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RESEARCH ARTICLE

DESIGN OF MODIFIED SINGLE INPUT MULTIPLE OUTPUT DC-DC CONVERTER

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Abstract: In this paper modified single input multiple output dc-dc converters can be used to give a multi outputs. It has three outputs. That is low voltage power source is converted into high-voltage dc bus and middle voltage output terminals. This dc-dc converter utilizes the properties of voltage clamping and soft switching based on a coupled inductor. In this paper, the design of SIMO dc-dc converter along with modes of operation has been presented using MATLAB / SIMULINK. Simulation results thus obtained show that, the objectives of high-efficiency, high step up ratio and various levels of output voltages.
Keywords— Coupled inductor, single-input multiple-output (SIMO) converter, soft switching, voltage clamping

I. INTRODUCTION

Multiple output converters are widely used in the industrial applications. Designing multi-output converters presents a remarkable challenge for the power supply designer. Converters utilizing a single primary power stage and generating more than one isolated output voltage are called multi-output converters. The basic requirements are 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. This 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. Zero Voltage Switched (ZVS) technique and Zero Current Switched (ZCS) technique are two commonly used soft switching methods. By using these techniques, either voltage or current is zero during switching transition, which largely reduce the switching loss and also increase the reliability for the power supplies. Applications may require step-up, or at times even a bipolar supply from the same battery supply. Bipolar supplies also find a wide range of application in organic light emitting diodes. As a result, the design of a power management IC typically comprises boost to step-up, buck-boost to generate negative supply, and linear regulators to meet different supplies for various circuit applications. Several methods have been proposed to regulate the multiple outputs, to reduce the conduction loss, the MOSFET switch with low turn-on resistance is used; dc–dc converters are widely used in low and high-power applications. Patra *et al*. [1] presented a SIMO dc–dc converter capable of simultaneously generating buck, boost, and inverted outputs. 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. Nami *et al*.[2] 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. In this scheme, 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. Chen *et al*.[3] investigated a multiple-output dc–dc converter with shared zero-current switching (ZCS) lagging leg. Although this converter with the soft-switching property can reduce the switching losses, this combination scheme with three full-bridge converters is more complicated, so that the achievement of high conversion efficiency is difficult and its cost is also increased. A new generation of single input multiple output (SIMO) dc–dc converters has been developed based on boost and inverted topologies. However, in these configurations, loads are independently constructed except the negative output [4]. In the proposed SIMO converter, the techniques of soft switching and voltage clamping are adopted to reduce the switching and conduction losses via the utilization of a low voltage rated power switch with a small R_{ds} (on). This project presents a newly designed SIMO dc–dc converter based on boost and inverted derived topologies with a coupled inductor. The motivation of this project is to design a single input multiple output converter for increasing the conversion efficiency, voltage gain [5], reducing the complex control and saving the cost of manufacturing.

II. LITERATURE REVIEW

Nami et al. proposed "Multi-output DC–DC converters based on diode-clamped converters configuration topology and control strategy" 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. Chen et al. "The Multiple-Output DC–DC Converter With Shared ZCS Lagging Leg" investigated a multiple-output dc–dc converter with shared zero-current switching (ZCS) lagging leg. Although this converter with the soft-switching property can reduce the switching losses, this combination scheme with three full-bridge converters is more complicated, so that the objective of high-efficiency power conversion is difficult to achieve, and its cost is inevitably increased. This study presents a newly designed SIMO converter with a coupled inductor. The proposed converter uses one power switch to achieve the objectives of high-efficiency power conversion, high step-up ratio, and different output voltage levels. In the proposed SIMO converter, the techniques of soft switching and voltage. clamping are adopted to reduce the switching and conduction losses via the utilization of a low-voltage-rated power switch with a small *R*DS(on) . Because 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 simple proportional-integral (PI) control.

III. TOPOLOGY OVERVIEW AND ANALYSES

A. *Block Diagram*

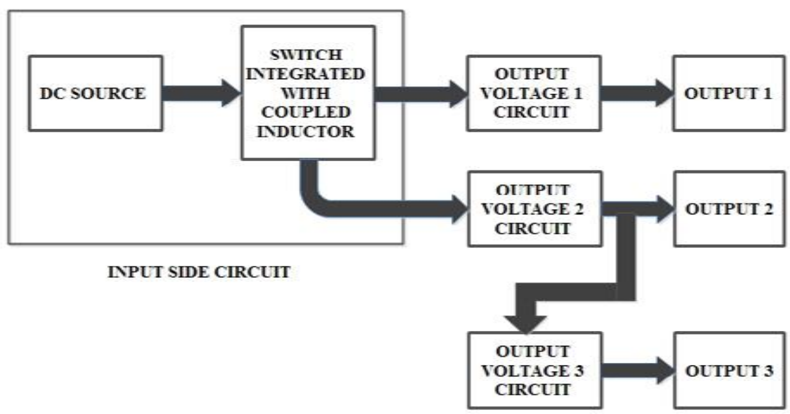


Fig.1 Proposed Single Input Multiple Output dc-dc converter Block Diagram

Single Input Multiple Output dc-dc converter. The DC Source block consists of the dc input power source and a capacitor. The value of input is in the range of 12V. Switch Integrated with Coupled Inductor block consisting of a coupled inductor, a MOSFET switch and a diode. The coupled inductor primary has a series connected leakage inductor and a parallel connected magnetizing inductor. Output Voltage 1 Circuit consists of an auxiliary inductor, a diode and a filter capacitor. The value of output voltage 1 is 28V. Output Voltage 2 Circuit consists of a capacitor combination. In addition, the series connected diode and a filter capacitor is used. The value of output voltage 2 is 200V. Output Voltage 3 circuit consists of two MOSFET switches, two diodes and two capacitors. The value of output voltage 3 is -200V.

B. *Circuit Diagram & Description*

The system configuration of the proposed SIMO converter topology to generate three different voltage levels from a single-input power source is depicted in Fig. 2. This SIMO converter contains six parts including an input side circuit (ISC), a clamped circuit, a coupled inductor secondary circuit, output voltage 1 circuit, output voltage 2 circuit and output voltage 3 circuit. The major symbol representations are summarized as follows. V_{dc} (i_{dc}) and V_{01} (i_{01}) denote the voltages (currents) of the input power source and the output load at the input side voltage circuit and the output voltage 1 circuit, respectively; V_{02} and i_{02} are the output voltage and current in the output voltage 2 circuit. V_{03} and i_{03} are the output voltage and current in the output voltage 3 circuit. C_{01}, C_{02} and C_{03} are the filter capacitors at the ISC, an output voltage 3 circuit, respectively; C_1, C_2 and C_3 are the clamped and coupled inductor secondary circuit capacitors in the clamped and coupled inductor secondary circuits respectively.

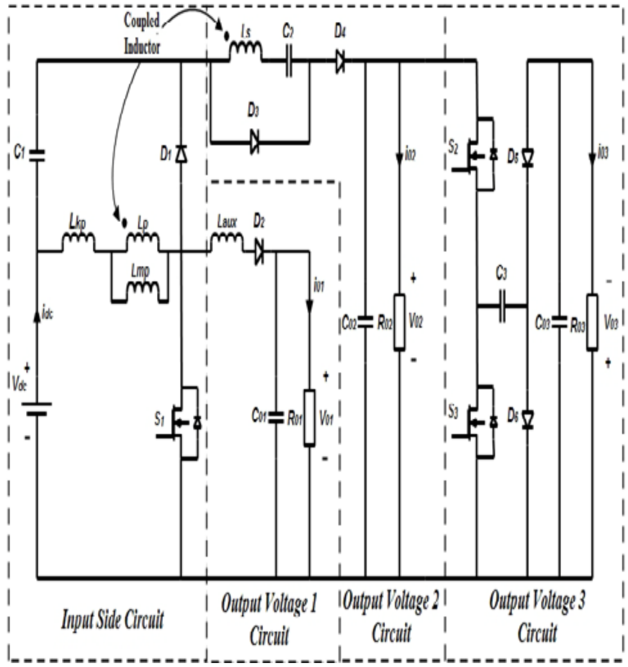


Fig.2 Proposed Single Input Multiple Output dc-dc converter Circuit Diagram

L_P and L_S represent individual inductors in the primary and secondary sides of the coupled inductor respectively, where the primary side is connected to the input power source; L_{aux} is the auxiliary inductor. The main switch is expressed as S_1 in the ISC, S_2 and S_3 are the switches used in the output voltage circuit 3. The equivalent load in the output voltage circuit 1 is represented as R_{01}, the output load is represented as R_{02} in the output voltage circuit 2 and the output load is represented as R_{03} in the output voltage circuit 3. The circuit diagram has the six diodes namely D_1, D_2, D_3, D_4, D_5 and D_6 respectively. The coupled inductor in Fig.2 can be modeled as an ideal transformer including the magnetizing inductor L_{mp} and the leakage inductor L_{kp}.

IV. SIMULINK MODEL AND RESULTS

The design of single input multiple output DC-DC converter is modeled using MATLAB/Simulink and the simulation model is shown in Fig.

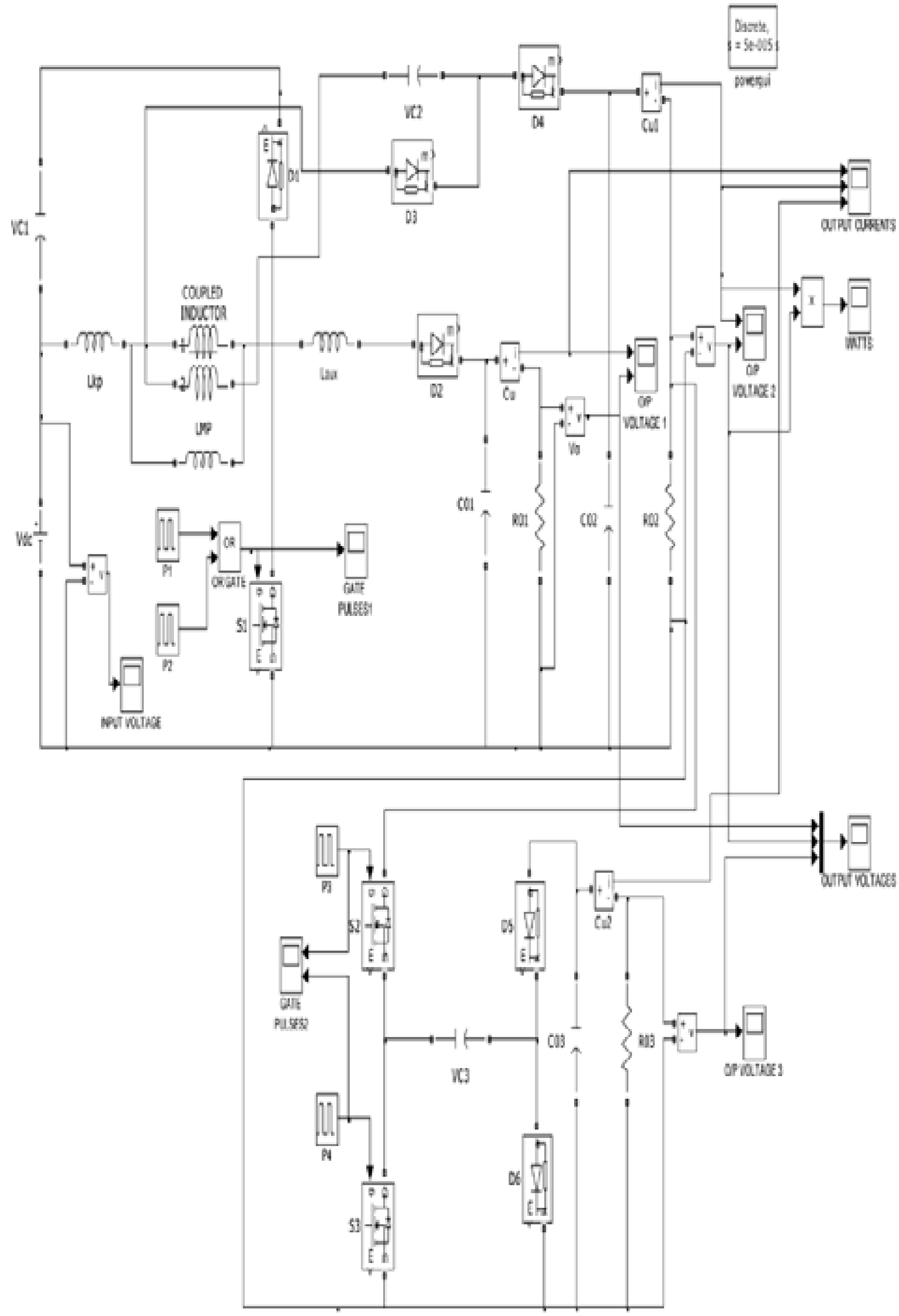
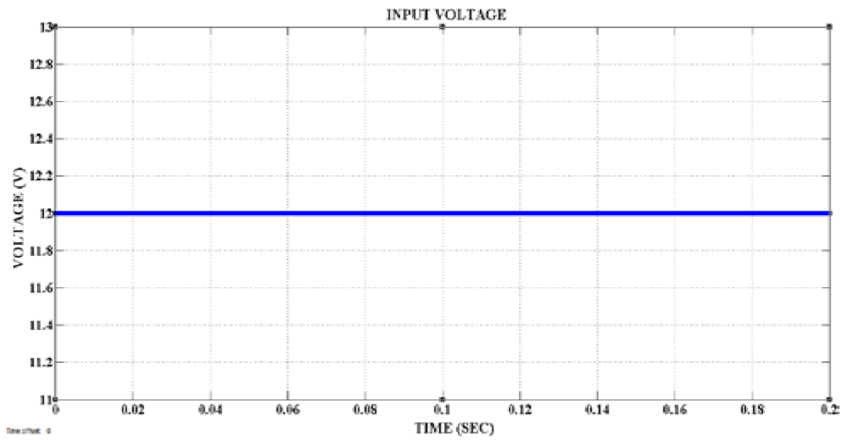
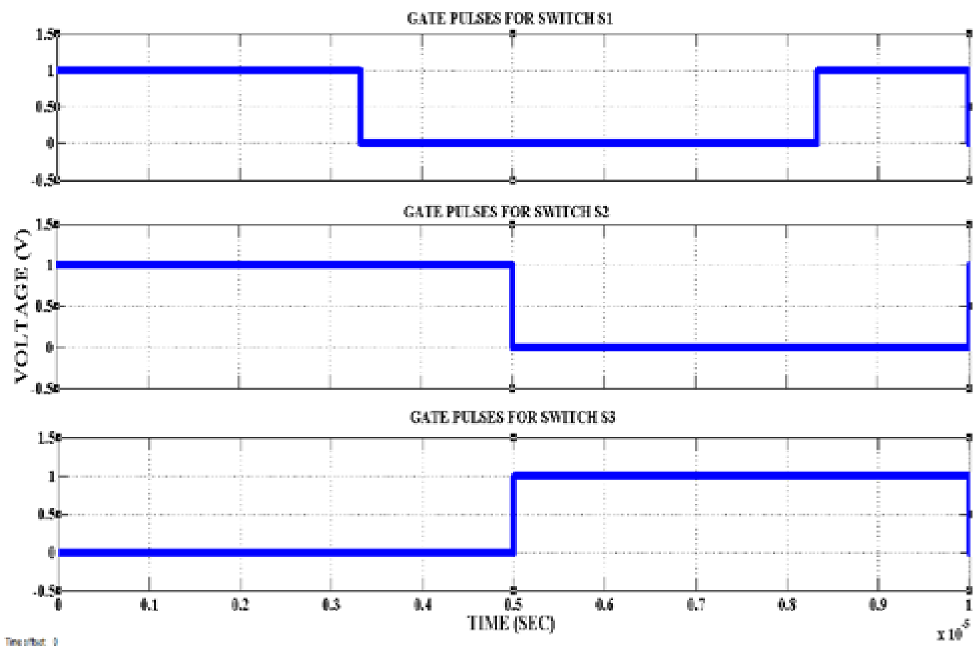
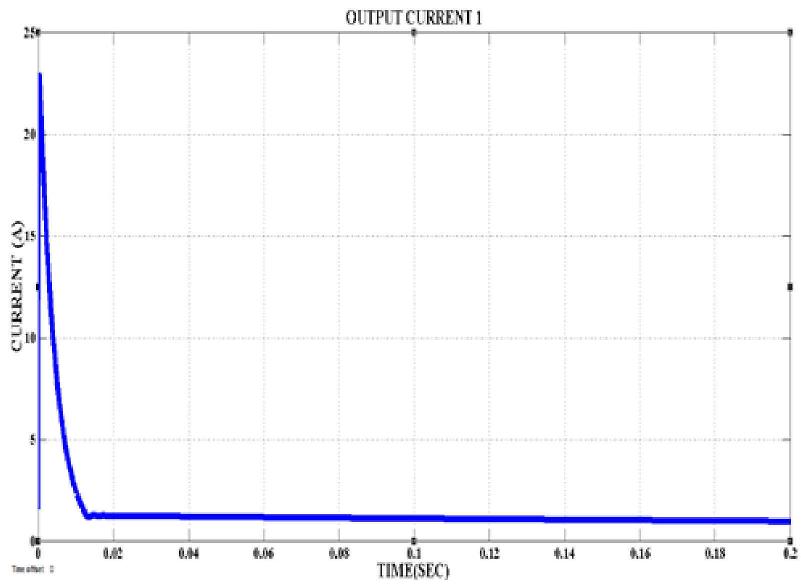


Fig.4 Simulink model of proposed converter

Fig.5(a) to Fig.5(h) shows the simulation results of the proposed circuit. Fig.5(a) shows the simulated waveform of input voltage, here the input voltage of circuit is about 12V. Fig.5(b) shows the simulated waveform of gate pulses for switch S_1, S_2&S_3.Fig.5(c) shows the simulated waveform of output current 1, here the output current of the circuit 1 is about 1A.







V. CONCLUSION

This paper has presented a SIMO dc–dc converter and this coupled inductor based converter was applied well to a single input power source plus three output terminals composed of two boost and one inverted voltages. The proposed SIMO converter is suitable for the application required one common ground, which is preferred in most applications. As mentioned above the voltage gain can be substantially increased by using a coupled inductor, the stray energy can be recycled by a clamped capacitor into the output terminal 1 or output terminal 2 to ensure the property of voltage clamping and an auxiliary inductor is designed for providing the charge power to the load 1 and assisting the switch turned ON under the condition of ZCS. Thus the proposed SIMO converter provides designers with an alternative choice for converting a low voltage source to multiple boost outputs with inverted voltage output efficiently.

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