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Dc-dc Non-isolated Immense gain converter simulation in MATLAB

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Abstract **Burning fossil fuels not only contributing towards emission of greenhouses gases that causes very harmful effects on atmosphere but also making world fossil fuels reserves running short to meet the future energy demand of our offspring. In order to cope with the aforementioned drawbacks of fossil fuels consumption we need to go with an alternate energy source which having ability to address the both loophole lying with fossil fuels use to meet electricity energy needs. In this regard currently world is rushing towards renewable energy resources because of their abundant availability and widespread distribution across globe besides their characteristic of being clean i.e no contribution of greenhouse gas emission. Among them wind and solar has attracted great attention. But among these renewable energy resources wind and solar have drawn great attention owing to their abundant and widespread distribution characteristics. Though the power generation from wind and solar is considered unreliable. However, enormous capability of power generation yet makes them attractive energy resource. But the generated power from these resources i.e solar and wind in particular, solar having very low magnitude to meet the load demand. Keeping their low power generation ability in view attempts were made to resolve this grim concern. In this regard, different researchers strived hard to develop a device known as boost converter. However, conventional topologies have drawbacks of power switch voltage stress, diode recovery issue, and low efficiency along with complex circuitry. In this paper efforts are made to device a convert that has capacity to address the traditional topologies' drawbacks. Further the proposed converter is equipped with coupled inductor and switched capacitor technique. Moreover, Zero current switching is employed for power switch turn ON and diode turn OFF. The converter is intended to operate at moderate duty cycle having input voltage 15, output voltage 180v with 250w rating.**

Keywords: Boost converter, DC-DC, high-gain,photovoltaic

I. Introduction

ENHANCED energy demand across globe has not only put conventional fuels under pressure but also encouraged to invest in slot of renewable energies. Due to changing climate condition and its associated effects, it creates grave concerns to address these issues at earlier *Torrico-Bascopé et al, A new isolated dc-dc boost converter using three-state switching cell.* The emissions of co2 and other gas is due to burning of fossil fuels at large scale. Almost, the share from GHS due to their burning to meet routine energy needs of world, is 80%.on the other hand major increment in world energy need has been enhanced between years 2002 to 2030, by average rate of 1.7% *Zeng et al, A single-switch isolated DC-DC converter for photovoltaic systems.* Moreover, what is most frustrating is that, by 2040 oil reserves would have been depleted, While gas reserves would be running short by 2060 Lopez-Santos et al.. Comparison of quadratic boost topologies operating under sliding-mode control. Therefore, the only alternative to address above mentioned drawbacks; we need to adopt green energies to meet our energy demands *Zhou et al, A single-switch high step-up DC-DC converter with coupled inductor.*

Renewable energy termed as clean, indigenous and abundant source of energy *X. Hu et al, A High Voltage Gain DC-DC Converter Integrating Coupled-Inductor and Diode Capacitor Techniques*. As the renewable energy resources exist in various forms such as: Biomass, Tidal, electrochemical, Hydro, Geothermal, solar and wind. In these renewable energy resources that is wind and solar are widely under consideration to generate power on larger scale in comparison to other resources though solar has low generated power *Liu, V. T et al, Design of high efficiency Boost-Forward-Flyback converters with high voltage gain*. More interestingly, since solar has attracted great concentration throughout the world because of its features, is estimated solar energy would have been replaced almost major energy need of world by 2040.

Renewable energy resources in particular solar and fuel cell generates low voltage that does not suit to many applications *Silveira, G. C et al, DC-DC non-isolated boost converter with high voltage gain adequate for split-capacitor inverter applications*. That necessitates the output voltage to be boosted *Chen, S. M et al, A cascaded high step-up DC–DC converter with single switch for micro source applications*. Therefore voltage output needs high gain. This motivates the development of boost converter in different configuration such as: Fly back converter, sepic converter and cuk converter . As the role played by high gain dc-dc converter in renewable applications, storage system and grid system is of vital importance The type of boost converter adopted for any application depends on various factors such as, voltage level, efficiency, cost etc *Muhammad, M et al,.. Analysis and implementation of high-gain non-isolated DC–DC boost converter*. Traditional topologies employed for voltage need to be operated at high duty cycle, that introduces with difficulty of high voltage stress across power switch and diodes, which raises the loss *Savakhande, V. B et al, Non-Isolated Enormous-Voltage-Boosting DC-DC Converter for High Step-up Application*.

In order to, resolve the problem of voltage stress in various applications. Boost converters having different combination may be cascaded. Like one shown in where the converter operates in Boost, forward and flyback stages. Similarly another converter showcased in having boost and boost-flyback stages. Having said that, letting the use of simple and cost effective gate drive circuitry, traditional topologies don't seem catchy for high power applications, owing to losses in converters main switch that leads to reduction in converter efficiency *Mathew, T. M, Non-Isolated High Gain DC-DC Converter for PV Applications with Closed Loop Control*.

This study aims at the development of high-gain dc-dc non-isolated boost converter, that serve in different renewable applications. The technique employing is of coupled inductor, which provides with voltage gain at moderate duty. Besides, switched capacitor incorporation, in presence of passive clamp circuit declines the voltage stress of semiconductor switch. Thus making it possible to incorporate device having lower turn on resistance consequently reduction in conduction loss.

Moreover, passive clamp circuit facilitates to put power switch under off state through Zero Current Turn ON technique, While Diode is brought to Off state employing same technique. Consequently, reverse recovery related losses are minimized. This not only enhances the device performance, but also mitigates ripple content present in the output voltage by adjusting duty cycle along with output capacitor. 20v at input intended to be boosted to 180v by operating the device at moderate duty cycle improves overall working hours.

II.Developed Model Circuit discrimination

Fig. 2 below shows the circuit diagram of proposed dc-dc boost convert. The subject converter contains coupled inductors L1 and L2. Primary inductor L1 facilitates removal of ripple content in input current. Moreover, Circuit holds Passive Clamp Circuit [PCC] which consists of Dc and Cc clamp diode and capacitor respectively. While voltage extension cell of devised converter is based on of Dc and Cc clamp diode and capacitor along with Dr and Cm that is regenerative diode and switched capacitor. Further D0,C0 and R0 represents output diode, capacitor and resistance in the order given.

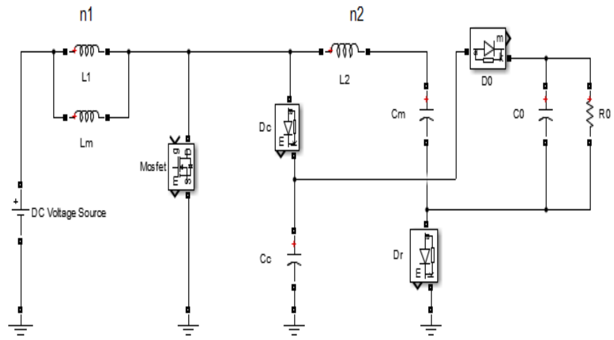

Fig.2. Propose dc-dc boost converter

During model development following assumptions to be considered:

Parasitic capacitance is included, while main switch incorporated is of ideal nature during study.

In order, to keep voltage across capacitors Cm, Cc and Co constant in each cycle, values chosen for them having high magnitude.

III. Model Operation Mode

The operation of proposed model is divided in five modes such as: [t0-t1]then [t1-t2]then [t2-t3]further [t3-t4] and at last[t4-t5]. Besides, model has ability to operate in continuous conduction mode throughout any varying duty cycle.

A.Mode 1

Mode 1 operation of devised model is presented in fig.3 below, where main switch along with regenerative diode are found to be in state of conduction. While clamp diode Dc, including output diode D0 exists in reversed biased state, during this mode of operation. Given, current decline rate controlled by leakage inductance and secondary of coupled inductor is engaged to supply energy for switched capacitor. Apparently,

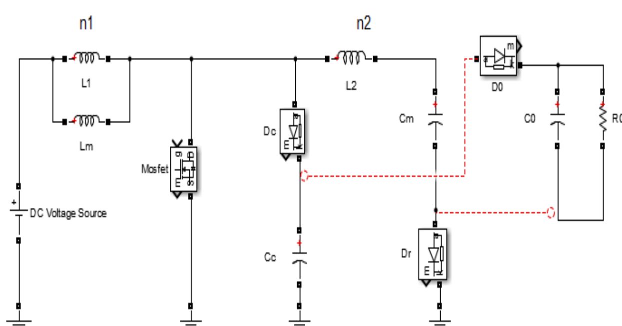

Fig.3 Operation mode 1

only output capacitor supplies energy to load.

B. Mode 2

In this mode output diode D0 turns up into forward biased position. However, regenerative diode is adjusted to be in turn off position in the presence of zero current switching normally. Whereas, clamp capacitor and switching capacitor including secondary winding contributes the voltage gain. Apparently, in order to fulfill energy requirement of load at output, converter behaves as fly back topology, Fig. 4 depicts as under:

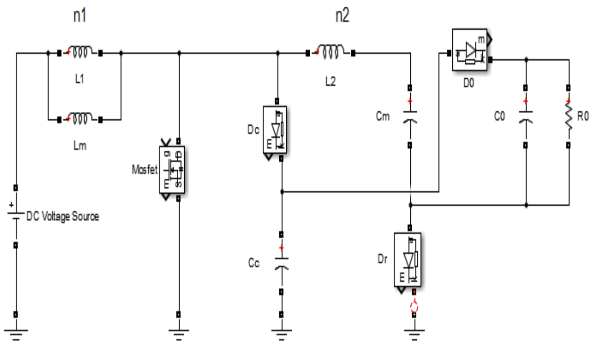

Fig.4. mode 2 putting Dr into off state

C. ***Mode 3***

During this mode of operation it is revealed main switch attains off status alongside clamp diode and regenerative diode are adjusted to achieve reversed biased state. Moreover, magnetizing inductance plays its role to provide energy required for charging parasitic capacitance of main switch, Fig 5 depicts as under:

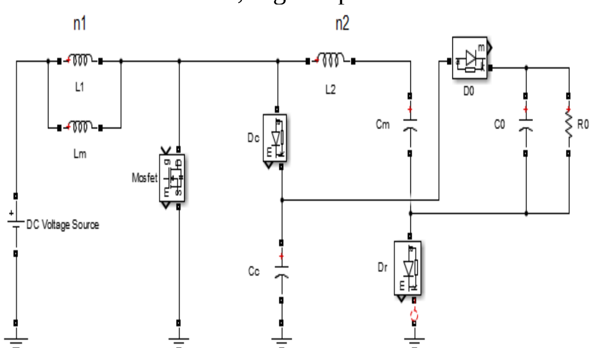

Fig.5. Depicts off state of power switch, while Dr and Dc in reversed

D. Mode 4

While analyzing this mode it is observed the power switch is subject to similar voltage pressure, likewise clamp capacitor with clamp diode unveiled to be in state of forward biased. Seemingly, inductor leakage energy transferred to clamp diode, whereas discharged through clamp capacitor. In the same span of time linear decline in current profile of leakage inductance along with output diode comes in account.

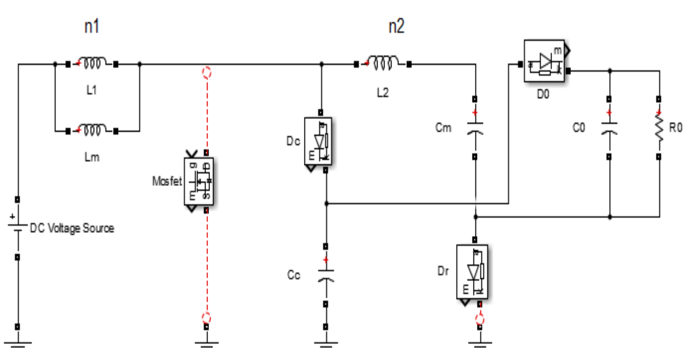

Fig. 6 main switch is subjected to similar voltage like that of Cc

E. Mode 4

In this mode of operation of operation output diode is sensed in off status at initial stage of this mode, due to zero current switching technique. Despite, circuit parameters are selected in such a manner that it manages to establish diode current linearly, while contributing decrement in the magnitude of current of leakage inductance respectively . Whereas input voltage meeting the provision of energy, needed by clamp and switched capacitor. Seemingly, energy demand of load during this mode served by output capacitor only, Whole circuit arrangement depicted in fig. 7 as under:

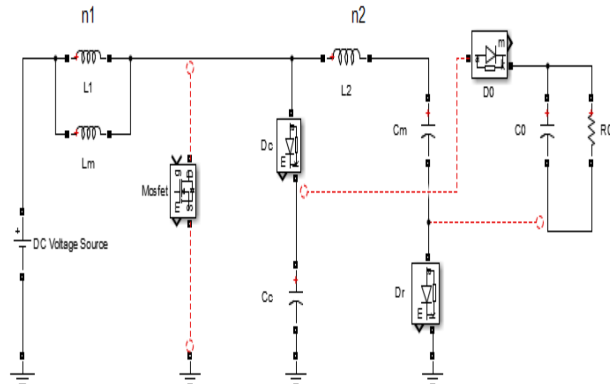

Fig.7 diode establish off state, using ZCS technique.

IV .Results and Discussion

In fig. 8 below it can be easily noticed that the voltage has been stepped up in proposed model of dc-dc boost converter, with les amount of overall ripple content. In proposed converter it is realized to establish constant voltage at output, through variation in value of output capacitor Co. More importantly in this case converter is made to Function at lower ON time in comparison to traditional boost topology. Operation of converter at lower duty cycle not only increases the life of device but also improves the efficiency. In particular, utilization of lower duty cycle, alongside favorable value of capacitor reduces the ripples content that otherwise de-rate the insulation level due to high voltage stress.

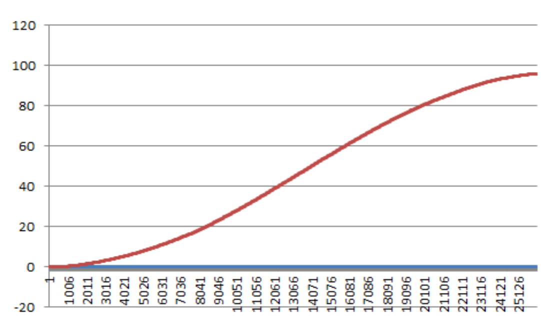

Fig. 8 output voltage profile

In fig.9 below current across output load is shown with steady state, having less amount of ripple content, resultantly performance and life of dc-dc boost converter is modified with enhanced efficiency. To obtain the current across load with reduced ripple content is accomplished by aligning inductor parameters at input.

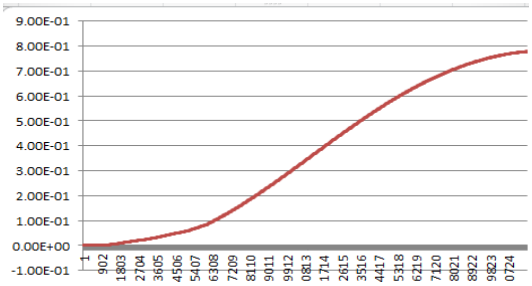

Fig.9. Current profile across load

Fig.10. below elaborates the switching profile of main power switch, in which turn on state of switch is accomplished at current zero crossing, consequently assisting in reduction of conduction loss alongside improvement in performance. This is done in order to overcome leakage energy of inductor as this energy is utilized for switching purpose of main switch. Further the voltage profile of main power switch is shown in fig.11.

Fig.10. Main power switch switching profile

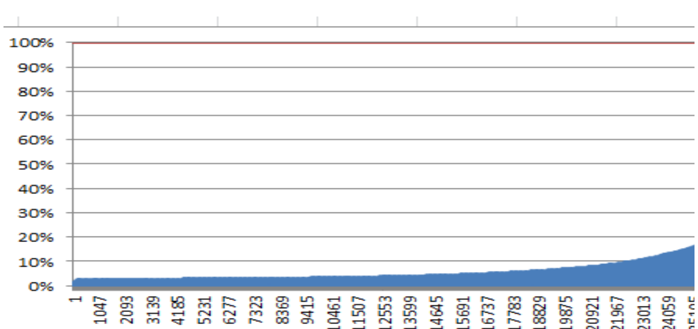

Fig.11. Main power switch voltage profile

Fig.12 below further depicts the switching pattern of regenerative diode. It facilitates reverse recovery related problems of diode in addition to reduction of conduction loss due to zero current turn off of regenerative diode. Thus efficiency is enhanced.

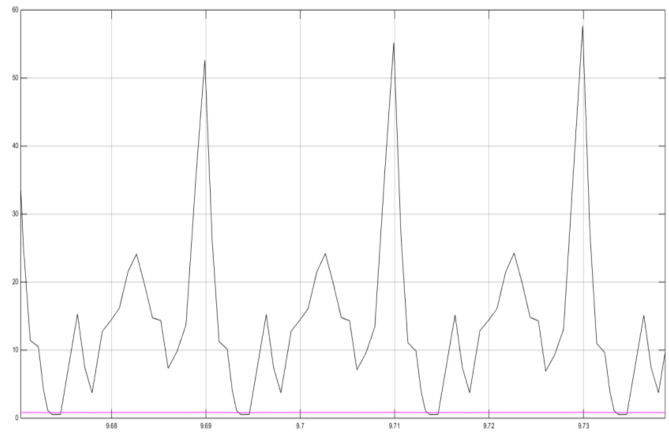

Fig.12 switch pattern of regenerative diode

It has been observed during simulating the proposed d-dc boost converter and analyzing the voltage gain relation to duty cycle. With increased duty cycle high voltage gain is achieved, however greater duty cycle imposes higher working hours on device, thus declining the lie of device. In order to boost the voltage level as per requirement and prevent the reduction of device life, output capacitor value is adjusted to accomplish the desired results. Fig.13 below depicts voltage gain with increment in duty cycle, while fig.14 represents the current profile of clamp capacitor.

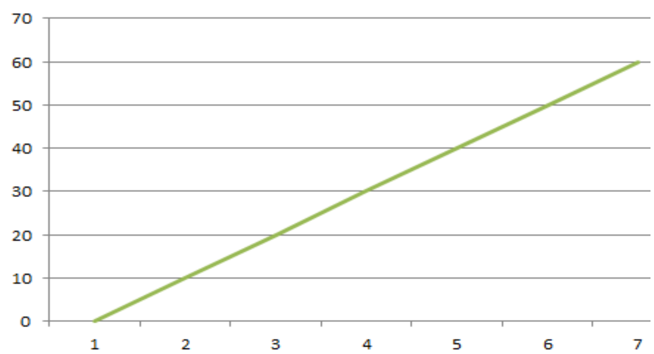

Fig.13 Voltage gain of proposed boost converter with increment in duty cycle

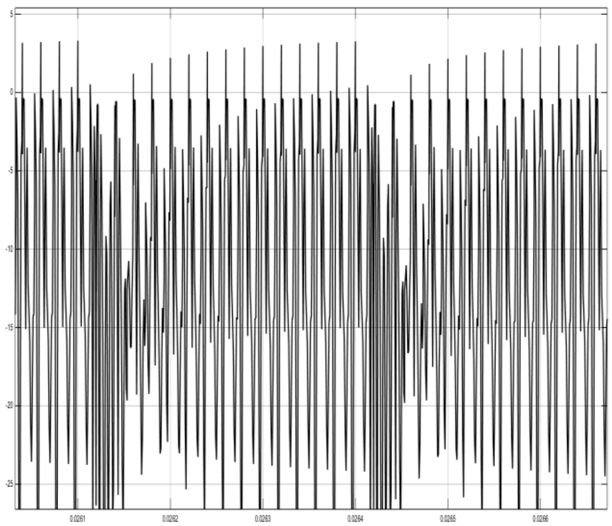

Fig.14 current profile of clamp capacitor

V. Conclusion

In this work Efforts are made to accomplish high-gain dc-dc boost convert in MATLAB Simulink environment. In addition to this operational mode of proposed converter is analyzed and elaborated in theoretically context. For development of proposed converter coupled inductor alongside switched capacitor is brought under consideration. Use of switched capacitor not only, over comes the problem to accomplish Boosted voltage at reduced duty cycle, but also allow use of switches , that bears low Ron, reducing conduction loss. . Moreover, incorporation of coupled inductor for boosting purpose facilitates in repeated use of leakage energy of inductor in presence of passive clamp circuit. This provides with boosting of voltage at reduced duty cycle by putting converter under reasonable duty and mitigation of diode reverse recovery problem. More importantly, performance of proposed converter has been improved in term of efficiency, as conduction losses has been clamped by employing zero current switching for diode and power switch respectively, alongside transient removal from voltage ensure stability.

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References

[1]A new isolated dc-dc boost converter using three-state switching cell. In *2008 Twenty-Third Annual IEEE Applied Power Electronics Conference and Exposition* (pp. 607-613). IEEE.

[2]A single-switch isolated DC-DC converter for photovoltaic systems. In *2012 IEEE Energy Conversion Congress and Exposition (ECCE)* (pp. 3446-3452). IEEE.

[3]Comparison of quadratic boost topologies operating under sliding-mode control. In *2013 Brazilian Power Electronics Conference* (pp. 66-71). IEEE.

[4] A single-switch high step-up DC-DC converter with coupled inductor. In *2014 IEEE Energy Conversion Congress and Exposition (ECCE)* (pp. 4251-4256). IEEE.

[5] “A High Voltage Gain DC-DC Converter Integrating Coupled-Inductor and DiodeCapacitor Techniques”, *Power Electronics, IEEE Transactions*, vol. 29, nº 2, pp. 789-800, Feb. 2014.

[6] Design of high efficiency Boost-Forward-Flyback converters with high voltage gain. In *11th IEEE International Conference on Control & Automation (ICCA)* (pp. 1061-1066). IEEE.

[7] DC-DC nonisolated boost converter with high voltage gain adequate for split-capacitor inverter applications. In *2013 Brazilian Power Electronics Conference* (pp. 58-65). IEEE.

[8] A cascaded high step-up DC–DC converter with single switch for microsource applications. *IEEE transactions on power electronics*, *26*(4), 1146-1153.

[9] Muhammad, M., Armstrong, M., & Elgendy, M. A. (2017). Analysis and implementation of high-gain non-isolated DC–DC boost converter. *IET Power Electronics, 10*(11), 1241-1249.

[10] Non-Isolated Enormous-Voltage-Boosting DC-DC Converter for High Step-up Application. In *2018 International Conference on Computer Communication and Informatics (ICCCI)* (pp. 1-5). IEEE.

[11] Non-Isolated High Gain DC-DC Converter for PV Applications with Closed Loop Control. In *2019 2nd International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT)* (Vol. 1, pp. 627-632). IEEE.