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# High Efficiency of Single Input Multiple Output DC-DC Converter Using Fuzzy Logic

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## Abstract:

The proposed converter can boost the voltage of a low-voltage input power source to a controllable high-voltage dc bus and middle-voltage output terminals. Moreover, middle-voltage output terminals can supply powers for individual middle-voltage dc loads or for charging auxiliary power sources (e.g., battery modules). In this study, a coupled-inductor based dc–dc converter scheme utilizes only one power switch with the properties of voltage clamping and soft switching, and the corresponding device specifications are adequately designed. As a result, the objectives of high-efficiency power conversion, high step up ratio, and various output voltages with different levels can be obtained. A fuzzy controller is designed to reduce the ripples.

## Keywords:
DC TO DC converter, PI controller, Fuzzy controller.

## 1. INTRODUCTION:

The natural environment of the earth has been protecting by developing the clean energies without pollution ,playing the major role from the last decades. By dealing with the issues of global warming, clean energies such as fuel cells, photovoltaic and wind energy etc., has been rapidly promoted. Due to the electrical characteristics of clean energy, the power generated is critically affected by the climate and has slow transient responses, and the output voltage can be influenced by load variations and the auxiliary components such as storage elements, control boards etc has usually requires the proper operation of clean energies. For example,the fuel cell generation system is one of the most efficient and effective solution to reduce the environmental pollution problems. In addition to the fuel cell stack and the other auxiliary components are the balance of plant (BOP) includes electronic control board, an air compressor and a cooling fan are useful for the normal work of FC generation system.

The generated power of the FC stack should also satisfy the power demand for the BOP.Thus, the various voltage levels should be required in the power converter of the FC generation system. the single-input single-output dc–dc converters with different voltage gains are combine to satisfying the requirements of various voltage levels, so that the system control is more complicated and the corresponding cost was expensively high. The motivation of this study is to design a single-input multiple-output (SIMO) converter to increase the conversion efficiency and the voltage gain, to reduce the control complexity and the manufacturing cost.

## 2. SIMO converter:

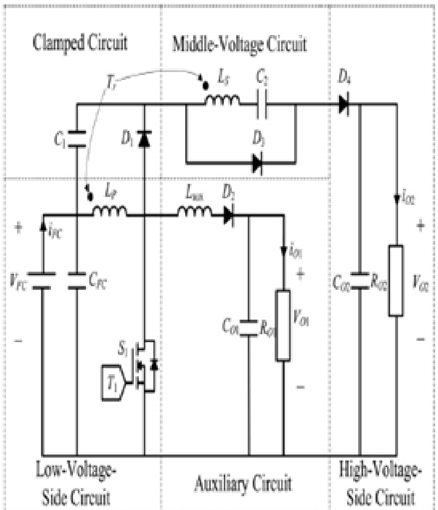


Fig 2.1 system configuration of SIMO converter

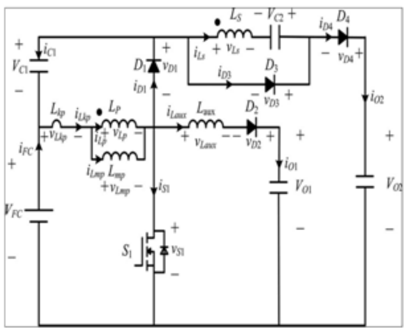

Fig 2.2 equivalent circuit of SIMO converter

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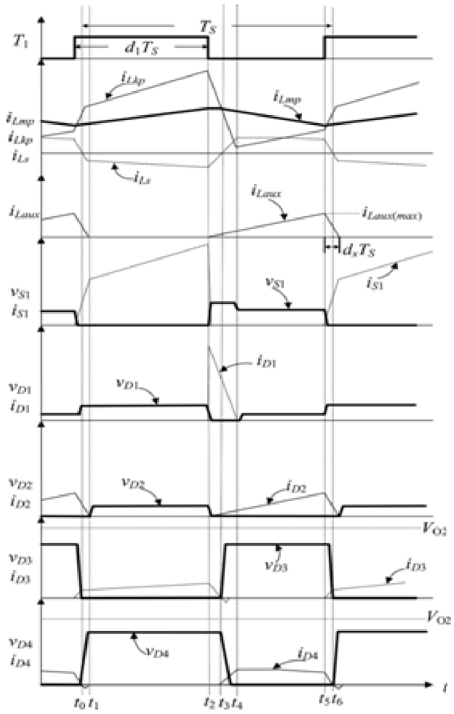

Fig 2.3 characteristics of proposed SIMO converter

## Operating Modes

This converter works upon the six modes of operation which are in cyclic process that means after the completion of the mode 6 , the operation begins from mode1. The operating modes are:

Mode 1 (t0-t1)
Mode 2 (t1-t2)
Mode 3 (t2-t3)
Mode 4 (t3-t4)
Mode 5 (t4-t5)
Mode 6 (t5-t6)

## Explation of the Operating Modes :

## MODE 1 (t0-t1)

At the time t=t0. In this mode, the main switch S1 was turned ON and the diode D4 turned OFF. Because the polarity of the windings of the coupled inductor Tr is positive, the diode D3 turns ON. So, the secondary current iLs reverses and charges the middle voltage capacitor C2. When the auxiliary inductor Laux releases its stored energy completely and then the diode D2 turns OFF, this mode ends.

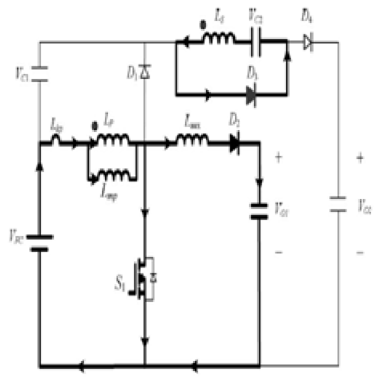

Fig2.4 operating mode1 (t0-t1)

## MODE 2 (t1-t2)

At time t = t1, the main switch S1 is persistently turned ON. Because the primary inductor LP is charged by the input power source, the magnetizing current iLmp increases gradually in an approximately linear way.At the same time, the secondary voltage vLs charges the middle-voltage capacitorC2 through the diode D3 as seen in mode1.Although the voltage vLmp is equal to the input voltage VFC both at modes 1 and 2, the ascendant slope of the leakage current of the coupled inductor (diLkp /dt) at modes 1 and 2 is different due to the path of the auxiliary circuit.Because the auxiliary inductor Laux releases its stored energy completely the diode D2 turns OFF at the end of mode 1, it results in the reduction of diLkp /dt at mode2.

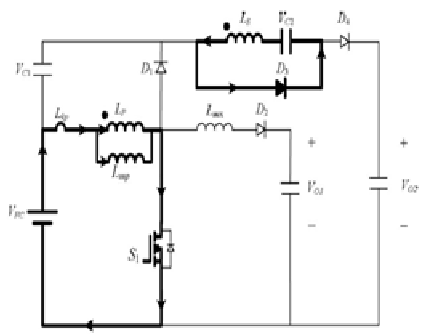

Fig2.5 operating mode2 (t1-t2)

## MODE 3 (t2-t3)

At time t = t2 , the main switch S1 is turned OFF. When the leakage energy still released from the secondary side of the coupled inductor, the diode D3 persistently conducts and releases the leakage energy to the middle-voltage capacitor C2.

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When the voltage across the main switch VS 1 is higher than the voltage across the clamped capacitor VC1, the diode D1 conducts to transmit the energy of the primary-side leakage inductor Lkp into the clamped capacitor C1. At the same time, partial energy of the primary-side leakage inductor Lkp is transmitted to the auxiliary inductor Laux and the diode D2 conducts.Thus, the current iL aux passes through the diode D2 to supply the power for the output load in the auxiliary circuit.When the secondary side of the coupled inductor releases its leakage energy completely the diode D3 turns OFF, this mode ends.

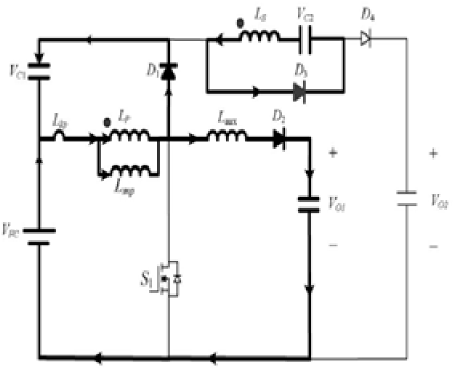

**Fig2.6 operating mode3 (t2-t3)**

## MODE 4 (t3-t4)

At time t = t3, the main switch S1 is persistently turned OFF.When the leakage energy has released from the primary side of the coupled inductor, the secondary current iLS is induced in reverse from the energy of the magnetizing inductor Lmp through the ideal transformer, and flows through the diode D4 to the HVSC.At the same time, partial energy of the primaryside leakage inductor Lkp is still persistently transmitted to the auxiliary inductor Laux, and the diode D2 keeps conducting.Moreover, the current iL aux passes through the diode D2 to supply the power for the output load in the auxiliary circuit.

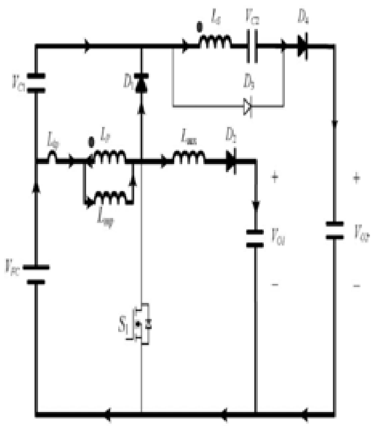

**Fig2.7 operating mode4 (t3-t4)**

## MODE 5 (t4-t5)

At time t = t4, the main switch S1 is persistently turned OFF, and the clamped diode D1 turns OFF because the primary leakage current iLkp equals to the auxiliary inductor current iL aux. In this mode, the input power source, the primary winding of the coupled inductor Tr, and the auxiliary inductor Laux connect in series to supply the power for the output load in the auxiliary circuit through the diode D2. At the same time, the input power source, the secondary winding of the coupled inductor Tr , the clamped capacitor C1 , and the middle voltage capacitor (C2 ) connect in series to release the energy into the HVSC through the diode D4 .

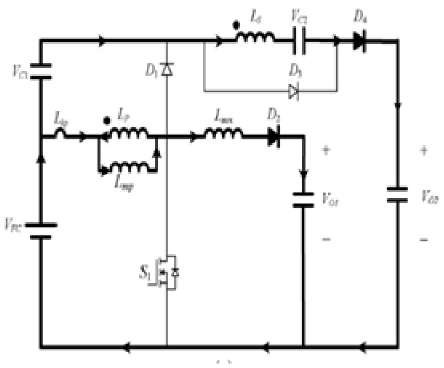

**Fig2.8 operating mode5 (t4-t5)**

## MODE 6 (t5-t6)

At time t=t5, this mode begins when the main switch S1 is triggered.The auxiliary inductor current iL aux needs time to decay to zero, the diode D2 persistently conducts. In this mode, the input power source, the clamped capacitor C1 , the secondary winding of the coupled inductor Tr , and the middle-voltage capacitor C2 still connect in series to release the energy into the HVSC through the diodeD4.Since the clamped diodeD1 can be selected as a low-voltage Schottky diode, it will be cut off promptly without a reverse-recovery current.Moreover, the rising rate of the primary current iLkp is limited by the primary-side leakage inductor Lkp.Thus, one cannot derive any currents from the paths of the HVSC, the middle-voltage circuit, the auxiliary circuit, and the clamped circuit. As a result, the main switch S1 is turned ON under the condition of ZCS and this soft-switching property is helpful for alleviating the switching loss.When the secondary current iLS decays to zero, this mode ends. After that, it begins the next switching cycle and repeats the operation in mode 1.

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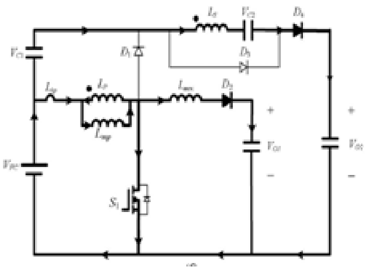


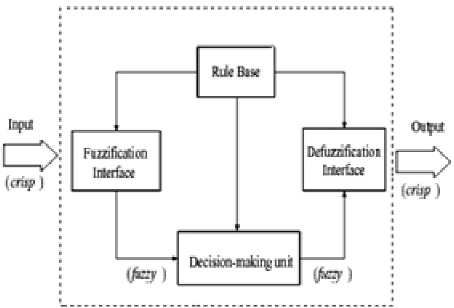
Fig2.9 operating mode6 (t5-t6)

## 3. Fuzzy system

The fuzzy interface system Fuzzy system basically consists of a formulation of the mapping from a given input set to an output set using Fuzzy logic. The mapping process provides the basis from which the interference or conclusion can be made.

### A Fuzzy interface process consists of following steps

Step 1: Fuzzification of input variables.
Step 2: Application of Fuzzy operator.(AND, OR, NOT) In the IF (antecedent) part of the rule.
Step 3: Implication from the antecedent to the consequent (Then part of the rule).
Step 4: Aggregation of the consequents across the rules.
Step 5: Defuzzification.
Generally there will be a matrix of rules similar tot eh ES rule matrix for Ex: There are 7MF for input variables 'x' and MF for input variable 'y' then there will be all together35 rules.




### 3.1 Fuzzy controller

## 4.SIMULATION DESIGNS

### 4.1.Simulation design of Open loop:

A simulation design open loop system as shown in Fig.4.1 is implemented in MATLAB SIMULINK with the help of coupled inductor, voltage clamping circuit and switched capacitor we get desired output voltage level, low voltage output(Fig.4.2 ) and high voltage output( Fig4.3) waveforms. A modified circuit of the system with single phase inverter is also designed which is shown in Fig.4.8. the inverter output is also shown in fig4.9.

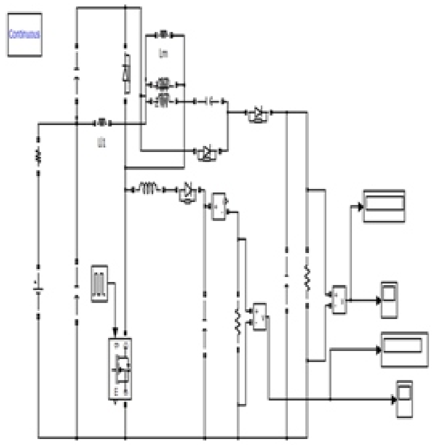


Fig.4.1. open loop system of SIMO Converter

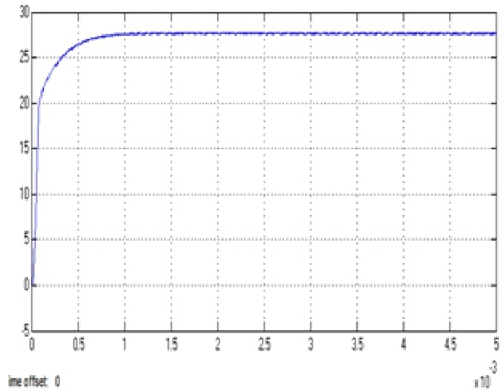


Fig.4.2. Low Voltage Output(28V DC)

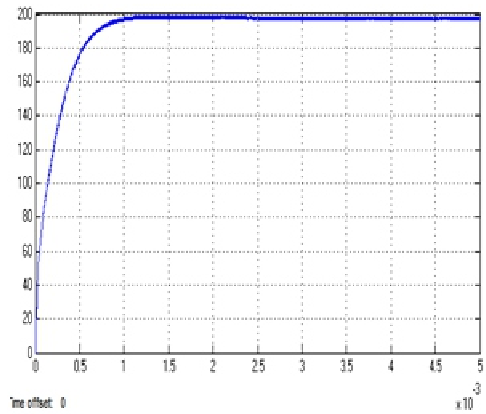


Fig.4.3. High voltage output(200V DC)

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### 4.2. Simulation Design of closed loop using PI controller:

A simulation design closed loop system as shown in Fig.4.4 is implemented in MATLAB SIMULINK with the help of coupled inductor, voltage clamping circuit and switched capacitor and PI controllers we get desired output voltage level, (Fig.4.5 ) low voltage output and high voltage output(Fig.4.6) waveforms.

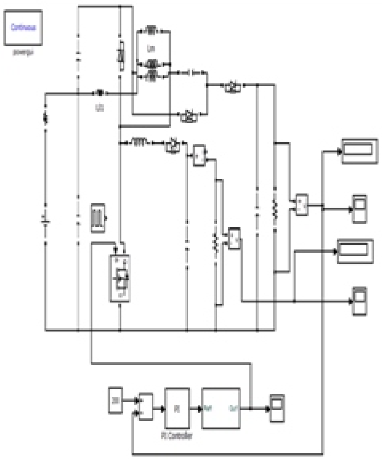

Fig.4.4. closed loop circuit of SIMO Converter with pi controller

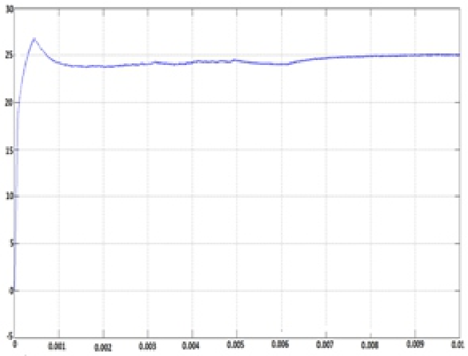

Fig.4.5 low output voltage(28V) of closed loop circuit of SIMO converter with PI controller

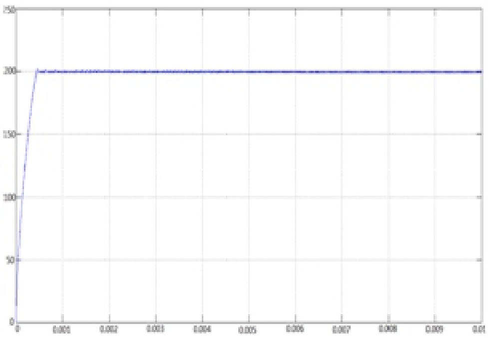

Fig.4.6 high output voltage(200V) of closed loop circuit of SIMO converter with PI controller

### 4.3.simulation design of closed loop using fuzzy controller:

A simulation design closed loop system as shown in Fig.4.7 is implemented in MATLAB SIMULINK with the help of coupled inductor, voltage clamping circuit and switched capacitor and FUZZY controllers we get desired output voltage level, low voltage output (Fig.4.8) and high voltage output(Fig.4.9) waveforms.

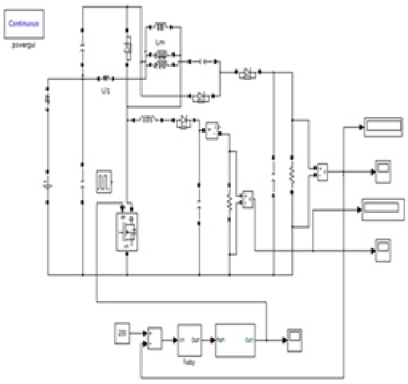

Fig.4.7. closed loop circuit of SIMO Converter with fuzzy controller

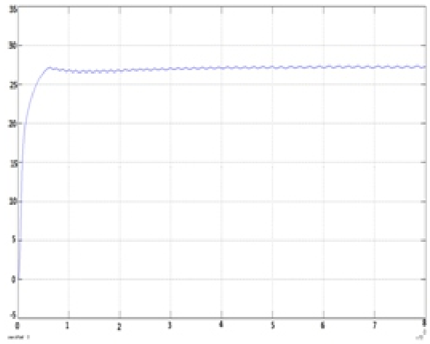

Fig.4.8. low voltage output (28V) of closed loop SIMO converter using fuzzy controller

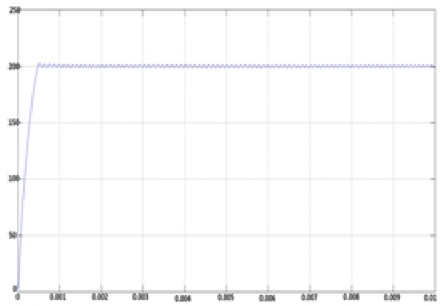

Fig.4.9. high voltage (200V) of closed loop SIMO converter using fuzzy controller

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## 5. CONCLUSION:

This project consists of a high-efficiency SIMO dc–dc converter, and this coupled-inductor-based converter was applied well to a single-input power source plus two output terminals composed of an auxiliary battery module and a high-voltage dc bus. The input to the converter is given by a solid oxide fuel cell. The controllers used are pi controller and fuzzy controller. The results obtained by using pi controller is compared with fuzzy logic controller. The ripple content is reduced by using fuzzy logic controller.

## REFERENCES:

[1] Rong-Jong Wai ,Senior Member ,IEEE, and Kun-Huai Jheng, “High efficiency Single Input Multiple Output DC-DC Converter,” IEEE Trans.Power Electron.,VOL.28,NO.2,FEB 2013.

[2] A. Kirubakaran, S. Jain, and R. K. Nema, “DSP-controlled power electronic interface for fuel-cell-based distributed generation,” IEEE Trans. Power Electron., vol. 26, no. 12, pp. 3853–3864, Dec. 2011.

[3] B. Liu, S. Duan, and T. Cai , “Photovoltaic dc-building-module-based BIPV system-concept and design considerations,” IEEE Trans. Power Electron., vol. 26, no. 5, pp. 1418–1429, May 2011.

[4] M. Singh and A. Chandra, “Application of adaptive network-based fuzzy interference system for sensorless control of PMSG-based wind turbine with nonlinear-load-compensation capabilities,” IEEE Trans. Power Electron. vol. 26, no. 1, pp. 165–175, Jan. 2011.

[5] C. T. Pan,M. C. Cheng, and C.M. Lai, “A novel integrated dc/ac converter with high voltage gain capability for distributed energy resource systems,” IEEE Trans. Power Electron., vol. 27, no. 5, pp. 2385–2395, May 2012.

[6] S. D. Gamini Jayasinghe, D. Mahinda Vilathgamuwa, and U. K. Madawala, “Diode-clamped three-level inverter-based battery/ supercapacitor direct integration scheme for renewable energy systems,” IEEE Trans. Power Electron., vol. 26, no. 6, pp. 3720–3729, Dec. 2011.

[7] H.Wu, R. Chen, J. Zhang, Y. Xing, H. Hu, and H. Ge, “A family of threeport half-bridge converters for a stand-alone renewable power system,” IEEE Trans. Power Electron., vol. 26, no. 9, pp. 2697–2706, Sep. 2012.

[8] M. W. Ellis, M. R. Von Spakovsky, and D. J. Nelson, “Fuel cell systems: Efficient, flexible energy conversion for the 21 st century,” Proc. IEEE, vol. 89, no. 12, pp. 1808–1818, Dec. 2001.

[9] T. Kim, O. Vodyakho, and J. Yang, “Fuel cell hybrid electronic scooter,” IEEE Ind. Appl. Mag., vol. 17, no. 2, pp. 25–31, Mar./Apr. 2011.

[10] F. Gao, B. Blunier, M. G. Sim˜oes, and A. Miraoui, “PEM fuel cell stack modeling for real-time emulation in hardware-in-the-loop application,” IEEE Trans. Energy Convers., vol. 26, no. 1, pp. 184–194, Mar. 2011.

[11] P. Patra, A. Patra, and N. Misra, “A single-inductor multiple-output switcher with simultaneous buck, boost and inverted outputs,” IEEE Trans. Power Electron., vol. 27, no. 4, pp. 1936–1951, Apr. 2012

[12] A. Nami, F. Zare, A. Ghosh, and F. Blaabjerg, “Multiple-output DC–DC converters based on diode-clamped converters configuration: Topology and control strategy,” IET Power Electron., vol. 3, no. 2, pp. 197–208, 2010.

[13] Y. Chen, Y. Kang, S. Nie, and X. Pei, “The multiple-output DC–DC converter with shared ZCS lagging leg,” IEEE Trans. Power Electron., vol. 26, no. 8, pp. 2278–2294, Aug. 2011.

[14] R. J.Wai and R. Y. Duan, “High step-up converter with coupled inductor,” IEEE Trans. Power Electron., vol. 20, no. 5, pp. 1025–1035, Sep. 2005. [14] N. Mohan, T. M. Undeland, and W. P. Robbins, Power Electronics: Converters, Applications, and Design. New York: Wiley, 1995.

[15] L. Schuch, C. Rech, H. L. Hey, H. A. Gr¨undling, H. Pinheiro, and J. R. Pinheiro, “Analysis and design of a new high-efficiency bidirectional integrated ZVT PWM converter for DC-bus and battery-bank interface,” IEEE Trans. Ind. Appl., vol. 42, no. 5, pp. 1321–1332, Sep./Oct. 2006