

# **A High Gain Input-Parallel Output-Series Interleaved Boost Converter for Home Appliances**

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**ABSTRACT:** This paper proposes a High voltage gain dc-dc converter which can be used in running house-hold appliances. Systems such as Photovoltaic energy conversion systems, fuel-cells, High-Intensity Discharge lamp (HID), DC back-up energy systems, and electric vehicles systems usually need high voltage gain. The converter employs dual coupled inductor whose primary are connected in parallel to share the input current and reduce the current ripple at the input. The secondary sides of coupled inductors are connected in series for increasing the voltage gain and balancing the primary-parallel currents. But the main problem associated with this system is that due to less voltage gain it cannot be used for useful applications such as running house-hold appliances. In order to alleviate the problem, existing system is modified using an inverter section with L-C filter. The turns ratio is also increased to improve the voltage gain further. Moreover, the high output voltage so obtained is utilized in running household appliances efficiently. A prototype circuit rated at 225 W output power is implemented in the laboratory, and the experimental results shows agreement with the theoretical analysis.

**KEYWORDS:** DC-DC converter, coupled inductor, input-parallel output-series.

## **I. INTRODUCTION**

The proposed interleaved boost converter with dual coupled inductor based topology is used to convert the given low input voltage to higher voltage and hence producing high voltage gain. Interleaved converters can improve voltage gain. Here interleaving is done by combing a conventional boost converter and boost converter with diode in the negative dc-link rail. The system also employs a dual couple inductor whose primary is connected in series and output side is connected in parallel (IPOS). IPOS connection has the advantage of having capability of handling high input current and high output voltage. Secondary sides of coupled inductor are connected in series to form a voltage doubler module. This module further doubles the voltage gain. The clamp capacitor and clamp diode in this module also serves as a path to release energy stored due to leakage inductance in coupled inductor.

The proposed system can be modified in such a way so as to run house-hold appliances. High voltage gain can be obtained by increasing the turns ratio of the coupled inductor windings. DC output voltage thus produced can be converted to AC. This can be done by including an inverter section at the output side so as to convert the DC output voltage to AC so as to run home appliances.

## **II. RELATED WORK**

A. Reatti proposed, "A low cost high power density electronic ballast for automotive HID lamps" [1], IEEE 2000, involves a ballast circuit having a dc-dc class E resonant inverter, a peak rectifier operated at same frequency, a square wave inverter supplying lamp by a 400 Hz square wave voltage. Automotive HID lamps are 35 W high-pressure Xenon gas discharge lamps, designed for a horizontal position operation at a steady state rms voltage ranging from 70 V to 100 V. These lamps offer higher lightning emission than 50 W halogen lamps. HID lamp steady-state operation at frequencies higher than same kHz suffers from the effect of acoustic resonance which causes unstable arc, flicker, arc extinguishing, lamp destruction. The proposed ballast operates at high efficiency, has lower number of components, low EMI, light weight, small size, high power density, long life operation, maximum efficiency at steady state operation.

# International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 9, September 2016

G. V. T. Bascope, R. P. T. Bascope, D. S. Oliveira Jr., S. A. Vasconcelos, F. L. M. Antunes, and C. G. C. Branco proposed, "A high step-up DC-DC converter based on three state switching cell" [2], IEEE 2006, in which a new non-isolated boost converter with high voltage gain is implemented. The input current is found to be non-pulsating with low ripple and the input inductor operates within the double of the switching frequency thus reducing weight and volume. The voltage stress across the switches is half of the output voltage. But one of the major disadvantages observed was that the converter cannot be operated for a duty cycle lower than 0.5 due to magnetic induction problems of the transformer.

G. Fontes, C. Turpin, S. Astier, and T. A. Meynard studied, "Interaction between a fuel cell and power converter" [3] with experimental and modelling work on a Proton Exchange Membrane (PEM) fuel cell, IEEE 2007. By methods such as impedance spectroscopy of verification by connection to power converter, the behaviour of the fuel cell can be studied. A fuel cell stack offers possibilities to filter high frequency current harmonics by the intermediary of double layer capacitor. The behaviour is naturally good and not distributed if its current is modulated at high frequency. In the case of buck or boost converters the electrochemical process can be fully decoupled from fast current variations. But in case of inverters, interactions between low frequency current harmonics and electrochemical phenomenon are likely to appear.

R. J. Wai, C. Y. Lin, R. Y. Duan, and Y. R. Chang proposed, "High-efficiency dc-dc converter with high voltage gain and reduced switch stress" [4], IEEE 2007, in which a three winding coupled inductor to increase the voltage gain is implemented. Moreover, the problem of leakage inductance and reverse recovery in conventional boost converter can also be solved so that it can achieve the aim of high efficiency power conversion. The maximum efficiency is obtained to be greater than conventional boost converter.

J. Y. Lee and S. N. Hwang proposed, "A non-isolated high gain boost converter using a voltage stacking cell" [5], IEEE 2008, for interfacing fuel cell to various loads. Non-isolated boost converter can reduce the size and cost of power conversion units where electrical isolation is not required. Voltage stacking cell provides a path for increase in voltage gain. It has a structure similar to flyback converter. Proposed converter has voltage stacking cells that can be increased to N times. Using this converter voltage gain can be increased to 3-4 times the conventional boost converter. The disadvantage is that voltage gain is affected by leakage inductance and amount of energy is transferred through voltage stacking cells is increased as leakage inductance decreases. Voltage stress across main switch is also increased.

M. Prudente, L. L. Pfitscher, G. Emmendoerfer, E. F. Romaneli, and R. Gules proposed, "Voltage multiplier cells applied to non-isolated DC-DC converters" [6], IEEE 2008, to provide high voltage gain and also reduction in the problems faced in battery powered systems. Non-isolated dc-dc converter as classical boost converter can also provide high voltage gain but with the penalty of high voltage and current stresses, high duty ratio and limited dynamic response. So a non-isolated boost converter with voltage multiplier cells can be used. These cells can be integrated with interleaved converters for high output voltage and high current applications.

C. Cecati, F. Ciancetta, and P. Siano proposed, "A full fuzzy logic based cascaded H-bridge multilevel inverter for grid connected and standalone applications" [7], IEEE 2010, which employs a modulator and controller realizing a new one step controller. The main advantages of the system are better THD, number of levels and phases can be modified. Low voltage MOSFETs are employed which are cheaper, faster, and more efficient than IGBTs. High frequency switching operation can be employed for improved output waveform and THD. This system can be used for large solar plants because they are arranged in separate small generators, reducing darkening problems, power losses and improves overall efficiency. But the main disadvantage is that power partitioning among four H-bridges is not uniform with the use of uniform modulation leads to power unbalances among the H-bridges can produce overheating.

G. A. L. Henn, R. N. A. L. Silva, P. P. Praca, L. H. S. C. Barreto, and D. S. Oa proposed, "Interleaved-boost converter with high voltage gain" [8], IEEE 2010, which can be used to provide high voltage gain of about 11 times the conventional boost converter. The main features are reduced voltage stress across the main switches and high voltage gain, voltage balancing between output capacitors, low input-current ripple, high switching frequency, reduced volume and weight, simple switching control and the possibility to make the voltage gain even higher by increasing the transformer turns-ratio. The main drawbacks related to this topology are the duty cycle limitation, as it must be higher than 50%, and the need of a soft start and initial charge of output capacitors.

S. Chen, T. Liang, L. Yang, and J. Chen proposed, "A cascaded high step-up dc-dc converter with single switch for microsource applications" [9], IEEE 2011, to increase the output voltage of microsource to a proper voltage level for the dc interface through dc-ac inverter to the main electricity grid. To achieve a high voltage gain cascaded dc-dc converter are used. The main features of this converter are that the input current ripple is reduced and leakage inductor energy of the coupled inductor can be recycled, which reduces the voltage stress on the active switch.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016

Y. P. Hsieh, J. F. Chen, T. J. Liang, and L. S. Yang proposed, “A novel high step-up dc-dc converter for distributed generation system” [10], IEEE 2013, to obtain high voltage gain and high efficiency. Diesel Generator systems are rapidly developed. These systems are composed of fuel cells, PV cells & wind power. For achieving high gain and efficiency two capacitors are added along with two diodes on the secondary side of coupled inductor to achieve high step up voltage gain. A passive clamping circuit is needed to clamp the voltage level of main switch and to recycle the energy of leakage inductance. The capacitors are charged in parallel and are discharged in series.

L. Henrique, S. C. Barreto, P. P. Praca, D. S. Oliveira Jr., and R. N. A.L. Silva proposed, “A high gain Boost converter based on three state commutation cell” [11], IEEE 2014, which deals with single-stage soft switching non-isolated dc-dc converter interconnecting battery charger, PV panels and high gain boost converter. Single stage converters has the problem of high voltage and current stresses and low efficiency. But in a three state commutation cell the number of conversion stages reduces, converter efficiency increases and control system is simplified. The main advantage of this topology is low voltage stresses across the active switches, low input current ripple, simplicity and high efficiency, switching losses is also reduced. Higher efficiency is achieved in lower load condition and decreases in rated condition.

W. Li, Y. Zhao, J. Wu, and X. He proposed, “Interleaved high step-up converter with winding-cross-coupled inductors and voltage multiplier cells”, [12], IEEE 2012, in which the concept of winding-cross-coupled inductors (WCCIs) and voltage multiplier cells is integrated to derive a novel interleaved high step-up converter in this paper. The voltage gain is extended and the switch voltage stress is reduced by the WCCIs and the voltage multiplier cells in the presented circuit, which minimizes the peak current ripple of the power devices and makes low-voltage MOSFETs with high performance available in high step-up and high output voltage applications. Moreover, the output diode reverse-recovery problem is alleviated by the leakage inductance of the WCCIs, which reduces the reverse-recovery losses. Zero current switching (ZCS) turn-on is realized for the power switches to reduce the switching losses. Furthermore, the voltage spikes on the MOSFETs are clamped and the leakage energy is recycled by the voltage multiplier cells, when the switch turns off.

### III. SYSTEM MODEL AND WORKING

The circuit can be divided into two parts: a modified interleaved boost converter and a voltage doubler module using capacitor-diode and coupled inductor technologies. The derivation procedure for the proposed topology is shown in Fig. 1. The basic boost converter topology shown in Fig. 1(a). In Fig. 1(b) is another boost version with output diode on the negative dc-link rail. Fig. 1(c) is called a modified interleaved boost converter, which is an input-parallel and output-series configuration derived from two basic boost converters as shown. Therefore, this part based on interleaved control has several main functions:

- 1) It can obtain double voltage gain of the conventional interleaved boost converter
- 2) Low output voltage ripple
- 3) Low switch voltage stresses.

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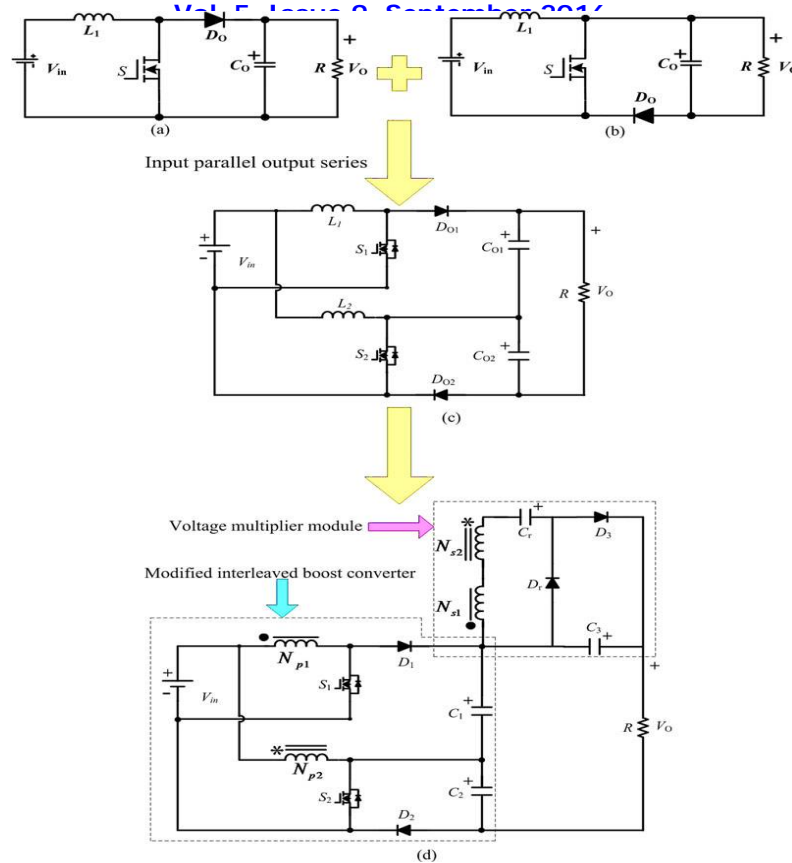


Fig. 1. Procedure to obtain the proposed converter with high voltage gain. (a) Conventional boost converter. (b) Other structure of boost converter. (c) Modified interleaved boost. (d) High gain input-parallel output-series dc/dc converter with dual coupled inductors.

Voltage multipliers are AC-DC power conversion devices, comprised of diodes and capacitors that produce a high potential DC voltage from a lower voltage AC source. Multipliers are made up of multiple stages. Each stage is comprised of one diode and one capacitor. A voltage doubler uses two stages to approximately double the DC voltage that would have been obtained from a single stage rectifier. The double independent inductors in the modified interleaved boost converter are separately replaced by the primary windings of coupled inductors that are employed as energy storage and filtering as shown in Fig. 2. The secondary windings of two coupled inductors are connected in series for a voltage multiplier module, which is stacked on the output of the modified converter to get high voltage gain. This connection is also helpful to balance the currents of two primary sides. Equivalent circuit of the proposed topology is shown in Fig. 2

Equivalent converter shows:

- $L_{m1}; L_{m2}$ : magnetizing inductances.
- $L_{k1}; L_{k2}$ : leakage inductances.
- $C_1; C_2; C_3$ : output and clamp capacitors.
- $S_1; S_2$ : main switches.
- $D_1; D_2$ : clamp diodes.
- $D_r; C_r$ : regenerative diode and capacitor.
- $D_3$ : output diode.
- $N$ : turns ratio of  $N_s/N_p$ .
- $V_{N1}; V_{N2}$ : the voltage on the primary sides of coupled inductors.

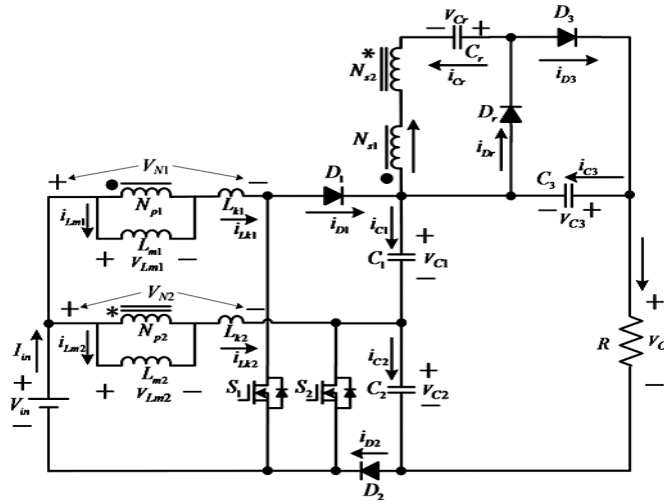


Fig. 2. Equivalent circuit

The duty cycles of the power switches are interleaved with  $180^\circ$  phase shift, and the duty cycles are greater than 0.5. That is to say, the two switches can only be in one of three states ( $S_1$ : ON,  $S_2$ : ON;  $S_1$ : ON,  $S_2$ : OFF;  $S_1$ : OFF,  $S_2$ : ON), which ensures transmission of energy from the coupled inductor's primary side to the secondary. The operating stages can be shown in Figs. 4-11. The different modes of operation of the proposed converter are:

1) **FIRST STAGE**  $[t_0-t_1]$ : At  $t = t_0$ , the switch  $S_1$  is turned on with zero-current switching (ZCS) due to the leakage inductance  $L_{k1}$ , while  $S_2$  remains turned ON, as shown in Fig. 3. Diodes  $D_1$ ,  $D_2$  and  $D_r$  are turned OFF, and only output diode  $D_3$  is conducting. The current through the diode  $D_3$  is controlled by the leakage inductances  $L_{k1}$  and  $L_{k2}$ . This stage ends when the current through the diode  $D_3$  decreases to zero.

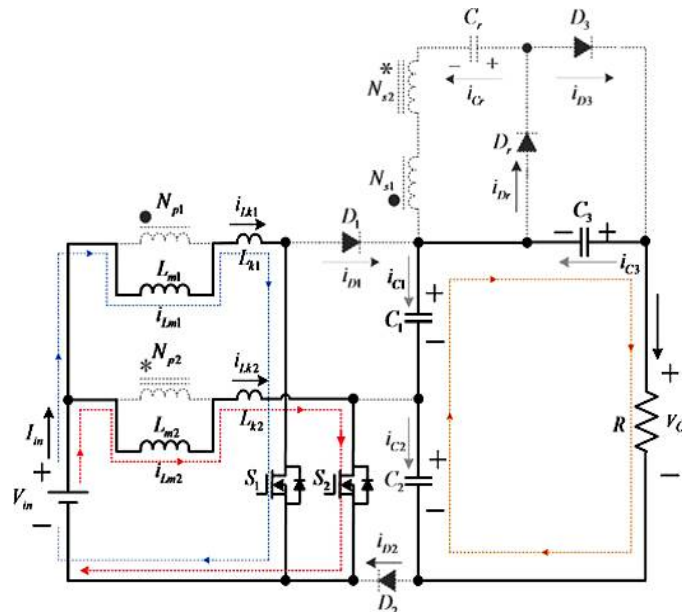


Fig. 3. First stage

2) **SECOND STAGE**  $[t_1-t_2]$ : During this interval, both the switches  $S_1$  and  $S_2$  are ON (as shown in Fig. 4) and all the diodes are reversed-biased. The magnetizing inductances  $L_{m1}$  and  $L_{m2}$  as well as leakage inductances  $L_{k1}$  and  $L_{k2}$  are linearly charged by the input voltage source  $V_{in}$ . This stage ends at the instant  $t_2$ , at which switch  $S_2$  is turned OFF.



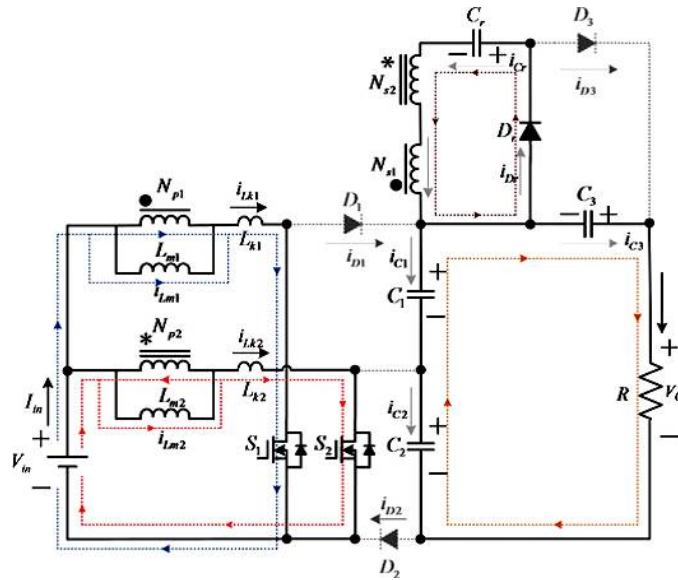


Fig. 4. Second stage

3) **THIRD STAGE** [ $t_2-t_3$ ]: At  $t = t_2$ , the switch  $S_2$  is turned OFF. This makes the diodes  $D_2$  and  $D_r$  to turn ON. The energy that stored in  $L_{m2}$  is transferred to the secondary side charging the capacitor  $C_r$  by the diode  $D_r$ . The current through the diode  $D_r$  and the capacitor  $C_r$  is determined by the leakage inductances  $L_{k1}$  and  $L_{k2}$ .

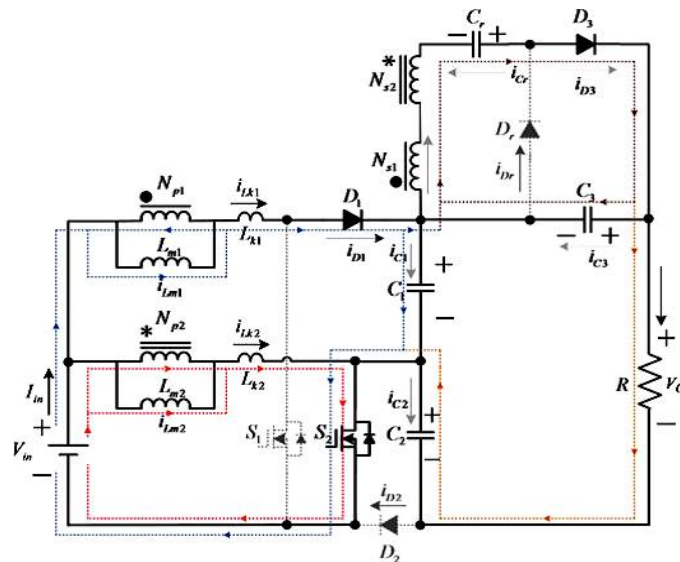


Fig. 5. Third stage

4) **FOURTH STAGE** [ $t_3-t_4$ ]: At  $t = t_3$ , diode  $D_2$  automatically switches OFF because the total energy of leakage inductance  $L_{k2}$  gets completely released to the capacitor  $C_2$ . The reverse recovery problem for the diode  $D_2$  decreases. The current flow path of this stage is shown in Fig. 6. Magnetizing inductance  $L_{m2}$  transfers energy to the secondary side charging the capacitor  $C_r$  through diode  $D_r$ . The current of the switch  $S_1$  is equal to the summation of the currents of the magnetizing inductances  $L_{m1}$  and  $L_{m2}$ .

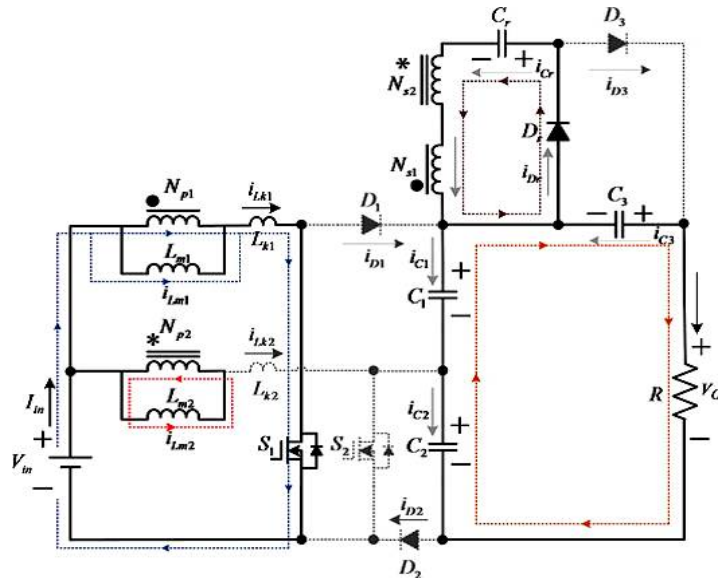


Fig. 6. Fourth stage

5) FIFTH STAGE [ $t_4-t_5$ ]: At  $t = t_4$ , switch  $S_2$  is turned ON with ZCS condition. Due to the leakage inductance  $L_{k2}$ , the switch  $S_1$  remains in ON state. The current flow path of this stage is shown in Fig. 7. The current falling rate through the diode  $D_r$  is controlled by the leakage inductances  $L_{k1}$  and  $L_{k2}$ , which reduces the diode reverse recovery problem. This stage ends when the current through the diode  $D_r$  decreases to zero at  $t = t_5$ .

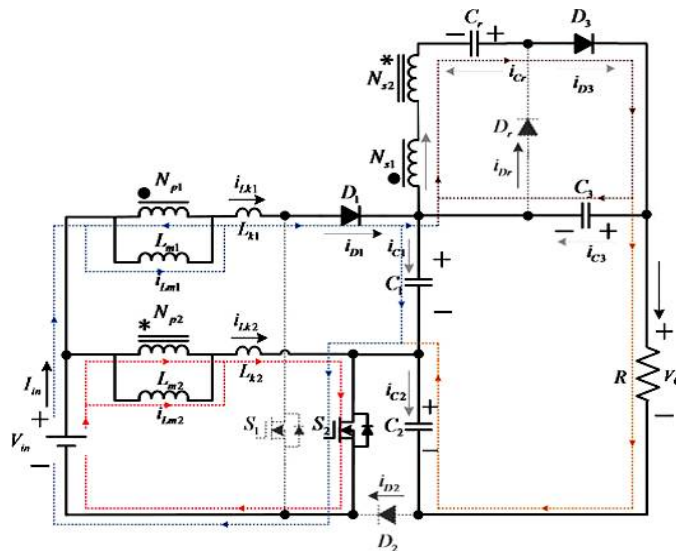


Fig. 7. Fifth stage

6) SIXTH STAGE [ $t_5-t_6$ ]: This stage is similar to stage 2. During this interval, all diodes are turned OFF. The magnetizing inductances  $L_{m1}$  and  $L_{m2}$ , and the leakage inductances  $L_{k1}$  and  $L_{k2}$  are charged linearly by the input voltage. The voltage stress of  $D_1$  is the voltage on  $C_1$ , and the voltage stress of  $D_2$  is the voltage on  $C_2$ . The voltage stress of  $D_r$  is the voltage on  $C_r$ , and the voltage stress of  $D_3$  is the output voltage minus the voltages on  $C_1$ ,  $C_2$  and  $C_r$ .

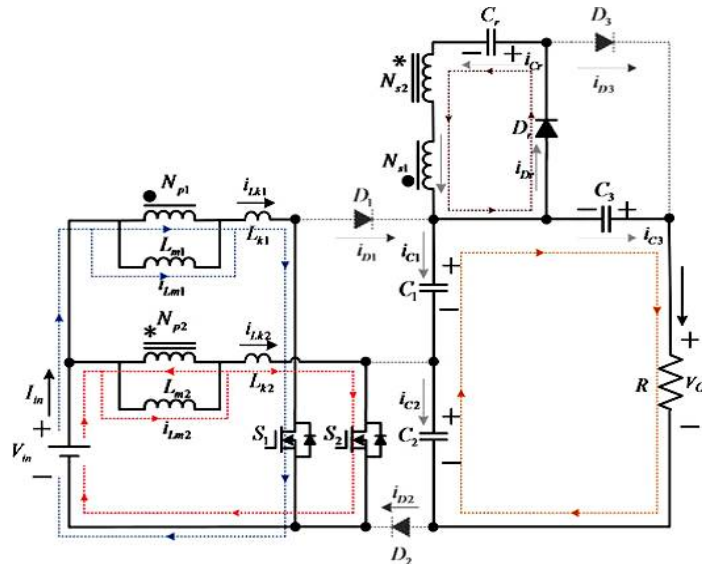


Fig. 8. Sixth stage

7) SEVENTH STAGE [ $t_6-t_7$ ]: The power switch  $S_1$  is turned OFF at  $t = t_6$ , which turns ON  $D_1$  and  $D_3$ , and the switch  $S_2$  remains in conducting state.

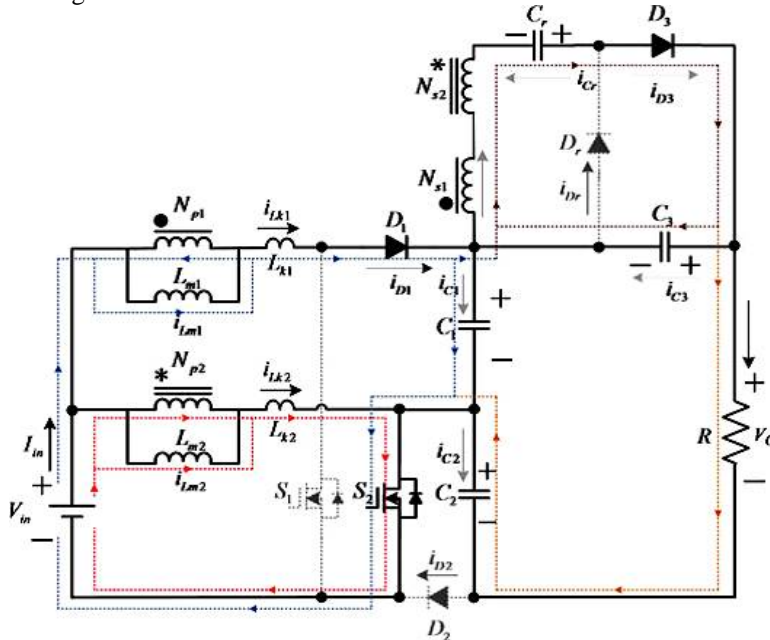


Fig. 9. Seventh Stage

The current-flow path of this stage is shown in Fig. 9. The input voltage source  $V_{in}$ , magnetizing inductance  $L_{m1}$  and leakage inductance  $L_{k1}$  release their energy to the capacitor  $C_1$  via the switch  $S_2$ . Simultaneously, the energy stored in magnetizing inductor  $L_{m1}$  is transferred to the secondary side. The current through the secondary sides in series flows to the capacitor  $C_3$  and load through the diode  $D_3$ .



# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016

8) Eighth stage  $[t_7-t_0]$ : At  $t = t_7$ , total energy of leakage inductance  $L_{k1}$  has been completely released to the capacitor  $C_1$ , diode  $D_1$  automatically switches OFF. The current of the magnetizing inductance  $L_{m1}$  is directly transferred to the output through the secondary side of coupled inductor and  $D_4$  until  $t_0$ .

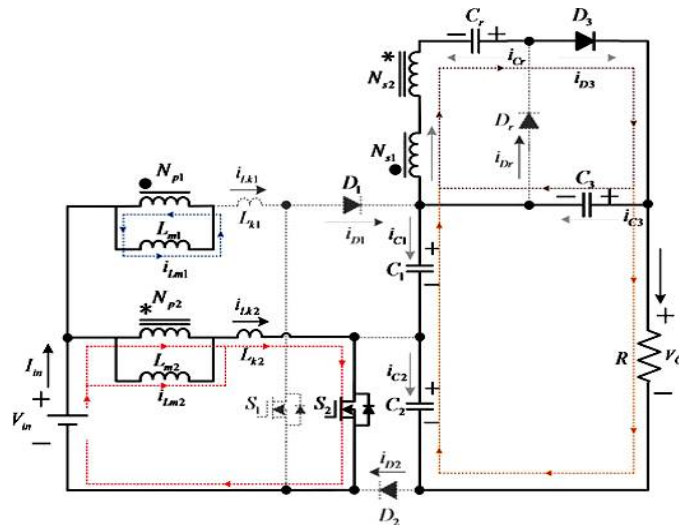


Fig. 10. Eighth stage

It should be pointed out that the time periods of stages 1, 4, 5, and 8 are much shorter than those shown in Fig. 3, which were enlarged in order to clearly show the waveform variations. The modified interleaved boost converter for home appliances is shown below:

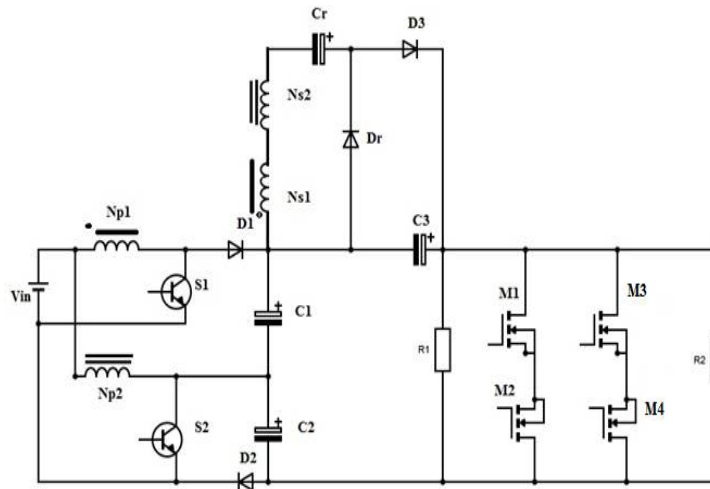


Fig. 11. Circuit Diagram of Proposed System

## III.SIMULATION

The simulation result was done in MATLAB/Simulink. The input-parallel output-series interleaved boost converter for running home appliances is shown in the Fig. 8. The output voltage from interleaved boost converter and inverter section are shown in Figs. 9 & 10. Closed loop control is adopted for the proposed system.

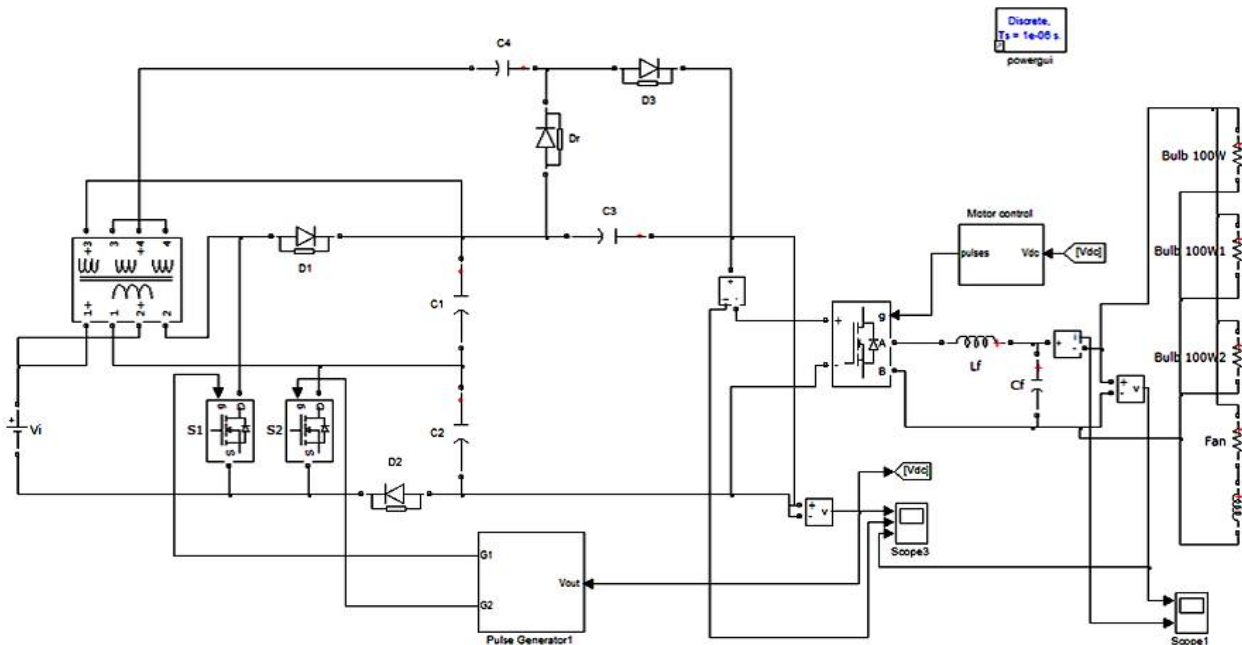


Fig. 8 Simulink model of interleaved boost converter for home appliances

The output voltage obtained at the output terminals of input-parallel output-series interleaved boost converter for home appliances is as shown in Fig. 9. In this figure we can see that the output voltage obtained is around 400 V, for a given input voltage of 24 V.

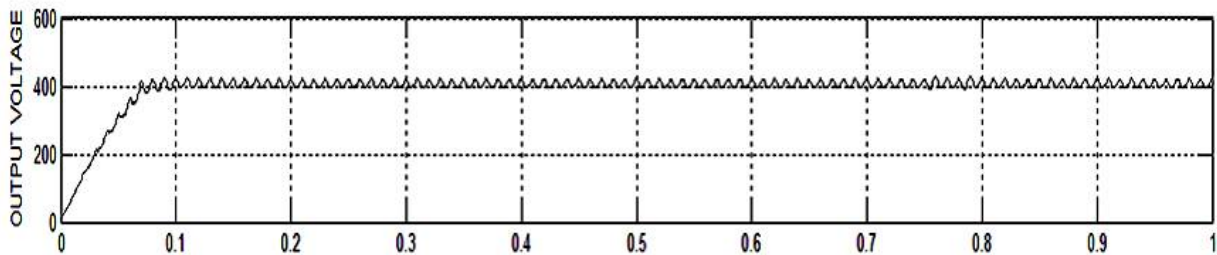


Fig. 9. Output voltage from interleaved boost converter

The output voltage across the inverter terminals are as shown in Fig. 10. Here the output voltage is around 300 V which is suitable for running home appliances. For preventing any harmonics, the output side of inverter is connected to an L-C filter.

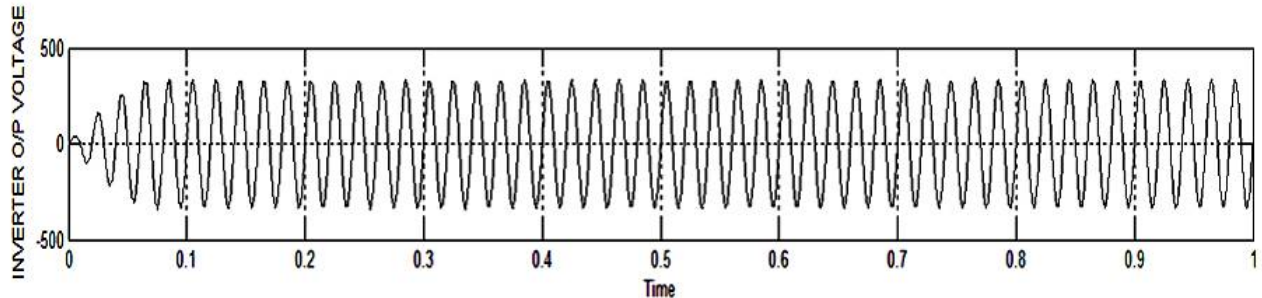


Fig. 10. Output voltage from inverter

Switching pulses for switches  $S_1$  and  $S_2$  are shown in Figs. 11 & 12. The switches are operated with  $180^\circ$  phase shift such that there are instants at which both switches operate and instants at which only one of the switches will operate. This is to ensure that maximum boost operation occurs at these instants.

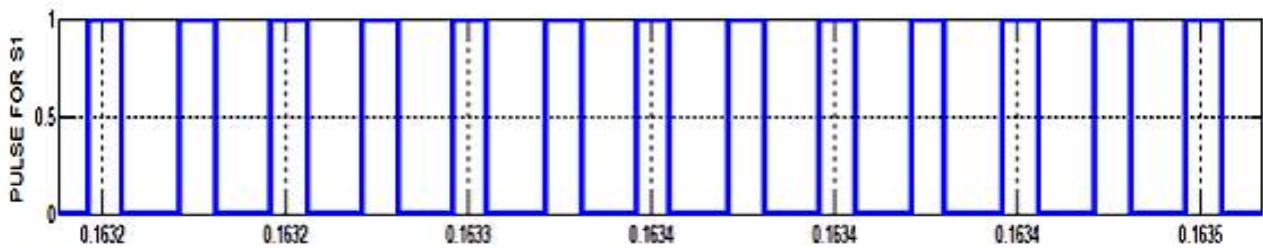


Fig. 11. Pulses for switch  $S_1$

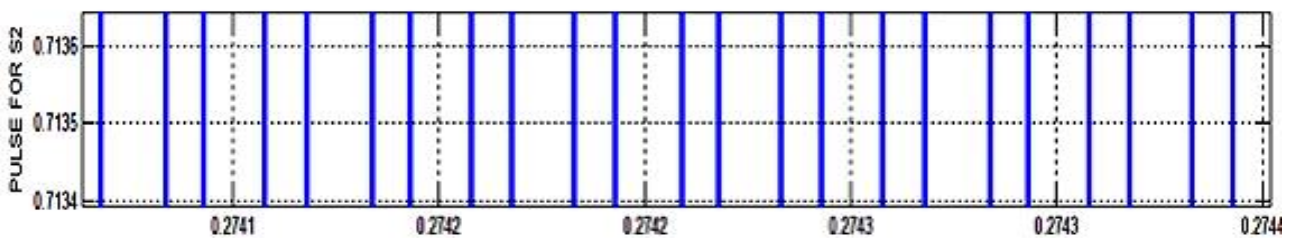


Fig. 12. Pulses for switch  $S_2$

#### IV. HARDWARE IMPLEMENTATION

Block diagram showing all the components required for hardware implementation is as shown in Fig. 12. The input supply, which is 24 V dc, is given to the interleaved boost converter. The pulses to both the switches  $S_1$  and  $S_2$  of the converter is given from a driver circuit which is provide with a 5 V dc supply. The gate triggering for both the switches is done by the driver circuit which then turns on the processes in the converter with different modes of operation. The output from the interleaved boost converter is then given to a full bridge inverter which converts the dc output of interleaved boost converter to AC. The produced AC output from inverter is given to a load which may be a fan, bulb or any other home appliance. Driver circuit generates SPWM and PWM signals to the inverter and to  $S_1$  and  $S_2$  switches respectively. The FAN7382, a monolithic half-bridge gate driver IC, can drive MOSFET's and IGBT's that operate up to +600V.

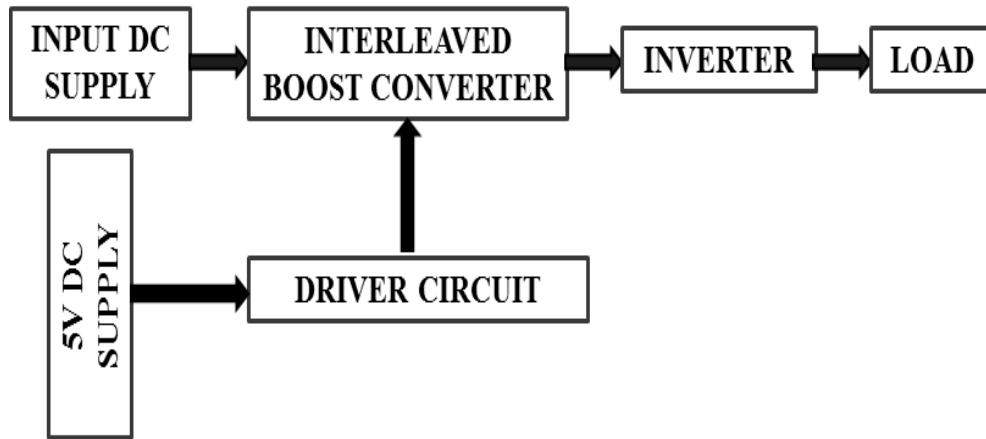


Fig. 13 Block Diagram of Hardware setup

Another IC that can be used to generate pulses for the inverter switches is IR2101(S)/IR2102(S) are high voltage, high speed power MOSFET and IGBT drivers with independent high and low side referenced output channels. Controller used is ATmega328, which is a single chip microcontroller created by Atmel in the megaAVR family. Hardware implementation of the proposed input-parallel output-series interleaved boost converter with voltage doubler module is given in the Fig. 14.

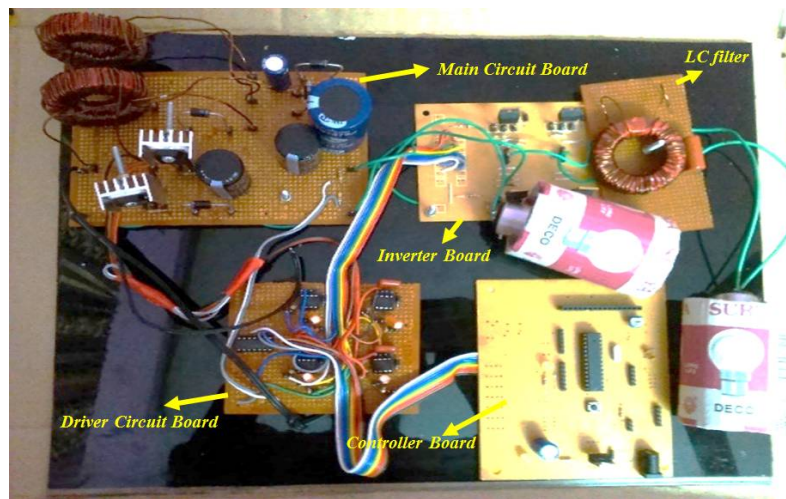


Fig. 14. Hardware implementation of input-parallel output-series interleaved boost converter

The input supply, which is 24 V dc, is given to the interleaved boost converter. For an input voltage  $V_{in} = 24$  V, an output voltage  $V_0$  of 325 V is obtained which stabilises to 300 V. So there is a net voltage gain of 12.5. This is due to the effect of coupling coefficient affecting the gain of the circuit. At ideal case, the output voltage should have been approximately equal to 400 V. The switching pulses for  $S_1$  and  $S_2$  are shown below:

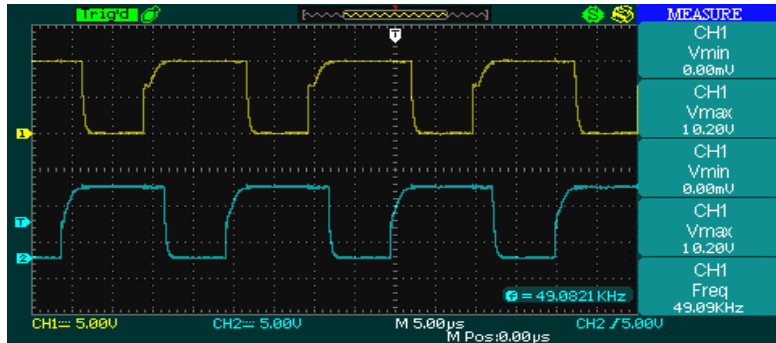


Fig. 15 Switching Pulses for  $S_1$  and  $S_2$

Switching pulses to inverter switches  $M_1$ ,  $M_2$ ,  $M_3$  and  $M_4$  are shown below:

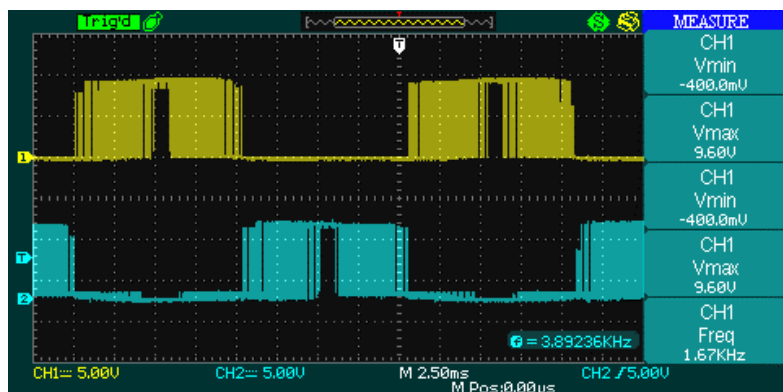


Fig. 16 Switching Pulses for  $M_1$  and  $M_3$

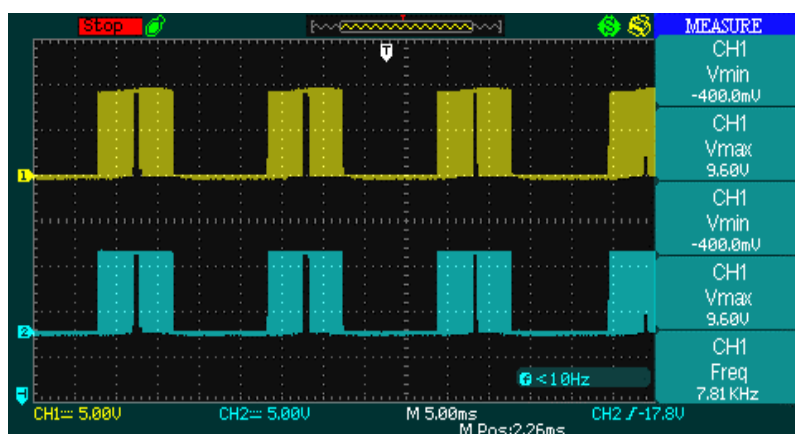


Fig. 16 Switching Pulses for  $M_2$  and  $M_3$

The working model of the converter is as shown in Fig .17.



# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016



Fig. 17 Working Model

Observed results are an output voltage  $V_0 = 300$  V. This can be obtained by connecting a multimeter at the main converter output terminals. For indicating boost operation at the DC-DC converter output and inverter output terminals a  $400\Omega$  (represented by a bulb) is connected.

## V. DESIGN PROCEDURE

This design parameters are applicable for input voltage  $V_{in}$  in the range of 12 V- 36 V. For a given input voltage ( $V_{in}$ ) of 24 V, the output voltage ( $V_{out}$ ) to be produced is 384 V. If  $N$  is the turns ratio and  $M_{CCM}$  is the voltage gain. Then:

### a) Design of Turns ratio for required $V_{out}$

$$D=0.383, N=19/18=1.055, V_0=200 \text{ V}, V_{in}=12-30$$

$$\frac{V_0}{V_{in}} = M_{CCM} = \frac{2(N+1)}{1-D}$$

$$\frac{2(N+1)}{1-D} = \frac{2(1.055+1)}{1-0.383} = 6.66$$

$$\frac{V_0}{V_{in}} = \frac{207.5}{30} = 6.78$$

$$\text{For } V_{in} = 24 \text{ V}, D = 0.627, N_s/N_p = 37/18(\text{Modification})$$

$$M_{CCM} = \frac{2(N+1)}{1-D} = \frac{2(2+1)}{1-0.627} = 16.08$$

$$V_0 = 16.08 * 24 = 384 \text{ V}$$

### b) Design of Capacitors

$$V_{in}=12-36 \text{ V}, V_{out}=200 \text{ V}, I_{out}=2.5\text{A}, \eta=90\%, f_{sw}=40\text{kHz}, D=0.38, V_{pmax}=75(\text{recommended value})$$

# International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 9, September 2016

$$C_{01}=C_{02}=\frac{(I_{out}*D*(1-D)*1000)}{f_{SW}*V_{pmax}}=\frac{(2.5*0.38*(1-0.38)*1000)}{(40*1000*75)}\approx 220\mu F$$

$$C_3\geq\frac{(V_0*DT_s)}{R*\Delta V_{C3}}\approx\frac{(200*0.382*25*10^{-6})}{80*0.05}\approx 470\mu F$$

$$C_r\geq\frac{(T_sV_0)}{R*\Delta V_{Cr}}\approx\frac{(200*25*10^{-6})}{80*0.05}\approx 47\mu F$$

## VI. RESULT AND DISCUSSION

Simulation of the modified circuit is shown in Fig. 8. Experimental verification of the modified circuit has also been done. In all the results it is evident that the output voltage obtained is much higher than obtained by conventional boost converter i.e., for an input voltage of 24 V, an output voltage of 400 V is obtained which agrees with the practical results obtained. Output voltage from converter is 400 V and for inverter output voltage is 330 V, for modified circuit simulation. Experimental results produce an output voltage of 300 V for an input voltage of 24 V which is in agreement with simulation result.

## VII. CONCLUSION

Conventional boost converters cannot be used to obtain high voltage gain due to presence of parasitic elements along with voltage stress on the power switches and diode reverse recovery problem. Modified interleaved boost converter with dual coupled inductor can be used for low input-voltage and step up power conversion but the output voltage is insufficient for running household appliances and there is an initial shoot in voltage. But the proposed system of input-parallel output-series interleaved boost converter for home appliances with increased turns ratio, the output voltage is sufficient to run home appliances and shoot of output voltage is reduced.

Some important characteristics of the proposed converter are that: 1) it can achieve a much higher voltage gain and avoid operating at extreme duty cycle and numerous turn ratios; 2) the voltage stresses of the main switches are very low; 3) low ripple currents are obtained at input; 4) the main switches can be turned ON at ZCS so that the main switching losses are reduced and 5) the current falling rates of the diodes are controlled by the leakage inductance so that the diode reverse-recovery problem is alleviated.

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