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Research Article

SECURITY ANALYSIS AND POSSIBILITY OF ENERGY HYBRID AC/DC MICRO GRIDS INCLUDING WIND TURBINE WITH NECESSARY SYNCHRONIZATION CONTROL

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ABSTRACT
We will study about the micro grids including dispersed producing sources with AC to DC and DC to AC converters. Studying system contains both AC and DC parts and Energy saver system in DC link has been used to get surplus current of system. This grid has been studied in different working scenarios such as wind speed change for wind turbine, radiation rate of change for solar cell and also change of available charge rate in AC part and a fuel cell has been used as a helpful dispersed producing source in emergency cases-decreasing producing current using coupled phase controller on a DC/DC converter. Simulation results show the grid stability, grid security and excellent synchronization in energy management.

Keywords: *Energy Management, Possibility and Security, Wind Turbine, Solar Cell, Fuel Cell, PID-phase Controller*

INTRODUCTION
After studying the dispersed producing sources such as wind turbine, solar cell, energy saving system and fuel cell, our purpose is to study the possibility, security and combining ability of these sources together and in the shape of one micro grid in this paper. To get to this point, in each of the dispersed producing sources, producer has been placed the power according to the specified input, suitable controllers for getting the maximum power (controller pitch for wind turbine and MPPT for solar cell) and has been placed by DC to DC converters suitable with desired output voltage. An energy saving system has been used as a variable charge in system which has the ability of charging and discharging until it saves the surplus current on the fixed charge in system and improves the voltage profile until we have the minimum fluctuation in voltage DC link.
A fuel cell has been used in voltage control of DC link as, a medium model BOOST converter has been used for switching and voltage stability. Using controller in the converter is of PID until it can have all the positive capabilities of a power systems common controller. This controller does the key tapping by comparing the real voltage of the line with the reference amount.
By studying the hybrid function in the system, it can be resulted that; basically in the system normal function of any of the renewable dispersed producing sources in system such as wind turbine or solar cell are capable of providing the primitive and nominal charge provided that placing in a desired function point (wind speed about desired nominal speed for turbine and radiation proportional with the desired current output for providing the primitive charge supplying for solar cell). This situation was studied in first and second scenarios of simulation for solar cell and turbine. Looking carefully in the shapes perception, it can be found out that the fuel cell has been technically placed out of the circuit in this time zone(the corresponding current of the fuel cell equals zero) and the hybrid system is fed with solar cell in [0,5-0] seconds zone and with wind turbine in(1-0,5) seconds zone, in next scenario, entrance error in voltage signal is understood and immediately the corresponding current is done to prevent the voltage fall with increasing the charge amount of the fuel cell Boost controller. The process of charge increasing is done one more time in system to examine the bearing amount of the fuel cell.
A DC to AC converter has been used to feed the 3phased charge. This converter had been controlled thoroughly and different kinds of voltage levels can be tested in it. Suitable function of the converter can be concluded by observing the voltage wave form and outlet current and also the total harmonic amount on voltage. As it was mentioned before, the charge amount is increased in two other stages and an

increased measured effective amount in current is seen too. When the appropriate key tapping factor exists, AC voltage level decrease in grid charge increase is prevented (Of course a limitation in proportion with the total entrance current exists. If the requested charge increase is more than producing amount makes a decrease in voltage level and system function mal-working.

Modeling and Grid Structure

Grid General Composition

In an overview, you find out that the grid structure contains two parts (AC and DC). AC part includes different sources of dispersed production such as wind turbine, solar cell and fuel cell as an energy supporting system and also energy saving system and electrolizer as a source for producing hydrogen for fuel cell are placed in DC part. AC part contains a changeable linear charge with time which will be increased in some times of working and will increase to 2.5 times of the first amount. Two parts (AC &DC) are connected to each other by a Dc to AC converter. Figure 1 shows the grid connections schematic.

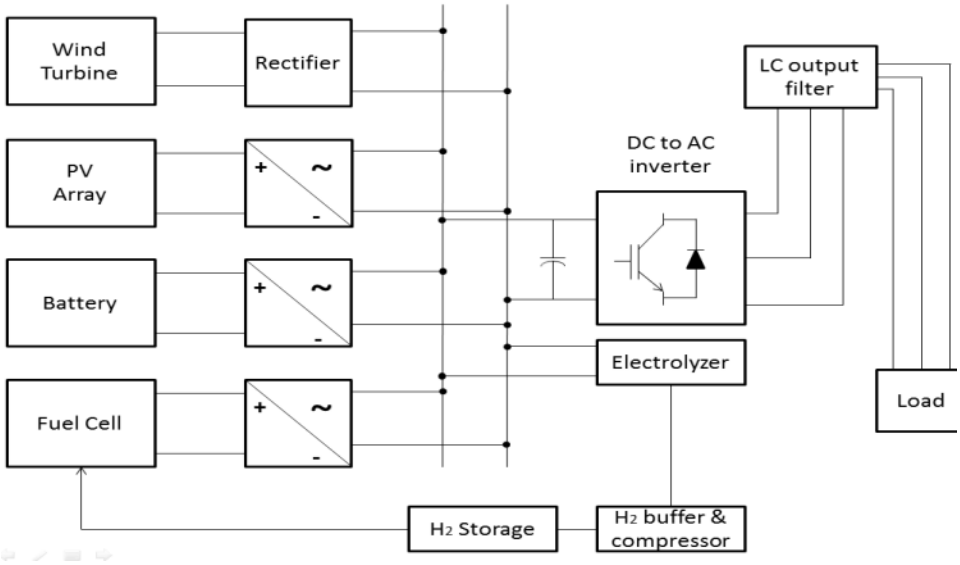

Figure 1: Diagram block of the energy hybrid grid

General Function of the Grid

System has a primitive charge of 30 kw and this amount can be fed by any of the dispersed producing sources which is tested within the first 1.5 seconds of this situation simulation. Then the charge amount will be doubled and the need for an energy supporting system for maintaining the DC line voltage and creating the power for charge part is felt. In this case a fuel cell with appropriate controlling tools is used. In DC to DC converter of a fuel cell which is a medium model of a Boost, a PID-phase controller is used for key tapping. Using a coupled phase controller with PID is because of the comparative nature of the mentioned controller. Since it will be needed to change the controller parameters in different working parts of the system.

Modeling of the Wind Turbine Generator

PMSG generators are used in wind energy changing systems with variable speed. These generators can be made with a lot of poles and get connected directly to the wind turbine.

Wind energy changing systems usually are controlled by three variables:

1. Maximum power which can be obtained from wind turbine.
2. Injecting Reactive power of the grid.
3. DC link voltage of the power electronic converters.

We have used methods one and three in this research.

To reach to the MPPT maximum power with feedback, Rotor speed is controlled. In this method, rotor's mechanical speed(W_m) has been measured and is controlled by PT controller. Reference amount of the rotor mechanics speed(W_m^*) is calculated by measuring the mechanical power(P_m).

$$w_m^* = K_m \sqrt[3]{P_m} \quad (1)$$

This controller controls the torque entered to the turbine shaft by changing the blades angle in proportion to the wind direction. So, if the wind speed is less than the nominal wind speed, the pitch angle will be kept in optimum amount. And if the wind speed is more than the nominal wind speed, the controller will calculates the power error and the controller outlet shows the required installation angle. Figure 2 shows the structure of this controller.

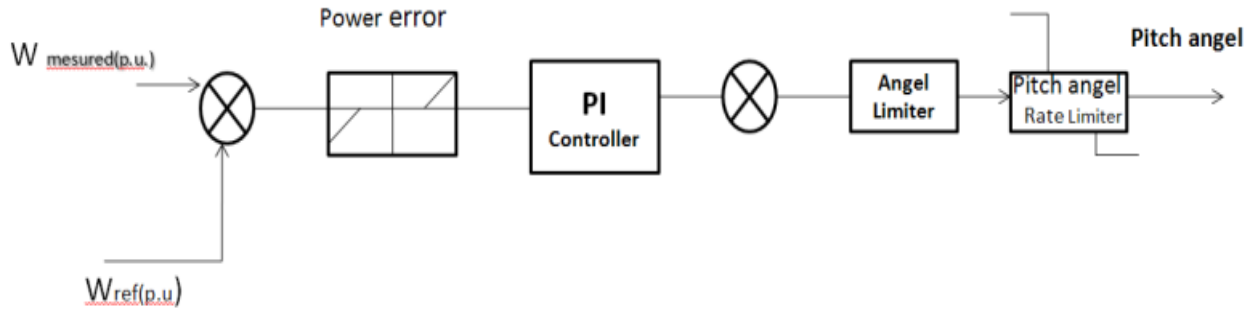

Figure 2: Pitch angle controller

Solar Cell Modeling

An increasing DC/DC converter has been used to connect to the DC link in PV system. Following figure shows the PV system general circuit.

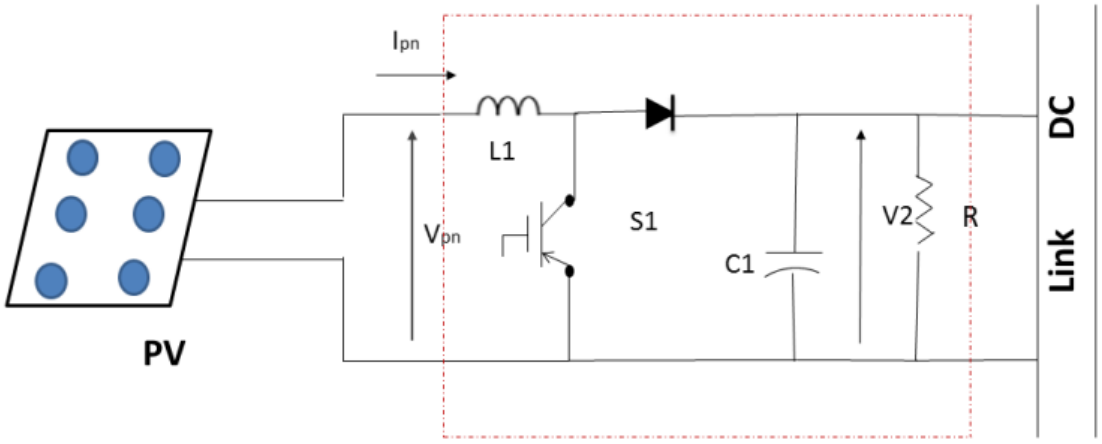

Figure 3: PV system with increasing chopper

To prevent big transformers with low frequency which usually are considered as weak parts because of their huge size and low efficiency, two phase converting systems vastly have been used for PV generators. The most common topologies of a PWN اینوتر of a DC-AC voltage source are about the tracking of the maximum power point (MPPT) and reinforcing the voltage.

Suggested MPPT method is Incremental (Incond) Conductance. You can see the feneral structure of the key tapping for PV converter in figure 4:

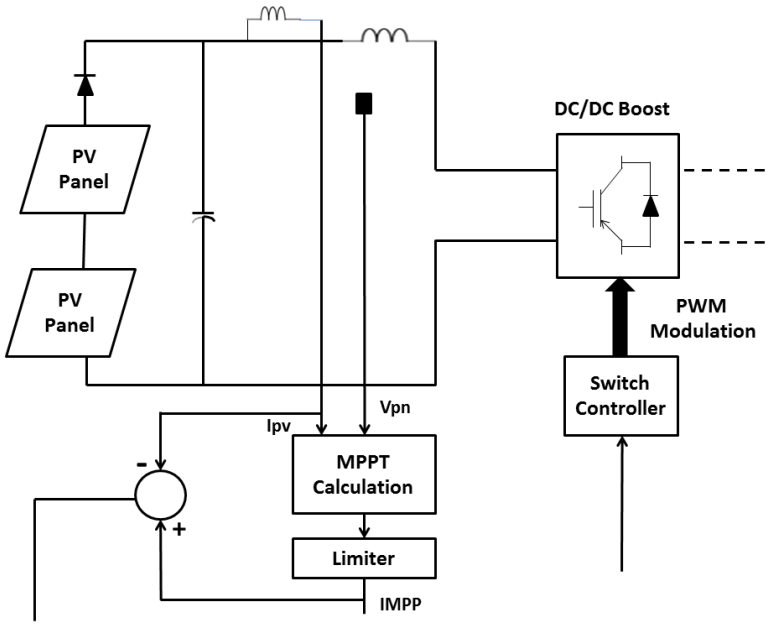

Figure 4: PV system with NPPT control in Incond method

Fuel Cell Modeling

Produced current from the fuel cell is one of the most determining parameters which should be free of ripple. As the current ripple is one of the parameters which is discussed with converters and power electronic structures. In this research it has been tried to decrease the current ripple by the converter or increase its frequency. In fact DC/DC converter's job is to increase the fuel for connecting to the DC link. Fuel cell with the converter has been shown in figure (5).

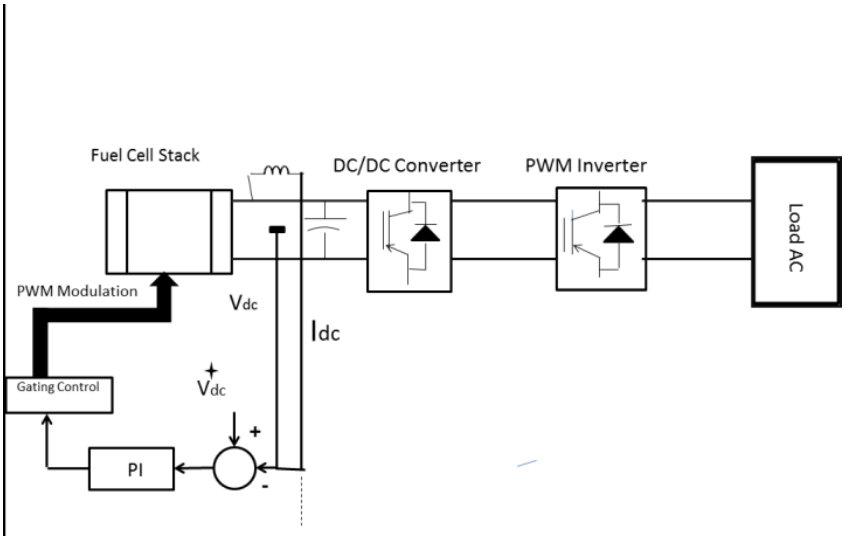

Figure 5: Method of controlling the Power electronic converter in fuel cell

DC/DC converter is intensifier. This converter increases the voltage level. One other benefit is to decrease the input current of the cell.

Simulation Results

Numeric specifications for simulation hybrid system has been used for each of the introduced systems temporarily according to the table (1).

Table 1: Digits used in Simulation

Source features Dispersed production source	Minimum current	Maximum current	Cells number
Wind Turbine	0 A	100 A	-
Solar Cell	0 A	100 A	300 set cell
Fuel cell	0 A	150 A	30
Energy Saving system	-30 A in charging mode	30 A in discharging mode	-

On the other hand, AC charge profile used in the system has been adjusted according to the figure (6). As you can see, charge in two zones has had instantaneous linear variations. In this manner that once in 1.5 seconds charge amount will be doubled and again in 2 seconds its amount will be 50% of the primary charge for 75 kw.

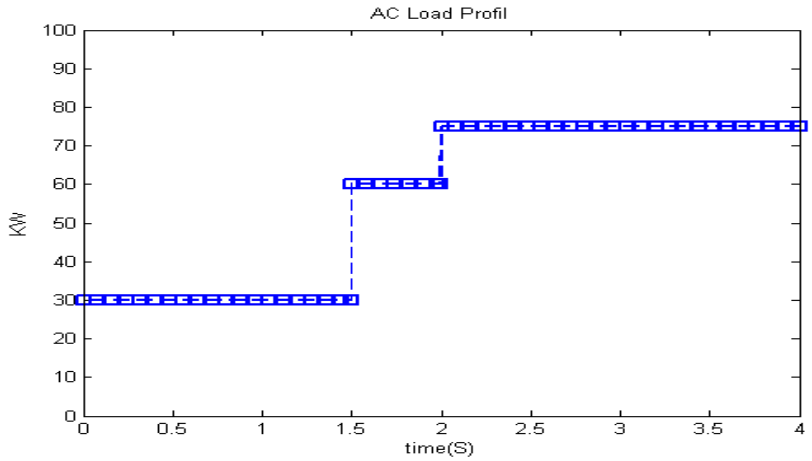

Figure 6: Charge profile used in simulation

Figures (7) to (12) show the simulation results which have been got for 4 seconds:
Firstly, you can see the DC link voltage wave form as a determining variable in figure 7:

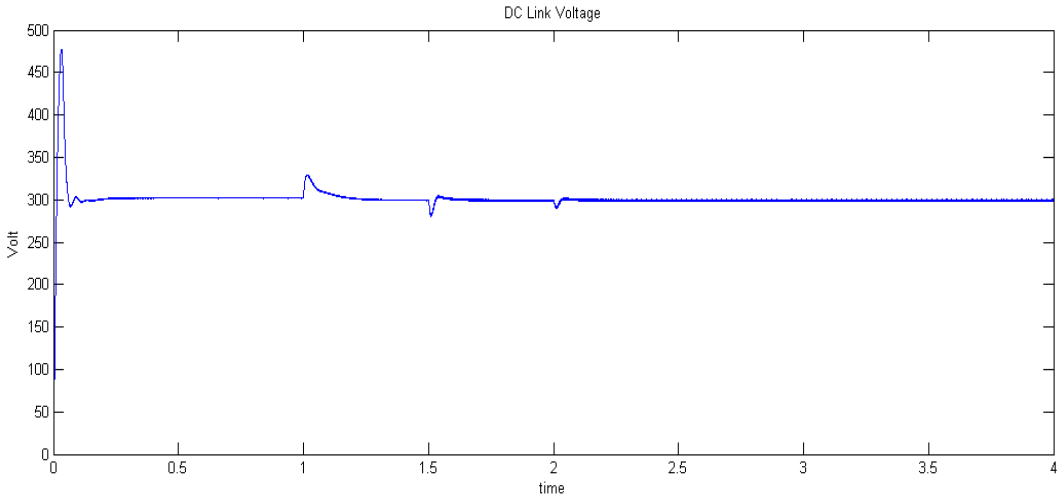

Figure 7: Wave form of the DC link voltage

As it was mentioned, DC link voltage is one of the most important and determining wave forms. Since this voltage is considered as the output of all of the dispersed producing sources and plays a key role in determining the power of these sources. Voltage profile quality, harmonic amount and its fluctuations are effective in the quality of the sources power. It also is a DC part of the DC to AC converter of the variable linear charge with time.

Looking carefully into the wave form and analyzing it temporarily and analyzing permanently, you can get:

1- Voltage wave form has 33% overshoot which can be collated with the signal settling time by changing the controller coefficient of the fuel cell converter and decrease it

2- Signal settling time is about 0.1 seconds which makes it more practical

3- In analyzing the signal permanent mode and by looking carefully into the figure (7), you can see that voltage fluctuations are about 2 volt which is an acceptable amount.

4- Voltage wave form has some permanent distortions which are because of the variations in AC part charge. Waves form(8) are related to the fuel cell power:

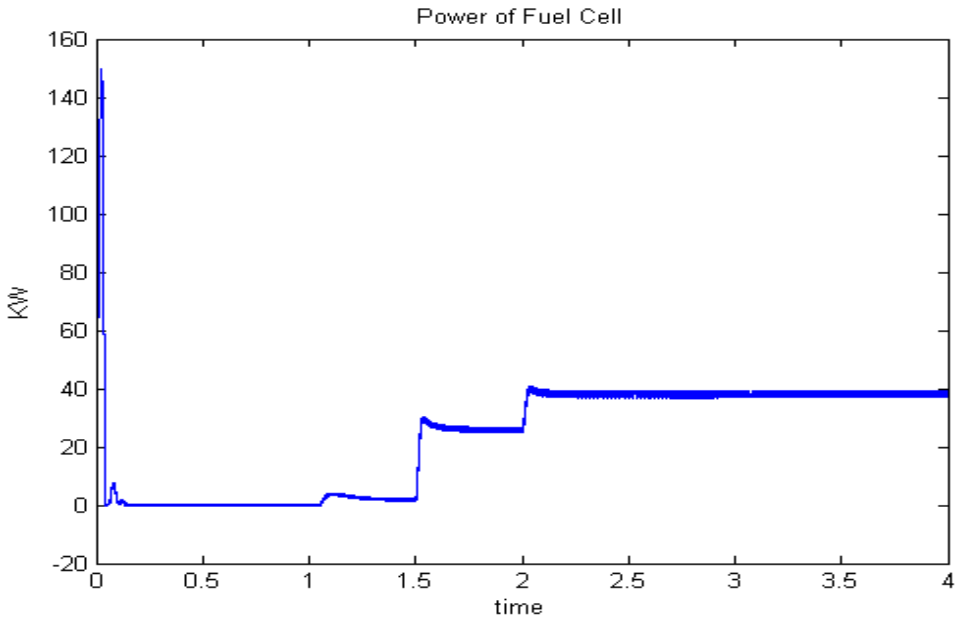

Figure 8: Wave form of the output power of the fuel cell

Looking carefully into the above wave form and paying attention to this point that the role of fuel cell in this system is to support and control the voltage level, you can find out that ;

1- System charge has been fixed in its primary amount at first 1.5 seconds, so the output power of the fuel cell equals to zero because in the first 1 second of the charge, turbine entering prevents the current producing of fuel cell by solar cell in 1 to 1.5 seconds despite of the decrease in solar cell power and fuel cell power amount shows only a temporary mode.

2- From 1.5 seconds, the output power charge of the fuel cell increase from 0 to almost 30 kW by doubling the charge amount.

3- This variation again increases in 2 seconds because of the 50% increase of the charge amount in comparison with the primary amount in proportion with the same amount.

4- Fuel cell current variations happen because of its nature and key tapping of the Boost converter which is controlled by a PID controller

Wave forms (9) to (12) are about the total voltage, current, frequency and harmonic on the AC charge voltage:

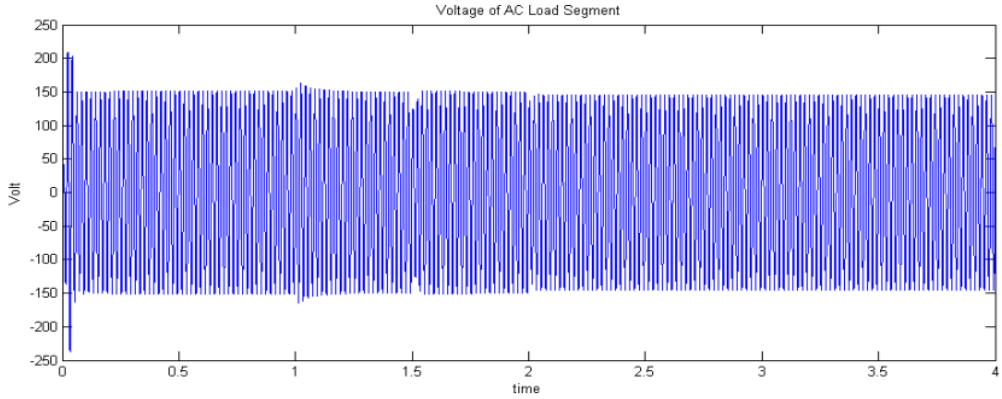

Figure 9: Wave form of the AC voltage on the charge

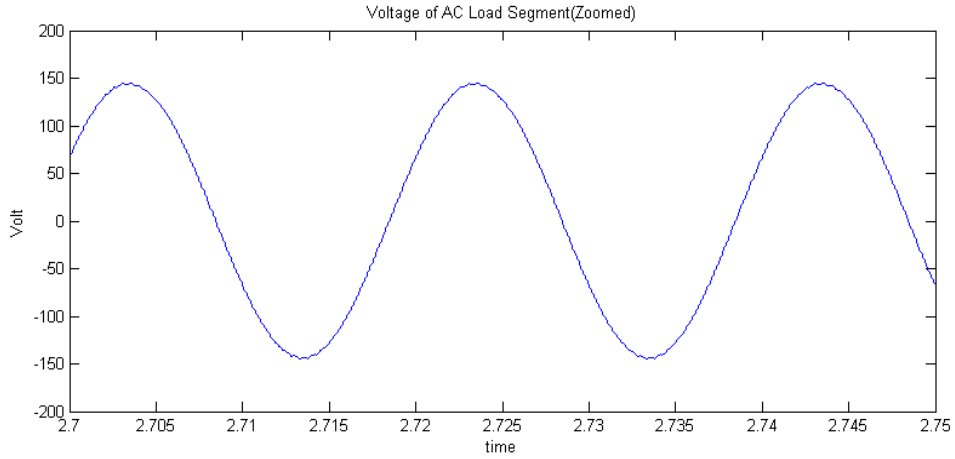

Figure 10: Wave form of the voltage on the AC charge in zooming mode

Figures (9) and (10) are about the AC voltage on the charge, as you can see the voltage level has always been stable despite of the charge amount variation and in the zoomed wave form, the amount of the harmonic on the signal is almost zero.

Also figure (11) which is about the frequency of the voltage wave form shows a signal frequency stability and its maximum uplift is less than 0.5%.

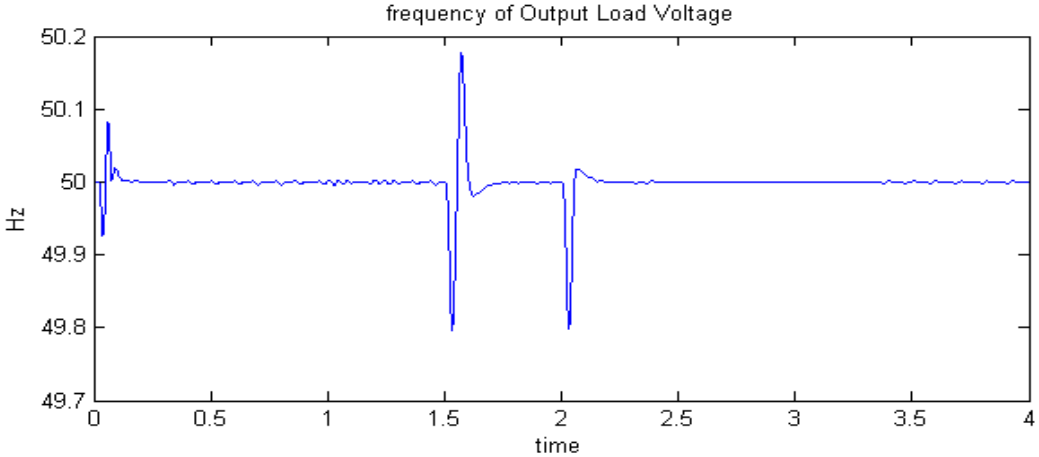

Figure 11: Wave form of the voltage frequency on the charge

Figure (12) shows the effective amount of the produced current of the charge:

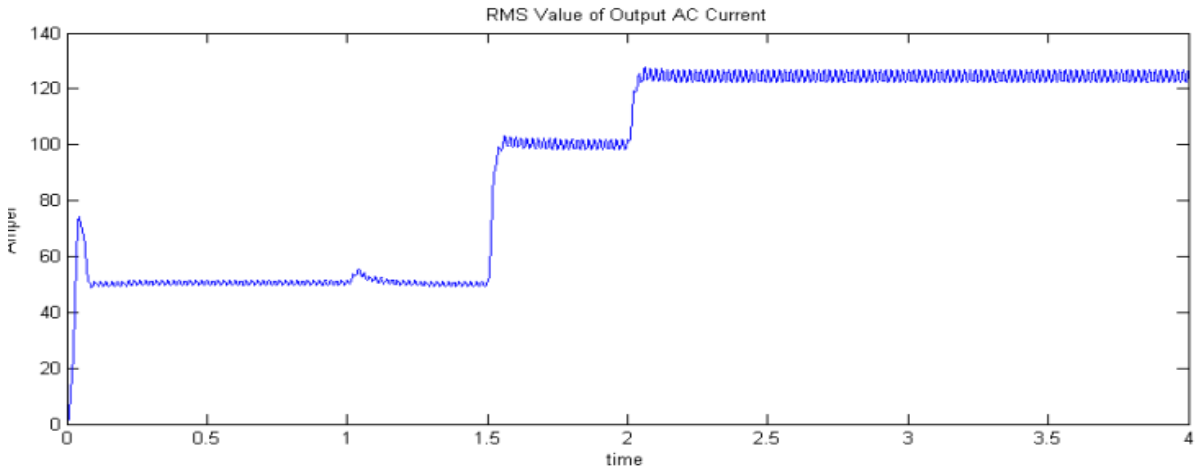

Figure 12: Wave form of the charge effective current

Wave form (12) is completely in proportion to the charge profile which is drawn in figure (6). It should be mentioned that the minimum fluctuations which is seen is because of the DC current part which has been gathered with AC wave.

CONCLUSION

As it was mentioned, linear charges have been used for testing the system in hybrid system. These charges are linear and their distortion in ideal mode equals zero. Nonlinear charges can be used in system and using the dispersed producing sources which work in suitable conditions of reinforcement as a source for an active filter in the entrance of the charge part and put the system current in the desired point of the work and in sinus shape far from the distortions by the nonlinear charge.

Besides, in other applied fields such as hybrid automotive, you can use a hybrid power system introduced for providing the electric power. Studying the error and using the sources for creating a potential stabilizer for emergency times for the system are other possible and practical researches for the system.

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