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Research Article

PV System Fed Bidirectional Converter using Fuzzy with PID Controller for Electric Vehicles

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Abstract

The charging of electric vehicles (EV) is widely high demand in using the renewable photovoltaic system. This paper proposes, the power is fed to the electric vehicles battery from the PV system using the control method of fuzzy with PID controller. Bidirectional converter is proposed to convert the power from the solar energy generation plant to electric vehicle energy storage battery system for the purpose of both charging and discharging power flow. The converter response is controlled using fuzzy with PID controller and the operation of the bidirectional converter is working in both forward and reverse direction. The voltage boosting ratio and buck voltage ratio are high which improves the system stability. The battery storage system is used for enhancing the satisfaction of electric vehicle charging demand while the variable conditions in PV system such as whether conditions, low irradiances and night time etc. Simulink results are obtained and verified in MATLAB/Simulink.

Keywords: Electric vehicles, PV system, PID control, fuzzy controller, bidirectional converter

I. INTRODUCTION

In recent years, the power system configuration is performing in under regular changes due to the environmental distress and pollution, the price and depletion of fossil fuels. The photo voltaic energy generation is increasingly installed at the buildings which are in commercial purpose and electric vehicles parking site [1-2]. Growing awareness about environmental problems and the greenhouse gas impacts are leading the way in Electric Vehicles (EV). Also, due to the fossil fuel energy exhaustion electric power is used to charge the EV batteries, which reduced power grid overabundance, produced from RES such as Photovoltaic (PV) arrays and Wind Turbine Generators (WTG) [3-4].

In future, the transportation is considered to be the mode of electric vehicles (EV). The merits of the EVs are having high efficiency and no emissions while measured up to other vehicles by using fuel's power now a days [5]. Nevertheless, the electric vehicles are charged by electricity from the power grid currently and in this the power provider (grid) also controlled by the fuel mix which is done by fossil fuel.

Inductive chargers can always be static or dynamic that are used in level 1 and level 2 AC charge systems [6-7]. A static charger is an inductive adapter that uses a main inductor in the charging point and a supplementary inductor with in vehicle to charge the vehicle. A magnet circuit is created and energy is transmitted when the main paddle is placed into the vehicle's charge port [8]. A contactless roadway EV battery charger in which energy is transferred from a static

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primary inductor embedded beneath the pavement surface to a supplementary inductor mounted in the passing vehicle is known as a dynamic charging [9-10]. The battery in the electric vehicle is used to the main purpose of PV system energy storage and in the distribution system the negative collision of the PV large scale integration is reduced. During the period of parking time the electric vehicles charging power supply requirement is low [11-12]. These system operations are accomplished by using power electronics converters which are made up of semiconductor devices.

The sustainability power is important for charging electric vehicles from electricity generation of sustainable source to build the EV system with sustainability. For that constraint, the PV system is better for future power generation to charge the electric vehicle [13]. Although, the characteristics of the PV is seasonal variations and changing climate conditions so that the power grid electricity is necessary for EV charging power supply. The PV produced DC supply is given to the connected BDC system to improve the PV voltage to satisfy the load demand that is EV charging [14-15]. The PID controller is used to control the BDC response and improve the proposed system performance. While the excess energy from the PV source and at no load conditions the DC power is stored at energy storage system (battery).

II. PROPOSED SYSTEM

In this proposed system, the bidirectional converter is fed electric vehicle charger and it is powered from the distributed PV renewable system. This paper consists of PV array, battery, and bidirectional converter. The PV fed electrical vehicle charging along BDC proposed block diagram is shown in fig. 1 and the energy storage system is considered to store the PV energy while the extremes period and use in variable conditions and characteristics of the PV system energy generation. The BDC is worked under the both boost mode when the load is connected and act as buck mode to reduce the power supply to store in battery system.

The presented approach even returns the variability in the break points to the desired reference value. This control design includes fuzzy logic as well as PID controllers. A PID controller usually has three value systems, like proportional, integral, and derivative, respectively.

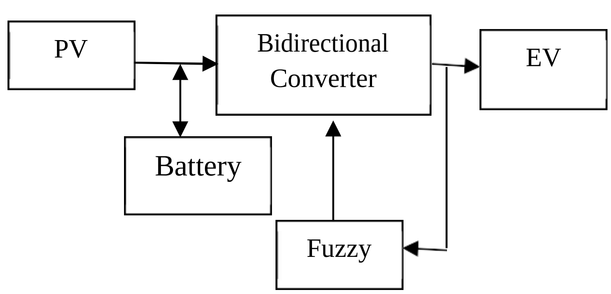
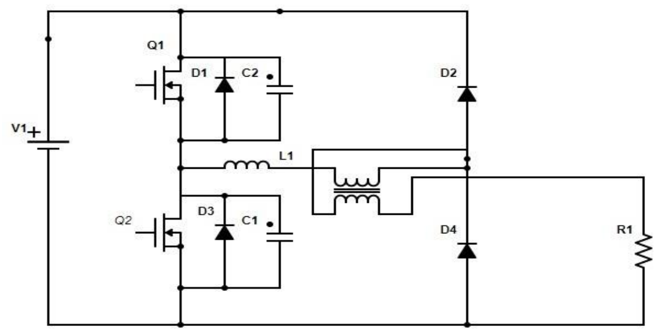


Fig. 1 Block diagram of the proposed system Proposed Bidirectional Converter System

The PV system for electric vehicle charger is consisting non-isolated DC-DC bidirectional



converter. The PV panel is acted as a main supply source and power MOSFETs are utilized with parallel connection of snubber capacitors. In the proposed power conversion topology is achieving the switching soft conditions depends on the direction of power flow automatically. This circuit comprises two power switches, named as Q1 and Q2, the inductor L1 is main inductor for circuit. The diodes D2, D4, and coupled inductor are composed in auxiliary circuit of the proposed converter.

Fig. 2 Block diagram of the proposed system Buck mode

In positive operation, Q1 is in ON state, and it becomes OFF state due to snubber C1, C2. While zero switching is ended the Q2 is turn on and voltage across Q2 decreases to 0. After that D2 is off and D3 is conducting and Q2 is turned off because of V_{Q2} is slowly increasing. Then the Q1 is conducting, and V_{Q2} decreases to 0 and soft switching for Q1.

In negative operation, the power supply is fed to load and which act as boost operation In this inductor current is negative and in entire time cycle. The negative to positive values and positive to negative changed continuously in this operation.

III. CONTROL METHOD

The control system-based plant controllers are used to control the performance of bidirectional converter system model. The converter is controlled by the operation control of the process variable as shown in figure 4. In the proposed system, PID closed loop control is used for the purpose of converter operation control and the proposed system response regarding the high voltage gain system.

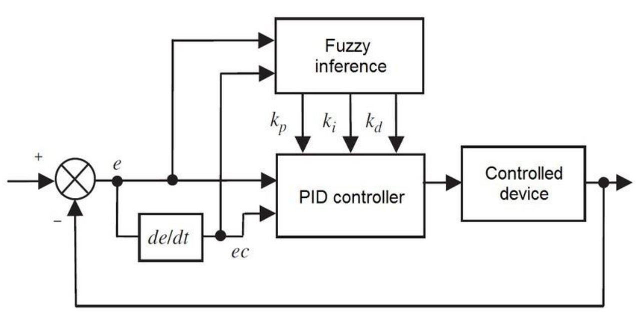


Fig. 3 Fuzzy-PID controller Block Diagram

The output feedback to the controller is to reduce the error while comparing with the reference input. The error signal e(t) calculated from the difference between actual feedback output signal Vo(t) and input reference or set point R(t). To achieve overall proposed system efficient, the necessary excitation is provided to the plant. The obtained error from the sum point is fed to computation of integral and derivative signal providing PID controller. The output of the PID controller u(t) to be applied to the BDC proposed converter.

In the proposed model, the fuzzy controller is suggested to handle the transformation of dc-dc BDC converter that is expanding the power supply DC. In this implemented 3*3 law based fuzzy logic technique in this scheme. Variables of Kp, Ki and Kd are calculated with fuzzy concepts in this scheme. The Fuzzy-PID input includes two inputs with error and mistake from the duta and three outputs with Kp, Ki and Kd. The control of the Fuzzy-PID and the settlement time are reduced. With the constructed Fuzzy-PID controller, the processing parameters of the voltage source has been boosted. The block diagram of the proposed dc-dc system design of the Fuzzy-PID controller.

IV. SIMULATION AND RESULTS

The proposed BDC based PV system for charging the electric vehicle as shown in fig. 4 and fig. 5. The input supply is generated from PV panel that installed at rooftops. The DC power is produced in PV panel and it is fed to power the proposed bidirectional converter. The BDC proposes, the boost operation mode as well as buck operation mode for the purpose of achieving the high voltage gain and storing the generated power in battery. The electrical vehicle charging system has a bidirectional converter which has two operation directions. The boost voltage is attained from the source supply DC in positive operation of the BDC to charge EV system. The reduced or buck voltage is achieved to store the power in the energy storage system which means battery for the future utilization. The switching signals are used for the bidirectional flow of power in the proposed system converter performance. The BDC power switches are controlled by the PID controller to improve the system performance.

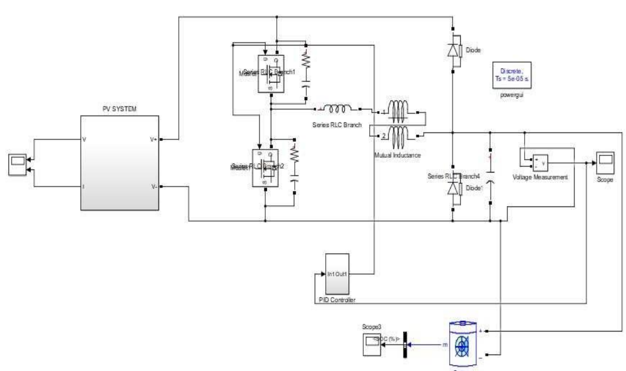


Fig. 4 Simulink model of buck mode for proposed system

The proposed BDC based buck mode operation of the converter is reducing the energy from the PV system and fed it to store in the battery. The buck operation of the proposed bidirectional converter simulink model is shown in fig. 4.

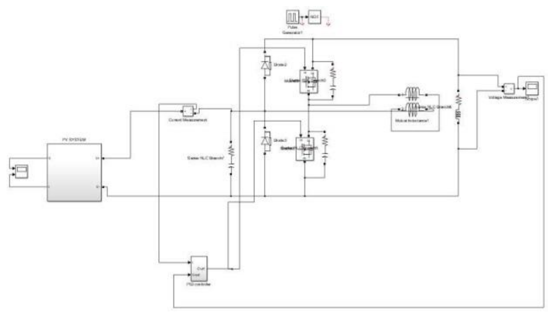


Fig. 5 Simulink model of boost mode for proposed system

The input voltage for the electric vehicle charging system is achieved from the renewable photo voltaic (PV) system. The boost operation mode based simulink model is shown in fig. 5. The installed PV for charging of electrical vehicle system 100V is generated and fed to the BDC.

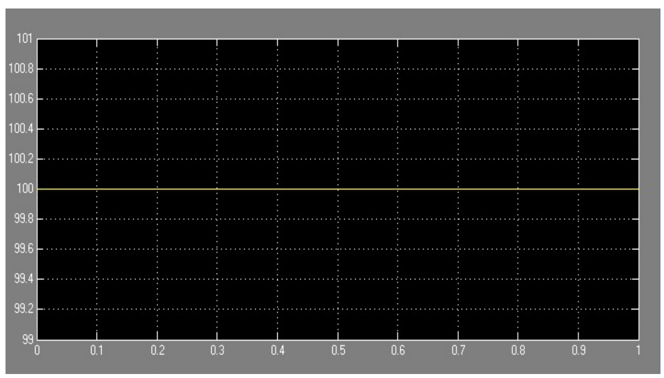


Fig. 6 PV input voltage for proposed system

The reduced voltage is obtained in the operation of BDC negative which is used to store at battery for the future EV requirement. Stored energy is after fed to load demand for the satisfaction and the energy from battery is improved to achieve regulated voltage power supply for EV charging. The buck mode BDC output voltage for storing in battery is nearly to 13V.

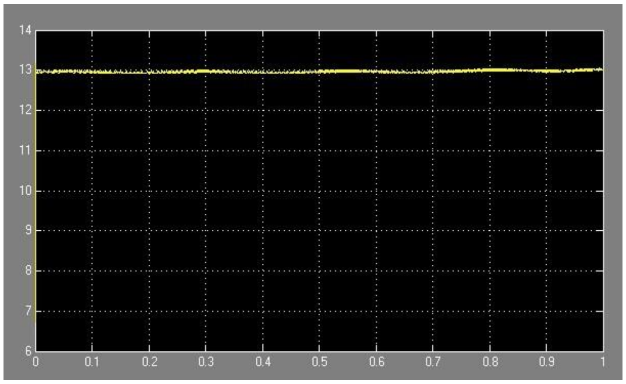


Fig. 7 Buck mode output voltage for battery

The SOC% of the battery is started to increasing and the battery is charging. The output voltage of the proposed BDC positive operation based buck voltage is shown in fig.7. SOC% of the battery while the BCD converter is under positive operation is represented in fig. 8. The negative operation of the BDC is increasing the input supply which fed from the PV system. The proposed bidirectional converter is operating as a boost converter for electric vehicle charging by means of high voltage gain. The BDC output voltage is around 155V while converter is act as boost converter under the negative operation. The negative operation output voltage is shown in fig. 9.

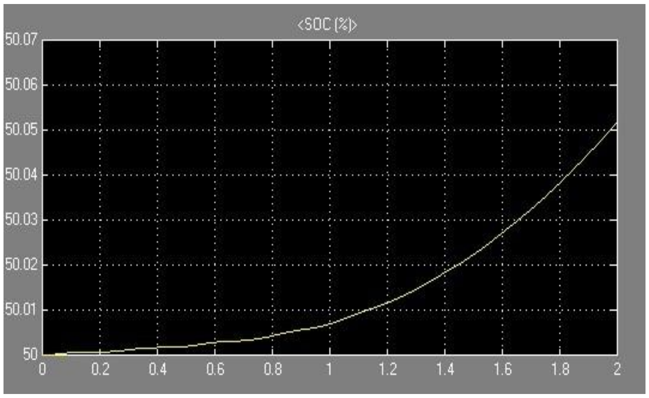


Fig. 8 charging of battery SOC%

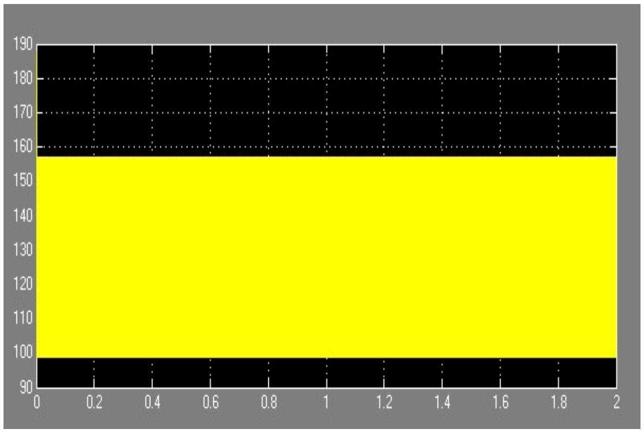


Fig. 9 Boost mode output voltage for EV charger

V. CONCLUSION

The electric motor charging focused on bidirectional converter operated by the solar pv system is suggested in this study. The basic structure is proposed with both the requirements of soft switching and containing two diodes, an inductor and mutual inductor. The BDC is used to charge the electric vehicle, and the PID control strategy is used to regulate the converter responses and output. EV charging from solar energy production with bidirectional power flow is used to verify and evaluate the proposed device. MATLAB/Simulink is used to obtain the effects of the proposed system's activities. The proposed scheme, as well as its outcomes, are examined and tested.

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