Design and Simulation of a Fast DC Electric Vehicle (EV) Recharging Station (V2G and G2V Mode) using MATLAB / Simulink

Abstract

The presented model of the charging system is considered for ultra-fast direct current (DC) charging of many electric vehicles. Components suitable for working at high voltages and currents are required and to be characterized by considerable dimensions. The location of these charging systems is outside the vehicle that is off-board. These systems are advantageous in the sense that the charging time is reduced and vehicle space is reduced which gives a margin to use more powerful batteries. A charging station design and modeling for fast DC recharging suitable for number of EVs is discussed. The station has a grid side inverter via DC bus with EVs connected. The charging station model was also designed to support vehicle-to-grid (V2G) and reactive power compensation. Each component is modeled and its parameters are tabulated. In addition, a control system is also included. MATLAB/Simulink SimPowerSystems tool is used to model and simulated the system. State of charge, current and voltage of battery and DC bus voltage is monitored throughout the simulation to prove the effectiveness of proposed model and a smooth change to V2G mode is observed and compensation reactive power is also feasible.

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

Simulation Results

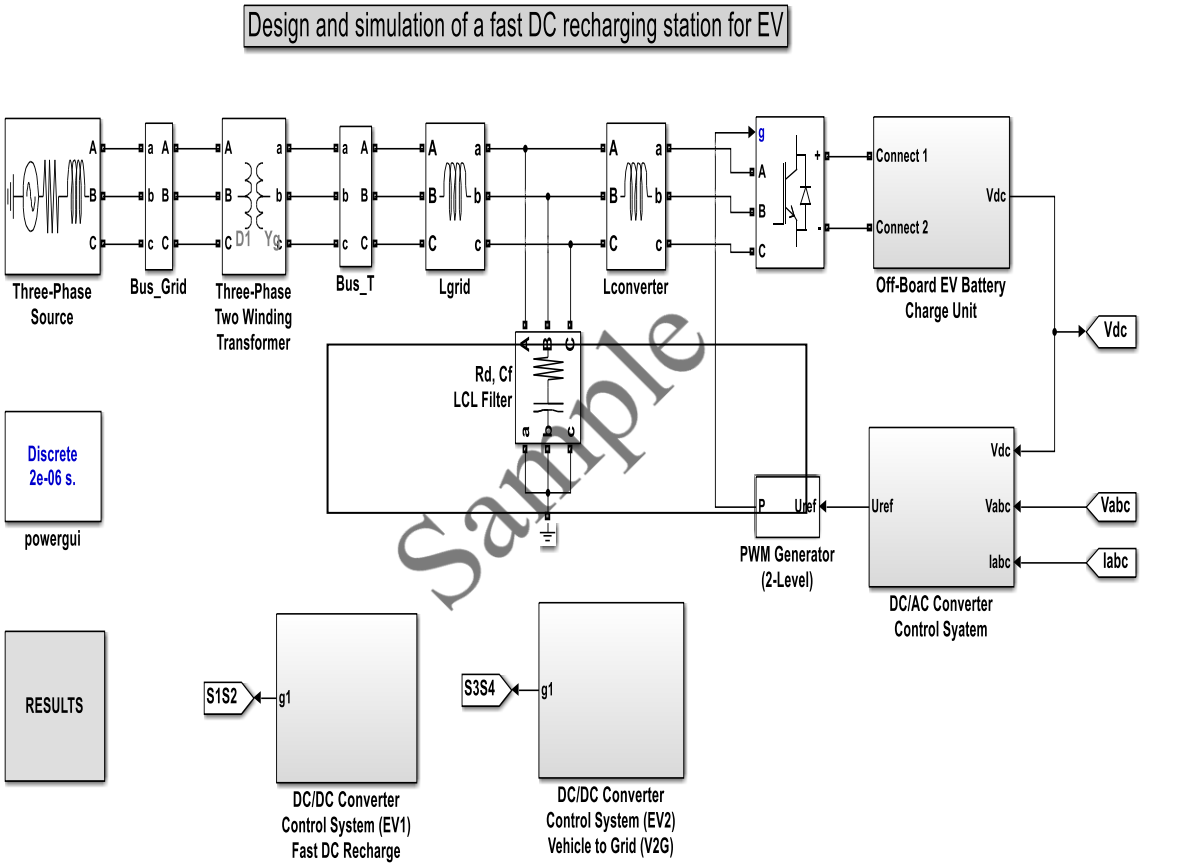

Figure: MATLAB/Simulink model of a fast DC recharging station for EV

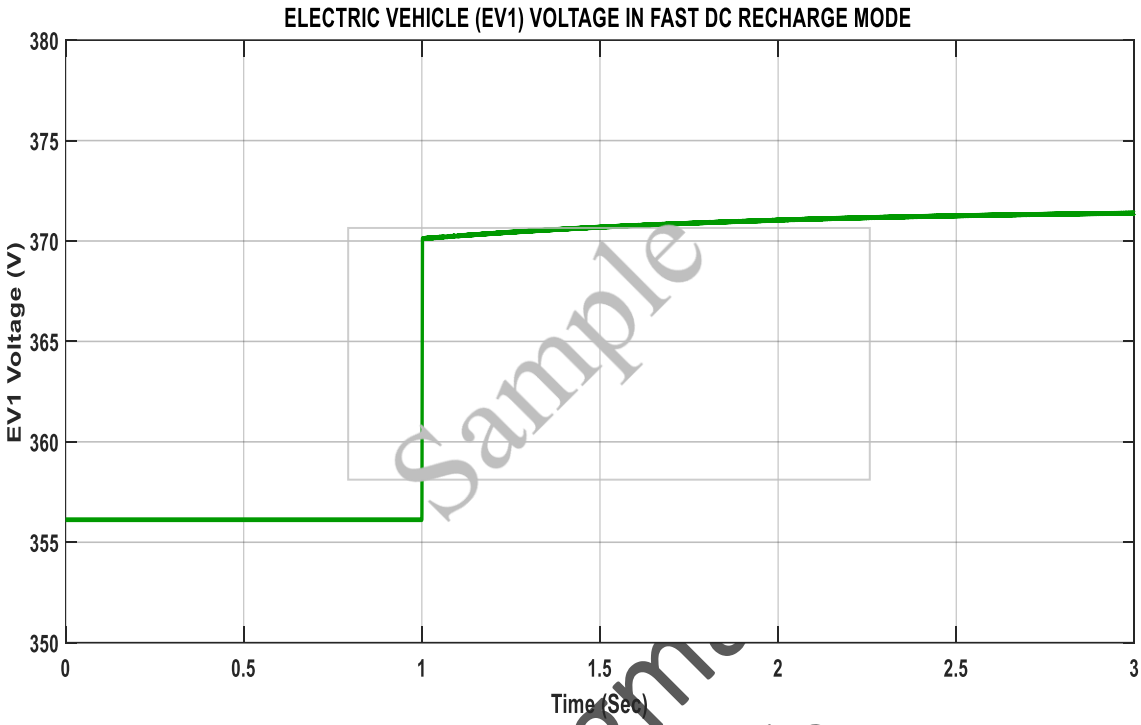

Figure: EV_1 voltage in fast DC recharge mode.

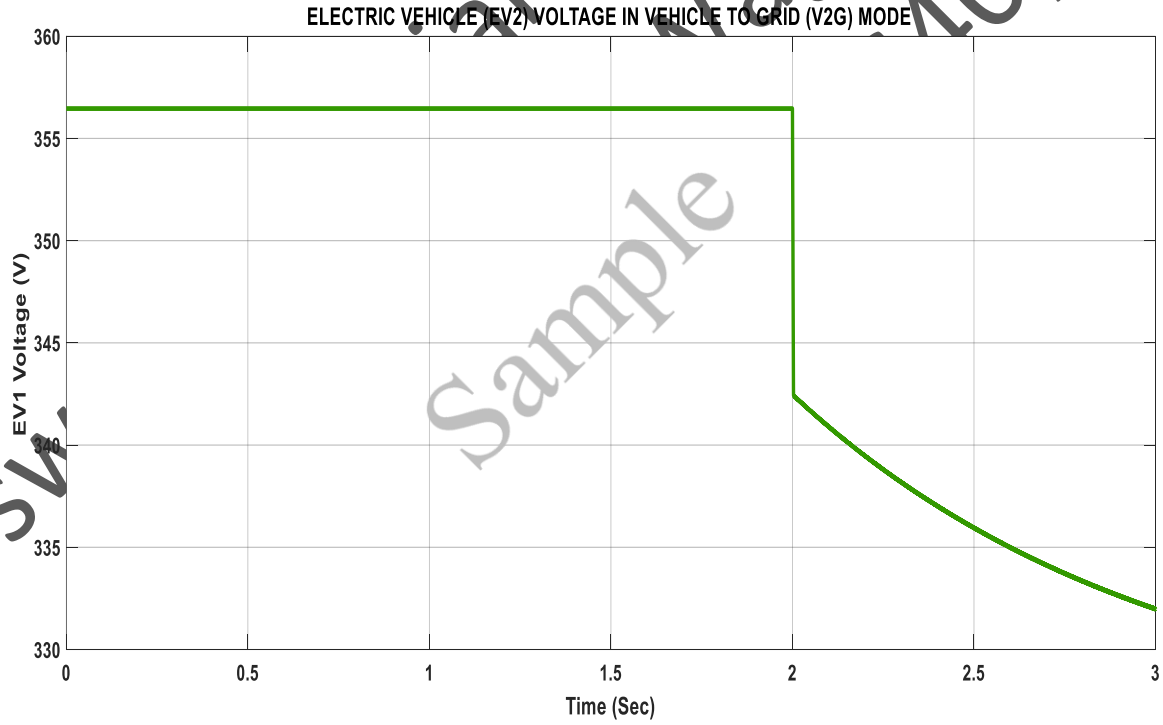

Figure: EV_2 voltage in V2G mode.

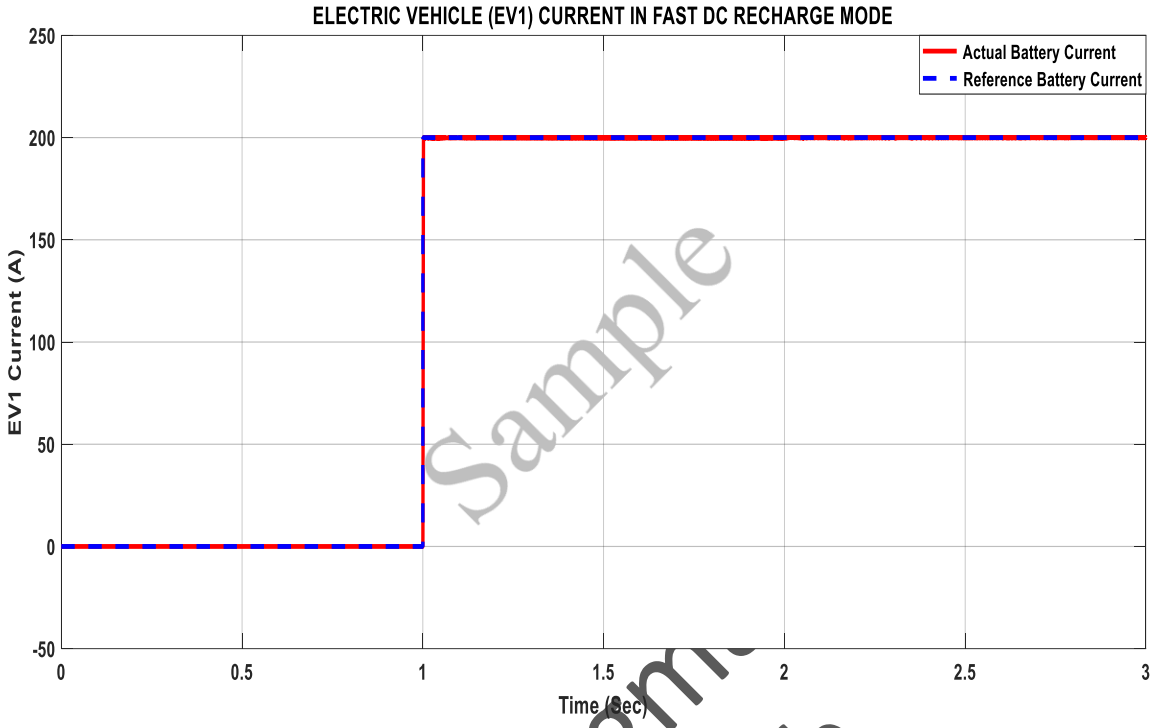

Figure: EV_1 current in fast DC recharge mode.

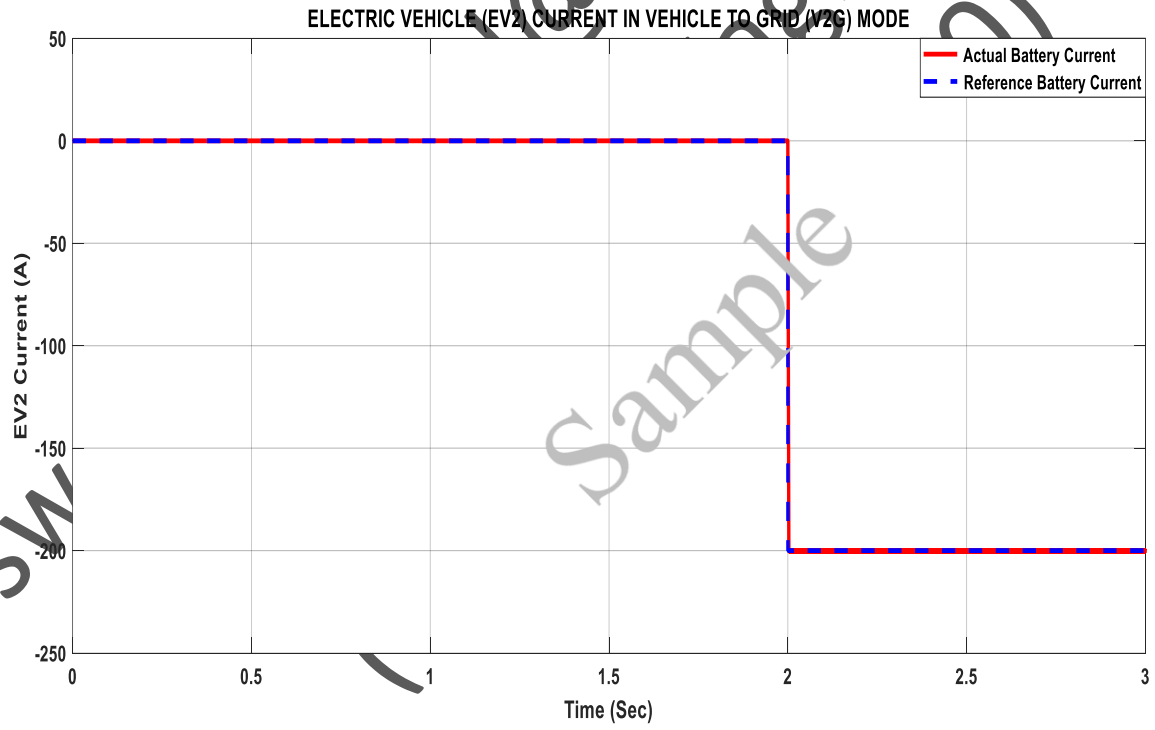

Figure: EV_2 current in V2G mode.

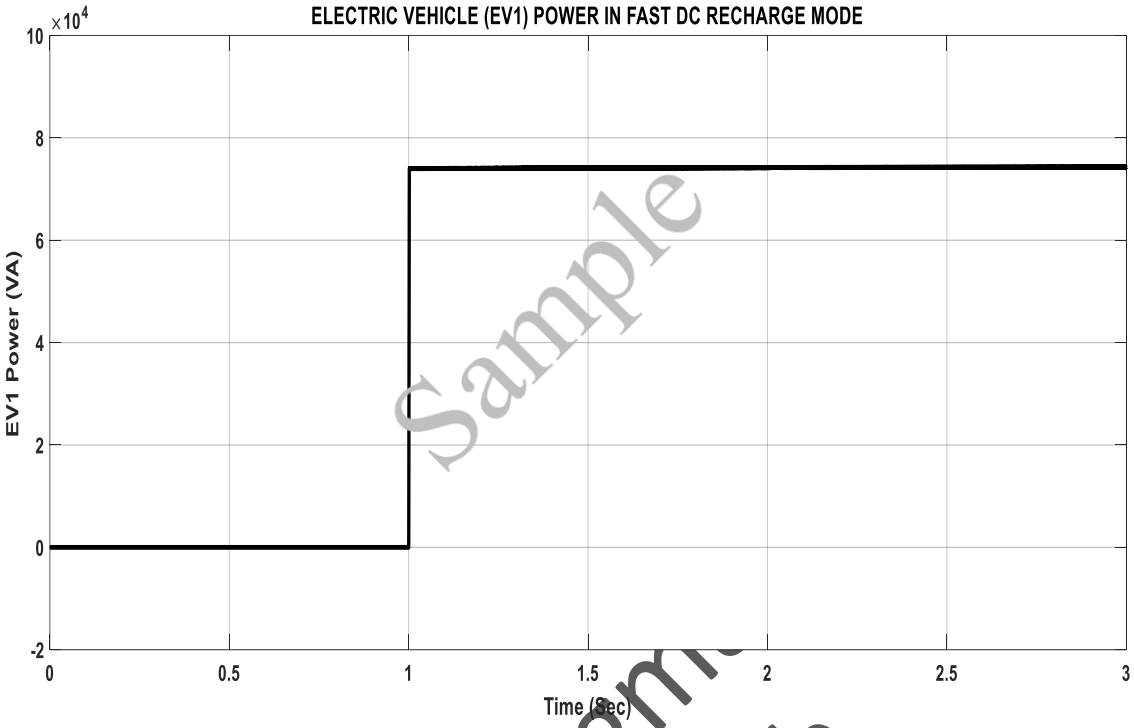

Figure: EV_1 power in fast DC recharge mode.

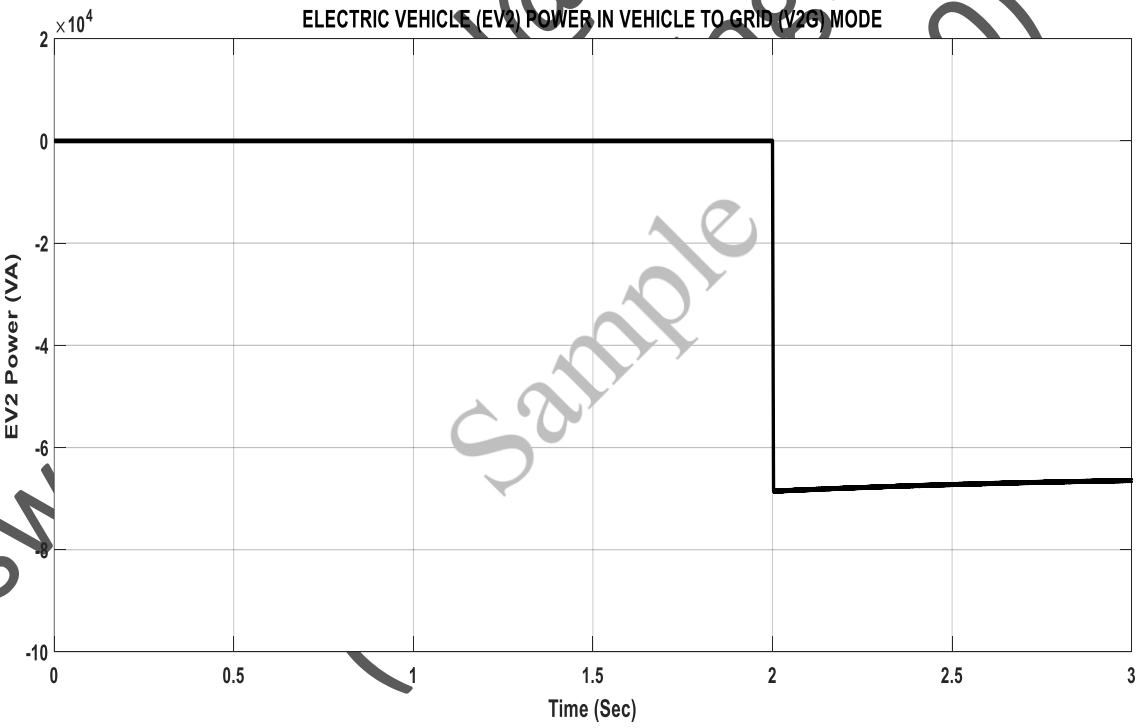

Figure: EV_2 power in V2G mode.

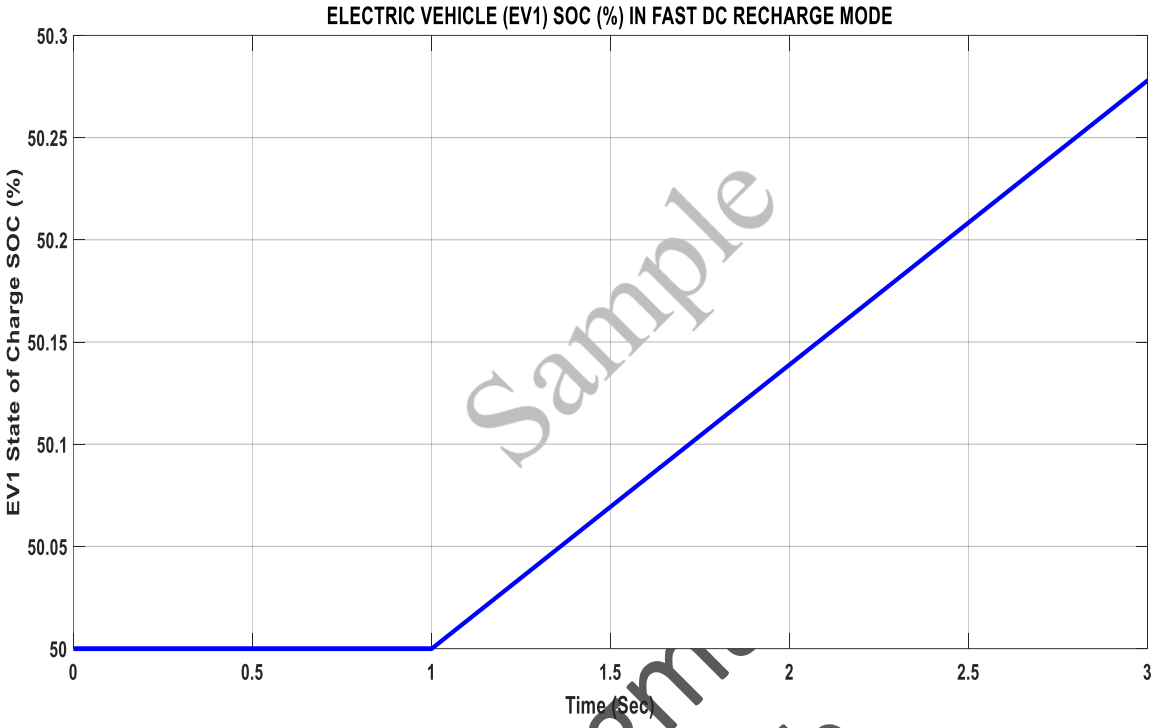

Figure: EV_1 SOC (%) in fast DC recharge mode.

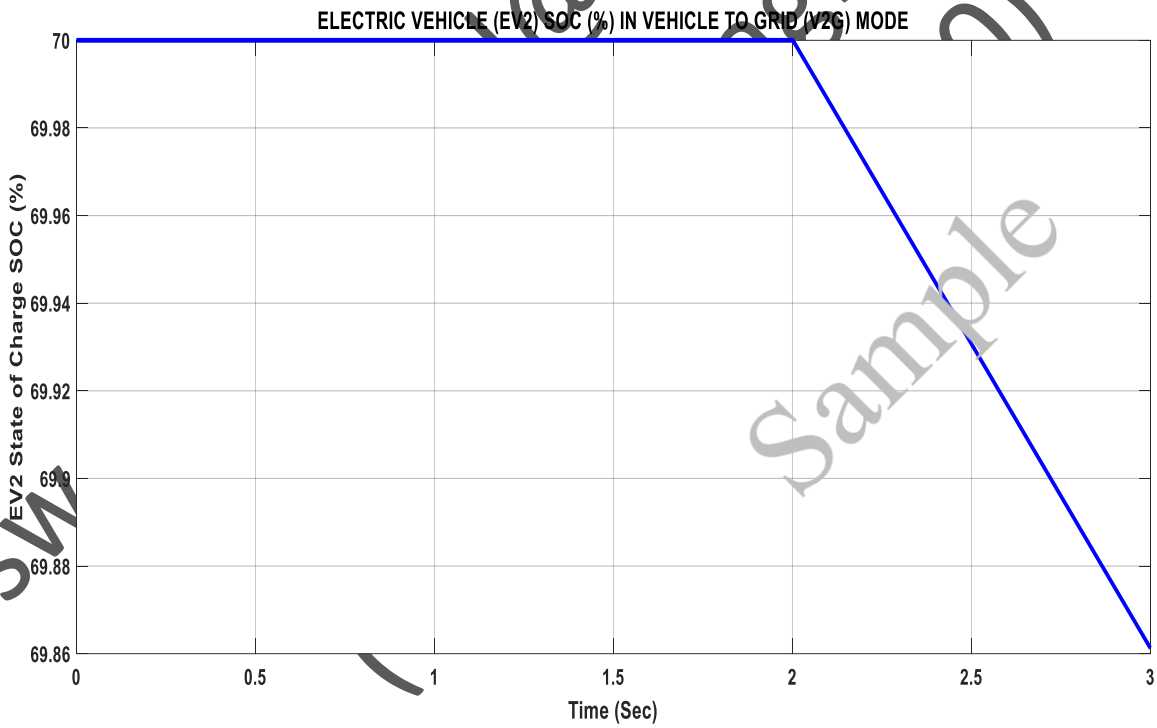

Figure: EV_2 SOC (%) in V2G mode.

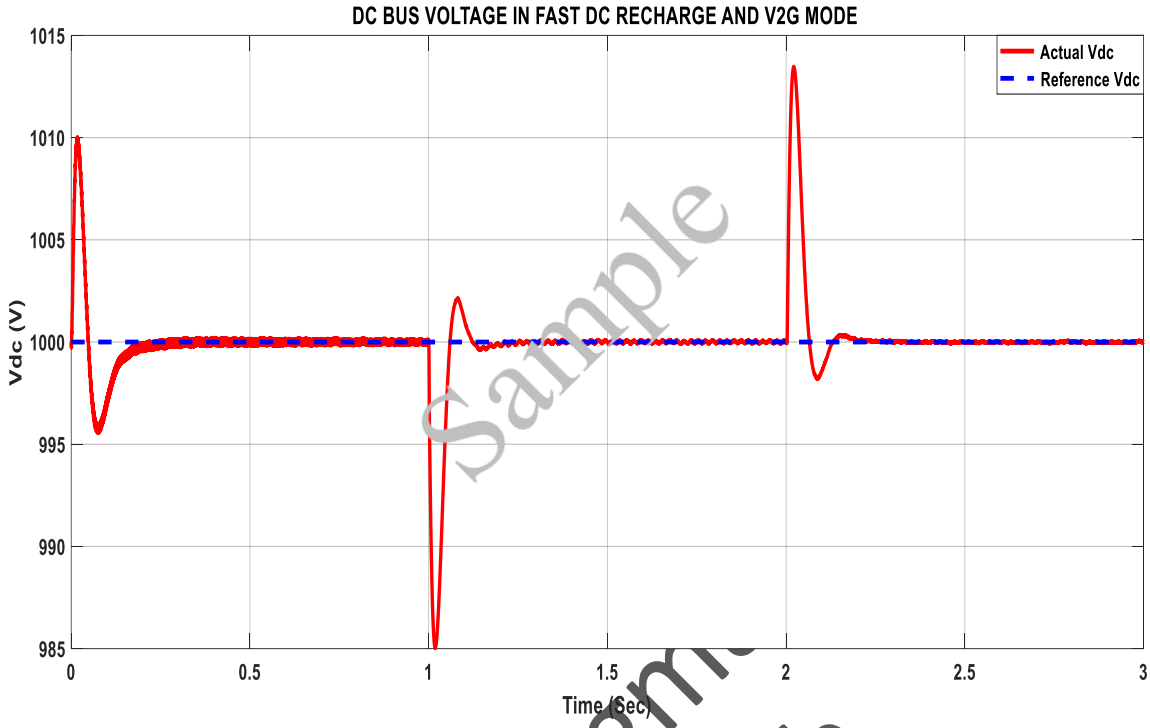

Figure: DC bus voltage.

At t=1 sec, after a short transient, the active power matches the power required from EV_1 summed to the loss of the system. At t=2 sec, EV_2 is connected in V2G mode.

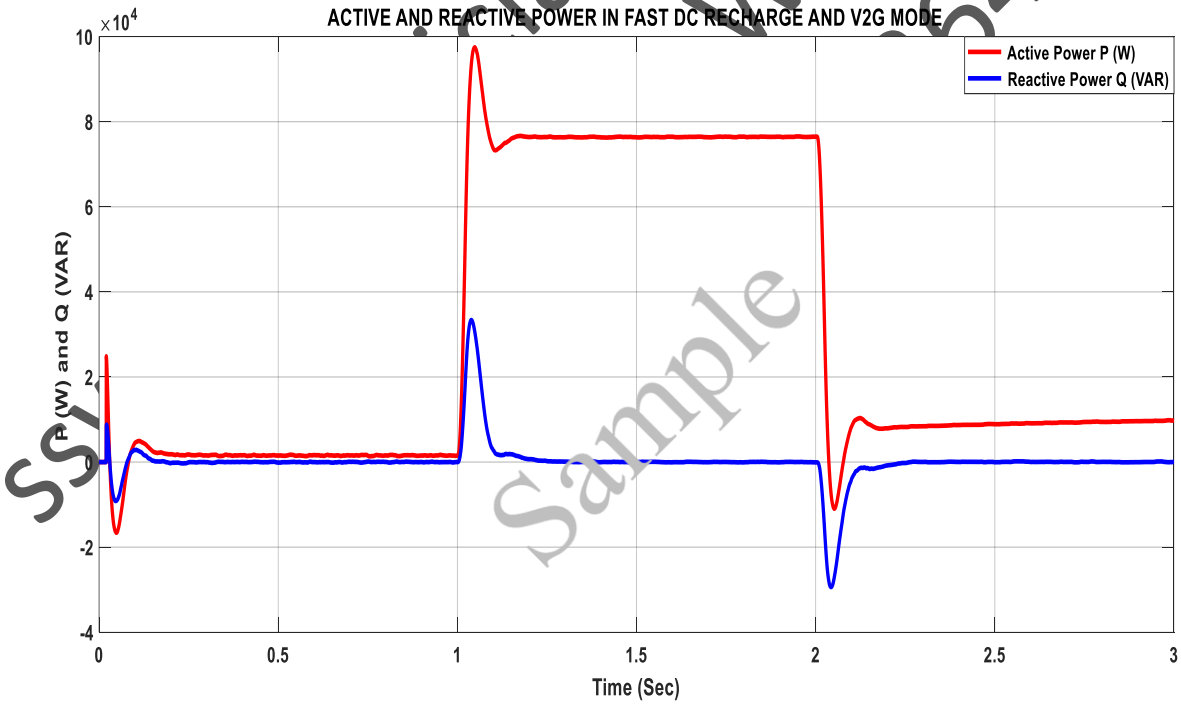

Figure: Active and reactive power flow.

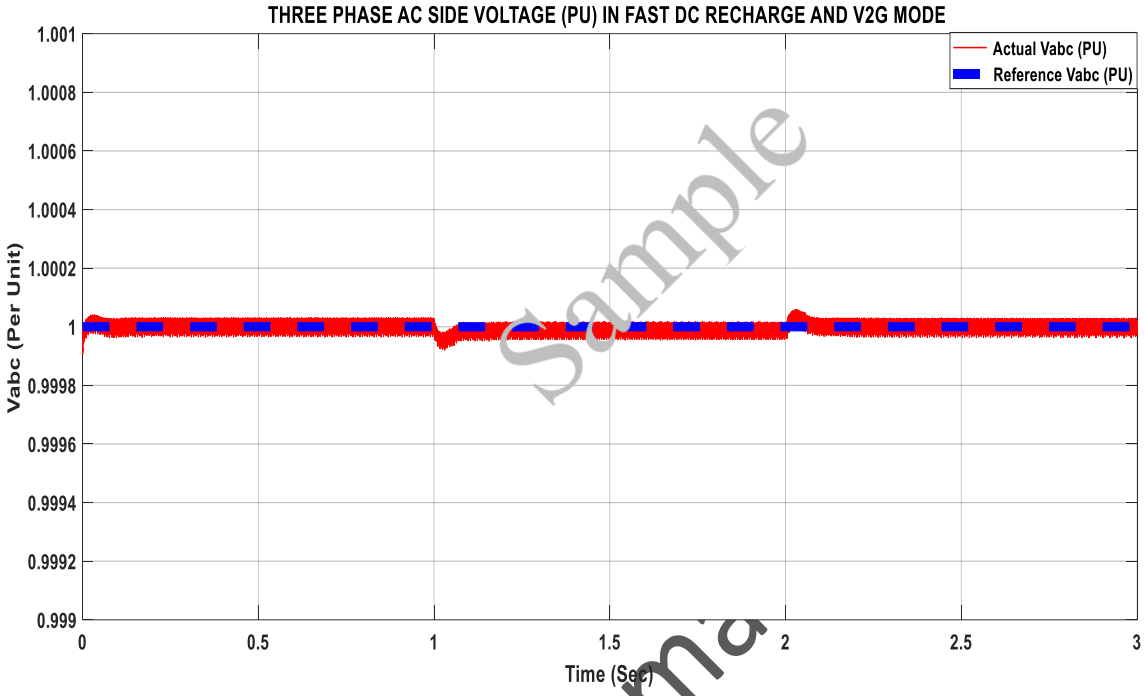

Figure: Per unit voltage on three phase supply side.

Figure shows the Fast Fourier Transform (FFT) analysis of current of a phase during selected time period and THD is found to be in the limits (0.98%).

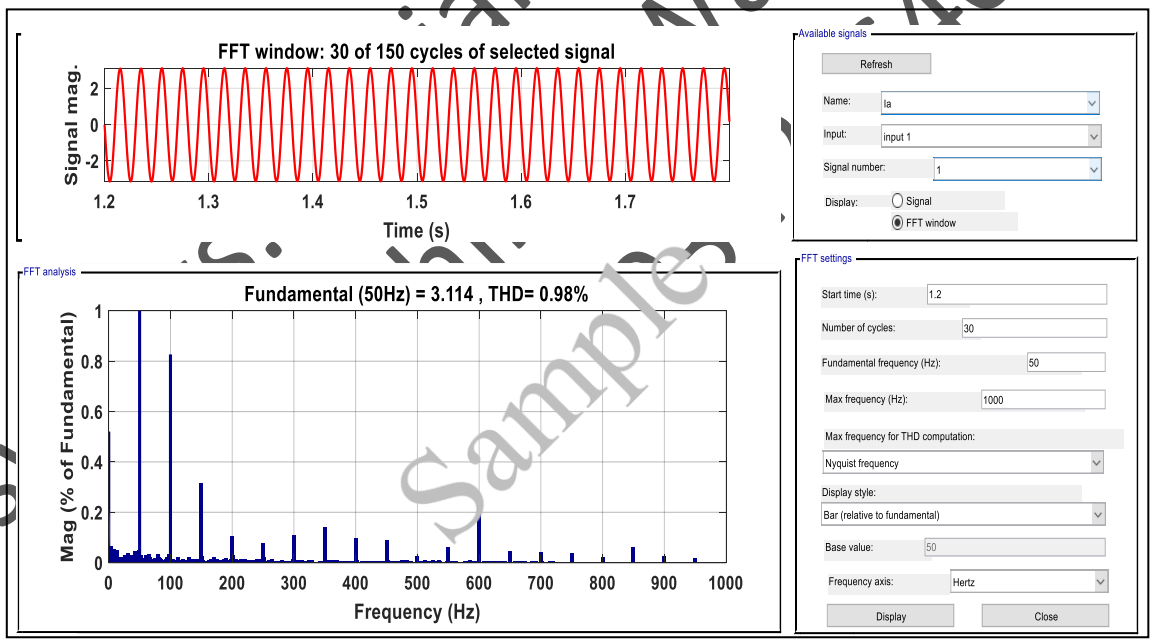

Figure: FFT analysis.

Conclusion

In this report, the design, model and simulation results of a recharging system including V2G mode for EVs is presented. It has the ability to perform ultra-fast recharging, so that recharging of battery is possible in less than an hour. 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. It has the ability for reverse power flow in case the vehicle is operating in V2G mode. 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. The results prove that model created is an efficient model with fast charging ability to charge EVs maintaining desired SOC of EV batteries. Simultaneously, local controller algorithm designed in this study discharge EVs efficiently and provide active and reactive power support to utilities.

References:

[1] V. Castiglia, P. Livreri, R. Miceli, F. Ricco Galluzzo, G. Santelia and G. Schettino, "Design and simulation of a fast DC recharging station for EV," *6th International Conference on Renewable Energy Research and Applications (ICRERA-2017)*, San Diego, CA, USA, Nov 2017, pp. 1198-1203.

[2] 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.