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On-Board Single-Phase EV Charger with High Gain Booster for Vehicle to Grid Applications

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ABSTRACT

The major goal of this study is to realise Vehicles to Grid (V2G) and Grid to Vehicles(G2V) application, hence a reversible on-board single-phase electric car charger is presented. The two primary components of the bidirectional charger are an inverter and a power density boost converter. Battery charges and discharges are controlled by the battery's charge level. In order to verify the effectiveness of the high gain boost converter in the bidirectional on-board charger, a simulation is performed in MATLAB Simulink..

KEYWORDS- High gain Boost converter, V2G, Bi- directional, Battery.

1. INTRODUCTION

Although internal combustion has been the standard in the transportation industry for almost a century, recent years have witnessed a marked shift away from this. Electric vehicle (EV) manufacturing has increased rapidly in both emerging and developed nations in response to the ongoing scarcity of traditional transportation fuels. Electric vehicles are good for the environment and the future[6]. Vehicle-to-grid (V2G) technology fills the void where peak load balancing is currently required. In other words, when linked to the grid, EVs may be thought of as devices for storing energy that can either charge or discharge electricity as needed [6]. This paves the way for electric cars to use the reserve power, which is beneficial to the power systems. Many studies have looked at the feasibility of using bidirectional converter topologies to charge electric vehicles. They may be roughly classified as either "outboard" or "built-in" bi-directional chargers. An AC-DC dc / dc and DC-DC converter are commonly used in tandem in outboard bidirectional chargers' two-stage designs. Its parts are often large and powerful, finding utility in applications such as rapid charging and discharging. External bi-directional charging are more suited for business load stations than residential settings because to their power rating, size, cost, and noise [12]. The included bidirectional chargers are suitable for home usage, however they charge slowly [2]. In order to reduce the peak demand during V2G operations, this article examines a bidirectional converter architecture for charging and discharging electric vehicles.

2. BATTERY ENERGY STORAGE SYSTEMS

This study primarily focuses on the evolution of battery storage as a form of electric storage in recent years. This presentation will explore the large range of battery types available for certain applications. Energy from a generator is converted into a chemical form by charging a chemical battery, which in turn produces reactions in electrochemical compounds. On demand, the battery's electrolyte may be reversibly charged, allowing power to flow back into the grid. The flooded lead-acid battery, the first commercially produced battery, was designed for stationary, centralised power storage.. The VRLA battery requires little upkeep, can't leak or spill, and is small. In contrast to older battery storage technologies, zinc/bromine has not yet made it to the mainstream. There are currently ongoing efforts to produce alternative lithium-based batteries. Batteries may be built with capacities ranging from a few hundred watts to modular setups with many megawatts of power. Hence, batteries have a wide range of potential uses throughout the utility industry, including in generation, transmission and distribution, and customer service.

3. LITERATURE SURVEY

The goal of this study is to examine the feasibility of G2V and V2G communication by analysing their functioning in a non-isolated charge topology that satisfies the design criteria [2, 10]. High duty ratios are typical for non-disengaged converter types due to the need of producing high voltage gain. With such demanding criteria for output, conduction loss tends to be significant. Hence, a high gain convertor is used in place of a standard boost converter to reduce losses and improve system efficiency [9]. Using rectifier, capacitors, and a linked inductor, the fast gain boost converter generates a lot of power. Large value boost converter topology's key benefits include high voltage gain while retaining a rapid working cycle, and the need of a transformer. [5] & [8]. For the bidirectional battery architecture to function, the battery's Status of Charge (SOC) must be monitored. In order for the topology as a whole to function, the condition under which both the buck as well as high gain converter will work must be specified. Otherwise, the two converter topologies will be in operation at the same time, and neither will be able to carry out its G2V or V2G function as intended. For the topology to function, it must account for a fixed target SOC. SoC level is used to determine if the battery is being charged or discharged [4, 7]. Converting between two distinct topologies in a converter requires careful attention to the cascading entire system

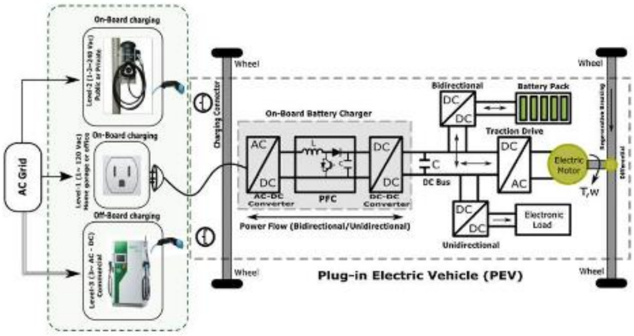


Fig-1: Bidirectional Charging Infrastructure

Fig-1: Bidirectional Charging Infrastructure

4. BIDIRECTIONAL CONVERTER TOPOLOGY

This research presents a topology that streamlines communications between the power grid and the batteries of electric vehicles. It's really just a combination of two different systems in a cascade. For G2V functioning, a) AC-DC converter from the power source, DC-DC buck converter, and battery Inverter with high gain for use in batteries in V2G applications. The primary goal of this work is to examine the feasibility of G2V and V2G operations using a non-isolated charging topology to fulfil the design criteria [2]&[10].

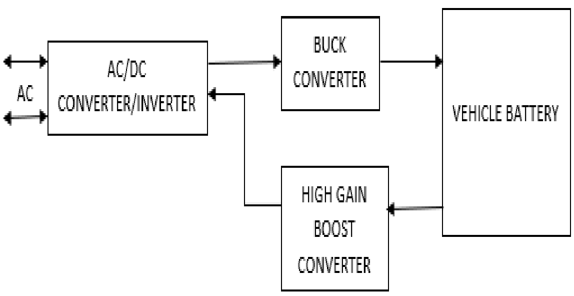


Fig-2: Bidirectional Charging Topology

A.BUCK CONVERTER DESIGN:

A buck converter is a common example of a topology used in non-isolated converters. The IC-controlled active switch, rectifier, and filtering element that make up a buck converter make it a fantastic, easy-to-implement option for distributing power efficiently and effectively across an application. With the bidirectional converter architecture, the buck converter is employed to reduce the 230V rectified output voltage to the 48V needed by the car battery [3].

$$D = \frac{V_o}{V_S} \dots\dots\dots\dots\dots (1)$$

$$L = \frac{R(1-D)}{2F_s} \dots\dots\dots\dots\dots (2)$$

$$C = \frac{(1-D)V_o}{8L\Delta V_0 F_s^2}$$

B.HIGH GAIN BOOST CONVERTER DESIGN

As a highly efficient, voltage level step up converter, the high input buck converter is a popular choice. The linked inductor is another component. Two further sets of capacitors and diodes provide the high voltage by being charged and discharged by the connected inductor [5]. Power switch S, clamp diode D1 , capacitor C1, blocked diodes D2 & D3, blocking capacitors C2 or C3, output capacitor Co with diode Do, and linked inductors make up the converter. The power Transistor and diodes are optimised for operation. In the course of V2G operations, the high output convertor is used [11]. The 48V from the car's batteries is amplified so that it may be safely used with the 230V from the grid. The following equations [5] may be used to determine the gain boost converter's necessary system parameters.

$$V_s = V_o(1-D)\dots\dots\dots\dots\dots(4)$$

$$L = \frac{D(1-D)^2 R}{2V_o f V_s}\dots\dots\dots\dots\dots(5)$$

$$C_o = \frac{I_o(1-D)V_o - V_s(2+nD)}{2V_0 f V_s} \dots\dots (6)$$

$$C_1 = \frac{2DV_o}{(1-D)\Delta V_{c1} Rf} \dots\dots\dots\dots (7)$$

$$C_2 = \frac{V_o}{2R\Delta V_{c1} f} \dots\dots\dots\dots\dots\dots (8)$$

$$C_3 = \frac{DV_o}{R\Delta V_{c1} f} \dots\dots\dots\dots\dots\dots (9)$$

$$L_m = \frac{D(1-D)^{2R}}{2(n+2)(2+nD)f}$$

C.BATTERY WORKINGALGORITHM

To determine whether to charge or discharge the battery, just the battery's current charge level is used. The state of charge is compared to a user-specified threshold, which then controls whether or not the battery is charged. The degree of charge in both batteries is crucial to the bidirectional charger's operation. The rechargeable batteries algorithm is programmed to allow the charger to charge the vehicle's battery in a grid-to-vehicle (G2V) operation if the state-of-charge (SOC) falls short of the set percentage, and to discharge the battery through the charger, returning the power it has stored to the grid, if the SOC surpasses the set value (G2V operation).

The battery's charging or discharging status is controlled by the converter topology, based on a predetermined reference value. If the state-of-charge (SOC) value of the battery is higher than the reference value, power is transferred from the battery to the grid via the power amplifier boost converter. Similarly, if the SOC is below the threshold, the battery will recharge using a buck converter to draw power from the grid.

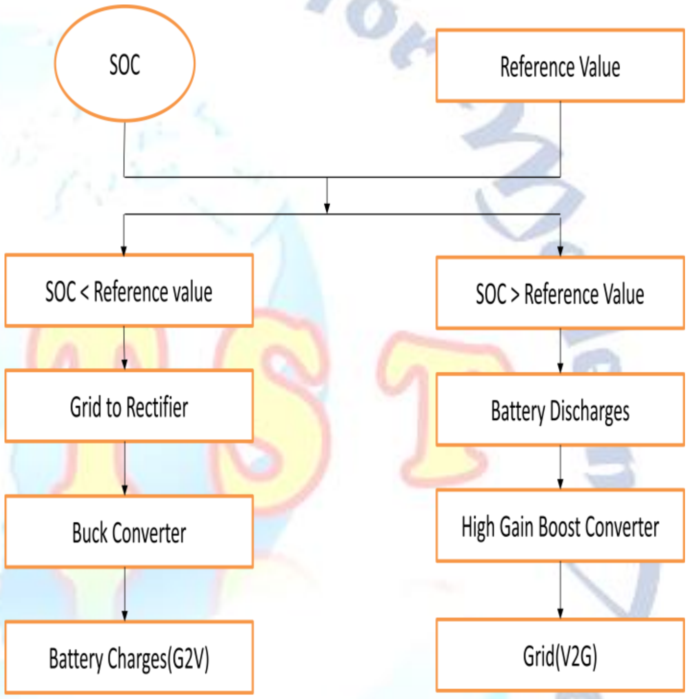


Fig-3: Flowchart of Battery working algorithm

5. SIMULATION AND RESULTS

In this analysis, we look at how well the bidirectional charger regulates reactive power and how well it handles V2G. While running a full simulation of the network would take too much time in practise, a simplified version of the issue is simulated instead by assuming reduced time constants. The electric automobile can be driven when its battery has been charged to its full potential. When both reactive and active power consumption at the demand are maximum, the EV may indeed be connected to the grid in order to shed some of that load.

Once the EV is plugged in, the bidirectional charger draws both reactive and active electricity from the PEV's battery to maintain the distributor voltage

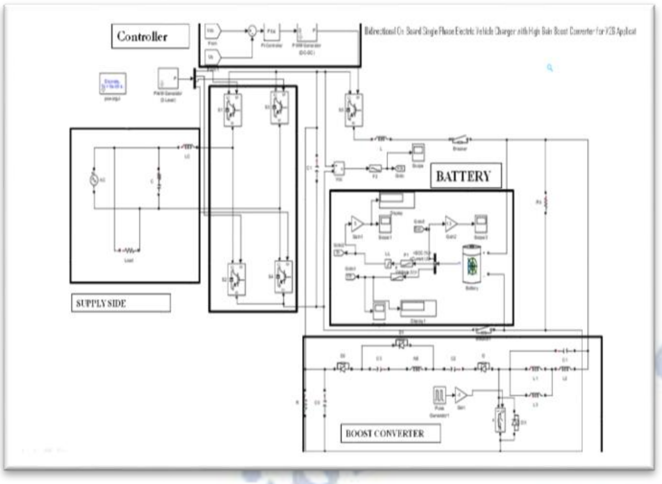
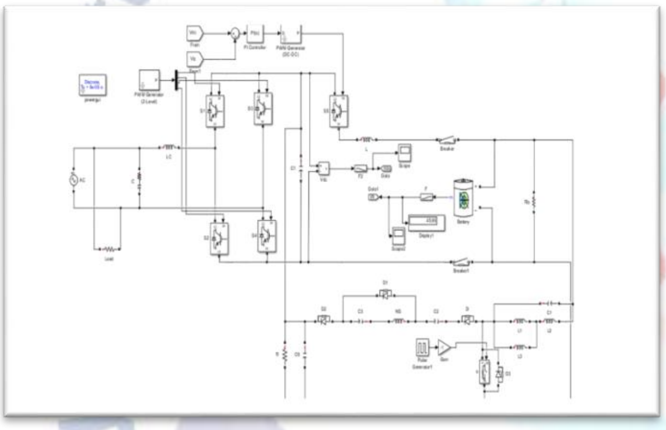
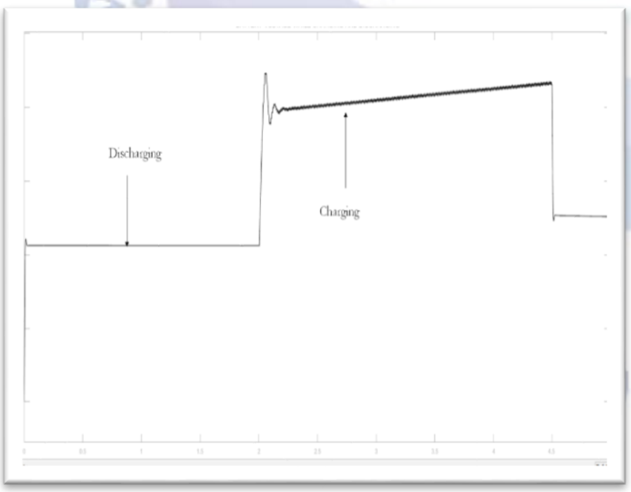


Fig-4: High gain boost for car-to-grid single-phase electric vehicle charging.

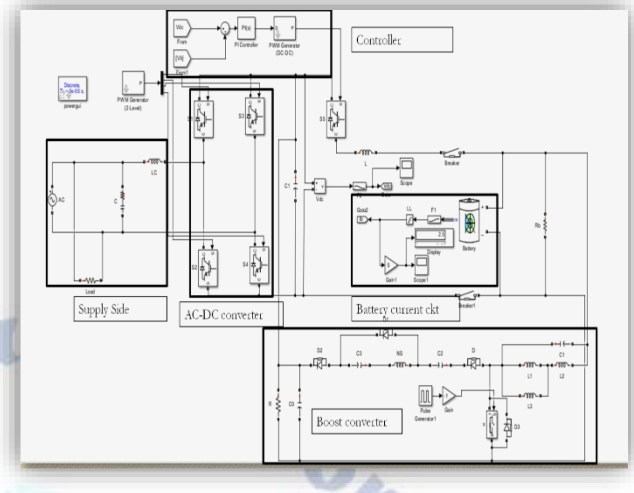
CASE :1 THE VOLTAGE OF THE BATTERY DURING CHARGING AND DISCHARGING



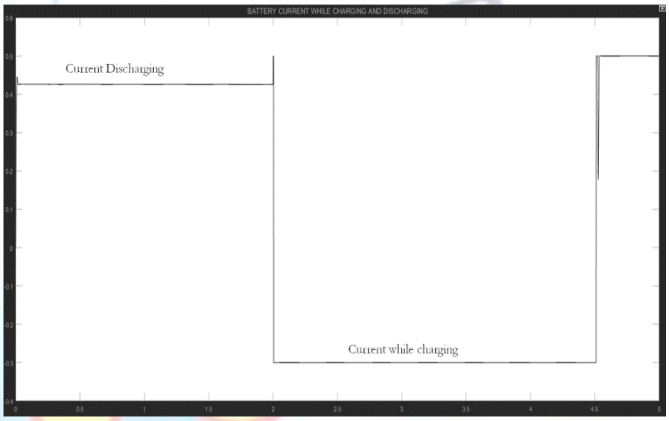
BATTERY VOLTAGE OUTPUT:



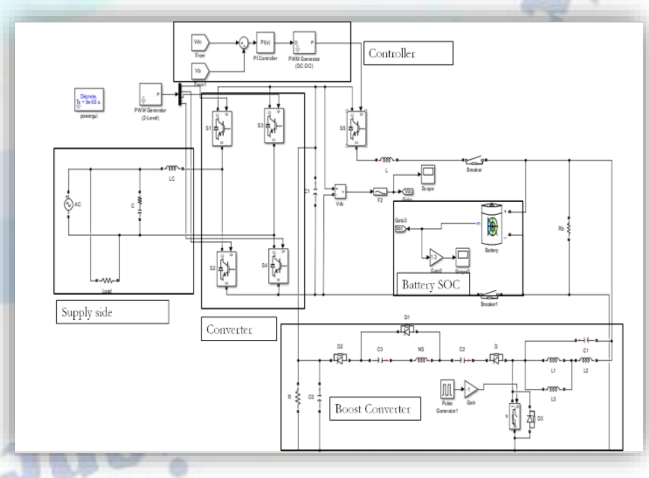
CASE: 2 CURRENT DRAWN FROM A BATTERY WHILE IT IS CHARGED AND DISCHARGED



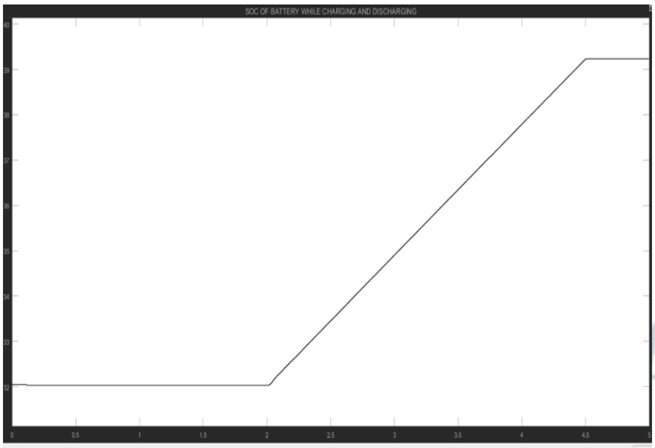
OUTPUT OF THE BATTERY CURRENT



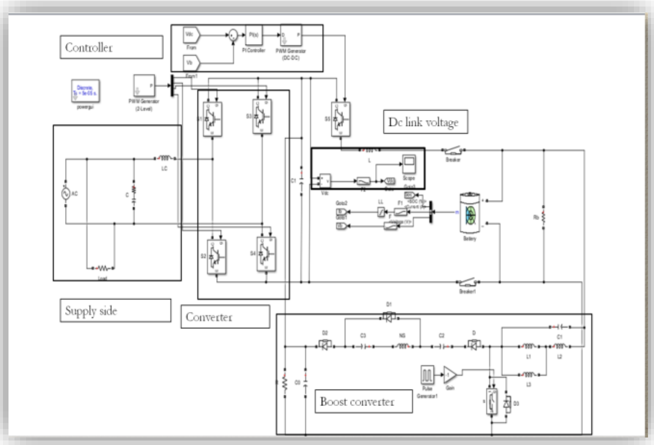
CASE: 3 BATTERY STATE OF CHARGE (SOC) WHEN CHARGING AND DISCHARGING



OUTPUT OF THE SOC



CASE: 4 DC LINK VOLTAGE



OUTPUT OF THE DC LINK VOLTAGE

6. CONCLUSION

It's possible that the electric car's ability to send and receive electricity will be an asset to the grid. Both G2V and V2G charging are supported by the device. It features a dual-use AC-DC charger and a cascade DC-DC converter. The buck converter is used for the G2V mode of the included DC-DC converter, while the high gain convertor is used for the V2G mode. The directional electric vehicle charging for the V2G app is successfully simulated in MATLAB using a 40V charge controller and a DC link voltage of 160V. The simulation results for both G2V & V2G modes show the converter's excellent performance. The battery takes on or loses charge in line with the prescribed procedure. The dc link voltage is consistently 160V when charging and draining. When the battery's state of charge (SOC) is higher than its set point, it delivers voltage to be restored to the grid; otherwise, it pulls power from the electrical grid. Hence, it seems that the converter is in direct competition including a bidirectional EV charger that allows for both G2V & V2G charging.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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