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Stability of Voltage and Frequency Parameters in an Autonomous Microgrid with Battery Energy Storage System

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Abstract: Microgrid (MG) stability based on Energy Storage System (ESS) in order to division of power between distributed generation (DG) units has been proposed as the main issue in this domain. Power stability is an important concept for planning in MGs. In this article, frequency and active power control in MG case study which is based on ESS will be analysed. Recent studies show the possibility of stable operation of a MG by using a suitable strategy for MG control will be possible. In this paper, MG control system to improve stability in island mode (off-grid) after the fault has been studied in the upstream Grid. MG model in this study consist of two units. These units and also load are connected in point of common coupling (PCC) together. In island mode, due to the high dependency dynamics of the system to improve the stability in MG after fault, efficient control strategy is necessary created for this purpose proposed controller is designed based energy storage system. The capability of islanding mode in a MG can increase the stability of the consumers, but protection issues could have a negative impact on their stability. The main goal of this study is designing an autonomous voltage and frequency controller to MG in isolated from main grid. Simulation has been evaluated in MATLAB software in Simulink toolbox.

Keywords— Microgrid, MATLAB Software, Wind Turbine, Energy Storage System (ESS)

I. INTRODUCTION

The necessity of solving the challenges of environmental issues, increasing the amount of carbon dioxide emissions and above all, the need for electrical energy due to increasing attention of engineers and experts in the field of power industry greater use of distributed generation and renewable sources of energy. This reasons caused a structure called MG [1].

MGs are small electric grids that can operate independently from the main grid. They can be isolated (islanded mode) or connected to the main grid. Some MGs can flexibly operate in both islanded and grid-connected modes, depending on some conditions or safety reasons [2].

Until now, researches on MG stability and production times for different connections have been made. A major study, small signal stability are conventional electrical network. The major methods used in the MG stability are limited to droop and methods of active and reactive power capacity to adjust and improve sustainable DG has taken place.

A MG usually consists of a set of distributed generation resources, energy storage system and loads which can be operated for connected to network and island performance. MG has many benefits, for consumers and also for electricity generation companies. From the perspective of the consumer, MG is the ability to provide combined heat and power, increase reliability, reduce emissions of greenhouse gases, improve power quality and reduce the cost of consumption and from the perspective of power generation companies, implementation of MG will reduce the potential of consumer demand and so reduce development facilities of transmission lines in addition to eliminates the peak demand as the result is reduced network losses [3]. Figure 1 shown the general structure for MG system which is connected to main grid in point of common coupling.

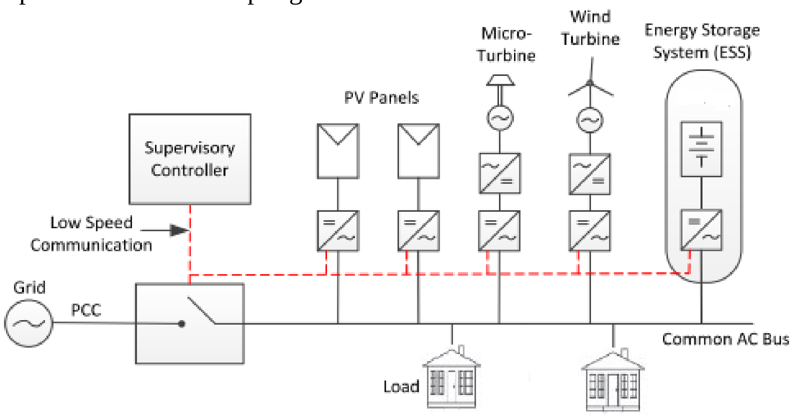


Fig 1. General structure for MG system [4]

A MG consists of DG sources such as Photovoltaic (PV), wind turbines, gas micro-turbines, and storage systems such as batteries. These DG sources cannot be readily interfaced to the grid being DC (PV and batteries) or variable AC frequency (wind turbines and gas micro-turbines). Therefore, power electronic converters are required to interface the DG sources to the grid. The grid interface DC/AC power electronic inverters are paralleled together to form one AC bus which is connected to the main grid.

In [5], a MG under dynamic loads based on low frequency oscillations have been studied. The purpose of this paper is to use small-signal model is a fine medium-voltage network to pay Instability low-frequency fluctuations. The results show that the MG under the influence of large motor loads will become more volatile. Proposed MG controller indicates that under the influence of transient state with severe variations in parameters such as engine load slip, torque and voltage will be.

In [6], The MG brief introduction to the problems and benefits of their use in modern power systems are discussed. MG control and improve stability parameters of a PID controller is used. Control structure presented in this paper, the applied disturbances and sudden load changes and production, among other parameters MG voltage and frequency coordination as necessary. This controller is trained by a set of input data and the desired output and the ability to implement the MG has different structures and under extreme load changes can maintain stability and prevent the collapse of the system voltage and frequency.

In [7], the nonlinear dynamic model of a MG with power electronic devices are used. Nonlinear model MG linearized around an equilibrium point review of the parameters that have been operating point. System analysis with specific values showed that the parameters were trying to secure MG system by shifting the poles of the system.

In [8], a MG sample consisted of two gas units and a photovoltaic unit were studied. The MG modelling process components described for dynamic studies. Storage system and an AC voltage and frequency control scheme to improve the quality of MG was introduced. In either scenario, unintentional and intentional islanding applied to the MG, in the presence and absence of AC storage system was studied.

Each MG consists of several small electric power generation source is made to DG their activity is to be the local bars. In sensitive places such as commercial buildings, industrial and hospitals generally have little inertia of the load under one megawatt, there is a backup for times when silence is needed now. So that if for any reason the distribution system becomes disrupted that the electricity generated by proper quality for the consumers does not reach and the relevant standards go lower, security systems act and Micro grid distribution system is isolated and responsible for delivering power local loads sensitive and insensitive to take care of [9-10]. In other words, the main task of the MG to maintain optimum power quality for sensitive loads.

Despite the numerous advantages of the MG, such as reducing environmental problems, increase system reliability, increase efficiency by reducing power losses in transmission and distribution systems have created new problems. Some of these problems could be to change the pattern of load flow, increase the high harmonics of frequencies and voltages fluctuations which caused by the use of power electronic devices [11].

Due to the low capacity of distributed generation units, these units do not have significant effects on the main network, but with the increase in power networks of the future be more to show their effects [12-13].

The aim of this article is on the island MG control can be appropriate to divide the resources, regulate voltage and frequency and improve transient behaviour of the network under study to be followed. Designing a MG controller is suitable for battery-based energy storage can be used for different load conditions to supply voltage and frequency stability and establish the power balance between production and consumption.

II. SYSTEM DESCRIPTION AND WORKING

The system studied in this paper has been shown given in Figure 2. The MG system consists of two units distributed generations, wind turbine and diesel generator which are in connected with the main grid PCC point. Diesel acts as a central controller and partly stability will be guaranteed.

III. RESULTS AND DISCUSSION

It is notable that the MG voltage line is 480 volts and frequency is 60 Hz. Figure 2 shows the MG study investigated scenarios.

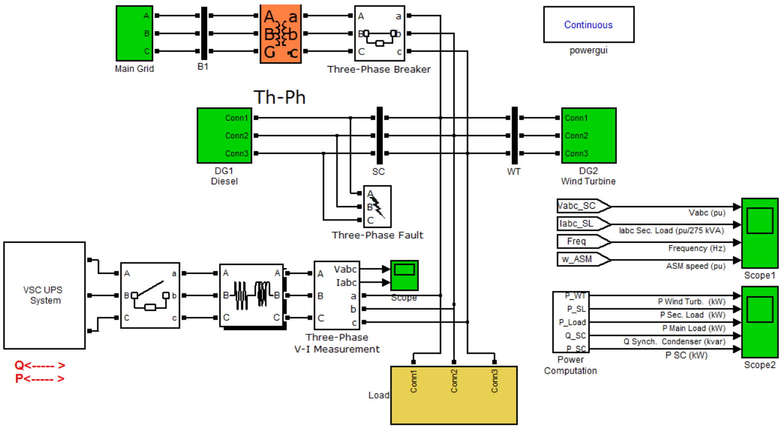
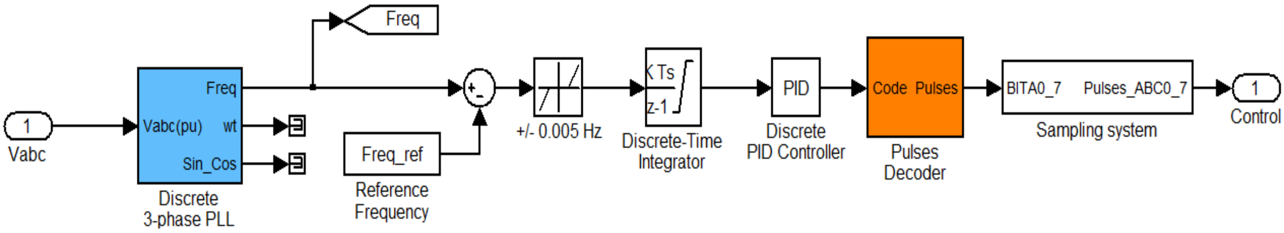


Fig 2. MG case study

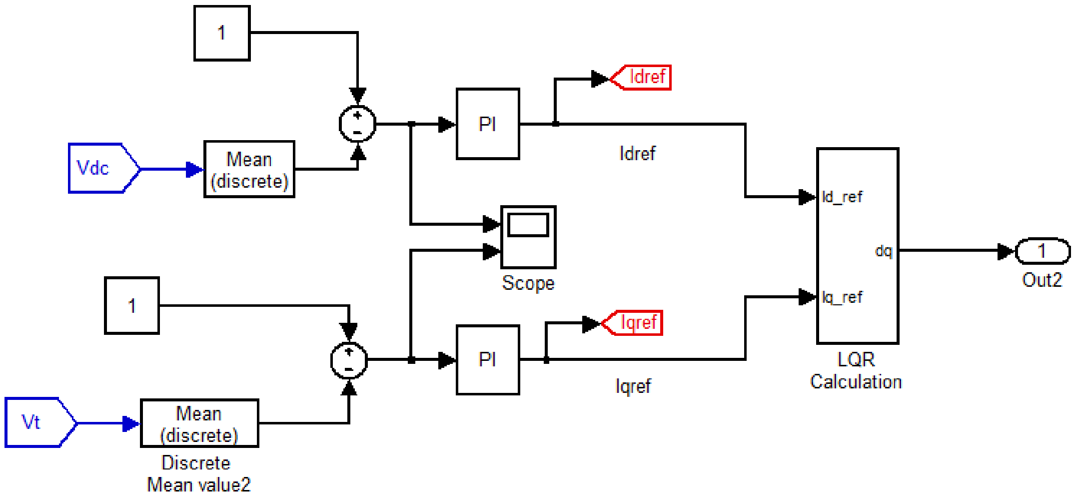
Control units used in the MG consists of two parts which shows in Figure 3. In this three-phase voltage of MG is input signal, then the amount of frequency error with the reference value to the controller Robust PID by the error will be compare and this signal is made to the pulse generator.

Main controller consists of two PI controllers that it used for the errors and main fluctuations for the two parameters V_T and V_{dc} reduced to a minimum. It was while the battery is in circuit good performance and parameters V_T and V_{dc} are also related to this field.

Figure 3 is related to the main controller in the simulation which is present at all times. Figure 4 shows the presence of a second controller for battery which improves the transient state in MG.



a. Microgrid control system



b. Control system designed in the presence of storage

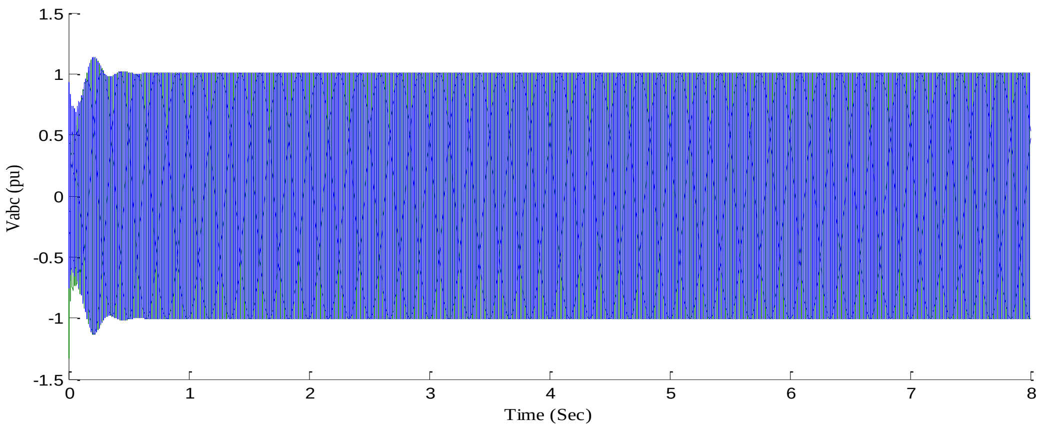
Fig 3. Control systems used in the Microgrid.

Implementation of MG scenarios under study in this MG will be discussed in three scenarios.

1. The use of wind speed 9/8 m/s as the maximum wind speed wind turbine type SCIG
2. Errors applied to the MG includes a three fault in t=3sec up to t=3+4/60 and also separation from main grid in t=3+5/60.
3. Add a 25kW ohmic load suddenly in t=3sec.

IV. MICROGRID CONNECTED TO A THE MAIN NETWORK WITHOUT THE FLUCTUATIONS

In this case all critical parameters are stable in the MG. According to the curve of Fig. 4, it can be seen voltage and current after a few seconds are balanced without any oscillation and also frequency is 60 Hz and synchronous speed is about 1/01 too. However, oscillations in the first few seconds of each curve is for connection of each distributed generation units to the main grid.



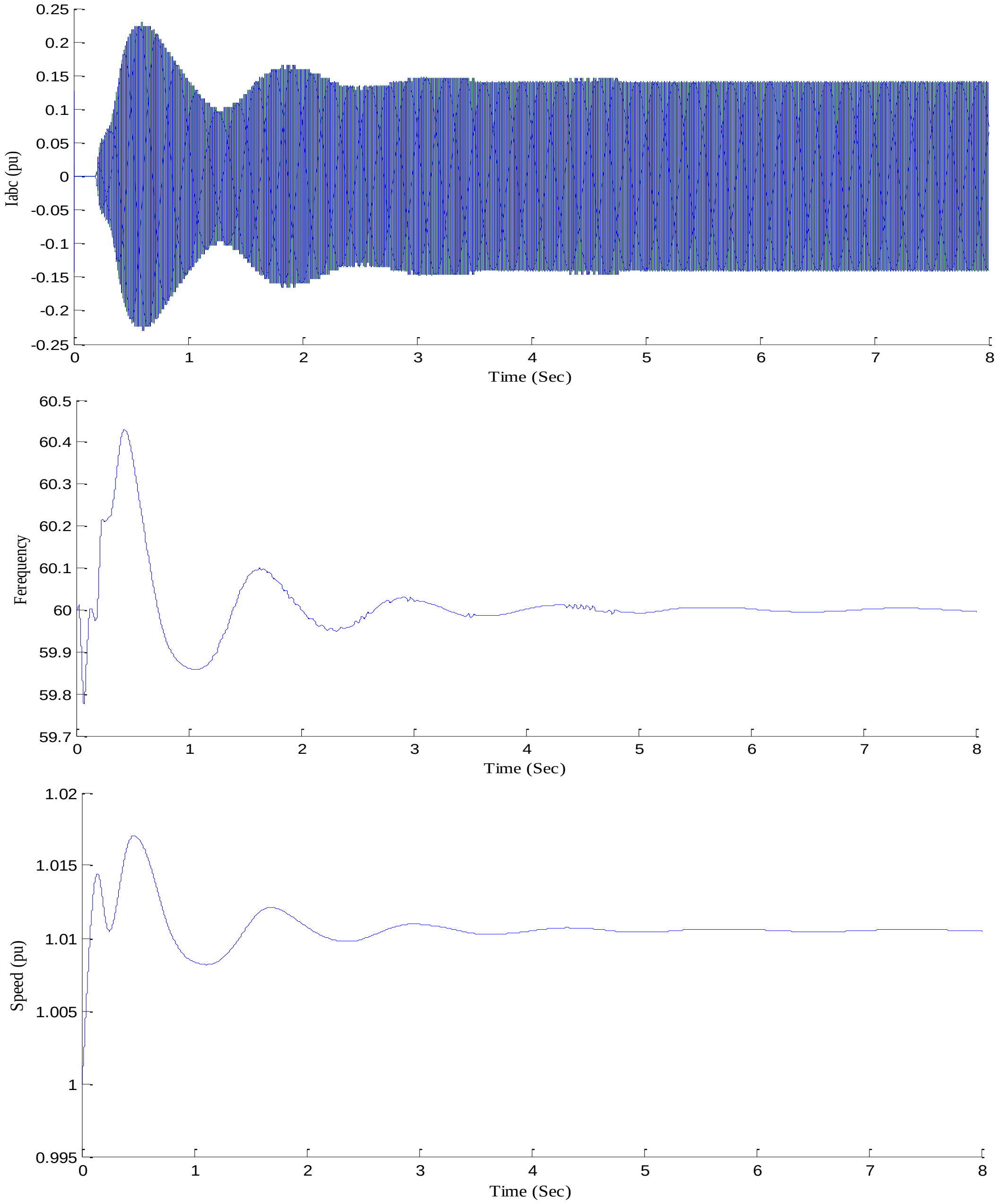
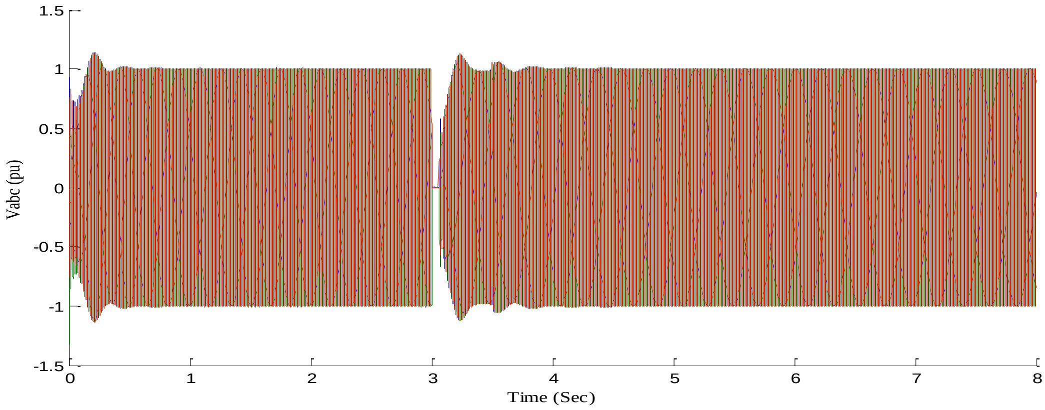


Fig 4. Voltage, current, frequency and speed changes of synchronous generators in the MG connected to the main grid without the oscillations

V. MICROGRID CONNECTED TO A THE MAIN NETWORK WITHOUT THE FLUCTUATIONS

In Figure 5, all parameters in MG except voltage are unstable. The main reason is separating MG from the main grid and also applying the fluctuations. To avoid instability in a system that has been subjected to a transient state that is only a few milliseconds, the system can return to steady state. In this implemented scenario, frequency and speed of synchronous generators are falling.



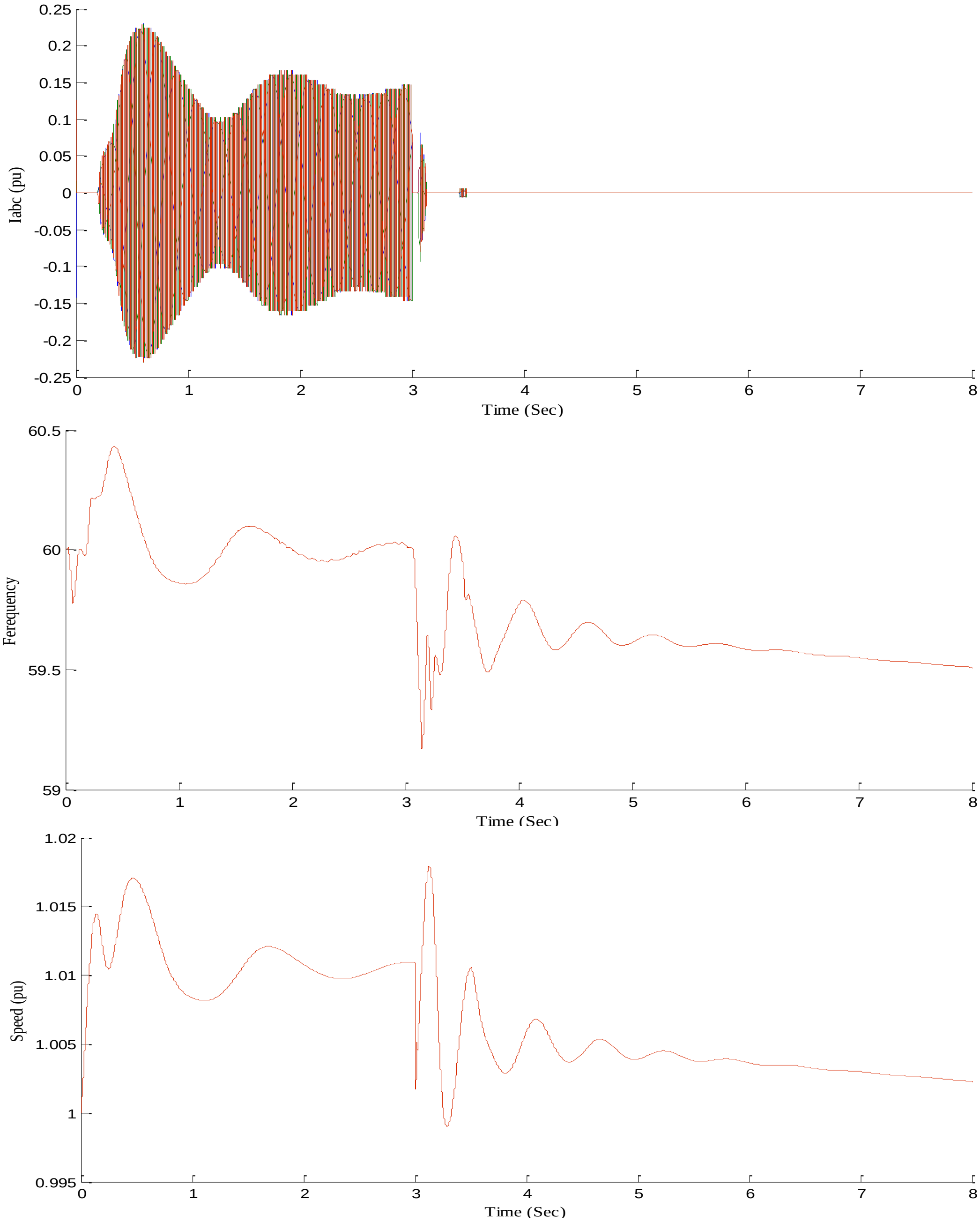
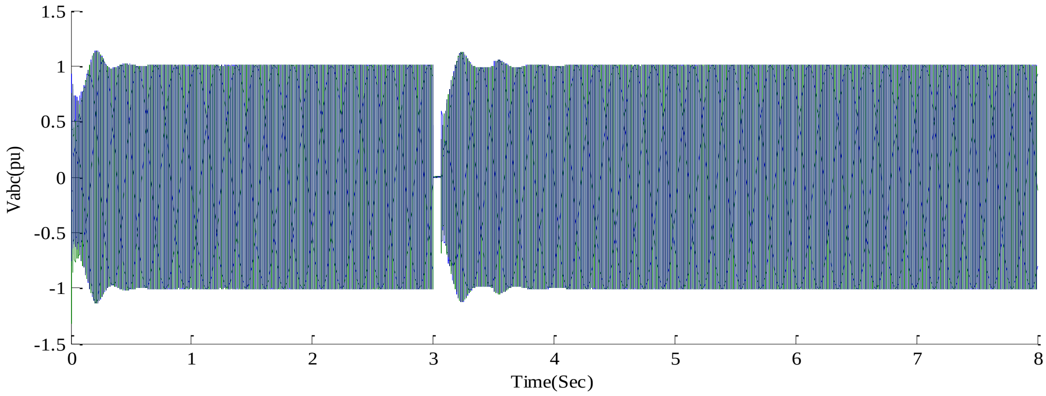


Fig 5. Voltage, current, frequency and speed changes of synchronous generators in the MG separate from the main network by applying the oscillations

VI. MICROGRID CONNECTED TO A THE MAIN NETWORK WITHOUT THE FLUCTUATIONS

To avoid instability in MG case study, a battery energy storage system suggested in the transient because it can return MG to steady state. The battery is properly applied in real time to the MG fluctuations caused by the passage of some time-sensitive parameters such as voltage and frequency MG return to steady state. This can be seen in Figure 6 that is noticeable.



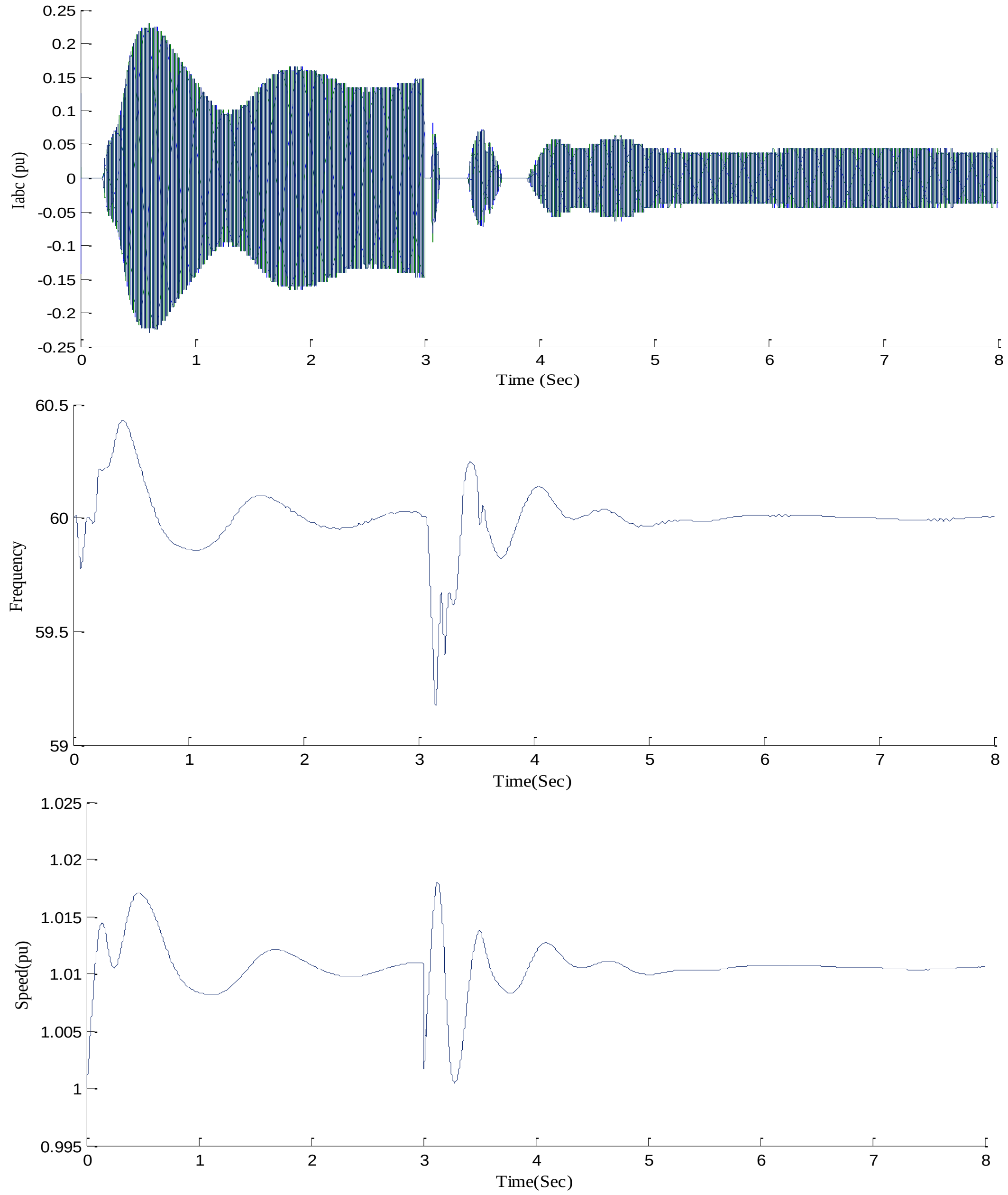


Fig 6. Voltage, current, frequency and speed changes of synchronous generators in the MG separate from the main network by applying the oscillations in presence of Battery Storage

VII. CONCLUSIONS

Voltage and frequency control are one of the most important factors in maintaining a constant parameters in the MGs. The interaction of voltage and frequency in this article is proportional to wind speed. In this article to improve the stability of the MG on the island mode, it has been used from a battery energy storage system. A balance between resource production and consumer demand in the MG is very difficult, especially when MG is not connected to the main grid or MG is in the island mode. The use of a MG control system suitable and appropriate changes will improve MG stability in this article, this role is taken by the battery storage system.

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