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Analysis and Design of High Step-Up DC-DC for Grid Connected Photovoltaic Converter Application

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Abstract- **Photovoltaic (PV) power-generation systems are suitable increasing significantly and predominant indistribution generation systems. A high voltage gain converter is necessary for the module's grid connection through a dc–ac inverter or for battery charging for standalone PV system.This paper proposes a new high step up DC-DC converter with floating active switch which acts as a high state drive. This floating active switch segregates energy from the PV panel when the AC module is off. It also regulates the DC interface between the DC-AC converters. The high step up voltage conversion ratio is accomplished with several turns ratio of a coupled inductor and appropriate duty ratios. The energy stored in the leakage inductor with the help of magnetizing inductor of a coupled inductor is efficiently recycled to the load through the output capacitor. With an input voltage of (Vin) 15V and 250V output voltage is obtained. An output power of 97W is also obtained from the designed converter circuit. Its maximum full load efficiency is better than conventional convert model.**

Index Terms- **AC Module,Coupled Inductor,High Step Up Voltage Gain.**

I. INTRODUCTION

FOSSIL fuels are an fundamental source of electricityand are carried out vastly in latest decades.Unfortunately, utilization of fossil fuels has led tolots of issues for the environment. Threat ofweather exchange and different comparable damages to theenvironment at the moment are very extreme. Now,researchers are inspired to search for uncontaminatedoptions for proposing strength [1] and [2].Renewable power resources were found asthe great opportunity for fossil fuels. Among thoseeasy electricity sources, photovoltaic (PV) structures,are considered because the leading generation. Incurrent years, plenty of researches are done forimproving the photovoltaic structures and makingthese structures more financial [3] and [4]. Also,other alternatives like fuel cells are studied and areconsidered as smooth and ability resources. The improvements within renewable strengthsystems include enhancements in electricityconversion systems, consisting of PV arrays and fuelcells, and enhancements in electrical circuits forcoping with the generated energy. Figure.1 indicates ahybrid renewable electricity grid-linked system. Thefundamental demanding situations within designing these renewablestructures are: green extracting electric strengthfrom the power conversion system and changingthe generated energy to the desired degree andshape. For example, for the renewable electricity machineproven in Figure.1, the most possible generatedpower through the PV array need to be extracted by means of thefollowing electricity converter and then the low voltageof the PY module ought to be transformed to a muchbetter voltage wanted by using the following block. Therefore,two crucial responsibilities of the high step-up convertersin Figure.1 are: Maximum Power Point Tracking(MPPT) and boosting the low generated voltageby means of PV array and fuel cell. So a ways, lots of researchesare finished to improve the performance,reliability, value and existence span of the DC-DCconverters for renewable electricity sources [1-10].

In [1-6] many DC-DC and DC-AC converters for thispurpose are reviewed. For this application,conventional boost converter might be the primary choice.But for the simple increase converter, the voltagestress of the transfer and diode are same to thehigh output voltage, where high-voltage ratedcomponents with high on-resistance need to areused, which reasons excessive conduction losses.Moreover, in excessive obligation cycles, excessive conduction lossesand critical opposite restoration problems are precipitated.Hence, inside the conversion ratios of extra than 7traditional improve converter isn't always an affordabledesire.

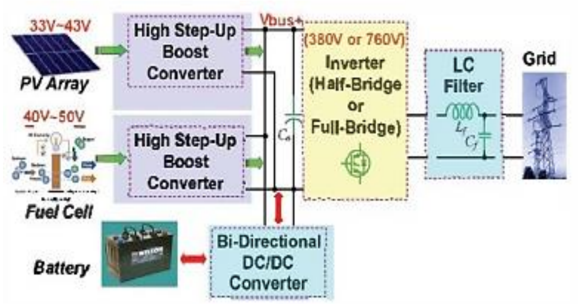

Fig. 1.Diagram of a single-phase renewable energy grid-connected system[8].

II. RELATED WORKS

So far, lots of research carried out to achieve a higheffciency, high-conversion ratio converter withoutextremely high operating duty cycle. The quadraticboost converter is an interesting topology for extendingconversion ratio which uses only a single active switch[10]-[12], where the voltage conversion ratio is a quadraticfunction of a conventional boost converter. However,voltage stress of the switch in these converters is equal tothe output voltage thus a high-voltage and high currentswitch should be selected.

Three-level boost converter can double the voltage gainand halve components voltage stess compared with theconventional boost converter [14] and [15]. Lower voltagerated MOSFETs with lower on resistance can be employedto reduce associated loss with switching and conduction thecircuit cost and the conduction losses due to the low voltagestress. However, the converter operates under a hardswitching condition, and the output diode reverse-recoveryproblem is toublesome. In [16] switchedcapacitors are used to achieve high step up conversion ratioconverter. However, in these converters as voltage gainincreases number of required components increase, whichresults in higher cost. Also, high switching losses andcurrent stess are toublesome too.

III. METHODOLOGY OF SYSTEM

The proposed converter is shown in figure.2. It consists of coupled inductor $T_1$with floating activeswitch S_1. The primary winding N_1 of a coupled inductor T_1 is similar to the input inductor of the conventionalboost converter and capacitor C_1 and diode D_1 receive leakage inductor energy from N_1. The secondary windingN_2 of Coupled inductor T_1 is connected with another pair of capacitor C_2 and diode D_2, which are in series withN_1 in order to further enlarge the boost voltage. The diode D_3 is a diode rectifier which is connected to theoutput capacitor C_3 and load.

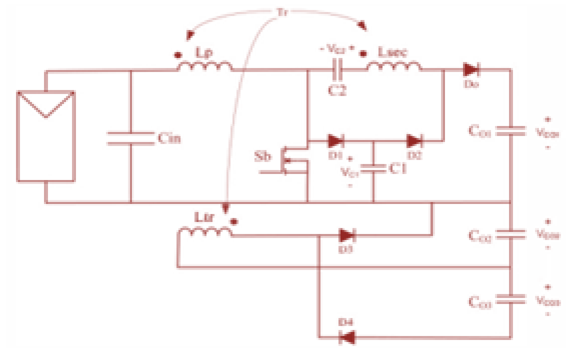

Fig. 2. Proposed High Step-Up Converter

In order to analysis the circuit of the proposed converter, the following assumptions are made.

1) All the components are ideal expect for the leakage inductance of coupled inductor T_1.

2) The on-state resistance $R_{DS(on)}$ and all the snubber capacitance of S1 are neglected.

3) The capacitors C1˜ C3 are sufficiently large that the voltages across them are considered to be constant.

4) The ESR of capacitors C1 ˜ C3 and the parasitic resistance of coupled inductor T1 are neglected.

5) The turn ratio n of the coupled inductor T1 windings is equal to N2 /N1.

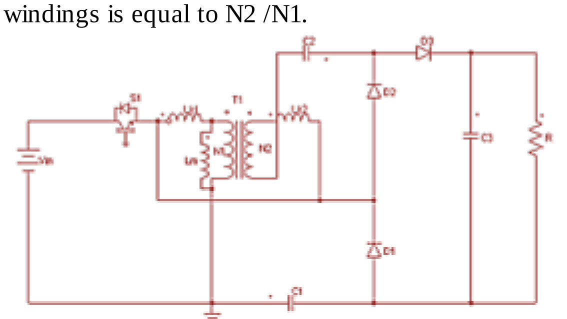

Fig.3. Polarity definitions of voltage and current in proposed converter

Continuous Conduction Mode Operation (CCM):

In the continuous conduction mode there are many transition intervals will takes place. Initiallywhenever the supply is applied and made the switch S_1 to turned ON, then the magnetizing inductor $L_m$continuously charges capacitor C_2 through coupled inductor T_1. The current i_{Lm} is continuously decreasesbecause the source voltage Vin crosses the magnetizing inductor L_m and primary leakage inductor L_{k1} during thistime the i_{D2} and i_{c2} are decreasing. Once the leakage current equals the decreasing i_{Lm}, then the V_{in} is seriesconnected with N_2, C_1 and C_2 to charges the output capacitor C_3 and load R. The rectifier diode D_3 is conductingbut diode D_2 will not conduct. The i_{Lm}, i_{Lk1}, and i_{d3} are increasing because the V_{in} is crossing L_{k1}, L_m and primarywinding N_1. The discharging current |ic1| and $|i_{c2}|$ are increasing.When the switch S1 is made off, instantly the energy stored in the inductor L_{k1} will flows through thediode D_1 to charge the capacitor C_1 meanwhile the energy stored in the leakage inductor L_{k2} is series connectedwith C_2 to charge the capacitor C_3 and the load R. L_{k1} and L_{k2} are far smaller than L_m due to this the iLm isincreasing with energy receiving from i_{Lk1} and i_{Lk2} decreases rapidly to zero. Once i_{Lk2} reaches the zero, the $L_m$released its energy to C_1 and C_2. Simultaneously diodes D_1 and D_2 are conducting. The energy stored in thecapacitor C_3 is constantly discharged to the load R. This process will continue for each turn on and turn offSwitch S_1

CCM Operation: For the steady state analysis of converter the two switching instants are considered, S1 ON and OFF instants.

During S1 ON

$V_{Lm}=V_{in}$

$V_{N2}=nV_{in}$

During S1 OFF

$V_{Lm}=-V_{c1}$

$V_{N2}=-V_{c2}$.

The voltage across C1 and C2 are obtained as

$V_{c1}= (D|\ 1-D)V_{in}$

$V_{c2}= (nD|\ 1-D)V_{in}$

The output voltage of the converter during switch S1 on is given by

$V_0=V_{in}+V_{N2}+V_{C2}+V_{C1}$;

$V_0=V_{in}+nV_{in}+ (D|1-D)V_{in}+ (D|1-D)V_{in}$

$MCCM=V_0/V_{in}= (1 + n|1-D)$

Dis-Continuous Conduction Mode Operation: In the discontinuous mode there are many transition intervals will takes place. Initially when the switchS_1 is made ON with input source V_{in}. The inV_0put source V_{in} is series connected with N_2, C_1 and C_2 to chargethe output capacitor C_3 and load R. Meanwhile L_m is also receiving energy from Vin. The i_{Lm}, i_{Lk1} and i_{D3} areincreasing because the V_{in} is increasing L_{k1}, L_m and primary winding N_1. The discharging current $|i_{c1}|$ and $|i_{c2}|$ areincreasing.When the switch S_2 made off then instantly the energy stored in the leakage inductor L_{k1} flows throughdiode D_1 to charge the capacitor C_1. $|i_{c1}|$ and $|i_{c2}|$ increases and current through i_{D3} also increase. Then the current$i_{lk1}$and i_{D1} are continuously decreased because the leakage energy flows through D_1 keeps charging a capacitorC_1. The energy stored in capacitor C_3 is constantly discharged to the load R. These energy transfers results indecrease in i_{Lk1} and i_{Lm} but increases in i_{Lk2}. Lm only constantly releasing its energy to C_2 and only Diode D_2 isconducting. The i_{Lm} is decreasing due to the magnetizing inductor energy flowing through the coupled inductorT_1 to secondary winding N_2 and D_2 continuous to charge capacitor C_2. The energy stored in capacitor C_2 iscontinued to be discharge to the load. This process will continue for each turn on and turn off Switch S_1.

DCM Operation

For the steady state analysis of the converter at two switching instants are considered, S_1ON and OFF instants.

During S_1ON

$V_{Lm}=V_{in}$

$V_{N2}=nV_{in}$

During S_1 OFF

$V_{Lm}=-V_{c1}$

$-V_{N2}=V_{c2}$

The voltage across C_1 and C_2 are

$V_{c1}=(D|DL)V_{in}$

$V_{c2}=(nD|DL)V_{in}$

$(V_o|V_{in})= ((n+1)|(D+DL))/D_L$

IV. RESULTS AND DISCUSSION

The designed high step-up DC-DC converter consists of single active switch, which acts as high state drive. It also contains the coupled inductor, 2diodes and 2capacitors used to step-up the voltage level and it also recycles the leakage energy. One diode is used as rectifier diode.

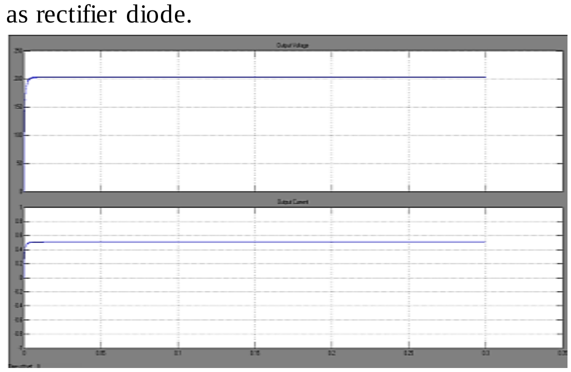

Fig.4. output voltage and current waveform at CCM

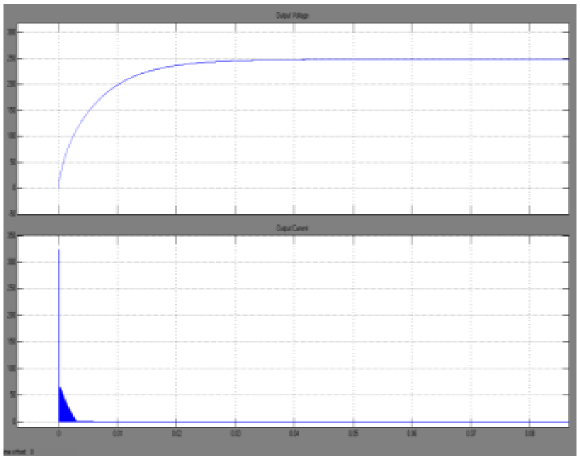

Fig.5. output voltage and current waveform at DCM

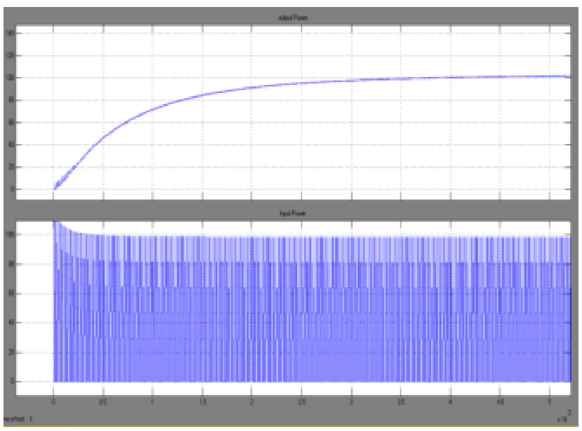

Fig.6. output and input power of proposed converter

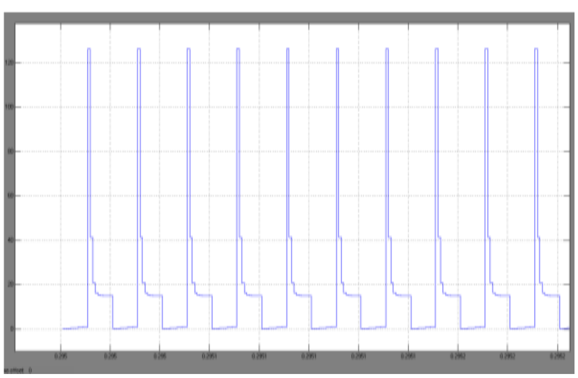

Fig.7.Voltage stress across the switch

These are the various results obtained from the proposed converter with the electrical specifications ofthe circuit components with an applied voltage V_{in}=15V, f_s=50kHz, and full load resistance of R=400Ω. Themajor components with the values of C_1=C_2=47μF and C_3=220μF, the switch used for the simulation is IGBT,for recycling and rectifying diodes are used. The turns ration of the mutual inductor is assumed to be n=5, andthe duty ratio D is derived as 50%. The magnetizing inductor of the coupled inductor L_m>30.54 for the full load.The maximum full load efficiency of the proposed converter at continuous conduction mode is given by 97%,this will be better than conventional converter. The proposed converter shows the wide range of efficiency.

V. CONCLUSION

The energy of leakage inductor's has been effectually recycled and the voltage stress across the switchis constrained. The switch here acts as an high state drive and also it protects panel and installers from theelectrical hazardous while the switch is in off state. The switching action is performed well by floating activeswitch during the system operation at all the condition with eliminating the residential energy effectively duringnon operating condition. Lacking an extreme duty ratio and with an numerous turns ratio the proposed converterachieved high voltage step-up gain. Thus improvements to the efficiency of the proposed converter haveachieved.

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