Design and Study of Interleaved Step up DC Converter with High Level Gain for the Application of Solar Photovoltaic Module

T. Kesavan , K. Lakshmi , S. Sheeba Rani , R. Kavin, M. Senthilkumar

Abstract: Solar Energy is a valuable and important energy resource and it is measured by solar radiation. The primary drawback is the intermittent nature of solar energy to produce similar voltage at all time. Conventionally, DC to DC converters are connected to solar energy source for producing output power but seem to be complicated to produce more output voltage in maximizing the triggering circuit for duty cycle. This paper introduces a new interleaved DC to DC converter with high level gain for the application of solar photovoltaic Module. The aim of this converter is to maximize the production voltage from solar photovoltaic Module, to reduce the input current ripple, to enlarge the efficiency and switching response of the system. The planned converter designs are simulated in MATLAB/Simulink software and the characteristics of voltage and load current are discussed.

Index Terms: DC-DC Converter, Coupled Inductor, Interleaved Converter, Solar photovoltaic system.

I. INTRODUCTION

Now days, Electrical power is needed for all engineering field and requirement of electrical power to be increased day by day. In view of that, non-conventional resources are only suggested to advance the requirement of electrical energy. Solar energy has been considering best choice from renewable energy source due to green environment and availability of resource other than renewable energy source. Even though, the output power has been generate from both sources without using any extra arrangement. Conventional Dc to DC converter mainly preferred in the conversion of both energy sources. Dc-dc step up converter also needed for most

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T.Kesavan*, Assistant Professor, Department of Electrical and Electronics Engineering Sri Krishna College of Engineering and Technology, Coimbatore.

Dr.K.LAkshmi, Professor & Head, Department of Electrical and Electronics Engineering Sri Krishna College of Engineering and Technology, Coimbatore.

Dr.S.Sheeba Rani, Associate Professor, Department of Electrical and Electronics Engineering Sri Krishna College of Engineering and Technology, Coimbatore.

R.Kavin, Assistant Professor, Department of Electrical and Electronics Engineering Sri Krishna College of Engineering and Technology, Coimbatore.

M.Senthilkumar, Assistant Professor, Department of Electrical and Electronics Engineering Sri Krishna College of Engineering and Technology, Coimbatore.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an <u>open access</u> article under the CC-BY-NC-ND license <u>http://creativecommons.org/licenses/by-nc-nd/4.0/</u> of industries and its applications of UPS and lamp ballasts [1]. The Conventional Dc to DC step-up converter design and operation are simple and it is used for step up operation. The drawback of conventional converter is producing short level voltage gain due to conduction loss. In practical, the voltage gain of converter is very low due to directly change duty ratio, intrinsic impedance and conduction losses. In addition, increases the gain of voltage in modifying regular boosts and the price will increase further [2]. Transformer connected interleave converter are mostly used for increase step up gain. Compare to transformer, inductor coupled converter has simple design, less I2R loss, self inductance of inductor.

The Inductor coupled converter very popular for the advantage of low swell current with simple size of circuit. The main application of proposed novel interleaved inductor coupled converter is to maximize the voltage for low input voltage, gain of voltage is high and voltage pressure Changing the difference and losses [3-10]. The resistor and capacitor based snubber circuit are

currently used to condense the stress of voltage. But it's expensive and circuit design is more complex. In conventional converter can operate in off-continuous conduction period for Voltage pressure decreases. But it produces high ripples in current. The more number of filters are required to reduce the ripples in conventional circuit. Legacy modified converts are used to increase the power and reduce voltage sharpness in the environment.But it is not possible with hard switching of converter [10]. The more number of snubber circuits are required to clamped converter for reducing losses in switching. The soft-switching converters are preferred for improvement of efficiency and improve the density of power conversion. In proposed converter, switching frequency can be improve by using soft switches, simple circuit and reduces the switching losses. An asymmetric pulse width modulation is used to achieve zero voltage concepts in converter. Active clamp converters are preferred for ZVS switch ON mode. Fly back converter are used for industrial application and low power application. The zeta converters are presented for getting maximum voltage with power factor correction. This type of converter with zero switching concepts used for reducing voltage stress, low switching losses and low converter volume. Combination of Asymmetrical and interleaved converter has produce the benefit of increasing gain of voltage and high conversion ratio of voltage .Multi-cascade source converter is another topology of DC to DC boost converter.



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It is used for high ratio of potential conversion and facing problem of power losses, voltage pressure and current ripples [22-24]. In this article, the working, operation, virtues and demerits of various DC converter topologies are discussing in Introduction. Definition, fundamental concept and operations of interleaved converter are presents in chapter II. Performance of projected converter are discusses in Chapter III. MATLAB/Simulink results are presents within Chapter IV and the conclusion of paper are presents in Chapter V.

II. INTERLEAVED CONVERTER

Interleaved converter concept is a major developing area in Dc to Dc boost converter. The main aim of this type converter is to advance performance, to diminish size of circuit, to enlarge efficiency and to shrink conversion losses. High potential and reliability are important facto of interleaved converter. Conventional inductors are static type components and fixed value. But coupled inductor is variable components and inductance to be varied based on high electrical energy renovation ratio. The proposed interleaved couple inductor gives less core loss, winding losses and low ripples in current. Steady state analyses of novel interleaved converter. The projected circuit diagram as exposed in figure .1. In this circuit diagram, there are four inductor are used in different ways.

First two inductors are inductors are seriously connected with source and another two inductors Lm are interleaved inductors. This two interleaved inductor are controlled by switch no S1 and S2 respectively. Switch S1 are series connect with source and connected by inductor and capacitor operation are connected by parallel diodes. So Inductor and capacitor may used in product overall performance and power factor the converter.

III. PROPOSED INTERLEAVED CONVERTER

The proposed interversion converter is a high voltage rate interface DC-DC boost converter and high-level up-rate



Fig 1. Proposed interleaved High Step-up Ratio Interleaved DC-DC boost converter

Interleaved DC-DC promotion. The following four modes and the proposed converter has given on Fig 1.

Retrieval Number: F2676037619/19©BEIESP Journal Website: <u>www.ijrte.org</u> *Mode 1*: At T=t0, Switch S1 and S2 may turn ON, static inductor Ls and Interleaved inductor Lm are charging from diodes D1,D2,D3 and D4 may be connected in reverse bias. Capacitor are started to discharge to load. Producing voltage of converter is equal to capacitor discharging voltage.

Mode 2: At T=t1, Switch S1 is turn OFF condition and S S2 turn ON condition .In this mode, Inductor Lm1 is discharging, Diode D1 is forward biasing and Lm2 is charging voltage from supply. Capacitor discharging through diode D1, D2 and D4 reverse biased. Circuit voltage is equal to discharging voltage of Lm,c2 and c3.

Mode 3: At T=t2, S2 in turn OFF condition and S1 with turn ON condition. In this mode, Lm_2 discharging, Diode D is forward biasing and Lm1 is charging supply voltage. Capacitor is discharging through diode D1 and reverse biasing of D2 and D4 diodes. In this mode converter voltage is like with discharging voltage of Lm1 and c2 and c3.

Mode 4: At T=t4, Switch S1 and Switch S2 are turn ON condition .In this mode, Lm2 charging, Diode D is forward biasing and Lm1 is charging voltage commencing supply. Capacitor discharging through diode D1and another semiconductor devices of D2 and D4 biased in reverse condition. The circuit expected voltage may be similar with discharging voltage of Lm1,c2 in addition to c3.

Mode 5 : At T=t5, Switch S1 and Switch S2 are turn OFF condition .In this mode, Lm2 discharging, Diode D is forward biasing and Lm1 is discharging in source voltage. Capacitor discharging through diode D1and diode D2 and D4 in turn around biased. The delivered voltage of circuit same with discharging voltage of Lm1 and capacitor c1,c2 and c3. *Mode 6:* At T=t6, Switch S2 expected turn OFF condition and S1 be turn ON condition. In this mode, Lm2 in discharging voltage supply. Capacitor discharging through diode D1and diode D2 and D4 making off position. The circuit probable voltage is identical to discharging voltage of Lm1 and capacitor c1 and c3.

Mode 7: At T=t7,S2 in turn OFF condition and S1 with turn ON condition. In this mode, Lm2 in discharging, Diode D is forward biasing and Lm1 is discharging supply voltage. Capacitor discharging through diode D1 and diode D2 and D4 both reverse biased. Discharging voltage of Lm1 and capacitor c1,c2 and c3 are similar with generated voltage.

Mode 8: At T=t8, Switch S1 and S2 turn OFF condition. In this mode, Lm2 in discharging, Diode D is forward biasing and Lm1 is discharging voltage . Capacitor discharging through diode D1 and diode D2 and D4 are inedible. The circuit voltage parallel with discharging voltage of Lm1 and capacitor c1,c2 and c3.







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IV. SIMULATION AND RESULTS

The triggering pulses of switches S1 and S2 are as shown in Figure 3. The proposed novel interleaved converter may simulated by MATLAB/Simulink software as exposed in Figure 4. The voltage of solar PV panel is considered 40V is given to input of converter and it revealed in figure 5 and voltage of planned converter is 120v and it mentioned in figure 6 and conversion ratio of voltage is 3. At t=0, voltage is increase up to 130v and is settled at 12v at t=0.006 Sec. That means settling time will be concentrated compare to conventional converter. The figure 7 shows the input waveform of proposed converter, at starting time t=0, the current is raising up to 17 amps and it is settled 9 amps at t=006 secs. In figure 8 and 9 shows, current through inductor Lm1 and Lm2 are respectively and each inductor having current level of 5.8 AMs to -5.8 Amps. In figure 10 shows, output current of proposed converter are the current level of +2.155 Amps to -2.155 Amps and initially current is raising up to 2.4 Amps and it is settled 2.155Amps at t=0.006 Sec. Firing pulses of switching S1 and Switch S2 are publicized in Figure 11 and 12 at switching frequency of 45 kHz. Table1 shows, components of interleaved converter



Fig 4. The circuit diagram of the proposed DC-DC MATLAB/SIMULINK simulation



Fig 5.Input Dc voltage to Proposed Converter

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Fig 6. Output voltage from proposed converter.



Fig 7. Input Current to proposed converter.



Fig 8.Current through inductor 1







Fig 9 .Current through inductor 2



Fig 10(a). Output Current from proposed converter



Fig 10(b). Output Current from proposed converter



Fig 11.Firing pulses for switch1



Fig 12.Firing pulses for switch2



S.NO	PARAMETER	VALUES
1.	Input voltage	60V
2.	Capacitor (C1)	30µ F/300V
3.	Capacitor (C2)	30µ F/600V
4.	Diodes	0.7V
5.	Switching frequency	45KHZ
6.	Load resistance	400Ω
7.	Self inductance	10µ H
8.	Mutual inductance	5µ H
9.	Turn's ratio (n2:n1)	1:1
10	Output voltage	600V
11	Output power	900W

V. CONCLUSION

This research paper focuses on a novel inductor coupled interleaved converter for solar photovoltaic cell. In this design, the voltage gain has increased compared to the genetically modified design and hence improves the proposed converter rate.



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The proposed converter output voltage also has considerably improved on the basis of the ratings of the inductor, condenser and switches. The performance of the proposed conversion has been modeled using the MATLAB / Simulink software and has been discussed with regard to the various voltages and current I/O properties. The future work of this research is to simulate and obtain high power generation process using low voltage AC inputs whereby the proposed circuit can be implemented for the use of AC load applications.

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