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A Hybrid Multiinput DC-DC Converter With Energy Storage Stage For Electric vehicle Application

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Abstract:

A three-input DC–DC boost converter is proposed in this paper. The two unidirectional input power ports and a bidirectional port interface with the proposed converter to achieve a unified storage structure. This converter is interesting for hybridizing alternative energy sources such as photovoltaic source, battery1, and battery2. Supplying the output load, charging or discharging the battery2 can be made by the PV and the battery individually or simultaneously. The proposed structure utilizes only four power switches that are independently controlled with four different duty ratios. Utilizing those duty ratios, tracking the maximum power of the PV source, setting the battery1, controlling the battery2 power, and regulating the output voltage are provided. Depending on utilization state of the battery2, three different power operation modes are defined for the converter. In order to design the converter control system, small signal model is obtained in each operation mode. Due to interactions of converter control loops, separate closed controllers are designed with the help of decoupling network. The validity and control performance of the proposed converters are verified by simulation and experimental results under different operation conditions.

Keywords — **Hybrid electric vehicle, DC-DC converter with multi input.**

I. INTRODUCTION

Global warming and lack of fossil fuels are the main drawbacks of vehicles powered by oil or diesel. In order to overcome the above mentioned problems and regarding the potential of clean energies in producing electricity, car designers have shown interest in hybrid electric vehicles (HEVs) and plug in electric vehicles. The overall structure of EV powered by renewable resources is depicted in Hybrid Electric vehicles (HEVs) have also been studied. HEVs rely on energy stored in energy storage system (ESS) [1]. However, by using a bidirectional on/off board charger; they could have the V2G capability. V2G allows the vehicle to provide power to help the load to be balanced by "valley filling" (if the requirement of demand is low, charging takes place at night) and "peak shaving" (if the requirement of demand is high, Power send to load). Solar-assisted EVs have also been studied. Required location and size of PV panels have made them impractical at present [2]. Employing battery as the main power source of EVs. The batteries have low cost and good transient performance than FCs. The less emission of carbon monoxide is the major advantage of Hybrid electric vehicle. Miaosen has studied employing a Z-source inverter for EV vehicles. Boosting input voltage in one stage is its advantage, while high voltage and current stress and complex control method are the main drawbacks of the presented converter. Another approach was done in [3]. The system was powered by a battery unit. V2G is one of the advantages of the proposed converter. However, the more number of power switches may lead to reduction in the reliability and to increase the cost. In a multi input dc–dc boost converter for hybrid PV/Battery is proposed, but the proposed converter cannot work properly because the battery2 can be only discharged by PV and only charged by battery1. In [4], a two-input dc–dc converter is proposed to interface two power sources with a dc bus or load. The converter has high efficiency due to achieving turn-on zero voltage switching of all switches. However, it lacks a bidirectional port. Hence, in applications in need of ESS, it cannot be used. However, the high number of semiconductors and passive elements reduce the efficiency. Control method preset in the vehicle's controller should control the power flow between renewable resources, battery unit, and electrical motor. Optimal utilization of power resources, providing demand power permanently, operating PV panel in their optimum region are the main duties of control scheme. Some converters have been proposed recently for PVs systems [5]–[6], but the required converter for HEV applications should extract power from PV and battery1.

Besides, in order to supply back-up power from the battery2, a bidirectional port is needed to charge and discharge the battery2 according to lack of congruence between generated power and demanded energy. A multi-input converter can provide power to the load from different energy sources simultaneously or individually. In the literature, several attempts have been done to get the task done. An attempt has been done, in which an intelligent optimal power management was introduced. The scheme has three main advances including control of temperature fan, fuzzy hydrogen control, and adaptive current–voltage fast-charging control. In, a two-layer energy management has been studied. Minimizing hydrogen consumption is the objective of this study. Due to the fact that initial cost of PVs is high and in order to increase the extracted power from the PV panels, MPPT

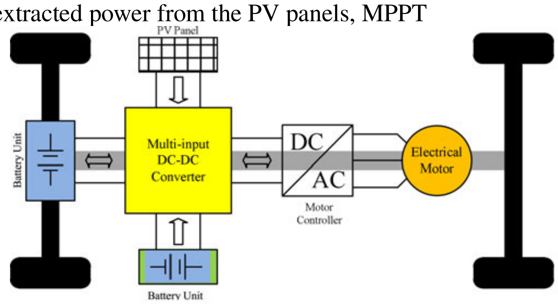


Fig 1.1

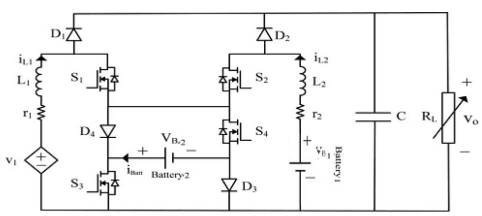


Fig 1.2

Algorithm has to be utilized. In a general comparison is made between different MPPT techniques with respect to tracking factor, dynamic response, PV voltage ripple, and use of sensors. The other way to improve the efficiency is to enhance the efficiency of the electric components. In this study, a novel three-input dc–dc converter is proposed to merge a PV, a fuel cell, and a battery and connect them to the grid. Furthermore, dc gain is enhanced in respect of conventional converters. Meanwhile, MPPT can be obtained for PV. The battery can be charged and discharged in order to achieve power management. In the following two sections, the proposed structure is studied and different operation modes are discussed. In Section IV, the converter is modelled and liberalized to control the converter. Principles of power management and MPPT algorithm are explained in Section V. Additional advantages and useful features of the presented converter and adapting it to HEVs are discussed in Section VI. In Section VII, practical results of the proposed converter are given. Finally, Section VIII concludes the whole paper.

II. PROPOSED METHOD

The structure of the proposed three input Dc-Dc converter is depicted in fig 1.1 the converters is formed of two conventional boost converters substituting extra capacitor in one of the converters and a battery2 to store the energy. Characteristic of the converter is suitable for hybrid systems.

In this paper, behavior of the converter in terms of managing the sources is analyzed in power management and control part. Then, vPV and Vbatt1 are two independent power sources that output is based on characteristic of them. L1 and L2 are the inductances of in- put filters of PV panel and battery1. Using L1 and L2 as in series with input sources change PV and battery1 modules to current sources. r1 and r2 are vPV 'S and vbatt1 'S equivalent resistance, respectively. R Load is the equivalent resistance of loads connected to the dc bus. S1, S2, S3, and S4 are power switches. Diodes D1, D2, D3, and D4 are used to establish modes, which will be described. Capacitor C1 is used to increase output gain and output capacitor Co is performed as an output voltage filter. System is operating in continuous-conduct mode to produce smooth current with least possible amount of current ripple.

A. Multi-Input DC–DC Converter

The proposed multi-input dc-dc converter is the fusion of the buck-boost converter. Combination of the multi input dc-dc converter is achieved by inserting the pulsating voltage source of the buck converter into the buck-boost converter. In order not to hamper the normal operation of the buck-boost converter and to utilize the inductor for the buck converter, the pulsating voltage source of the buck converter must be series-connected with the output inductor. If one of the voltage sources is failed, the other voltage can still provide the electric energy.

B. Advantages & Disadvantages

Dc-Dc converters are most common and are widely used in renewable energy Systems to provide a controlled and regulated supply from an uncontrolled and regulated renewable energy source. In power applications is proposed.

III. MODES OF OPERATION

In this section, principles of the proposed converter are discussed. Operation of the converter is divided into three states:

1) The load is supplied by PV and battery1 and battery2 is not used. 2) The load is supplied by PV, battery1, and battery2, in this state, battery2 is in discharging mode. 3) The load is supplied by PV and battery1 and battery2 is in charging mode.

The proposed structure utilizes only four power switches that are independently controlled with four different duty ratios. Utilizing these duty ratios facilitates controlling the power flow among the input sources and the load. Powers from the input power sources can be delivered to the load individually or simultaneously. Moreover, the converter topology enables the storage element to be charged or discharged through both input power sources. Besides, in order to design the control system, converter small-signal model is obtained in each operation mode. Due to multivariable nature of the control system, decoupling network is utilized in order to separately design closed-loop controllers. The conventional method of three input source of hybridizing with three boost cells the proposed converter leads to reduction of usage inductors, allows using low-voltage batteries, works in operating points with high stable margin and access to high-voltage of boost factor. As another improvement in our proposed system in comparison with converter represented in the battery2 can be charged and discharged through the both power sources individually and simultaneously. Also, four duty ratios of the converter are controlled independently, so the restriction of the duty ratios summation is eliminated which results in high level of the output voltage.

B. FIRST MODES OF OPERATION

During stage 1, switches S1 and S2 are turned ON and inductors L1 and L2 are charged with voltages across vb1 and vb2 , respectively

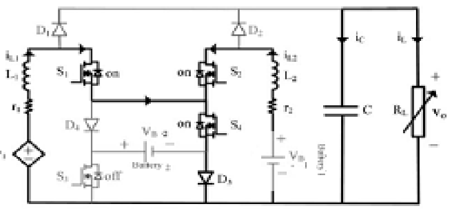
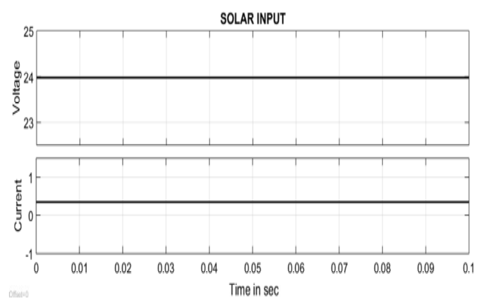
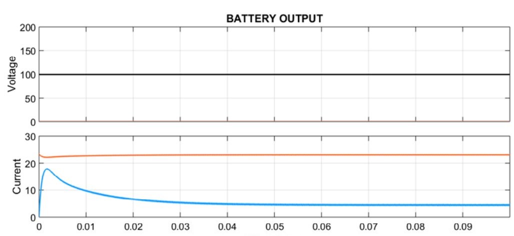


Fig 3.1





(a)

During stage 2,

switch S1 is turned OFF, while switch S2 is still ON Therefore, inductor L1 is discharged with voltage across V1 – V0 into the output load and the capacitor through diode D1 , while inductor L2 is still charged by voltage Across V2.

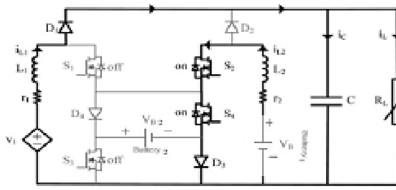


Fig 3.2

During stage 3,

switch S2 is also turned OFF and inductor L2 is discharged with voltage across v2 – vo , as like as inductor L1

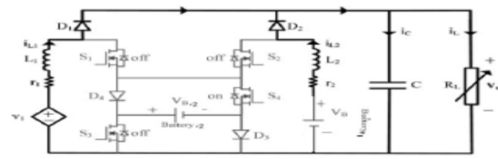


Fig 3.3

C. SECOND MODE OPERATION

During stage 1, switches S1 ,S2 , and S4 are turned ON, so inductors L1 and L2 are Charged with voltages across v1 + VB and V2 + VB

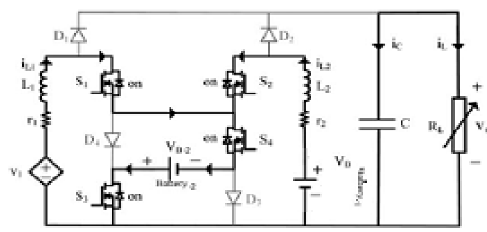


Fig 3.4

During stage 2, switch S4 is turned OFF, while switches S1 and S2 are still ON. Inductors of L1 and L2 are charged with voltages across v1 and v2 , respectively

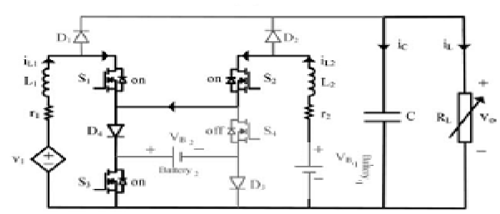


Fig 3.5

During stage 3, switch S1 is turned OFF, so inductor of L1 is discharged with voltage across V1 – Vo, while inductor L2 is still charged with voltages across v2

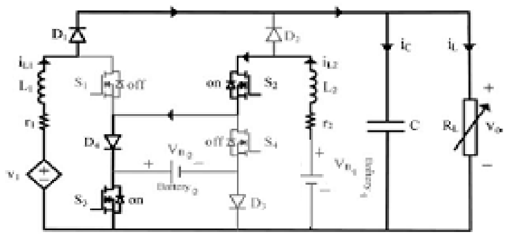
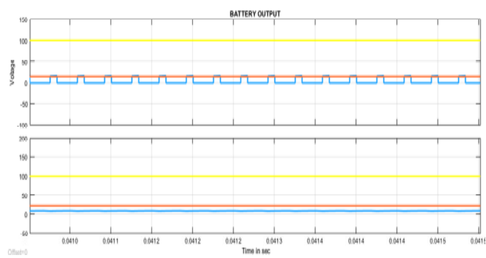


Fig 3.6



D. THIRD MODE OPERATION

Switch S2 is also turned OFF and inductors L1 and L2 are discharged with voltage across V1 – Vo and V2 – Vo

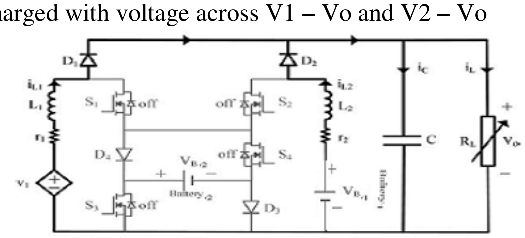
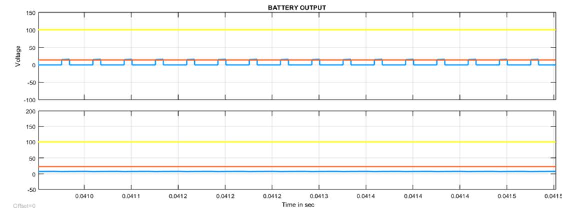


Fig 3.7



IV. CONVERTER STRUCTURE AND MODES OF OPERATION

The structure of the proposed three-input dc–dc boost converter is represented in Fig.3.7 As seen from the figure, the converter interfaces two input power source of v1, v2 and a battery as used in the storage element. For an example, for a PV source at the first port, v1 is identified as a function of current is iL 1, light intensity, and ambient temperature. In the converter structure, two inductors L1 and L2 make the input power ports as two current type sources, which result in drawing smooth dc currents from the input power sources. The RL is the load resistance, which can represent the equivalent power feeding an inverter. Four power switches of S1, S2, S3, and S4 in the converter structures are the hybrid power system is use to control the power flow of an elements. The circuit topology enables the switches are used to control the four independent duty ratios d1, d2, d3, and d4, respectively. As like as the conventional boost converters, diodes D1 and D2 conduct in complementary manner with switches S1 and S2.

V.CONCLUSION

A new three-input dc–dc boost converter with unified structure for hybrid power systems is proposed in this paper. The proposed converter is applied to hybridize a PV, Battery 1, and battery 2 storage systems. Four independent duty ratios of the converter facilitate power flow among input sources and the load. Three different power operation modes are defined for the converter and its corresponding transfer function matrix is obtained in each operation mode. To design the closed loop compensator of converters, two types of decoupling networks are used. Utilizing these decoupling networks and frequency-domain bode plot analysis, the converter controllers are separately designed which lead to achieve phase margin $60^\circ \leqslant$ P.M $\leqslant 80^\circ$ and gain margin G.M $\geqslant$ 10 db and enough cutoff frequency for the system. As the simulation results show, the converter control system provides good transient and steady state responses for the converter with respect to the different step changes in the PV power generation and the load condition. In addition, the designed converter closed-loop control system is highly stable for the all possible operating points. The simulation results are verified by a low power range laboratory prototype with an acceptable efficiency.

REFERENCES

[1] A. Ostadi and M. Kazerani, “Optimal sizing of the battery unit in a plug-in electric vehicle,” *IEEE Trans. Veh. Technol.*, vol. 63, no. 7, pp. 3077–3084, Sep. 2014.

[2] P. Mulhall, S. M. Lukic, S. G. Wirashingha, Y.-J. Lee, and A. Emadi, “Solar-assisted electric auto rickshaw three-wheeler,” *IEEE Trans. Veh. Technol.*, vol. 59, no. 5, pp. 2298—2307, Jun. 2010.

[3] O. Hegazy, R. Barrero, J. Van Mierlo, P. Lataire, N. Omar, and T. Coose- mans, “An advanced power electronics interface for electric vehicles applications,” *IEEE Trans. Power Electron.*, vol. 28, no. 12, pp. 1–14, Dec. 2013.

[4] R. J. Wai, C. Y. Lin, and B. H. Chen, “High-efficiency DC–DC converter with two input power sources,” *IEEE Trans. Power Electron.*, vol. 27, no. 4, pp. 1862–1875, Apr. 2012.

[5] R. B. Mohammad, H. Ardi, R. Alizadeh, and A. Farakhor, “Non-isolated multi-input–single-output DC/DC converter for photovoltaic power gen- eration systems,” *IET Power Electron.*, vol. 7, no. 11, pp. 2806–2816, Jun. 2014.

[6] L. W. Zhou, B. X. Zhu, and Q. M. Luo, “High step-up converter with multiple input,” *IET Power Electron.*, vol. 5, no. 5, pp. 524–531, May 2012.