IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 4, April 2016.
www.ijiset.com
ISSN 2348 – 7968

Single Input Multiple Output Dc-Dc Converter with Inverted Output

Fatima Kudchi
Assistant Professor, Department of E&EE, B.L.D.E.A's CET, Vijayapur, Karnataka

ABSTRACT-This paper proposes a design of single input multiple output (SIMO) DC-DC converter. The proposed converter can generate the voltage of a low voltage input to controllable levels of boosted output voltage and it can also produce the inverted output voltage. This dc-dc converter utilizes the properties of voltage clamping and soft switching based on a coupled inductor. In this paper, the design of SIMO dc-dc converter along with modes of operation has been presented using MATLAB/SIMULINK. Simulation results thus obtained show that, the objectives of high efficiency, high step up ratio and various levels of output voltages.

I. INTRODUCTION

In today's advanced world the switching power supply market is flourishing quickly. Main target in power electronics is to convert electrical energy from one type to a different. Power converters control the flow of power between two systems by changing the character of electrical energy from DC to AC or vice versa, from one voltage level to a different voltage or in another way to make electricity to succeed in the load with highest potency are that the target to be achieved. DC-DC converters are electronic circuits that change the DC operating voltage or current. They have recently aroused the interest in the current market due to its wide range of applicability. Reliability of the converters becomes a key to industrial focus. Electronic devices and control circuits should be extremely strong so as to achieve a high standard life. A special concentration should be set on the total efficiency of the power electronic circuits, first because of the economic and environmental value of wasted power and, second because of the cost of energy dissipated that it will generate.

Multiple output converters are widely utilized in the industrial applications. Planning multi-output converters presents a noteworthy challenge for the power supply designer. Converters utilizing one primary power stage and generating more than one isolated output voltage are referred to as multi-output converters. The fundamental necessities are small size and high efficiency. High switch frequency is necessary for achievement of small size. If the switching frequency is raised then the switching loss will increase. This decreases the efficiency of the power supplies. To resolve this drawback, some sorts of soft switching techniques have to be compelled to be used to operate under high switching frequency. Zero Voltage Switched (ZVS) technique and zero Current Switched (ZCS) technique are two normally used soft switching ways. By using these techniques, either voltage or current is zero throughout switching transition that for the most part reduce the switching loss and also increase the reliability for the power supplies. Applications may need step-up, or at times even a bipolar supply from identical battery supply. Bipolar provides also find a large range of application in organic light emitting diodes. As a result, the design of a power management IC generally contains boost to step-up, buck-boost to generate negative supply, and linear regulators to satisfy different supplies for various circuit applications. Many strategies are proposed to regulate the multiple outputs, to reduce the conduction loss, the MOSFET switch with low turn-on resistance is used; dc–dc converters are widely utilized in low and high-power applications.

A new generation of single input multiple output (SIMO) DC-DC converters has been developed based on boost and inverted topologies. However, in these configurations, loads are independently constructed except the negative output. In the projected SIMO converter, the techniques of voltage clamping and soft switching are adopted to reduce the switching and conduction losses via the utilization of a low voltage rated power switch with a small Rds (on). This project presents a new designed SIMO dc–dc converter based on boost and inverted derived topologies with a coupled inductor. In general, various single-input single-output dc–dc converters with completely different voltage gains are combined to satisfy the requirement of various voltage levels, so that its sys- tem control is more complicated and therefore the corresponding price is costlier. The motivation of this study is to style a single-input multiple-output (SIMO) device for increasing the voltage gain and conversion efficiency, reducing control complexness and saving the manufacturing price.

1.1 Objective of the study

The objective of this paper is to develop a single input multiple output dc-dc converter having high efficiency. The circuit uses a coupled inductor with zero current switching, thereby reducing the switching losses. Various output voltages with different levels can be obtained making it ideal for power converter. It can boost the low voltage input to high voltage output and middle voltage0output. The circuit has the advantages of high conversion efficiency, less switching losses, less complex control0circuitry, high voltage gain, low cost of manufacturing.

I. SYSTEM REQUIREMENTS

2.1 Hardware Requirements

1. Intel Pentium IV Processor
2 GB RAM
3.0 GB HDD

2.2 Software Requirements

- Operating System: Windows XP SP-3, Windows 7
- MATLAB (version R2011a), Simulink

II. BLOCK DIAGRAM OF SIMO MODEL

3.1 Block Diagram:

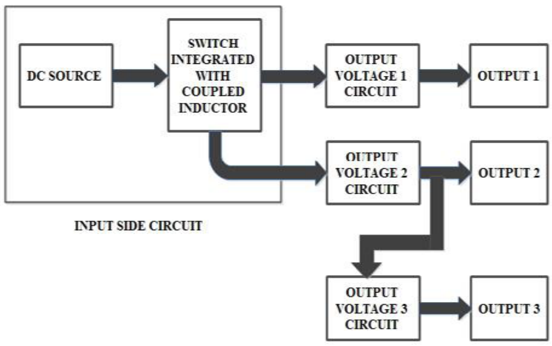


Fig. 3.1 Block diagram of SIMO model

The Fig.3.1 shows the block diagram of proposed Single Input Multiple Output dc-dc converter. The DC supply block consists of the dc input power supply and a capacitor. The value of input is in the range of 12V. Switch Integrated with Coupled inductor block consisting of a coupled inductor, a MOSFET switch and a diode. The coupled inductor primary incorporates a series connected leakage inductance and a parallel connected magnetizing inductance. Output Voltage one Circuit consists of an auxiliary inductor, a diode and a filter capacitor. The value of output voltage one is 28V. Output Voltage two Circuit consists of a capacitor connected serial

IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 4, April 2016.
www.ijiset.com
ISSN 2348 – 7968

with the coupled inductor secondary and a diode connected in parallel with the above combination. Additionally, the series connected diode and a filter capacitor is used. The value of output voltage two is 200V. Output Voltage three This circuit consists of 2 MOSFET switches, 2 diodes and 2 capacitors. The value of output voltage three is -200V and inverted output voltage is ±100V.

3.2. Circuit Diagram & Description

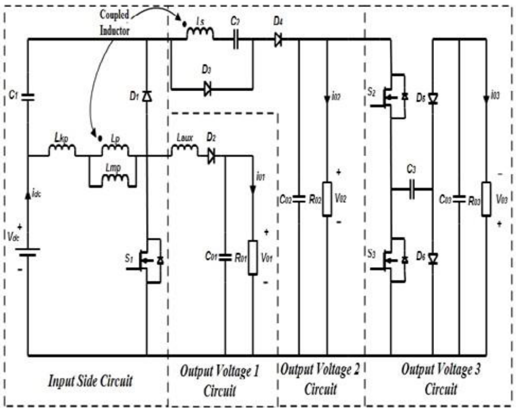


Fig 3.2 Proposed Single Input Multiple Output dc-dc converter Circuit Diagram

The system configuration of the proposed SIMO converter topology to generate three completely different voltage levels from a single-input power source is represented in Fig. 4.2. This SIMO converter contains six parts including an input side circuit (ISC), a clamped circuit, a coupled inductor secondary circuit, output voltage one circuit, output voltage two circuit and output voltage three circuit. The most important symbol representations are summarized as follows. Vdc (idc) and V01 (i01) denote the voltages (currents) of the input power source and also the output load at the input side voltage circuit and the output voltage one circuit, respectively; V 02 and i02 are the output voltage and current in the output voltage two circuit. V03 and i03 are the output voltage and current in the output voltage three circuit. C01 , C02 and C03 are the filter capacitors at the ISC, a output voltage one circuit, a output voltage two circuit and a output voltage three circuit, respectively; C1 , C2 and C3 are the clamped and coupled inductor secondary circuit capacitors in the clamped and coupled inductor secondary circuits respectively. lp and LS represent individual inductors in the primary and secondary sides of the coupled inductor respectively, where the primary side is connected to the input power source; Laux is that the auxiliary inductor. The main switch is expressed as S one in the ISC, S2 and S3 are the switches utilized in the output voltage circuit three. The equivalent load in the output voltage circuit one is represented as R01 , the output load is represented as R02 in the output voltage circuit two and the output load is represented as R03 in the output voltage circuit three. The circuit diagram has the six diodes namely D1, D 2, D3, D4, D5 and D6 respectively. The coupled inductor in Fig.2 is modeled as an ideal transformer including the magnetizing inductor Lmp and also the leakage inductor Lkp .

The system configuration of the proposed SIMO converter topology to generate three completely different voltage levels from a single-input power source is represented in Fig. 4.2. This SIMO converter contains six parts including an input side circuit (ISC), a clamped circuit, a coupled inductor secondary circuit, output voltage one circuit, output voltage two circuit and output voltage three circuit. The most important symbol representations are summarized as follows. Vdc (idc) and V01 (i01) denote the voltages (currents) of the input power source and also the output load at the input side voltage circuit and the output voltage one circuit, respectively; V 02 and i02 are the output voltage and current in the output voltage two circuit. V03 and i03 are the output voltage and current in the output voltage three circuit. C01 , C02 and C03 are the filter capacitors at the ISC, a output voltage one circuit, a output voltage two circuit and a output voltage three circuit, respectively; C1 , C2 and C3 are the clamped and coupled inductor secondary circuit capacitors in the clamped and coupled inductor secondary circuits respectively. lp and LS represent individual inductors in the primary and secondary sides of the coupled inductor respectively, where the primary side is connected to the input power source; Laux is that the auxiliary inductor. The main switch is expressed as S one in the ISC, S2 and S3 are the switches utilized in the output voltage circuit three. The equivalent load in the output voltage circuit one is represented as R01 , the output load is represented as R02 in the output voltage circuit two and the output load is represented as R03 in the output voltage circuit three. The circuit diagram has the six diodes namely D1, D 2, D3, D4, D5 and D6 respectively. The coupled inductor in Fig.2 is modeled as an ideal transformer including the magnetizing inductor Lmp and also the leakage inductor Lkp .

The turn's ratio N and coupling coefficient k of this ideal transformer are defined in equations one & two as,

$$N = {}^{N_2}/_{N_1}$$

$$k = {}^{L_{mp}}/_{(L_{mp} + L_{kp})} = {}^{L_{mp}}/_{L_{kp}}$$

Where N1 and N 2 are the winding turns in the primary and secondary sides of the coupled inductor. because the voltage gain is less sensitive to the coupling coefficient and also the clamped capacitor C1 is appropriately selected to completely absorb the leakage inductor energy, the coupling coefficient could be simply set at unity to obtain Lmp = lp

3.3Modes of Operation

The proposed converter has the six modes of operation, which can be discussed in the following sections.

Mode 1: the main switch S1 was turned ON and the diode D4 turned OFF. Because the polarity of the windings of the coupled inductor is positive, the diode D3 activates. The secondary current reverses and charges the capacitor C2. When the auxiliary inductor Laux releases its stored energy completely, and also the diode D2 turns OFF. Here S 2 is turned ON and S3 is turned OFF, D 6 is forward biased and D5 is reverse biased. V02 is connected in series with C3, S 2 and D6 forms a closed loop and charges C3, this mode ends. The Fig.3.3.1 shows the mode one of operation

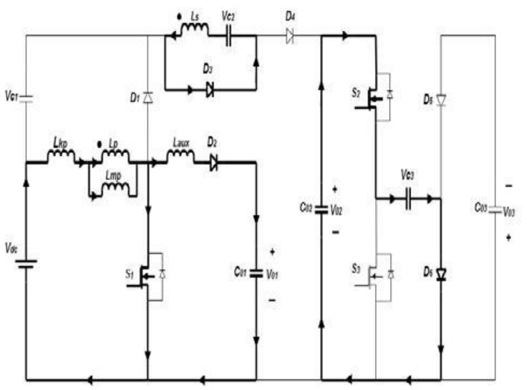


Fig 3.3.1. Mode 1

Mode 2: As represented in Fig.3.3.2(b) the main switch S1 is turned ON, because the primary inductor L P is charged by the input power supply and also the magnetizing current I Lmp will increase gradually in an approximately linear way. At the same time, the secondary voltage of coupled inductor charges the capacitor C2 through the diode D3. because the auxiliary inductor Laux releases its stored energy fully and also the diode D2 turns OFF at the end of mode1, it leads to the reduction of Lkpdi /dt at mode two. Here S3 is turned OFF and S2 is turned ON, D 6 is forward biased and D5 is reverse biased. V02 is connected in series with C3, S 2 and D6 forms a closed loop and charges C3, this mode ends. The Fig.3.3.2 shows the mode one of operation

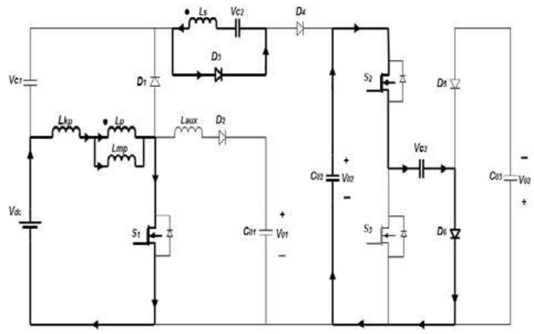


Fig 3.3.2 Mode 2

Mode 3: the main switch S1 is turned OFF. When the leakage energy still released from the secondary side of the coupled inductor, the diode D3 conducts and releases the leakage energy to the capacitor C2. When the voltage across the main switch is higher than the clamped capacitor, the diode D1 conducts to transmit the energy into the clamped capacitor C1. Thus, this passes through the diode D2 to supply the power for the output load in the output voltage one circuit. When the secondary side of the coupled inductor releases its leakage energy completely and therefore the diode D3 turns OFF. The closed loop of S2, C3 and D 6 has been continued till the C02 fully discharged, this mode ends. The Fig. 3.3.3 shows the operation of mode three.

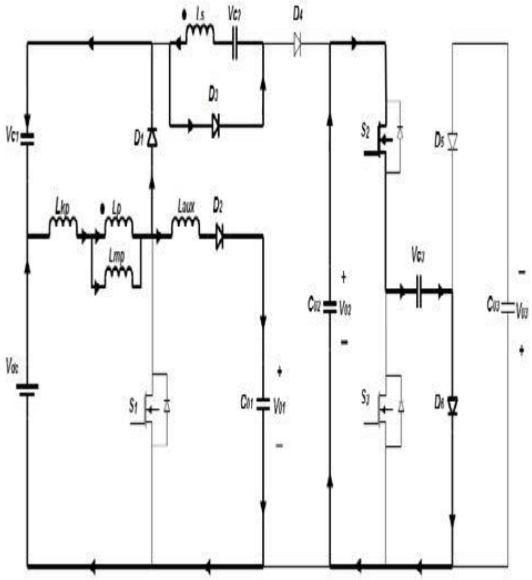


Fig. 3.3.3 Mode 3

Mode 4: As shown in Fig.3.3.4, here the main switch S1 is turned OFF. When the leakage energy has released from the primary side of the coupled inductor, the secondary current is induced in reverse from the energy of the magnetizing inductor Lmp through the ideal transformer and flows through the diode D four to the output voltage 2 circuit. At the same time, partial energy of the primary side leakage inductor Lkp is still persistently transmitted to the auxiliary inductor Laux and the diode D2 keeps conducting. Moreover, the current ILaux passes through the diode D2 to supply the power for the output load in the output voltage one circuit. Here S1 is turned OFF and S3 is turned ON, D5 is forward biased and D6 is reverse biased. C3 is connected in series with S3, D5 and C03 to form a closed loop and delivers the total voltage to C03, so the output voltage across C03 is inverting voltage.

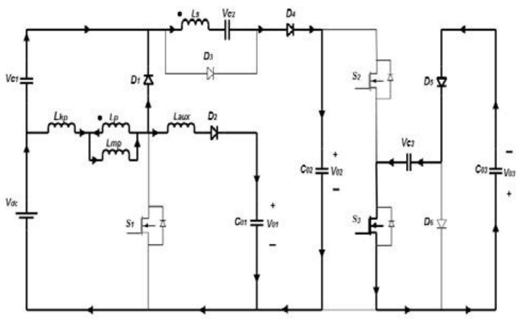


Fig. 3.3.4 Mode 4

Mode 5: As represented in Fig. 3.3.5, the main switch S1 is turned OFF and also the clamped diode D1 turns OFF because the primary leakage current equals to the auxiliary inductor current. In this mode, the input power source, the primary winding of the coupled inductor and also the auxiliary inductor Laux connect in series to supply the power for the output load in the auxiliary circuit through the diode D2. At the same time, the input power source, the secondary winding of the couple inductor, the clamped capacitor C1 and also the capacitor C2 connect in series to release the energy into the output voltage two circuit through the diode D4. Here S3 is turned ON and S1 is turned OFF, D5 is forward biased and D6 is reverse biased. C3 is connected in series with S3, D5 and C03 to form a closed loop and delivers the total voltage to C03, so the output voltage across C03 is inverting voltage.

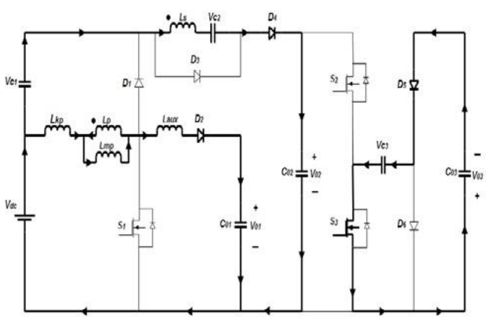


Fig.3.3.5 Mode 5

Mode 6: The operation of mode 6 is represented in Fig.3.3.6. This mode begins when the main switch S1 is triggered. The auxiliary inductor current needs time to decay to zero, the diode D2 conducts. The input power supply, the clamped capacitor C1, the secondary winding of the coupled inductor and also the capacitor C2 still connect in series to release the energy into the output voltage 2 circuit through the diode D4. Moreover, the rising rate of the primary current ILkp is limited by the primary-side leakage inductor Lkp. Here S1 & S 3 is turned ON, D5 is forward biased and D6 is reverse biased. C3 is connected in series with S3, D5 and C03 to form a closed loop and delivers the total voltage to C03, therefore the output voltage across C03 is inverting voltage. When the secondary current of the coupled inductor decays to zero, this mode ends.

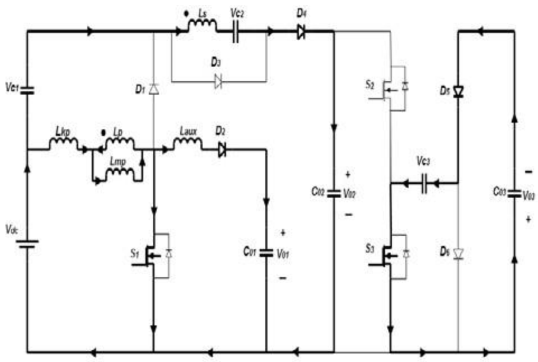
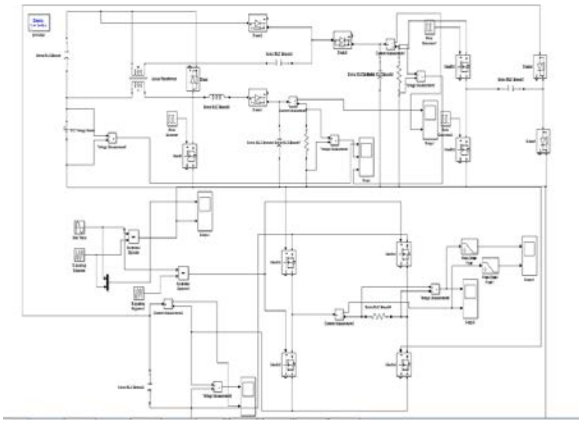


Fig. 3.3.6 Mode 6

III. SIMULATION MODEL



4.1 Simulation model of proposed model

IV. SIMULATION RESULTS

5.1. Input voltage

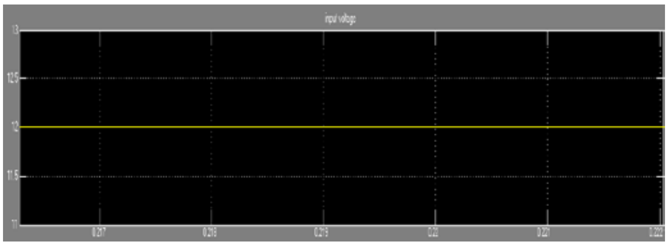


Fig. 5.1 Input voltage of the proposed circuit

X axis – Time (SEC)

Y axis – voltage (V)

5.2. Output voltage 1

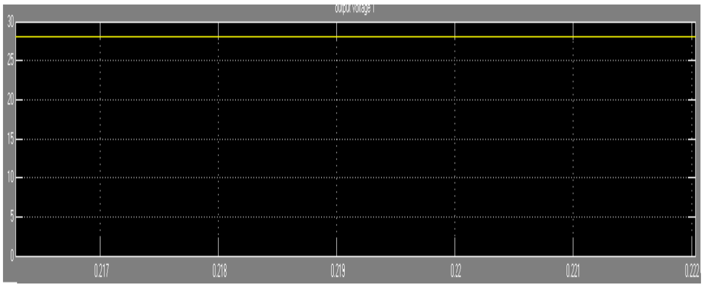


Fig. 5.2 Input voltage of the proposed circuit

X axis – Time (SEC)

Y axis – voltage (V)

5.3. Output current 1

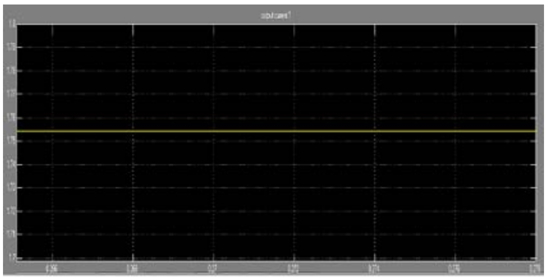


Fig. 5.3 Output Current of the proposed circuit

X axis – Time (SEC)

Y axis – Current(C)

5.4. Output voltage 2

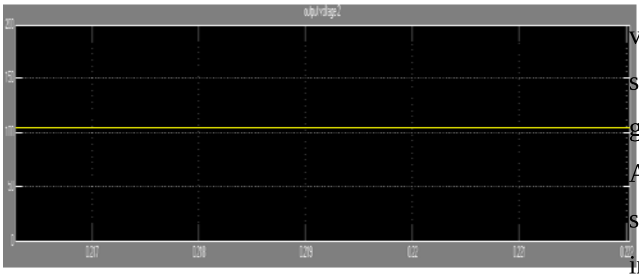


Fig. 5.4 Output voltage of the proposed circuit

X axis – Time (SEC)

Y axis – voltage (V)

5.5. Output current 2

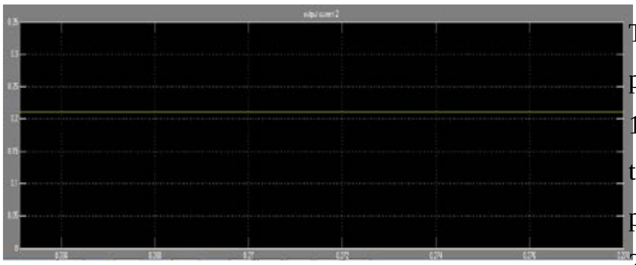
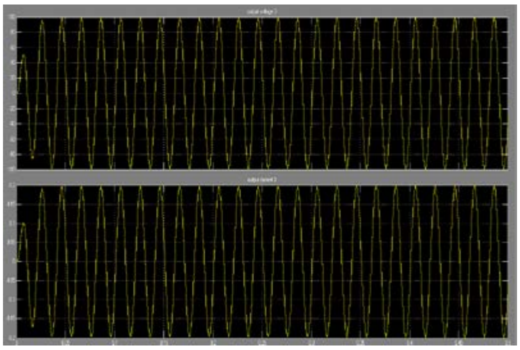


Fig. 5.5 Output Current of the proposed circuit

X axis – Time (SEC)

Y axis – Current (C)

5.6. Inverted Output



V. CONCLUSION

This paper has presented a SIMO dc–dc converter and this coupled inductor based converter was applied well to a single input power source plus three output terminals composed of two boost and one inverted voltages. The proposed SIMO converter is suitable for the application required one common ground, which is preferred in most applications. As mentioned above the voltage gain can be substantially increased by using a coupled inductor, the stray energy can be recycled by a clamped capacitor into the output terminal 1 or output terminal 2 to ensure the property of voltage clamping and an auxiliary inductor is designed for providing the charge power to the load 1. Thus the proposed SIMO converter provides designers with an alternative choice for converting a low voltage source to multiple boost outputs with inverted voltage output efficiently. The major scientific contributions of the proposed SIMO converter are recited as follows:

1) This topology adopts only one power switch to achieve the objective of high-efficiency SIMO power conversion;

2) The voltage gain can be substantially increased by using a coupled inductor.

3) The stray energy can be recycled by a clamped capacitor into the auxiliary battery module or high-voltage dc bus to ensure the property of voltage clamping.

VI. LIMITATIONS AND FUTURE SCOPE

The efficiency of proposed converter decreases when the number of outputs increases beyond three. However, it is not appropriate to be used as the active front for dc–ac multilevel inverters. It is worthy to investigate the proposed converter's efficiency of power conversion when used to power multi-level inverter requiring more than two sources.

VII. REFERENCES

ISSN 2348 – 7968

1. P. Patra, A. Patra, and N. Misra, "A single-inductor multiple-output switcher with simultaneous buck, boost and inverted outputs," IEEETrans. Power Electron, vol. 27, no. 4, pp. 1936–1951, Apr. 2012.

2. A. Nami, F. Zare, A. Ghosh, and F. Blaabjerg, "Multiple-output DC–DC converters based on diode-clamped converters configuration: Topology and control strategy," IET Power Electron., vol. 3, no. 2, pp. 197–208, 2010.

3. Y. Chen, Y. Kang, S. Nie, and X. Pei, "The multiple-output DC–DC converter with shared ZCS lagging leg," IEEE Trans. Power Electron., vol. 26, no. 8, pp. 2278–2294, Aug. 2011.

4. Dongwon Kwon, Graduate Student Member, IEEE, and Gabriel A. Rincon- Mora, Senior Member, IEEE,, "Single-Inductor-Multiple-Output Switching DC-DC Converters," IEEE transactions on circuits and systems- ii: express briefs, vol. 56, no. 8, august 2009.

5. Rong – Jong Wai, Senior Member, IEEE, Chung- You Lin, Rou-Yong Duan, and Yung-Ruie Chang, Member, IEEE, "High Effeciency DC-DC Converters With High Voltage Gain and Reduced Switched Stress," IEEE transactions on industrial electronics, vol. 54, no 10, February 2007.

6. R. J.Wai and R. Y. Duan, "High step-up converter with coupled inductor," IEEE Trans. Power Electron., vol. 20, no. 5, pp. 1025–1035, Sep. 2005.

7. C. T. Pan, M. C. Cheng, and C.m. Lai, "A Novel Integrated DC/AC Converter with High Voltage Gain Capability for Distributed Energy Resource System," IEEE trans. Power Electron., vol. 27, no. 5, pp. 2385-2395, May 2012.

8. S. D. Gamini Jayasinghe, D. Mahindra Vilathgamuwa, and U.K. Madawala, "Diode-Clamped three-level inverter-based battery/super capacitor direct integration scheme for renewable energy system," IEEE Trans. Power Electron., vol 26, no 6, pp. 3720-3729, December. 2011

9. H. Wu, R. Chen, J. Zhang, Y. Xing, H. Hu, and H. Ge, "A family of three port half-bridge converters for a stand-alone renewable power energy," IEEE Trans . Power Electron, vol 27, no 5, pp. 2697-2706, September. 2012.

10. S. H. Cho, C. S. Kim, and S.K. Han, "High Efficiency and low cost tightly regulated dual-output LLC resonant converter," IEEE Trans. Ind. Electron., vol. 59, no. 7, pp 2982-2991, July-2012.

11. Sujata Verma, S.K. Singh and A.G. Rao, "Overview of Control Techniques for DC-DC Converters" Research journal of Engineering science Vol.2(8), 18-21, August(2013).

12. Pulla Sravani Kumari, Kasturi Guavardhan, "DC-DC Converter with Coupled Inductor for Multiple –Outputs" International Journal of Advance Research in Electrical, Electronics and Instrumental Engineering vol. Issue 9, September 2014

13. S.K. Anuja, R. Satheesh Kumar, "A High Efficient DC-DC Converter with Soft Switching for Stress Reduction" International conference on VLSI, Communication and Instrumentation (ICVCI) 2011.

14. Thulasi V. S, H. Satish Kumar, "Single-Input Double Output High Efficient Boost DC-DC Converter" International of Modern Engineering Research (IJMER)" Vol.4, Iss. 3, March 2014.

15. Power Electronics: Essential and Application by L. Umanand

16. N. Mohan, T. M. Undeland, and W. P. Robbins, Power Electronics: Converters, Applications, and Design. New York: Wiley, 1995.