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A Unique Variable Voltage Quadruple Boost Converter with lesser Voltage Stress on Switch

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Abstract: A unique transformer-less variable voltage quadruple interleaved boost converter with extremehigh-voltage transfer gain and decreased semiconductor voltage stress is featured. The proposed topology uses input-parallel output-series pattern for giving a much higher voltage gain excluding implemention of very large duty cycle. The projected converter not only be able to achieve high maximise voltage gain with lowered element count but also lessen the voltage stress of each active switches and diodes. So this makes one to opt lower voltage rating MOSFETs and diodes for minimising both switching and conduction losses. Along with, due to the charger of the blocking capacitor, the converter highlights spontaneous uniform current sharing characteristics of two interleaved phase for voltage boosting mode rather than adding an additional circuitry or complex control techniques. The operative principle and steady analysis as well as a comparison with other latest existing high boost topologies are showed. At last simulation results isshown to exhibit the effectiveness of the proposed converter.

Keywords: Automatic uniform current sharing, high boostconverter, low voltage stress, transformer-less, voltage quadrupler.

I. INTRODUCTION

By means of global energy scarcity and tough environmental movements, renewable or clean energy sources likesolar cells and fuel cells are gradually valued across the world. However, due to the integral low voltage characteristics of these energy sources, a boost dc-dc converter is necessary as a pre stage of the corresponding power situation. The conventional buck–boost and boost converters, cannot satisfies the application requirements because of lower quality in overall efficiency as duty ratio approaches one. Other wise the very high duty cycle, not only gets very high voltage spikes and rises conduction losses and makes extreme diode reverse-recovery problem. Many topology models have beenproposed to give a high step-up dc voltage gain without peak duty cycle as can be seen.

Till now many models have been proposed to get high voltage gain. But there are lot of disadvantages from these models such as high voltage stress on switches, degradation in efficiency, high diode recovery problem, extra bulky circuit,etc. So this paper is provided to overcome almost all severe problems while stepping up dc voltage. Before dc-dc flyback converter is introduced which is simple in its construction but faces severe voltage stress because of leakageinductance in transformer. After this much more papers have been provided to reduce the leakage inductance by recycling the energy of leakage inductance, for this energy re generation method is implemented. Phase-shifted full bride converter which comes under isolated voltage type converter can attain high voltage gain but efficiency is low. So in isolated current type converter like active clamp dual boost converter can maintain both high voltage gain and high efficiency but it needs extra circuit or components separately for start up which makes conversion quiet costly and also feedback controller is essential. Switched capacitor based converters is also shows the improvement in high step up gain and rise in efficiency then again large conduction loss and high transient current sufferings are observed

So here, a unique transformer-less changeable voltage quadrupler configuration is proposed. It has two-phase interleaved boost dc-dc converter to enhance a high voltage gain and keeps an automatic current sharing proficiency simultaneously. Much more to this, the voltage stress on diodes and active switches in the proposed converter can be highlydecreased to achieve overall conversion efficiency.

II. WORKING PRINCIPLE OF THE CONVERTER MODEL

The designed model of converter hasseries output & parallel input configuration as shown in above Figure1. The modelled step up dc-dc converter mostly obtained from2 phase interleaved boost dc-dc converter as shown in Fig. 2. By matching designed converter with 2 leg boost dc-dc converter can observe that extradual capacitors &2 more diodes are included , so that during the energy transmission time fractional inductor stored energy is stored in one capacitor and partial inductor stored energy composed by the other capacitor energy storehas transferred to the output

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to attain much higher voltage gain. Anyway, the designed converter's voltage gain is double of the interleaved 2 leg boost converter. And also, the voltage stress of either active switches and diodes can obtain muchlesser than latter. The suggested converter attains automatic identical current sharing ability without enhancingcomplex control techniques or an extra circuitry.

The present boost converters main objective is to obtain high voltage transfer gain , for this usually duty ratio is more than 0.5 but the designed step up converter also gets the drawback of pulsating out-put periods. Like any other current converter and in continuous conduction mode (CCM); So analysis of steady state is done. Any way if duty ratio is lesser than 0.5 or in discontinuous conduction mode(DCM), it is not possible to transfer energy from stored inductor to capacitors, load. Hence more than 0.5 duty ratio is essential for high voltage transfer gain. More over automatic current sharing behaviour in converter can eliminate additional circuitry for control and this is just because of duty ratio exceeds 0.5 which makes charge residue of blocking capacitors results equal current sharing.

There are 4 modes of operation in proposed model. They are mode1, mode2, mode3 and mode 4.
In Mode 1 [$t_0<t<t_1$] : Both the switches S1 and S2 are turned ON (conducting). And all the diodes are Off.
Mode 2 [$t1 \leq t < t2$]: For this operation mode, switch S1 isON and S2 is turned OFF. Diodes D2a and D2b are in ON state.

Mode 3 [$t2 \leq t < t3$]: both S1 and S2 are turned ON.
Mode 4 [$t3 \leq t < t4$]: Here in this operation, switch S2 stays conducting orON state and S1 is OFF state. Diodes D1a and D1b become On condition or ON state. It is observed that the portion of stored energy in inductor L1 and the stored energy of C_B is now given to C2 output capacitor and load. At same time, portion of stored energy in inductor L1 is stored in $C_{A.}$ In thisMode 4, the voltage of output capacitor V_{C2} = VCB +VCA.

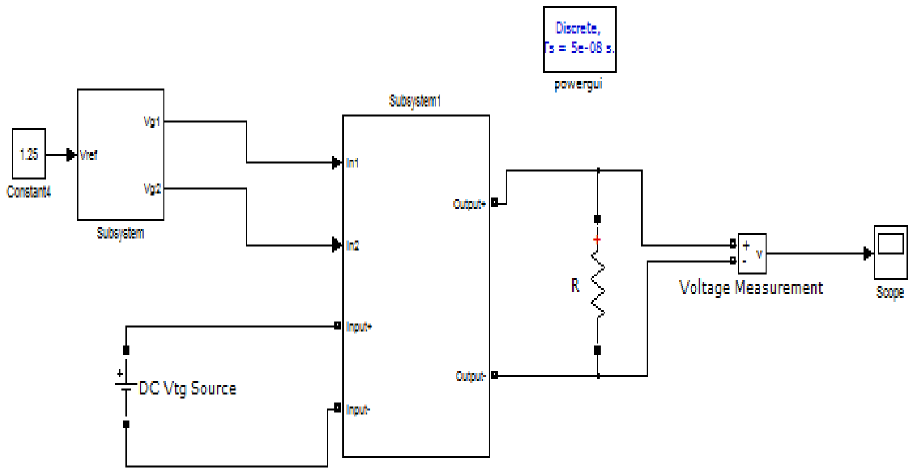

Figure 1: Schematic Diagram showsopen loop model of proposed two phase interleaved boost converter

The converter is designed in such a way that, it should boost the input voltage. The converters part contains two MOSFET's for switching action. It is nothing but subsystem1 in schematic diagram. For this MOSFET, gate pulses are given by driver circuit which is enclosed in subsystem of model. To give gate pulses to MOSFET, TLP250 IC is being used as driver circuit. The TLP 250 IC is 8 pin IC base. Converter gets DC voltage source of 25 Volt which is to be boosted. By considering, not extreme duty ratio, 0.75 Duty cycle is choosen. And switching frequency is 40K Hertz. The expected 400V output voltage is seen at output.

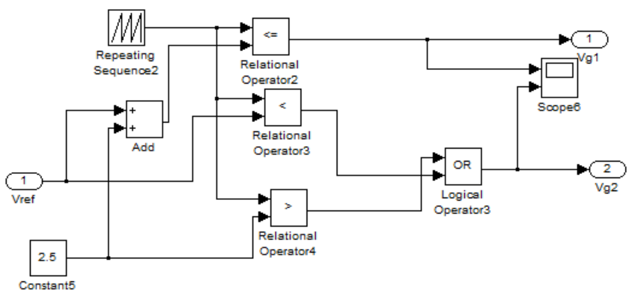

Figure2: Schematic Diagram of PWM for switches(MOSFET)

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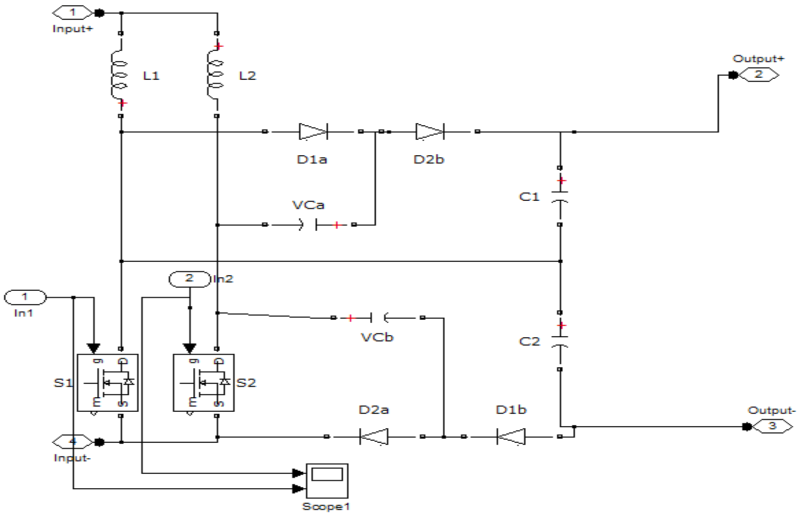

Figure3: Schematic Diagram of subsystem1 of designed converter in closed loop model as conversion part

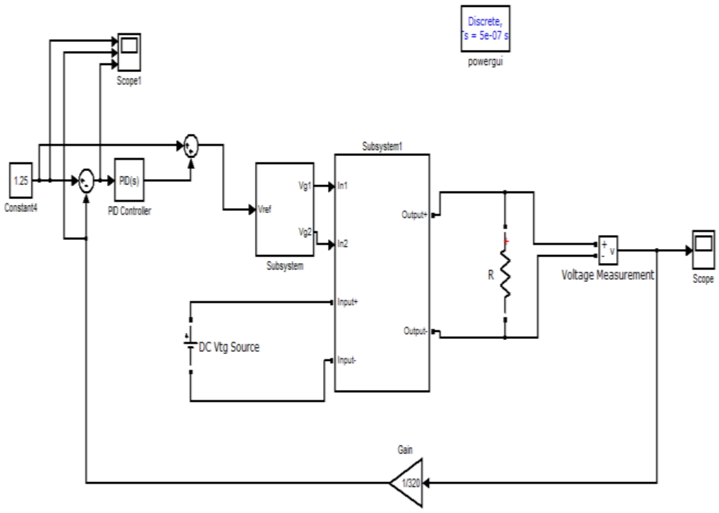

Figure4: Schematic Diagram of closed loop model of designed model as 2 phase interleaved boost converter

III. SIMULATION AND EXPERIMENTAL RESULTS

To make better understanding of designed converter, first simulation is done. In simulation 400 Volt output is observed against 25 volt input for 0.75 duty ratio. In MAT lab, simulation is observed for 2 second time period. Current ripples are getting down because of blocking capacitor. The 2 mosfets get triggerd at 120 degree phase shift. The MOSFET conduction result is shown in figure below. In below figure is also shows 400 volt boost of voltage against 25 volt input.

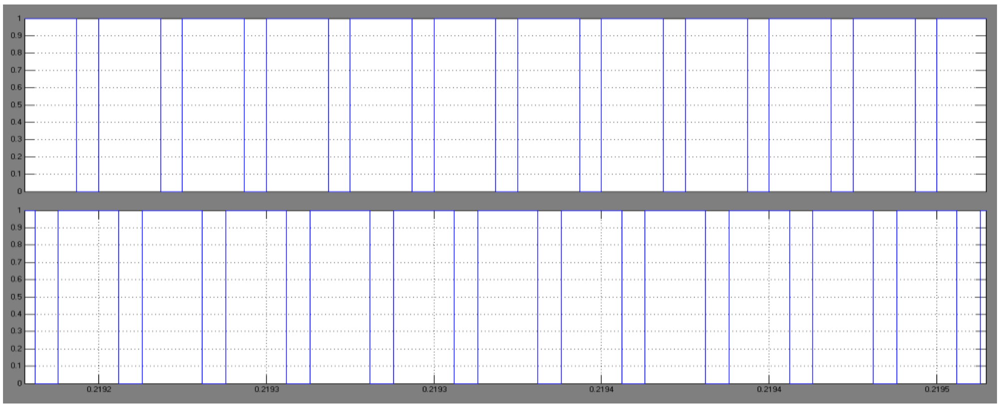

Figure 5: Conduction of two MOSFET's in MAT lab simulation.

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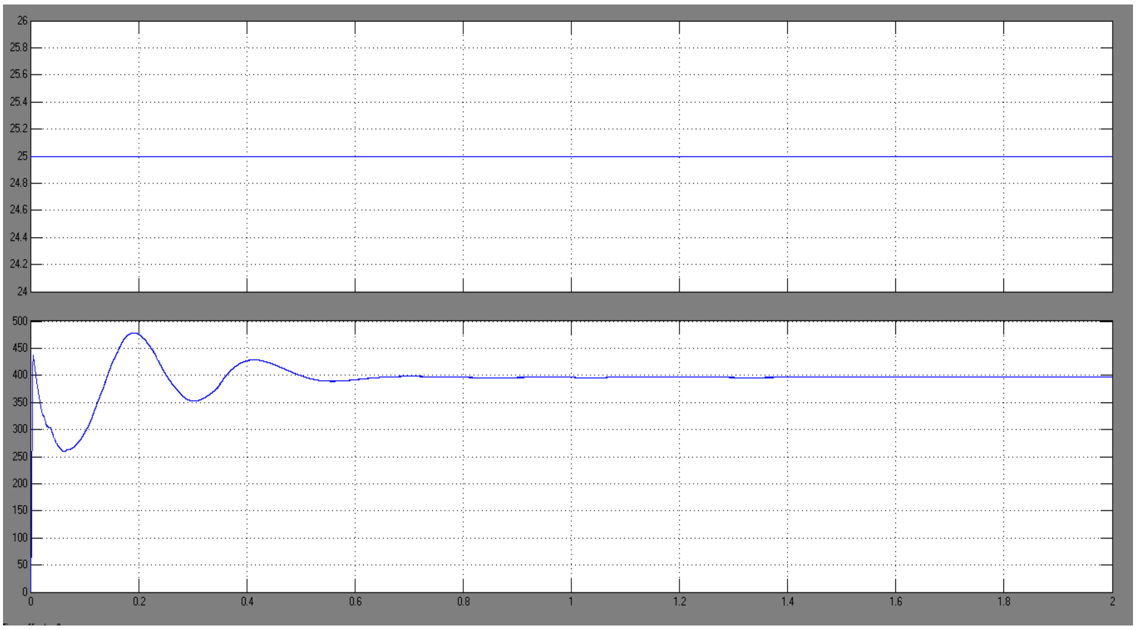

Figure6: 400 Volt Output Simulation result against 25V input in MAT Lab simulation.

IV. CONCLUSION

It can be seen that, 400V output is obtained in MAT lab simulation for 25V input. For this 0.75 duty cycle is assumed and switching frequency is 40KHz.Very low voltage stress is on both diodes and active switches is achieved. Main intention of this converter is to get high transfer gain is obtained for that low ratings of Mosfets can be used. Overall efficiency is better in designed model. Conduction loss and switching losses are also made low by using lower ratings of MOSFET. No extra circuits needed to controlsince the use of blocking capacitor, automatic uniform current sharing of 2 phase interleaved boost converter featured.

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