An Advanced No isolated High-Efficiency Single-Input Multiple-Output Converters

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ABSTRACT:
The aim of this study is to develop a high-efficiency single-input multiple-output (SIMO) dc–dc converter. In a photovoltaic (PV)- or fuel-cell-based grid connected power system, a high step-up dc–dc converter is required to boost the low voltage of a PV or fuel cell to a relatively high bus voltage for the downstream dc–ac grid-connected inverter. 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.

INTRODUCTION
In Order to protect the natural environment on the earth, the development of clean energy without pollution has the major representative role in the last decade. By dealing with the issue of global warming, clean energies, such as fuel cell (FC), photovoltaic, and wind energy, etc., have been rapidly promoted. Due to the electric characteristics of clean energy, the generated power is critically affected by the climate or has slow transient responses, and the output voltage is easily influenced by load variations. Besides, other auxiliary components, e.g., storage elements, control boards, etc., are usually required to ensure the proper operation of clean energy. In this project presented a SIMO dc–dc converter capable of generating buck, boost, and inverted outputs simultaneously. However, over three switches for one output were required. This scheme is only suitable for the low output voltage and power application, and its power conversion is degenerated due to the operation of hard switching. Proposed a new dc–dc multi-output boost converter, which can share its total output between different series of output voltages for low- and high-power applications Unfortunately, over two switches for one output were required, and its control scheme was complicated. Besides, the corresponding output power cannot supply for individual loads independently.
DC TO DC CONVERTERS

DC to DC converters are important in portable electronic devices such as cellular phones and laptop computers, which are supplied with power from batteries primarily. Such electronic devices often contain several sub-circuits, each with its own voltage level requirement different from that supplied by the battery or an external supply (sometimes higher or lower than the supply voltage). Additionally, the battery voltage declines as its stored power is drained. Switched DC to DC converters offer a method to increase voltage from a partially lowered battery voltage thereby saving space instead of using multiple batteries to accomplish the same thing. Most DC to DC converters also regulate the output voltage. Some exceptions include high-efficiency LED power sources, which are a kind of DC to DC converter that regulates the current through the LEDs, and simple charge pumps which double or triple the output voltage.

Equivalent Circuit and Characteristics wave form of SIMO converter

![Equation Diagram]
Fig. 1 characteristics of proposed SIMO converter

**Operating Modes**

**Mode 1 (t₀-t₁)**

In this mode, the main switch S₁ was turned ON for a span, and the diode D₄ turned OFF. Because the polarity of the windings of the coupled inductor Tr is positive, the diode D₃ turns ON.
The secondary current \( i_Ls \) reverses and charges to the middle voltage capacitor \( C_2 \). When the auxiliary inductor \( L_{aux} \) releases its stored energy completely, and the diode \( D_2 \) turns OFF, this mode ends.

MODE 2 (\( t_1-t_2 \))

At time \( t = t_1 \), the main switch \( S_1 \) is persistently turned ON. Because the primary inductor \( L_P \) is charged by the input power source, the magnetizing current \( i_{Lmp} \) increases gradually in an approximately linear way.

At the same time, the secondary voltage \( v_{Ls} \) charges the middle-voltage capacitor \( C_2 \) through the diode \( D_3 \).

Although the voltage \( v_{Lmp} \) is equal to the input voltage \( V_{FC} \) both at modes 1 and 2, the ascendant slope of the leakage current of the coupled inductor \( (di_{Lkp}/dt) \) at modes 1 and 2 is different due to the path of the auxiliary circuit.

Because the auxiliary inductor \( L_{aux} \) releases its stored energy completely, and the diode \( D_2 \) turns OFF at the end of mode 1, it results in the reduction of \( di_{Lkp}/dt \) at mode 2.

MODE 3 (\( t_2-t_3 \))

At time \( t = t_2 \), the main switch \( S_1 \) is turned OFF. When the leakage energy still released from the secondary side of the coupled inductor, the diode \( D_3 \) persistently conducts and releases the leakage energy to the middle-voltage capacitor \( C_2 \).

When the voltage across the main switch \( V_S \) is higher than the voltage across the clamped capacitor \( V_{C1} \), the diode \( D_1 \) conducts to transmit the energy of the primary-side leakage inductor \( L_{kp} \) into the clamped capacitor \( C_1 \).
At the same time, partial energy of the primary-side leakage inductor $L_{kp}$ is transmitted to the auxiliary inductor $L_{aux}$, and the diode $D_2$ conducts. Thus, the current $i_{L_{aux}}$ passes through the diode $D_2$ 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, and the diode $D_3$ turns OFF, this mode ends.

**MODE 4 (t3-t4)**

At time $t = t_3$, the main switch $S_1$ is persistently 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 $L_{mp}$ through the ideal transformer, and flows through the diode $D_4$ to the HVSC.

At the same time, partial energy of the primary-side leakage inductor $L_{kp}$ is still persistently transmitted to the auxiliary inductor $L_{aux}$, and the diode $D_2$ keeps conducting. Moreover, the current $i_{L_{aux}}$ passes through the diode $D_2$ to supply the power for the output load in the auxiliary circuit.

**MODE 5 (t4-t5)**

At time $t = t_4$, the main switch $S_1$ is persistently turned OFF, and the clamped diode $D_1$ turns OFF because the primary leakage current $i_{L_{kp}}$ equals to the auxiliary inductor current $i_{L_{aux}}$. 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 $D_2$.

At the same time, the input power source, the secondary winding of the coupled inductor $T_r$, the clamped capacitor $C_1$, and the middle voltage capacitor ($C_2$) connect in series to release the energy into the HVSC through the diode $D_4$.
MODE 6 (t5-t6)

At time \( t = t_5 \), this mode begins when the main switch \( S_1 \) is triggered. The auxiliary inductor current \( i_{L_{aux}} \) needs time to decay to zero, the diode \( D_2 \) persistently conducts. In this mode, the input power source, the clamped capacitor \( C_1 \), the secondary winding of the coupled inductor \( Tr \), and the middle-voltage capacitor \( C_2 \) still connect in series to release the energy into the HVSC through the diode \( D_4 \). Since the clamped diode \( D_1 \) 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 \( i_{L_{kp}} \) is limited by the primary-side leakage 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 \( S_1 \) 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.

**SIMULATION RESULTS & DISCUSSIONS**

**Fig. 6 operating mode (t5-t6)**

**Fig. 7 simulation block dig, output voltages**

**CONCLUSION**

The major scientific contributions of the proposed SIMO converter are recited as follows: 1) this topology adopts only one power switch to achieve
the objective of high-efficiency SIMO power conversion; 2) the voltage gain can be substantially increased by using a coupled inductor; 3) the stray energy can be recycled by a clamped capacitor into the auxiliary battery module or high-voltage dc bus to ensure the property of voltage clamping; 4) an auxiliary inductor is designed for providing the charge power to the auxiliary battery module and assisting the switch turned ON under the condition of ZCS; 5) the switch voltage stress is not related to the input voltage so that it is more suitable for a dc power conversion mechanism with different input voltage levels.

REFERENCES


BIBLIOGRAPHY

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