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A Review Article on the Improvement of Polyphase Boost Converter Integration with Lithium Ion Battery

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Abstract: This paper is to investigate about the working of polyphase boost converter over conventional boost converter. If polyphase boost converter is integrated with lithium-ion battery the conclusions are to be check after review of this article. The main aim of this article is to study about the different research papers based on dc to dc converter and lithium-ion battery and their application on EV and plug-in hybrid vehicles. The advantages of lithium ion battery over other battery and to study about minimizing the ripple current and reducing the size of inductor?
Keywords: polyphase boost converter, boost converter, lithium-ion battery.

I. INTRODUCTION

In present trend increases fuel price and high pollution level demands for the alternative option available then it come to mind about the Ev (electrical vehicles) and plug-in hybrid vehicles. They are eco-friendly and no need of fuel. They only need a powerful battery and a fast charging capacity with the help of dc-dc converter circuit it is possible to improve the quality of the demand that time needed. We are going to investigate the entire dc-dc converter for this type of requirement. Now one by one we start to review the late and latest research paper and articles about dc-dc converters, uses, about integration of lithium ion battery and advantages over other converters.

II. DC-DC CONVERTERS

There are many type of converter but here we are considering only boost converters and polyphase boost converter.

A. Boost Converter

Boost converter or step-up converter is a DC-DC converter. This converter step up the dc to other high level dc means it step up the voltage and step down the current. The circuit of boost

Converter have at least one diode and a semiconductor switch and a power source fig1 shows a simply boost converter circuit

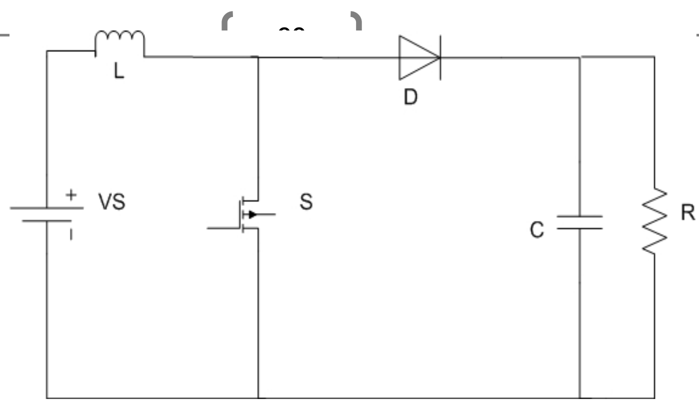

Fig 1. Boost converter circuit with R load

The basic principal of boost converter consists of 2 different states on-state and off-states shown one by one.

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B. In on-state the Switch is s is Closed then an Increase in the Inductor Current Shown in fig 2.

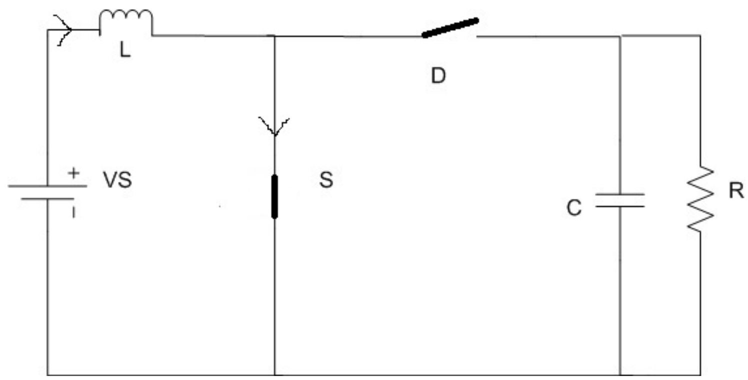

Fig 2 On state of Boost converter

In off-state the switch is open and the only path for inductor to discharge is through the diode then to capacitor C and load resistance R. this shows after the switch is off the circuit is on with is driven by inductor fig 3 shown. The input current is same as the inductor current.

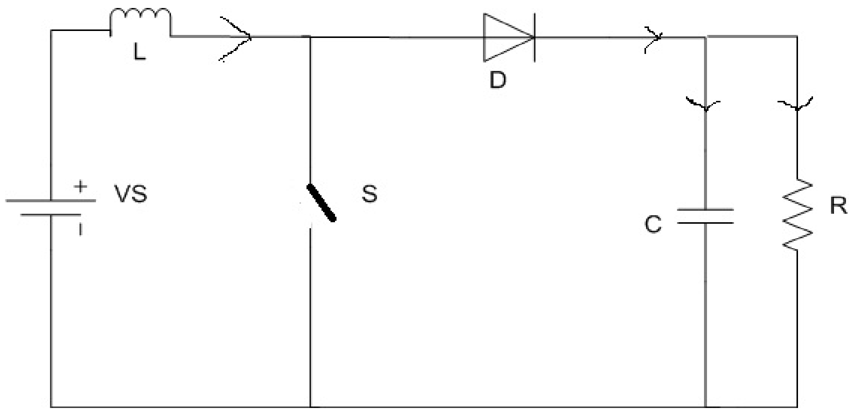

Fig 3 shows the off state of the Boost converter

When boost converter work in continuous mode the current trough the inductor never become zero. A typical wave form is shown in fig 4. Where the Pm is power, is source current, Vs is voltage across the source

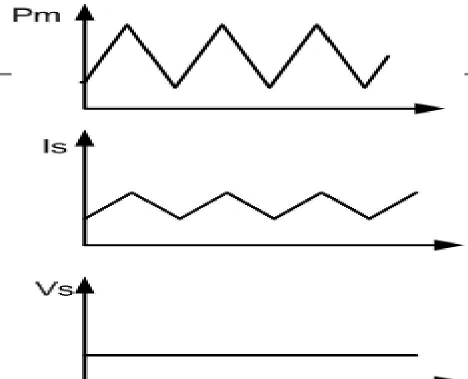

Fig 4. Shown variation in Pin, Is and Vs

The Vs voltage waveform from fig 4. The average value of Vs is (1-D) V_o where D is duty cycle of the wave form if we start the switch s then we get ideal transfer function.

$$V_i = (1\text{-}D)\, Vo \text{ or } Vo/Vi = 1/(1\text{-}D).$$

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During the on-state the switch s is closed then input voltage applied through the inductor means change in IL flowing though the inductor during the time period t given by formula.

$$\frac{\Delta I_L}{\Delta t} = \frac{V_i}{L}$$

Where L is the inductor value

In the end of on-state the increases of IL is therefore

$$\Delta I_{LON} = \frac{1}{L}\int_0^{DT} V_i \, dt = \frac{DT}{L} V_i$$

Where D is duty cycle it represents the fraction of the time period T during which the switch is on

During the off-state the switch s is open. Then the inductor current flow through the load. Suppose no voltage drop across the diode D and capacitor large enough for keeping the voltage constant. Then IL is given by

$$V_i - V_O = L\frac{dI_L}{dt}$$

The variation of IL during off-state is given by

$$\Delta I_{LOFF} = \int_{DT}^{T} \frac{(V_i - V_o)dt}{L} = \frac{(V_i - V_O)(1 - D)T}{L}$$

The store energy in the inductor is given by

$$E = \frac{1}{2} L I_L^2$$

Inductor current is same at starting and at the end of the time period. This means overall change in current is zero.

$$\Delta I_{LON} + \Delta I_{LOFF} = 0$$

Substituting ΔI_{LON} and ΔI_{LOFF} in above equation given by

$$\Delta I_{LON} + \Delta I_{LOFF} = \frac{V_i DT}{L} + \frac{(V_i - V_o)(1 - D)T}{L} = 0$$

This can be written as

$$\frac{V_O}{V_i} = \frac{1}{1 - D}$$

The above equation shows that output voltage remain higher than the input voltage and increases with the Duty cycle D. it means that this converter is referred to be a step-up converter or boost converter.

If we rearrange the above equation the duty cycle to be.

$$D = 1 - \frac{V_i}{V_O}$$

C. Polyphase Converter

In polyphase boost converter, additional inductor, diode and switch is required where as number of source and capacitor remain same as conventional boost converter (Thounthong and Davat, 2010) as shown in fig 2. The working of polyphase boost converter depends on number of sequence and duty ratio in this particular case the practice is done on double phase boost converter with duty ratio taken as 0.5 in calculation (Mirzaei and Ramanarayanan 2005).The different parametric comparison of conventional boost converter current with respect to 2-phase boost converter is shown in table-1. In boost converter current (IL) delivered by inductor (L) is given in table-1 by equation (Eq -2a) is dependent on duty ratio (D) and load current (Io) while in 2-phase boost converter, the current (IL1, IL2) shared by each Inductor (L1, L2) is half with respect to conventional boost Converters shown in equation (eq-1a). As the ripple current (ΔIL, ΔIL1, ΔIL2)is also dependent on load current (Io) from equation (eq-1b) and (eq-2b), so it also reduced by half factor shown in Equation (1c) and (2c) if the load current (Io) remain constant for both cases.

Tab.1 (a) Comparison of Polyphase Boost converter With Boost Converter.

S.NO	Parameters	2- phase polyphase boost converter	Boost converter	Analysis
1	$I_L = I_{L1} = I_{L2}$	$I_L = I_{L2} = \frac{\left(\frac{I_O}{2}\right)}{1-D}$ Eq-1(a)	$I_L = \frac{I_O}{1\ D}$ Eq-2(a)	$I_{L1} = I_{L2} = \frac{I_L}{2}$ Eq-3(a)
2	$\Delta I_L = \Delta I_{L1} = \Delta I_{L2}$	$\Delta I_{L1} = \Delta I_{L2} = 0.4 \times \left(\frac{I_O}{2}\right) \times \frac{V_O}{V_S}$ Eq-1(b)	$\Delta I_L = 0.4 \times \left(\frac{I_O}{2}\right) \times \frac{V_O}{V_S}$ Eq-2(b)	$\Delta I_{L1} = \Delta I_{L2} = \frac{\Delta I_L}{2}$ Eq-3(b)
3	$L = L_1 = L_2$	$L_1 = L_2 = \frac{V_S \times (V_O - V_S)}{f_S \times \Delta I_L \times V_O}$ Eq-1(c)	$L_1 = L_2 = \frac{V_S \times (V_O - V_S)}{f_S \times \Delta I_{L1} \times V_O}$ Eq-2(c)	$L_1 = L_2 = \frac{L}{2}$ Eq-3(b)

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III. LITHIUM ION BATTERY

There are many type of battery available but lithium ion is one of the best battery available it have no self discharge issue as well as high concentrated energy which improve working on lithium ion battery. it has been used in several electronic gadgets, space craft and aircraft power system. to understand its dynamic behaviour a model is shown in fig 3 it have a set capacitor and resistor (Bhattacharya et al.2009).in this model it contains mainly three components.

A. Electromotive force (EMF).
B. An internal resistance with two component Rs and Rc.
C. A capacitive nature that mainly comes from transient response of charging porous electrodes.

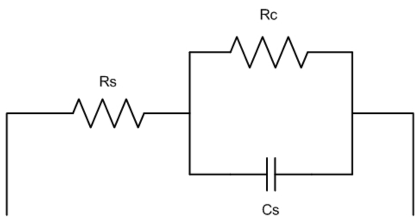

Fig 3 - Lithium ion battery

The equivalent circuit of lithium ion battery have ohmic resistance (HU, Li and Peng, 2012) the activation polarization resistance, the concentration polarization resistance and double layer capacitance. Rs represent activation polarization resistance. Cs exists on the surface of electrode and Rc is concentration polarization resistance.

IV. CONCLUSION

From above explanations its conclude that if No. of inductor increases ripple current and frequency is double for the sake of simple experiment we consider 2- stages of polyphase boost converter and we can be integrated lithium-ion battery with polyphase boost converter. If polyphase boost converter integrated with lithium-ion battery it causes less heating effect.

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