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INTEGRATED COUPLED-INDUCTOR AND DIODE-CAPACITOR FOR A HIGH VOLTAGE GAIN DC-DC CONVERTER

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Abstract: This project aims to design and implementation of high efficiency and high step –up non-isolated DC-DC converter. The high power non –linear loads and low power loads produce voltage fluctuations, harmonic currents and an imbalance in network which results into lower Power factor operation of power supply. There is a need of improved Power factor and reduced harmonic current in input line. In this project high step-up boost converter with coupled inductor has been introduced to regulate the line voltage. The DC power to this proposed converter is derived from AC lines by using diode bridge rectifier with filter. The main objective of design and implementation is to improve source side power factor with reduced harmonic content and also to improve the voltage conversion ratio at the DC load side.

Keywords: component- coupled inductor,diode bridge rectifier,low voltage sress, power factor correction.

I. INTRODUCTION

In many industry applications such as uninterrupted power supplies (UPS), electric traction, distributed photovoltaic (PV) generation systems, fuel cell energy conversion systems, automobile HID headlamps, and in some medical equipment, a high voltage gain DC-DC boost converters play a major role. In these applications, a classical boost converter is normally used, but the voltage stress of the main switch is equal to the high output voltage, hence, a high-voltage rating switch with high on-resistance should be used, generating high conduction losses. An extremely high duty cycle will results in large conduction losses on the power device and serious reverse recovery problems. As a result, the conventional boost converter would not be acceptable for realizing high step-up voltage gain (Vout⩾8•Vin) have been researched to achieve a high conversion ratio and avoid operating at extremely high duty cycle. The switched-capacitor types, switched-inductor types the voltage-doubler circuits, the voltage-lift types,and the capacitor-diode voltage multiplier are included in these converters[5].

The conventional boost converter gives low voltage gain compared with the other. For an extremely large conversion ratio, more switched-capacitor or switched inductor stages are necessary resulting in higher cost and complex circuit [3]. The quadratic boost converter using a single active switch is another interesting topology for extending the voltage gain where the voltage conversion ratio gives a quadratic function of the duty ratio. Since the output voltage level is determined only by the duty cycle, the voltage gain of this converter is moderate. The Voltage stress of the active switch is equal to output voltage if the components used are idea ones. A high-voltage rating switch should be selected for a high output voltage applications. The converters based on transformers or coupled-inductors or tapped inductors have been used without operating at extremely high duty ratio to achieve a high conversion ratio [7]. For achieving high voltage gain by adjusting the turns ratio of the transformer the conventional flyback converter is adopted. However, it induces energy losses and high voltage spikes on the power device due to the leakage inductor of the transformer. In order to improve above problems, a resistor-capacitor-diode (RCD) snubber can be used, by dissipating leakage inductor energy. Although active clamped techniques can release high voltage spikes and reduce switching losses, an additional active switch leads to complex structures and control.

To achieve a high voltage gain, and low voltage stress on the active switch without the penalty of high duty ratio many boost converters based on coupled inductor or tapped inductor provides output. However, the input current is not continuous. An input filter is inserted into a coupled-inductor boost converter and its turn ratio is increased to extend the voltage conversion ratio then the input current becomes larger. [4]

A cascaded high step-up converter with an individual input inductor was proposed which can be partitioned as a basic boost converter and boost-flyback converter [1] in order to satisfy the high step-up applications and low input current ripple, which can be divided as a basic boost converter and a boost-flyback converter .In this paper, a novel single switch dc-dc converter with high voltage gain is presented.

The features of the proposed converter are as follows: 1) the voltage gain is efficiently increased by a coupled-inductor and the secondary winding of the coupled inductor is inserted into a diode-capacitor for further extending the voltage gain dramatically; 2) a passive clamped circuit is connected to the primary winding of the coupled-inductor to lamp the voltage across the active switch to lower voltage level. As a result, the power devices with low voltage rating and low on-state resistance RDS (ON) can be selected. On the other hand, this diode-capacitor circuit is useful to increase voltage conversion ratio; 3) improving the efficiency ,the leakage inductance energy of coupled inductor can be recycled 4) the potential resonance may

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be cancelled between the leakage inductance and junction capacitor of the output diode.

II. SURVEY OF EXISTING SYSTEMS

The dc power supplies are extensively used inside most of Electrical and Electronic appliances such as in computers, monitors, televisions, audio sets and others .The high power non-linear loads (such as static power converter, arc furnace, adjustable speed drives etc) and low power loads (such as fax machine, computer, etc) produce voltage fluctuations, harmonic currents and an imbalance in network system which results into low power factor operation of the power system. There is a need of improved power factor and reduced harmonics content in input line currents as well as voltage regulation during power line over-voltage and under voltage conditions. The uncontrolled diode bridge rectifier with capacitive filter is used as the basic block in many power electronic converters. Due to its non-linear nature, non-sinusoidal current is drawn from the utility and harmonics are injected into the utility lines. The nature of rectifiers either it is conventional or switch mode types, all of them contribute to low PF, high THD and low efficiency to the power system. It is well known that these Harmonic currents cause several problems such as voltage distortion, heating, noises, reducing the capacity of the line to supply energy.

Owing to this fact there's a need for power supplies that draw current with low harmonic content & also have power factor close to unity. So far, a variety of passive and active PFC techniques have been proposed. While the passive PFC techniques may be the best choice at low power, cost sensitive applications, the active PFC techniques are used in majority of the applications owing to their superior performance. The objective of this work is to develop a circuit with all the necessary components and control system that will incorporate into the design of any single-phase rectifier and hence, improves the power factor. The AC mains utility supply ideally is supposed to be cleaned and free from high voltage spikes and current harmonics in order to ensure good quality and efficient power system harmonics to electronics equipment. Discontinuous input current that exists on the AC mains caused by the non-linearity of the rectification process could be shaped to follow the sinusoidal form of the input voltage. The process of shaping the input current is done by the Boost converter. The control circuits for this project used low-cost components, easily available yet giving excellent performance and satisfactory results.

The problem of power factor in single phase line commutated rectifiers and DC-DC converters**:**

Classical line commutated converters suffer from the following disadvantages:

1) They produce a lagging displacement factor w.r.t the voltage of the utility.

2) They generate a considerable amount of input current harmonics.

3) The voltage conversion efficiency is poor.

III. COUPLED INDUCTORS

Coupled-inductor and other integrated-magnetic techniques have existed for many years, but most power electronics engineers are uncomfortable with them [7]. This may be because of limited experience with coupled magnetics or it could be explained by the level of complexity in many treatments of coupled magnetic devices. Unlike most networks, coupled-inductor techniques involve simultaneous parallel energy-transfer pathways: electrical and magnetic. Despite the difficulty, the circuits are useful and deserve to be better appreciated. This technique replaces a series smoothing choke with a "smoothing transformer" (a pair of coupled inductors) and a dc blocking capacitor. Because these components form a linear two-port filter, the building block can be implemented in any dc circuit to reduce the ripple current wherever a choke is currently used. Thus it may be applied to the dc input of a converter, its dc output, or an internal dc link (in applications such as motor drives or HVDC transmission).

IV. PROPOSED SYSTEM

To achieve a high conversion ratio without operating at extremely high duty ratio, some converters based on transformers or coupled- inductors or tapped-inductors have been used. Many boost converters based on Coupled-inductor or tapped-inductor provide solutions to achieve a high voltage gain, and low voltage stress on the active switch without the penalty of high duty ratio [7]. However, the input current is not continuous. Particularly, as the turn ratio of the coupled-inductor or tapped-inductor is increased to extend the voltage conversion ratio, the input current ripple becomes larger. In order to satisfy the extremely high step-up applications and low input current ripple, a cascaded high step-up converter with an individual input inductor was proposed which can be divided as a basic boost converter and a boost-flyback converter.

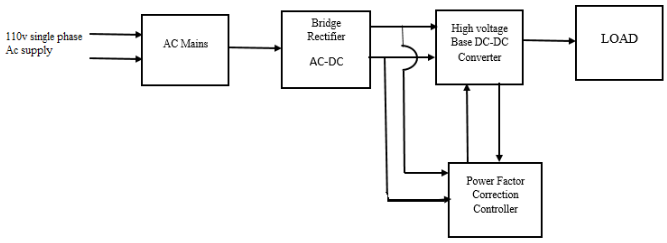

Fig 1: Block diagram of the proposed network

When a 110V AC supply is given to the AC mains and it is then converted into DC by using a rectifier. Rectifier is nothing but which converts AC –DC. Then a High Voltage Base DC-DC is connected across the load which is used to reduce the current ripple and increase the efficiency.

The magnitude of voltage and current is calculated using Power factor (PF) controller and also the active and reactive power.

The circuit structure of the proposed converter Fig.2, which consists of an active switch Q_1, an input inductor L_{L1} and a coupled-inductor T_1, diodes D_{d1}, D_{d2} and D_{dO}, a storage energy capacitor Cc_1 and a output capacitor Cc_O, a clamped circuit including diode D_d3 and capacitor Cc_2, an extended voltage doubler cell comprising regeneration diode D_{dr} and capacitor Cc_3 and the secondary side of the coupled-inductor.

The Dual winding coupled inductor is modeled as an ideal transformer with a turn ratio N (n_2/n_1), a parallel magnetizing inductance L_m, primary and secondary leakage inductance L_{Lk1} and L_{Lk2}.

In order to simplify the circuit analysis of the converter, some assumptions are followed:

1) The input inductance L_{L1} is assumed to be large enough so that i_{LL1} is continuous; every capacitor is sufficiently large, and the voltage across each capacitor is considered to be constant during a switching period.

2) All components are ideal except the leakage inductance of the coupled inductor.

3) Both inductor currents i_{L1} and i_{Lm} are operated in continuous conduction mode, which is expressed as C-CCM; the inductor

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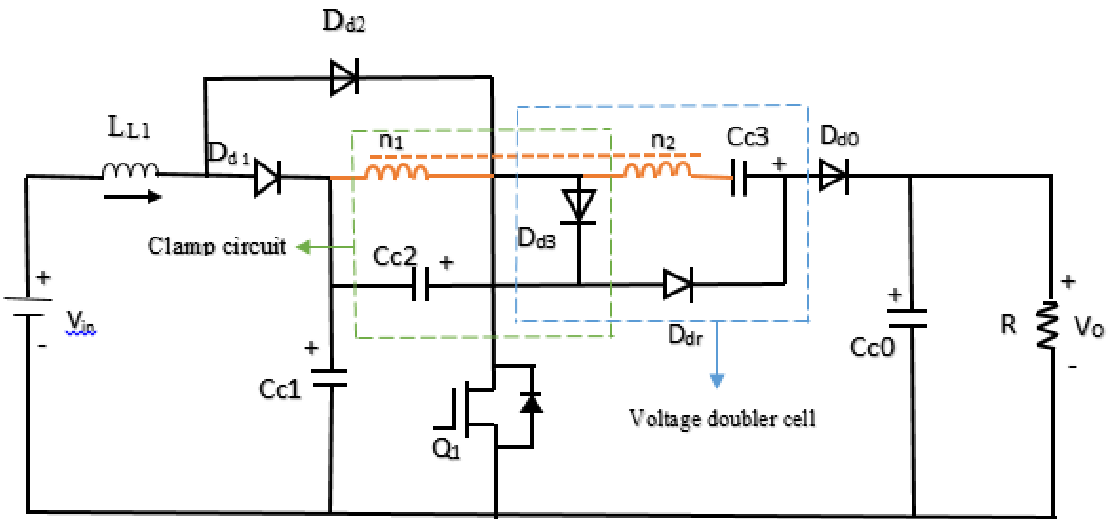
current i_{LL1} is operated in continuous conduction mode, but the current i_{LLm} of the coupled inductor is operated in discontinuous conduction mode, which is called C-DCM.
The Continuous conduction mode (CCM) and Discontinuous conduction mode (DCM) operations are explained in a tabular column by different stages.



CONTINUOUS CONDUCTION MODE – CCM

STAGE	SWITCH Q_1	DEVICES ON	DEVICES OFF
t_o-t_1	CONDUCTS	D_{d2} & D_{dr}	D_{d1}, D_{d3}& D_{d0} are reverse biased.
t_1-t_2	OFF	D_{d3} & D_{dr}	D_{d0} & D_{d2} are reverse biased.
t_2-t_3	OFF	D_{d0} Conducts	D_{dr} is Blocked
t_3-t_4	OFF	D_{d1} is turned ON	D_{d2} &D_{dr} are turned OFF Dd_3 is Blocked
t_4-t_5	ON	D_{d2} & D_{d0} are turned ON	D_{d1}, D_{d3} & D_{dr} are reverse biased.

DISCONTINUOUS CONDUCTION MODE-DCM

STAGE	SWITCH Q_1	DEVICES ON	DEVICES OFF
t_o-t_1	ON	D_{d2} & D_{dr}	D_{d1}, D_{d3}& Dd_0 are Blocked.
t_1-t_2	OFF	D_{d3} & D_{d1} are ON	D_{d2} & D_{dr} are turned OFF
t_2-t_3	OFF	D_{d1} & D_{d0} are turned ON	D_{d2} &D_{dr} turned OFF D_{d3} is Blocked
t_3-t_4	OFF	D_{d1} is conducting	D_{d2} is OFF. D_{d3} is Blocked
$t = t_4$	ON	D_{d2} & D_{dr} conducts	D_{d1},D_{d3} & D_{d0} are blocked

V. SIMULATION RESULTS AND DISCUSSION

Simulation is carried out in MATLAB 2013 version. In this paper complete system is divided into various section and are simulated. Simulink is a block diagram environment for multi domain simulation and Model-Based Design. It supports system-level design, Simulation, automatic code generation, and continuous test and verification of embedded systems.

UTILIZED COMPONENTS AND PARAMETERS

Components	Parameters
Input voltage V_{in}	110V
Output voltage Vo	450V
Switching Frequency	40/kHZ
Input inductor L_{L1}	161.96µH
Capacitor Cc_1, Cc_2, Cc_3	1µF
Capacitor Cc_0	220µF

Fig 3: Voltage and current IN Phase

In this Fig.3 voltage and current are in-phase due to which source side of the power factor can be improved.

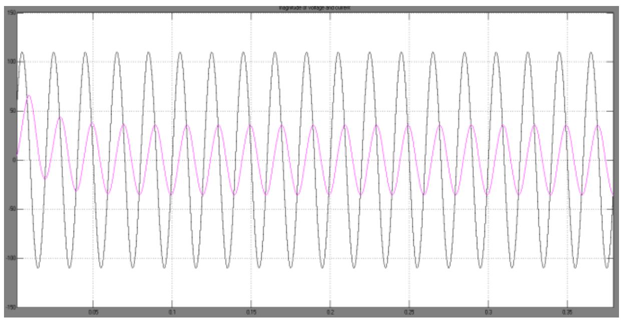


Fig 4. Improved Source side Power Factor

In many applications the swithching frequency is different this will affect the source side Power factor. To improve the Power factor voltage and current should be in-phase and pulse is given by creating error between input and output side. Thus the source side Power factor is improved.

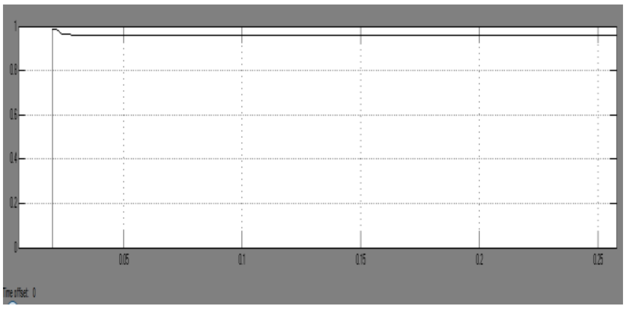
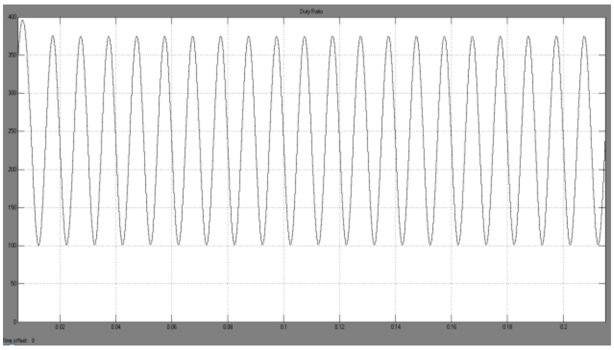


Fig 5: Duty ratio of converter parameters



VI .ANALYSIS OF CONVERTER PARAMETERS

In order to get the proper output from the converter it is necessary to design the inductance and capacitance, and also the duty cycle.

1) Duty cycle is given by,

Maximum duty cycle is given by,

$$D = 1 - \frac{(Vs \times efficiency)}{Vo}$$

V_{IN}(min) = minimum input voltage
V_{OUT} = desired output voltage
efficiency of the converter, e.g. estimated 85%

The above equation indicates that the output voltage is always greater than the input voltage and with increase in the value of duty cycle the output voltage also increases.

2) Inductor calculation

The boost is operated in the continuous current mode in which the inductor current never falls to zero. So the inductor should be chosen such that maximum output voltage is obtained. The inductor value is given by,

L=(Vs*(Vo-Vs))/(ΔI_L*f*Vo)

ΔIL=ripple current of the inductor which should be maintained between 20% to 40% of the output current and is given by

ΔI_L= (0.2 to 0.4)*Iomax*Vo/Vs

Iomax= maximum output current

Also the minimum value of the capacitance is maintained in order to keep the output voltage when the load value exceeds.

3) The capacitance value is given by the Filter Capacitor selection

Cmin = (Iomax*D)/(fs*ΔVo)

VII.CONCLUSION

This paper presents a efficient, reliable and a compact model. The high voltage gain converter is widely employed in many industry applications, such as photovoltaic systems, fuel cell systems, electric vehicles and high intensity discharge lamps. The presented converter overcomes the following drawbacks such as reduction in the current ripple, reduction of conduction losses and voltage stress of the stress closed to the low level voltage stress by coupled inductor Boost converter. Proposed converter improves the source side Power factor by reducing the errors in both input and output side which helps in long life span of the equipment.

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