Design, Modeling and Simulation of an Electric Vehicle (EV) Charging Station for Fast DC Charging

Abstract

This work presents a smart compactible integration of EV with the distribution grid assuring a quality power. Charging station is the place where an EV integrates with the grid. In this study, work is done for a level 3 off-board EV charging infrastructure that can employ multiple EVs which will alleviate the down-time required for vehicle charging. There is a master control to deal with the power exchange between the AC and DC bus (AC-DC Converter Control). The control of individual EV is de-centralized (DC-DC Converter Control). The work looks into two different aspects of EV integration to grid a) Grid to Vehicle mode-G2V (EV charging), b) Vehicle to Grid Mode-V2G (EV discharging Mode). Simulation platform is MATLAB (Matrix Laboratory). Results show the feasibility of the proposed model during grid integration.

Index Terms: Electric Vehicle (EV), Vehicle-to-Grid (V2G), MATLAB/Simulink, Constant Current (CC) and Constant Voltage (CV).

Simulation Results

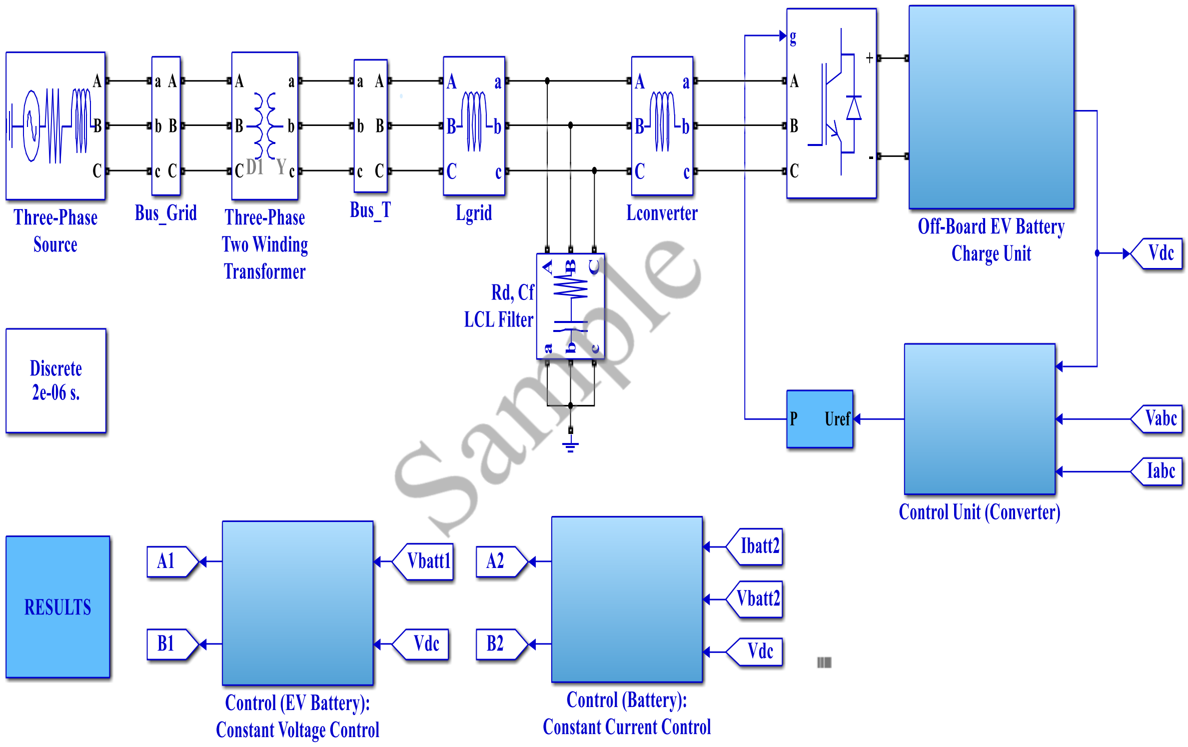

Fig.: MATLAB/Simulink based model of EV charging station (constant voltage control).

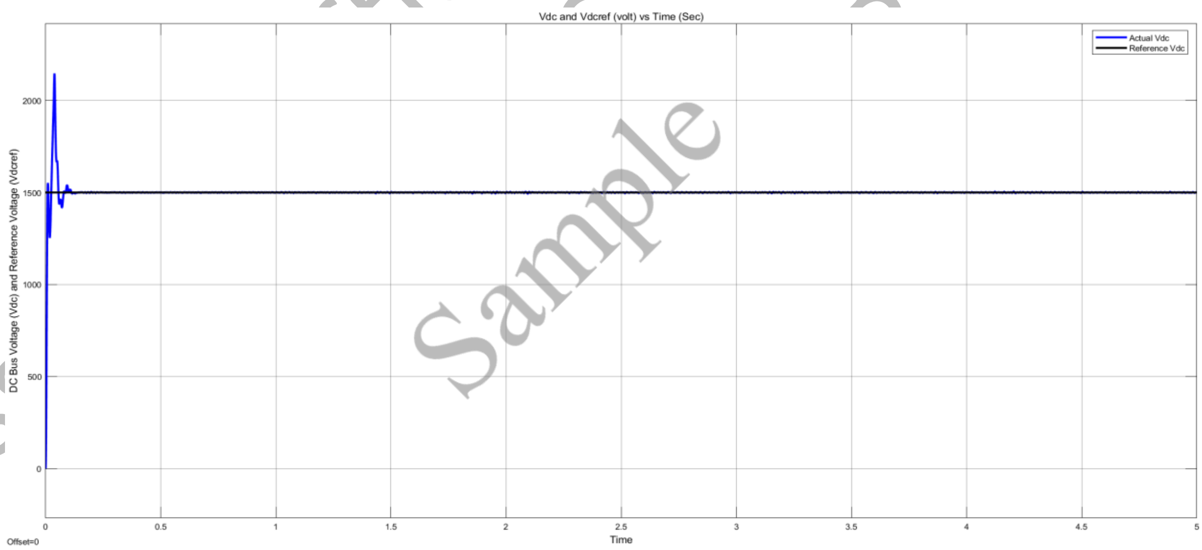

Fig. : DC bus voltage during charging

by constant voltage control method.

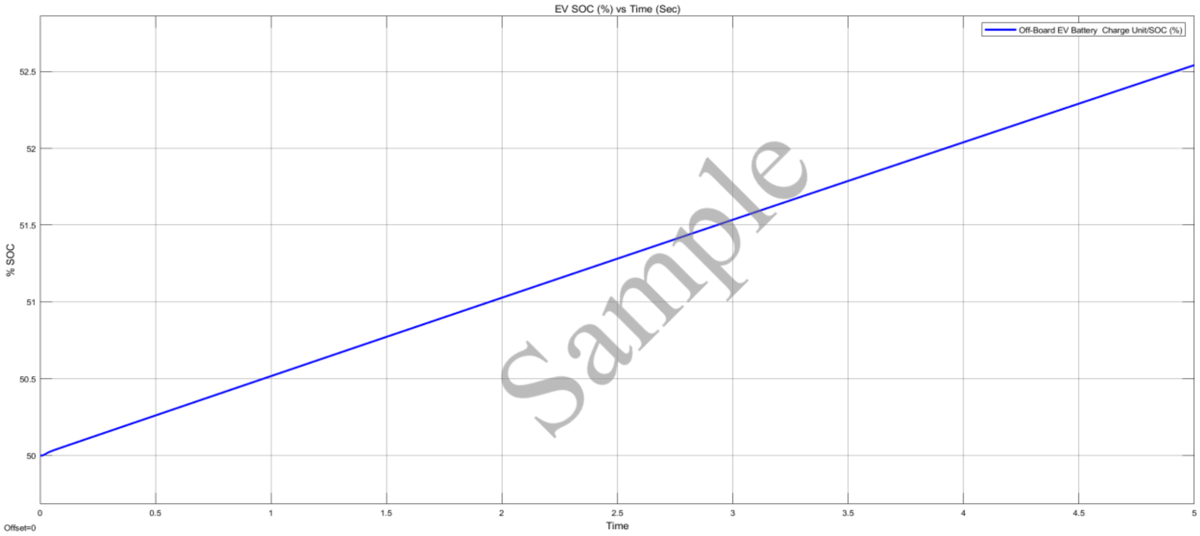

Fig. : EV battery state of charge during charging by constant voltage control method.

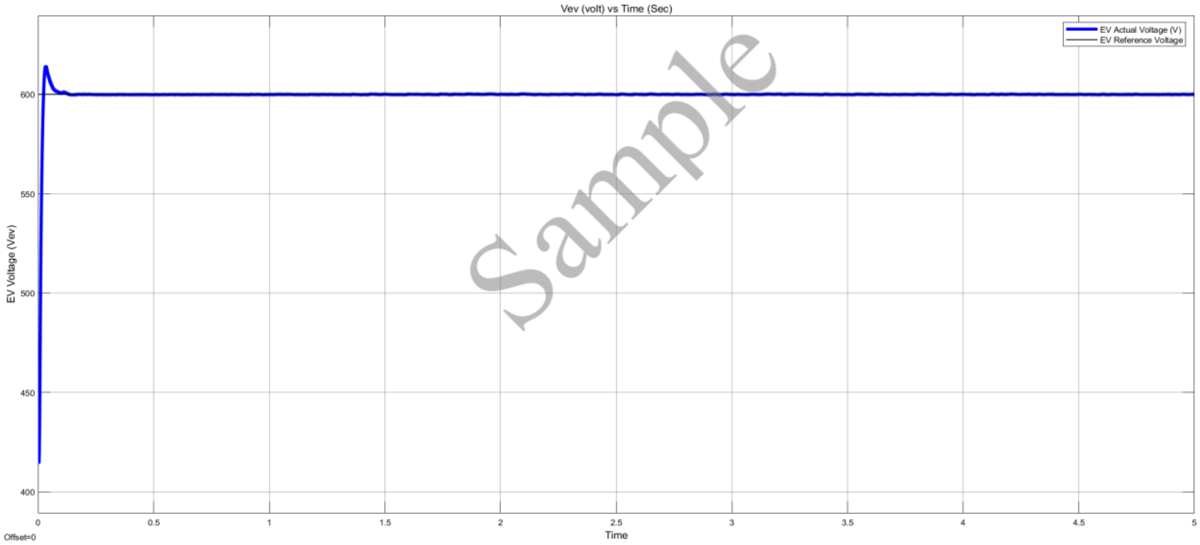

Fig. : EV battery voltage during charging by constant voltage control method.

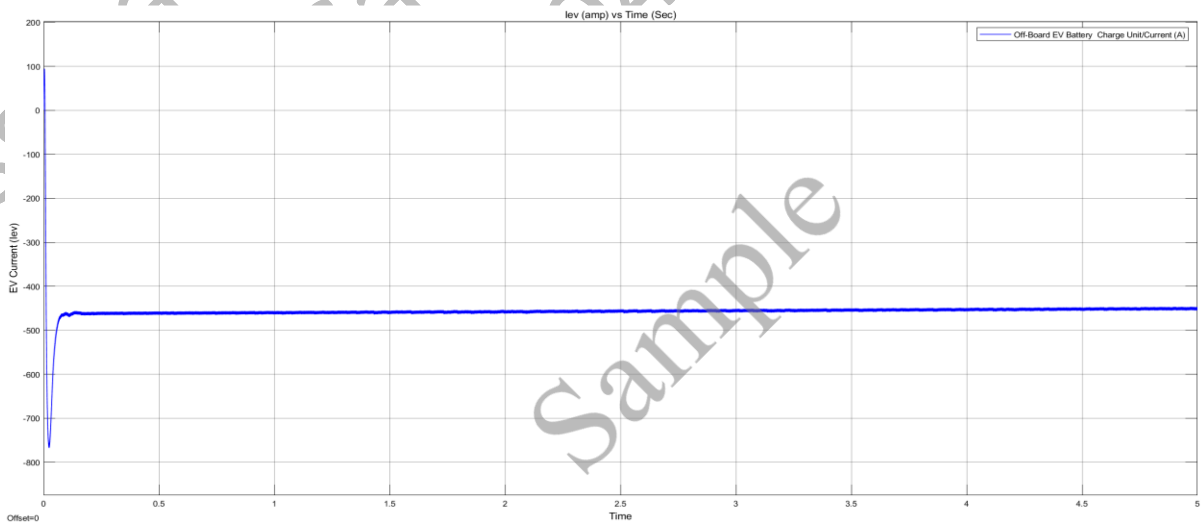

Fig. : EV battery current during charging by constant voltage control method.

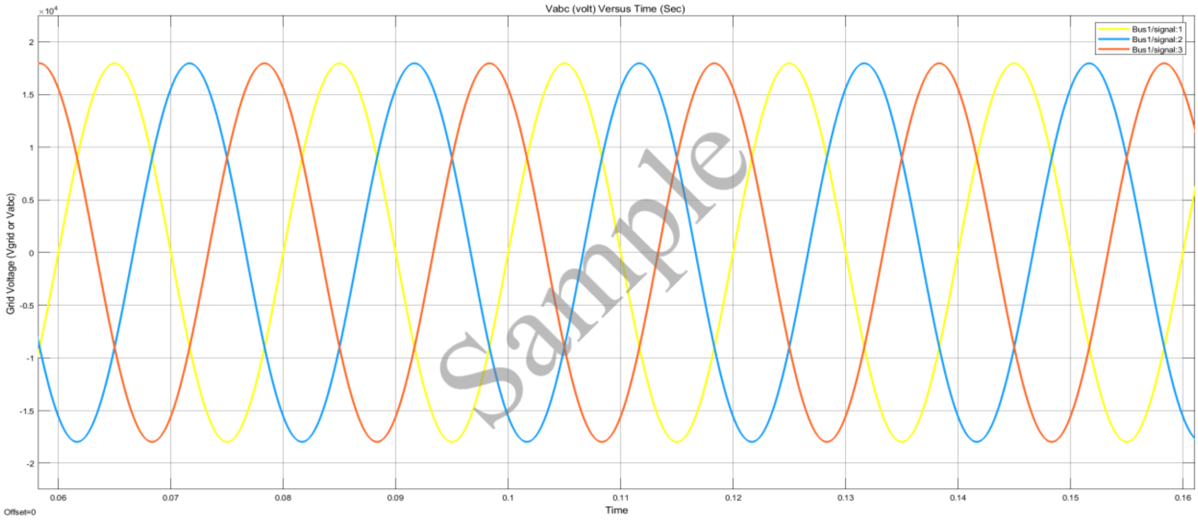

Fig. : Supply side (Vgrid/Vabc) voltage.

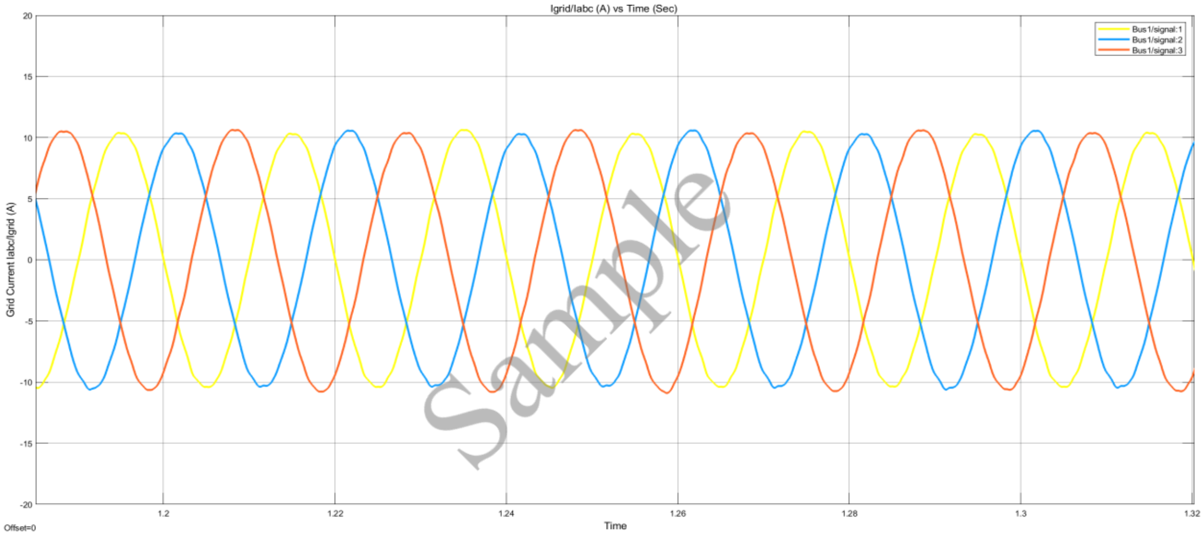

Fig. : Supply side (grid) current.

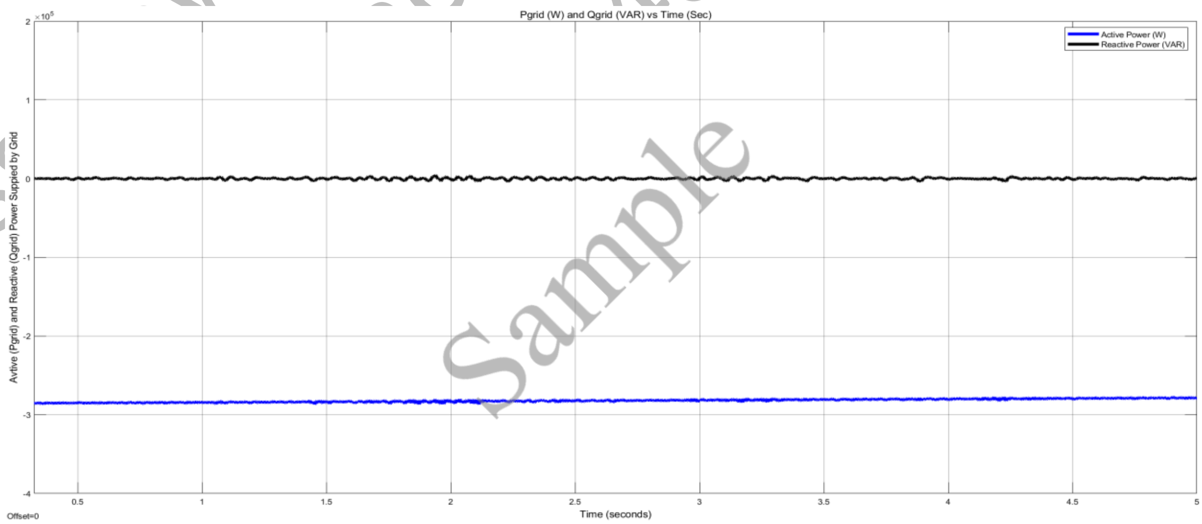

Fig. : Active and reactive power supplied by grid during charging.

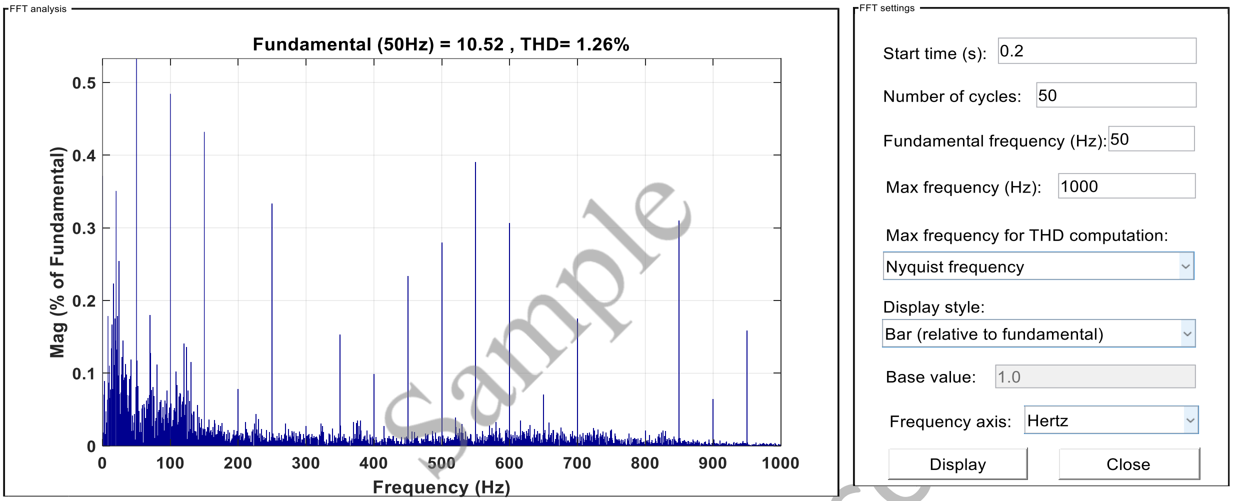

Fig.: Fast Fourier Transform (FFT) analysis and Total Harmonic Distortion (THD) value during charging by constant voltage control method.

Case 2: EV Discharging Mode (V2G operation)

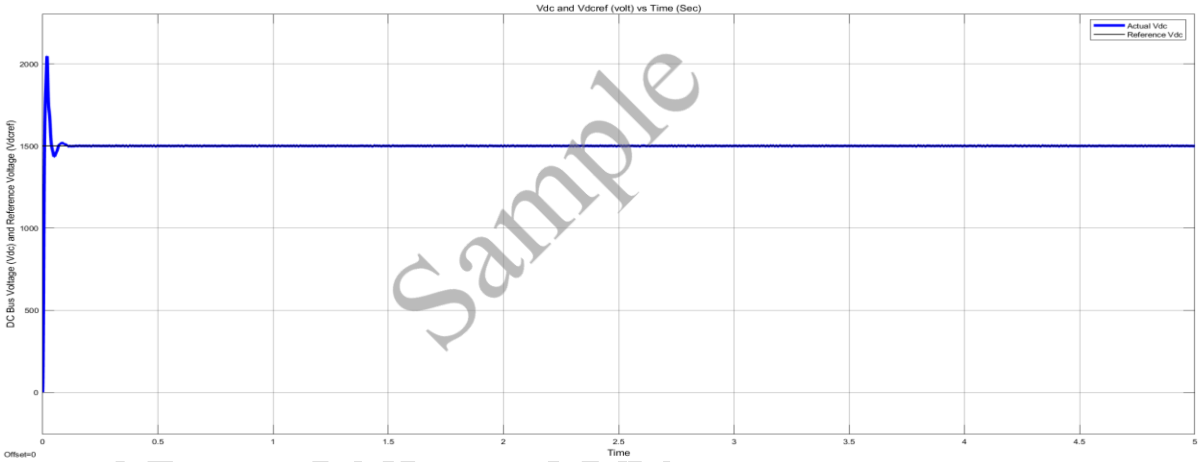

Fig. : DC bus voltage during discharging by constant current control method.

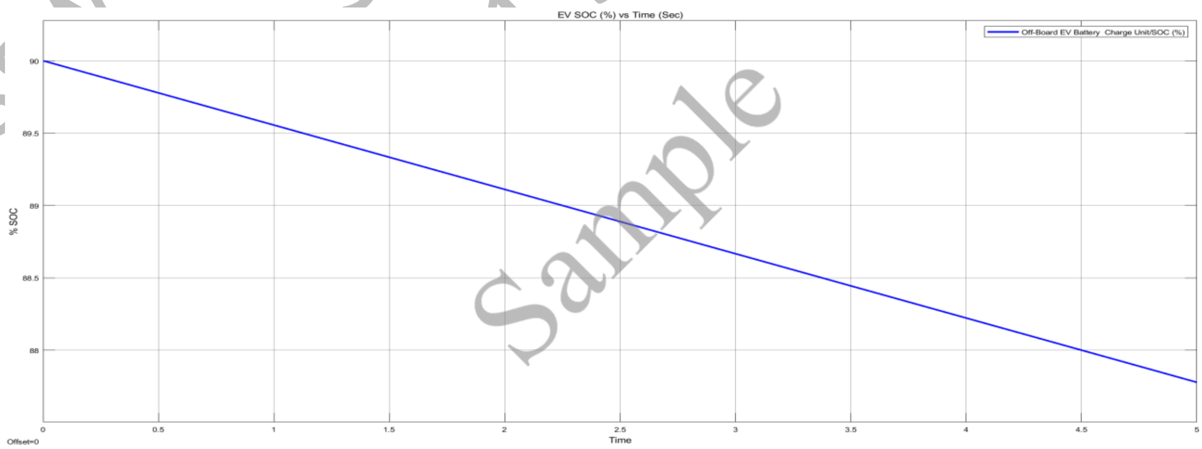

Fig. : EV battery state of charge during discharging by constant current control method.

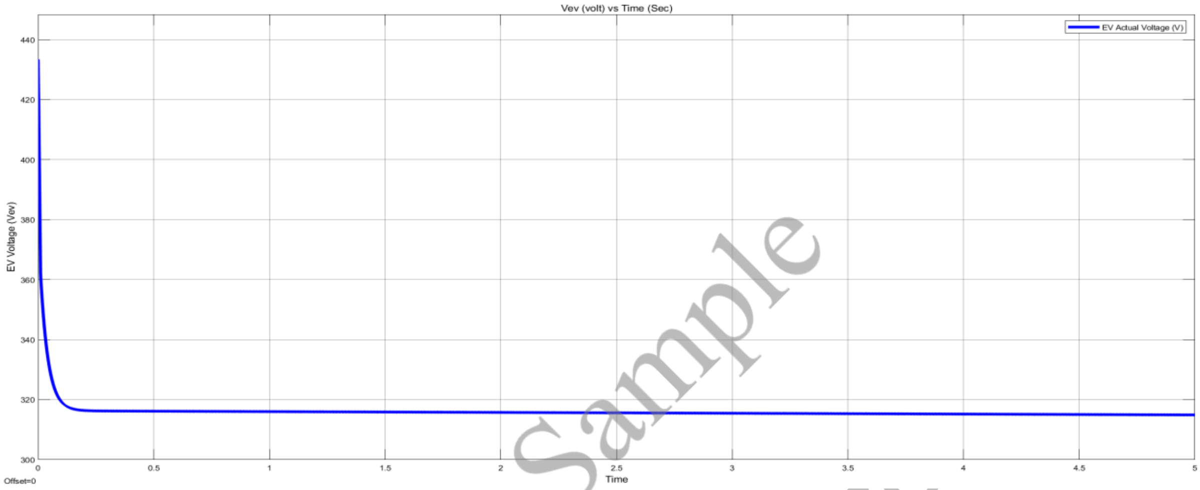

Fig. : EV battery voltage during discharging by constant current control method.

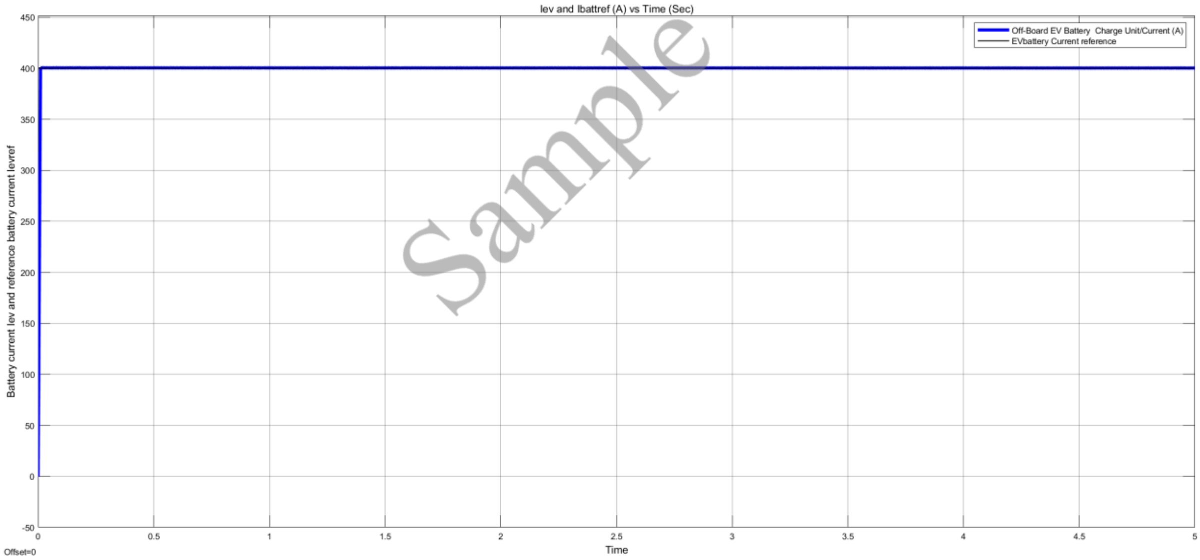

Fig. : EV battery current during discharging by constant current control method.

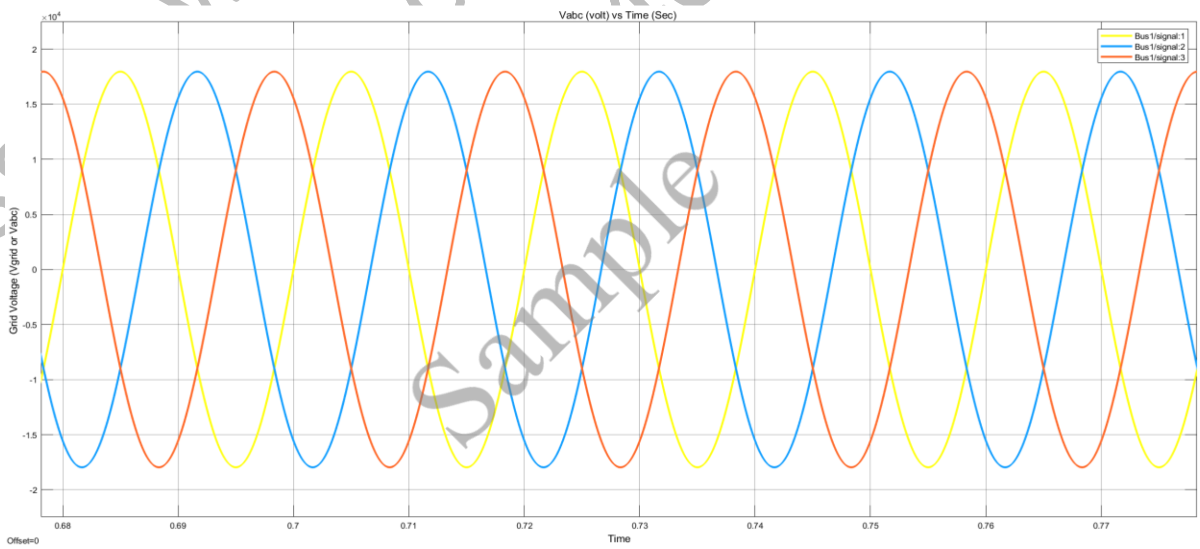

Fig. : Supply side (grid) voltage.

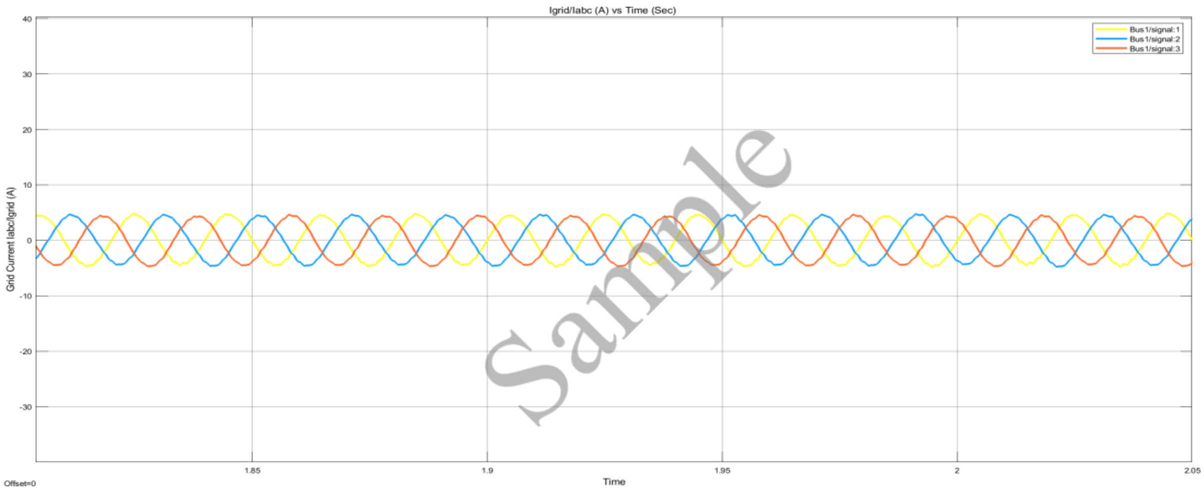

Fig. : Supply side (grid) current.

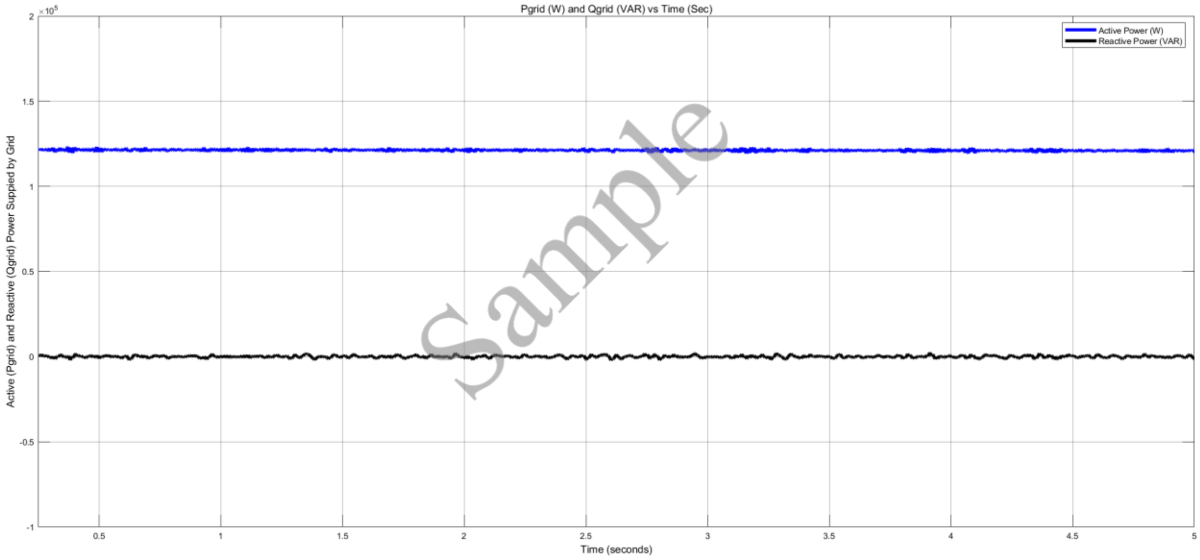

Fig. : Active and reactive power supplied by grid during discharging.

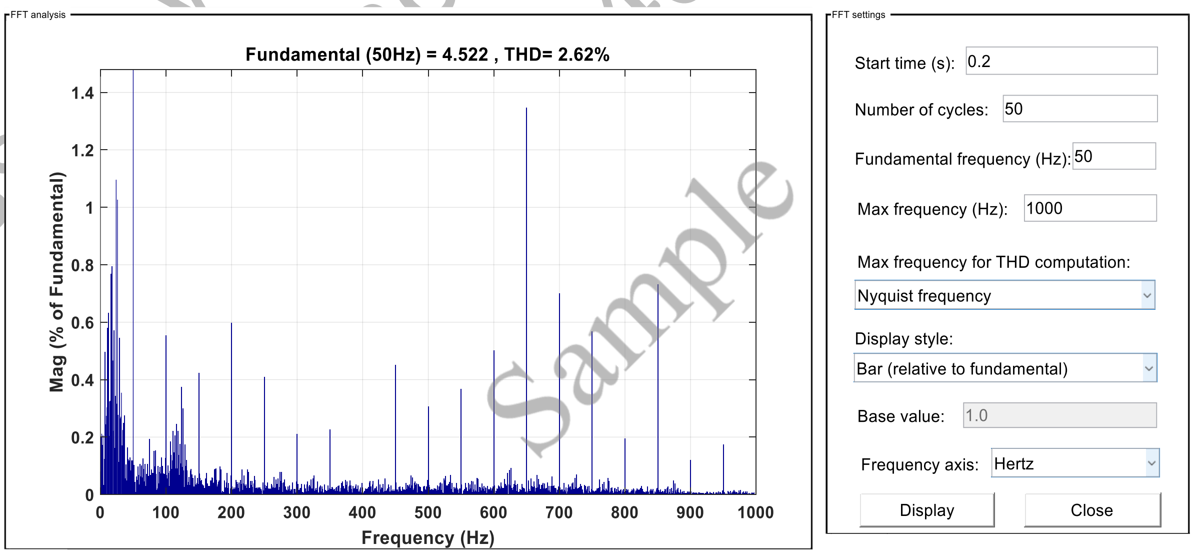

Fig. : FFT analysis and THD value during discharging by constant current control method.

Conclusion

In this report, the design, model and simulation results of a model for integrating EVs to the distribution grid assuring the quality power has been proposed. The modeling of each part is proposed along-with their related parameters. Also, the control systems are explained. The modeling procedure is explained in an educational way to allow future research and implementation in this area.

The practical implementation of the model in MATLAB/Simulink SimPowerSystems is also described, V2G mode and reactive power compensation are also considered in the charging station model. Simulation results provide the feasibility of charging and discharging of EV. EV integration to the power grid will limit the harmonic distortion sufficiently in this case. It is advantageous that when the EV is connected to the charging system, the electric power distribution grid can also be provided with auxiliary services. Model created in MATLAB/ Simulink for integrating EVs with electric grid and utilities achieves the objectives. From results obtained, it is deduced that EV batteries are charging and discharging as per utility requirement, as well as, EV owners' desire.

References:

[1] Arnaldo Arancibia and Kai Strunz, "Modeling of an electric vehicle charging station for fast DC charging," in *IEEE International Electric Vehicle Conference*, 2012, pp. 1-6.

[2] Polly Thomas, Fossy Mary Chacko, "Electric Vehicle Integration to Distribution Grid Ensuring Quality Power Exchange", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), Vol. 2, Special Issue, Dec 2013, pp. 403 – 412.