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Control of an High Step -Up Interleaved Converter Integrating Built- In Transformer Voltage Multiplier Cell With Fuzzy Logic Controller

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ABSTRACT: In this paper,the closed loop control of an high step up interleaved converter with a multiplier cell is done.The closed loop control of the converter is done by a fuzzy logic controller.A fuzzy logic controller analyzes analog input values in terms of logical variables that take continuous values between 0 and 1.The converter is derived from an interleaved boost converter and an multiplier cell is inserted to each phase of the converter.The multiplier cell consist of transformer windings,diodes, capacitors.This provide high voltage gain for the converter.Moreover switch voltage stress and diode peak current are minimized .From this converter for an input voltage of 40 an output voltage of 380 is obtained.

KEYWORDS*:* fuzzy logic controller, multiplier cell,diode peak current.

I.INTRODUCTION

With the decline in production of fossil fuels, the sustainable energy sources such as the photovoltaic(PV),fuel cells and wind energy has been taken as the promising candidates for future energy supply. This energy sources has random energy fluctuations[1][2]. To absorb the random energy fluctuation the sustainable energy sources require backup storage elements. The PV panel and back up battery cell has low output voltage, high step up boost converters are required to lift the low voltage to a high one.

In industrial applications we require high voltage gain ,so we depend on step –up converters .The conventional converters has many problems such switch voltage stress, diode reverse recovery problem etc.The converter proposed in this paper can alleviate this problems, The converter is having a built-in multiplier cell which consists of transformer windings, regenerative capacitors, regenerative diodes, clamp capacitors, clamp diodes etc.The desired voltage gain achieved and also switch voltage stress, diode reverse recovery problems are alleviated. The output voltage trace the input by fuzzy logic closed loop control of the converter.

II. LITERATURE SURVEY

Many non-isolated step –up ratio converters are aimed to be used as an inter face between these low voltage renewable energy sources, one among is the conventional interleaved boost converter[1].When these converter is employed it can provide high voltage gain,but the converter is having high switch duty cycle and its turn off period is very narrow.The peak current on the power devices and diode reverse recovery problem exist in the converter.

The switched capacitor based converter can provide high voltage gain. The converter is also having the advantage of small size,light weight and high power density so it can be used in small portable electronics[3]. In these converter due to swiched capacitor technique ,large transient current it shortens the usage life of the switched capacitors.
The coupled inductor can achieve high voltage gain and the voltage stress on the switch is reduced.In coupled inductor, it has only one magnetic component,which reduces the volume and the complexity of the converter[4].The problem with coupled inductors is that the leakage inductance of the coupled inductor cause high voltage spikes on the switch when it turns off and also induce large energy losses.

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When compared with non-isolated converters for isolated converters it is easy to achieve high voltage gain. It is done by selecting the transformer turns ratio properly, high voltage conversion ratio can be obtained by optimal duty cycle.The switch duty cycle and the transformer turns ratio are controlled to lift the voltage ratio. In this paper an built-in transformer multiplier cell is inco-operated in an interleaved boost converter to obtain high voltage gain.The main advantage of this converter switch voltage stress reduction,switch turn-off voltage spikes suppression and diode reverse recovery problem alleviation.

This paper shows the operational analysis and simulation results of the proposed converter.In section II structure and operational principle of the converter is explained.In section III fuzzy logic control of the converter is explained.In section IV simulation results obtained by doing fuzzy controller is presented and the conclusion is presented in sectionV.

III.STRUCTURE AND OPERATIONAL PRINCIPLE

The proposed high step-up converter with built-in transformer voltage multiplier cell ,consists of two power MOSFETs,S_1 and S_2,input filter inductors L_1 and L_2 .The output diode D_{o1} and D_{o2},C_o the output capacitor.The converter consists of an built –in transformer with three windings,n1 turns is the primary winding,n2 turns is the secondary winding and tertiary winding.The converter consisting of a multiplier cell is made of transformer winding with n2 turns,clamp diodes D_{c1},regenerative diodes D_{r2},clamp capacitor C_{c1},multiplier capacitor C_{m1}.L_{Lk} the leakage inductance on the primary winding of the built in transformer.V_{in} is the input voltage and V_{out} is the output voltage

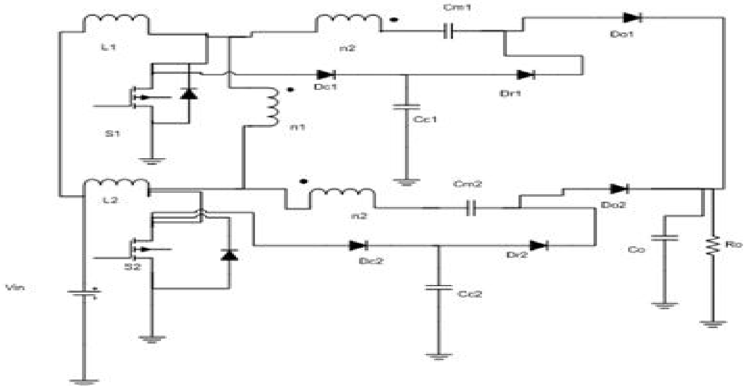

Fig. 1 Proposed converter

Mode 1

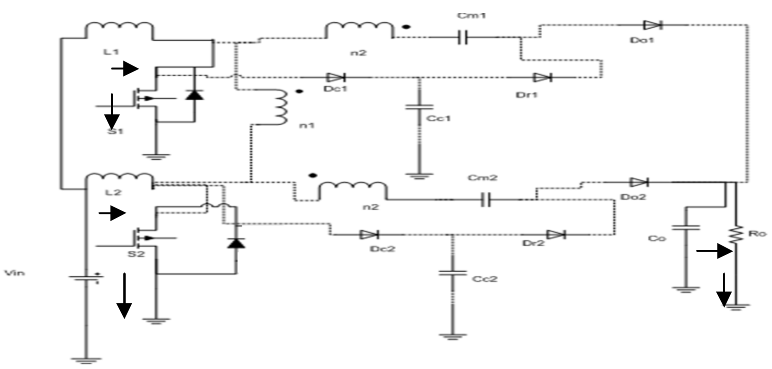

Fig. 2 Mode 1 operation of proposed converter

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In this mode switches S_1 and S_2 are conducting. The clamp diodes D_{c1},D_{c2},regenerative diodes D_{r1},D_{r2},the output diodes D_{o1},D_{o2} are reverse biased. The input inductors L_1 and L_2 are charged to input voltage ,V_{in}.

Mode 2

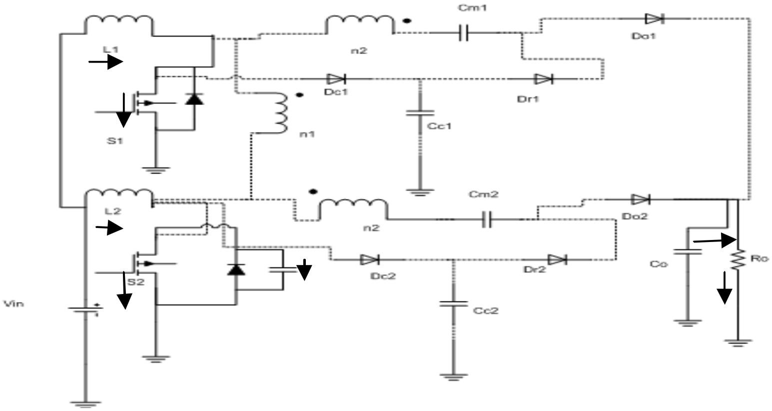

Fig. 3 Mode 2 operation of proposed converter

In mode two, switch S_2 is turned off, parasitic capacitor of switch S_2 is charged.

Mode 3

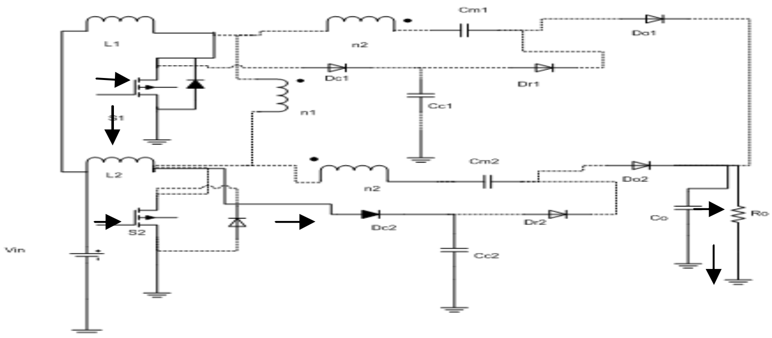

Fig. 4 Mode 3 operation of proposed converter

In this mode drain source voltage across the switch V_{ds} is increased to voltage value that make the clamp diode D_{c2} to be forward biased.The clamp diode D_{c2} conducts and the clamp capacitor C_{c2} is charged by the input inductor L_2 .In this mode the switch S_2 is turned off and the drain source voltage of the switch charges the clamp capacitor C_{c2}.

Mode 4

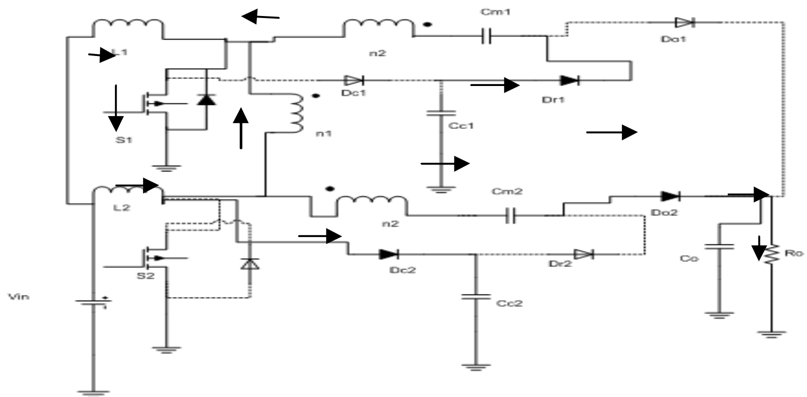

Fig. 5 Mode 4 operation of proposed converter

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In this mode of operation the voltage of the output diodes Do2 falls to zero and it starts conducting. The current through output diode Do2 increases ,thus the current through clamp capacitor Cc2 decreases.In this mode the muyltiplier capacitors Cm1,Cm2 and the second,third windings of the built in transformer act as voltage sources.The regenerative diode Dr1 strats conducting.The stored energy in in clamp capacitor Cc1is made to charge the multiplier capacitor Cm1 through regenerative diode,switch S1 and second winding of built in transformer.The current flowing through clamp capacitor and multiplier capacitor C_{c1} and C_{m1} is controlled by the leakage inductance L_{Lk}.

Mode 5

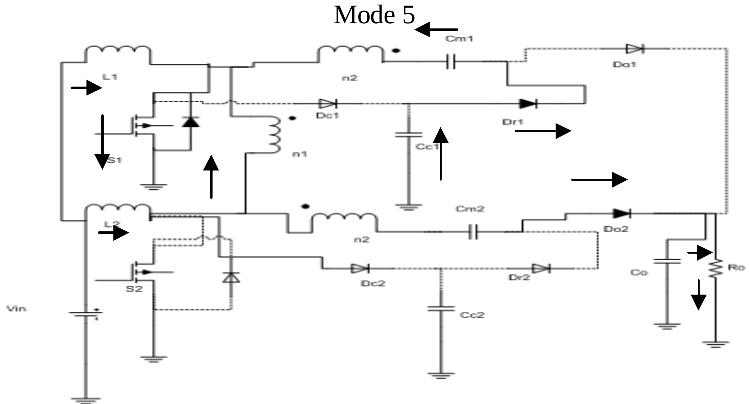

Fig. 6 Mode 5 operation of proposed converter

In this mode the current through clamp capacitor C_{c2} decreases to zero.The clamp diode D_{c2} is turned off naturally in this mode.There is no reverse recovery problem for the clamp diode.The stored energy in multipler capacitor C_{m2} is transfered to the load.

Mode 6

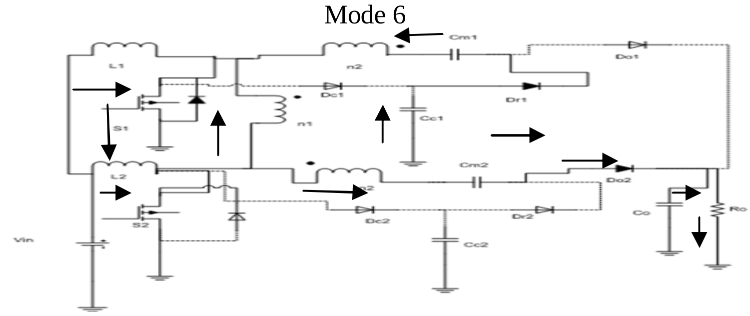

Fig. 7 Mode 6 operation of proposed converter

In this mode, switch S_2 is turned on, because of the effect of leakage inductance L_{Lk},S_2 is turned on.The current falling of the output diode D_{o2} is controlled by leakage inductance L_{Lk},which removes the problem of diode reverse recovery problem of output diode.This mode ends when the output diode D_{o2} is turned off.

IV. FUZZY LOGIC CONTROL OF THE CONVERTER

The input stage of the fuzzy logic controller senses the input and select the membership functions and truth values. In the processing stage the rules are evaluated and results are generated. The output stage converts the fuzzy value to the crisp value and the output is given.In this converter Mamdani fuzzy logic controller is used.The input to a fuzzy logic controller should be a fuzzy value ,so the crisp value at input is converted to fuzzy value.Then after completing process,the fuzzy value is to be converted to crisp value by defuzzification techniques. Here we are using centroid method as the defuzzification technique.

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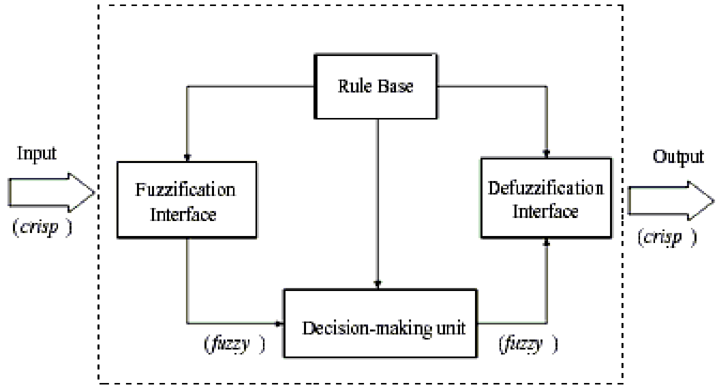

Fig . 8 Block diagram of a Fuzzy Logic Controller

The error between input and output is reduced by the closed loop control .Here the fuzzy logic controller employ five rules.If error is negative output decreases.If error is zero and error change negative output decreases.If error is zero and error change is zero output ,no change.If error is zero and error change is positive output increases.If error is positive ,output increases.So the output follows the input and it changes only when input or load is been changed

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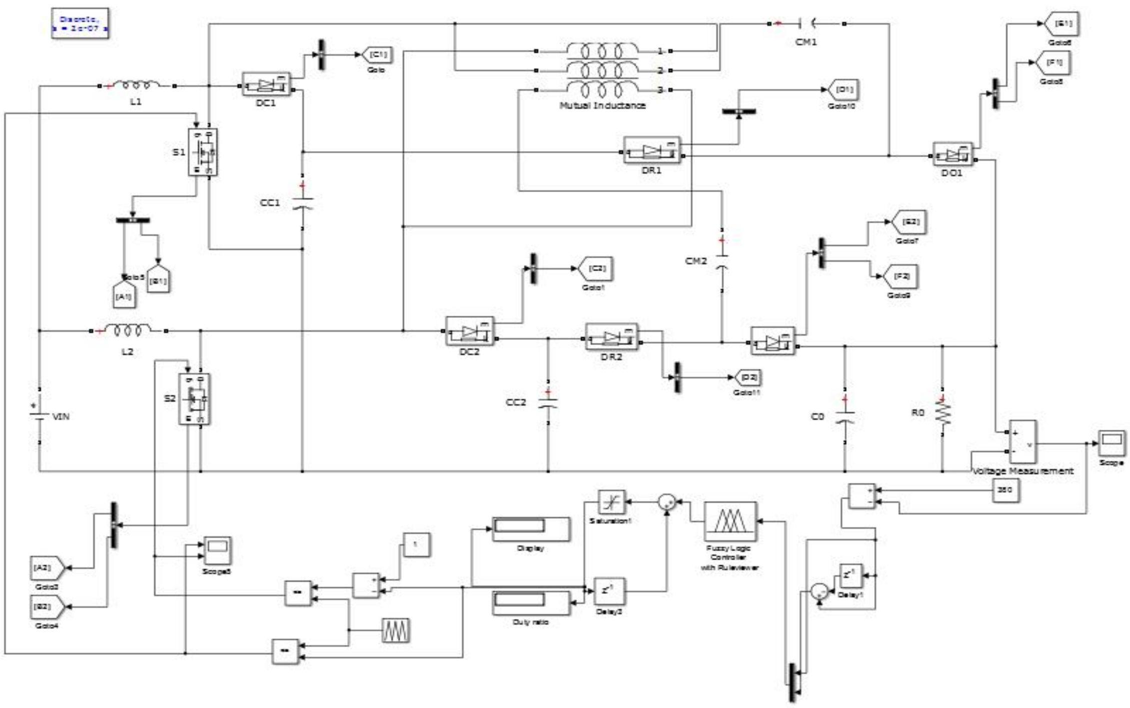

Fig. 9 Simulation diagram of the modified converter

V SIMULATION RESULT

The simulation result with the fuzzy logic controller is shown .For an input of 40V an output of 380V is obtained. For a switching frequency 100kHz,clamp capacitors of 4.7µF,multiplier capacitors 4.7µF,output capacitors 470µF,input inductors of 50µF,turns ratio of 14:14.

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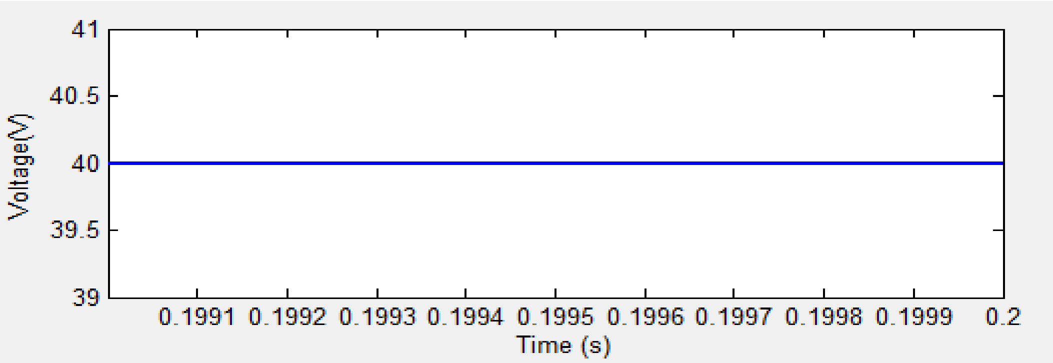

Fig.10 Input Voltage Waveform of the converter

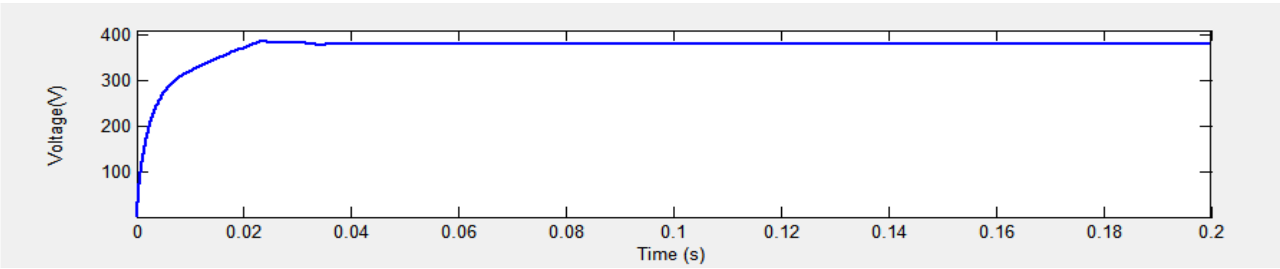

Fig .11 Output waveform of the converter

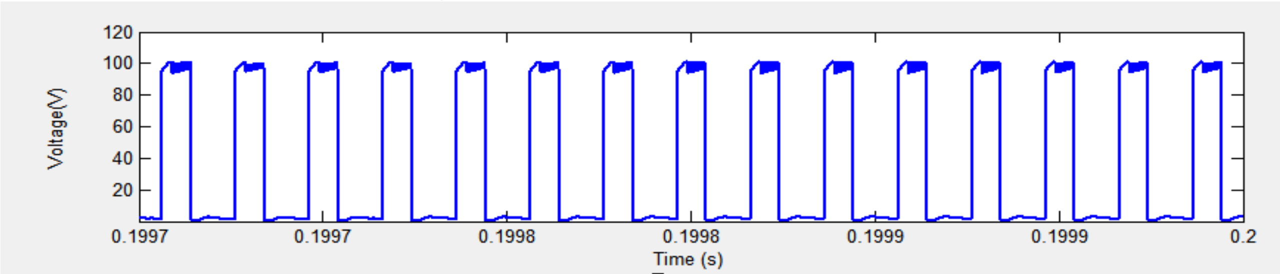

Fig.12 Voltage stress waveform across the switches

VI.CONCLUSION

In this paper an high step-up interleaved converter with an Built-in transformer integrating an multiplier cell is been explained. The simulation of the converter with a fuzzy logic controller is done. The control of converter is modified with a fuzzy logic controller. Here for an input of 40V an output of 380V is obtained. The reverse recovery problem of the diodes are alleviated ,switch stress is also reduced since for an output voltage of 380The reverse recovery problem of the diodes are alleviated ,switch stress is also reduced since for an output voltage of 380 V ,voltage drop reduced to 100 V across the switches.

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