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DESIGN AND ANALYSIS OF TWO PHASE COUPLED INDUCTOR BOOST CONVERTER

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Abstract

The paper a high step up boost converter. The proposed converter has used a coupled inductor with switched capacitors. The inductor were made to get charged in parallel and were made to get discharged in series by the configuration to achieve high step up voltage gain. And the voltage across the load is maintained constant by using a closed loop control.

Keyword: Interleaved, coupled inductor, boost converter

1.INTRODUCTION

The tightening requirements of power quality, offline power supplies are required to operate at high power factor and to draw low harmonic currents from the ac mains. The conventional method of reducing input current harmonics using an LC input filter is no longer practically sufficient to meet the requirements in many high-power applications. Active power-factor correction using buck, boost, buck–boost, Cuk and Sepic converters has been proposed."

"Among these converters, the single-ended boost converter has been widely adopted as a front-end power-factor-corrected (PFC) regulator."

"A converter consisting of two interleaved and intercoupled boost converter cells is proposed and studied. The converter can be designed to have a simple circuit, excellent current sharing characteristics, low input current ripple."

"In high-power applications (greater than 1.5 kW), boost converters are often paralleled in an interleaved manner to increase the output current and reduce the input current ripple. However, current sharing among the parallel paths is a major design problem. It can be shown that, when two similar but independently controlled boost converters are connected in parallel (with the same input and output voltages), the converter with a larger duty cycle may operate in CICM, while the other will then automatically operate in DICM. Under this condition, any further additional loading current will be taken up by the converter in CICM operation. Thus, current sharing is very sensitive to the mismatch in duty cycle."

2.BOOST CONVERTER

"The traditional boost converter is shown in Fig 1, this converter is able to step-up the input voltage, but when a high gain it is required a high duty cycle is needed, then the boosting capability is reduced, and also penalized with the efficiency."

$$V_0 = \frac{V_{in}}{1 - D} \quad \text{............(1)}$$

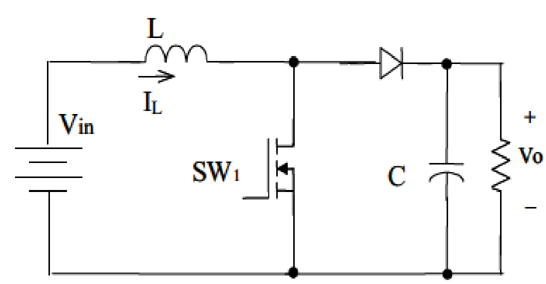


Fig 1: Boost converterTapped Inductor Boost Converter

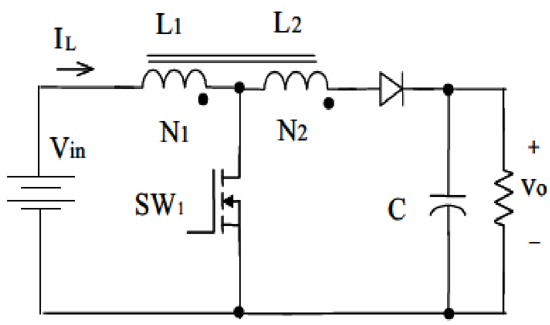


Fig 2: Tapped Inductor Boost Converter

"The tapped-inductor boost converter is the natural extension to the normal boost converter. In converters such as a flyback converter, a coupled inductor is used to transfer the energy from the input to the output, allowing the designer to change the turns ratio to affect the voltage transfer ratio. The tapped-inductor boost converter uses a similar approach, allowing one to change the turns ratio as well as the duty ratio, to affect the voltage transfer function. This converter operates and appears very similar to the typical boost converter, utilizing both a single active and passive switch. The waveforms during the different modes is as shown in Fig 3."

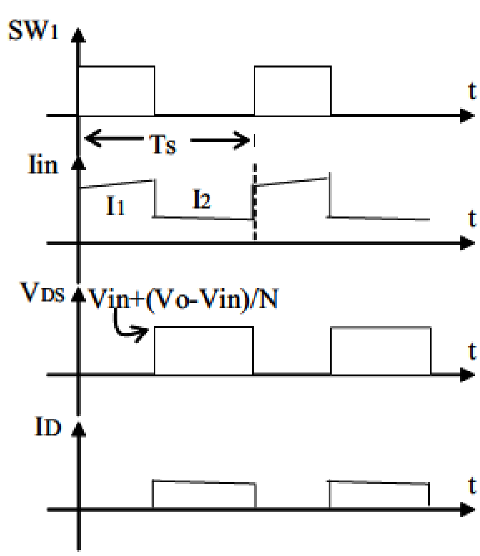


Fig 3: Waveforms of coupled inductor boos converter

The output voltage for a tapped inductor boost converter is given by

$$V_o = V_{in}\left(\frac{1}{1-D} + \frac{ND}{1-D}\right) \quad ......(2)$$

3.PHASE INTERLEAVED BOOST

3.1. converter with coupled inductor

"One of the largest disadvantages to the tapped inductor boost converter when considering its use with solar panels is its non-continuous input current. For the converter to be successfully used for this application, a prohibitively large input capacitor would need to be used. A method in use which causes a converter utilizing coupled inductors to have continuous input current involves using two interleaved stages, each of which increases its own current in response to a decrease in the other stage's current."

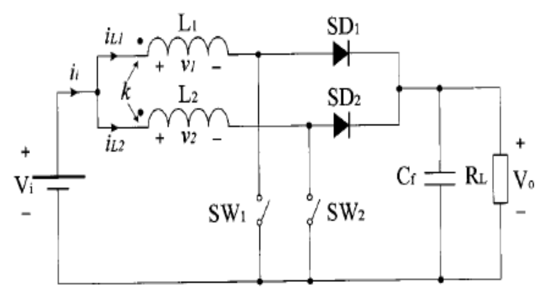


Fig 4: 2 phase coupled inductor boost converter

The relation between L1 and L2 is determined by the turns ratio of the magnetic element, that is:

$$\frac{L_2}{L_1} = \frac{(N_2)^2}{(N_1)^2} \quad .....(3)$$

The inductance is proportional to the turns square of the inductor:

$$L_1 = K(N_1)^2 \quad .....(4)$$

Then equivalent inductance of L1 and L2 is:

$$L_{eq} = K[(N]_1 + N_2)^2 \quad .....(5)$$

"Considering that *N2=N N1*, this is the equivalent of the coupled inductance L1 and L2 when the magnetic element is discharged."

Mode 1 ($t_0<t< t_1$)

"Starts when switch S1 is turned on. Inductor L1 is charged with vitality from power source VS and current IL1 increments directly. The heap gets vitality from the source through inductor L1, L2."

$$\frac{di_{L1}}{dt} = \frac{V_i - V_{lm}}{L_{lk}} \quad ....(6)$$

$$\frac{di_{L2}}{dt} = \frac{(V_i - V_0) + V_{lm}}{L_{lk}} \quad ......(7)$$

$$\Delta i_{L1} = \frac{V_i - V_{lm}}{L_{lk}} dt \quad ....(8)$$

$$\Delta i_{L2} = \frac{[(V]_i - V_0) + V_{lm}}{L_{lk}} dt \quad ....(9)$$

Mode 2 (t1<t<t2)

"Starts when switch S1, S2 both killed .Inductor L1 is demagnetized and current IL1, IL2 decreases straightly. The heap gets vitality from the source and the inductors L1, L2."

$$\frac{di_{L1}}{dt} = \frac{V_i - V_{lm}}{L_{lk}} \quad ....(10)$$

$$\frac{di_{L2}}{dt} = \frac{V_i + V_{lm}}{L_{lk}} \quad ....(11)$$

$$\Delta i_{L1} = \frac{V_i - V_{lm}}{L_{lk}} dt \quad ....(12)$$

$$\Delta i_{L2} = \frac{V_i + V_{lm}}{L_{lk}} dt \quad ....(13)$$

Mode 3 (t2<t<t3)

"Starts when switch S2 is turned on switch S2 turn off. Inductor L2 is magnetized with energy from power source V_S and current I_{L2} increases linearly I_{L1} decreases linearly. The load receives energy from the source through inductor L1, L2."

$$\frac{di_{L1}}{dt} = \frac{(V_i - V_0) - V_{lm}}{L_{lk}} \quad ......(14)$$

$$\frac{di_{L2}}{dt} = \frac{V_i + V_{lm}}{L_{lk}} \quad ....(15)$$

$$\Delta i_{L1} = \frac{(V_i - V_0) - V_{lm}}{L_{lk}} dt \quad .....(16)$$

$$\Delta i_{L2} = \frac{V_i + V_{lm}}{L_{lk}} dt \quad ....(17)$$

Mode 4: The mode 4 is same as that of the mode 2

$$\frac{di_{L1}}{dt} = \frac{V_i - V_{lm}}{L_{lk}} \quad ....(18)$$

$$\frac{di_{L2}}{dt} = \frac{V_i + V_{lm}}{L_{lk}} \quad ....(19)$$

$$\Delta i_{L1} = \frac{V_i - V_{lm}}{L_{lk}} dt \quad ....(20)$$

$$\Delta i_{L2} = \frac{V_i + V_{lm}}{L_{lk}} dt \quad ....(21)$$

The output voltage is given by

$$V_0 = \frac{1}{1-D} + \frac{2N+1}{1-D} \quad ....(22)$$

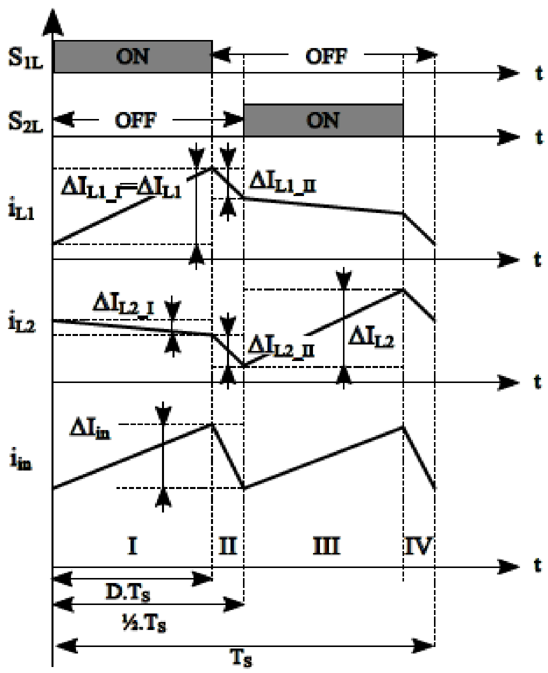


Fig 5: Waveforms for 2 phase coupled inductor boost converter

4.DESIGN CONSIDERATIONS

"The parameters are designed in such a way as to obtain optimum result."

Parameters	Values
Input voltage	12v
Output voltage	24v
L_1 and L_2	120µH
Magnetizing inductance	100µH
Capacitor	10µF
Load resistor	500Ω

5.SIMULATION RESULTS

"Simulation is obtained for 2 phase coupled inductor boost converter. The simulation is done for open loop and closed loop."

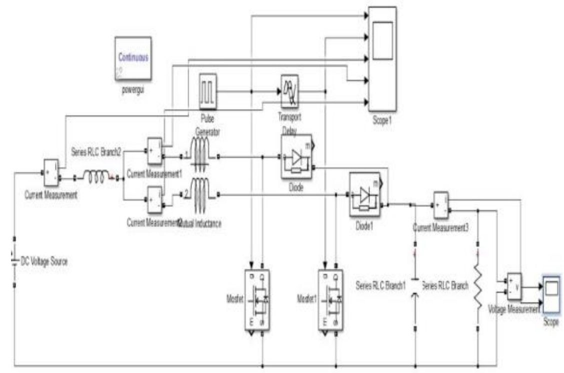


Fig 6: Open loop simulation for 2 phase coupled inductor boost converter

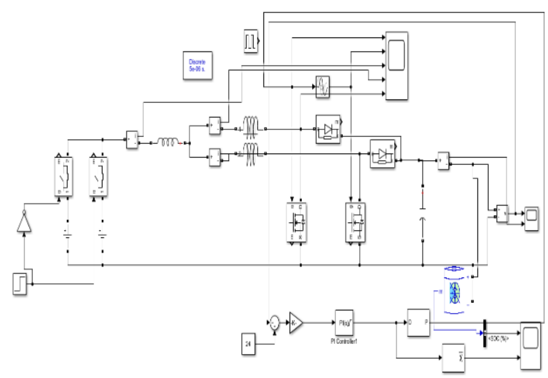
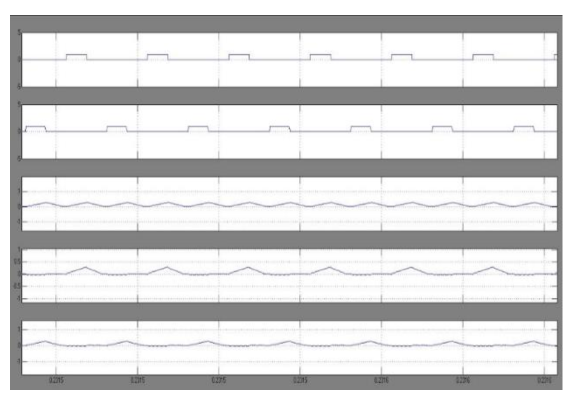


Fig 7: Closed loop simulation for 2 phase coupled inductor boost converter



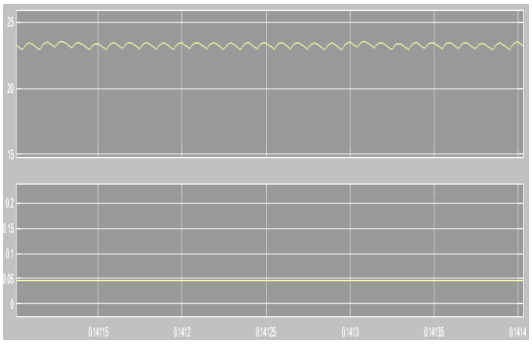


Fig 8: Waveforms showing the inductor and capacitor voltages

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