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Assessing the Application of AC Storing, in Directing and Controlling-The Frequency of Micro-Grids

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Abstract: This study examines the role that a storage system of AC, plays, micro-grid frequency control. Micro-grid study is part of a network of radial distribution, medium voltage and contains 2 types of DG units, gas units and a photovoltaic unit. Depending on the type of production units is used in micro-grid? So, dynamical behavior micro-grid, using a storage system AC and a primary control of frequency and voltage change in a manner that requires loads sensitive within micro-grid met. Two different scenarios in the form of unplanned island and the deliberate Island have been considered as micro-grid response to the applied perturbation is investigated. Finally, micro-grid dynamic behavior, compared with the case where micro-grid no reserve system is AC. Simulation results show that the storage system and its control scheme as well is accountable to the standards required, AC for sensitive loads.

Key words: AC, guidance and control, frequency, micro-grids, the dynamic behavior

INTRODUCTION

The need to reduce carbon dioxide emissions, in terms of electricity generation, recent technological developments in the field of micro manufacturing and restructuring, trade in electricity are factors that have led to increased interest in the use of micro manufacturing. One way to understand the underlying cause of micro manufacturing the following system, called “micro-grid”. Can be defined as a micro-grid as a network-LV (e.g., a small urban area, a shopping center or an industrial area) with its lode and a small variety of production systems connected to it which products, may be able to provide power and heat for local loads (Lopes *et al*., 2006). Some feeders micro-grid are sensitive loads. The feeders need to produce locally so the unit production in micro-grid, called “Micro Source”. Micro source and can include the following: micro-fuel cells, internal combustion engines, based on the inverter and the production of renewable such as wind farms, photovoltaic systems or micro-hydro units (though to be a micro-grid, there are all kinds of these technologies, it is not necessary) when micro-grid, works as a part of, utility systems, micro source the feed the local loads. If the production exceeds the level of power demand in micro-grid, extra energy, delivered to the grid and if micro-grid, unable to feed all of its local loads, energy, flows into micro-grid the main network. When the problem occurs the utility (at major events such as short circuit the breakdown voltage on the grid and in general, global outage or when the quality of the network, drops, below certain standards such as voltage drop), instrument separation the micro-grid, opens and separates, critical loads the power grid thus micro-grid, can operate in island mode and providing the power will be provided, in micro-grid without interruption. This feature which is capable of operating in island mode so that the resources available provide, required power loads, provides local high reliability which is generally greater than reliability, resulting the grid (Piagi and Lasseter, 2006).

Micro-grid, should continue to work, after the separation of the network and maintain its stability. In this situation, the existing criteria for sensitive loads in micro-grid should also be provided that they need to employ measures to control the voltage and frequency in micro-grid. In this study we examine the role that a storage system, AC can play in controlling the frequency and voltage micro-grid.

The system studied: Figure 1 shows the single line diagram of a 20 kV distribution feeder will as part of a distributed system. At the end of the feeder 1, there are three DG units the units of production and their loads, have formed a micro-grid it. DGS, included are 2 conventional gas units, each with a capacity of 1.8 MVA, and a photovoltaic plant with a capacity of 1.8 MWp. Waste heat from gas turbines, can be used in applications of CHP. Software PSCAD/EMTDC is used to simulate the time domain, the dynamic study the prototype system of Fig. 2.

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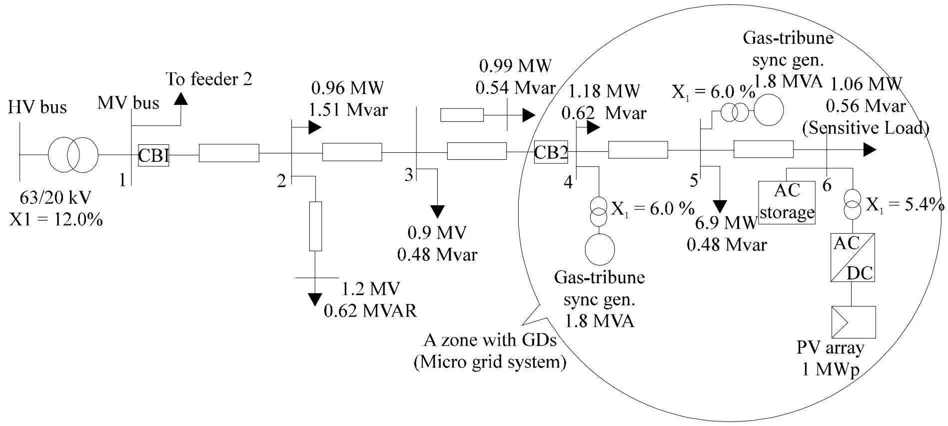

Fig. 1: Single line diagram of the prototype system

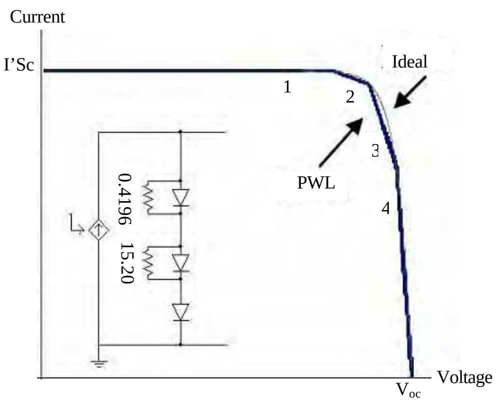

Fig. 2: Curve IV the circuit of a four-part piece-linear characteristic of PV array

MATERIALS AND METHODS

Modeling system for dynamic studies: Global network, the post HV the distribution has been modeled as a three-phase supply voltage with a nominal frequency of 50 Hz and a voltage of 63 kV. Short of it is MVA 1600 and the ratio X/R, = 15 to model the cable lines we use the circuit is = to π, in each phase. Elements of RL are used in each phase in the airline distribution model and we ignored the parallel capacitance overhead line 20 kV. Used the transformer model, the system is linear transformer model core saturation; the transformer is not considered in our study. Distribution feeder transformers and transformer manufacturing units and over again, have the quality connection. The prototype system has the types of loads, static and dynamic loads. The model used for turbine control system is a simplified mathematical model for uniaxial gas turbines with a simple-cycle and is suitable for studies of the dynamics of the power system. The model used for the array of PV, perfectly suitable for connection to the power electronic converters, the study of transient and dynamic modes of power systems and reflects the non-linear characteristics of the system (Rowen, 1983). Model was designed based on single-diode model of photovoltaic cells but the changes in the current-voltage characteristic of the cell is converted to a linear characteristic fragmented so that the characteristic, almost matched that of the curve Voltage-actual flow of the cells. We have extended this method to provide desired (Fig. 2) (Shahabi *et al*., 2009). In this study, changes in radiation is considered. The temperature of the photovoltaic cells, can not change rapidly so given the short period of the simulation the transient and dynamic studies, most of the cell temperature is assumed to be constant (Campbell, 2007) NB this is here.

Operation and control of micro-grid: In general, utilization micro-grid performed in 2 different modes, grid-connected mode and disconnected from the network (the island). In grid-connected mode the economics point of view it is desirable that the unit of DG, feed their local loads or otherwise to work at their optimal operating point. Also to avoid interference with existing voltage regulation device the network the DG and act, the constant power factor (close to 1) and do not interfere with the voltage control (Shahabi *et al*., 2009). Micro-grid studied in grid-connected mode, the unit of gas is produced the constant active power, power factor close to 1 and the photovoltaic module, delivers the maximum obtained power, biomass energy the power factor of the system. In this case, load changes and fluctuations in the unit (due to climate change), compensated, by the network, in other words, the network as Bass Slack is kept constant, micro-grid frequency and response to changes in active power and reactive within micro-grid. If for any reason, micro-grid separation instrument, act, micro-grid will be separated from the slack bus. In a micro-grid, production units it is necessary to be equipped, algorithms that detect islanding micro-grid and the autonomy, change, control mode on. In this study, it is assumed that the island of micro-grid diagnosed, the maximum duration of 100 ms (5 cycles at 50 Hz). After diagnosis of the island, gas units or switch to island mode operation so that the set looks, their voltage in amount of pu with excitation system and using the AVR. And they control the generator rotor speed deviation, the governor system (Lopes *et al*., 2006). Governor system, acts on Drop characteristic frequency-active power. After arriving in the island, the task of retrieving micro-grid frequency, temperature, put the gas unit, connected to bus 5 (DG1). The work is done automatically, using an integrator in frequency recovery loop.

Therefore, the islanding mode, the unit of PV, providing maximum possible throughput the network and the control mode is changed. In order to control the tracking of the maximum power point, Algorithm 1 is used to determine the reference value of the active power output of the inverter array of PV. Where Pref is the reference value of the inverter, Pa-avg is the average value of the solar array and Δ, the shift step the previous value of the reference (Kim, 2007). During islanding, the power balance between production and demand is not established, in real time. As a result, voltage and frequency micro-grid is a diversion and if there is a proper procedure for balancing the supply and demand of power, micro-grid, may lead to the total extinction. Deviation value obtained depends on the circumstances of the exploitation of micro-grid 1 before islanding, 2 types of events that leads to the island, 3 types of DGs within micro-grid (Shahabi *et al*., 2009).

$$\begin{cases} P_{ref} \le P_{a-avg} \Rightarrow P_{ref} = P_{ref} + \Delta \\ P_{ref} > P_{a-avg} \Rightarrow P_{ref} = \text{Hold previous value} \end{cases} \quad (1)$$

Due to the low inertia of the micro-grid, micro-grid frequency may be changed, quickly with the occurrence of a disturbance because the sources such as diesel engines, gas turbines and fuel cells, show a relatively slow reaction the control signal. Therefore, it is necessary to adopt a method to create enough inertia in micro-grid. Energy storage systems has therefore, incapable of providing the necessary inertia. A variety of energy storage devices can be traced to the flywheel, the traditional and advanced batteries, super capacitors and magnetic energy storage system using superconducting. From one point of view, it can be divided, storage systems into two categories: storage and storage DC AC. Save instruments, DC, installed on the DC micro-source the bass. However, the storage system, AC, storage devices directly connected to the grid, using power electronic converters. Since, in the case micro-grid (Fig. 1), bus 6 is a feeder of sensitive loads, you need to be constructed, a mechanism that, in addition to ensuring the stability of micro-grid, passing from connecting to the network, the island state, the network was bare, build, damping oscillations caused, quickly and control the frequency and voltage of the micro-grid, desirably and satisfy the requirements of sensitive loads. For this purpose we have used from a storage systems, AC, on 6 bus system connecting the storage location is selected, depending on the location of sensitive loads, in addition to meeting the above requirements, the effect of photovoltaic power fluctuations (due environmental changes) decreases. Next, check the storage systems AC-to control frequency and voltage micro-grid-come.

Primary frequency control: To implement primary control of frequency we use the concept of Drop Frequencies-active power so that, by injection active power is determined, by the energy storage system, the equation (Piagi and Lasseter, 2006).

$$P = P_0 - \frac{1}{R_p}(\omega - \omega_0) \quad (2)$$

$$Q = Q_0 - \frac{1}{R_Q}(V - V0) \quad (3)$$

Where:

P = The active power injection
P_0 = The active power reference value
R_P = The drop which is a positive quantity
ω = The angular frequency micro-grid
ω_0 = The angular frequency reference

According to the characteristic Eq. 2 and 3 whereas micro-grid island is faced with a drop in frequency/voltage, energy storage systems, offset the lack of active power/reactive, quickly and conversely, if the frequency/voltage exceeds the reference value, absorbing excess production of active power/reactive, shall establish a balance of power. When micro-grid connected to the grid, the initial control system of voltage and frequency are passive and do not interfere with the performance of micro-grid. But always tracking, demand for power, voltage and frequency measurements. In practice, the capacity of the energy storage system is determined by considering the type of power generating units the most difficult time of turbulence may be filled in and the time that is necessary to storage systems respond to the needs micro-grid. However, considering the short period of time, the dynamic behavior micro-grid analysis

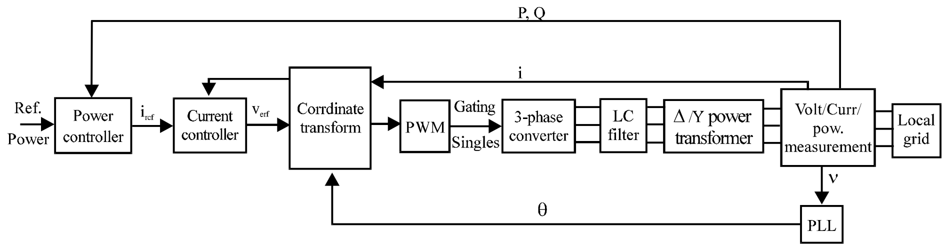

Fig. 3: Block diagram of the control of power electronic converters

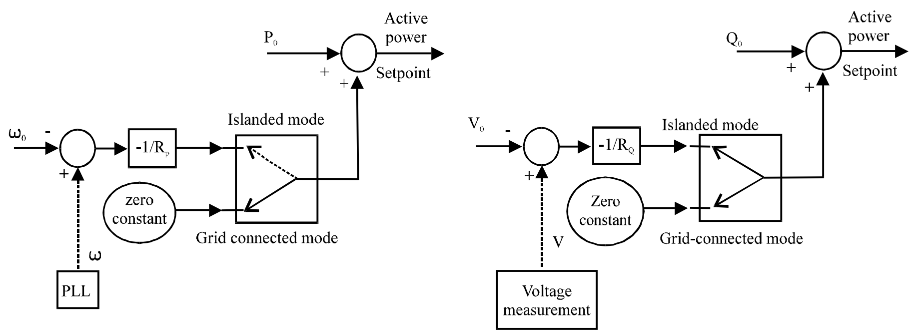

Fig. 4: Implementation of a primary control of frequency and voltage

we assume that there is enough energy storage, the short duration of the simulation. Accordingly we have modeled, storage devices, constant voltage source dc (not ideal), connected to the power electronic converters. Control of power electronic converters is as follows.

Control of power electronic converters: When micro-grid works in grid-connected mode, power storage devices is held constant at 0. Therefore, it is necessary that the electronic transition of power, a converter, PQ. In this case, the control block diagram of the converter is shown in Fig. 3. The power controller, includes 2 controllers PI which one controls the active power output and the other controls reactive power output of the converter. Given the size of the deviation of the active power and reactive their reference values, PI controllers which determine how the output current, the size of the component d and the components of q and the error is 0. This means that controllers can be determined are the components of the current reference value. To ensure that the power electronic converters seek reference value of output current, 2 other PI controllers, used as controls, the components of output current. Flow controller, by comparing the reference values and the real component of the current the output of the converter is set the components of the voltage reference value which is then converted into component abc are used on a PWM block. Exchangers for the synchronization of the network, a PLL, are used. It should be noted that when analyzing the dynamic behavior micro-grid, converters, modeling is only based on the control functions so that, regardless of the cause, due to switching transient, harmonics and the loss of ADC (Lopes *et al*., 2006). After arriving in the island, the primary control of frequency and voltage active and its intervention in the set point of the active power and reactive, a converter. Figure 4 shows how this process. Storage system includes five converters transformers and a network interface (Roger *et al*., 1996).

RESULTS AND DISCUSSION

Simulation and case studies: Before proceeding to the simulation results, it is necessary to note the following points. Control parameters, the system were chosen over several stages of evaluation outputs at different exchange rates so that, at each stage the response of the system is improved. However, parameters such as drop values used for the generators and the primary frequency control and voltage gain controlling power electronic converters and storage systems have been optimized parameters, therefore, the displayed waveforms have been, represents the best answer and again, there is potential for improving the quality of the system response.

To evaluate the system's response to unplanned Island of the exercise is a severe disturbance (connecting three phase to ground fault resistance is zero), the micro-grid, so we will see better performance, with errors occurring with less severe.

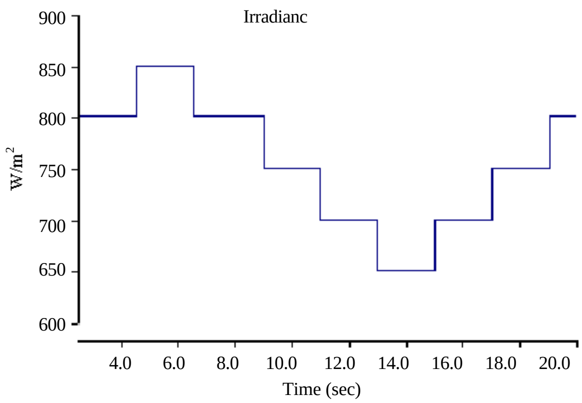

Fig. 5: The changing pattern of radiation the photovoltaic module

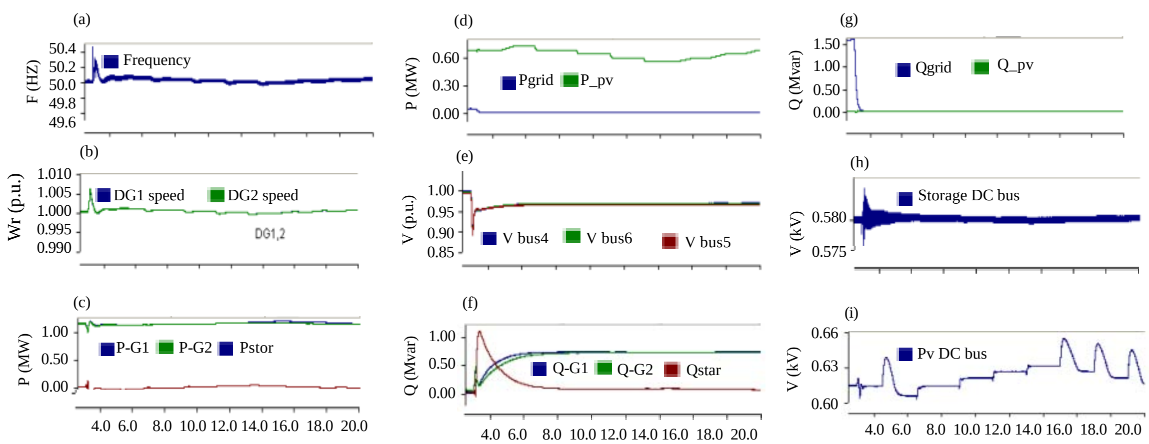

Fig. 6: Island of intentionally save in the presence of AC. a) microgrid frequency; b) rotor speed DG 1, 2; c) active power; d) P grid; e) bus voltage; f) reactive power; g) Q grid; h) DC bus voltage; i) PV DC bus

The purpose of this study is not to present a dynamic model for electrical energy storage devices such as batteries NAS, lead-acid batteries, super-capacitor, flywheel, etc. but also is to develop a strategy for implementing Micro-grid using a storage system AC. Thus, as mentioned earlier, due to the short period of time, the analysis of the dynamic behavior of micro-grid, we assume that the short duration of the simulation, there is enough energy storage and storage devices, the constant voltage source DC, connected to the power electronic converters of the model. Of course, we have not neglected the dynamic energy storage devices as part of storing-system, current and voltage is taken into consideration during the process of delivery of a sudden. To study the control of storage systems, AC and its effect on the dynamic behavior micro-grid, two scenarios have been considered.

Occurrence of an intentional islanding: In this case, the objective is to investigate micro-grid response to the disturbance caused by an intentional island. Before the island and is connected to the network, 2 gas units, at work with the power to 15.1 MW-0.03 Mvar, power factor close to 1 in the photovoltaic unit at a power factor of 1, delivery, the maximum throughput of radiant energy into the system. Changes in the radiation pattern that is in Fig. 5. Difference between the supply and demand load enters the micro-grid (0.03 MW-1.61 Mvar), of the network. Both gas unit has therefore, drop 5% (on the basis of their ability) and participate in one of the power-sharing. At the moment t = 3 see by opening CB2, micro-grid removed from the network and after 100 msec, mode control is enabled the island state. In Fig. 6. the response to the intentional islanding of micro-grid seen. This Fig. 6 indicates that the voltage is not less than the nominal value of 0.9 and the activation of island operation mode, frequency micro-grid, controlled, quickly and without the down mutants. Changes can DG3, seen in Fig. 6. To see the effect of storage systems, AC, storage

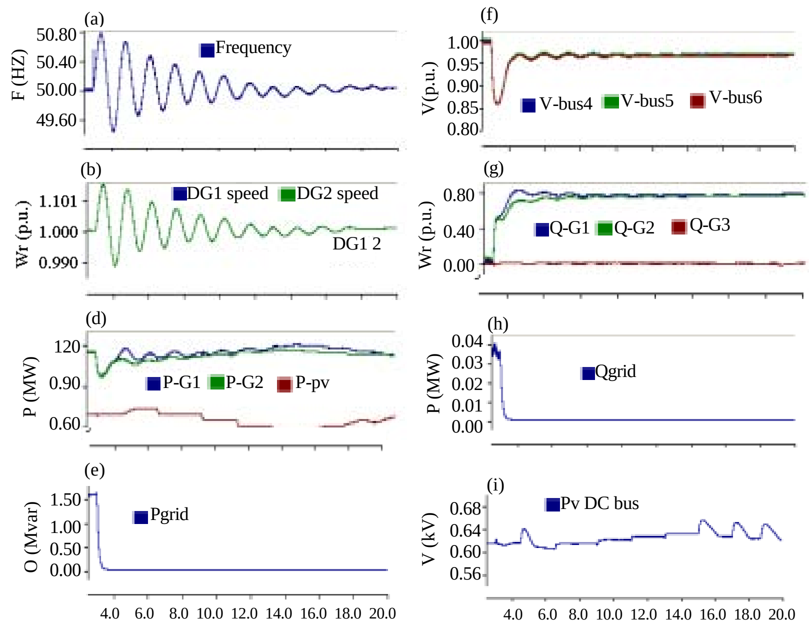

Fig. 7: Island of intentional, in the absence of AC supply. a) microgrid frequency; b) rotor speed DG 1, 2; c) active power; d) P grid; e) bus voltage; f) reactive power; g) Q grid; h) DC bus voltage; i) PV DC bus

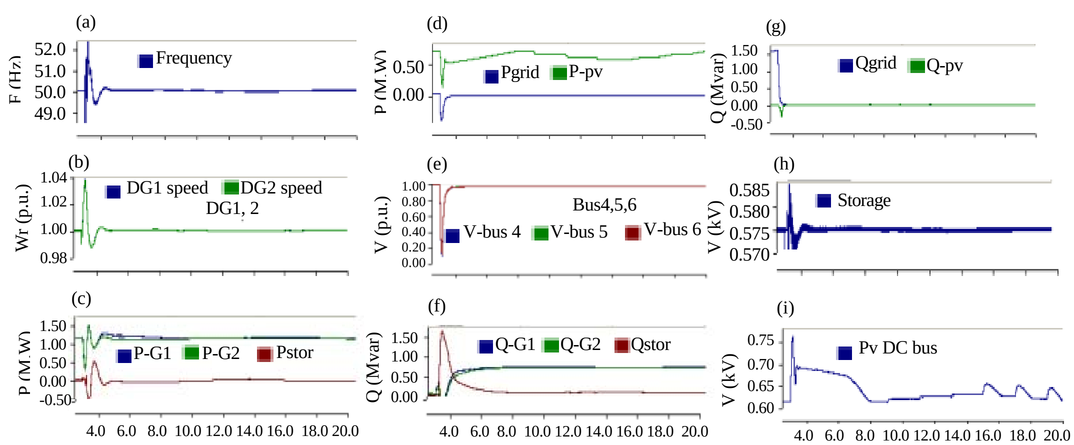

Fig. 8: Unpredicted the island in the presence of AC supply. a) microgrid frequency; b) rotor speed DG 1, 2; c) active power; d) P grid; e) bus voltage; f) reactive power; g) Q grid; h) DC bus voltage; i) PV DC bus

systems and design of control in the absence of intentional islanding process, applied to micro-grid and the results are presented in Fig. 7.

An unforeseen occurrence, the island of: In this case, it is assumed that a fault occurred in the upstream of the feeder and leads to the occurrence of an unplanned island. Before the fault, the system is similar to the previous one. At the moment t = 3.0 sec, a connection phase occurs on bus 2, upstream of the feeder. We assume that the error is detected after a period of 150 msec and CB2, opens. In this situation, the loss of voltage islanding detection mode, it will be possible in 2 cycles. Ie, at the instant t = 3.19 sec, the island is diagnosed and micro-grid, imported in island operation mode. Figure 8 shows the results of the transient. It can be seen that the oscillation frequency, the damping quickly and after diagnosis island state, down mutant frequency, no t>0.5. System response, making the island, in the absence of storage system and the control scheme is shown in Fig. 9. By comparing the 2 Fig. 8 and 9 we can see how storage systems, AC, responds promptly to voltage and frequency variations from micro-grid. With the connection of bus 2, bus voltage, 5 drops severely

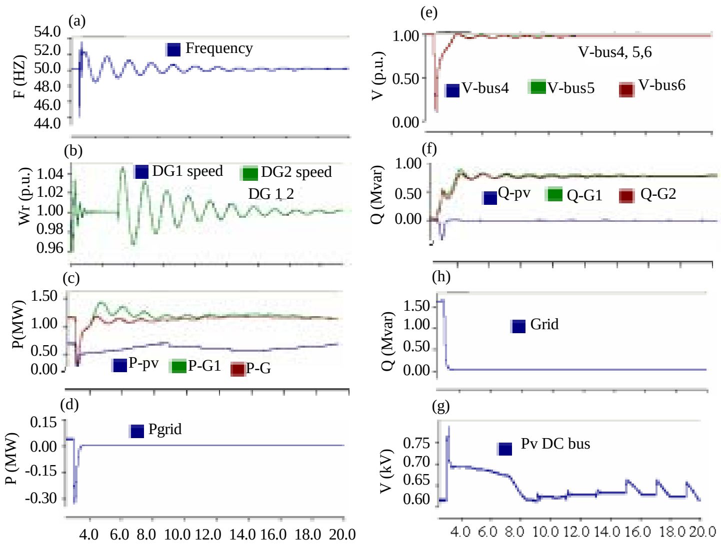

Fig. 9: Unpredicted the island, in the absence of AC supply. a) microgrid frequency; b) rotor speed DG 1, 2; c) active power; d) P grid; e) bus voltage; f) reactive power; g) Q grid; h) DC bus voltage; i) PV DC bus

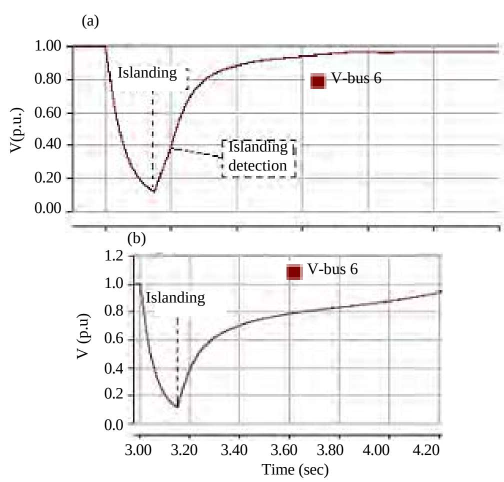

Fig. 10: a, b) Bus 6 voltage in the presence and absence of reserve, after the unexpected island

and its output power decreases abruptly and this causes an increase in the speed of the generator. Therefore, the islanding operation mode, micro-grid is faced with increasing frequency. Figure 8 shows, storage system, the active power absorbed is aimed at primary frequency control. Comparing this figure with the c9 indicates differences in the speed of response of the AC supply and the DG1. Voltage drops, the intensity of mistake and that before the separation micro-grid. After entering the island operation mode, storage system, reacts to changes in voltage with a rapid infusion can be reactive. The voltage and frequency close to nominal values, power supply system, the less and less. In Fig. 10, the voltage at bus 6, following the unplanned construction of the island, has been examined, more precisely, in the presence and absence of storing AC (Voltage Sag Lmmunity Standards, 2007).

We know, computer equipment, advanced controllers, consisting of semiconductor devices (such as driver speed control) and some industrial processes are considered, including sensitive loads. The curve ITI, for sensitive computer equipment and standard semi F 47, for equipment Semiconductor, any voltage drop as much as 70-80% of nominal, shall be resolved within 20-500 msec (Fig. 8 and 9) . According to Fig. 10 we find that, although the voltage stability has been maintained, the system did not save the AC but the standard curve, ITI and standard semi F 47 have not been satisfied.

CONCLUSION

In this study, micro-grid samples including 2 gas units and a photovoltaic unit were studied. The process modeling component of the micro-grid, described for dynamic studies. AC storage systems and a control scheme were introduced to increase the voltage and frequency of micro-grid. In both scenarios, intentional acts of unintentional islanding, the micro-grid were investigated in the presence or absence, storage systems, AC. Simulation results show that not only micro-grid is able to maintain its stability and reach a point of a new job but could respond quickly to incoming disturbances and maintain quality necessary power for critical loads. In this study the control parameters have not been optimized parameters.

RECOMMENDATIONS

In the future, it is necessary that the small signal analysis of system performance and the optimal values is calculated. Then the follow-up project to retrofit control system for dealing with large disturbance, it would be useful.

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