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IMPROVED INTERLEAVED HIGH STEP-UP CONVERTER WITH HIGH EFFICIENCY FOR RENEWABLE ENERGY APPLICATIONS

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ABSTRACT

The proposed converter consists of switched capacitors and two active coupled inductors. This combination can provide a relatively high voltage boost gain while operating with small duty cycle. The converter can be powered either by one individual DC voltage source in an interleaved manner of two independent DC voltage sources as a multiport converter. The configuration of the proposed converter has advantages such as low power losses, longer lifetime of input sources due to non-pulsating input current, and low voltage stress across the main switches and slight output voltage fluctuation.Generally, high voltage boost gain cannot be achieved using conventional step-up converters since the parasitic parameters will set an upper limit on the duty ratio at which the converter can efficiently operate. In recent years many high step-up DC-DC converters have been proposed. Among the developed converters, the high step-up single switch converters exhibit small input current ripple which make them suitable to operate at heavy load due to low conduction losses.

INTRODUCTION

Today due to the limited resources of fossil fuels and also their serious environmental impacts including greenhouse gas emissions, global warming and environmental pollution, the renewable technologies such as photovoltaic CPY) systems, fuel cells and wind energy systems have received extensive attention as sustainable and clean sources of energy Among renewable energy sources, PY systems are predictedto become the largest target for energy investment by year2040 owing to the clean, efficient, and environmentally friendly performance . Since PY cells generate low outputvoltage, a high step-up DC/DC converter is necessary to boostthe PV voltage to a level of DC load/micro-grid voltage orrequired level of inverter DC-link voltage supplying an AC load/utility shows a typical photovoltaic systemsincluding PV array, a step-up converter and an inverter forconverting the DC voltage for AC applications.Generally, high voltage boost gain cannot be achieved usingconventional step-up converters since the parasitic parameterswill set an upper limit on the duty ratio at which the convertercan efficiently operate. In recent years many high step-upDC-DC converters have been proposed. Among the developedconverters, the high step-up single switch converters exhibitlarge input current ripple which make them unsuitable tooperate at heavy load due to high conduction losses.

Analternative solution for high power applications conventional two-switch interleaved step-up converter.Although the conventional interleaved converter alleviates theinput current ripple, similar to the conventional boostconverter it has not been developed for handling high voltageboost gain. The limited step-up gain could be overcome byintegrating the active coupled-inductor into the interleaved converter. The switch voltage stress is also reduced by thetransformer function of the coupled-inductor. However, inorder to achieve an extreme voltage gain, it is required toincrease the turn's ratio of the active coupled inductor which affectsthe transformer linearity and increase the leakage inductancecausing the voltage spike across the switches during the offstate]. Extreme voltage gain can also be realized throughdiode-capacitor voltage multiplier.

This solution hasallowed the DC-DC converter to operate with low inputcurrent ripple which is suitable for high power application.Nevertheless, many cascaded diode-capacitor voltagemultipliers is needed to increase the voltage gain, thus, theconverter efficiency would be affected for high voltage gain. anew high step-up DC-DC converter isproposed. The proposed converter can be powered either byone

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individual DC voltage source in an interleaved manner ortwo independent DC voltage sources as a multiport converter.

This converter combines the advantages of the active coupledinductors with the diode-capacitor multipliers and hence asuper step-up gain can be easily achieved with minimumnumber of multipliers and low turns ratio of the active coupledinductors while the converter operates at low duty ratio. Theproposed converter exhibits high efficiency in a wide range ofoperation. It also presents low current ripples and lowconduction losses which make it suitable for high powerapplications. In addition, the voltage stress across the switchesand diodes is much lower than the output voltage.

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EXISTING SYSTEM

The existing interleaved high step-up converter is shown. The converter is composed of two coupled-inductors and four diode-capacitor voltage multiplier (DCVM) stages. Each DCVM stage consists of one diode and one capacitor. The DVCM stages are inserted between the input and output stages of the converter to enhance the voltage conversion ratio. By increasing the number of DCVM stages, it is possible to reach a higher voltage gain at constant duty ratio. however, for simplicity and better understanding, four DCVM stages are used. The active coupled inductors are resided in the converter so that a modified fly back-forward interleaved structure is formed.

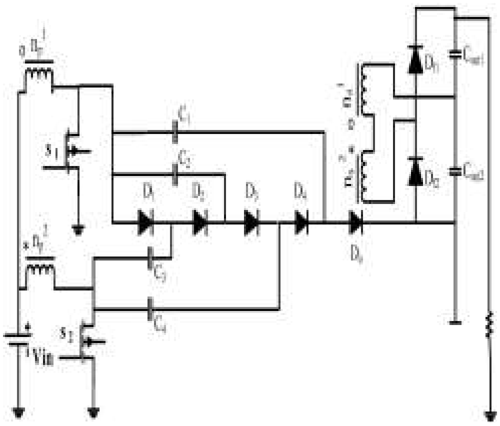

Fig1 Existingconverter circuit

OPERATING PRINCIPLE OF EXSISTING SYSTEM

The converter is composed oftwocoupled inductorsand four diode-capacitor voltage multiplier (DCVM) stages Each DCVM stage consists of one diode and one capacitor. The DVCM stages are inserted between the input and outputstages of the converter to enhance the voltage conversion ratio. By each increasing the number of DCVM stages, it is possibleto reach a higher voltage gain at constant duty ratio. However, forsimplicity and better understanding, four DCVMstages are used. Thecoupled inductorsare resided in theexisting converter so thata modifiedfly back-forward interleaved structure is formed. The primary windingsof the activecoupled inductors with np_1 and np_2 turnsare employed in theinputstage to decrease the input current ripple, whereas thesecondary windings with ns and n turns are connectedinseries with the output stage to enlarge the voltage gain. The coupled inductorshave the same turn's ratio.The coupled inductor can be modeledas the combination ofa magnetizing inductor, an ideal transformer and seriesleakage inductors ineach winding. The equivalent circuit ofthe existingconverter where Lm_i andL,n_2 are the inductances,$Lip_i$and$Llp_2$are the primarywindingsof leakage inductances, Lis is the summation ofsecondary windings of the leakage inductances, S_1 and $S_2$are powerswitches, $Cout_1$, $Cout_2$and $Cout_3$are the output capacitors, C_1 to$C_4$and D_1 to D_4, respectively, indicate the capacitors and thediodes of DCVM stages, Df_1 and Df_2 are the output diodes ofthe fly back-forward structure and ndenotes turns rationp/ns.In the circuit analysis, it is assumed that the converter operates in continuous conduction mode (CCM) and the dutyratio of the switches are greater than 0.5. The operational waveforms of theexisting converterin CCMduring one switching cycle. There are some over lappingtime whentwo switches are ONan alsosome timeintervals when only one of the switches is ON. six operation modes exist in eachswitching cycle for the existing converter.

OPERATING MODES OF EXISTING SYSTEM

Mode 1 Operation

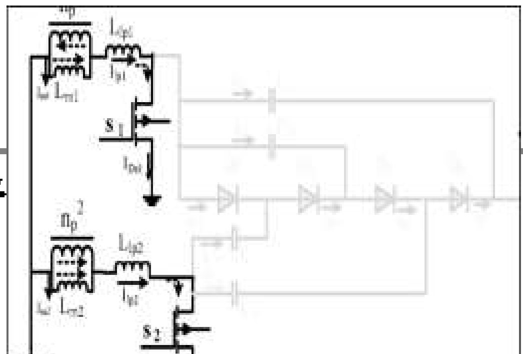

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Fig 3.6 Mode 1 operation

Fig 2 Mode 1 operation circuit

Mode 1 [t_o, t_1]:

At t = t_o, while the power switch S_2 remains ON, the power switch S_1 is switched ON. The diodes DrD_4, D_o and $Dj_J$are reverse biased as. During this mode the energy stored in the series leakage inductance LIs is completely discharged into the output terminal through fly back-forward diode Dj_2 and decreases to zero; hence, the leakage inductor current linearly increases and the leakage inductor current ilp_2 inversely decreases.

3.3.3.2Mode 2 Operation

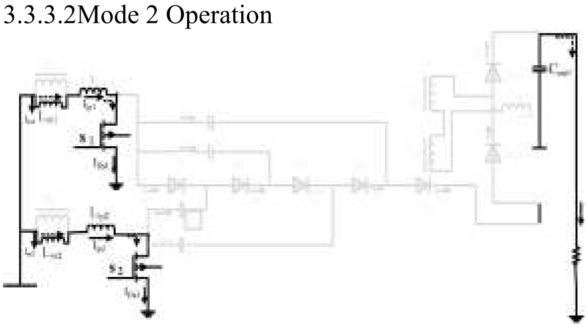

Fig 3Mode 2 operation circuit

Mode 2 [t_1, t_2]:

At t = t_1,the powerswitches Sand ,£ are still ON and all of the diodes are reversebiased . Therefore, both the primary leakageinductances and the magnetizing inductances are charged by the input source and the currents hp_J, Ilp_2, Img_1 and Img_2 linearly increase.

Mode 3 Operation

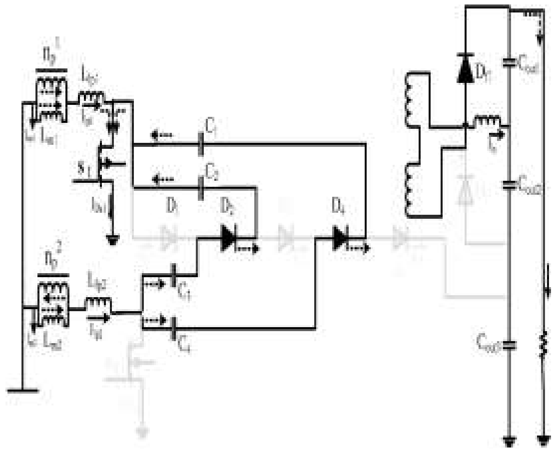

Fig4 Mode 3 operation circuit

Mode3 [t_2' t_3]:

At t= t_2, the powerswitch S_2 is turned OFF while theswitch S_1 remains ON. The diodes D_1, D_3, D_o and Dj_2 are reverse biased in this mode and Lm_l and $Llp_l$are still charged through the input source. Incontrast, the energy stored in the Llp_2 releases into the capacitors C_1 to C_4 and the energy stored in $L,n_2$is transferred to the secondary side of the coupled inductor and charges the output capacitor through the diode Dj_l.

Mode 4 Operation

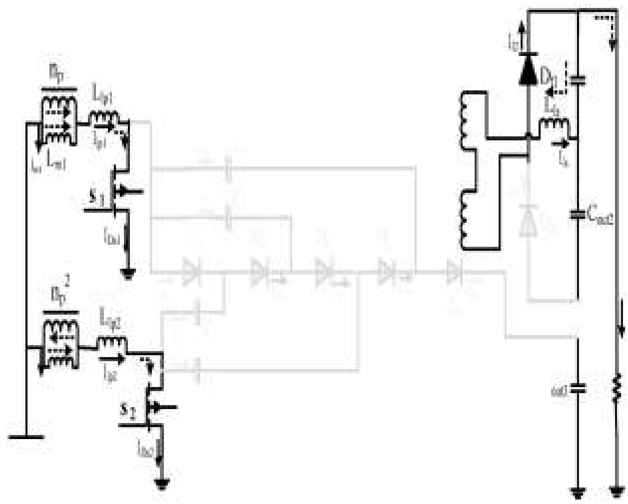

Fig5Mode 4 operation circuit

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Mode 4 [t_3, t_4]:

At t = t_3, the power switch S_1 remains ON where as the power switchS_2 is switched ON. The diodes DrD_4, D_o and Dj_2 arereverse biasedin this mode. The energy stored in Lm $_1$is transferred to the secondary sideof the inductor and the output capacitors are chargedthrough Df_1.

Mode 5 Operation

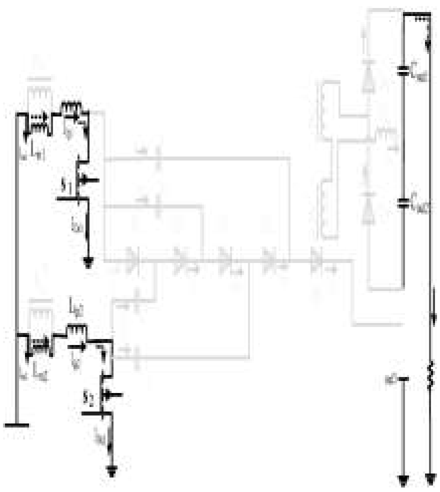

Fig 6Mode 5 operation circuit

Mode 5 [t_4, t_5]:

At t = t_4, both of power switches S_1 and S_2 remain ON. All of diodes are reverse biased in this mode. The current ofthe leakageinductances Lip_1 and Lip_2linearly increases by the input source.

Mode 6 Operation

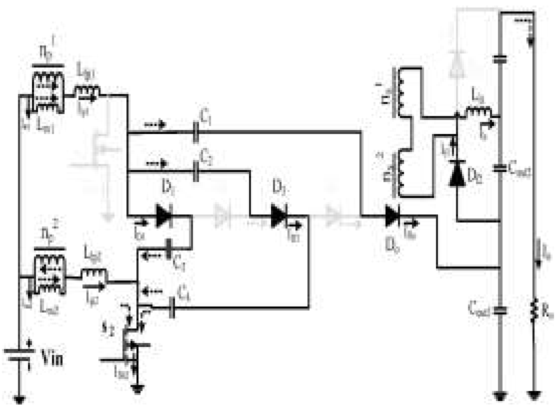

Fig 7 Mode 6 operation circuit

Mode 6 [t_5, t_6]:

At t = t_5, the power switch S_2 remains on-state while the powerswitch $S_1$is turned off. The diodes D_2, D_4 and Df_1 are still reverse biased, whereas the diodes D_1, D_3, $D_o$and $Dj_2$are turned ON. The energy stored inLipi andC_1 is released to the output capacitor $Cout_3$ through Do. Moreover, a part of the energy stored in Lipi charges C_2 and C_3 and the energy stored in Lmiis transferred to the secondary side of thecoupled inductor and charge emf_2.

3.3.4 OPERATIONAL WAVE FORM OF EXISTING CONVERTER

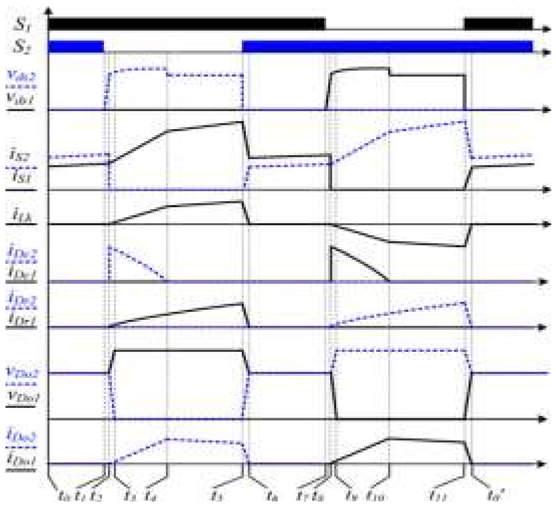

Fig8Wave form of existing converter

The switched capacitor based converters can also achieve the large voltage gain conversion. however, they should suffer large transient current due to the switched capacitor technique, which shortens the usage life ofthe switched capacitors

PROPOSED SYSTEM

The proposes of a high step-up voltage gain converter which combines an active coupled-inductor network (ACLN) and a traditional boost converter with a passive clamping circuit, called the ACLN converter (ACLNC). The proposed converter has the following advantages: high voltage conversion gain, small volume, low voltage stresses on switches, low diodes count, low conduction losses on switches. The basic operating principle is first illustrated in detail, then, the stresses expressions are deduced, and finally, some experimental results are provided to verify

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theeffectiveness of the proposed converter.

3.3.1 PROPOSED SYSTEM CIRUIT DIAGRAM

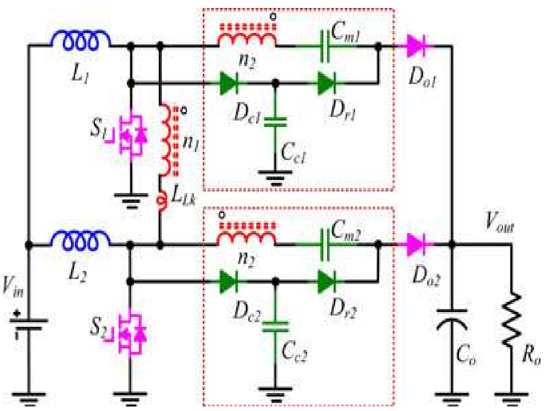

Fig 9 Circuit diagram of proposed system

3.3.1 OPERATION OF PROPOSED CONVERTER

The problems in the conventional boost converter which works under the high step-up condition can be solved by introducing a coupled inductor The voltage gain is extended and the voltage stress on the switch is reduced. Moreover, the cores can be integrated and the volume is reduced.

However, the leakage inductance may cause the same problems as in isolated converters. Compared to the boost converter, an active network converter (ANC) has been proposed in where the voltage stresses and current stresses of the switches are much lower, and the voltage conversion ratio is higher.

The switch voltage resonance due to the switches parameters inconsistency. Switched inductor ANC is proposed to extend the voltage gain, but the voltage conversion gain can only be controlled by duty cycle and the overall system volume is larger. The ANC with the switched-inductor and switched-capacitor is proposed but the system volume is large and part count is increased greatly under the high voltage conversion gain.

The ANC with coupled inductors is further proposed in and the voltage gain is increased by adjusting turns ratio of the coupled inductor and the duty cycle, but the part count is still high.

3.3.3 OPERATING MODES OF PROPOSED SYSTEM

3.3.3.1 Mode 1 operation

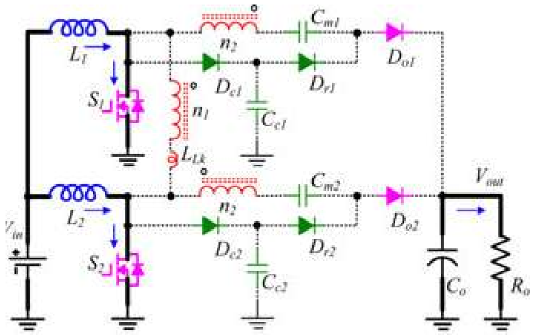

Fig 10 mode 1 operating circuit

Mode1 [t_0, t_1]:

Before t_1 , switches S_1 and S_2 are both in the turn-on state. Clamp diodes Dc_1 and Dc_2 , regenerative diodes Dr_1 and Dr_2 , and output diodes Do_1 and Do_2 are all reverse-biased. Both the two input inductors L_1 and L_2 arecharged by the input voltage V_{in} , respectively

3.3.3.2 Mode 2 operation

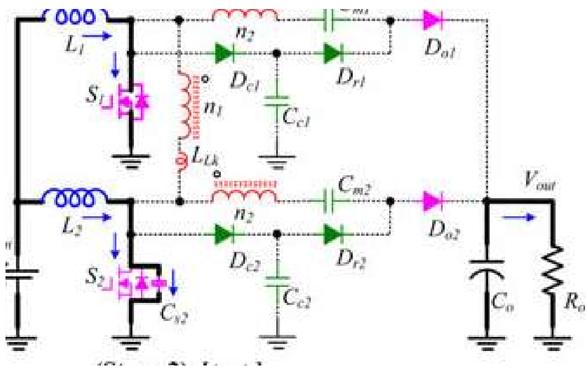

Fig 11 mode 2 operating circuit

Mode 2 [t_1, t_2]:

At t_1 , switch S_2 turns off, its parasitic capacitor Cs_2 is charged by the current of the input inductor L_2 in an approximately linear way

3.3.3.3 Mode 3 operation

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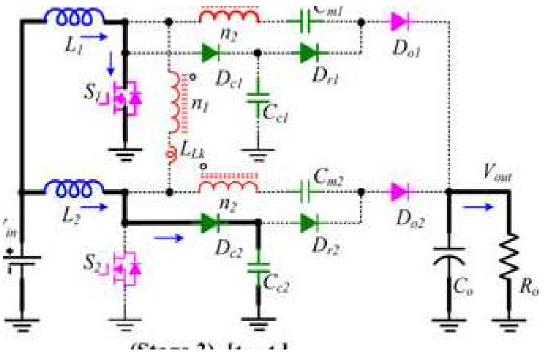

Fig 12 Mode 3 operating circuit

Mode3 [t_2, t_3]:

At t_2 , the drain–source voltage vds_2 is charged and increased to make clamp diode Dc_2 forward-biased. Then, Dc_2 begins to conduct and clamp capacitor Cc_2 is charged by the current of the input inductor L_2 linearly. Switch S_2 turns off and its drain–source voltage vds_2 is clamped by capacitor Cc_2

3.3.3.4 Mode 4 operartion

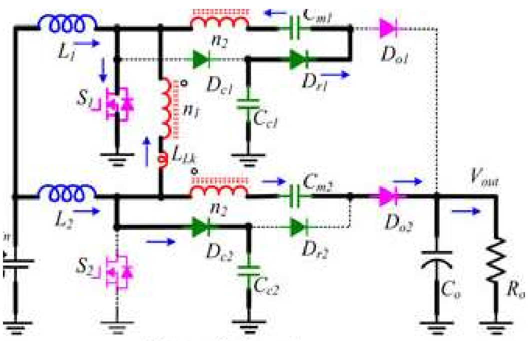

Fig 13 Mode 3 operating circuit

Mode 4 [t_3, t_4]:

At t_3 , the voltage of output diode Do_2 decreases to zero and it begins to turn on. As the current through Do_2 increases, the current through clamp capacitor Cc_2 decreases. The multiplier capacitors Cm_1, Cm_2 , the second and third windings of the built-in transformer operate as voltage sources. This is the inherent reason why the proposed converter can greatly extend the voltage gain. Meanwhile, regenerative diode Dr_1 begins to conduct. The energy stored in clamp capacitor Cc_1 starts to transfer to multiplier capacitor Cm_1 through regenerative diode Dr_1 , second winding of built-in transformer and switch S_1 . The current through Cc_1 and Cm_1 is controlled by the leakage inductance LL_k

3.3.3.5 Mode 5 operation

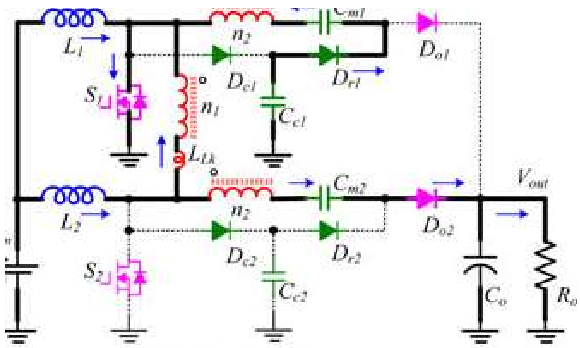

Fig 14 Mode 5 operating circuit

Mode 5 [t_4, t_5]:

At t_4 , the current through clamp capacitor Cc_2 decreases to zero and clamp diode Dc_2 turns off naturally. As a result, there is no reverse-recovery problem for the clamp diodes. The energy stored in the multiplier capacitor Cm_2 continues to transfer to the load

3.3.3.6 Mode 6 operation

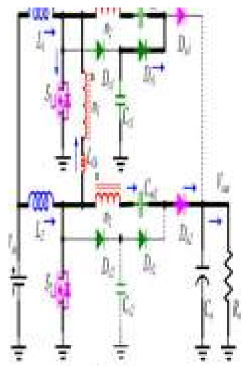

Fig 16 Mode 6 operating circuit

Mode 6 [t_5, t_6]:

At t_5 , switch S_2 turns on. Due to the leakage inductance LLk,S_2 turns on with zero current switch (ZCS) soft switching condition. The current falling rate through output diode Do_2 is controlled by leakage inductance LLk, which alleviates the output diode reverse-recovery

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problem. This stage ends when output diode Do_2 turns off

3.4 OPERATIONAL WAVEFORM OF PROPOSED CONVERTER

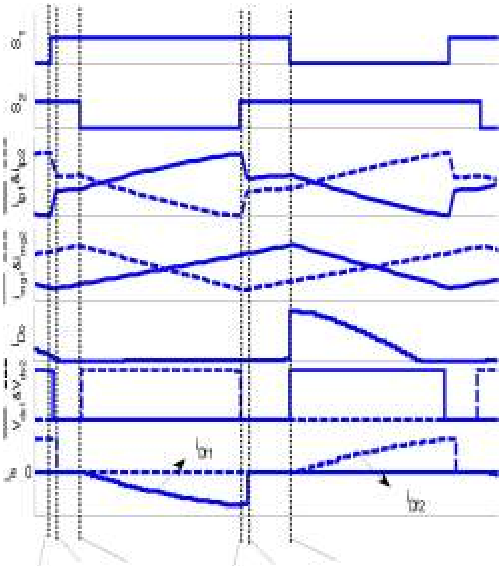

Fig 17 Waveform of proposed converter

The operational waveforms of the existing converter in the CCM during one switching cycle. As it is shown in the figure, there are some overlapping time when two switches are ON and also some time intervals when only one of the switches is ON . Six operation modes exist in each switching cycle for the proposed converter

5.3SIMULATION CIRCUIT FOR EXESTING SYSTEM

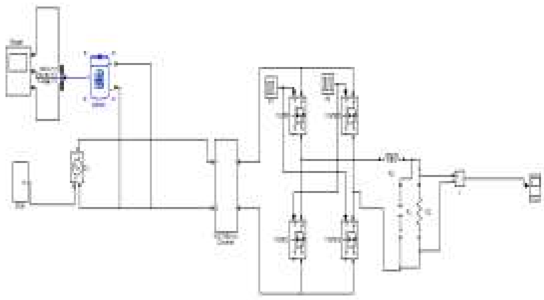

Fig 18 Simulation Circuit of Existing system

5.4OUTPUT WAVEFORM FOR EXSISTING SYSTEM

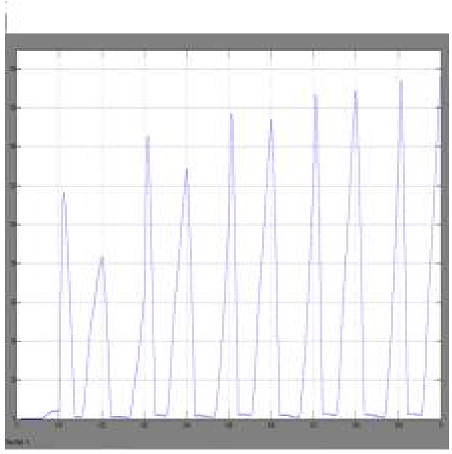

Fig 19 Output waveform of existing system

The graph is plotted in X-axis and Y-axis.
The input voltage applied is 12 volts.
The output voltage is 140 volts

5.5 SIMULATION CIRCUIT FOR PROPOSED SYSTEM

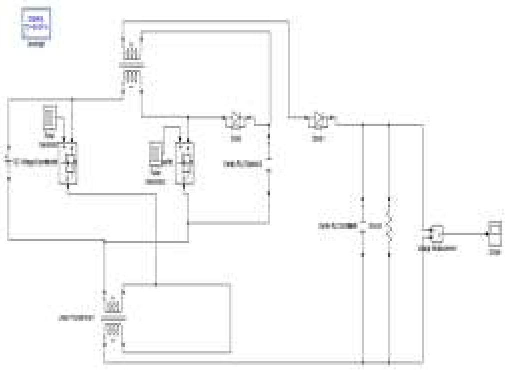

Fig 20 Simulation circuit of proposed system

5.6 OUTPUT WAVEFORM FOR PROPOSED SYSTEM

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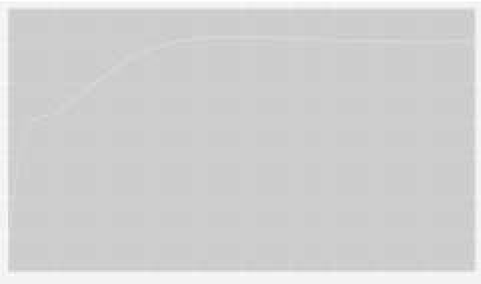

Fig 21 wave form for proposed system

5.7 SIMULATION CIRCUIT FOR SOLAR INPUT SYSTEM

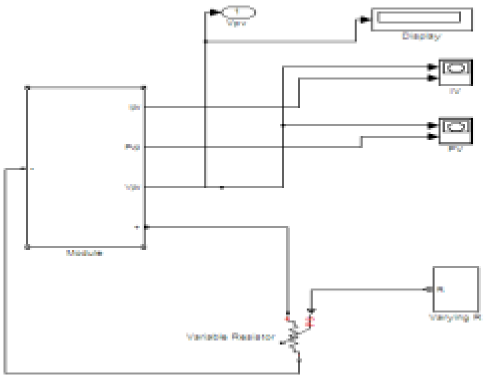

Fig 22 Simulation circuit for solar system

CONCLUSION

A new interleaved high step-up converter is proposed. The proposed converter combines the advantages of the coupled inductors with the diode-capacitor voltage multipliers and hence a super step-up gain can be easily achieved with minimum number of multipliers and low turns ratio of the coupled inductor while the converter operates at low duty ratio with low current ripples and low conduction losses. Therefore, the proposed converter exhibits high efficiency in a wide range of operation which makes it suitable for high power application. The simulations results verify the authenticity of the theoretical analysis and the effectiveness of the proposed system as a super high step-up converter.

Fig 23 Hardware setup

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