# Power Transfer from V2G Using Supercapacitor and Battery

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***Abstract-*** *Plug-in hybrid electric vehicles (PHEVs) and Electrical vehicles will play a vital role in future's sustainable transportation systems since this technology is promising for the environment, energy security, and improved fuel economy. Therefore, the automotive industry is going through a significant restructuring, and automakers are looking for new generations of hybrid vehicles, PHEVs. This research work primarily focuses on two major thrust areas of PHEVs; (a) introducing a novel bi-directional AC/DC rectifier/inverter for facilitating Vehicle-to-grid (V2G) integration and grid –to-vehicle(G2V); (b) Using a supercapacitor as a DC-DC regulator in series and parallel to charge and discharge the coupled battery/ultra-capacitor energy storage system for PHEVs and Electrical vehicles. This bi-directional charger must have the capability to charge PHEVs and EV batteries while producing a minimum of current harmonics and also have the ability to return the energy to the grid following regulations.*

***Keywords***- Plug-in hybrid electric vehicle, vehicle-to-grid (V2G), grid-to vehicle (G2V), Bidirectional AC-DC Converter, Supercapacitor

## I. INTRODUCTION

The fundamental idea of vehicle-to-grid power is used in EDVs (Electric Drive Vehicles) to give electric power to the grid when the vehicle is parked. Hybrid, plug-in hybrid and battery electric vehicles are known collectively as electric drive vehicles (EDVs). Also, EDVs may represent a clean and affordable option to meet growing vehicle demand. They have stored energy within them in the battery and power converters which is competent in generating a 50 Hz AC voltage that powers our offices and homes. Further, when connections are fixed to provide this electricity to course from cars to power lines, individual calls it V2G (Vehicle to Grid). Reverse it is termed as G2V (Grid to Vehicle) when all required connections are established to charge the battery of EDVs from grid [1].

In this paper, a configuration with the bidirectional power converters is derived for the bi-directional power management of a PHEV battery. The system is composed of two parts: three-phase bidirectional AC-DC converter and a DC-DC converter. Three-phase bidirectional AC-DC converter is to convert AC to DC [2]. The supercapacitor is used in this system for charging and discharging.

## II. REVIEW OF LITERATURE

Shi et al. (2008) studied the fundamental requirements and specifications for PHEV bidirectional AC-DC converter. Also, detailed analysis has been done for two converter topologies and suggest combination topology emphasized. Plug-in hybrid electric vehicles (PHEVs) are a class of hybrid electric vehicles which get sufficient energy from batteries for average daily commuting. These batteries used to charge from the power grid and thus allow to reduce petroleum consumption as well as greenhouse gasses. To implement the plug-in function, a single phase bidirectional AC-DC converter interfacing with the grid is essential. The implementation of a bidirectional AC-DC converter can allow for battery recharge from the grid, battery energy injection to the AC grid, and battery energy for AC power stabilization [2], [3].

PHEVs present many advantages in comparison to regular vehicles, all-electric vehicles, and conventional HEVs. However, they bring up challenges that require further developments, as well. Due to the electric drive contribution of PHEVs, significant amounts of fuel can be displaced with electricity. Based on CalCar's Initiative, in a well-built PHEV, which gets charged once a day, each kWh of battery capacity in use will displace up to 50 gallons of gasoline a year with electricity [4].

Adoption of PHEVs can significantly reduce greenhouse gas emissions. Although there are losses at generation, transmission, distribution of electricity, and recharging the batteries, the overall electric generation emissions are less than that of the petroleum-fueled vehicles. Based on the variety of power sources supplying the US electric power system, American Council for Energy-Efficient Economy (ACEEE) has indicated that a PHEV can achieve around 15% decrease in net $CO_2$ emissions in comparison to a regular HEV. It is also observed that in locations where coal-fired power plants generate more than 80% of the power, local net CO2 emissions will increase; however, net CO2 emissions related to PHEVs will decrease in locations where the grid is supplied by power sources with lower CO2 emissions than the current average [5].

## III. MODELING

This Paper will primarily review some of the power electronic topologies of bi-directional AC/DC and DC/DC converters that fulfill these requirements and then discusses the best choice for combining two topologies to form a bi-directional charger. Today's electrical grid has inefficiencies that are both costly and wasteful. Some of these issues are merely a result of the mismatch in demand for voltage and frequency regulations [6].

During these conditions, when load demand on the grid exceeds the base-load capacity of the power plants, to full fill, this marginal increment in demand the peak power plants, and sometimes spinning reserves, must be turned on [7]. Whereas during low demand periods, the electricity usage falls below the output of base-load capacity of power plants and corresponding all the excess unused energy used to waste. These problems could significantly reduce with coordinated charging [6].

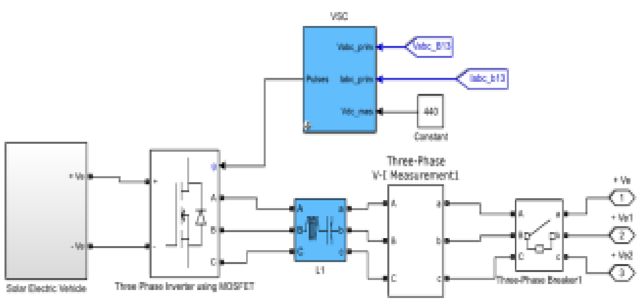


Fig.1 MATLAB Simulink model for V2G-G2V solar electric Vehicle

Many different power electronic circuits can complete this task, but they tend to follow the same general circuit topology. During battery charging mode, the AC first goes through a filter which helps ensure that the proper sinusoidal waveform is drawn from the grid. Next, the AC is rectified into DC as it passes through the bi-directional AC/DC converter. Since this AC/DC converter output voltage might not match the voltage of the DC energy storage, a bi-directional DC/DC converter (supercapacitor) regulates the proper charging voltage which is being delivered to the energy storage unit. From the general viewpoint, three-phase topologies follow the same steps. If the charger is in the battery depletion mode, the process is reversed. The electric current leaves the energy storage unit and is changed back to the proper DC voltage by the bi-directional DC/DC converter supercapacitor. This DC is then converted into AC by the bidirectional AC/DC converter. After that, it passes through the filter, which smoothes out the AC, so it is suitable for injection back into the grid [8].

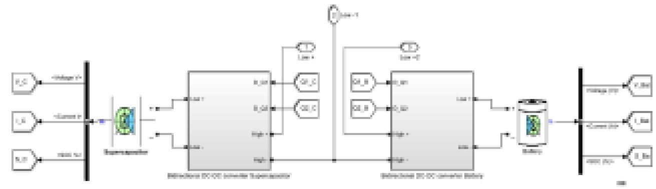

Fig. 2 MATLAB Simulink model for V2G-G2V electric Vehicle Storage Management system with Super-Capacitor, and Battery

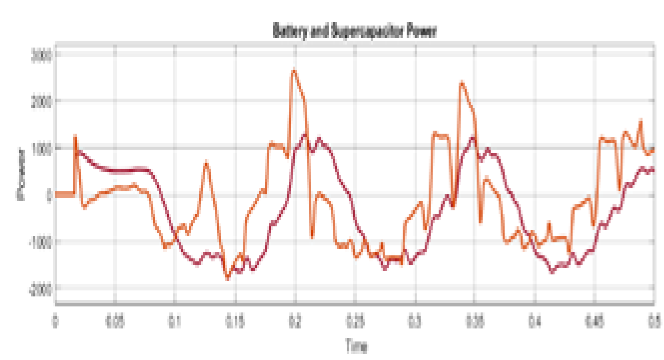


Fig. 3 Battery and Supercapacitor Charging and Discharging of power variations

The variation in charging and discharging power of a battery concerning supercapacitor charging and discharging power is illustrated in Fig. 3.

## VI. CONCLUSION

In this study, the simulations experiments proofed that the combined operations of battery and supercapacitor show that the grid interface converter can be employed compatible forming a complete solution for a PHEV and EV. The battery pack is designed and controlled to work as the primary energy storage reservoir of the vehicle, providing average power to the load; and the supercapacitors are used to support the battery, it increases the battery life. A supercapacitor is also responsible for providing a regularly maintained load bus voltage to provide a fixed voltage.

The results show that although the initial cost increases, the proposed topology offers a better fuel economy, reduced size and cost for the battery, increased the system efficiency and battery life.

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