systems Research, 2009.

[11] Lu. Yuping, Y. Xin, X. Ji’an, W. Lin, “An Intelligent Islanding Technique Considering Load Balance for Distribution System with DGs”, IEEE, pp. 567-573, 2006.

[12] H. Kazemi Kargar, A. Shtayy, “A New Method for Diagnosing of Islanding State of Wind Turbines Using Current THD in Unstable Atmospheric Conditions”, International Conference on Electrical Engineering, Tehran, Iran, 15 November, 2006.

[13] N. Hatziargyriou, G. Kariniotakis, N. Jenkins, J. Pecas Lopes, J. Oyarzabal, F. Kanellos, X. Pivert Le, N. Jayawarna, N. Gil, C. Moriera, and Z. Larrabe, “Modelling

of Microsources for Security Studies", CIGRE Session, Paris, France, p. 7, Aug.-Sept. 2004.
[14]Y. Zhu, K. Tomsovic, "Development of Models for Analyzing the Load-Following Performance of Microturbines and Fuel Cells", Electric Power System Research, Vol. 62, pp. 1-11, May 2002.
[15] K. Bipirayeh, O. Abedinia, H.A. Shayanfar, "Optimal Multi-Stage Fuzzy PID Bundled PSOTVAC in Multi-Machine Environment", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 14, Vol. 5, No. 1, pp. 37-43, March 2013.

BIOGRAPHIES

M. Sezai Dincer was born in Ankara, Turkey, in 1952. He received the B.Sc. degree from Gazi University, Ankara, Turkey in 1975, the M.Sc. degree from Middle East Technical University, Ankara, Turkey in 1980, and the Ph.D. degree from University of Windsor, Windsor, ON, Canada, in 1985 all in Electrical Engineering. He is currently a Professor of Electrical Engineering with Gazi University, and he also performs consultancy services in the field of high voltage engineering and gas insulated systems. His research activities are in the field of high voltage engineering and gas insulated systems.

Suleyman Sungur Tezcan was born in Iskenderun, Turkey in 1979. He received his B.Sc. degree in Electrical Engineering from Yildiz technical University, Istanbul, Turkey in 2001. He is a Ph.D. student of Electric and Electronics Engineering at Gazi University, Ankara, Turkey. He researches, on high voltage technique, gaseous electronics, and electronegative gas mixtures. His main research interests are include high voltage technique, power system analysis, electric power plants, lighting technique, electric power lines, power distribution.

Saman Korjani was born in Tabriz, Iran in 1986 and received his B.Sc. degree in Electric and Electronics Engineering degree from Islamic Azad University, Iran in 2009. Currently he is a M.Sc. student of Electric and Electronics Engineering at Gazi University, Ankara, Turkey. He researches, on power systems, electrical grid, electric power lines and power distribution. His main research interests islanding detection on the micro-grids.