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Implementation of Sido DC-DC Step-Up Converter

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ABSTRACT: This paper deals with a fully integrated boost dc-dc converter that provides two different output's with a 100vinput using only one inductor is presented. This converter works under PI control mode to have better efficiency, uses fewer power switches/external compensation components to reduce cost, and is thus suitable for portable application. it is consider monolithic device with both output voltages generated by the same integrated power converter. Besides the proposal of the suitable power converter, this paper present its control strategy and modulation approach.

KEY WORDS: Boost converter, single inductor, DC-DC converter

I. INTRODUCTION

Today's modern battery-operated portable products demands for advanced power management integration in portable application .To minimize power consumption, multiple supply voltages and dynamic voltage scaling schemes are widely adopted [2]. Recently, several single-inductor multiple-output (SIMO) DC-DC converters [3-10] have been proposed as the most promising solution to minimize component (inductor and power switch) counts/footprints and production cost. However, there exists many design challenges for the SIMO converters, such as cross-regulation, efficiency, system stability, and flexibility, for achieving better step-up conversion.

In many applications, there are need for a single-inductor dual- output DC-DC converter with one output voltage set to be higher (boost) than the supply voltage. In traditional SIDO Fig.1 (c) topology which has three power switches, and it uses power-distributive control from [6] and applies them to voltage control. Thus, there needs only one output compensation loop, which reduce the amount of external compensated components used, such as [6]. Mr.T Ramkumar is a Assistant Professor of the Department of Electronics and Instrumentation Engineering in Jerusalem College of Engineering, Chennai – 600100.

Moreover, this paper also extends the availability of Fig.1(c) topology to implement Boost converter according to different demands.

In this paper, operation and control of the proposed SIDO converter and the effect of cross regulation are discussed in Section II. Section III presents circuit design and implementation issues. Post-layout simulation and results are shown in Section IV. The conclusions are given in Section IV.

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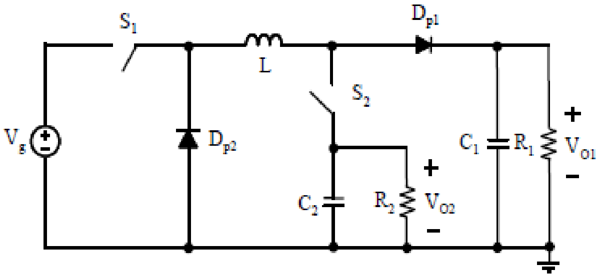
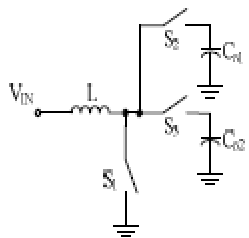


Fig:1Conventional buck type single input dual output dc-dc converter

II. PROPOSED TOPOLOGIES



(a)

Fig:2. Architecture of boost converter

The single-inductor multi-output DC-DC converters [12-16] were developed to effectively reduce the amount of electronic components for providing multiple output voltages, as shown in Figure 1 [3]. In order to further save the switch Sa or Sb from the single-inductor multi-output DC-DC converter showed in Figure 1, the prior work in [6] presented a novel boost-type single-inductor dual-output DC-DC converter, as shown in Figure 2

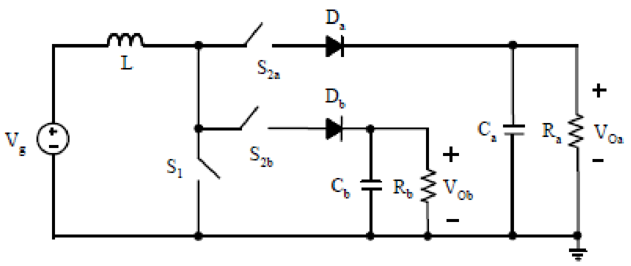


Fig:3.Single-Inductor multi-output switching converter

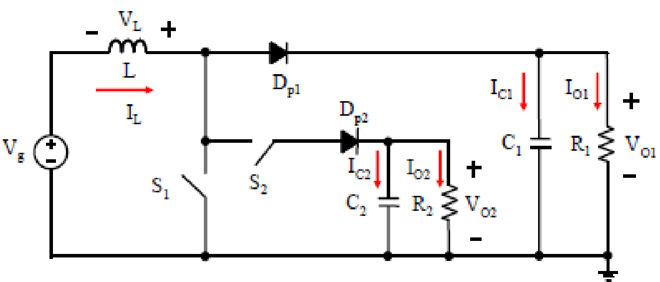


Fig4.:Boost type Single-Inductor Dual-output dc-dc converter

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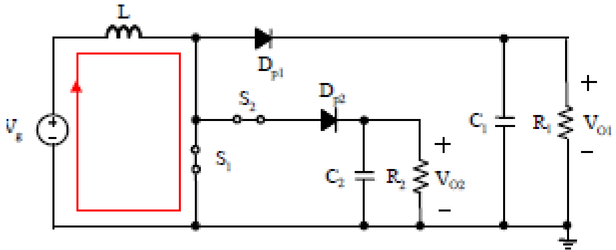
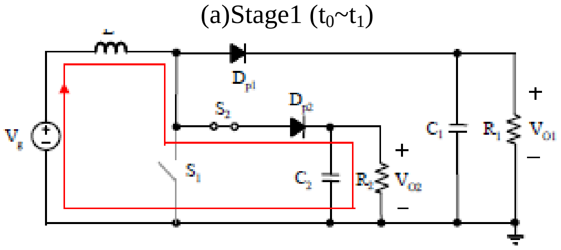
III. BOOST-TYPE SINGLE-INDUCTOR DUAL-OUTPUT DC-DC CONVERTER

A. *Operational Principles:*

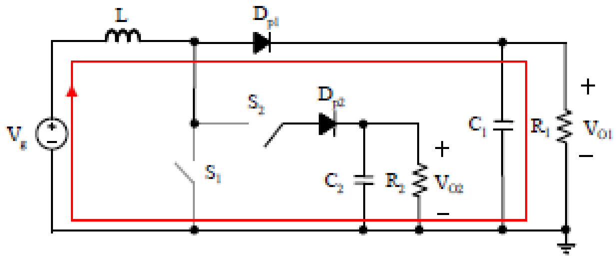
The operation of the boost-type single-inductor dual output DC-DC converter can be divided into three operating stages at steady state, as shown in Figure 3.[8] At Stage 1, the switches S1 and S2 are turned on simultaneously at time t0. The inductor L is charged by the input DC source and the inductor current increases, as shown in Figure 4(a). At Stage 2, the switch S1 is turned OFF at time t1 but switch S2 is still kept ON until t2. Meanwhile, the inductor discharges to the low-voltage side with output capacitor C2 and load resistor R2 through diode Dp2, such that the inductor current decreases, as shown in Figure 4(b). At Stage 3, the switch S2 is turned OFF at time t2 but switch S1 is still kept OFF until t3.[9] Meantime, the inductor discharges to the high-voltage side with output capacitor C1 and load resistor R1 through diode Dp1, which makes the inductor current decrease more rapidly, as shown in Figure 4(c).[10]



(a)Stage1 (t_0~t_1)



(b) stage(t_1~t_2)



©stage(t_2~t_3)

Fig:5.Operational principle of single-input dual-output dc-dc boost converter.

B. *Derivation of Voltage Ratios:*

At Stage 1, the incremental inductor current, as shown in Figure 5, can be obtained from Equation (1).

$$\Delta I_1 = \frac{V_g \cdot D_1 \cdot T}{L}, \qquad (1)$$

Where D1 is the duty cycle of the switch S1, and T is the switching period.

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During Stage 2, to fulfill the requirement of the volt second balance at steady state, the decrease I2 in inductor current can be calculated by Equation(2)

$$\Delta I_2 = \frac{(V_{O2}-V_g)\cdot(D_2-D_1)\cdot T}{L},$$

where D2 is the duty cycle of the switch S2.

Similarly, during Stage 3, the decrease 3 ΔI in inductor current can be obtained, as shown in Equation (3

$$\Delta I_3 = \frac{(V_{O1}-V_g)\cdot(1-D_2)\cdot T}{L}, \text{ and} \qquad (3)$$

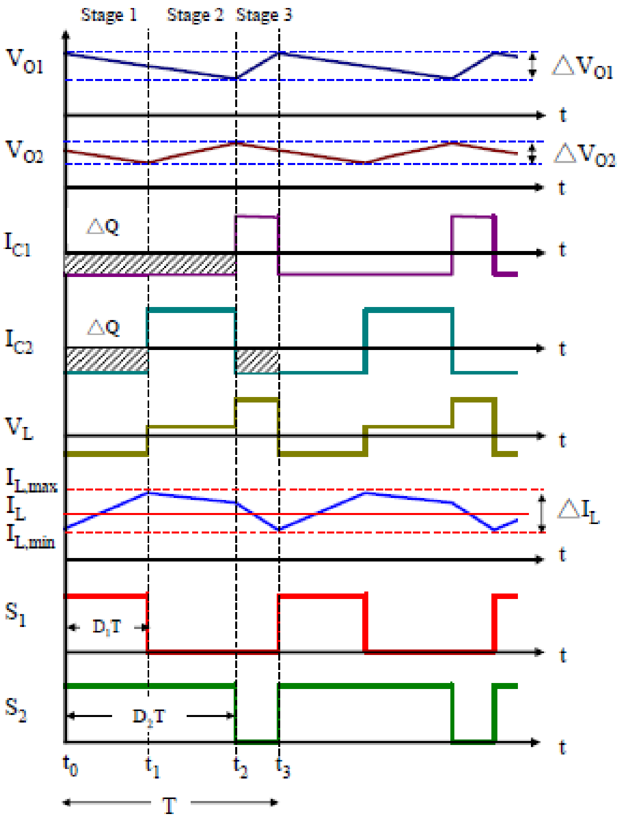
At steady state, the increase in the inductor current 1 is equal to the summation of the decreases($\Delta I_2 + \Delta I_3$) , in the inductor current.[12] Therefore, the voltage ratio relationship in between Vg, VO1 and VO2 can be obtained, as shown in Equation (4).

Fig:6.Key waveforms of single-inductor dual-output dc-dc boost converter

A. Derivation of Minimum Inductance in CCM

:

In order to ensure the operation of CCM condition, the inductance must be greater than a minimum value, as shown in Figure 3, which can be derived by utilizing the principles of energy conservation, as shown in Equation (5).



$$P_{in} = V_g \cdot I_L = P_O = \frac{V_{O1}^2}{R_1} + \frac{V_{O2}^2}{R_2}. \qquad (5)$$

where

Pin is the input power, and

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PO is the output power.
Based on Equation (4) and the minimum level of inductor current IL,min in Figure 3, the minimal inductance Lmin can be obtained, as shown in Equation (6)

$$L_{min} \geq \frac{[V_{O1} \cdot D_2 \cdot (1-D_2)+V_{O2} \cdot (D_2^2-D_1^2-D_2+D_1)] \cdot [V_{O1} \cdot (1-D_2)+V_{O2} \cdot (D_2-D_1)] \cdot T \cdot R_1 \cdot R_2}{2 \cdot (R_2 \cdot V_{O1}^2+R_1 \cdot V_{O2}^2)}.$$

B. Derivation of Output-Voltage Ripples:

Since the capacitors C1 and C2 are connected to the two output terminals of the boost-type single-inductor dual output DC-DC converter, the output voltage ripples ΔVO1 and ΔVO2 of the output capacitors C1 and C2 can be calculated by utilizing the amp-second balance principle, as shown in Equations (7) and (8), respectively

$$\Delta V_{O1} = \frac{T}{C_1} \cdot \frac{(1-D_2)}{R_1} \cdot V_{O1}. \quad (7)$$

$$\Delta V_{O2} = \frac{T}{C_2} \cdot \frac{[1-(D_2-D_1)]}{R_2} \cdot V_{O2}. \quad (8)$$

IV. SIMULATION RESULT

The simulation was used to verify the feedback loop design for steady state and large dynamic signal pertubation. Figure 5 shows the simulation results of boost converter with PI controller, converting universal AC input voltage at A100V to a load at 250 V DC and 1.6 kW.[13] Figure7illustrates: No Filtering technique. Middle: The boost inductor current with PI control applied, and Bottom: Series capacitor current in the coupled inductor filter.[14]

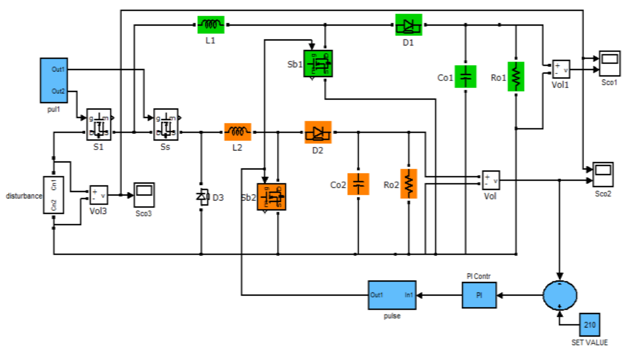

Fig: 7.Simulation circuit diagram of single input dual-output dc-dc boost converter

The proposed output is steady state and dynamic response improved. The steady state response in output constant voltage maintain in system.[15]

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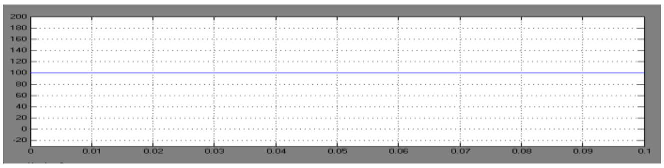
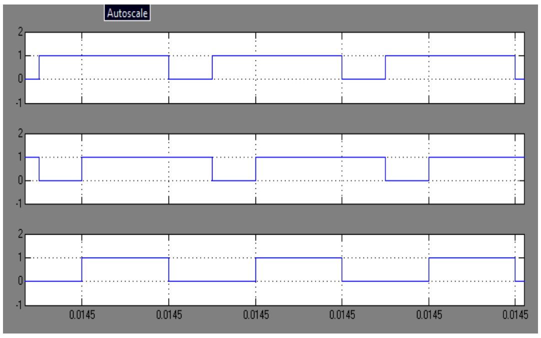
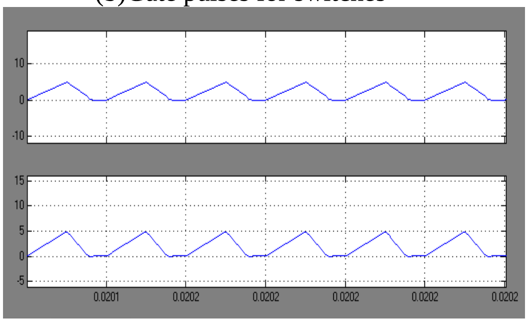


(a) DC input voltage



(b)Gate pulses for switches



(c)Inductor current through L_1 and L_2

Fig:8. dc input voltage (a) ,gate pulses for switches(b) ,inductor current L_1 and L_2(c)

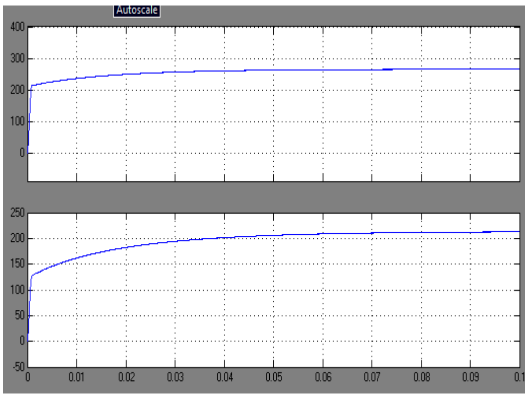


Fig:9.Simulation result of Dc output voltage 1 and voltage2

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V. CONCLUSION

This paper has presented the single inductor dual-output DC-DC converters. The boost-type single-inductor dual-output DC-DC converter has been introduced and analyzed, including the output voltage ripples, the voltage ratios and the minimum inductance in CCM by using amp-second balance principle and volt second balance principle . Further more, the boost-type single-inductor multi-output DC-DC converter can be extended from the boost-type single-inductor dual-output DC-DC converter. Additionally, the experimental results show the waveforms of the output voltages, inductor current and duty cycles for the boost-type single-inductor dual-output DC-DC converter. Finally, the experimental results are in good accordance with the operation the boost-type single inductor dual-output DC-DC converter at steady state.

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