ARTIFICIAL NEURAL NETWROK BASED BIDIRECTIONAL ELECTRIC VEHICLE CHARGER FOR V2G APPLICATION

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ABSTRACT:

In this paper, reversiblecharger for electric vehicles that employs a high-gain boost converter and an ANN controller. This research indicates that a bidirectional converter is required for a state of charge of a EV charger to accommodate many types of charging, including vehicle-to-grid (V2G). Bidirectional charger will typically consist of a buck converter and a high gain boost converter setup. We present a bidirectional on-board single-phase electric vehicle charger that is managed by the battery's charge level. In comparison to the current PI controller, the on-board electric vehicle charger built on ANN technology offers greater efficiency. To verify the bidirectional on-board charger's high gain boost converter capabilities, simulation is done using the MATLAB/SIMULINK software.

Keywords: Artificial Neural Network (ANN), Electric Vehicle (EV), Vehicle to Grid (V2G), Grid to Vehicle (G2V), state of charge (SOC),

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1. INTRODUCTION

Many people think that electric cars willsomeday outnumber those that run on gasoline. The Indian government has devised a variety of initiatives to fund EV research in an effort to increase EV adoption and reduce the country's long-term reliance on fossil fuel imports. The majority of these studies aim to improve electric vehicle technology by making it safer, friendlier to users, or cheaper to produce. Due of its significance, the V2G technology is the subject of intensive research. When plugged into the grid, electric cars may perform dual roles as loads and generators. Additional factors increase the burden of PEVs [1]. Among them are typical charging procedures, preferredcharging methods, and common charging patterns. V2G and G2V are the terms used to describe the two major modes of operation. In the G2V mode, vehicles function as traditional loads, whereas in the V2G mode, energy is transmitted in the opposite way. Subset of V2G called vehicle-to-home (V2H) functions like a home's uninterruptible power supply (UPS) [1]. Based on the power requirements, electric car chargers may be installed either inside or outside the vehicle. When power consumption is modest, a single-phase on-board charger should suffice (3-6 kW). A vehicle's battery may be charged using the voltage and current waveforms generated by a standard one-way charger. In fact, the reverse is true, since a modern charger for an electric car may also serve several other purposes.

Some of the functions that may be performed by V2G-specific advanced chargers include: 1) voltage support; 2) reactive power adjustment; 3) harmonic filtering; 4) power factor management; 5) load balancing; and 6) peak shaving. To have the EV battery function as a UPS during a blackout, it is important to have a charger with energy feedback capabilities [2]. Internal combustion engine cars were the norm for almost a century. The trend away from them, however, has accelerated in recent years. As the need for fossil fuels decreases, more governments are investing in the infrastructure and technology required to generate electric cars. This trend may be seen in both developing countries and more mature democracies. In terms of long-term effects on the environment, EVs are the way to go [6]. Vehicle-to-grid (V2G) technology may help reduce the present peak demand for energy. Electric vehicles may be used as mobile power plants when hooked up to the grid, absorbing and discharging energy as needed [6]. With this, it becomes feasible for EVs to reap the benefits of utility networks by tapping into reserve capacity. Quite a bit of attention has been given to bidirectional converter topologies as a potential charging option for electric vehicles. You may categorize them as either external (or "outboard") or built-in (or "in") bi-directional chargers. Modern bidirectional chargers often employ a two-stage architecture. Strong and strong, its components are used in processes like rapid charging and discharging. Due to its high-power rating, enormous size, expensive price, and considerable noise, external bi-directional chargers are more appropriate for commercial load stations than residences [12]. The low current of the integrated bidirectional chargers makes them ideal for domestic use and gradual charging [2].

2. BIDIRECTIONAL CONVERTER TOPOLOGY

Figure 1 is a schematic diagram of the ANN controller bidirectional electric vehicle charger. Our research suggests a certain configuration for networks that would facilitate interaction is taking place. Grid-to-voltage (G2V) applications employ an AC-to-DC (buck) converter, battery, and utility grid; voltage-to-current (V2G) applications use a high gain booster, inverter, and grid. This study aims to better understand how G2V and V2G systems function in practice.

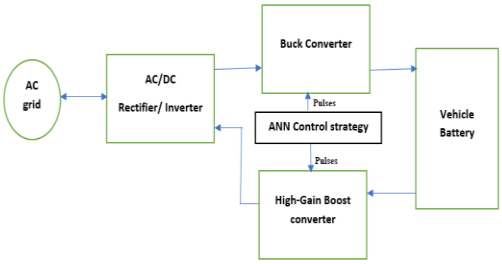

Fig. 1: Block diagram of the Bidirectional PEV'sBattery System

This study explains a protocol for two-way communication between the battery of an EV and the electrical grid. To provide G2V capability, the principal system employs a cascade DC-DC buck converter and AC-DC converter to transition from the utility to the battery. The second strategy involves transferring power sequentially from the battery to the inverter and the utility.

Since non-disengaged converter types are often relied upon to produce a sizable voltage gain, high duty ratios are not uncommon. Due to the high conduction loss that follows, this is impractical for high-output applications. High gain boost converters are preferred over standard boost converters because they may minimize system losses while increasing overall efficiency [9].

High gain boost converter parts include two diodes, two capacitors, and a linked inductor. The fundamental advantage of the high gain boost converter design is the elimination of the transformer, which enables a high voltage gain together with a fast duty cycle.

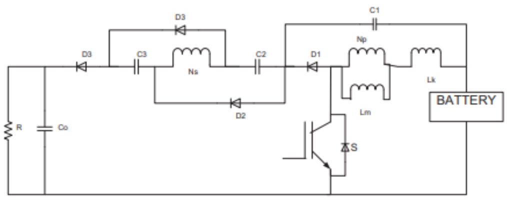

Fig. 2: Circuit Diagram for a High-Gain Boost Converter in Detail

The bidirectional battery design relies on constant monitoring of the battery's state of charge (SOC). It is essential to the design of a buck and high gain boost converter to define their operating circumstances. If the procedures are not performed in the correct order, the G2V or V2G conversion will fail. In the absence of a SOC, this network architecture is useless. SOC monitoring may be used to check on a battery's condition while charging and discharging [4, 7]. With two distinct converter topologies in play, the whole system has to be cascaded with care.

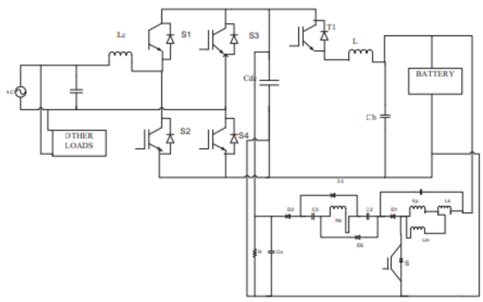

Fig. 3: Bidirectional converter topology

3. DESIGN OF CONVERTERS

Buck Converter Design: The buck converter topology is one of the most common examples of a non-isolated converter design. The IC-controlled active switch, rectifier, and filtering device that make up a buck converter make it a fantastically straightforward means of distributing power across an application. In the bidirectional converter architecture, the buck converter is utilized to reduce the 230V rectified output voltage to the 48V needed by the car battery.

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

$$L = \frac{R(1-D)}{2F_S} \quad (2)$$

$$C = \frac{(1-D)V_o}{8L\Delta V_o F_S^2} \quad (3)$$

High Gain Boost Converter Design: High gain boost converters are an efficient kind of boost converter that may significantly increase output voltage. Additionally, a linked inductor is included. Adding two additional groups of capacitors and diodes yields a high voltage [5]. The capacitors are charged and discharged through the inductor. Power switch (S), clamp diode (D1), capacitor (C1), two blocking diodes (D2 and D3), two blocking capacitors (C2 and C3), output capacitor (Co), diode (Do), and coupled inductors make up the converter's hardware. It is possible to fine-tune the performance of a power MOSFET and diodes. The high gain boost converter is used in V2G operations [11]. To meet the grid's requirements, the 48V from the car's batteries must be amplified. You may find the formulas for determining the high gain boost converter's required system parameters in [5].

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

$$L = \frac{D(1-D)^2 R}{2F_s} \quad (5)$$

$$Co = \frac{I_o(1-D)V_o - V_s(2+nD)}{2V_o f V_s} \quad (6)$$

$$C1 \frac{2\,DV_o}{(1-D)\Delta V_{c1} Rf} \quad (7)$$

$$C2 = \frac{V_o}{2R\Delta V_{c1} f} \quad (8)$$

$$C3 = \frac{DV_o}{R\Delta V_{c1} f} \quad (9)$$

$$Lm = \frac{D(1-D)^{2R}}{2(n+2)(2+nD)f} \quad (10)$$

Working Algorithm for Battery

During charging and discharging, the battery's charge level is continuously monitored and maintained. Users may control charging and discharging by setting a target state-of-charge value. This is achieved through the State-of-Charge balancing algorithm, commonly known as the battery operating algorithm. There must be some charge left in the battery before the bidirectional charger can be used. When the battery's state of charge (SOC) falls below a certain level, it will begin sending power back to the grid through the charger.

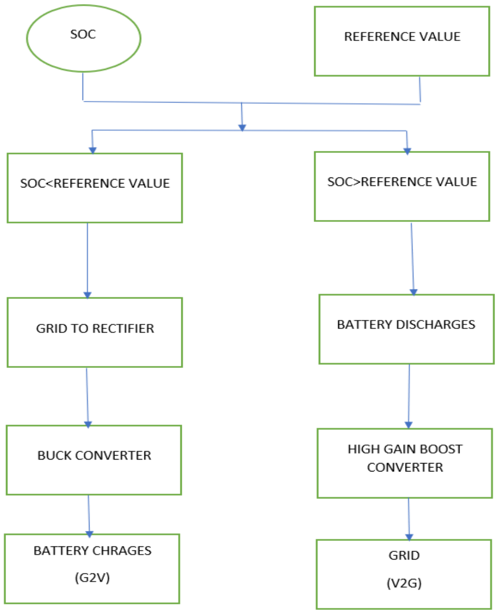

Fig. 4: Flow chart of working of the system

To achieve a desired state of charge in relation to another measure, a converter topology is used to charge or drain the battery. The high gain boost converter will allow the battery to discharge to the grid if the battery's state of charge (SOC) is above a predetermined level. The battery will be charged via a buck converter when its state of charge (SOC) drops below a predetermined threshold.

4. ARTIFICIAL NEURAL NETWORK CONTROLLER

The offline trained Neural Network (NN) controller as shown in Fig. 5.

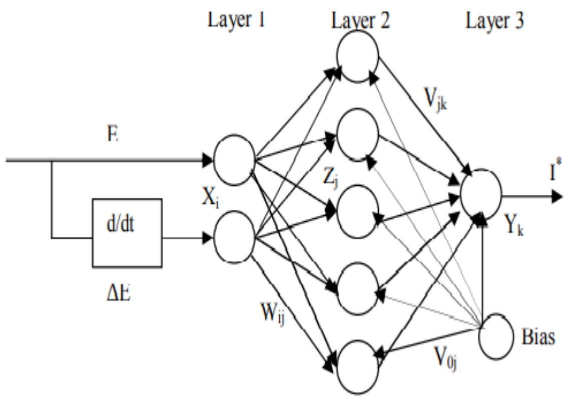

Fig. 5

As the connective weights of the NN-based controller, NNs are ideally suited for the prediction, control, and optimization of industrial processes. There are a total of seven neurons: two inputs (Xi), one output (Ky), and five more that are not visible to the outside world (Xi+1) (Zj). Performance during training of the Neural network controller is affected by neurons. The hidden layer uses a tan sigmoid activation function, whereas the output layer employs a purlin activation function. Our neural network was trained using data collected from conventional controllers.

5. SIMULATION RESULTS

Parameters	Values
Grid Voltage	230V
Vehicle Battery Voltage	48V
Switching Frequency	50KHz
DC Link Capacitance	7.4μF

Table 1: System Specifications

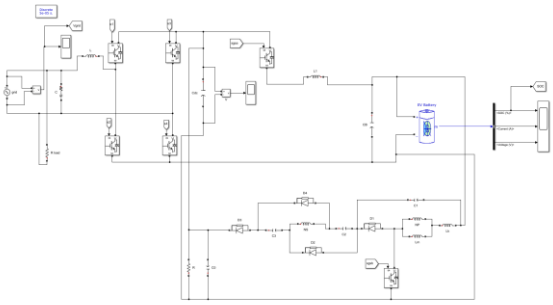

Fig. 6: MATLAB/SIMULINK circuit diagram of the bidirectional converter (Buck and cascaded high gain boost converter topology)

A) SIMULATION RESULTS WITH PI CONTROLLER

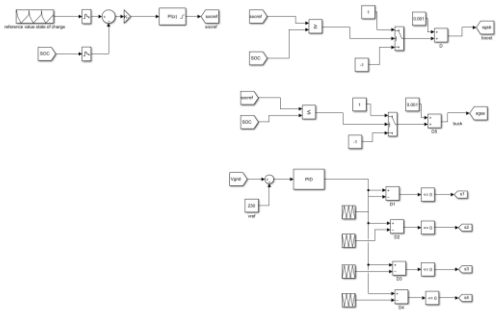

Fig. 7: Control system implemented using a PI controller

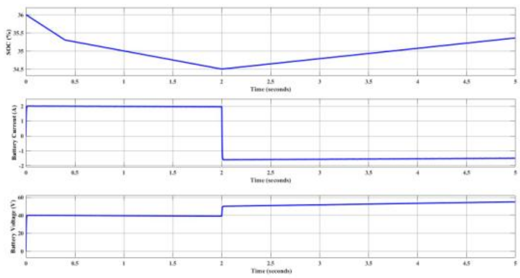

Fig. 8: Charging and Discharging statistics for voltage, current, and state of charge for a battery

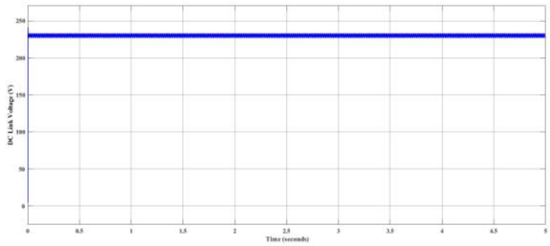

Fig. 9: DC Link Voltage

B) SIMULATION RESULTSWITH NEURAL NETWORK CONTROLLER

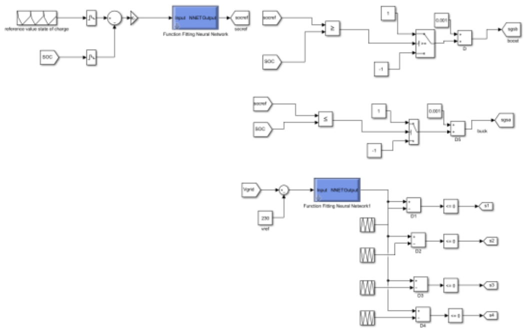

Fig. 10: Control system using an artificial neural network controller

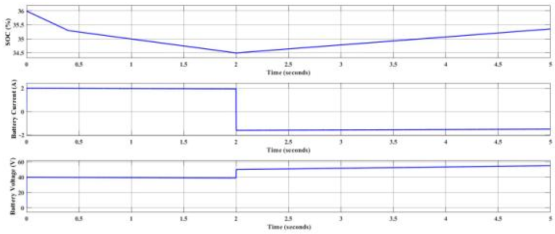

Fig. 11: During charging and discharging, it displays the battery's current, voltage, and SOC

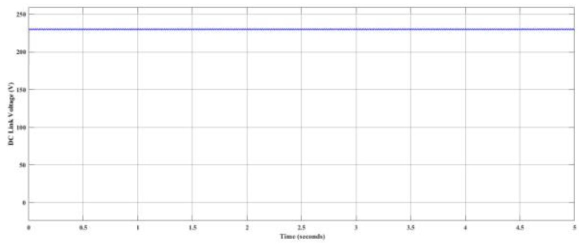

Fig. 12: DC Link Voltage

6. CONCLUSION

Utilities have a lot of potential to the electric vehicle's ability to act as both a generator and a consumer of electricity. You may either charge from a generator to a battery, or from a battery to a generator. The needed voltage is generated via a bidirectional AC-DC charger and a cascade DC-DC converter included inside the charger. With the G2V mode of the integrated DC-DC converter, a buck converter is employed rather of a boost converter, as is the case in the V2G mode. Successful modeling of a bidirectional electric vehicle charger in MATLAB for a V2G application requires a

48V battery model and a DC connection voltage of 230V. The simulation graphs show that the converter works as expected in both the G2V and V2G modes of operation. When batteries are charged or drained in accordance with the guidelines, they perform as expected. Furthermore, a constant 230V dc link voltage is maintained throughout the charging and discharging procedures. The battery discharges and sends voltage back to the grid when its state of charge (SOC) is greater than the reference value; otherwise, it charges and consumes power from the grid. We've upgraded the onboard electric vehicle (EV) system to be powered by an artificial neural network (ANN), which results in far less turbulence than the present technology. The proposed ANN-based converter holds its own in compared to current bidirectional EV chargers, which only provide G2V or V2G modes of operation.

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