Power Quality Improvement in EV Charging & discharging time with interfaced grid using instantaneous current control technique.

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Abstract:

Vehicle-to-Grid technology has become a hotspot of current research because it can cause peak load switching; it is also a technological means for improving the grid's capacity to absorb new energy. Electric Vehicle -grid interaction is primarily controlled by pulse width modulation in bidirectional AC/DC transformation. Batteries and AC/DC converters in electric vehicles are damaged by large amplitude fluctuations. This problem was solved by implementing instantaneous current generation method to reduce the impact of volatile energy and improve the charging/discharging power quality of electric vehicles, reduce harmonics and improve the current THD to below 5% according to IEEE standards, and improve the grid power factor. It is implemented by using the Field Programmable Gate Array controller.

Keywords: Total harmonics distortion (THD), Electric vehicle (EV), Field Programmable Gate Array controller (FPGA)

Introduction:

As the number of electric vehicles grows, vehicle-to-grid (V2G) technology is becoming a hotspot for current research because it can shift peak-loads; it is also a means of improving the grid capacity of absorbing new energy. It is mostly pulse width modulation control that controls this bidirectional AC to DC conversion between electric vehicles and power grids. Its bidirectional AC/DC transform control is mainly pulse width modulation control in this interaction between electric vehicles and the grid.

The environmental concerns for increased pollution, resource conservation have led to the increase in the usage of the electrical vehicles (EVs).This project deals with the power quality improvement in EV charging section. The charging section is the compensation of the reactive power for the improvement of the grid power quality. The charging section serves the following purposes: harmonics current compensation, EV battery charging/discharging control, simultaneous EV battery charging and harmonics current compensation and simultaneous discharging and harmonic current compensation. The charging station is controlled in such a manner that EV owner decides the charging/discharging of EV battery. If it is required to charge the EV battery using grid power, the system operation is known as G2V (Grid to Vehicle). However, if EV battery discharges to provide power to the grid, the system operation is known as V2G (Vehicle to Grid). Moreover, the charging station has the ability to provide the reactive power compensation (lagging/leading) as per the requirement.

Proposed Work:

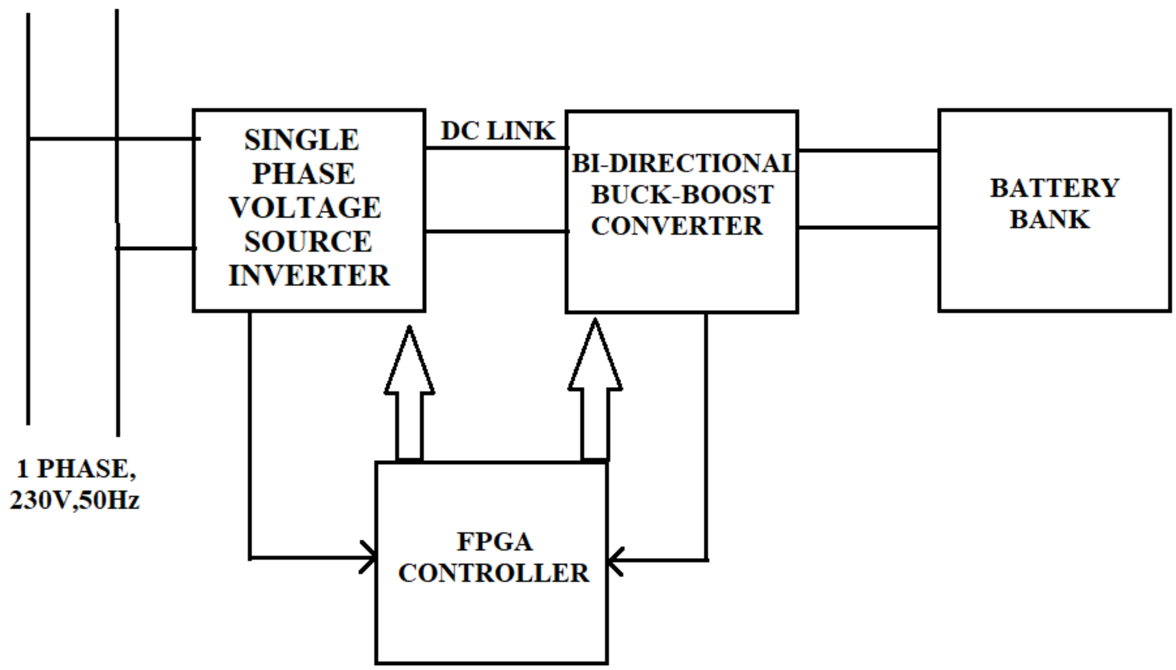


Figure.1: Charging and Discharging EV Battery Interfaced With Single Phase Grid

The basic block diagram of charging and discharging EV battery interfaced with single phase grid is shown in figure.1. Block diagram consist of single phase voltage source inverter, DC link, Bi directional buck –boost converter, battery bank and FPGA controller. Here the all blocks are operated in bidirectional way[1]. The feedback controller is used to control the current of both inverter and converter and it is used to improve quality of power under battery is charging and discharging mode. Depends on charging and discharging the voltage in battery with grid current is converted from nonlinear to linear by closed loop system. Single phase supply is given voltage source inverter and output of this inverter is fed to DC link converter. The output of buck-boost converter is charging the battery.

In Vehicle to grid, the power is flow from load to source that means battery to grid. In this time, bidirectional DC-DC converter acts as a boost mode and will maintain the voltage as constant as per the reference value given in the control method. Here used Instantaneous current control method for to feed the power to grid from battery. By this method, Harmonics level is reduced to maintain below 5%. When battery voltage is in discharging condition, the current is positive direction and maintain the voltage as set level by boost converter.

This project deals with utilization of battery in useful way. At the time of charging gird power quality is improved. Battery is one of the storage element, use that the EV at rest days or not used days[6-8]. Whenever the EV rest days, discharge the battery and power feed to the grid in peak demand hours. This way improve the overall power utilization of grid.

Simulation:

In this simulation, battery is used as a load and the harmonics will be removed by using the hysteresis current control method & power quality will be increased. By Instantaneous current generation method the battery charging and discharging current is controlled. Here PWM generator is control the Bidirectional DC-DC converter switches[2]. This bidirectional DC-DC converter is in Buck converter mode while battery is charging , current is negative and voltage is positive and battery is discharging current is in positive direction and always voltage is in positive . In buck converter mode, battery voltage is maintained the constant voltage level in both charging and discharging, here the non linear current is controlled by Instantaneous method. At start of charging (SOC) the current is reduced after 80% level of charging is reached. Battery is charged by either grid or inverter. The distinct logic was implemented to control the current. First one is inverter switches are controlled by instantaneous method. Second one is bidirectional DC-DC converter switch is controlled by hysteresis control. When the battery is discharging the voltage level, the DC-DC converter will act as a Boost converter mode and maintains the voltage is constant.

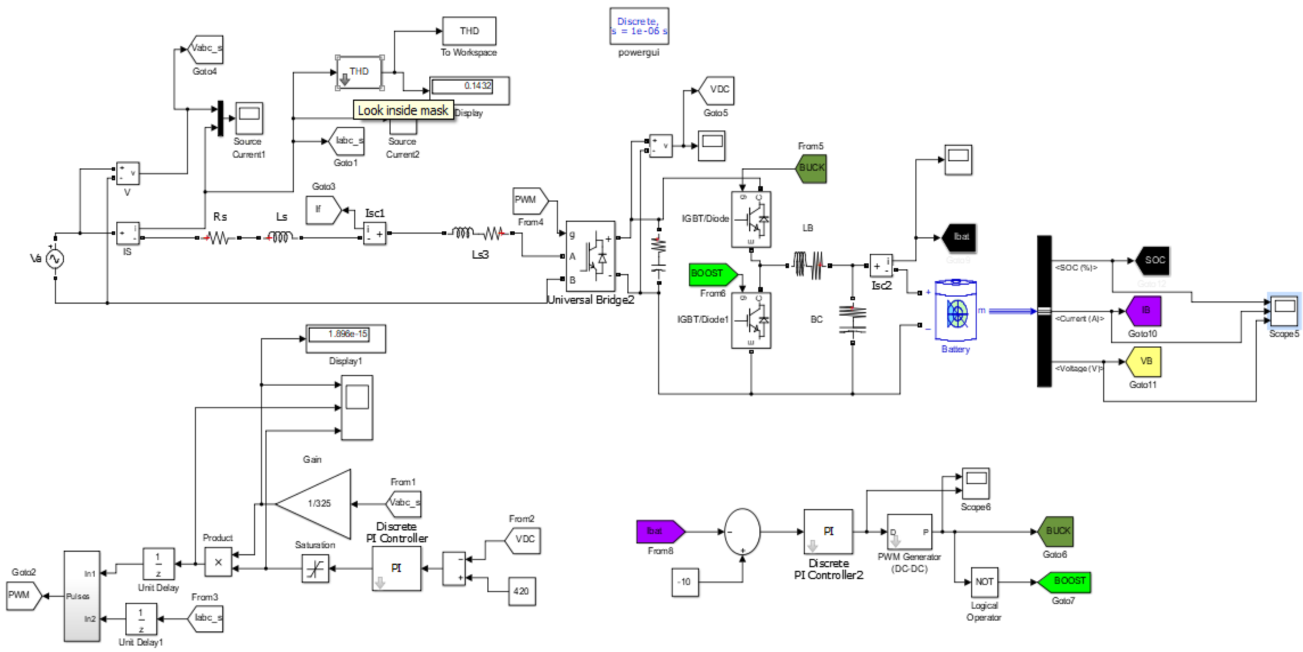


Figure.2: Simulation model of charging and discharging EV battery interfaced with single phase grid.

It is possible to reduce the harmonic performance of a hysteresis current controller by varying the hysteresis band over the fundamental cycle and keeping a constant switching frequency [12]. Current controllers are designed to control load currents by forcing them to follow reference currents. Here the Simulation model of charging and discharging EV battery interfaced with single phase grid is shown in figure.2.

In this research, distinct logic is implemented for the current control. The PI controller is used for control the H bridge inverter switches by PWM techniques .PWM generator is control the DC-DC converter switches by comparing the set value with battery current[1&3]. In the Instantaneous current method, grid current is compared with reference current by feedback. Here the reference current is in negative. This method decided the voltage level of PWM by controlling the current and also the non linear current is converted into linear current by this closed loop method.

Simulation Result:

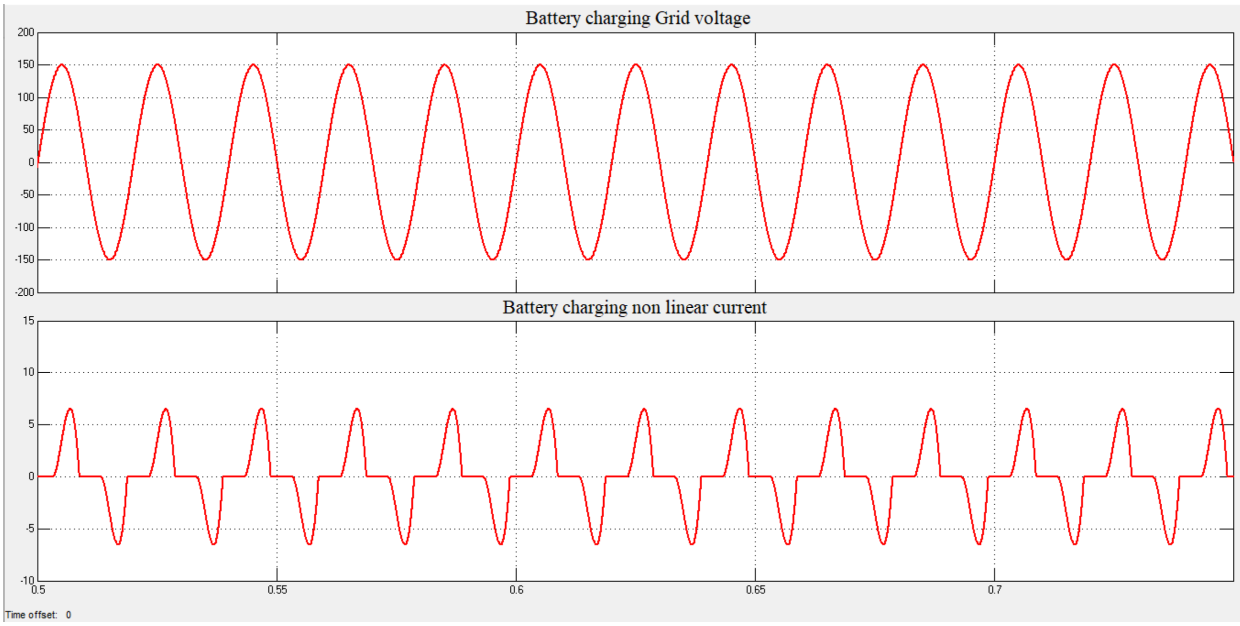
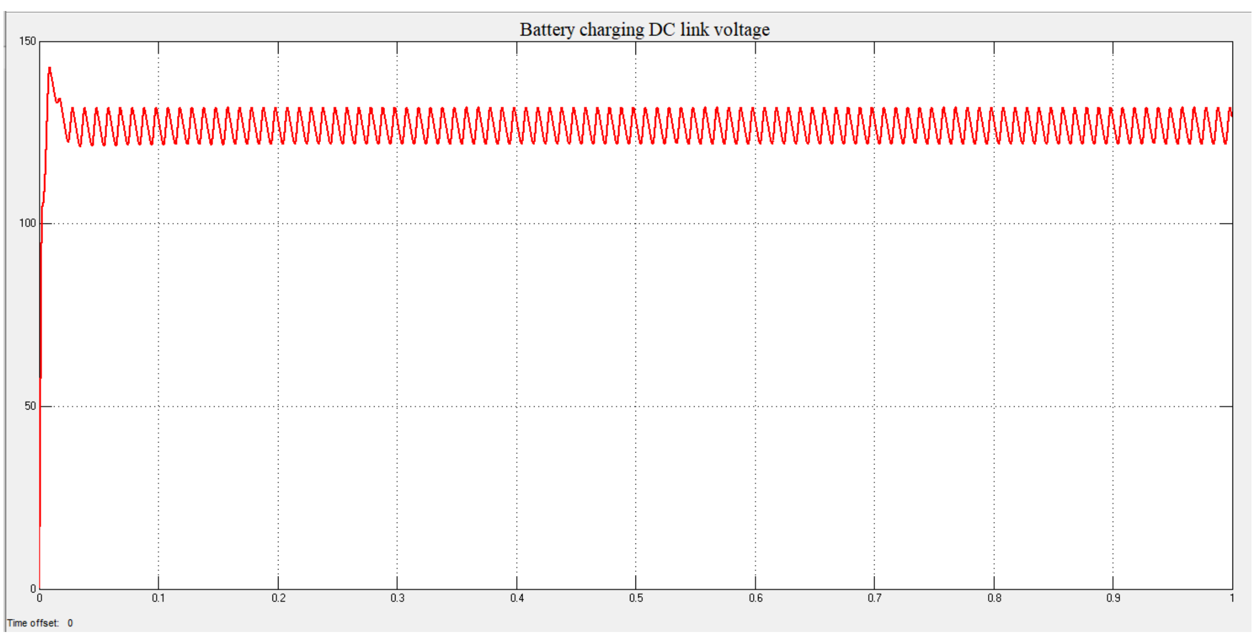
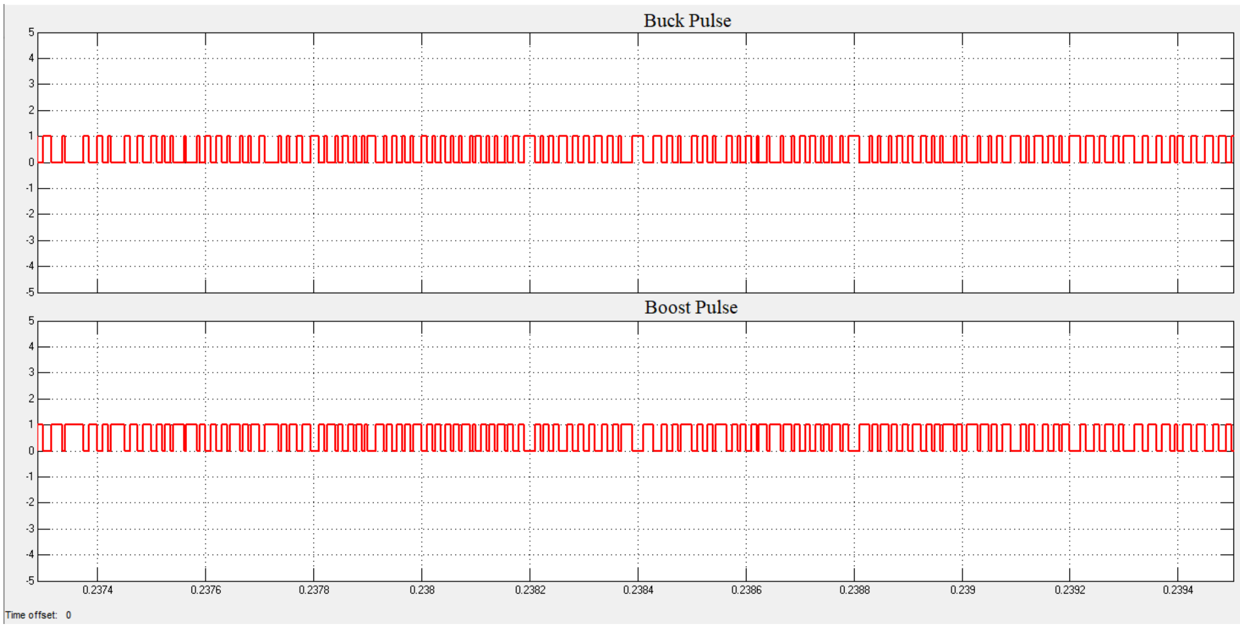


Figure 3.Battery Charging Grid Voltage and Grid Non-Linear Current

In the simulation, the battery is in charging mode, the grid voltage and non-linear current waveform is shown in figure 3. The single phase bridge rectifier circuit produces the non linear current. The aim of this paper is to change the non linear current to linear current in EV battery side by Instantaneous current control method[5].



(a)



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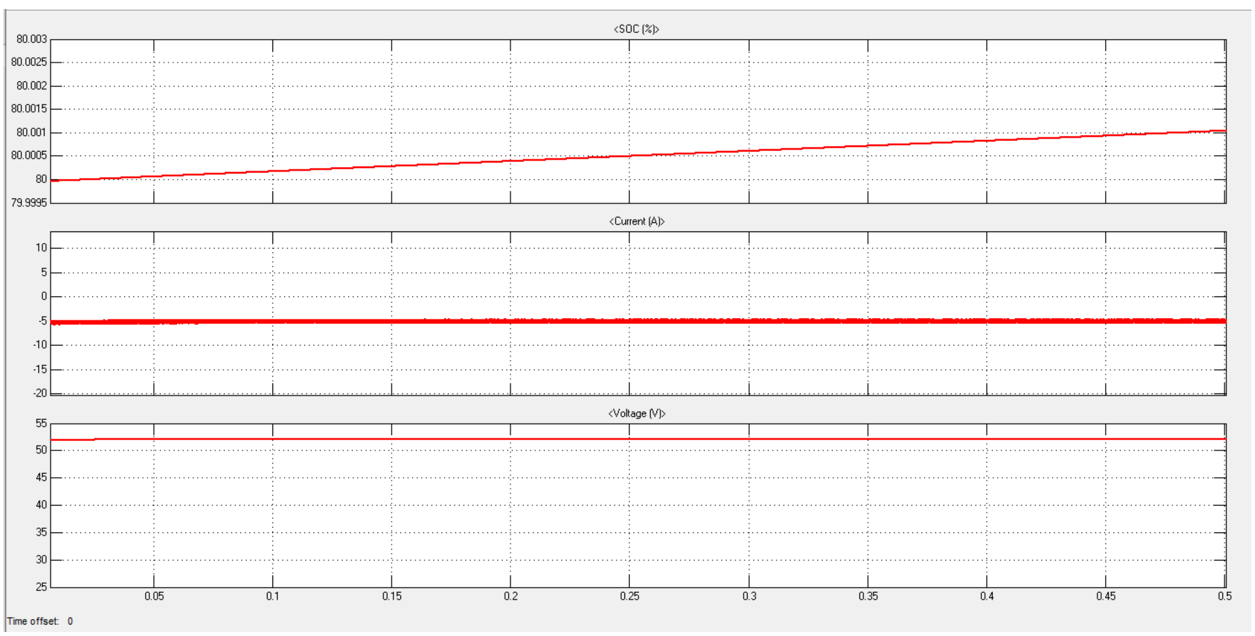


(c)

Figure.4: Battery charging –(a)DC Link Voltage (b)Bi-directional Converter Pulses (c)Battery Current, Voltage and SOC.

Single phase voltage source inverter and bidirectional buck boost converter are used in it. At the time of battery charging, VSI act as a controlled rectifier and bidirectional converter act as a buck converter. Battery charging DC link voltage is shown in figure 4. (a). In battery discharging period VSI act as a grid tied inverter and bidirectional converter act as a boost converter. Pulses of bi-directional converter switches when act as buck or boost converter mode is shown in figure4. (b). At SOC, battery voltage and current is shown in figure 4. (c).

Battery Charging Using Instantaneous Current Generation Method with IGBT Based VSI & Bidirectional Converter

In Grid to vehicle, the power is flow from source to battery. Normal bridge rectifier gives the AC to DC .grid current is non linear mode and this is decay the battery life. This drawback is overcome by using instantaneous current control method, to avoid the nonlinear current and increase the life span of battery[9-11]. In this method, DC-DC Bidirectional converter will act as a buck converter mode and by closed loop method the voltages is maintained as per reference level[4]. At the time battery is charging, the current direction is changed from positive to negative. We know the result of battery is charging and discharging by current level. This paper deals with battery charging and discharging with improved power quality of single phase grid and no need of PV source also.

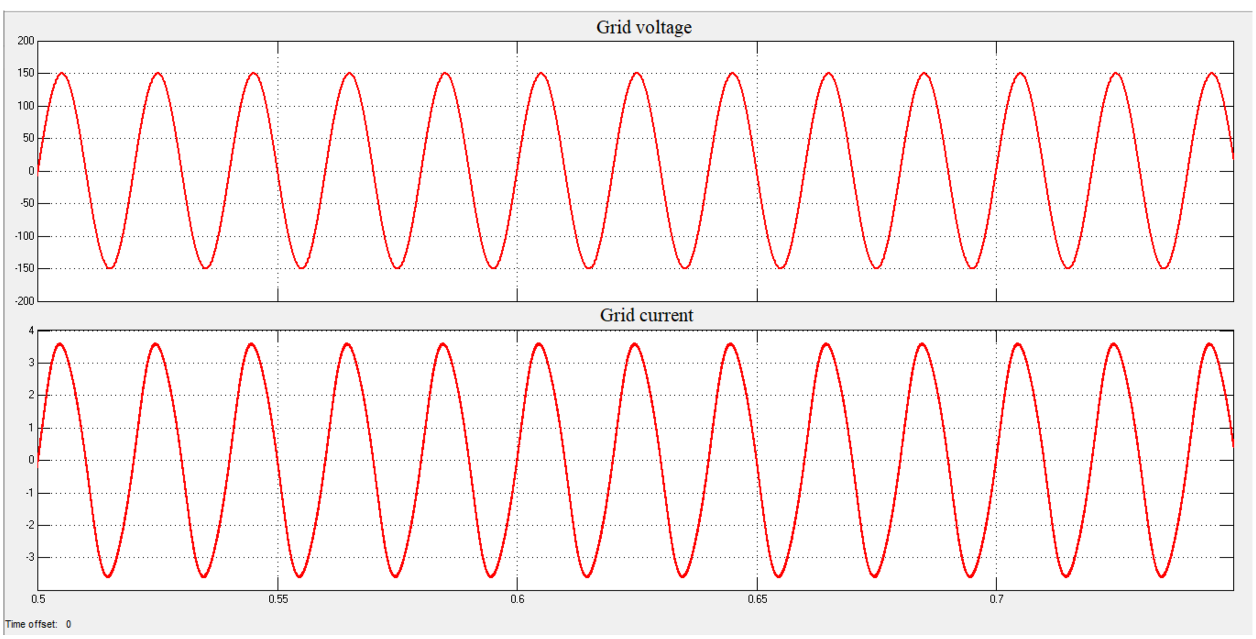
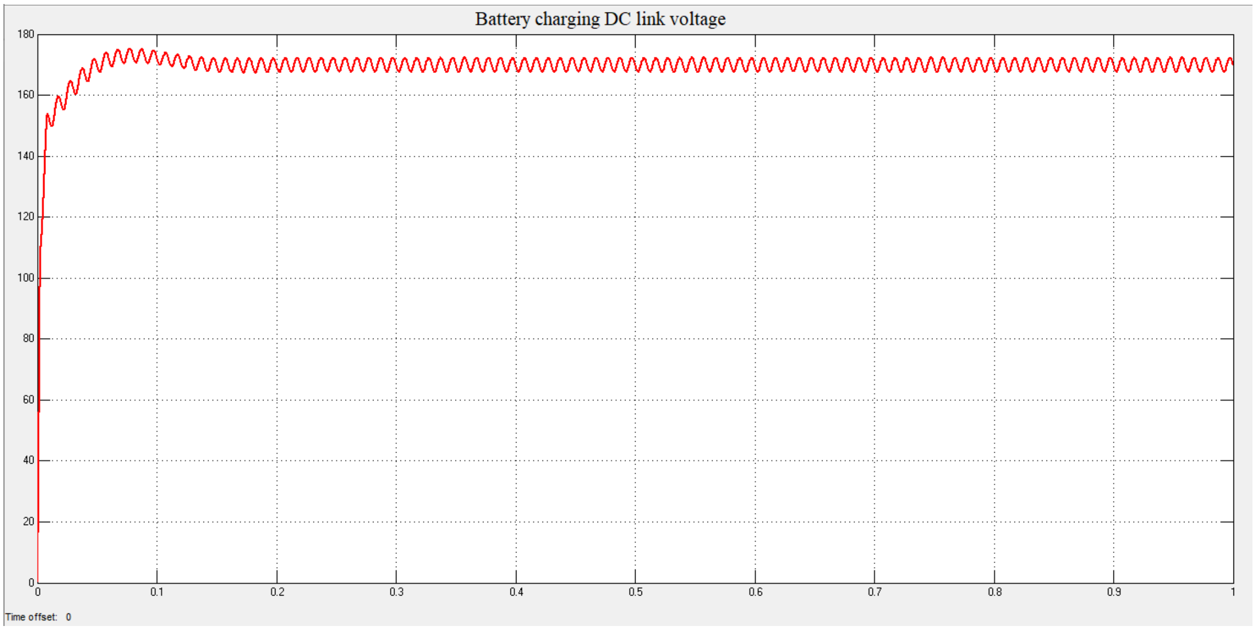
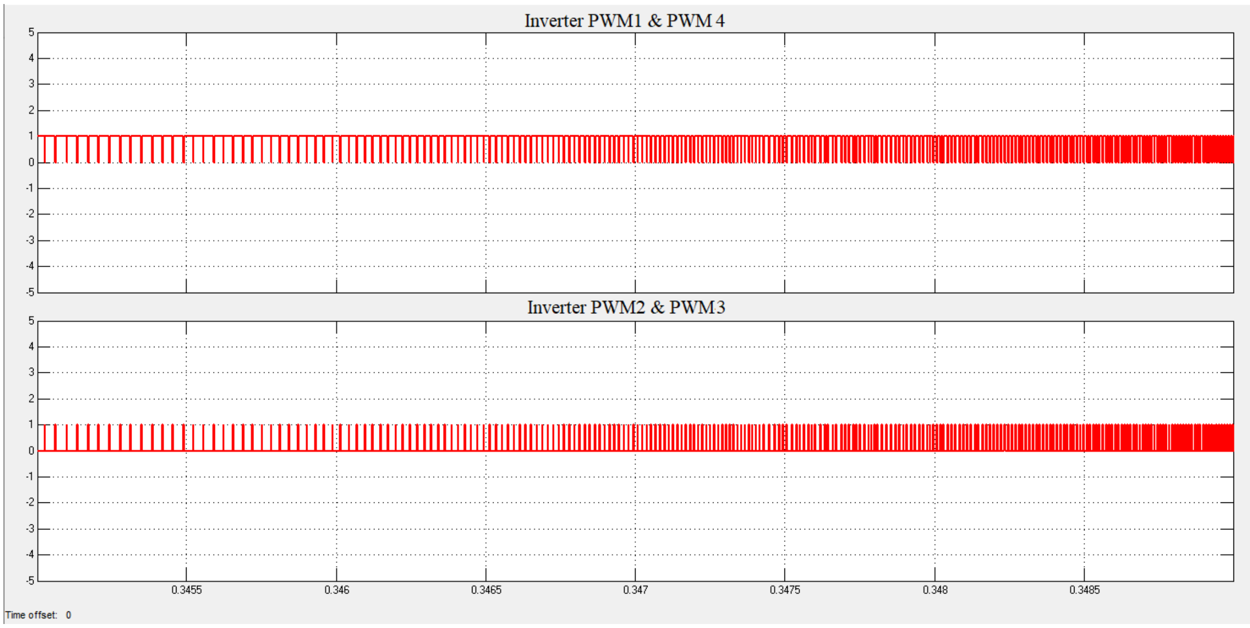


Figure 5(a). Battery Charging Grid Voltage and Linear Current

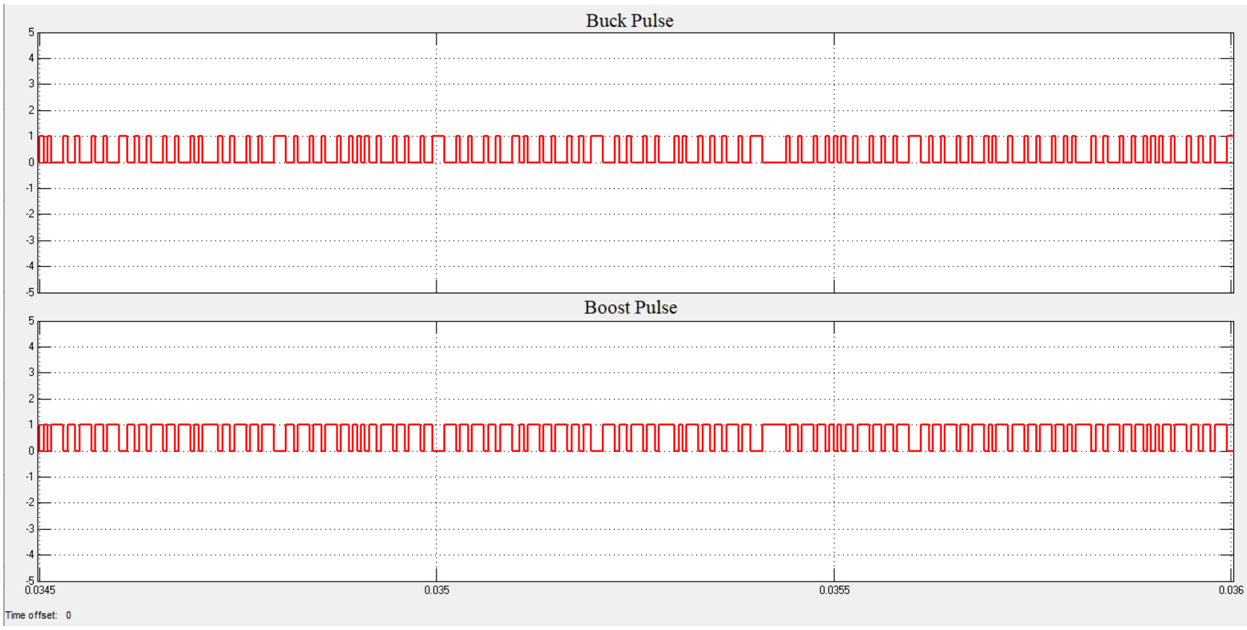
In this simulation result, the battery is in charging mode grid voltage and linear current waveform is shown in figure 5(a).



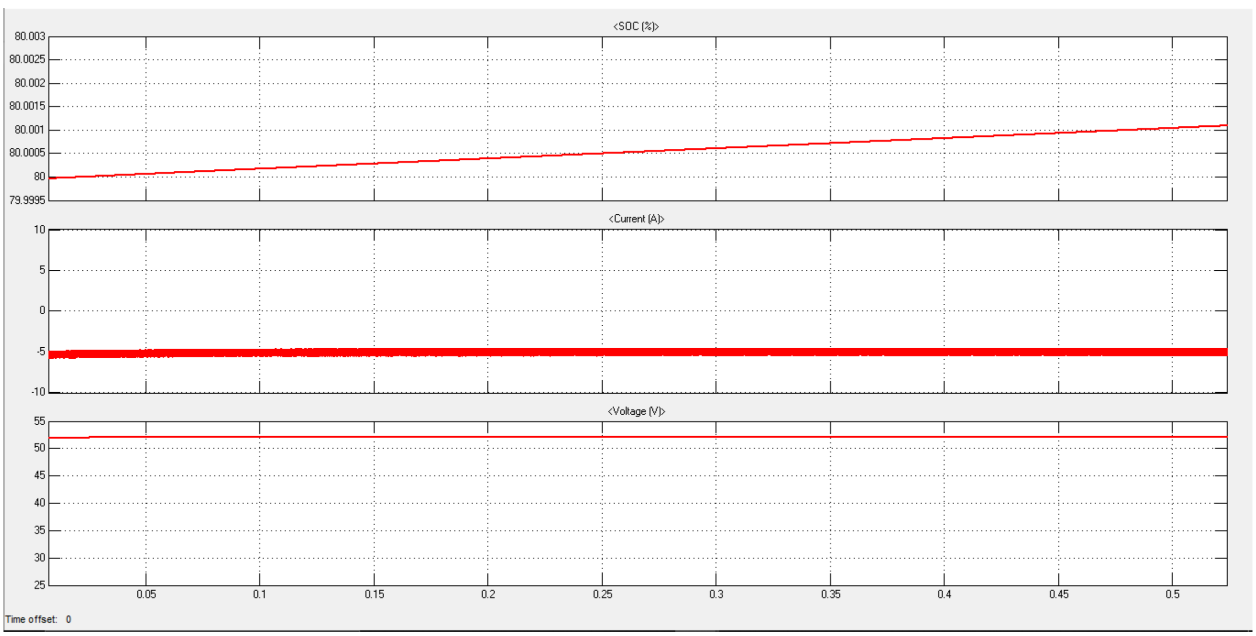
(b)



(c)



(d)



(e)

Figure.5: Battery charging using instantaneous current generation method –(b)DC Link Voltage (c)Inverter Pulses (d)Bi-directional Converter Pulses (e)Battery Current, Voltage and SOC

At the time of battery charging using instantaneous current generation method, the grid voltage and current is shown in figure 5(a), Battery charging DC Link Voltage is shown in figure 5(b). Bidirectional converter switching pulses are shown in figure 5(d) and at battery charging mode, inverter pulses are shown in figure 5(c) finally the voltage and current waveform of SOC time is shown in figure 5(e).

BATTERY DISCHARGING USING INSTANTANEOUS CURRENT GENERATION METHOD USING IGBT BASED VSI & BIDIRECTIONAL CONVERTER

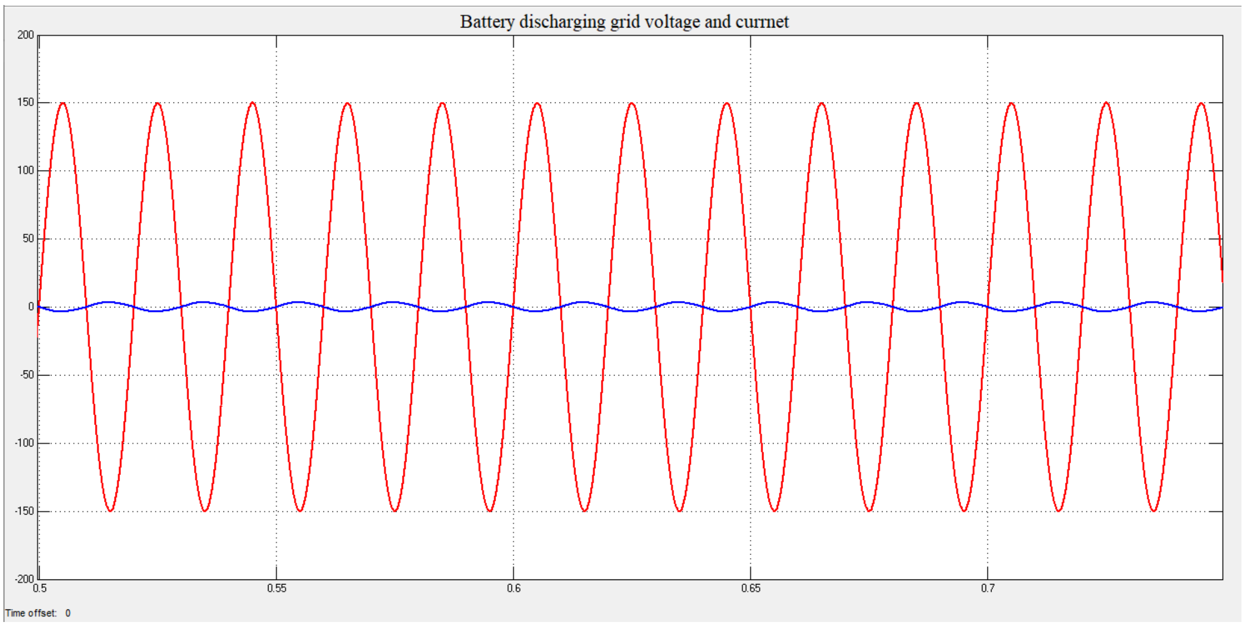


Figure 6 (a). Battery Discharging Grid Voltage and Current

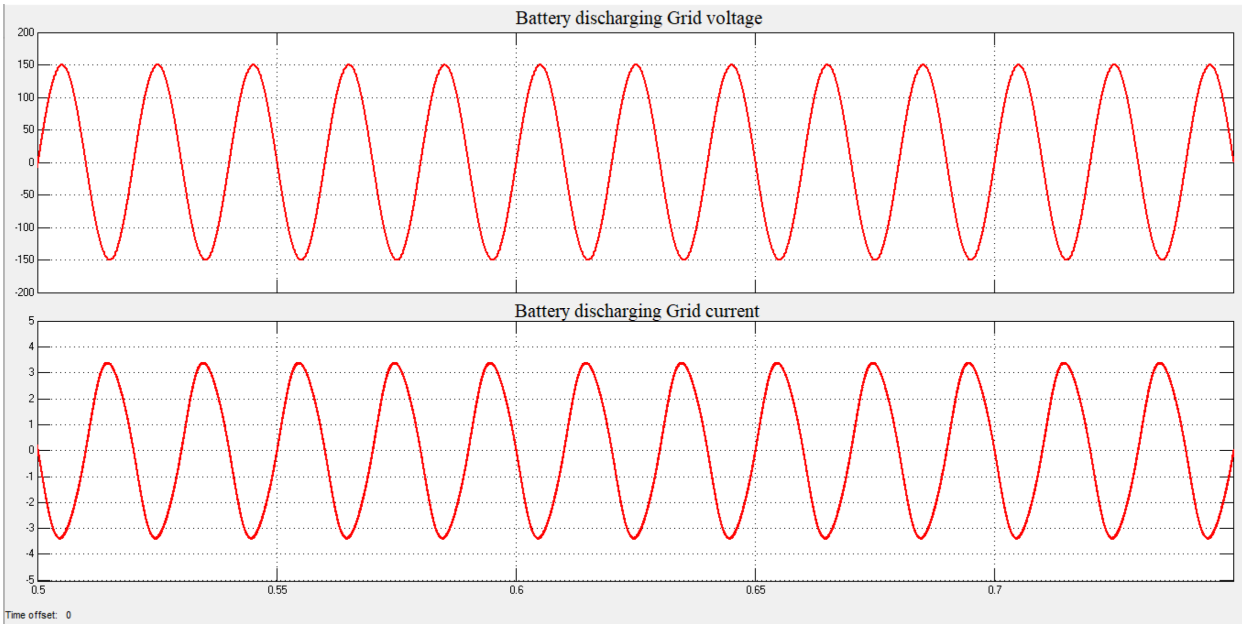


Figure 6(b). Grid Voltage and Current

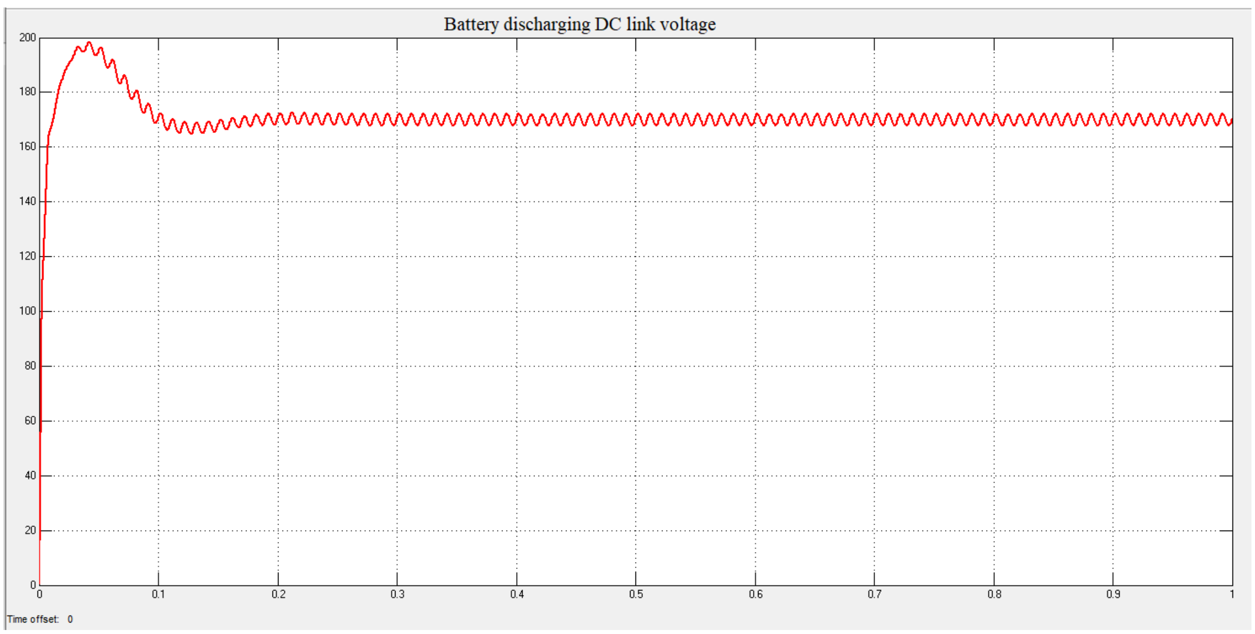


Figure 6 (c). Battery Discharging DC Link Voltage

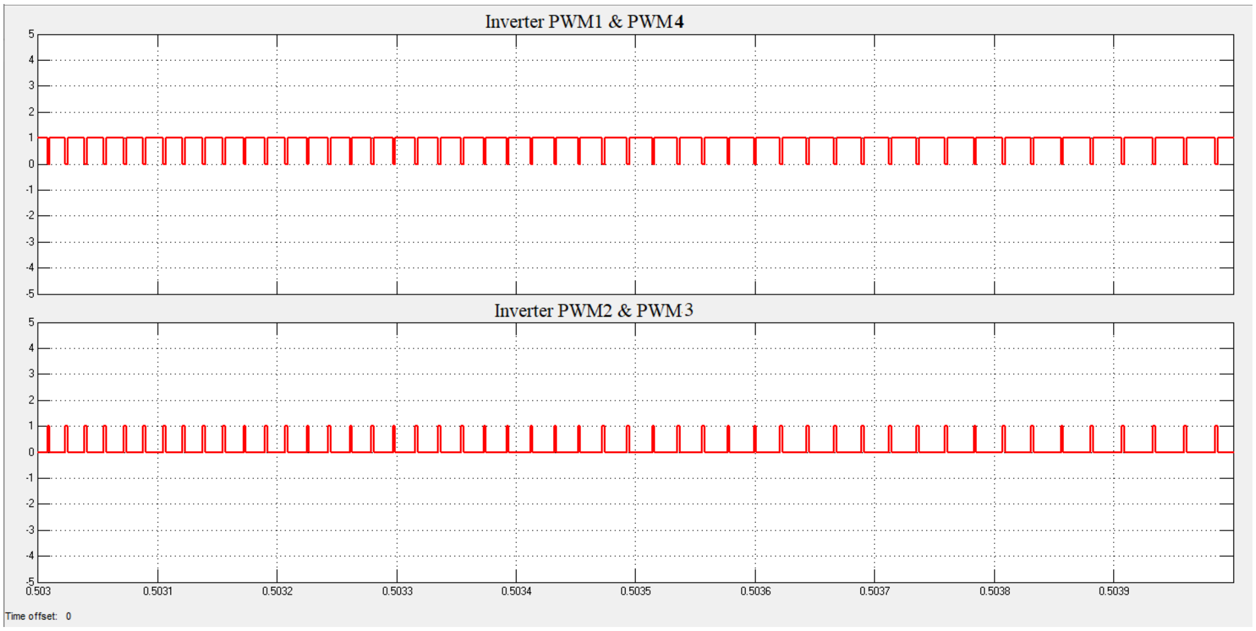


Figure 6 (d). Inverter PWM

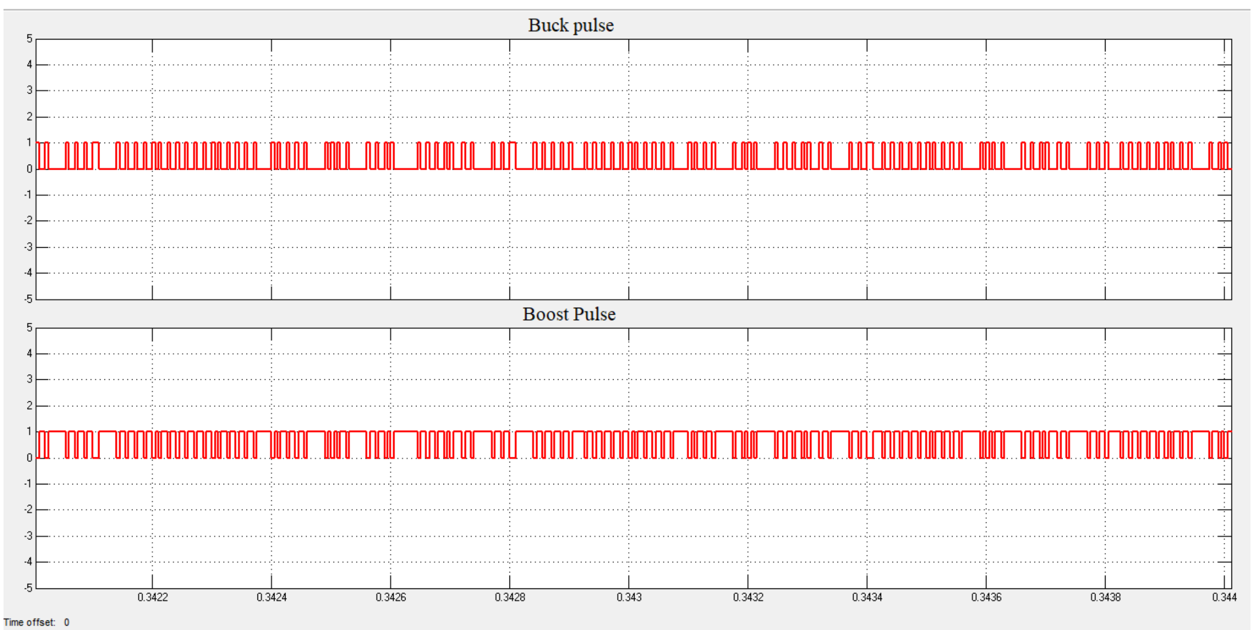


Figure 6(e). Bi-Directional Pulses

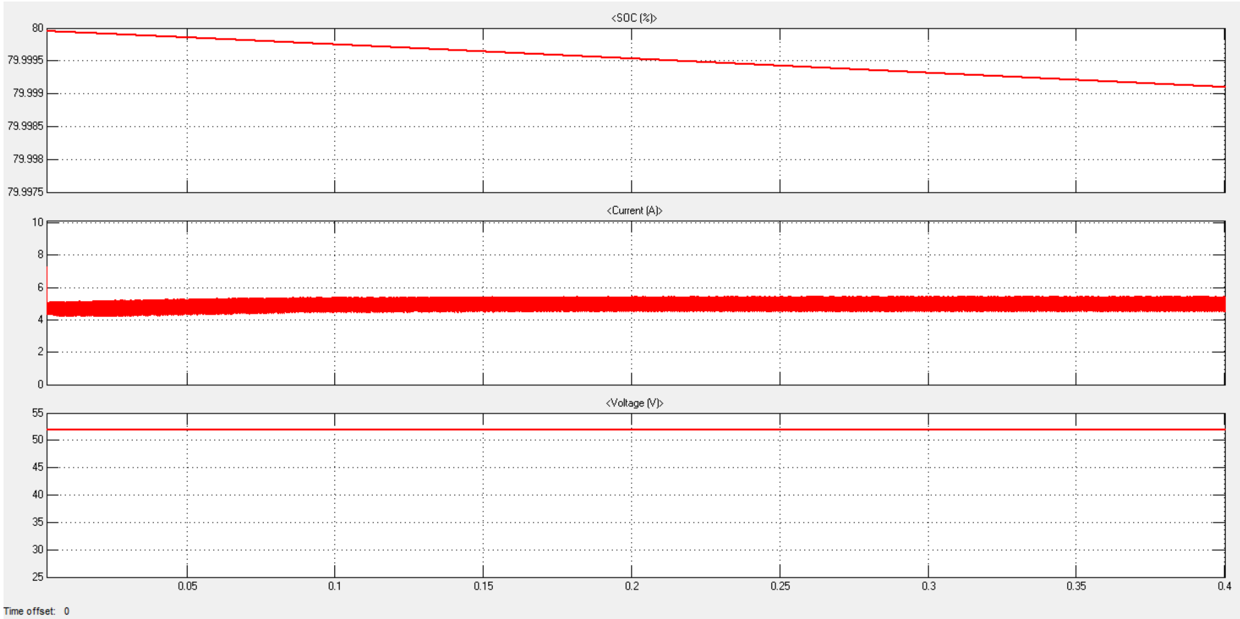


Figure 6 (f). Battery Discharging Current, Voltage & SOC

At the time of battery discharging using instantaneous current generation method, Battery Discharging Grid Voltage and Current is shown in figure 6(a), the grid voltage and current is shown in figure 6(b), Battery Discharging DC Link Voltage is shown in figure 6(c). Bidirectional converter switching pulses are shown in figure 6(e) and At battery discharging mode, inverter pulses are shown in figure 6(d) finally the voltage and current waveform of SOC time is shown in figure 6(f).

Conclusion

The distortion and fluctuation created by the charging process of electric vehicles connected to intermittent new energy fields will reduce the life of their chargers and batteries, while, at the same time, it will affect the accuracy of their electric energy meters. By introducing the instantaneous current generation method, we can reduce the impact of these factors. The simulation results were reduce the THD by these results improved the power quality.The EV charging station has been intended with the capability of synchronizing to the grid and to earn profits by selling power by discharging EV batteries to the grid during peak hours.

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