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ACTIVE AND PASSIVE SNUBBERS: ISOLATED SOFT-SWITCHING FULL-BRIDGE CONVERTERS WITH BIDIRECTIONAL CAPABILITY

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ABSTRACT: This research suggests a soft-switching, nine-fold dc-dc converter with bidirectional isolation for battery charging and discharging. Soft switching at near zero voltage and current, as well as reduced voltage and current spikes and stresses, are provided by the converter's active flyback and two passive capacitor diode snubbers. The paper begins with a discussion of the proposed converter's operating principle before diving into the analysis and design of the device. The execution of a 1.5 kW prototype with low-side voltage of 48 V and high-side voltage of 360 V has proven the stated characteristics.

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

1. INTRODUCTION:

When the power goes out, batteries are frequently required in renewable DC supply sources to keep electronics working. The voltage levels of the batteries are generally substantially lower than the voltage level on the DC bus. Two-way converters are required to charge and drain the batteries. Bridge-type bidirectional separated converters have been widely employed in fuel cell and electric vehicle driving systems in the past. A twin full-bridge configuration with boost- and buck-type designs on the high and low sides is commonly utilized to increase power levels. Diode-reverse-recovery current and MOSFET drain-source voltage, on the other hand, increase component stress, switching loss, and electromagnetic interference (EMI) noise, making the device less reliable. The leakage inductance of the isolation transformer is a significant issue since it would generate a large voltage jump during the switching transition. It is possible to reduce the voltage spike by pre-exciting the leaking inductance to bring its current level up to that of the current-fed inductor.

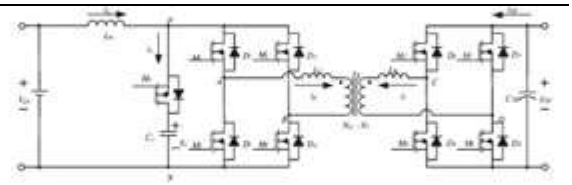


Fig.1. DC-DC converter that operates in both directions, is isolated, and has an active clamp snubber.

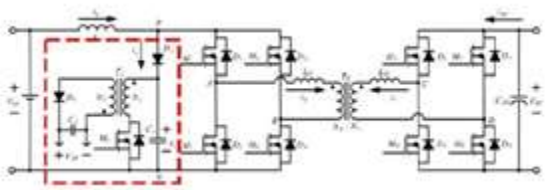


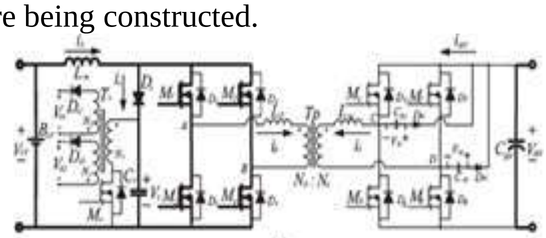
Fig.2. A two-way, full-bridge, separated DC-DC converter with a flyback snubber (type A).

2. EXISTING SYSTEM:

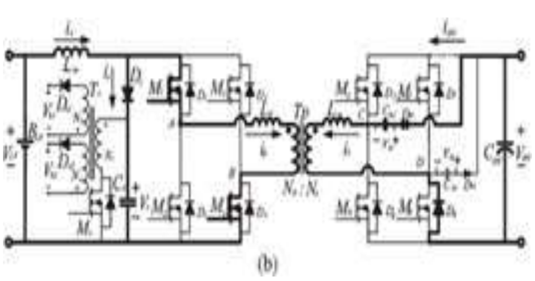
Figure 4 depicts the proposed soft-switching bidirectional complete bridge converter. It includes two passive capacitor-diode snubbers as well as an active fly back. The two types of conversions that can be used are step-up and step-down modifications. A voltage-fed switch bridge, a pair of inactive snubbers on the high voltage side, an active fly back snubber on the low voltage side, and a current-fed switch bridge are depicted in Figure 4. Step-down conversion refers to the process of transferring power from the high-voltage side to the low-voltage side. During this operation, Lm inductors screen the output. It does, however, work in the step-up translation. When the isolation transformer (TP) changes states, the snubber capacitor (CC) and the diode DC absorb the current difference between the current-fed inductor current (iL) and the leaking inductance current (iP). When the flyback snubber is activated, the energy in the snubber capacitor CC is transferred to the buffer capacitors Cb1 and Cb2. This causes the voltage VC to drop to zero. This indicates that the voltage loads on switches M1–M4 can be kept low in order to get near to ZCS turnoff. The key advantages of the recommended snubber are that it achieves soft-switching characteristics and prevents spike current from flowing through the switches. It is critical to remember that excessive spike current can cause charge to migrate, excessive current density, and increased magnetic force. Because of these factors, the channel width, wire bonding, and carrier density of the MOSFET will all deteriorate. This increases the device's conduction resistance.

3. PROPOSED SYSTEM:

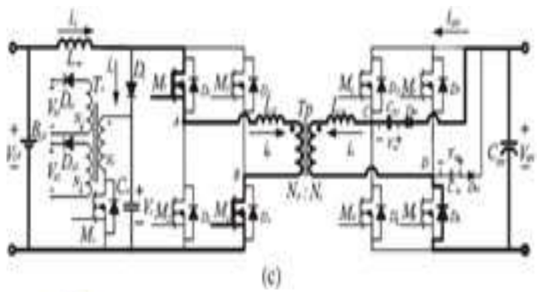
An active flyback snubber transfers energy from the CC snubber capacitor to the Cb1 and Cb2 buffer capacitors. This can give a soft-switching feature similar to ZCS. The flyback snubber is set to interrupted conduction mode to prevent switch MS from receiving too many high-voltage spikes. Here are the key components of the recommended snubber that are being constructed.



(a)



(b)



(c)

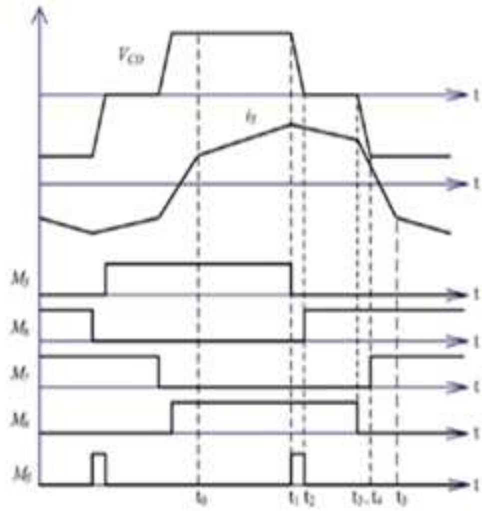


Fig. 3. For the step-down conversion, the principal voltage and current patterns from the indicated converter were employed.

4. EXPERIMENTAL RESULTS

Three 1.5 kW experimental prototypes were planned and built to evaluate the performance and working theory of the proposed converter. These were the converters depicted in Fig. 2 (type A), Fig. 3 (type B), and the suggested converter depicted in Fig. 4 (type C). In the following part, we will compare type A to the suggested converter to ensure that a soft-switching feature that can be turned off works in both step-up and step-down adjustments. On the low side, the voltage is 42-54 V. To halt the ringing current, two snubber diodes, Db1 and Db2, are required. This is evident from the type B voltage and current curves, both intended and measured. The energy held in CC is reused by the snubbers and does not pass through the main switches when the current is released, as shown by both the predicted and measured current waveforms iP from the converter with an active clamp circuit [13].

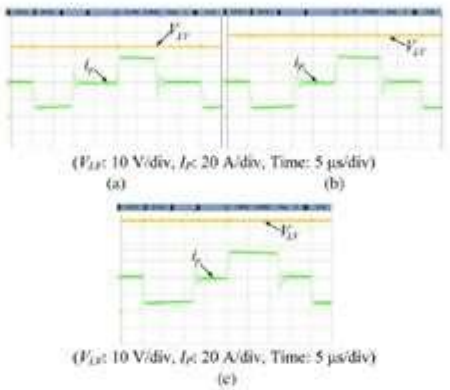


Fig. Measured waveforms of voltage V_{LV} and current i_P from input voltages (a) 42, (b) 48, and (c) 54 V under step-up conversion.

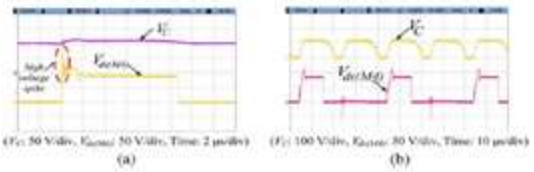


Fig. 11. Measured voltage waveforms of V_{Cl} and $V_{ds(M8)}$ from (a) type A, and (b) the proposed one of which V_{Cl} is discharged completely in each switching cycle, under step-up conversion and with 1.5-kW power rating.

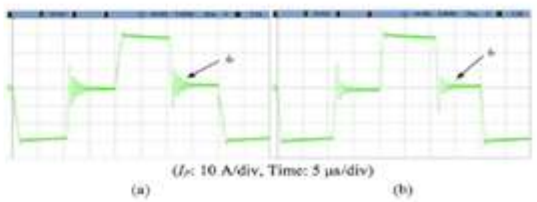


Fig. 12. Measured current i_P waveforms from (a) type A and (b) the proposed one under step-up conversion and with 1.5-kW power rating.

Figures 13(a) and (b) with a 1.5 kW load and Figure 13(c) with a 500 W load demonstrate IDs(M4) from type A and the suggested ID(M4) during the M4 turnoff shift. Type A exhibits a voltage spike of up to 197 V, as can be seen. This is owing to the circuit's additional inductance and the extra capacitance of switches M1 through M4. However, as illustrated in Fig. 13(b), the proposed method not only accomplishes soft-switching that is close to ZCS turnoff, but it also reduces the voltage spike to 107 V. Furthermore, Figs. 13(b) and (c) demonstrate that the easy switching functionality may be employed in both light- and heavy-load circumstances. The voltage Vds(M8) and current Ids(M8) waveforms can be measured from type A. Figure 14 depicts the anticipated waveform at the M8 turnoff transition. As Cb1 and Cb2 increase, the recommended converter's Vds(M8) increases with a smaller slope, as does its switching loss (Vds(M8) Ids(M8)). As a result, it soft-switches close to zero-crossing mode. Figure 15 depicts the patterns of type B voltages Vds(M5) and Vds(M6), as well as the one proposed for stepdown conversion. The voltage Vds of type B rings at the switching transition, as shown in Figure 15(a). Because of the big buffer capacitors Cb1 and Cb2, this is the case. The forms of the voltages Vds(M5) and Vb1, as well as the current Ids(M5) from type B and the recommended one under step-down, are shown in Figure 16.

5. CONCLUSION

A soft-switching bidirectional isolated full-bridge converter with an input voltage range of 42 to 54 V was presented in this study for application in battery charging and draining. The proposed converter may be able to achieve near-ZVS and ZCS soft-switching while lowering the voltage spike caused by the difference in current between leakage inductance and current-fed inductor currents, the current spike caused by diode reverse recovery, and the current and voltage stressors. To reduce duty loss, the passive snubber can hold voltage Vb1 or Vb2 and increase the diP/dt slew rate. In step-down conversion, however, the near ZVS turn-on shift cannot occur when the load is low. Three different kinds of 1.5-kW isolated bidirectional full-bridge dc-dc converters were tested and measured. The suggested converter, Type C, can create fewer voltage and current spikes, as well as improved efficiency and reduced ringing. Because of its galvanic isolation, it can be used for high-power applications.

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