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A High Step-Up DC/DC Converter Based on Integrating Coupled Inductor Technique

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ABSTRACT: This paper proposes a high step-up dc-dc converter based on integrating coupled inductor. The converter consists of a coupled inductor and two voltage multiplier cells, in order to obtain a high voltage gain**.** The converter achieves large voltage conversion ratio with appropriate duty cycle and also reduces voltage stress on power devices**.** The capacitors are charged using energy stored in coupled inductor and increases the voltage transfer gain. . This paper investigates a coupled inductor integrated high step-up dc-dc converter. The proposed converter can step up low dc voltage into a high dc voltage. The topology of proposed converter can achieve large conversion ratio and high efficiency.

KEYWORDS: DC/DC Converter, high step-up, coupled inductor.

I.INTRODUCTION

Renewable energy sources have experienced a fast development in recent years. Distributed generation systems based on renewable energy systems include photovoltaic cells, fuel cells ,wind power etc. In order to overcome such adverse effects, this distributed energy systems can be utilized by the high step up converter to produce high voltage and satisfy the demands. Conventional boost converters can't provide such a high DC voltage gain for extreme duty cycle. Thus high step up dc-dc converters are used as front end converters to step from low voltage to high voltage which are required to have a large conversion ratio, high efficiency and small volume .In some converters active clamp circuit is used to overcome voltage spikes caused by the leakage inductance of the coupled inductor. Low level voltage from battery is connected to Kilo watt level using step up dc/dc converter and inverter circuits. Voltage spikes and switching losses are eliminated by active clamping. In dc-ac, inverter always tends to draw ac ripple current at twice the output frequency. In some converters high voltage conversion is obtained by changing transformer turns ratio which will increase the overall efficiency but still the operation of main switch involves hard switching, reverse recovery problem and also EMI noise gets raised. Here, the voltage boost is done without a transformer and a high voltage gain is achieved without an extremely high duty ratio. The energy stored in leakage inductance is recycled with the use of passive clamp circuit. The voltage stress of main power switch is also reduced in this topology.

II.SYSTEM MODEL AND WORKING

The proposed high step-up dc/dc converter based on integrating coupled inductor technique is shown in figure1. Here the converter operates using a single switch without zero switching network and complex control. The proposed converter comprises a dc input voltage (V_I), active power switch (S), coupled inductor, four diodes, and four capacitors. The clamp circuit is constituted by capacitor C_1 and diode D_1 . The capacitor C_3 is employed as the capacitor of the extended voltage multiplier cell. The capacitor C_2 and diode D_2 are employed to increase the voltage of clamping capacitor C_1 .

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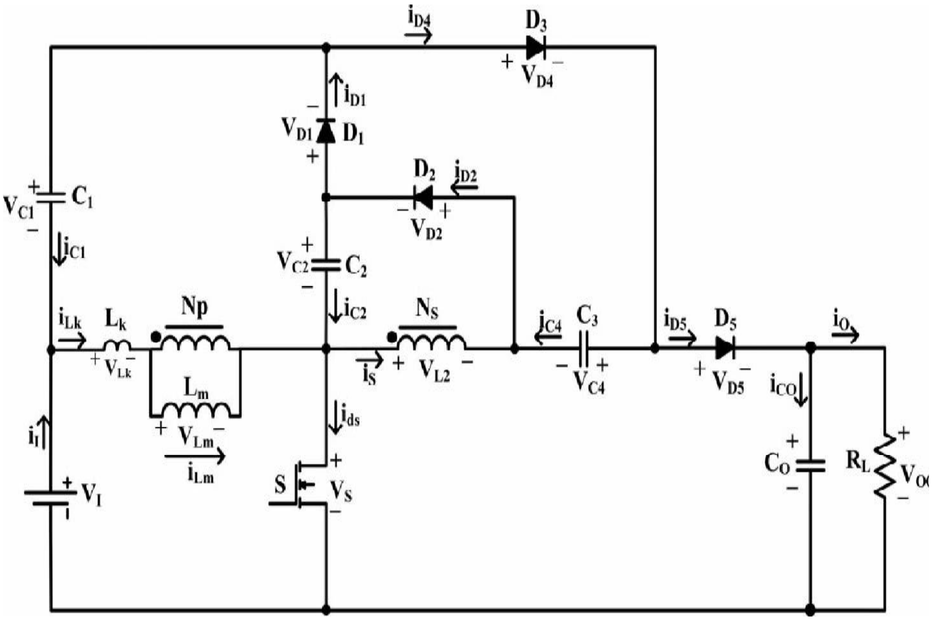

Fig. 1 High step-up converter based on integrating coupled inductor

The high step-up dc/dc converter based on integrating coupled inductor has five modes of operation.
MODE 1

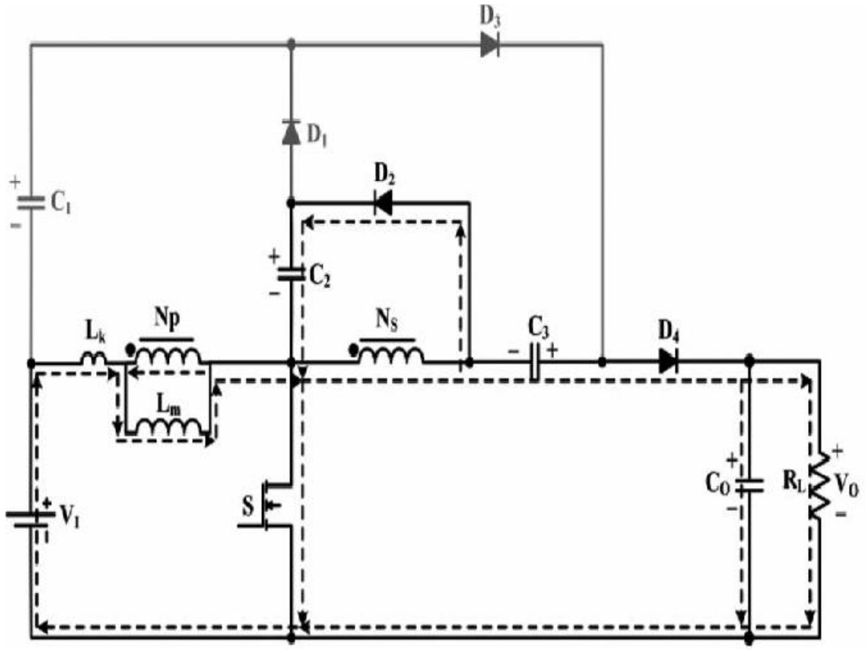

Fig. 2.Mode 1 operation of high step-up converter based on integrating coupled inductor

In this mode, Switch S ,diodes D_2 and D_4 are turned on. The leakage inductor current increases linearly and secondary side current of coupled inductor decreases linearly. The output capacitor C_o supplies required energy of the load. The dc source magnetises L_m through main switch S.

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MODE 2

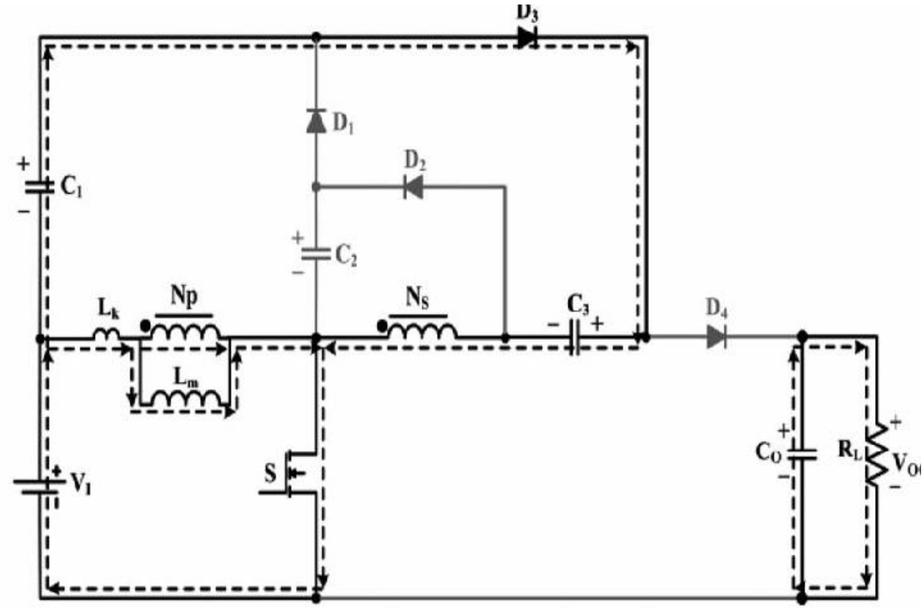

Fig. 3.Mode 2 operation of high step-up converter based on integrating coupled inductor

In this mode, switch S and diode D_3 are turned ON and diodes D_1 ,D_2 ,and D_4 are turned OFF. The current of the magnetizing inductor L_M and leakage inductor L_K increase linearly. The capacitor C_3 is charged by dc source , clamp capacitor and the secondary-side of the coupled inductor. Output capacitor supplies the demanded energy of the load .

MODE 3

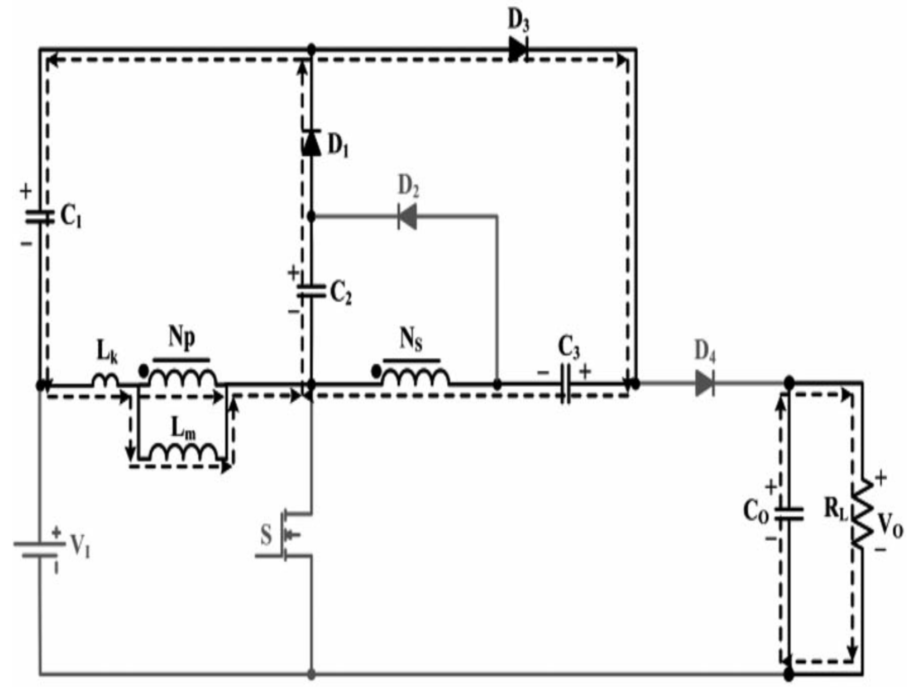

Fig. 4.Mode 3 operation of high step-up converter based on integrating coupled inductor

In this mode, Diodes D_1 and D_3 are turned ON and diodes D_2 and D_4 are turned OFF. The stored energy in capacitor C_2 and the energies of leakage inductor and magnetizing inductor charges clamp capacitor C_1 .

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MODE 4

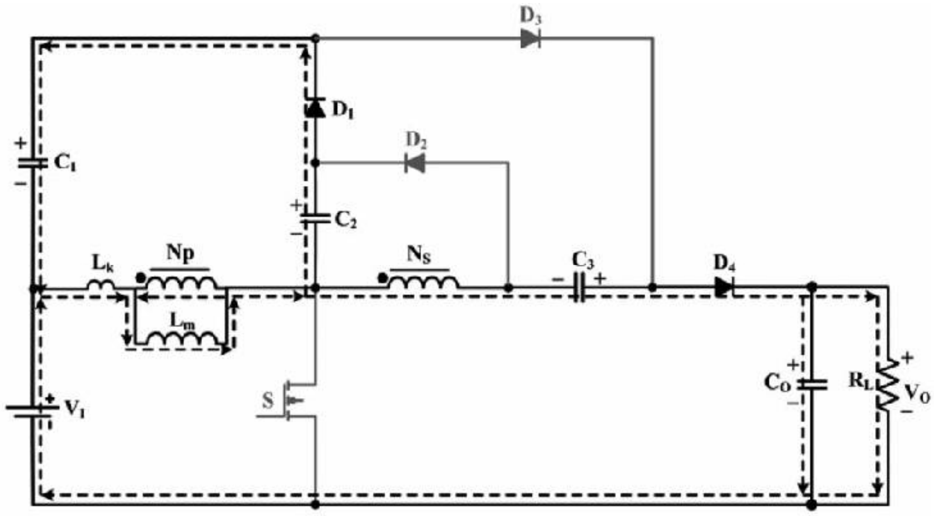

Fig. 5.Mode 4 operation of high step-up converter based on integrating coupled inductor

In this mode, the leakage inductor and magnetising inductor current decreases linearly. The dc source V_I , capacitor C_3 and either sides of the coupled inductor charge output capacitor C_o and provide energy to the load .

MODE 5

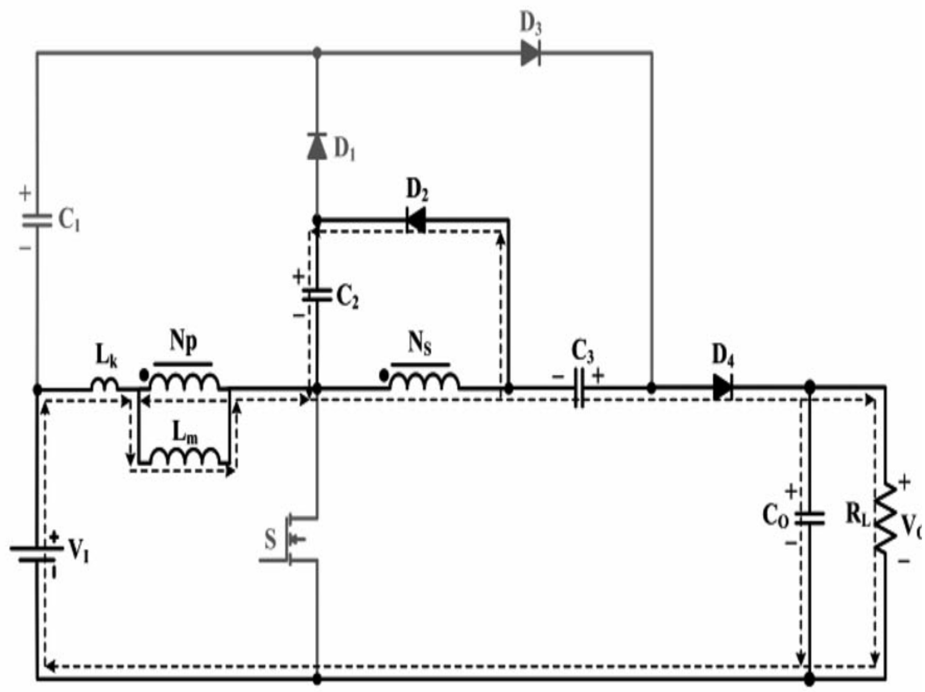

Fig. 6. Mode 5 Operation of high step-up converter based on integrating coupled inductor

In this mode, Diodes D_2 and D_4 are turned ON and diodes D_1 and D_3 are turned OFF. The energy stored in L_m is transferred to secondary side of coupled inductor to charge C_2. The dc input voltage and stored energy in the capacitor C_3 and inductances of both sides of the coupled inductor charge the output capacitor and provide the demand energy to the load .

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III.SIMULATION

The simulation result was done in MATLAB/Simulink. The Simulink model of the high step-up dc/dc converter based on integrating coupled inductor technique is shown in the Fig. 7. The output voltage waveform is obtained. Closed loop control is adopted for the proposed system. Closed loop control schemes are more accurate than open loop system due to their complex construction. They are equally accurate and are not disturbed in the presence of non-linearities. Because of a feedback mechanism, so they clear out the errors between input and output signals, and hence remain unaffected to the external noise sources. The closed loop PI controller is used in the high step-up dc/dc converter based on integrating coupled inductor technique to achieve the desired output voltage.

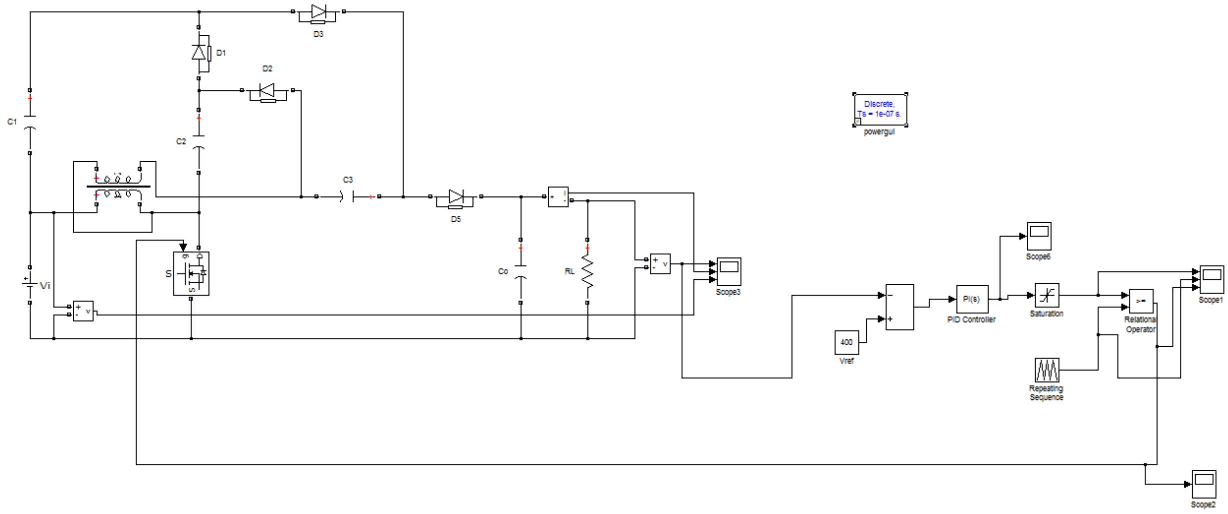

Fig. 7 Simulink model of high step-up dc/dc converter based on integrating coupled inductor

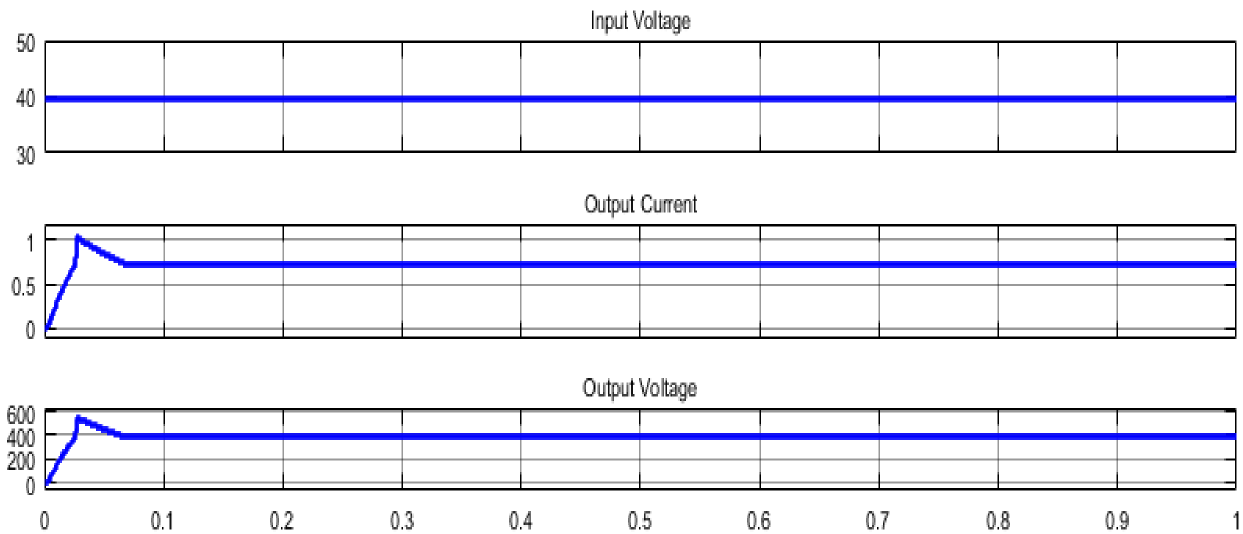

Fig. 9 Simulation results of high step-up dc/dc converter based on integrating coupled inductor

Here the output for proposed converter is designed for 400V. The input DC voltage is taken as 40 V. The voltage across switch are shown in figure 10 .

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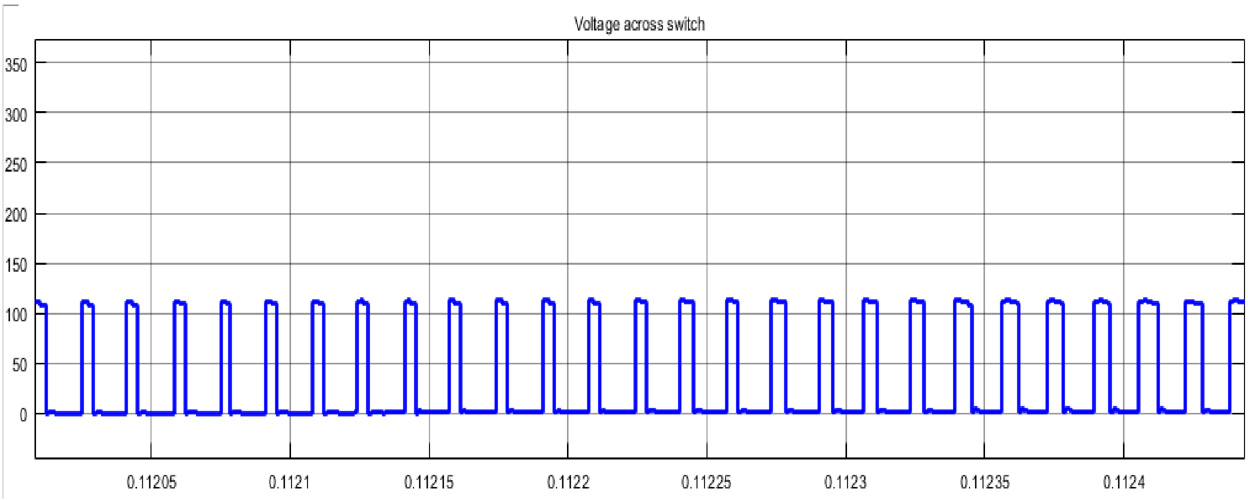

Fig. 10 Voltage across main switch S

IV.HARDWARE IMPLEMENTATION

Hardware implementation of the High step-up dc/dc converter based on integrating coupled inductor is given in the figure 12.

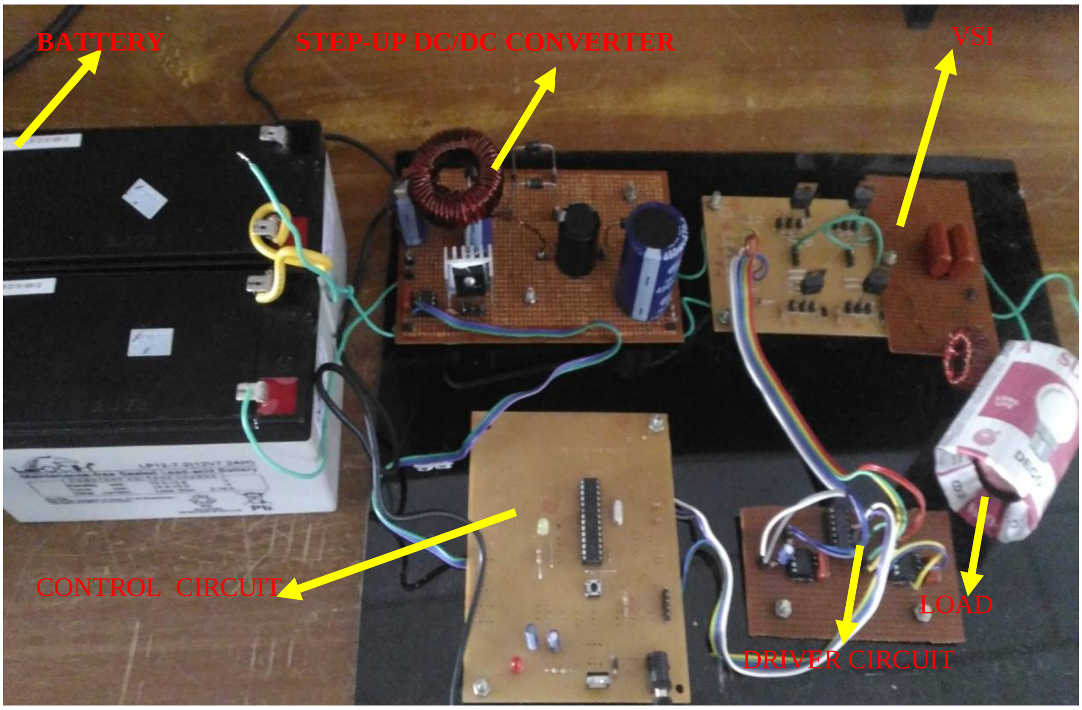

Fig. 11 Hardware implementation of the high step-up dc/dc converter based on integrating coupled inductor

The hardware setup consists of high step-up dc/dc converter, driver circuit, and control circuit. To perform the various operations and conversions required to switch, control and monitor the devices a processor is needed. The processor chosen is ATmega16. The gate pulses to the main switch S and to the inverter switches are given below.

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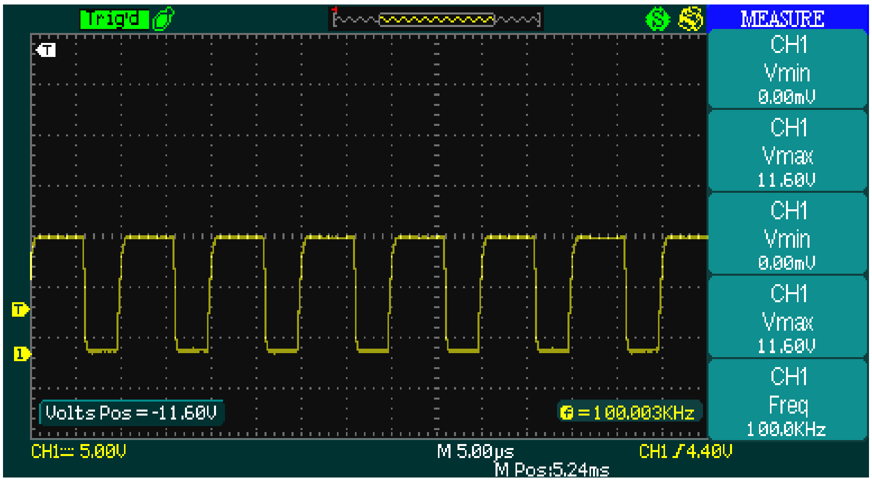

Fig. 12 Gate pulse for main switch S

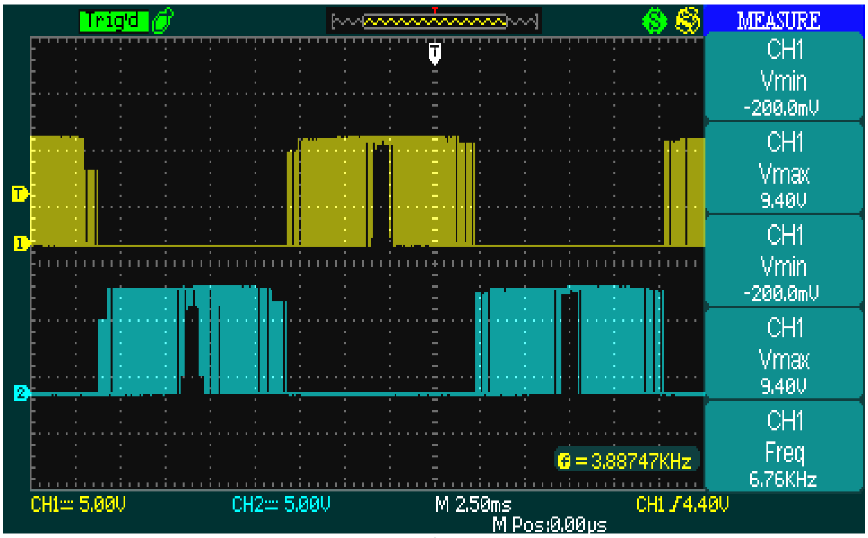

Fig. 13 Gate pulses for inverter switches

V. RESULT AND DISCUSSION

The proposed step down converter is shown in the figure 1 and its simulink model and hardware setup are given in figure 7 and 1l respectively. The converter is simulated for closed loop control strategy in MATLAB and their corresponding output voltages can be analysed. The high step-up dc/dc converter is simulated for input voltage of 40V to obtain a higher constant dc voltage of 400V .We get the simulation results which are given in the figures 9 and 10.Then we implement the hardware. The inverter SPWM frequency is at 7.8kHz and microcontroller works at 16MHz. Employing a higher frequency PWM input makes the response smoother by virtue of the fact that there is less time in the ON and OFF states for the circuit output to decay and rise, respectively .The gate pulses of converter and inverter for hardware setup of high step-up dc/dc converter based on integrating coupled inductor are given in figures 12 and 13.

VI.CONCLUSION

A high step-up dc/dc converter based on integrating coupled inductor technique is proposed in this paper. The coupled inductor integrated high step-up dc-dc converter proposed is suitable for distributed generation systems based on renewable energy sources which require high voltage transfer gain. The voltage stress on the main power switch is reduced . The energy stored in the leakage inductance is recycled to improve the performance of the converter.

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