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Active and Passive Snubbers for Soft-Switching Bidirectional Isolated Full-Bridge Converter

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ABSTRACT:

A bidirectional isolated full-bridge dc–dc converter with a conversion ratio around nine times, soft start-up, and soft-switching features for battery charging/discharging is proposed in this paper. The converter is equipped with an active flyback and two passive capacitor diode snubbers, which can reduce voltage and current spikes and reduce voltage and current stresses, while it can achieve near zero-voltage-switching and zero-current-switching soft-switching features. In this paper, the operational principle of the proposed converter is first described, and its analysis and design are then presented. A 1.5-kW prototype with a low-side voltage of 48 V and a high-side voltage of 360 V has been implemented, from which measured results have verified the discussed features.

*Index Terms—****Bidirectional, snubbers, soft switching***

INTRODUCTION:

In Renewable dc supply systems, batteries are usually required to back up power for electronic equipment. The voltage levels of the batteries are typically much lower than the dc-bus voltage. Bidirectional converters for charging/ discharging the batteries are therefore required. In past studies, bridge-type bidirectional isolated converters have been widely applied to fuel cell and electric vehicle driving systems . For raising power level, a dual full-bridge configuration is usually adopted and their low and high sides are typically configured with boost- and buck-type topologies, respectively. However, component stress, switching loss, and electromagnetic interference (EMI) noise are increased due to diode-reverse-recovery current and MOSFET drain–source voltage, resulting in low reliability. A more severe issue is due to leakage inductance of the isolation transformer, which will result in high-voltage spike during switching transition. A possible solution is to pre-excite the leakage inductance to raise its current level up to that of the current-fed inductor, which can reduce their current difference and, in turn, reduce voltage spike.

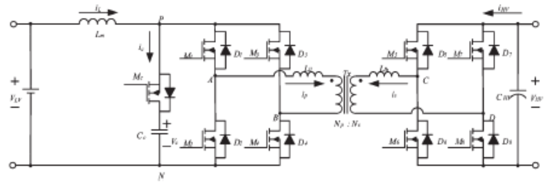


Fig. 1. Bidirectional isolated full-bridge dc–dc converter with an active clamp snubber.

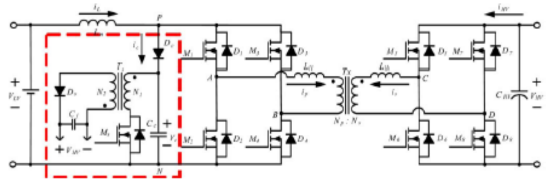


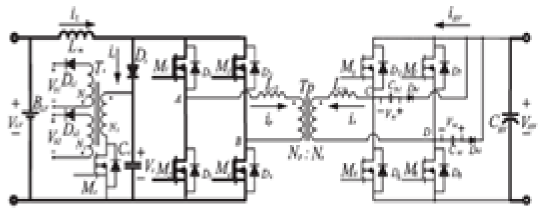
Fig. 2. Bidirectional isolated full-bridge dc–dc converter with a flyback snubber (type A).

Existing System:

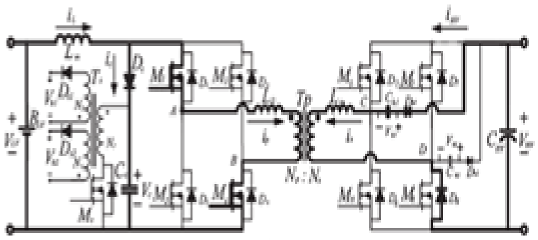
The proposed soft-switching bidirectional fullbridge converter with an active flyback and two passive capacitor–diode snubbers is shown in Fig. 4. It can be operated with two types of conversions: step-up conversion and stepdown conversion. Fig. 4 consists of a current-fed switch bridge, an active flyback snubber at the low-voltage side, a voltage-fed switch bridge, and a passive snubber pair at the high-voltage side. Inductor *Lm* performs output filtering when power flows from the high-voltage side to the low-voltage side, which is denoted as a step-down conversion. On the other hand, it works in the step-up conversion. Moreover, snubber capacitor *CC* and diode *DC* are used to absorb the current difference between current-fed inductor current *iL* and leakage inductance current *iP* of isolation transformer *TP* during switching commutation. The flyback snubber is operated to transfer the energy stored in snubber capacitor *CC* to buffer capacitors *Cb*1 and *Cb*2, and voltage *VC* can drop to zero. Thus, the voltage stresses of switches *M*1 ∼ *M*4 can be limited to a lower level, achieving near ZCS turnoff. The main merits of the proposed snubber include no spike current circulating through the switches and achieving soft-switching features. Note that high spike current can result in charge migration, over current density, and extra magnetic force which will deteriorate in MOSFET carrier density, channel width, and wire bonding and, in turn, increase its conduction resistance.

Proposed System:

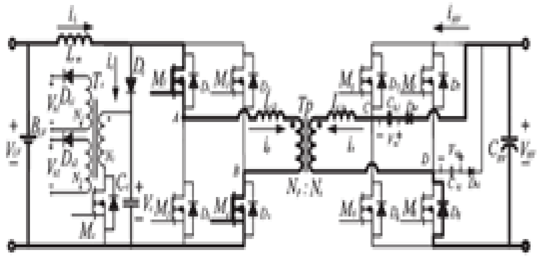
The purpose of using an active flyback snubber is to transfer energy from snubber capacitor *CC* to buffer capacitors *Cb*1 and *Cb*2, which can attain a near ZCS soft-switching feature. To reduce high-voltage spike occurring on switch *MS*, the flyback snubber is operated in discontinuous conduction mode, and the key components of the proposed snubber are designed as follows.



(a)



(b)



(c)

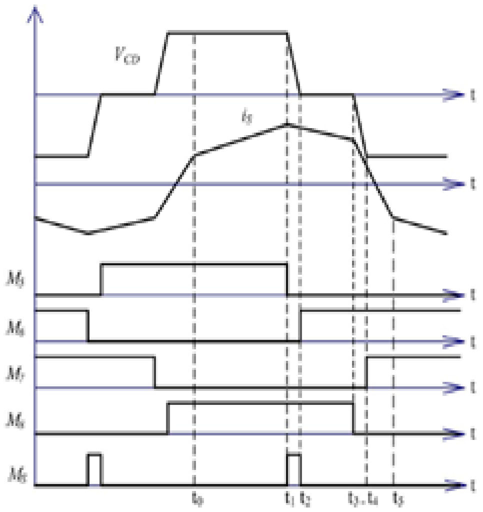
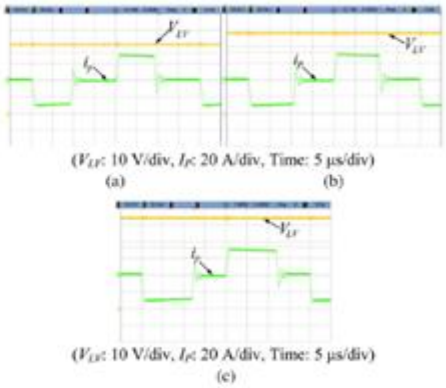


Fig. Key voltage and current waveforms of the proposed converter operated in the step-down conversion.

EXPERIMENTAL RESULTS

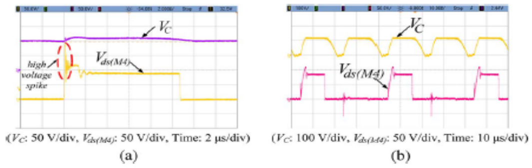
To verify the operational principle and performance of the proposed converter, three experimental prototypes of 1.5 kW, the converter shown in Fig. 2 (type A), the one shown in Fig. 3 (type B), and the proposed, shown in Fig. 4 (type C), were designed and built. The low-side voltage is 42–54 V, and the In the following discussion, type A will be first compared with the proposed converter to verify that a turnoff soft-switching feature can be achieved in both step-up and step-down conversions. The voltage and current waveforms measured from type B and the proposed one prove that two snubber diodes *Db*1 and *Db*2 are needed to block the ringing current. Then, the current waveforms *iP* measured from the converter with an active clamp circuit [13] and the proposed one show that the energy stored in *CC* is recycled by the proposed snubbers and its discharging current does not flow through themain switches.



(V_{LV}: 10 V/div, I_P: 20 A/div, Time: 5 µs/div)
(a) (b)

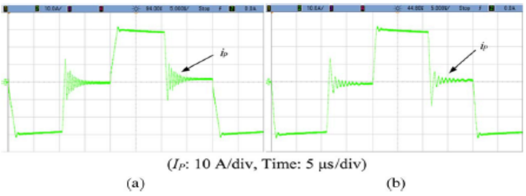
(V_{LV}: 10 V/div, I_P: 20 A/div, Time: 5 µs/div)
(c)

Fig. Measured waveforms of voltage V_{LV} and current i_P from input voltages (a) 42, (b) 48, and (c) 54 V under step-up conversion.



(V_C: 50 V/div, $V_{ds(M4)}$: 50 V/div, Time: 2 µs/div) (V_C: 100 V/div, $V_{ds(M4)}$: 50 V/div, Time: 10 µs/div)
(a) (b)

Fig. 11. Measured voltage waveforms of V_C and $V_{ds(M4)}$ from (a) type A, and (b) the proposed one of which V_C is discharged completely in each switching cycle, under step-up conversion and with 1.5-kW power rating.



(I_P: 10 A/div, Time: 5 µs/div)
(a) (b)

Fig. 12. Measured current i_P waveforms from (a) type A and (b) the proposed one under step-up conversion and with 1.5-kW power rating.

and current $Ids(M4)$ from type A and the proposed one at $M4$ turnoff transition, in which Fig. 13(a) and (b) are with a load of 1.5 kW and Fig. 13(c) is with 500 W. It can be observed that the voltage spike in type A is up to 197 V, due to the parasitic capacitance of switches $M1 \sim M4$ and stray inductance on the circuit. On the other hand, the proposed one can not only achieve near ZCS turnoff soft-switching feature but also can alleviate the voltage spike to 107 V, as shown in Fig. 13(b). Moreover, Fig. 13(b) and (c) shows that the soft switching feature can be achieved at both light- and heavy-load conditions. Fig. 14 shows the measured waveforms of voltage $Vds(M8)$ and current $Ids(M8)$ from type A and the proposed one at $M8$ turnoff transition. It can be observed that, with $Cb1$ and $Cb2$, $Vds(M8)$ of the proposed converter rises up with a lower slope and the switching loss of ($Vds(M8)\cdot Ids(M8)$) becomes lower, achieving near ZCS turnoff soft-switching feature. Fig. 15 shows the measured waveforms of voltages $Vds(M5)$ and $Vds(M6)$ from type B and the proposed one under stepdown conversion. It can be observed that, due to large buffer capacitors $Cb1$ and $Cb2$, voltage Vds of type B is ringing at switching transition, as shown in Fig. 15(a). Fig. 16 shows the measured waveforms of voltages $Vds(M5)$ and $Vb1$ and current $Ids(M5)$ from type B and the proposed one under step-down.

CONCLUSION

This paper has presented a soft-switching bidirectional isolated full-bridge converter, which allows input voltage variation from 42 to 54 V, for battery charging/discharging applications. The proposed converter can reduce the voltage spike caused by the current difference between leakage inductance and currentfed inductor currents, the current spike due to diode reverse recovery, and the current and voltage stresses, while it can achieve near ZVS and ZCS soft-switching features. The passive snubber can hold voltage $Vb1$ or $Vb2$ and improve the slew rate of diP/dt, which can reduce duty loss. However, near ZVS turn-on transition cannot be achieved under light-load condition in step-down conversion. Experimental results measured from the three types of 1.5-kW isolated bidirectional full-bridge dc–dc converters have verified that the proposed converter (type C) can yield the performance of lower voltage and current spikes, higher efficiency, and less ringing. It is suitable for highpower applications with galvanic isolation.

REFERENCES

[1] Z. Zhang, O. C. Thomsen, and M. A. E. Andersen, “Optimal design of a push–pull–forward half-bridge (PPFHB) bidirectional DC–DC converter with variable input voltage,” *IEEE Trans. Ind. Electron.*, vol. 59, no. 7, pp. 2761–2771, Feb. 2012.

[2] D. V. Ghodke, K. Chatterjee, and B. G. Fernandes, “Modified softswitched three-phase three-level DC–DC converter for high-power applications having extended duty cycle range,” *IEEE Trans. Ind. Electron.*, vol. 59, no. 9, pp. 3362–3372, Sep. 2012.

[3] F. Zhang, L. Xiao, and Y. Yan, "Bi-directional forward-flyback DC–DC converter," in *Proc. IEEE Power Electron. Spec. Conf.*, 2004, vol. 5,

[4] H. Li, D. Liu, F. Z. Peng, and G.-J. Su, "Small signal analysis of a dual half bridge isolated ZVS bi-directional DC–DC converter for electrical vehicle applications," in *Proc. IEEE Power Electron. Spec. Conf.*, 2005, pp. 2777–2782.

[5] L.-S. Yang and T.-J. Liang, "Analysis and implementation of a novel bidirectional DC–DC converter," *IEEE Trans. Ind. Electron.*, vol. 59, no. 1, pp. 422–434, Jan. 2012.

[6] D. Liu and H. Li, "Design and implementation of a DSP based digital controller for a dual half bridge isolated bi-directional DC–DC converter," in *Proc. IEEE Appl. Power Electron. Conf.*, 2006, pp. 695–699.

[7] B. Zhao, Q. Yu, Z. Leng, and X. Chen, "Switched Z-source isolated bidirectional DC–DC converter and its phase-shifting shoot-through bivariate coordinated control strategy," *IEEE Trans. Ind. Electron.*, vol. 59, no. 12, pp. 4657–4670, Dec. 2012.

[8] U. K. Madawala, M. Neath, and D. J. Thrimawithana, "A power-frequency controller for bidirectional inductive power transfer systems," *IEEE Trans. Ind. Electron.*, vol. 60, no. 1, Jan. 2013.

[9] D. Aggeler, J. Biela, S. Inoue, H. Akagi, and J. W. Kolar, "Bi-directional isolated DC–DC converter for next-generation power distributioncomparison of converters using Si and SiC devices," in *Proc. Power Convers. Conf.*, 2007, pp. 510–517.

[10] H. Krishnaswami and N. Mohan, "A current-fed three-port bidirectional DC–DC converter," in *Proc. Telecommun. Energy Conf.*, 2007, pp. 523–526.

[11] O. Garcia, L. A. Flores, J. A. Oliver, J. A Cobos, and J. de la Peña, "Bidirectional DC–DC converter for hybrid vehicles," in *Proc. IEEE Power Electron. Spec. Conf.*, 2005, pp. 1881–1886.

[12] S. Yujin and P. N. Enjeti, "A new soft switching technique for bidirectional power flow, full-bridge DC–DC converter," in *Conf. Rec. IEEE IAS Annu. Meeting*, 2002, vol. 4, pp. 2314–2319.

[13] K.Wang, C. Y. Lin, L. Zhu, D. Qu, F. C. Lee, and J. S. Lai, "Bi-directional DC–DC converters for fuel cell systems," in *Proc. IEEE Power Electron. Transp.*, 1998, pp. 47–51.

[14] L. Zhu, "A novel soft-commutating isolated boost full-bridge ZVS-PWM DC–DC converter for bidirectional high power applications," *IEEE Trans. Power Electron.*, vol. 21, no. 2, pp. 422–429, Mar. 2006.

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