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INTERLEAVED DC-DC MULTIPLE OUTPUT BOOST CONVERTER USING FUZZY

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Abstract - The aim of this project is to develop a high-efficiency single-input multiple-output (SIMO) dc–dc converter. 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. The high-voltage dc bus can take as the main power for a high-voltage dc load or the front terminal of a dc–ac inverter. 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 project, 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. The Fuzzy Logic control is used to generate the PWM pulses to control the MOSFET switch.

1. GENERAL

The SISO (single input and single output) system proposed a single input. This single-input and single-output (SISO) system has a simple single variable control system with one input and one output. The controller exhibits output voltage regulation characteristic that is robust against load variations and reference voltage changes.

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voltage regulation characteristic that is robust against load variations and reference voltage changes.

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. The newly designed multi output converter with a coupled inductor uses only one power switch with the properties of voltage clamping and soft switching, and the corresponding device specifications are adequately designed to boost the voltage levels. As a result, the objectives of high-efficiency power conversion, high step up ratio, and various output voltages with different levels can be obtained. The basic requirements of this converters small size and high efficiency. High switching frequency is necessary for achievement of small size. If the switching frequency is increased then the switching loss will increase. It decreases the efficiency of the power supplies. To solve this problem, some kinds of soft switching techniques need to be used to operate under high switching frequency.

The techniques of soft switching and voltage clamping are adopted switching and conduction losses via the utilization of a low-voltage-rated power switch with a small *RDS (on).* The slew rate of the current change in the coupled inductor can be restricted by the leakage inductor, the current transition time enables the power switch to turn ON with the ZCS property easily, and the effect of the leakage inductor can alleviate the losses caused by the reverse-recovery current. Additionally, the problems of the stray inductance energy and reverse-recovery currents within diodes in the conventional boost converter also can be solved, so that the high-efficiency power conversion can be achieved. The voltages of middle-voltage output terminals can be appropriately adjusted by the design of auxiliary inductors; the output voltage of the high-voltage dc bus can be stably controlled by a Fuzzy Logic control.

This topology adopts only one power switch to achieve the objective of high-efficiency SIMO power conversion. The
voltage gain can be substantially increased by using a coupled inductor. The copper loss in the magnetic core can be greatly reduced. The developing cost is Low and the size is reduced. This system provides high efficiency comparing with the existing system.

2. OPERATION

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. The newly designed multi output converter with a coupled inductor uses only one power switch with the properties of voltage clamping and soft switching, and the corresponding device specifications are adequately designed to boost the voltage levels. As a result, the objectives of high-efficiency power conversion, high step up ratio, and various output voltages with different levels can be obtained. The basic requirements of this converters small size and high efficiency. High switching frequency is necessary for achievement of small size. If the switching frequency is increased then the switching loss will increase. It decreases the efficiency of the power supplies. To solve this problem, some kinds of soft switching techniques need to be used to operate under high switching frequency.

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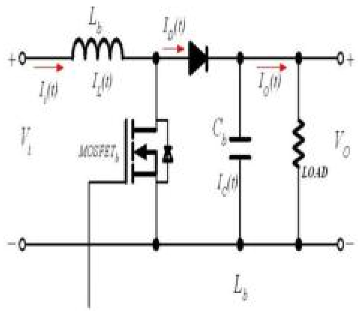
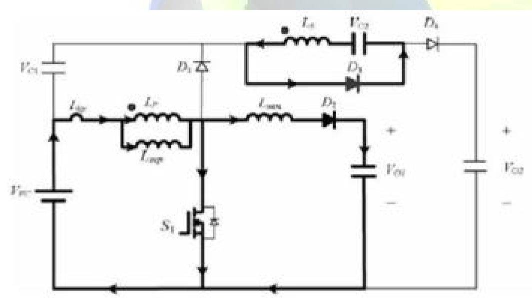


Figure1: Equivalent Circuit of the DC to DC Converter

3. MODES OF OPERATION

MODE 1 (T0 –T1):

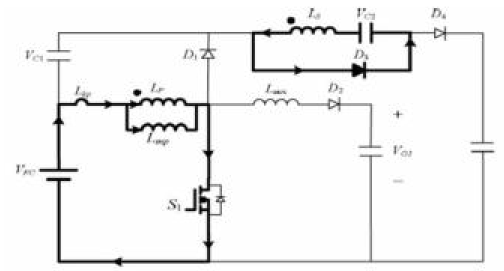
The main switch S1 was turned ON, and the diode D4 turned OFF. Because the polarity of the windings of the coupled inductor is positive, the diode D3 turns ON. The secondary current iLs reverses and charges to the middle voltage capacitor C2 . When the auxiliary inductor Laux releases its stored energy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



Mode 1 $[t_0 - t_1]$

Figure2: Mode 1

MODE 2 (T1 –T2) :

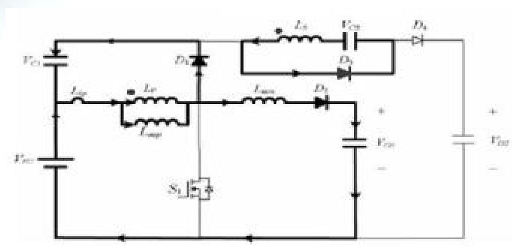


Mode 2 $[t_1 - t_2]$

Figure3: Mode 2

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 capacitor C2 through the diode D3 . Although the voltage vLmp is equal to the input voltage VFC at modes 1 and 2, the leakage current of the coupled inductor (diLkp /dt) at these modes are different due to the path of the auxiliary circuit. Because the auxiliary inductor Laux releases its stored energy completely, and the diode D2 turns OFF at the end of mode 1, it results in the reduction of diLkp /dt at mode

MODE 3 (T2 –T3) :



Mode 3 $[t_2 - t_3]$

Figure4: Mode 3

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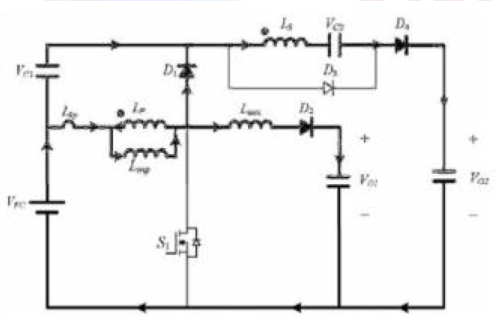
At time t = t2, the main switch S1 is turned OFF. When the leakage energy still released from the secondary side of the coupled inductor, the diode D3 persistently conducts and releases the leakage energy to the middle-voltage capacitor C2. When the voltage across the main switch vS 1 is higher than the voltage across the clamped capacitor VC 1 , then the diode D1 conducts and 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 iLaux passes through the diode D2 to give power for the output load in the auxiliary circuit. When the secondary side of the coupled inductor releases its leakage energy completely, and the diode D3 turns OFF, this mode ends.

MODE 4 (T3 –T4) :

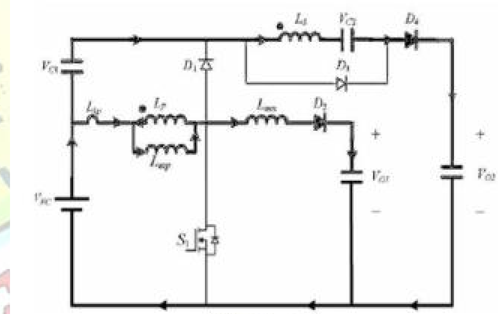


Mode 4 [$t_3 - t_4$]

Figure5: Mode 4

At time t = t3, the main switch S1 is turned OFF. When the leakage energy has released from the primary side of the coupled inductor, the secondary current i_{LS} 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 primary side 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.

MODE 5 (T4 –T5) :



Mode 5 [$t_4 - t_5$]

Figure6: Mode 5

At time t = t4, the main switch S1 is turned OFF, and the clamped diode D1 turns OFF because the primary leakage current iL_{kp} equals to the auxiliary inductor current iL_{aux}. In this mode, the input power source, the primary winding of the coupled inductor T_r, and the auxiliary inductor L_{aux} connect in series to supply the power for the output load in the auxiliary circuit through the diode D2. Since the clamped diode D1 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 primary-side leakage

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inductor L_{kp}. 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 i_{LS} decays to zero, this mode ends. After that, it begins the next switching cycle and repeats the operation in mode 1. At the same time, the input power source, the secondary winding of the coupled inductor T_r the clamped capacitor C1, and the middle voltage capacitor (C2) connect in series to release the energy into the HVSC through the diode D4

Mode 6 (t5 –t6) :

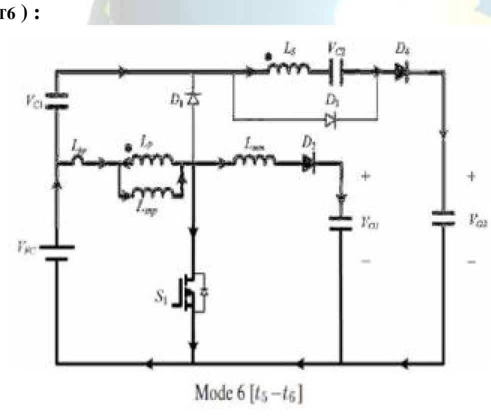

Figure7: Mode 6

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.

4. STIMULATION OUTPUT

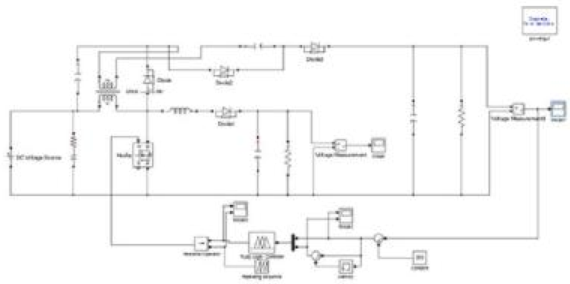

Figure8: Closed Loop Stimulation Circuit With Fuzzy

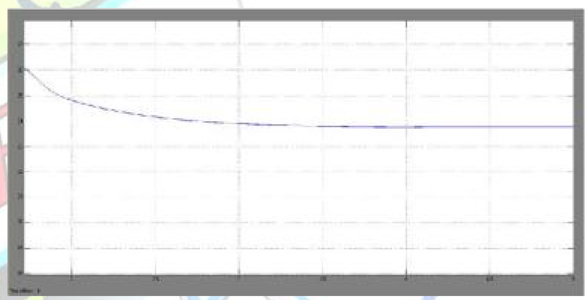

Figure9: Output-1

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5. CONCLUSION

This project has presented high - efficiency dc - dc converter, and this coupled – inductor - based converter was applied well to a single - input power source having two output terminals of an auxiliary battery module and a high - voltage dc bus. The results of SIMO converter is the maximum efficiency was measured to be exceed 95%, and the average conversion efficiency was measured over 91%.The proposed SIMO converter is suitable for the application such as one common ground, is preferred in most applications. The major scientific contributions of the SIMO converter are recited as follows:

- This topology has only one power switch to achieve the objective of SIMO power conversion.
- The voltage gain is substantially increased by using a coupled inductor
- The stray energy is recycled by a clamped capacitor into the auxiliary battery module or high - voltage dc bus to ensure the property of voltage clamping.
- An auxiliary inductor is providing the charge power to the auxiliary battery module and assisting the turned ON under the conditions of ZCS.
- The switch voltage stress is not on the input voltage so that it is more suitable for a dc conversion mechanism with different input voltage levels.
- The copper loss in the magnetic core can be greatly reduced, due to copper film with lower turns.

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