Design Analysis & Experimental Verification of Boost Converter

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Abstract— The research trend of Boost converter had introduced various topologies of Boost converters & alongside it had marked its importance in field of renewable area. The proposed DC-DC Boost converter shows the effectiveness in terms of Gain, Core loss & Voltage stress. Through this research work the performance of proposed DC-DC Boost converter is verified through prototype developed in the laboratory, along with C^+ programming as a switching control signal. The Arduino-UNO with Bitwise operation logic used as programming tool.

Key words: Boost Converter

I. Introduction

Development in the field of power electronics had enhanced the Boost converter with different technical features. Along with time researchers enlists the different improvement in Boost converter, this paper proves the effectiveness of proposed Boost converter with features such as voltage gain, stress on MOSFET, Inductor core loss, ripple current.

The ripple current cancellation of Conventional boost converter had made by tapping of LC branch. The inductor tapping reduces the input ripple current, CBC [1]. The voltage from PV system is boosted efficiently using level boost converter. The perturbation & observation method used to achieve maximum power [2]. In [3], a zero ripple input current boost converter for high gain applications, clamp capacitor connected in series, so the converter can produce a very high voltage & high conversion efficiency. Non-isolated high gain converter has better performance as compared to CBC & three level boost converter in terms of gain, voltage stress & switching losses. This converter having inherent voltage balancing [4]. The capacitor and inductor are apply in the switched manner that increases output voltage gain. Here the size of converter is reduced but as no. of cells are increased the duty ratio is reduced & converter becomes more complex [5]. Quadratic boost converters output voltage is double of input voltage with advantages like reduced hardware, low switching losses [6]. In [7], flying capacitor boost converter is having high voltage gain ratio & improved conversion efficiency that can achieved with low inductor core & copper losses. FCBC has high gain as compared to QBC.

II. Analysis of Boost Converter

The Boost converter "Fig.1" comprises of two switches S1& S2 with a switching period T. At input side of the converter the two inductors L1 & L2 that opposes the input ripple current. Capacitors C1, C2, & C3 which charge and discharge according to switching of switches. Diodes D1, D2, D3, & D4 gets forward biased when anode is more current positive than cathode.

A brief introduction is given in section-I, while in section-II & III modelling & analysis of DC-DC Boost converter is discussed in detail. The simulation & experimental results are discussed in section IV, V, VI respectively.

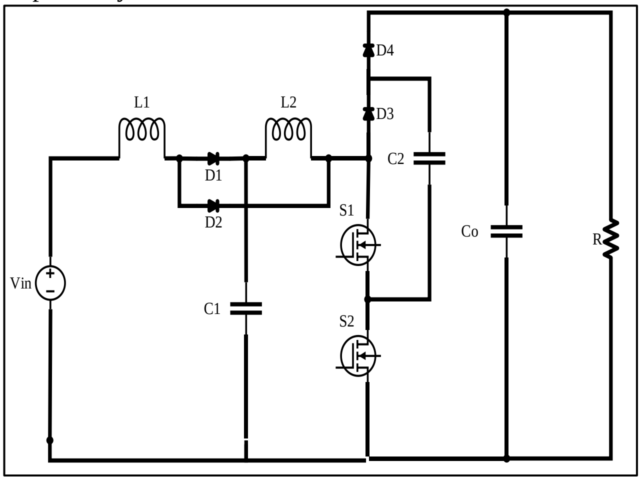

Fig. 1: Schematic of Boost converter.

In Continuous Conduction Mode (CCM), operation of the Boost converter is divided into four subintervals.

Switching state1- The switches S1 & S2 are close for period t, $\left[0 < t < \frac{DT}{2}\right]$. "Fig.2" Inductors L1& L2 gets charge during this period. The diode D2 forward biased due to inductor voltage VL1 & D1, D2, D3 are reverse biased.

$$Vin - VL1 = 0 \tag{2.1}$$

$$\Delta iL1 = \frac{Vin * DT}{2 * L1} \tag{2.2}$$

$$VL2 = Vc1 \tag{2.3}$$

$$\Delta iL2 = \frac{Vc1 * DT}{2 * L2} \tag{2.4}$$

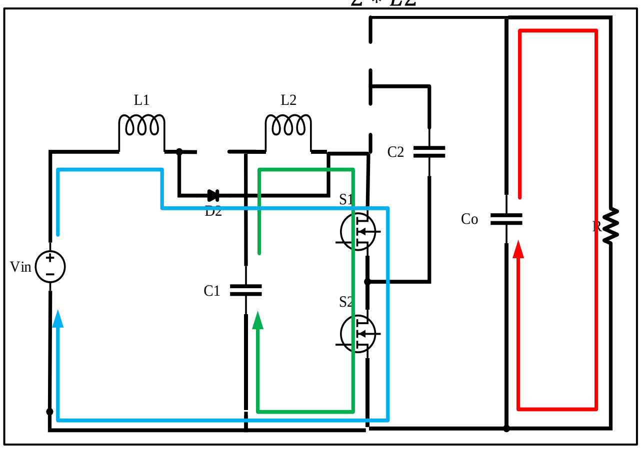

Fig. 2: Boost converter both switches closed.

Switching state- The switch S1is open for period t, $\left[\frac{DT}{2} < t < \frac{T}{2}\right]$. "Fig.3" Diodes D1 & D3 conducts due to forward biased & diodes D2 & D4 becomes reverse biased.

$$VL1 = Vin - Vc1 \tag{2.5}$$

$$\Delta iL1 = \frac{(Vin - Vc1 * (1 - D)T)}{2 * L1} \tag{2.6}$$

$$VL2 = Vc1 - Vc2 \tag{2.7}$$

$$\Delta iL2 = \frac{Vc1 - Vc2 * (1 - D)T}{2 * L2} \tag{2.8}$$

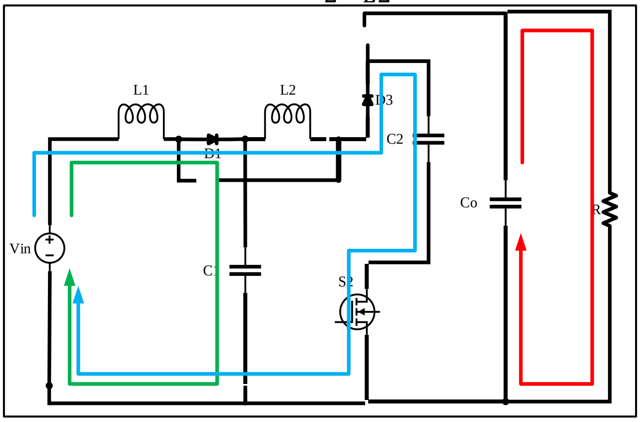

Fig. 3: Boost converter with switch S1 open.

Switching state3- The switches S1 & S2 are close for period t, $\left[\frac{T}{2} < t < \frac{(1+D)T}{2}\right]$. Inductors L1 & L2 passes their stored energy to capacitor C1 & C2 respectively. "Fig.3" Diodes D1 & D3 conducts due to forward biased condition and diodes D2 & D4 become reverse biased.

Switching state4- The switch S2 is open for period t, $\left[\frac{(1+D)T}{2} < t < T\right]$. "Fig.4" the stored energy in inductor L1 delivered to capacitor C1 and stored energy of L2 is pass to C0 & load along with the capacitor C2.

$$VL2 = Vc1 + Vc2 - Vout \tag{2.9}$$

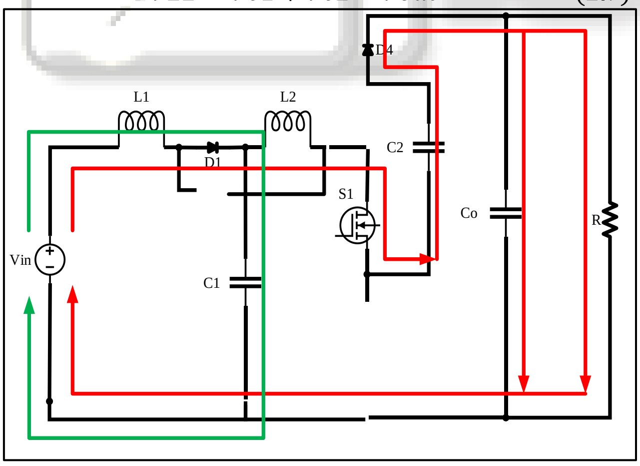

Fig. 4: Boost converter with switch S2 open.

III. Design of Boost Converter

For steady state operation, the net change in inductor current must be zero for inductor L1"3.1,"

$$\Delta iL1closed + \Delta iL1opened = 0 \tag{3.1}$$

$$\frac{Vc1}{Vin} = \frac{1}{1 - D} \tag{3.2}$$

Similarly for inductor L2,

$$Vout = \frac{2Vin}{(1 - D)^2} \tag{3.3}$$

The average current in the inductor is determined by recognizing that average power supplied by the source must be same as the average power absorbed by the load.

$$Pin = Vin * Iin = Vin * IL \tag{3.4}$$

$$IL1 = \frac{4Vin}{R(1 - D)^4} \tag{3.5}$$

The output equation was develop with the assumption that the inductor current is continuous, meaning that it is always positive. A condition necessary for continuous inductor current is $Imin$ to be positive. The boundary between continuous an discontinuous inductor current is determined from $Imin$.

$$Imin = 0 \tag{3.6}$$

$$L1min = \frac{D(1-D)^4 R}{16f} \tag{3.7}$$

Input ripple current in conventional boost converter is related to inductor value, larger the inductor smaller the ripple current and vice versa. "3.9," For the same ripple current as the CBC the proposed Boost converter require almost eight times less inductance.

$$\Delta iL1max = \frac{VinDT}{2L1} \tag{3.8}$$

$$\Delta iL1max = \frac{Vo}{32L1f} \tag{3.9}$$

IV. Simulation

The performance analysis done using PSIM software,"Fig.5" shows the simulation performance in PSIM. For analyzing the performance of Boost converter, the parameters considered are $Vin = 7V; Vo = 25V; fs = 50kHz; Io = 0.5A$; the design parameters of passive components known by carrying out the mathematical modelling on proposed converter.

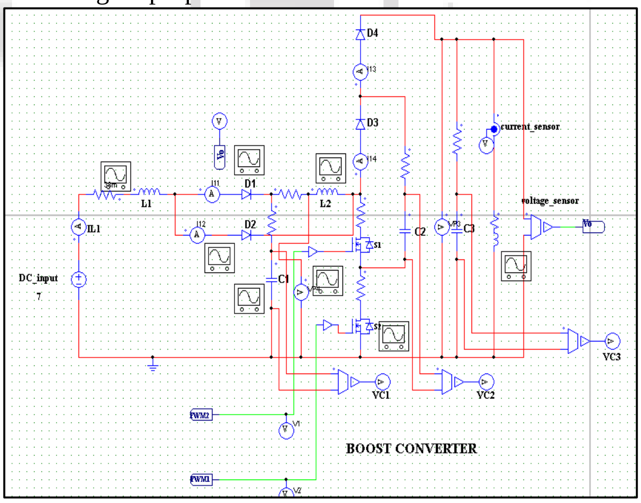

Fig. 5: Simulation of Boost converter in PSIM

V. Simulation Results

"Fig.6" Shows output voltage, $Vo = 25V$, $F = 50KHz$ on resistive load basis, which is done by real time simulation on PSIM. "Fig.7" It is observed that the output current ripple of converter $Io = 0.5A$ is very much negligible due source side inductance, thus avoids the need of separate filter.

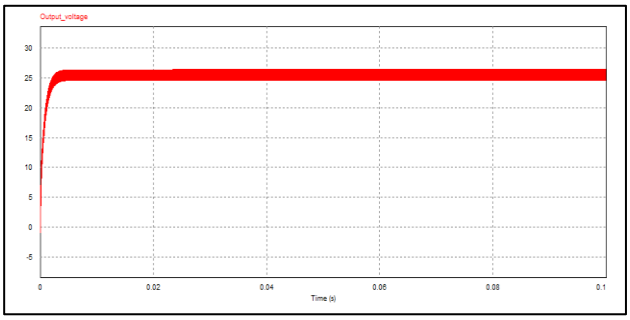

Fig. 6: Output voltage.

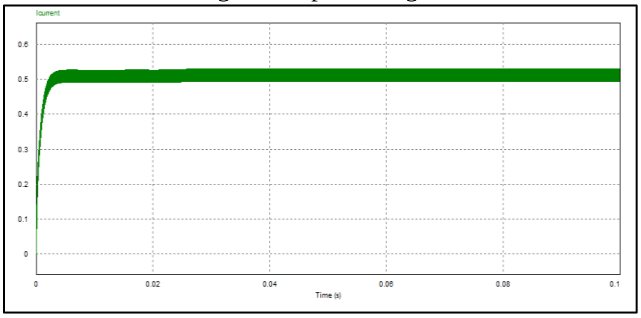

Fig. 7: Output current.

VI. EXPERIMENTAL RESULTS

A. Detail of prototype circuit

The hardware setup of Boost converter is done on perfboard. The computer hardware Arduino-UNO used as programming tool, which has microcontroller ATmega328P. Two MOSFET are used for switching at minimum 2.5 Threshold voltage. The 4 batteries are connected in parallel at constant 7v.

The output voltage 23V is achieved with an input voltage 7V and Gain is 3. The switching signal for two MOSFET "Fig.10" on Digital oscilloscope having frequency, $\boldsymbol{f} = \mathbf{50}\boldsymbol{KHz}$.

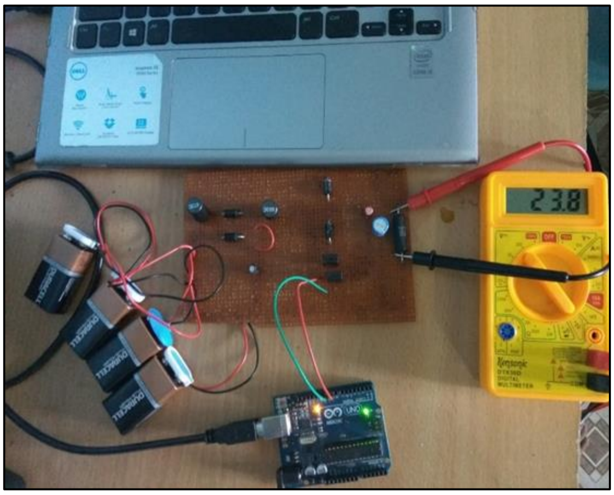

Fig. 8: Hardware Setup

Parameter	Name	Specification
MOSFET	FDPF680N10T	100V, 12A, N-Channel
D1,D2	1N5820	Schottky Diode, 20V,3A
D3.D4	SB180	Schottky Diode, 80V, 1A
L1, L2	Radial	$47\mu H, 68\mu H$
C1, C2, C3	Electrolytic	10µF, 15µF,32µF

Table. Hardware parameter

A. Experimental results

The output voltage 23V is achieved with an input voltage 7V and Gain is 3. The switching signal for two MOSFET "Fig.10" on Digital oscilloscope having frequency, $f = 50KHz$.

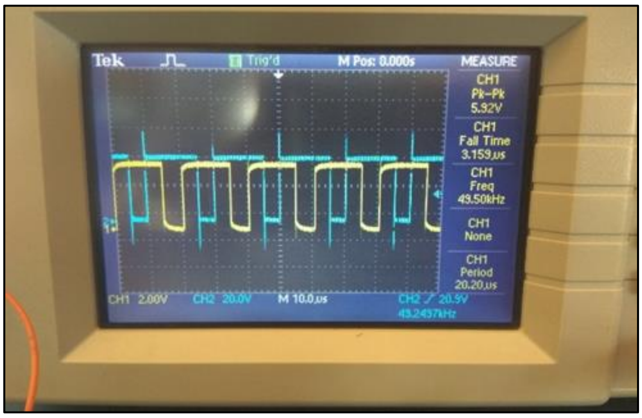

Fig. 9: signals on DSO.

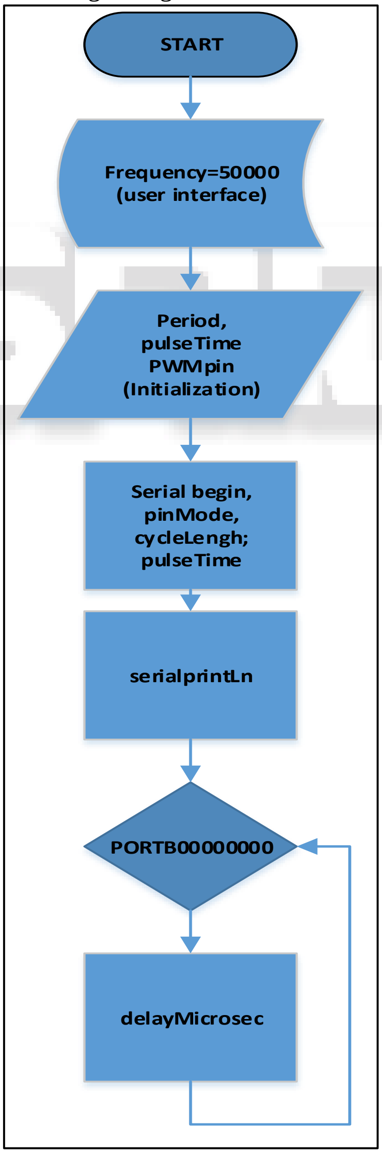

Fig.10.Flow chart of programme.

VII. Conclusion

The hardware implementation of proposed Boost converter suggest that, the boost converter achieves voltage Gain of 3, with output voltage 23V, it acquires lower inductor core. A designing, modelling & analysis of DC-DC Boost converter is done. Its simulation on PSIM is discussed. The prototype of designed DC-DC Boost converter is discussed.

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