Research Article

Frequency voltage stability in network-independent hybrid micro grids with V2G electric vehicles and reactive power compensators

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Abstract: Today, due to technical and environmental issues as well as economic issues, the tendency towards smart grids and the creation of microgrids has received more and more attention. In terms of network connectivity, microgrids can be classified into two categories: connected and disconnected from the network. When connected to the network, control issues are not very visible. When the microgrid goes to the island state, the discussion of power balance, maintaining the desired frequency and voltage stability is one of the important and key issues of a microgrid. For this reason, microgrid stability requires a controller that can keep these parameters at the desired level and prevent the microgrid from collapsing. Another type of microgrid classification is based on the type of power, ie AC and DC powers or a combination of The two call this type of combination a hybrid microgrid. In this paper, a method based on the use of distributed generation control method based on active power distribution and frequency recovery is used. The proposed controller is located in the frequency control loop, and by applying a control signal to the sources, the frequency fluctuations following the power changes in the microgrid are reduced. With the advent of compensators, the voltage and frequency stability results produced by the controller were improved, and the outputs from the SVC were far better than those from STATCOM. The presence of the vehicle in the microgrid causes a frequency change that the proposed controller provides a good output of the frequency.

Keywords: Svc, Statcom, Micro grids, v2g.

Introduction

With the increasing power of electricity and the importance of environmental conditions, the desire to use renewable energy has increased. [1] Micro-networks can be provided with different powers and can be connected or disconnected in the network [2] IEE 1547 standard defines how the network endoconnection and the microgrid connection to the main power network [3]

According to the definition of frequency stability, it means the ability to maintain and stabilize the network frequency after the occurrence of a fault. [4] We have a central controller and also a telecommunication link to transfer data. The disadvantages of this method of control can be the existence of a telecommunication link that is both economically and technically difficult. Scattered method: In the scattered method, measurements are performed locally, in which case the telecommunication infrastructure is eliminated and due to the local performance, the reliability of the system will increase. Electric vehicles (EVPs) are a new example of distributed generation sources that are gaining more and more use. [8] Electric vehicles have three characteristics, which are market and technical environmental characteristics that lead to the expansion of frequency regulation sources. Rotating storage, reducing load demand, reducing losses, increasing reliability and reducing greenhouse gas emissions [12-9] Electric car batteries can be used in two ways, so-called charge or discharge, which causes the use of Provides the car in a variety of situations, which is called the V2G network. [15-13] the concept of facsimile devices was first used by Hingorani in 1988. Today, these devices are based on electronic power exchangers that respond in time. It offers better and also better controllability levels than the models [16, 17] Static compensator is widely used in today's industry. Reactive power compensator is always considered as an economical method [20-18]. In fact, SVC includes harmonic filters and thyristors that control existing reactors. Its capacity is dynamically adjustable. SVC control methods follow both direct and indirect formats [18, 19, 23-21] In fact, having a suitable controller with micro-network conditions can ensure micro-network stability in [24 A control method for microgrid is presented. The purpose of this paper is frequency and voltage stability. Using the electric vehicle element, SVC and STATCOM, its changes and effects are observed.

Theoretical Foundations:

Micro bridge:

Electrical micro grids, as one of the main elements of smart grids, are an ideal solution for connecting renewable sources and new energies to the power grid and increasing their participation. These small electrical networks, by using different sources of energy production and storage, while increasing the reliability of the system, reduce costs and greenhouse gases. The power grid consists of three parts: production, transmission and distribution. For years, researchers have focused on the two parts of production and transmission, and the problems of these two parts have been largely solved. With the growth of loads and the development of the distribution system, this part has faced many problems, so this part of the distribution networks has attracted a lot of attention, which has led to the provision of new solutions to solve its problems.

One of the new topics in this discussion is smart distribution network. A network with unique features that can solve many distribution system problems. Two features of smart distribution network that are very important and should be considered in the design are: self-repair and self-sufficiency. Self-sufficiency means getting the least amount of power from adjacent microgrids, and self-repair means detecting, isolating, and recovering. These two important features must be considered in order to prepare for the creation of a smart network. Solutions have been provided in this regard. One of these solutions is to divide the distribution network into micro-networks with the ability to be islanded.

Electric car

The concept of V2G was first introduced in 1997. In this sense, the power grid can receive power from the electric vehicle, and therefore the electric vehicle charger has the ability to transfer power in two ways (the ability to deliver power to the network and receive power from the network).

V2G technology has led to the development of this type of vehicle that provides the ability to transmit electricity to the network. [11] V2Gs have the ability to store energy, which is a good advantage in micro grids [25] for Affordable car charging for network (V2G) aggregators has been introduced. (26).

After expressing this concept, V2G technology was examined in order to use electric vehicles as storage and supply of peak power. Despite the different definitions for the concept of V2G, what is considered in most studies of V2G technology is this Explanation: Car to grid is a concept for the use of electric vehicles to deliver power to the grid.

Four independent factors limit the amount of V2G power that electric vehicles can provide:

-Capacity of charging station lines and other V2G connecting circuits

-Maximum allowable power of car power electronics

-Number of vehicles connected to the network

-The amount of electrical energy stored in car batteries

The second factor is less important than the other factors, because the maximum allowable power of electronic power devices of electric vehicles reaches an average of more than 100 kW, and calculations show that this value is much higher than the other limiting values.

Electric vehicle aggregators are a factor in the efficiency of V2G technology

The storage capacity of a battery alone cannot have much effect on the power grid and is like a small noise in the grid. To create a megawatt and effective capacity, it was introduced to the network of actors who play the role of collector of electric vehicles. . [27] This aggregation can be used for the network both as a load and as a source of energy production and storage. From a load point of view, the aggregation of electric vehicles cannot be considered as a large industrial or commercial load, which will significantly reduce the cost of charging for each electric vehicle. From an economic point of view, the integration of electric vehicles has the advantage that a single decision maker enters into an energy supply contract for the integration of electric vehicles at a lower price than the owner of any electric vehicle. Therefore, it is profitable for electric car owners in terms of electricity, batteries and other services. So far, different models have been proposed for the aggregators. In the first model, the aggregator is intended to manage a group of vehicles parked in a particular parking lot. In the second model, a group of vehicles dispersed in different locations. , Is considered to be the aggregator of a retailer that buys electricity from hundreds and thousands of vehicles and sells services in the electricity market. In the network, it replaces the batteries for free. In another model that has been proposed, the aggregator takes into account the points in the purchase of the battery and the discount in the charge of the batteries. Electric car owners, on the other hand, connect their vehicles to the grid at times specified in the contract. If the car owner does not comply with the contract, he will be fined. This model is more attractive to owners of electric vehicles due to lower charging costs and no worries about battery consumption. Regardless of the model offered to the aggregators, the presence of these actors is essential for the efficiency of V2G technology. With the aggregation of electric vehicles, the expected power and energy per hour can be predicted with less uncertainty than a vehicle and can act as a load or an effective source.

Microgrid frequency control control scheme

The microgrid frequency control control scheme for different scattered products consists of 3 main parts, the first part includes common droop control, which due to changes in frequency and output power, try to reduce and minimize the changes caused by changes. Loads and disturbances including voltage drop and fault in the power network and the equations related to active power-frequency and reactive power-voltage are expressed based on the following relation: (28-29).

$$V_{i,ref} = V_{nom} + n_i (Q_{i,dis} - Q_i) \qquad (1)$$

$$f_{i,ref} = f_{nom} + m_i (P_{i,dis} - P_i) \qquad (2)$$

The second part of this control part is related to the recovery of self-frequency control, which is the task of distributing the active power between the sources of distributed generation in order to better regulate the microgrid frequency, which is expressed based on the following equation.

$$\Delta f_{i,res} = k_f \int (f_{nom} - f_i) dt \tag{3}$$

$$f_{i,ref} = f_{nom} + m_i (P_{i,dis} - P_i) \tag{4}$$

So that kf is the same for all distributed generation units, which means that the frequency recovery task is divided equally among all distributed generation units. In transient mode (as opposed to permanent mode) the instantaneous output frequency may differ between DG units due to differences in impedance in the DG unit and the location of the output load change [24], which can be represented using a simple power system network model as shown below. Be. So that P is equal to the active power output from the receiving location to the receiving location and R and X are equal to the resistance and reactance of the power grid, respectively. Vs and Vr are equal to the voltage range at the beginning and end of the line, respectively (4).

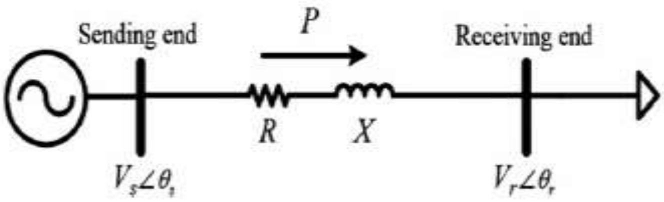

Figure 1- Single-line diagram of a simplified micro grid model in island mode.

Active power is obtained through the following equation:

$$P = \frac{RV_rV_s\cos(\theta_s - \theta_r) + XV_rV_s\sin(\theta_s - \theta_r) - RV_r^2}{R^2 + X^2} \tag{5}$$

In high or medium voltage power networks, the resistance is much smaller than the reactance value (R << X) and the voltage angle difference is considered very small and *as a result we have:* $(\theta_s - \theta_r) = \delta \approx 0$ ، $\sin\delta \approx \delta$ ، $\cos\delta \approx 1$

The active power is then simplified to the following relation:

$$P = \frac{V_rV_s(\theta_s - \theta_r)}{X} \tag{6}$$

Because the voltage amplitude of the DG unit varies slightly in the medium power network, the voltage angle change is related to the change in active power. Therefore, when changing the output load, the voltage angle deviation will vary between DG units. [30] The output frequency of the DG unit as a function of the output voltage angle θ_i *it is expressed as follows:*

$$\int 2\pi f_i dt = \theta_i \tag{7}$$

The third part of this control method is related to restorative or corrective control, which is used to compensate for errors in the active power distribution in regaining its own frequency control. Its main purpose is to reduce the changes and frequency fluctuations in the microgrid, even if the amount of these changes is small and is expressed based on the following equations.

$$\Delta P_{i,dis} = P_{i,dis} - P_{i,dis} \tag{8}$$

$$c_i = \frac{1/m_i}{\sum_{j=1}^{N}(1/m_j)} \tag{9}$$

$$\Delta f_{i,com} = k_c \int (c_i \Delta P_{dis,tot} - \Delta P_{i,dis})dt \tag{10}$$

By combining these three control parts, we achieve the final control equation below.

$$f_{i,ref} = f_{nom} + m_i(P_{i,dis} - P_i) + k_f \int (f_{nom} - f_i)dt$$
$$+ k_c \int (c_i \Delta P_{dis,tot} - \Delta P_{i,dis})dt \tag{11}$$

The following figure shows an overview of this control. (24).

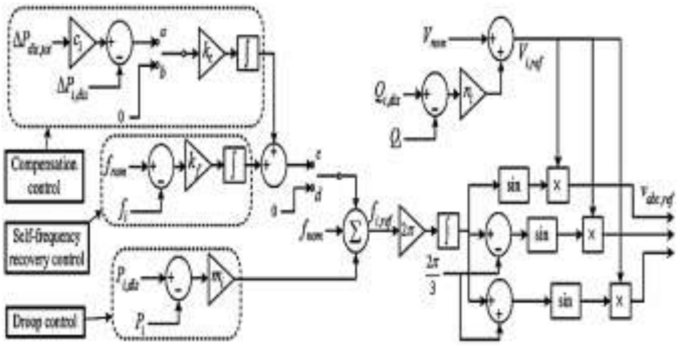

Figure 2 - self-regulatory control method for distributed generation used in a micro grid.

Simulation

The simulated micro grid system consists of three sources of scattered generation and different loads that are separated from the power grid at a specific time and operate independently**.**

The following figure shows an overview of the simulation system. The power grid system operates at a frequency of 60 Hz and a voltage of 69 kV, which is reduced to a voltage of 13,8 kV by using a power transformer in the place of electric charge and then to a voltage of 4,14 kV by using the next transformer. The micro grid is initially a network-connected simulation, disconnecting from the power grid in 1 second and operating independently. The electric charge in the micro grid consists of three charges with a power of 1,5 MW, which in 1 second 1 MW is out of circuit and in 2,8 seconds a very large load with a value of 12 MW is placed in the circuit. The effect of these changes in the output system is visible and it should also be considered that the system remains stable using the control method and does not have problems and the frequency and voltage do not exceed the allowable limit. In the second part, electric vehicle simulations are introduced into the circuit and its effects on the simulated system are shown. The electric vehicle consists of 1000 vehicles with a capacity of 2 kW and a total capacity of 2 MW. . In this system, two load models, AC and DC, are used, and the DC part is specified using a rectifier**.**

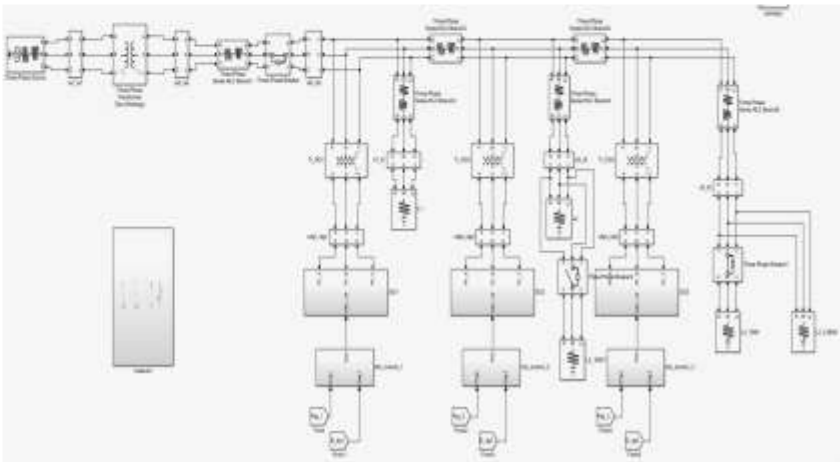

Figure 3. overview of the simulated system**.**

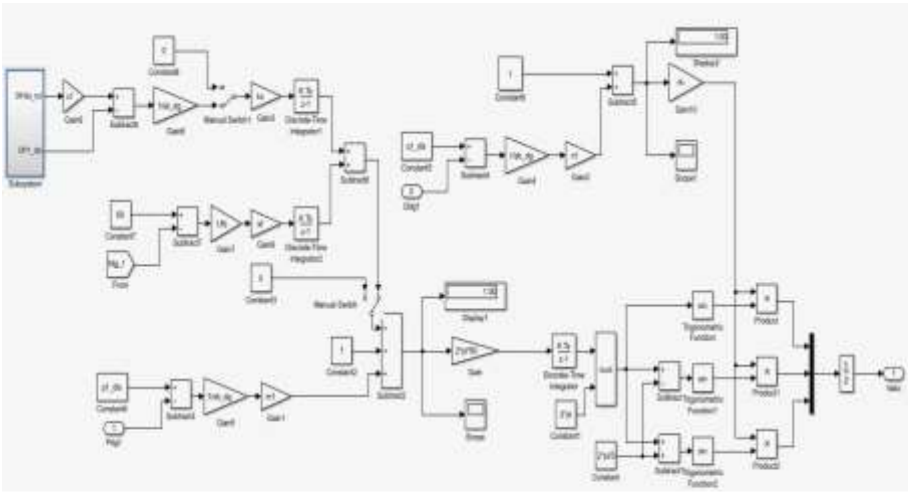

Figure 4- Control system used for dispersed products.

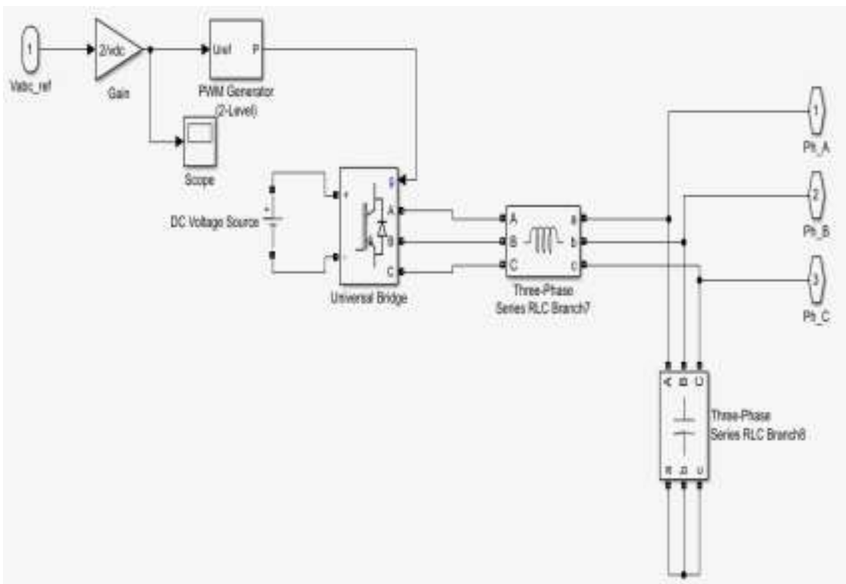

Figure 5 - general form of equivalence of distributed generation system.

The following figure shows the output results in order.

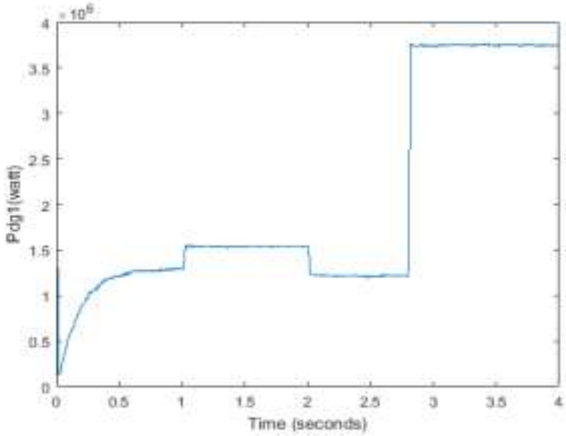

Figure 6- active output power obtained from scattered production number one.

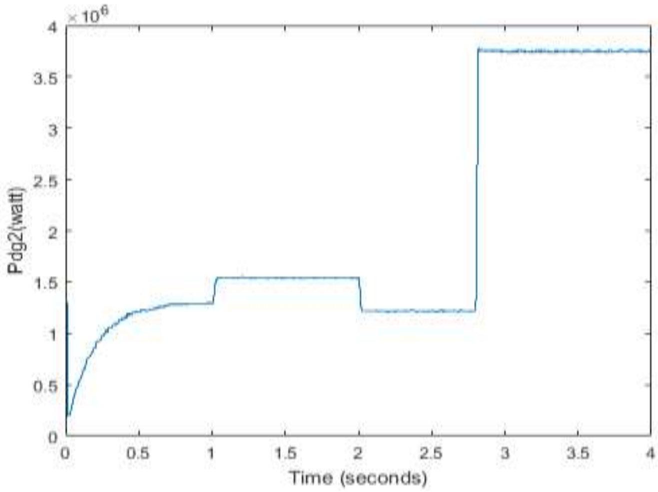

Figure 7- active output power obtained from the second generation of distributed generation.

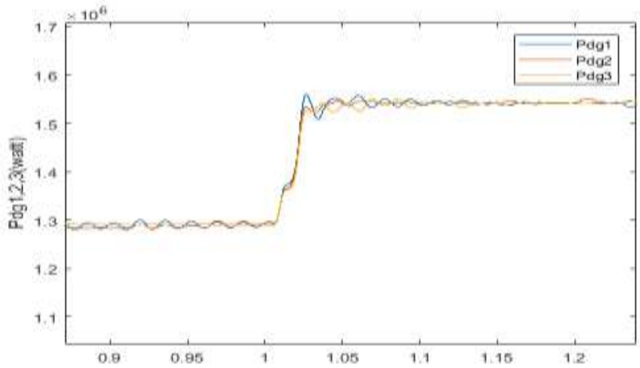

Figure 8. active output power obtained from the distributed generation of three different units together.

The active output power of the three DG units is shown in the figures above. The first change in the output value is due to the change from the state connected to the power grid to the island state, which occurs in one second. Then the output load decreases in two seconds, at which time we see a decrease in the amount of output power of the DG unit. In 2, 8 seconds, a large load is placed in the circuit, which increases the output power of the distributed generation Unit.

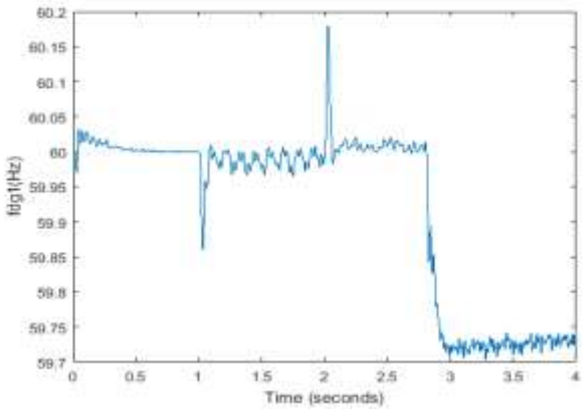

Figure 9- output frequency obtained from scattered generation number one.

The output frequency of the circuit changes during load changes. It is also observed that during 2, 8 seconds when a large load is placed in the circuit, the output frequency of the circuit changes more and cannot return to its standard value, which is due to the limited power output of the DG unit.

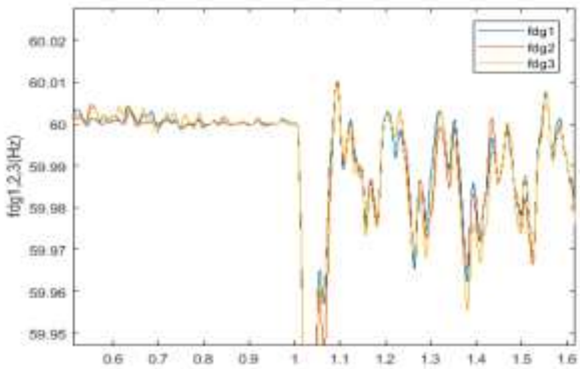

Figure 10 - output frequency obtained from the scattered production of three different units together.

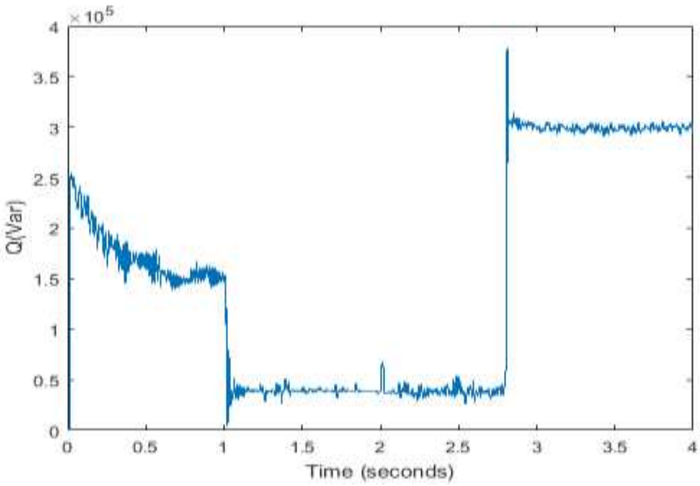

Figure 11 - reactive power output obtained from the scattered generation number one.

The reactive power output of the distributed generation unit also changes at times when the output load of the circuit changes, with the maximum change being in 2.8 seconds, with more load being placed in the circuit.

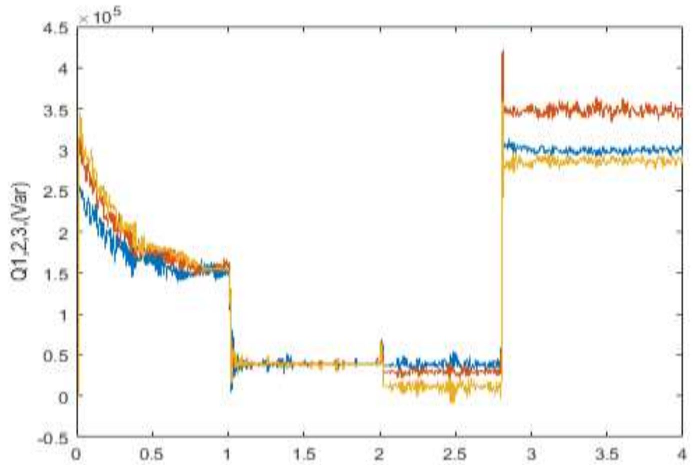

Figure 12 - reactive power output obtained from the scattered production of three different units together.

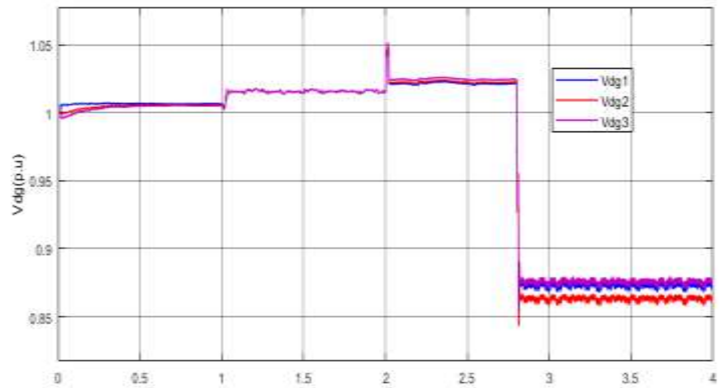

Figure 13 - output voltage obtained from the distributed generation of three different units together.

The output voltage of DG units, like other parameters, changes due to the change of the output load in the circuit.

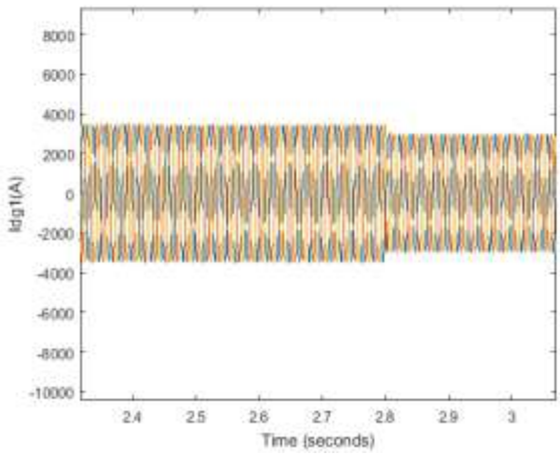

Figure 14 - output current obtained from the first number scattered generation.

The output current of the first scattered generation unit is observed in the above circuit, which depending on the amount of output load located in the amplitude circuit, the output current of the distributed generation is also affected. The electric vehicle consists of 10 electric vehicles with a nominal capacity of 200 kW. It has a capacity of 2 MW. The effect of the electric vehicle can be seen in the following output results.

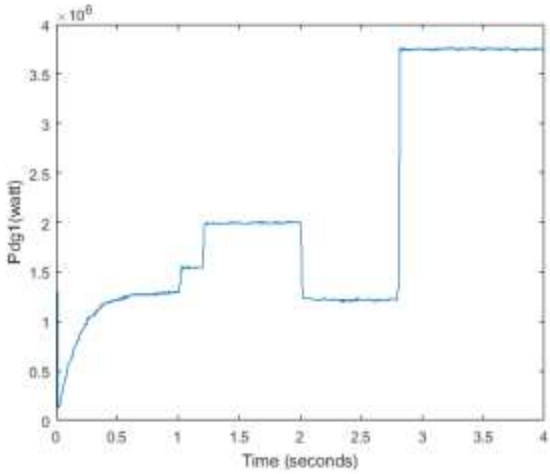

Figure 14 - active output power obtained from distributed generation number one.

The electric vehicle is in orbit for 1,2 seconds and goes out of orbit in 2 seconds, which has an effect on the active output power.

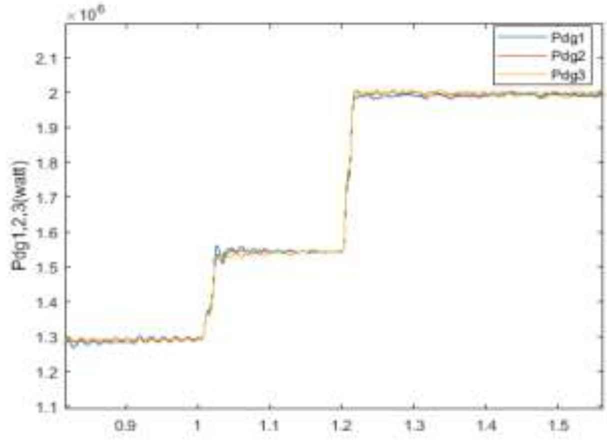

Figure 15- active output power obtained from the scattered production of the first, second and third numbers.

Also, in Figure (19-19) is seen the active production capacity of all three scattered production units.

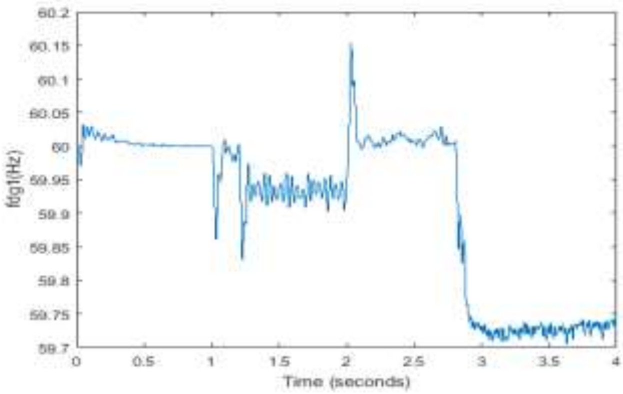

Figure 16 - output frequency obtained on the scattered generation side of the first number.

Like the active power in the output frequency of the scattered generation side of the first number, due to the entry of the electric vehicle in the circuit in 1, 2 seconds to 2 seconds, we see its effect on the circuit and it is effective.

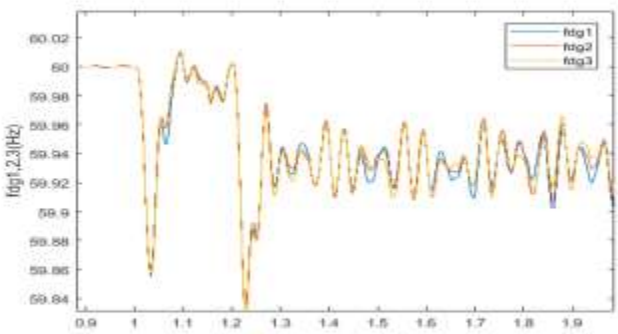

Figure 17- output frequency obtained in the scattered generation side of the first, second and third numbers.

Check system performance in the presence of Statcom reactive power compensator

Flexible AC transmission systems (FACTS) with power distribution control and voltage control are the appropriate choice to eliminate or modify the problems of electrical transmission systems. The separate operation of each of these devices with proper control leads to positive and acceptable results in the system. But when the number of these devices in the system increases and the distance between them decreases, controlling the parameters of these devices without coordination between the controllers may not always lead to the desired results and lead to interference and incompatibility between their goals. Static power compensator Reactive (SVC) and Static Synchronous Compensator (STATCOM) are static generators of reactive power, in which the output is changed so that certain parameters are maintained or controlled in electrical power systems. A static reactive power generator may be of the controlled reactive impedance type - using reactors and capacitors controlled and switched with a thyristor - or of the voltage source type - using a switchable power converter - or of the mixed type - which is a combination of Uses these components - be. However, the operating principles of these reactive power generators are very different

V-1 losses are quite different from their output reactive power, as well as the response speed and bandwidth of their achievable frequency, all of which can generally compensate for a controllable reactive shunt, with similar operational capabilities, within a linear operating range. Show yourself. This means that the basic structure of the external control that defines the operational function of the compensator, and thus provides the reference inputs for the reactive power generator, is essentially the same regardless of the type of reactive power generator used. (Note that the converter-based reactive power generator can be equipped with a suitable energy storage to provide active and reactive compensation; in this case, the compensator control must be with additional control loops to manage the actual power exchange between the AC system and Converter, complete.

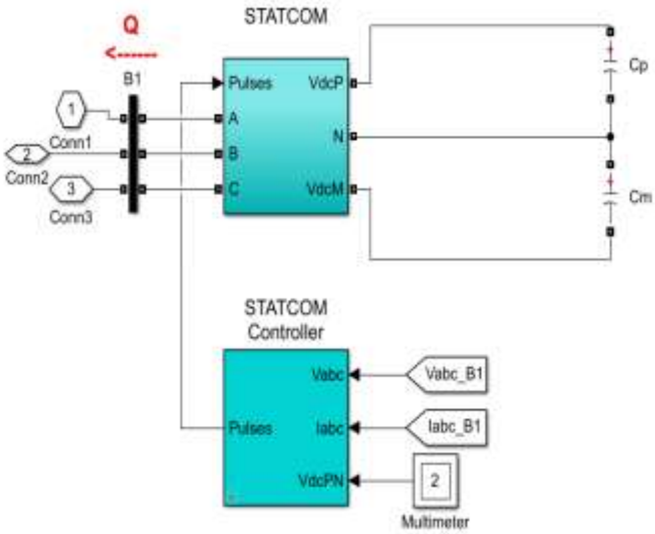

Figure 18- general structure of statcom reactive power compensator used in micro grid.

In the figure, the frequency response of the system is observed after the application of reactive power compensator. The system frequency shows a better performance in this case.

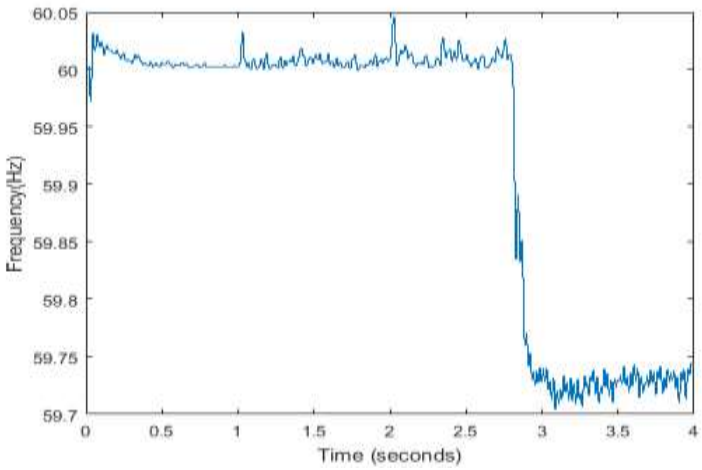

Figure 19- system frequency after using statcom reactive power compensator in the circuit.

Figure 20 shows the system voltage after using the Statcom reactive power compensator and it can be seen that the system voltage improves after using the system and shows a better response.

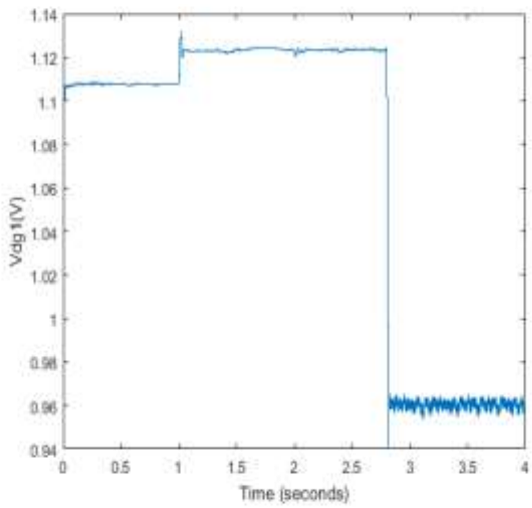

Figure 20- simulation system voltage after using statcom reactive power compensator.

Check system performance in the presence of SVC reactive power compensator

Static reactive power compensator (SVC) is one of the most common types of FACTS devices and plays a significant role in controlling reactive power in transmission and distribution networks. Extensive voltage level, power factor improvement, load balancing, etc. are of increasing

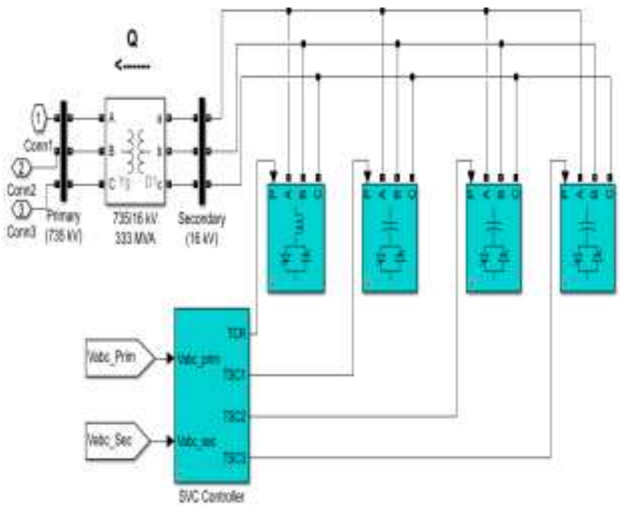

Figure 21- general structure of svc reactive power compensator used in microgrid.

In the figure above, it can be seen that by using the SVC reactive power compensator, the frequency system response shows better performance and the circuit stability is increased. Also in the figure below, the system voltage improves after using the SVC reactive power compensator.

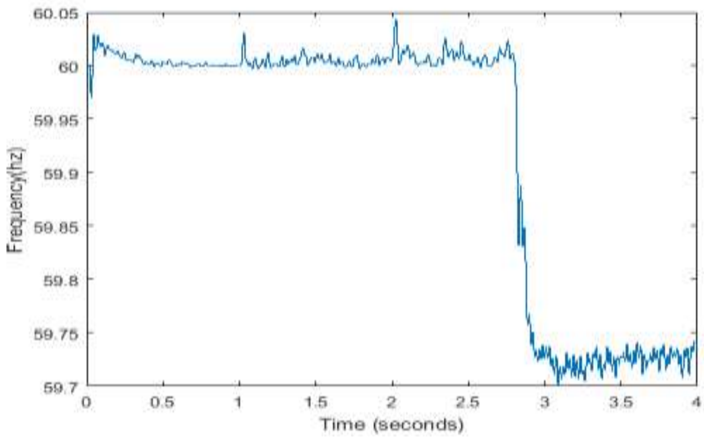

Figure 22- frequency of simulation system after using svc reactive power compensator

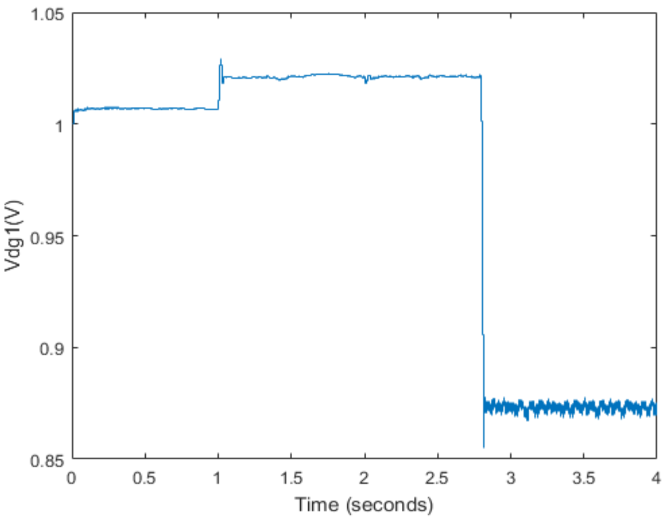

Figure 23- simulation system voltage after using svc reactive power compensator

Finally, it can be seen that the system response in the case of reactive power compensators has a desirable and better performance and the SVC reactive power compensator has better results than Statcom. It should be noted that we assumed that the electric vehicle did not initially have a stored electrical charge and needed to charge and power itself from the microgrid. If they are assumed to have enough energy and do not require more energy than other results can be applied to the presence of an electric vehicle. Instead of an electric car, a battery can be used to dazzle and power the grid when needed, which improves the grid's instantaneous response. The electric vehicle has a better performance in the AC part of the network than it is used in the DC part of the network because our control part is more in the AC part for the network and in this part of the network, we see a better and more desirable response from the network. The results of the electric vehicle on the two different sides of the network are shown in the figure below.

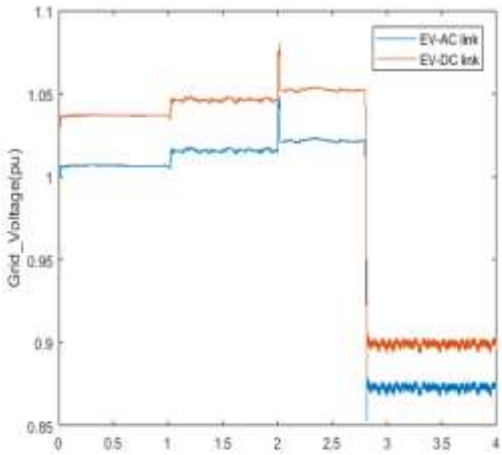

Figure 24- system voltage using an electric vehicle on the ac and dc side of the network.

But for the battery, it is better to use the grid in DC DC, because its voltage is DC, and if it supplies itself with a DC load, we will see better performance and higher efficiency of the system. An electric vehicle can be used as a replacement battery in the circuit, but the battery performance in the exhaust system is more important and better. It should be noted that the network hybrid structure in this simulation has always remained the same and has not changed.

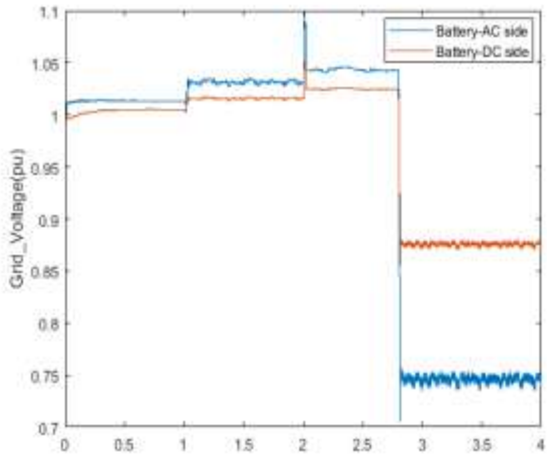

Figure 25- system voltage using the battery on the ac and dc side of the network.

The figure above also shows the output of the power grid, including voltage in terms of pronate when the battery is in use and when the battery is not in use, and when the electric vehicle is supposed to act as a power saver.

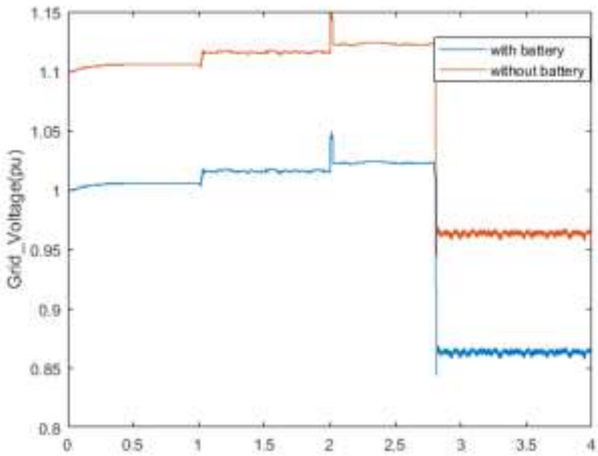

Figure 26- system voltage if from the battery and without using the battery in the network.

Conclusion

Looking to the future of the electricity industry, it can be seen that traditional power systems are gradually giving way to new structures and systems, and smart grids are rapidly becoming pervasive, and in parallel with smart grids, microgrids have also become very important with the development of microgrids. The issue of controlling microgrids independently is one of the major concerns in this area. It is very important to design a controller that can consider both economic and sustainability perspectives. Due to the reduction of fossil resources in the world and the replacement of fuel to meet human needs, including automobile fuel, electric vehicles are evolving over time. They are targeting fossil vehicles. So by adding an electric vehicle in this research, the aspects of the presence of this device in the microgrid were examined. Also, in this study, it was tried that the improvement of microgrid stability does not rely only on the control view and the existing devices in the field of power were used and it was possible to improve the microgrid stability along with the controller.

Voltage and frequency maintained their stability using the proposed controller. With the addition of reactive power compensators, the desired performance was better than the previous state. By combining these two structures, better outputs were obtained. Compared to STATCOM, the results showed that the storage by the battery is better than the car itself, and by using both together, they showed much better performance. Due to the fact that most of the control units are connected to the AC side of the microgrid, the car performance on the AC side was associated with higher efficiency due to receiving DC voltage.

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