International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-9, Issue-1, February 2022
https://doi.org/10.55524/ijirem.2022.9.1.110
Article ID IJIRDP-1161, Pages 520-524
www.ijirem.org

P-V Based Off-Board Electric Vehicle Battery Charger

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ABSTRACT- Research on renewable energy based Electric Vehicle battery charging system is booming in the automobile industry in recent years. The intermittent nature of the renewable energy sources leads to the grid connected renewable energy systems for Electric Vehicle battery charging applications. In this paper, a photovoltaic array-fed off-board battery charging system using a bidirectional interleaved DC-DC converter is proposed for light-weight electric vehicles. This off-board charging system is capable of operating in dual mode, thereby supplying power to the electric vehicles battery from the photovoltaic array in standstill conditions and driving the DC load by the electric-vehicle battery during running conditions. This dual mode operation is accomplished by the use of a three-phase bidirectional direct-current. The model of the proposed system is simulated in MATLAB/Simulink software.

KEYWODS- Electric Vehicle, Battery Charger, Electric Vehicle, Battery Charger

I. INTRODUCTION

Always expanding impacts of green house gases from the customary IC motors lead to natural worries [1-3]. This cleared to the blasting of contamination free Electric vehicles(EVs) in the auto industry. EV battery charging from the utility lattice builds the heap interest on the lattice and in the long run expands the power bills to the EV properties which require the utilization of sustainable energy sources. Due to endless and contamination free nature of sustainable power sources, it very well may be utilized to charge the EV battery. Subsequently, RES driven EV can be named as 'green transportation'. Sun powered is one of the promising RESs which can be effortlessly tapped to use its energy to charge EV battery. Thus, PV exhibt power is utilized to charge the EV battery in the proposed framework with the assistance of force converter geographics.

Lithium particle batteries are generally utilized in the EV because of its high power thickness, high effectiveness, light weight and minimal size. Likewise, these batteries have the limit of quick charging and long lifecycle with low self-release rate. They additionally have generally safe of blast assuming that it is over charged or shortcircuited. During charging these batteries require exact voltage control. Thus, different power electronic converters with voltage regulator are utilized for charging EV battery. Because of the irregular idea of the PV cluster, there is a needfor the power converters to charge the EV battery[4-6]. Among various converters, multiport converters(MPCs) are liked in the installed chargers of mixture EVs because of its ability of connecting power sources and energy stockpiling components like PV cluster, ultra capacitors, super capacitors, energy units and batteries with the loads in EV like engine, lights, power windows and entryways, radios, intensifiers and cell phone charger.

II. OPERATION OF THE PROPOSED SYSTEM

The proposed PV-EV battery charger comprises of a PV cluster, a sepic converter, a half-span BIDC, an EV battery [7], a reinforcement battery bank and a regulator as displayed in Fig 1. The regulator is utilized to create the door heartbeats to the sepic converter for acquiring the consistent result voltage at the dc interface. The door heartbeats to the switches of BIDC are additionally produced to work BIDC in support mode to charge the reinforcement battery from PV exhibit and in buck mode to charge EV battery from the reinforcement battery. Likewise, the regulator produces the entryway heartbeats to the helper switches Sa,Sb, what's more, Sc [8]. During high sunlight based illumination, every one of the helper switches are ON to connect dc interface with PV cluster through the sepic converter, dc interface with the reinforcement battery through BIDC and dc connect with EV battery. Whenever sun powered light is low, switch Sa is switched OFF segregating the PV exhibit and sepic converter from the dc interface [9]. Though the switch Sc is switched OFF to detach BIDC and reinforcement battery from the dc connect, when the sunlight based power is deficient to charge reinforcement battery. The proposed framework works in three modes viz., mode 1, mode 2 and mode 3 are in this part.

A. Mode 1

During top daylight hours, when the produced PV cluster power is higher, every one of the assistant switches are ON to charge both EV battery also, reinforcement battery all the while from PV exhibit through sepic converter and

BIDC, individually. In this mode, BIDC works in forward bearing supporting the dc connect voltage to charge reinforcement battery.

B. Mode 2

During low sun oriented illumination conditions and non-daylight hours, PV cluster power is lacking to charge EV battery. Subsequently, the PV exhibit is detached from the dc interface by switching OFF the switch Sa what's more, switches Sb & Sc are ON associating EV battery to the reinforcement battery through BIDC. In this mode, BIDC works backward bearing venturing down the reinforcement battery voltage to charge EV battery.

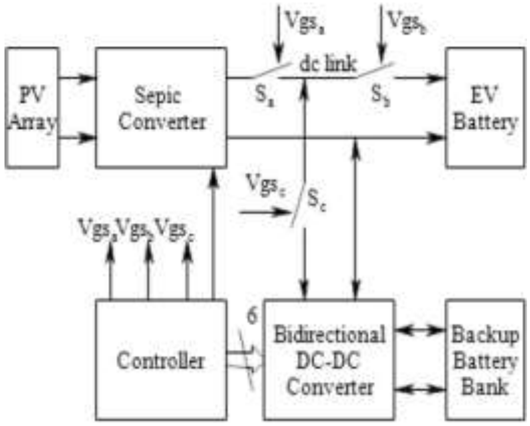

Figure 1: Block diagram of the EV battery charger

C. Mode 3

At the point when PV exhibit power created is adequate to charge just EV battery, switches Sa what's more, Sb are ON and switch Sc is OFF to separate the BIDC and reinforcement battery bank from the dc connect.

III. DESIGN OF THE CONVERTERS USED IN THE PROPOSED CHARGER

3.1 Sepic converter

In the proposed charging framework, the sepic converter gives the consistent result voltage regardless of the PV exhibit voltage by changing its obligation proportion utilizing the PI regulator. The sepic converter comprises of one IGBT switch, one diode, two inductors and two capacitors as displayed in Fig. 2. The significant benefits of the sepic converter are: (I) it can work in both lift and buck modes contingent upon the obligation proportion; (ii) it gives the result voltage a similar extremity as information voltage dissimilar to buck-help and cukconverters . The voltage gain of the sepic converter is given by the accompanying condition:

$$Vdc/ VPV = D /1 – D \quad (1)$$

where Vdc is the dc connect voltage, VPV is the PV exhibit voltage and D is the obligation proportion of the sepic converter. The upsides of inductors and capacitors of the sepic converter are picked according to (2)- (4) [17]:

$$La = Lb = VPVminDmax /2\Delta iPV\ fsw \quad (2)$$

$$C1 = IdcDmax /\Delta VC1\ fsw \quad (3)$$

$$C2 = IdcDmax /\Delta Vdc\ fsw \quad (4)$$

where VPVmin is the base PV cluster voltage, ΔiPV is the information current wave, fsw is the exchanging recurrence, Idc is the dc connect current, ΔVC1 is the capacitor, C1 voltage swell, ΔVdc is the result voltage swell, and Dmax is the most extreme obligation proportion determined as follows:

$$Dmax = Vdc + VD /VPVmin + Vdc + VD \quad (5)$$

where VD is the diode voltage drop.

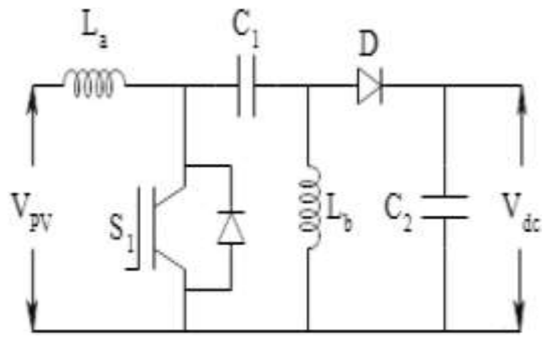

Figure 2: Schematic diagram of sepic converter

3.2 Bidirectional interleaved DC-DC converter

Fig. 3 shows the schematic chart of the BIDC utilized in the proposed charging framework. Reinforcement battery bank is situated on the high voltage side while the dc connect is on the low voltage side of the converter. This converter works in support mode in forward bearing and in buck mode in invert course. In support mode, switches SL1 , SL2 furthermore, SL3 are the dynamic switches while, in buck mode, the dynamic switches are SU1 , SU2, Fig. 3 shows the schematic chart of the BIDC utilized in the proposed charging framework. Reinforcement battery bank is situated on the high voltage side while the dc connect is on the low voltage side of the converter. This converter works in support mode in forward bearing and in buck mode in invert course. In support mode, switches SL1 , SL2 furthermore, SL3 are the dynamic switches while, in buck mode, the dynamic switches are SU1 , SU2.

$$VBackupBatt /Vdc = 1 /1 – Dboost \quad (6)$$

$$Vdc/vBackupBatt= DBuck \quad (7)$$

where VBackupBatt is the reinforcement battery voltage and DBoost is the obligation proportion of BIDC in support mode and DBuck is the buck mode obligation proportion. The upsides of inductors are thought of as not exactly the basic inductance values in both lift and buck modes to work the converter in spasmodic conduction mode to further develop proficiency. The basic inductance esteem is determined in lift and buck modes utilizing (8) and (9), separately

$$Lcric = 3VBackupBatt\ 2\ DBoost\ 1 - DBoost /2P\ fs \quad (8)$$

$$= 3Vdc\ 2\ 1 - DBuck /2P\ fs \quad (9)$$

where P is the Backup battery power. The upsides of the capacitors on the low and high voltage side of BIDC are thought of as founded on the accompanying conditions:

$$CH=DboostP / 2\ fsVBackupBatt\ 2 \quad (10)$$

$$CL =VBackupBattDBuck\ 1–Dbuck / 8\ fs\ 2\ L\Delta Vdc \quad (11)$$

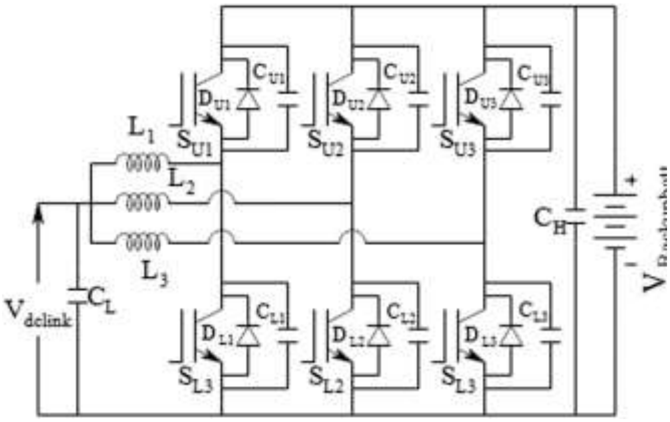

Figure 3: Schematic diagram of half-bridge BIDC

IV. DESIGN OF CONTROLLERS

Regulator of the proposed charger creates entryway heartbeats to the switches present in the sepic converter, BIDC and furthermore to the three helper switches. The calculation to turn ON and switch OFF the helper switches is displayed in Fig. 4. Regulator detects the PV cluster voltage and current, and figures the PV exhibit power. If then the regulator creates the door heartbeats to turn ON all the helper changes to charge both EV battery and reinforcement battery bank all the while from the PV cluster. Assuming that the PV cluster power is lesser than EV battery evaluated power however higher than the base required power, PM, the switch, Sc is switched OFF detaching the reinforcement battery from the charging framework and switches, Sa also Sb are turned ON to charge the EV battery alone from the PV cluster. On the off chance that the PV exhibit power is lesser than the base required power, PM, then the switch, Sa is switched OFF to disconnect the PV exhibit and sepic converter from the charging framework. The switches, Sb also, Sc are turned ON empowering the reinforcement battery to charge EV battery. The PI voltage regulator is utilized in the proposed charging framework to create door heartbeats to the MOSFET in the sepic converter to keep a consistent voltage at the dc interface regardless of varieties in the PV exhibit voltage. BIDC involves three legs with two switches in every leg. Entryway beats must be given to the two switches in a similar leg with the stage shift of 180° from one another. The regulator in the proposed framework creates six entryway heartbeats to the BIDC depending on the PV cluster power.

V. SIMULATION STUDIES AND RESULTS

Simulink in the MATLAB programming is utilized for the reproduction investigations of the proposed framework. PV exhibit is displayed utilizing its old style condition [28, 29]. The Sepic and BIDC converter is displayed utilizing power MOSFETs, inductors and capacitors accessible in SimPowerSystems Blockset in simulink library. Regulator is created utilizing PWM generator, beat generator, rationale doors, comparator, multiplier and PI regulator accessible in the Simulink library. PV exhibit model is coordinated with the created sepic converter and BIDC alongside the battery models accessible in Simulink library for fostering the proposed charging framework as displayed in Figure 4.

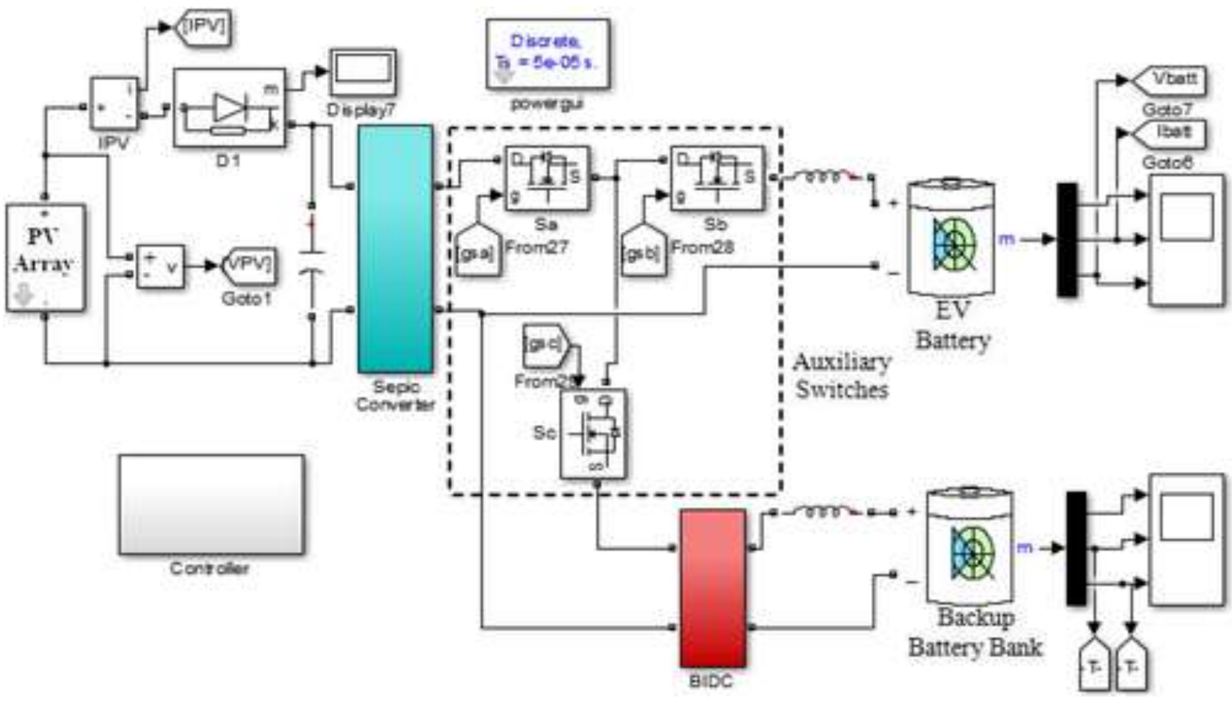

Figure 4: Simulation model of the proposed charger

The created recreation model of sepic converter and BIDC displayed as subsystems in Figure 4 are portrayed in Figure 5(a) and 5(b), individually
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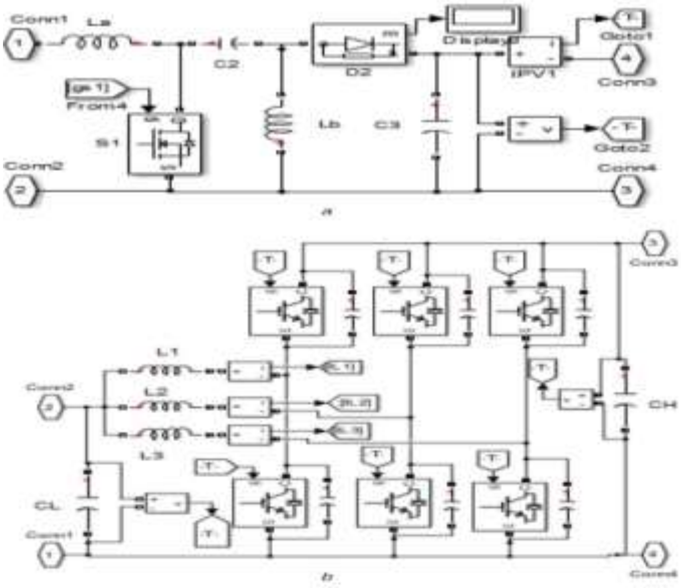

Figure 5: Simulation model of (a) Sepic converter, (b) BIDc

Figure 5 shows that the entryway heartbeats to the switch Sb is generally high as the EV battery is continually charged in every one of the three modes. If the EV battery is completely energized, EV battery is segregated from the charging framework by switching OFF Switch, Sb to stay away from stream charging of EV battery.

VI. EXPERIMENTAL SETUP AND RESULTS

The Simulink model of proposed charger is developed in MatLab. The results of the proposed characteristics as shown in the below plots

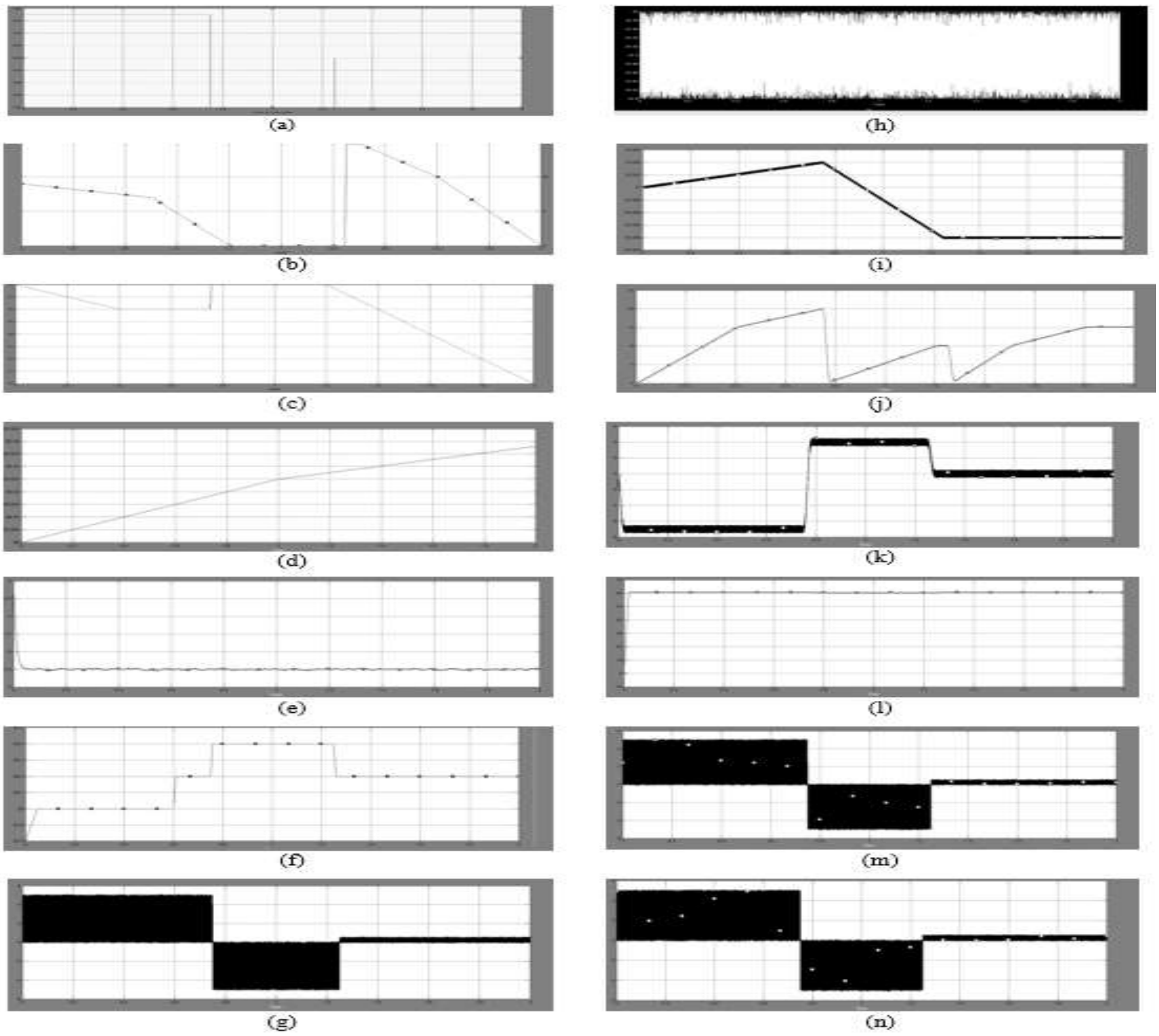

Figure 6: Mat Lab developed Simulink model(plots)

VII. CONCLUSION

In this paper, an off-board EV battery charging framework took care of from PV exhibit is proposed. This paper examines the adaptability of the framework to charge the EV battery continually independent of the illumination conditions. The framework is planned and recreated in Simulink climate of the MATLAB programming. The equipment model is created and tried in research facility for the three methods of activity of the proposed charging framework independently and the outcomes are outfitted. In OPAL-RT Real time test system OP4500, exploratory examination is completed in RCP strategy and the dynamic reaction of the framework is outfitted both in reproduction and trial examination. Relationship between's the reenactment and trial results underline the adequacy of the proposed charger.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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