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Computational Intelligent Based Control of Electric Driving System with Bidirectional DC-DC Converter

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Abstract:

In this paper, a two stage basic converter popularly known as Bidirectional DC-DC converter is proposed for Grid-2-Vehicle, Vehicle-2-Grid and Vehicle-2-Home applications. The Bidirectional Converter provides the independent control at each mode of power conversion stage. By using this unique feature, the power sharing or power transferring between Vehicle/Grid/Home has been developed. In addition, this converter uses less number of components, with good operating efficiencies and most economical. The entire system has been developed using MATLAB Simulink software, the simulation results are present as well.

Keywords

MATLAB,Vehicle,Grid,Coverter.

1. Introduction

The low cost bidirectional DC-DC converter for V-2-G, G-2-V, and V-2-H. A series LC resonant circuit is included in the circuit, thus further minimizes the ratings and employs zero switching. From the developments of semiconductor technology the power electronic engineers made reliable products with the use of solar energy (or) renewables. Name a few, DC-DC converters are Buck/Boost chopper, Buck-Boost etc. are considered as classical converters. These converters provides basic knowledge and leads to the development of interleaved converters and Bidirectional converters. One of the best applications like battery charging system with solar energy for domestic purpose (or) commercial purpose using classical converters gives desired output voltages, however, the operating efficiencies are very less. In addition, the switching losses are quite high, and thus less reliable. In comparison with the performance of operating efficiencies of classical converters, the bidirectional converters are fairly good and more reliable in power sharing at all modes. In addition, the bidirectional converter distributes the energy between the grid to load, electric vehicles and vice versa. Popularly, the interfaces between Vehicle-to-Grid (V-2-G)/Grid-to-Vehicle (G-2-V) and also Vehicle-to-Home (V-2-H) can be developed with load balancing and active power regulation. Also a very few converters shown the improvement of battery performance in EVs. Still, the battery continues to be a major concern across all segments of EVs, with the two stage topology, bidirectional converters plays an important role in efficient utilization of electrical energy between batteries and vehicle/load.

The Bidirectional converter typically a two stage topology, which includes a DC-AC rectifier (stage I) and an isolated DC-DC converter (stage II) with LC filter. The block diagram of Bidirectional converter is shown in the figure 1, with control block.

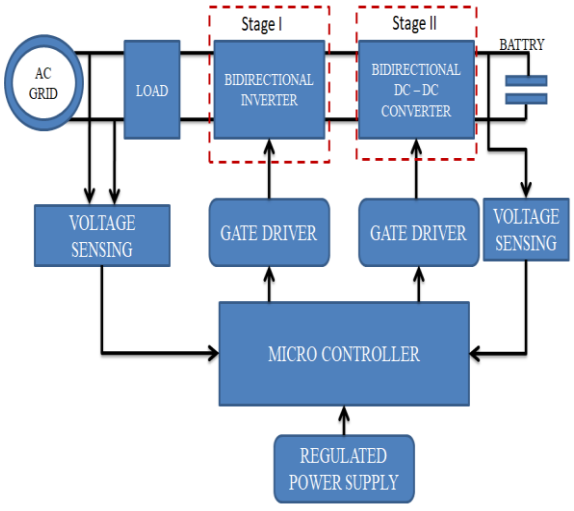

Fig. 1. Basic Bidirectional Converter Block Diagram

The paper is organized as follows:in section II,the Electric Vehicle Battery Technologies are explained, the mode of operation of Bidirectional converter is explained in section III, the system specifications are presented in section IV,the MATLAB-Simulink model is presented in section V and finally, the results and observations are concluded.

2. Electric Vehicle Battery Technologies

The first EV was seen on the road shortly after the invention of rechargeable lead–acid batteries and electric motors in the late 1800s.In the early years of 1900s, there was a golden period of EVs. At that time, the number of EVs was almost double that of gasoline power cars. However, EVs almost disappeared and gave the whole market to internal combustion engine (ICE) cars by 1920 due to the limitations of heavy weight, short trip range, long charging time, and poor durability of batteries at that time.EV batteries are quite different from those used in consumer electronic devices such as laptops and cell phones. They are required to handle high power (up to a hundred kW) and high energy capacity (up to tens of kWh) within a limited space and weight and at an affordable price. Extensive research efforts and investments have been given to the advanced battery technologies that are suitable for EVs all over the world.The current two major battery technologies used in EVs are Nickel Metal Hybrid (NiMH) and Lithium ion (Li-ion). Nearly all HEVs available in the market today use NiMH batteries because of its mature technology.

Due to the potential of obtaining higher specific energy and energy density, the adoption of Li-ion batteries is expected to grow fast in EVs, particularly in Plug-in-Hybrid Electric Vehicles (PHEV) and BEVs. It should be noted that there are several types of Li-ion batteries based on similar but certainly different chemistry.EVs can be integrated into the power grid in future. They can be aggregated together for grid supports such as renewable accommodation, frequency regulation, voltage profile regulation, and system optimization. They can also be operated in a distributed way and work with local loads to achieve demand side management. As to the EV grid integration, the battery inside the EVs is the key component. It is particularly important for power engineers to understand the basic chemistry of the different batteries, and specific EV battery requirements of energy density, specific energy, power density, cost, durability, etc. The EV battery modeling will be introduced in the way that it is suitable for power engineers to appreciate and use it for power electronic interfacing converter design, battery management, and system level studies.

3. Mode of Power Transfer

The DC-DC Bidirectional Converter Circuit is operated in 2 modes, based on the power flow requirement and shown in figure 2.In mode I (Grid-to-Vehicle): In this mode, the battery used for EV is charged to a voltage of 12V through a rectifier and a capacitor. The State of Charge (SoC) of battery, voltage and current waveforms of the battery are shown in the figures 3,4,5 respectively.

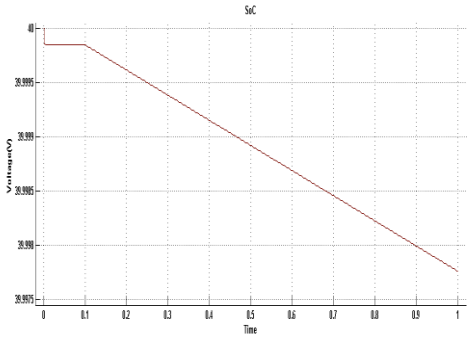

Fig. 3. State of Charge of the Battery

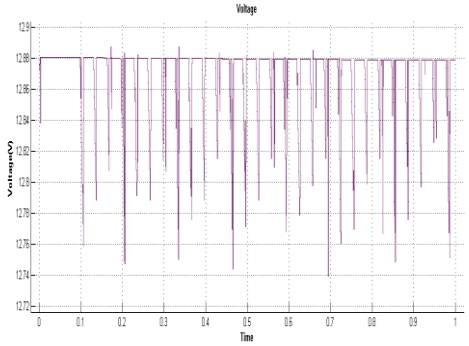

Fig. 4. Battery Voltage

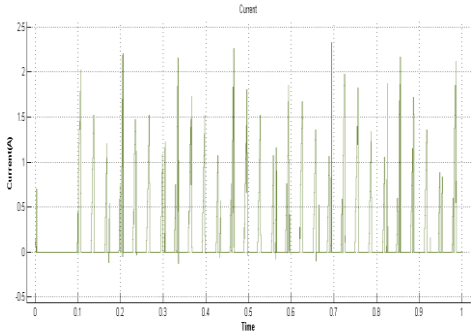

Fig. 5. Battery Current

fig. Also, the grid voltage is also shown in the figures 6,7,8 respectively.

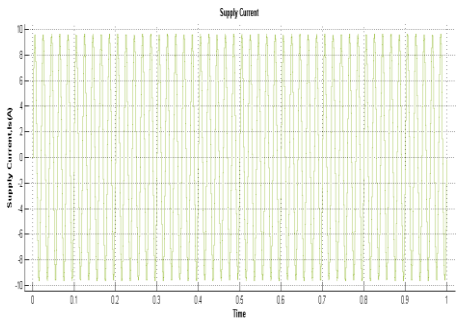

Fig. 6. Supply Current

1

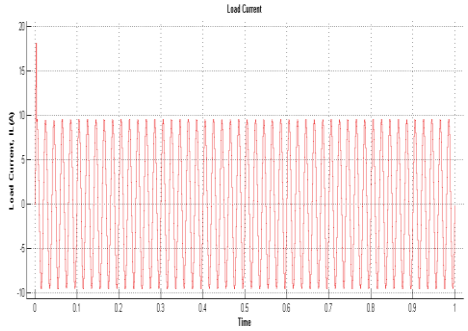

Fig. 7. Grid Current

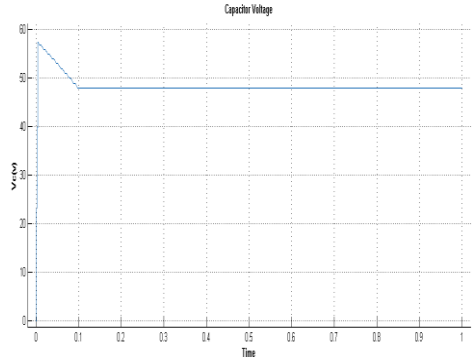

Fig. 8. Voltage at the Capacitor

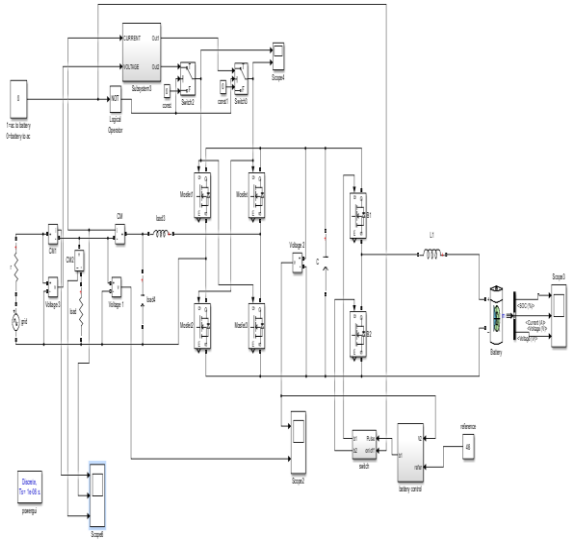

Fig. 9. DC-DC Bidirectional Converter Circuit

7. Conclusion

In this paper, the proposed model of Bidirectional DC-DC converter is simulated and the flow of energy is efficiently transferred for the applications V-2-G, V-2-H or G-2-V and the various waveforms are shown for the analysis.

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