PalArch's Journal of Archaeology of Egypt / Egyptology

SWITCHED CAPACITOR CONVERTER-BASED MULTIPORT CONVERTER INTERGRATING BIDIRECTIONAL PWM AND SERIES RESONANT CONVERTERS FOR STANDALONE PHOTOVOLTAIC SYSTEMS

Raja.M,Yeswanth.R,Sri Sari.A
Student
Department of Electrical Electronics Engineering
Engineering VISTAS Chennai-India
Mail ID: rajamarudhairajan@gmail.com,
yeswanthragupathi@gmail.com
srhari.kkl@gmail.com

T.R.Premila.
Assistant Professor
Department Electrical Electronics
VISTAS
Chennai-India
Mail ID: trpremilashaji@gmail.com

T.R.Premila., Raja.M,Yeswanth.R,Sri Sari.A; Switched capacitor converter-based multiport converter intergrating bidirectional pwm and series resonant converters for Standalone photovoltaic systems-Palarch's Journal Of Archaeology Of Egypt/Egyptology 17 (9). ISSN 1567-214x
Key words: Bidirectional converter, Maximum power point trackers (MPPTs), Pulse Width Modulation (PWM), DC-distribution applications, Sim Power System.

Abstract:
Photovoltaic (PV) systems containing a rechargeable battery as an energy buffer require multiple dc–dc converters for PV panel control and battery regulation, and hence, they are pronto be complex and costly. To simplify the system by reducing the number of converters, this paper

proposes the non isolated switched capacitor converter (SCC)-based multi port converter (SC-MPC) for standalone PV systems. The proposed SC-MPC can be derived by integrating a bidirectional pulse width modulation (PWM) converter, series-resonant converter (SRC), and an SCC with sharing switches. PWM and pulse frequency modulation (PFM) controls are employed for the PWM converter and SRC, respectively, to regulate either a battery voltage, output voltage, or input power from a PV panel, depending on power balance among the input, battery, and load. The 150-W prototype was built for an experimental verification, and the results demonstrated the output voltage could be regulated independently on the battery voltage or input port of PV panels.

I. Introduction

MULTIPORT dc-dc converters have attracted a great deal of research interest recently, which could be attributed to the growing demand of renewable energy, the development of power electronic systems, and the increasing use of micro grids. Compared to several separate dc-dc converters, multiport dc-dc converters suggest a compact structure with a lower cost and less component counts. At higher voltages, switches voltage stress is a major challenge for multiport dc-dc converters. The reason for that are the issues such as the cost and the inaccessibility of high voltage switches, which could also have a negative effect on overall efficiency due to their high forward voltage drop and ON-state resistance. Moreover, the typical semiconductors used in high voltage applications are IGCT and high voltage IGBT. Which are not good solutions for multiport dc-dc converters. Due to the very high switching losses of those switches, their switching frequency is practically limited to about 1 KHz; therefore, the size of the passive components will increase dramatically. This study aimed at designing a high-efficiency multiport dc-dc converter with reduced voltage stress across semiconductor devices and shrunken passive components size.

Renewable energy sources have become an important part of energy production. The application of clean and renewable energy sources, such as wind energy, solar energy and hydrogen, in dc micro grids or nano grids has been a focus in academia and industry. However, due to intermittent feature of wind and solar sources, wind power and photovoltaic (PV) systems need energy storage units to balance electricity generation and consumption within a power system, which has a high wind/solar energy penetration. In order to fulfill various system requirements, many hybrid system configurations and converter topologies have been proposed and investigated as reviewed. In order to combine several input power sources two approaches are usually adopted: multiple-converter systems and multiple-port systems. On the one hand, multiple-converter systems are formed by connecting the input sources by individual dc-dc converters. This system configuration offers some advantages such as easier implementation of the power management and control scheme. However, it presents the disadvantage of higher number of components and, consequently, low power density and high cost. On the other hand, multiple-port or multiple-input converters (MIC) have recently been introduced and have attracted increased research interest. In these topologies, the common characteristic is the shared output stage by the different input ports, reducing the cost by reducing the number of components, and increasing the system efficiency and power density.

Fuel cell stacks and photovoltaic panels generate low DC voltages and these voltages need to be boosted before converted to AC voltage. Therefore, high step-up ratio dc– dc converters are preferred in renewable energy systems. A new topology to boost the input voltage to desired levels with low duty ratios, utilizing coupled inductor and to achieve high step-up voltage gain with an appropriate duty ratio have been proposed [1],[2]. In addition, the voltage stresses on the main switch and Output diode are reduced by a passive clamp circuit; therefore low resistance *R*DS (ON) for the main switch can be adopted to reduce conduction loss.

The key factors for renewable energy power conversion systems in industrial applications are Efficiency, power quality, and reliability. Du [3] suggested a novel scheme to improve performances of high-voltage large-capacity photovoltaic power stations. The power conversion of photovoltaic system is divided into two stages, i.e. DC/DC power conversion and DC/AC power conversion. In DC/DC stage, many power units are connected in parallel, each one of which includes a photovoltaic array and a non isolated DC/DC converter. The DC/AC power conversion is equivalent to a voltage source in series with a current source.

A family of a single-switch three-diode dc–dc pulse width-modulated (PWM) converters operating at constant frequency and constant duty cycle is presented by Ismail[4] . They described that the converters are different from the conventional DC–DC step-up converters, and they posses higher voltage gain with small output voltage ripples.

However, A high step-up converter with high step-up gain and low diode voltage stress, suitable for green power source conversion by employing a coupled inductor and switched capacitor, achieves high step-up conversion ratio without adopting extremely high duty ratio or high turns ratio. The voltage spike that occurs on the power switch is alleviated allowing a low-voltage-rated power switch with low *R*DS*(*ON*)* and thus reduces the conduction losses is presented by Kuo-Ching Tseng[5],[6],[13].

High Step-Up Trans-Inverse (Tx^{-1}) DC–DC Converter for Distributed Generation System is presented by Yam [7] . The topology utilizes magnetic coupling for boosting its output voltage, unlike other converters with coupled magnetic and voltage gain is increased by reducing its magnetic turns ratio. The name “Trans-inverse (Tx^{-1})” is used for representing this inverse operating principle of the converter. The converter draws a continuous current from the source, and suitable for many types of renewable sources. Its leakage energy from the coupled magnetic has further been recycled and transferred to the load by an integrated regenerative snubber circuit. Moreover, the use of DC-current-blocking capacitors has also helped to prevent core saturation.

Ching[8] proposed a novel high step-up converter for fuel-cell system applications. They illustrated a two-phase version configuration. First, an interleaved structure is adapted for reducing input and output ripples. Then, a Cuk-type converter is integrated to the first phase to achieve a much higher voltage conversion ratio and avoid operating at extreme duty ratio. In addition, additional capacitors are added as voltage dividers for the two phases for reducing the voltage stress of active switches and diodes, which enables one to adopt lower voltage rating devices to further reduce both switching and conduction losses.

A novel two-switch high-step-up isolated converter with voltage lift is proposed by Liang [9] .In this paper; the proposed isolated converter utilizes a transformer with low turn ratio to achieve high step-up gain. The secondary winding charges two boosting capacitors in parallel as switches during the switch-on period, and two boosting capacitors are discharged in series during switch-off period. Thus, the converter has high voltage gain with appropriate duty ratio. In addition, by using two clamping diodes and capacitor on the primary side, leakage energy is recycled and the voltage spikes of the two active switches are clamped, thereby improving conversion efficiency.

II. System Description

The block diagram of existing system is shown in Fig 2.1. Low voltage DC is stepped up to the required value using boost converter and rated DC is applied to the load.

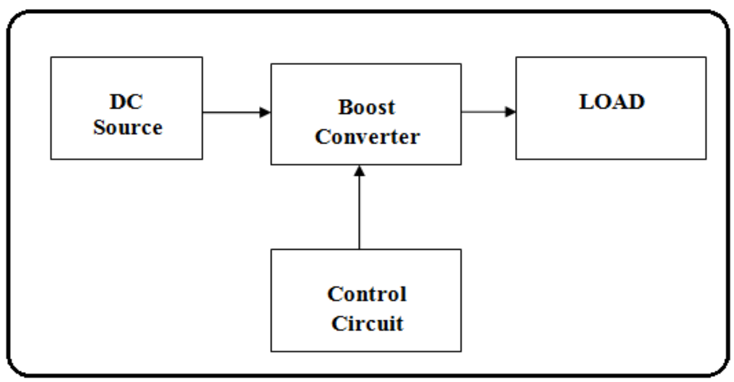

Fig 2. 1. Block diagram of Existing System

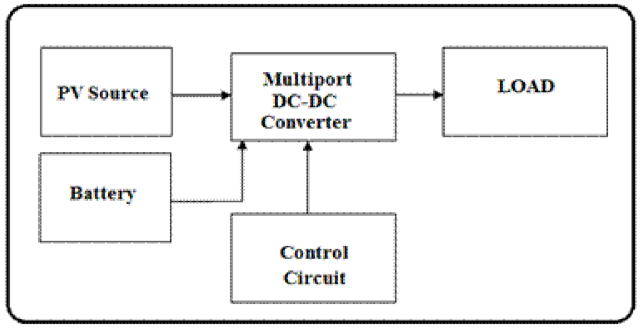

Fig 2.2 Block diagram of Proposed multiport DC-DC converter system.

The block diagram of the proposed multiport DC-DC system is shown in Fig 2.2. The multiport DC-DC is proposed to reduce the ripple voltage of the open loop system. Ripple voltage is compared with C, π, T and cascaded filter. The proposed circuit diagram is shown in fig 2.3.

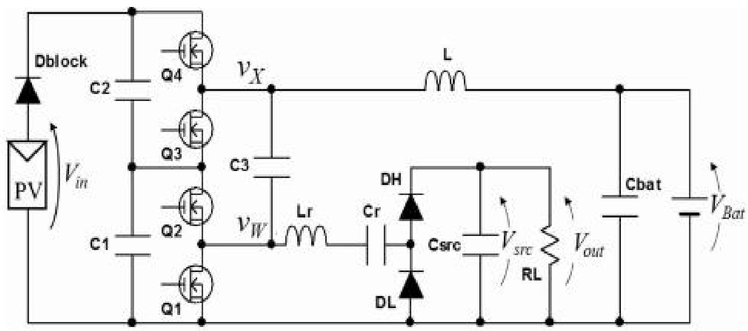

Fig. 2.3. Circuit diagram of multiport DC-DC converter system.

III. Simulation Results

Multiport DC –DC converter systems with C, ∏,T and cascaded filters are modeled and simulated using simulink. The results of these systems are presented in this section. MP DC-DC system is shown in Fig 3.1. The PWM produces updated pulses for the main switch of M1&M2. The Fig 3.2 shows the input voltage form the DC is 24V. The output current with MP DC-DC converter is 0.7A as shown in Fig 3.4. The output voltage with MP DC-DC converter is 160Volts as shown in Fig 3.5.

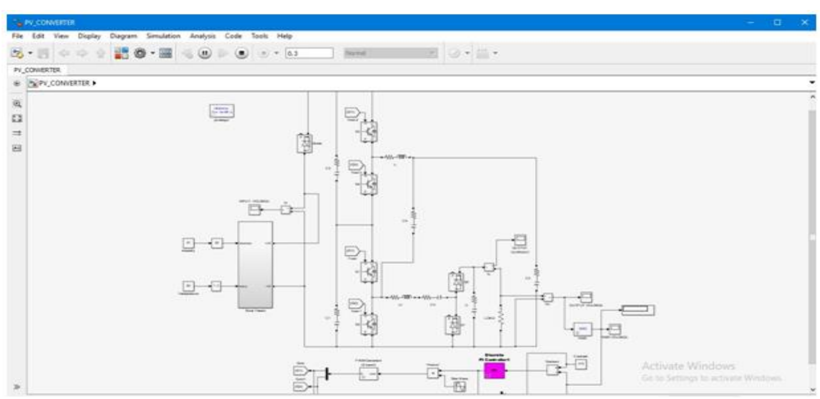

Fig 3.1 HGSC system with C-Filter

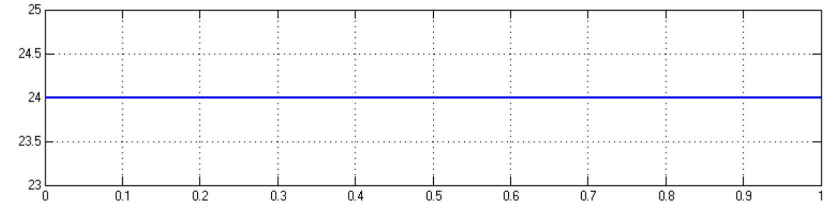

Fig 3.2 Input voltages

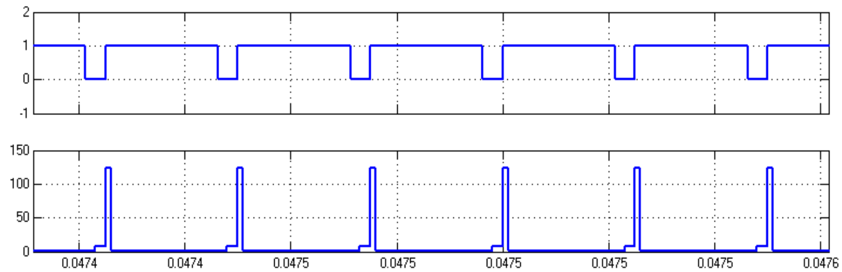

Fig 3.3 Switching pulse for M1 & Vds

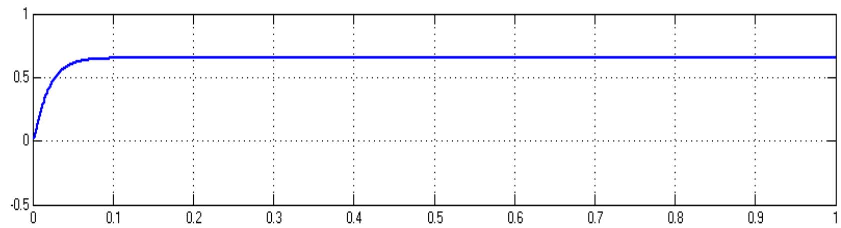

Fig 3.4 Output current

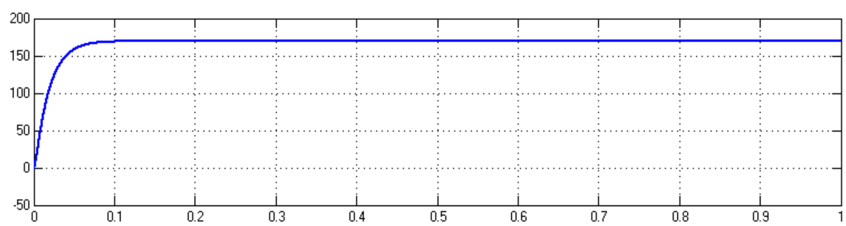

Fig 3.5 Output voltage

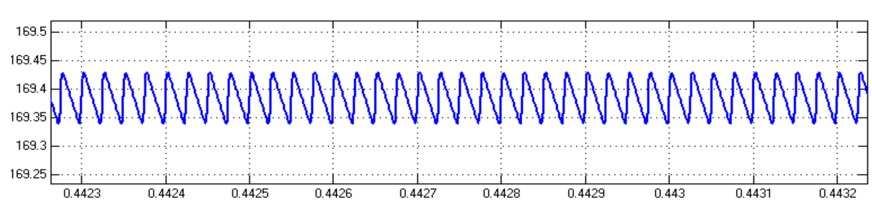

Fig 3.6 Output ripple voltage

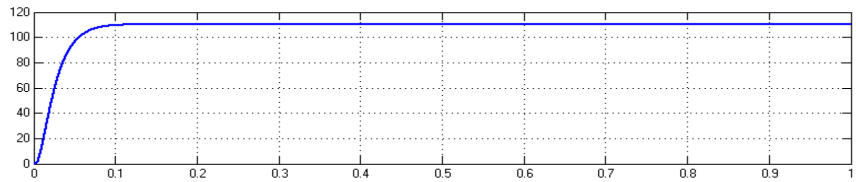

Fig 3.7 Output Power

Table-1
Comparison of Ripple voltages

MP DC-DC Converter	Output Voltage ripple
C-filter	0.08v
∏-filter	0.05v
T-Filter	0.04v
Cascade-filter	0.003v

The comparison of different Filters with various output ripple voltage is shown in Table-1. The C-Filter Ripple voltage is 0.08v, ∏-Filter Ripple voltage is 0.05v, T-Filter Ripple voltage is 0.04v and Cascaded-Filter Ripple voltage is 0.003v. C-Filter is 0.08v and Cascaded-Filter is 0.003v. It is observed that the Ripple voltage is minimum with cascaded Filter.

IV. Exprimental Results

The Hardware snap shot for MP DC-DC system is shown in Fig 4.1. The hardware consists of control board, rectifier board, MP DC-DC board and the load .The Output voltage of solar panel is shown in Fig 4.2. Switching pulses for S_1 are shown in Fig 4.3. The Output voltage of MP DC-DC converter is shown in Fig 4.4.

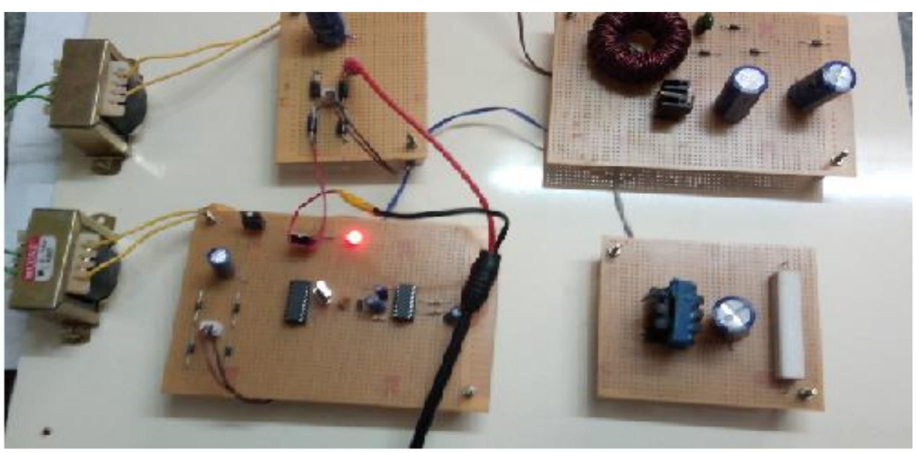

Fig 4.1 Hardware snap shot for HGSC

It can be seen that the experimental results given in this section match with the results given in section IV.

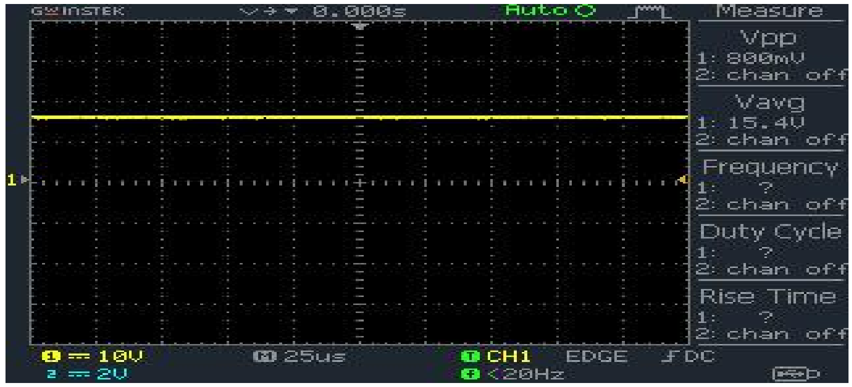

Fig 4.2 Output voltage of solar system

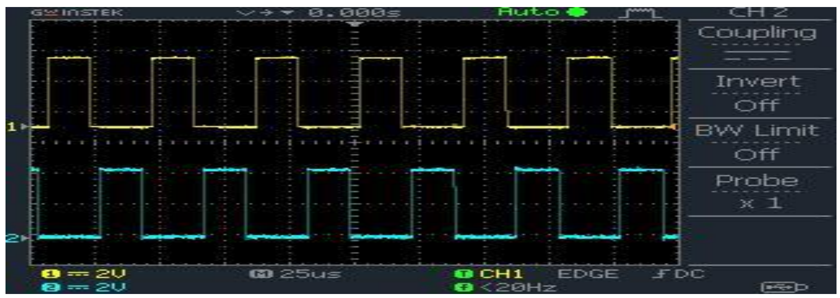

Fig 4.3 Switching pulses for S1

Fig 4.4 Output voltage of high step up converter

V. Conclusion

Open loop multiport DC-DC converter systems with C,∏,T and cascaded filters are modeled and simulated. The results indicate that multiport DC-DC with cascaded filter has minimum voltage ripple. Therefore multiport DC-DC with cascaded filter is investigated. The advantages of proposed system are high voltage gain and the reduced the ripple voltage from 0.08v to 0.003v. The disadvantages of multiport DC-DC converter system are requirement of coupled inductor, four switches and six capacitors. The scope of the present work is to compare the open loop with different filters. The closed loop PI and FOPID controlled MP DC-DC converter systems will be done in future.

APPENDIX-I

Simulation and Hardware parameters used for MP DC-DC Converter system

Vin	**24V**	**24V**
L1, L2	**5mH**	**4.5 mH**
C1,C2	**104µF**	**100 µF**
C3,C4	**155µF**	**150 µF**
Cbo	**2000µF**	**2200µF**
Lo	**2.2mH**	**2.0mH**
MOSFET(IRF840)	**500V/8A**	**500V/8A**
DIOED	**230V/1A**	**230V/1A**
Vo	**160V**	**150V**

REFERENCES

C. Zhao, S. D. Round, and J.W. Kolar, “An isolated three-port bidirectional dc–dc converter with decoupled power flow management,” IEEE Trans. Ind. Electron., vol. 23, no. 5, pp. 2443–2453, Sep. 2008.

H. Tao, A. Kotsopoulos, J. L. Duarte, and M. A. M. Hendrix, “Transformercoupled multiport ZVS bidirectional dc–dc converter with wide input range,” IEEE Trans. Power Electron., vol. 23, no. 2, pp. 771–781, Mar. 2008.

H. Krishnaswami and N. Mohan, “Three-port series-resonant dc–dc converter to interface renewable energy sources with bidirectional load and energy storage ports,” IEEE Trans. Power Electron., vol. 24, no. 10, pp. 2289.

H. A. Atrash, F. Tian, and I. Batarseh, “Tri-modal half-bridge converter topology for three-port interface,” IEEE Trans. Power Electron., vol. 22, no.1, pp. 341–345, Jan. 2007.

Z. Qian, O. A. Rahman, H. A. Atrach, and I. Batarseh, “Modeling and control of three-port dc/dc converter interface for satellite applications,” IEEE Trans. Power Electron., vol. 25, no. 3, pp. 637–649, Mar. 2010.

D. Debnath and K. Chatterjee, “Two-stage solar photovoltaic-based standalone scheme having battery as energy storage element for rural deployment,” IEEE Trans. Ind. Electron., vol. 62, no. 7, pp. 4148–4157, Jul2015.

X. Sun, Y. Shen, W. Li, and H. Wu, "A PWM and PFM hybrid modulated three-port converter for a standalone PV/battery power system," IEEE J.Emerging Sel. Topics Power Electron., vol. 3, no. 4, pp. 984–1000, Dec. 2015.

G. J. Su and L. Tang, "A multiphase, modular, bidirectional, triple-voltage dc–dc converter for hybrid and fuel cell vehicle power systems," IEEE Trans.Power Electron., vol. 23, no. 6, pp. 3035–3046, Nov. 2008.

W. Li, J. Xiao, Y. Zhao, and X. He, "PWM plus phase angle shift (PPAS) control scheme for combined multiport dc/dc converters," IEEE Trans. Power Electron., vol. 27, no. 3, pp. 1479–1489, Mar. 2012.

H. Wu, K. Sun, R. Chen, H. Hu, and Y. Xing, "Full-bridge three-port converters with wide input voltage range for renewable power systems," IEEE Trans. Power Electron., vol. 27, no. 9, pp. 3965–3974, Sep. 2012.

H. Wu, P. Xu, H. Hu, Z. Zhou, and Y. Xian, "Multiport converters based on integration of full-bridge and bidirectional dc–dc topologies for renewable generation systems," IEEE Trans. Ind. Electron., vol. 61, no. 2, pp. 856– 869, Feb. 2014.

W. Li, C. Xu, H. Luo, Y. Hu, X. He, and C. Xia, "Decoupling-controlled triport composited dc/dc converter for multiple energy interface," IEEE Trans. Ind. Electron., vol. 62, no. 7, pp. 4504–4513, Jul. 2015.

J. Zhang, H. Wu, X. Qin, and Y. Xing, "PWM plus secondary-side phase shift controlled soft-switching full-bridge three-port converter for renewable power systems," IEEE Trans. Ind. Electron., vol. 62, no. 11, pp.

7061– 7072, Nov. 2015.

Y. Hu, W. Xiao, W. Cao, B. Ji, and D. J. Morrow, "Three-port dc–dc converter for stand-alone photovoltaic systems," IEEE Trans. Power Electron., vol. 30, no. 6, pp. 3068–3076, Jun. 2015.

M. C. Mira, Z. Zhang, A. Knott, and M. A. E. Andersen, "Analysis, design, modeling, and control of an interleaved-boost full-bridge threeportconverter for hybrid renewable energy systems," IEEE Trans. Power Electron., vol. 32, no. 2, pp. 1138–1155, Feb. 2017.

P. Yang. C. K. Tse, J. Xu, and G. Zhou, "Synthesis and analysis of doubleinput single-output dc/dc converters," IEEE Trans. Ind. Electron., vol. 62, no. 10, pp. 6284–6295, Oct. 2015.