ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization *Vol. 4, Special Issue 1, March 2015*

National Conference on Recent Advances in Electrical & Electronics Engineering (NCREEE 2015)

Organized by

Dept. of EEE, Mar Baselios Institute of Technology & Science (MBITS), Kothamangalam, Kerala-686693, India
On 26th & 27th March 2015

Soft Switched KY Step Up Converter with Load Regulation

Anjaly Jose[1], Soumya C[2]

M. Tech Student, Dept of EEE, Jyothi Engineering College, Thrissur, Kerala, India [1]

Assistant Professor, Dept of EEE, Jyothi Engineering College, Thrissur, Kerala, India [2]

ABSTRACT: This paper presents a novel voltage gain enhanced KY step up converter with soft switching. A KY converter is a voltage step up converter which always operates in continuous conduction mode. To further improve the voltage gain a coupled inductor can be employed. Soft switching is applied for reducing the switching losses and it improves the efficiency of the converter. Simulation is done with 12V input voltage. The obtained output voltage is 72V, output current is 0.8A, and output power is 60W.

KEYWORDS: KY converter; Synchronous rectification; Voltage gain enhancement; soft switching

I.INTRODUCTION

The term Gain in electronics can be defined as the ability of a circuit to increase the power or amplitude of a signal from its input value. A voltage gain enhancement or a voltage boosting is required in many applications. High voltage conversion converters are used for the same. These converters increase the output voltages to a higher level from a lower input voltage level according to the requirement of load.

For improving the voltage gain, we can adopt different methods. The traditional methods are to use the converters like boost converter, buck-boost converter. But the voltage gains of these converters are not so high. Upto now many kinds of voltage boosting are available. The other techniques for voltage boosting are use of several inductors connected in series which are magnetized and then pumping the stored energy into the output, by the use of coupled inductors, Voltage super position based on switching capacitors, use of auxiliary transformers, use of multiplier cells[1]-[6], use of voltage lift circuits, use of KY converter etc. Among them one of the efficient methods is the use of KY converter. [7]-[12]

The base circuits of this novel voltage gain enhanced step up converter are a KY converter and a synchronous buck-boost converter. A KY converter is a boost converter and its behaviour can be considered as a buck converter with synchronous rectification. The feature of KY converter which makes it different from other converters is that it always operates in continuous conduction mode. Also the output current is non pulsating. A synchronous buck-boost converter is similar to buck boost converter with the diode is replaced by a MOSFET switch. By doing so, the conduction losses can be reduced and effectively the efficiency can be improved. [12]-[18]

Soft switching can be applied for reducing the switching losses. Different methods are available for achieving the same like parallel resonance circuit, series resonance circuit etc. In this paper a detailed description of the proposed converter, modes of operations, simulation results are explained. Simulation results include load regulation.[19]

II.OVERALL SYSTEM CONFIGURATION

Figure 1 shows the proposed step up converter with soft switching, which contains two MOSFET switches namely S_1 and S_2 along with their body diodes D_1 and D_2. A coupled inductor with primary turns Np and secondary turns Ns is used to obtain voltage gain enhancement. Capacitor C_1 is energy transferring capacitor and capacitor C_2 is charge pump capacitor. At the output side, one output inductor Lo, one output capacitor Co is connected. The load is signified as Ro. The input voltage and output voltages are represented as Vi and Vo respectively. A resonance inductor Lr and a resonance capacitor Cr is also used.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization *Vol. 4, Special Issue 1, March 2015*

National Conference on Recent Advances in Electrical & Electronics Engineering (NCREEE 2015)

Organized by

Dept. of EEE, Mar Baselios Institute of Technology & Science (MBITS), Kothamangalam, Kerala-686693, India

On 26th & 27th March 2015

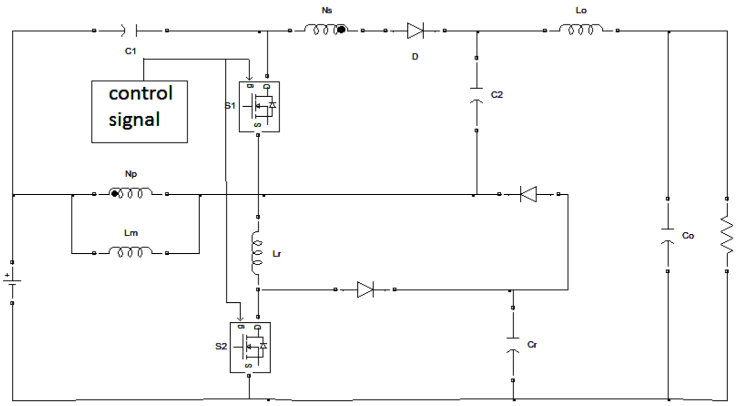

Fig 1 proposed step up converter

III.BASIC OPERATING PRINCIPLES

Fig 2 describes the modes of operations of the circuit.

Mode 1(to-t1)

Figure 2(a) describes the mode1 operation. During this mode switch S_1 is turned on and switch S_2 is turned off. Current flows through resonance inductor and capacitor. Resonance capacitor Cr charges through resonance inductor Lr. Thus the voltage across capacitor Cr increases.

Mode 2 (t1-t2)

Switch S_1 is still on and switch S_2 is off. When the voltage across capacitor Cr increases and exceeds the voltage across capacitor C_1, the direction of current reverses. The switch conducts through the anti parallel diode. This is shown in figure 2(b).

Mode 3 (t2-t3)

When the voltage across capacitor Cr reaches its maximum value, Vcr stays at a constant value. This mode of operation is shown in figure 2(c)

Mode 4 (t3-t4)

Mode 4 is shown in figure 2(d).In this mode of operation, switch S_1 is turned off and switch S_2 is turned on. Due to the presence of a series inductor, the current across switch S_2 increases slowly which is responsible for zero current turn on of switchS_2. The energy stored in the capacitor Cr discharges through diode and resonance inductor Lr. Due to this discharge the voltage across switch S_1 increases slowly only. Thus zero voltage turn off can be achieved.

Mode 5 (t4-t5)

In this mode, switch S_2 is still on and switch S_1 is off. When the energy stored in the capacitor Cr becomes zero the power flow changes which is shown in figure 2 (e).

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization *Vol. 4, Special Issue 1, March 2015*

National Conference on Recent Advances in Electrical & Electronics Engineering (NCREEE 2015)

Organized by

Dept. of EEE, Mar Baselios Institute of Technology & Science (MBITS), Kothamangalam, Kerala-686693, India

On 26th & 27th March 2015

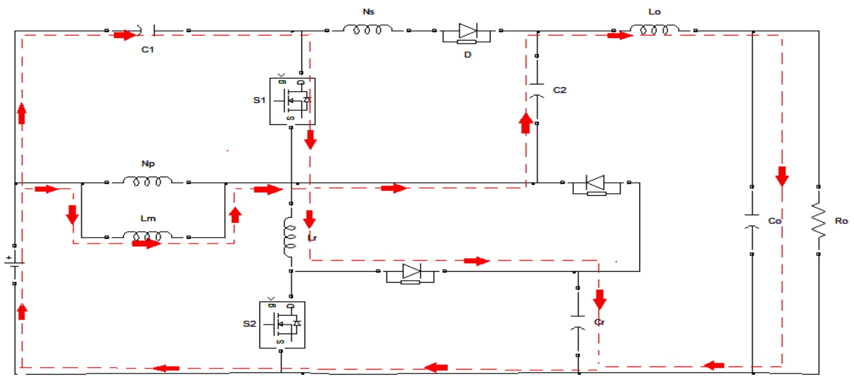

Fig 2(a)

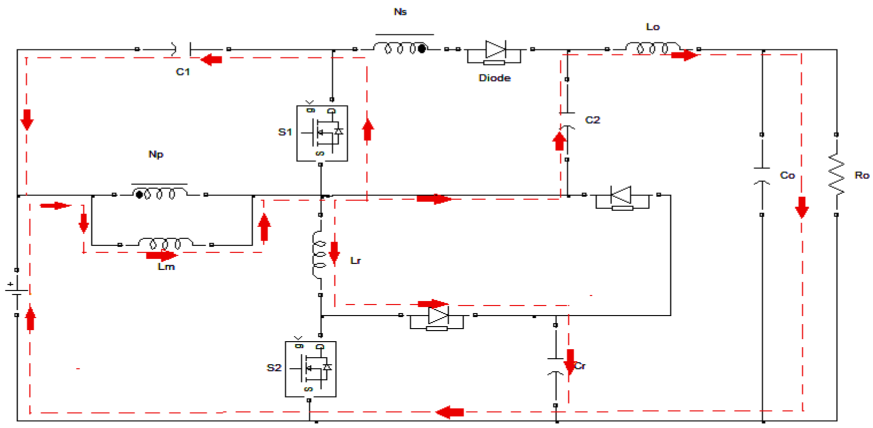

Fig 2(b)

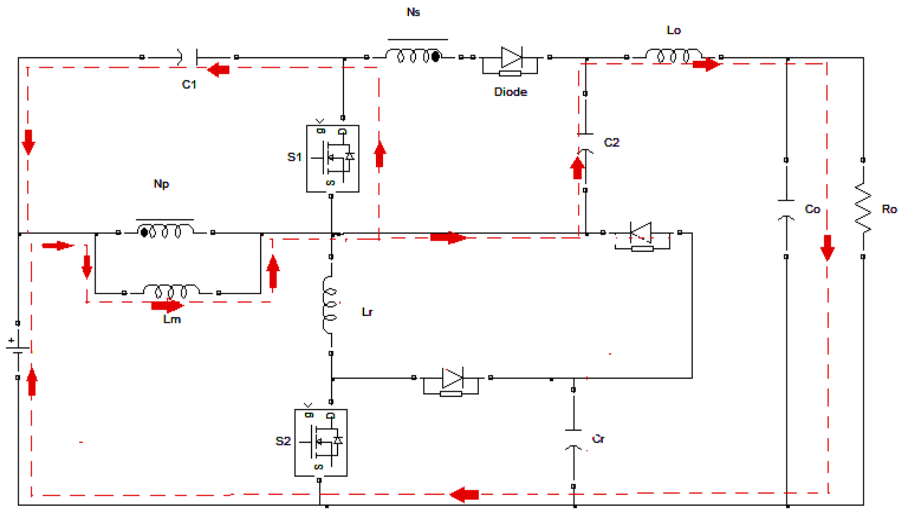

Fig 2(c)

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization *Vol. 4, Special Issue 1, March 2015*

National Conference on Recent Advances in Electrical & Electronics Engineering (NCREEE 2015)

Organized by

Dept. of EEE, Mar Baselios Institute of Technology & Science (MBITS), Kothamangalam, Kerala-686693, India

On 26th & 27th March 2015

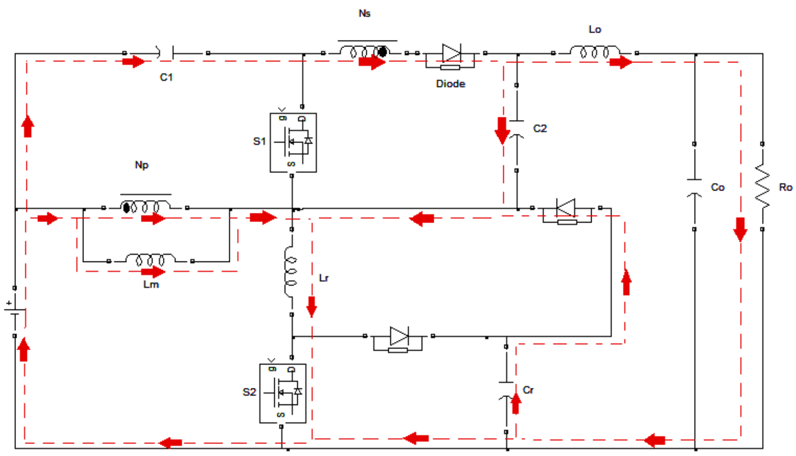

Fig 2(d)

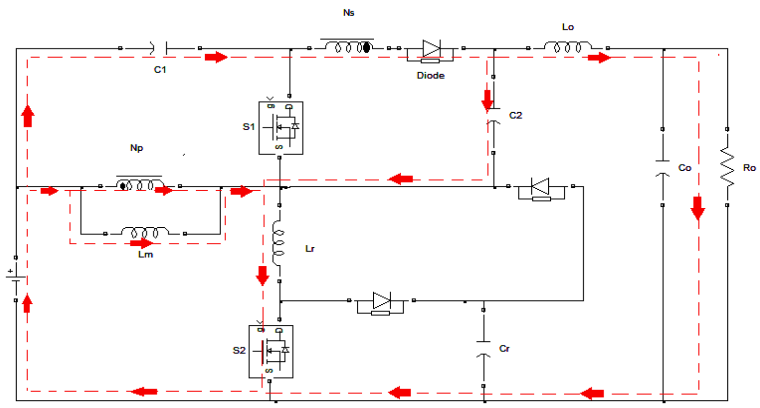

Fig 2(e)

IV SIMULATION RESULTS

The simulation was done using MATLAB/SIMULINK. The closed loop simulation diagram is as shown in figure 3. To obtain soft switching, a resonance inductor and resonance capacitor namely Lr and Cr are connected in the circuit. The specifications of components used are given in Table I. The design values are given in Table II.

TABLE I. CIRCUIT PARAMETERS

Parameter	*Values*
Magnetizing inductor, Lm	100 µH
Energy transferring capacitor, C1	174µF
Charge pump capacitor, C2	69µF
Output capacitor,C0	300µF
Output inductor, Lo	180 µH
Output resistor, Ro	90Ω
Resonance inductor, Lr	10µH

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization

Vol. 4, Special Issue 1, March 2015

National Conference on Recent Advances in Electrical & Electronics Engineering (NCREEE 2015)

Organized by

Dept. of EEE, Mar Baselios Institute of Technology & Science (MBITS), Kothamangalam, Kerala-686693, India

On 26th & 27th March 2015

Parameter	*Values*
Resonance capacitor, Cr	10nF

TABLE II. DESIGN PARAMETERS

Parameter	*Values*
Input voltage, Vi	12V
Output voltage,Vo	72V
Output current Io	0.8A
Output power	60W
Switching frequency	100 KHz

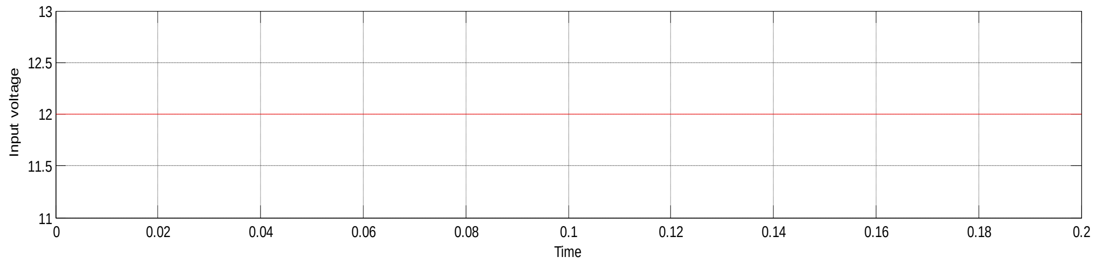

Fig 3. Input voltage, Vi=12V

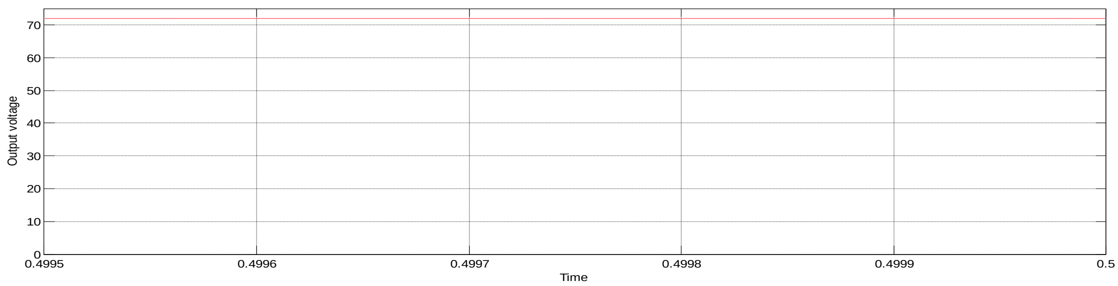

Fig 4. Output voltage, Vo= 72V

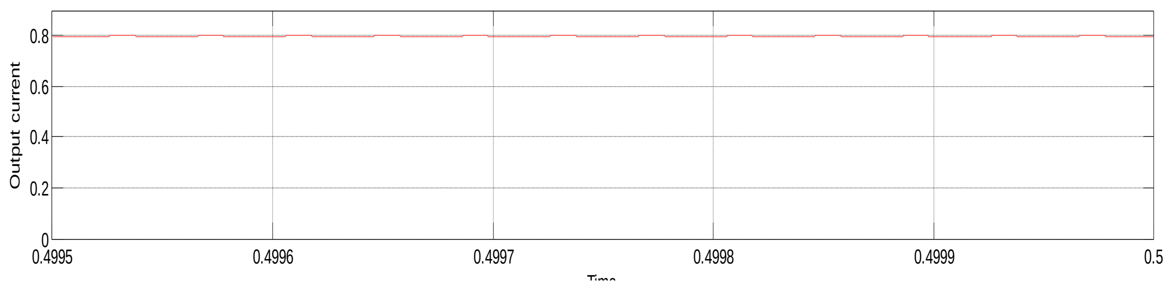

Fig 5. Output current, Io

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization *Vol. 4, Special Issue 1, March 2015*

National Conference on Recent Advances in Electrical & Electronics Engineering (NCREEE 2015)

Organized by

Dept. of EEE, Mar Baselios Institute of Technology & Science (MBITS), Kothamangalam, Kerala-686693, India

On 26th & 27th March 2015

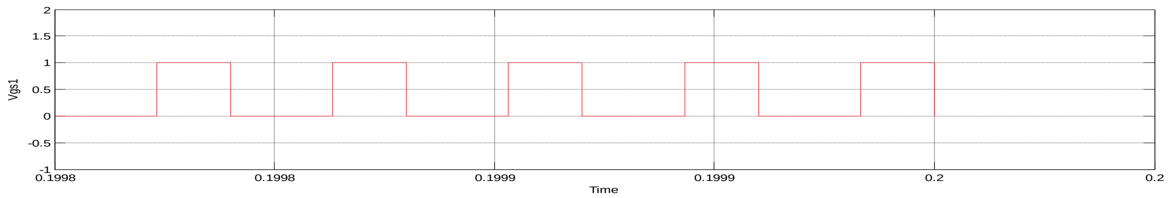

Fig 6. Gate pulse for switch S1

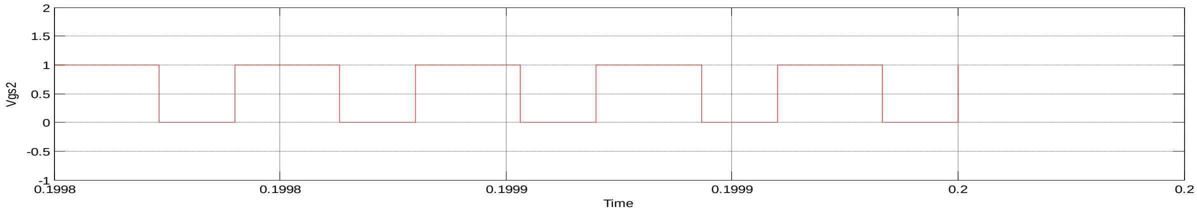

Fig 7 Gate pulse for switch s2

The DC input voltage Vi=12V is shown in figure 3.The output voltage obtained is shown in figure4. Vo=72V.The output current Io=0.8A is given in figure 5. The gate pulse for switch S1 and switch S2 are shown in figure 6 and figure 7 respectively. The switching pulse for switch S1 and S2 are given as complimentary pulses.

Voltage and current across switch S1 is represented as Vsw1 and Isw1 respectively. Similarly voltage and current across switch S2 in represented as Vsw2 and Isw2 respectively. Zero current turn on and zero current turn off is obtained for both switches. Figure 8 shows the voltage and current across switch S1 and switch S2 respectively. Switch S1 is turned on first. Then the voltage across switch S1 is zero. The current across switch increases slowly. This results in zero current turn on. Voltage across switch S2 is maximum. When switch S2 is turned on voltage across it becomes zero and current increases slowly to achieve zero current turn on. During this period zero voltage turn off is applicable for switch S2.

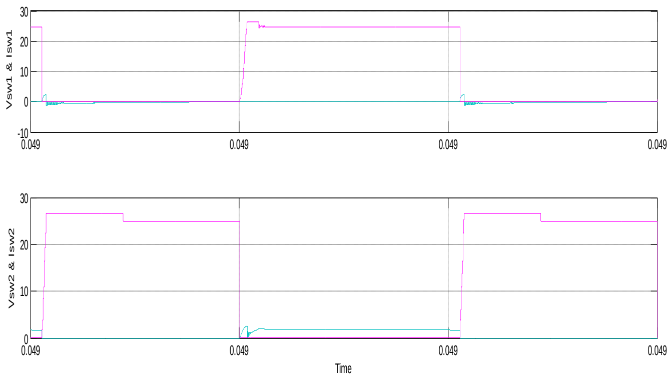

Fig 8. Soft switching waveforms

Now, performing the load regulation. Full condition is first analysed. The corresponding waveform is given in figure9. In this case output voltage is 72V and output current is 0.8A

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization Vol. 4, Special Issue 1, March 2015

National Conference on Recent Advances in Electrical & Electronics Engineering (NCREEE 2015)

Organized by

Dept. of EEE, Mar Baselios Institute of Technology & Science (MBITS), Kothamangalam, Kerala-686693, India

On 26th & 27th March 2015

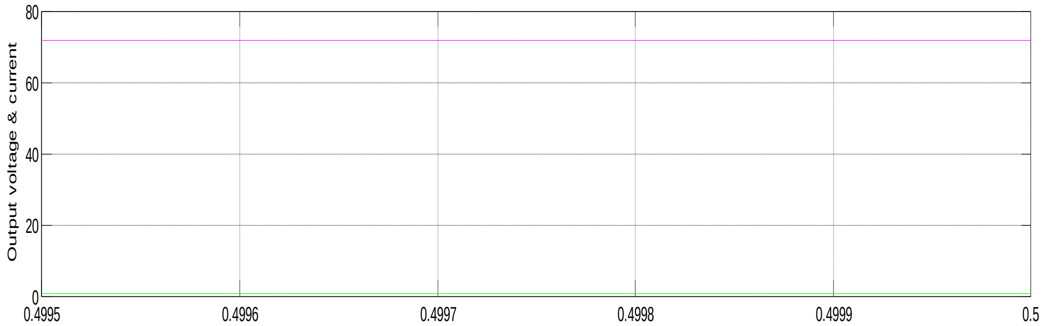

Fig 9 . Full load condition

Now performing the no load condition.

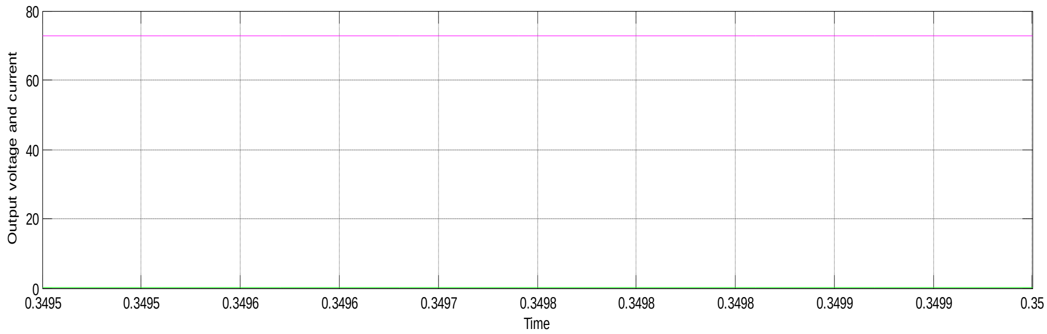

Fig 10 . No load condition

In this case, output voltage is 72V and output current is 0A.

V. CONCLUSION

This paper describes about a novel voltage gain enhance KY step up converter with soft switching, its features, and modes of operation. A KY converter along with a synchronous buck boost converter structure is presented here. To obtain a high voltage gain a coupled inductor can be employed. Simulation is done using Matlab. Load regulation is performed. The gain enhanced output voltage is obtained.

REFERENCES

[1] B. R. Lin, F. Y. Hsieh, and J. J. Chen, "Analysis and implementation of a bidirectional converter with high converter ratio," in Proc. IEEE ICIT, 2008, pp. 1–6.
[2] K. B. Park, G. W. Moon, and M. J. Youn, "Nonisolated high step-up stacked converter based on boost-integrated isolated converter," IEEE Trans. Power Electron., vol. 26, no. 2, pp. 577–587, Feb. 2011.
[3] Y. Deng, Q. Rong, Y. Zhao, J. Shi, and X. He, "Single switch high step-up converters with built in transformer voltage multiplier cell," IEEE Trans. Power Electron., vol. 27, no. 8, pp. 3557–3567, Aug. 2012.
[4] W. Li,W. Li, X. He, D. Xu, and B.Wu, "General derivation law of nonisolated high-step-up interleaved converters with built-in transformer," IEEE Trans. Ind. Electron., vol. 59, no. 3, pp. 1650–1661, Mar. 2012.
[5] C. M. Lai, C. T. Pan, and M. C. Cheng, "High-efficiency modular high step-up interleaved boost converter for DC-microgrid applications," IEEE Trans. Ind. Electron., vol. 48, no. 1, pp. 161–171, Jan./Feb. 2012.
[6] R. J. Wai and R. Y. Duan, "High-efficiency power conversion for low power fuel cell generation system," IEEE Trans. Power Electron., vol. 20, no. 4, pp. 847–856, Jul. 2005.
[7] K. I. Hwu ,W. Z. Jiang,"Voltage Gain Enhancement for a Step-Up Converter Constructed by KY and Buck-Boost Converters" , Ieee Transactions On Industrial Electronics, VOL. 61, NO. 4, APRIL 2014
[8] K. I. Hwu and Y. T. Yau, "KY converter and its derivatives," IEEE Trans. Power Electron., vol. 24, no. 1, pp. 128–137, Jan. 2009.
[9] K. I. Hwu and Y. T. Yau, "A KY boost converter," IEEE Trans. Power Electron., vol. 25, no. 11, pp. 2699–2703, Nov. 2010.
[10] K. I. Hwu, K. W. Huang, and W. C. Tu, "Step-up converter combining KY and buck-boost converters," IET Electron. Lett., vol. 47, no. 12,pp. 722–724, Jun. 2011.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization *Vol. 4, Special Issue 1, March 2015*

National Conference on Recent Advances in Electrical & Electronics Engineering (NCREEE 2015)

Organized by

Dept. of EEE, Mar Baselios Institute of Technology & Science (MBITS), Kothamangalam, Kerala-686693, India
On 26th & 27th March 2015

[11] K. I. Hwu and Y. T. Yau, "Inductor-coupled KY boost converter," IET Electron. Lett., vol. 46, no. 24, pp. 1624–1626, Nov. 2010.
[12] K. I. Hwu and W. C. Tu, "Voltage-boosting converters with energy pumping," IET Power Electron., vol. 5, no. 2, pp. 185–195, Feb. 2012.
[13] K. I. Hwu, Y. T. Yau, and Y. H. Chen, "A novel voltage-boosting converter with passive voltage clamping," in Proc. IEEE ICSET, 2008, pp. 351–354.
[14] A Novel Voltage-boosting Converter: KY Converter, K. I. Hwu , Y. T. Yau, 1-4244-0714-1/07 2007 IEEE.
[15] Negative-Output KY Buck-Boost Converter, K. I. Hwu, Y. H. Chen and Zhi-Fan Lin, 978-1-4244-2800-7/09/2009 IEEE
[16] K. I. Hwu and Y. T. Yau, "Two types of KY buck-boost converters," IEEE Trans. Ind. Electron., vol. 56, no. 8, pp. 2970–2980, Aug. 2009.
[17] Bidirectional Control of Inverse KY Converter, K. I. Hwu, Member, IEEE, and Y. H. Chen, Student Member, IEEE, IEEEInternational Symposium on Industrial Electronics (ISlE 2009) Seoul OlympicParktel,Seoul, Korea July 5-8, 2009
[18] "Voltage Gain Enhancement of KY Converter", K. I. Hwu, W. Z. Jiang, H. M. Chen, 978-1-4799, 2013 IEEE
[19] "Soft Switching of KY Converter "K. I. Hwu1, Y. T. Yau, 978-1-4244-1874-9/08,2008 IEEE