# A Novel Transformer-less Voltage Quadruple with Low Switch Voltage Stress Solar DC-DC Converter by using Fuzzy Logic Controller

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## Abstract

In this paper, a novel transformer-less adjustable voltage quadruple solar dc–dc converter with high-voltage transfer gain and reduced value of settling time & semiconductor voltage stress by using (FLC) fuzzy logic controller is proposed. The proposed topology utilizes input-parallel output-series configuration for providing a much higher voltage gain. The proposed converter cannot only achieve high step-up voltage gain with reduced component count but also reduce the voltage stress of both active switches and diodes. This will allow one to choose lower voltage rating MOSFETs and diodes to reduce both switching and conduction losses. In addition, due to the charge balance of the blocking capacitor ,the features of converter provides automatic uniform current sharing characteristic of the two interleaved phases without adding extra circuitry or complex control methods. By using fuzzy logic controller the output voltage of the proposed converter can improve with reducing the settling time. The output part is connected to the PMSM through which we can calculate stator current & rotor speed of the machine & uses in many applications. The operation principle and steady analysis as well as a comparison with other recent existing high step-up topologies are presented. Finally, some simulation and experimental results are also presented to demonstrate the effectiveness of the proposed converter.

**Keywords: dc-dc, MOSFET, FLC**

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## I. INTRODUCTION

Power Electronics is the art of converting electrical energy from one form to another in an efficient, clean, compact, and robust manner for convenient utilization. The power conversion systems can be classified according to the type of the input and output power

- AC to DC (rectification)
- DC to AC (inversion)
- DC to DC (chopping)
- AC to AC (transformation)

### A. *Conventional Method:*

The conventional switched capacitor technique makes the switch suffer high transient current and large conduction losses. Furthermore, many switched capacitor cells are required to obtain extremely high step-up conversion, which increases the circuit complexity. The authors presented some design rules useful for developing high-efficiency switched-capacitor converters, based on their analysis. several modular converter topologies were presented based on a switched-capacitor cell concept in which a soft-switched scheme was used to reduce the switching loss and electromagnetic interference. The coupled inductor-based converters are another solution to implement high step-up gain because the turns ratio of the coupled inductor can be employed as another control freedom to extend the voltage gain. However, the input current ripple is relatively larger by employing single stage single-phase-coupled inductor-based converters, which may shorten the usage life of the input electrolytic capacitor.

### B. *Drawbacks:*

- High transient current and large conduction losses.
- Current ripple is high.
- Voltage stress is high.
- Low output voltage.
- High settling time.

### C. Proposed Method:

A novel transformer-less adjustable voltage quadruple solar dc–dc converter with high voltage transfer gain and reduced settling time & semiconductor voltage stress by using fuzzy logic controller is proposed. The proposed topology utilizes input-parallel output-series configuration and is derived from a two-phase interleaved boost converter for providing a much higher voltage gain with low settling time and without adopting an extreme large duty cycle. The proposed converter cannot only achieve high step-up voltage gain but also reduce the voltage stress of both active switches and diodes. This will allow one to choose lower voltage rating MOSFETs and diodes to reduce both switching and conduction losses. In addition, due to the charge balance of the blocking capacitor, the converter features automatic uniform current sharing characteristic of the two interleaved phases for voltage boosting mode without adding any extra circuitry or complex control methods. In the output side an inverter is connected which converts the dc output to the ac, this ac signal is provided to the PMSM (Permanent magnet synchronous machine) for application purpose through which we can calculate stator current, torque etc. of the motor.

## II. LITERATURE REVIEW

Q. Zhao et al.[3] proposed high-efficiency, high step-up DC–DC converter, A family of high-efficiency, high step-up dc–dc converters with simple topologies is proposed in this paper. The proposed converters, which use diodes and coupled windings instead of active switches to realize functions similar to those of active clamps, perform better than their active-clamp counterparts. High efficiency is achieved because the leakage energy is recycled and the output rectifier reverse-recovery problem is alleviate. N. P. Papanikolaou et al.[4] proposed Active Voltage Clamp in Fly back Converters Operating in CCM Mode Under Wide Load Variation This paper proposes Active clamp topologies of low power dissipation have become a very attractive solution in order to limit over voltages in fly back converters. Although many suitable topologies have been introduced for the case of discontinuous conduction mode (DCM), where the duty cycle value depends on the load level, in continuous conduction mode (CCM). L. S. Yang et al. [9] proposed transformer less DC–DC converters with high step-up voltage gain. This paper proposes transformer less dc–dc converters to achieve high step-up voltage gain without an extremely high duty ratio. In the proposed converters, two inductors with the same level of inductance are charged in parallel during the switch-on period and are discharged in series during the switch-off period. The structures of the proposed converters are very simple. Only one power stage is used. Shaik Samdhani et al. proposed a New High Step up DC-DC converter for Grid connected system. This paper presents a New Bidirectional DC-DC converter with high conversion ratio. The proposed converter uses the coupled-inductor to achieve high voltage conversion ratio. This paper first analyzes the proposed converter operating principles and steady state circuit characteristics. Eventually, a Simulation circuit with conversion voltage 24 V/400 V and output power 500 W is implemented to verify the feasibility of the proposed converter. In this the voltage gain is efficiently increased by a coupled inductor. The leakage inductance energy of coupled inductor can be recycled, improving the efficiency. C. C. Ming Wang et al. [7] proposed A Novel ZCS-PWM Fly back Converter With a Simple ZCS-PWM Commutation Cell, This paper proposes a novel zero-current-switching pulse-width-modulation (ZCS-PWM) fly back dc/dc converter using a simple ZCS-PWM commutation cell. The main switch and auxiliary switch operate at ZCS turn-on and turn-off conditions, and all uncontrolled devices in the proposed converter operate at zero-voltage-switching (ZVS) turn-on and turn-off. In addition, given constant frequency and decreasing commutation losses, the proposed converter has no additional current stress and conduction loss in the main switch compared to the conventional hard switching fly back converter. The averaging approach is used to estimate and examine the steady-state of the proposed converter. The principle of operation, theoretical analysis, and experimental results of the new ZCS-PWM fly back converter, rated 150 W and operating at 80 kHz, are provided in this paper to verify the performance of the proposed converter. F.L.Tofoli et al. [11] proposed, Survey on non isolated high-voltage step-up dc-dc topologies based on the boost converter, In the last few years high-step-up non isolated dc-dc converters are quite popular because of its wide applicability. The conventional non-isolated boost converter is the most popular topology for this purpose, although the conversion efficiency is limited at high duty cycle values. In order to overcome such limitation and improve the conversion ratio, derived topologies can be found in numerous Publications as possible solutions for the aforementioned applications. This work intends to classify and review some of the most important non-isolated boost-based dc-dc converters. Chia-Chi Chu et al. [12] proposed, A Novel Transformer-less Adaptable Voltage Quadruple DC Converter with Low Switch Voltage Stress, In this paper, a novel transformer-less adjustable voltage quadruple dc–dc converter with high-voltage transfer gain and reduced semiconductor voltage stress is proposed. The proposed topology utilizes input-parallel output-series configuration for providing a much higher voltage gain without adopting an extreme large duty cycle.

## III. PROBLEM IDENTIFICATION

The conventional switched capacitor technique makes the switch suffer high transient current and large conduction losses. Furthermore, many switched capacitor cells are required to obtain extremely high step-up conversion, which increases the circuit complexity. The authors presented some design rules useful for developing high-efficiency switched-capacitor converters, based on their analysis. Several modular converter topologies were presented based on a switched-capacitor cell concept in which a soft-switched scheme was used to reduce the switching loss and electromagnetic interference. The coupled inductor-based converters are another solution to implement high step-up gain because the turns ratio of the coupled inductor can be employed as another control freedom to extend the voltage gain. However, the input current ripple is relatively larger by employing single stage single-phase-coupled inductor-based converters, which may shorten the usage life of the input electrolytic capacitor.

 

### *A. Drawbacks:*

- High transient current and large conduction losses.
- Current ripple is high.
- Voltage stress is high.
- Low output voltage.
- High settling time.
- Low efficiency

But in the base paper converter proposed, transformer –less dc-dc converter with high step-up voltage gain & reduce value of voltage stress of both active switches and diodes. By using this type of converter some drawbacks are removed, but also having small drawbacks like-

- Low output voltage.
- High settling time.

## IV. METHODOLOGY

This proposed converter can be achieve by a two-phase interleaved boost converter with parallel-input series-output configuration shown in Fig.4.1. The proposed converter topology is basically derived from a two-phase interleaved boost converter and is shown in Fig.4.2. Comparing Fig.4.1 with Fig.4.2, one can see that two more capacitors and two more diodes are added so that during the energy transfer period partial inductor stored energy is stored in one capacitor and partial inductor stored energy together with the other capacitor store energy is transferred to the output to achieve much higher voltage gain.

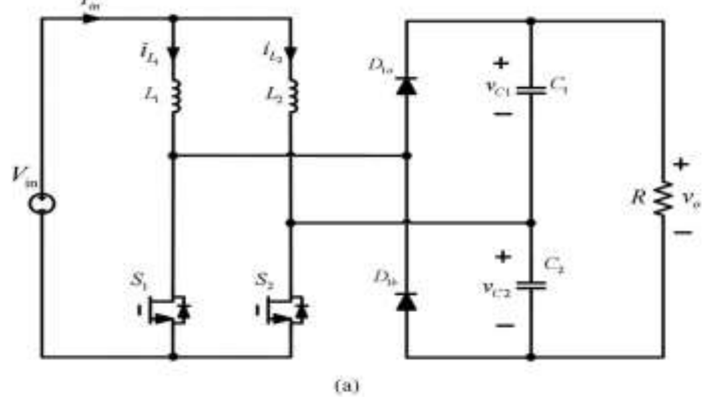


Fig. 4.1: A Two-Phase Interleaved Boost Converter With Parallel-Input Series-Output

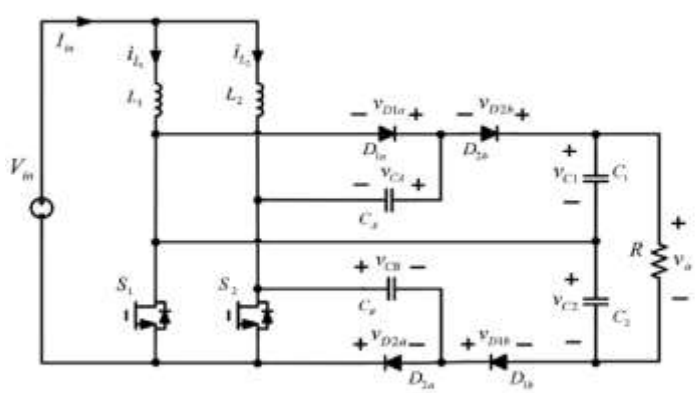

Fig. 4.2: The Proposed Converter Topology Derived From A Two-Phase Interleaved Boost Converter

The proposed voltage gain is twice that of the interleaved two-phase boost converter. In order to simplify the circuit analysis of the proposed converter, some assumptions are made as follows.

1) All components are ideal components.
2) The capacitors are sufficiently large, such that the voltages across them can be considered as constant approximately.
3) The system is under steady state and is operating in CCM and with duty ratio being greater than 0.5 for high step-up voltage purpose.

The operating principle of the proposed converter can be classified into four operation modes.

1) Mode 1 ($t0 \leq t < t1$ ): For mode 1, switches S1 and S2 are turned ON,D1a,D1b,D2a,D2b are all OFF. The corresponding equivalent circuit is shown in Fig.4.2.1. From Fig.4.2.1, it is seen that both iL1 and iL2 are increasing to store energy in L1

 

and L2, respectively. The voltages across diodes D1a and D2a are clamped to capacitor voltage VCA and VCB, respectively, and the voltages across the diodes D1b and D2b are clamped to VC2 minus VCB and VC1 minus VCA, respectively. Also, the load power is supplied from capacitorsC1 andC2.

2) Mode 2 (t1 ≤ t < t2 ): For this operation mode, switch S1 remains conducting and S2 is turned OFF. Diodes D2a and D2b become conducting. The corresponding equivalent circuit is shown in Fig.4.2.2. It is seen from Fig.4.2.2 that part of stored energy in inductor L2 as well as the stored energy of CA is now released to output capacitor C1 and load. Meanwhile, part of stored energy in inductor L2 is stored in CB. In this mode, capacitor voltage VC1 is equal to VCB plus VCA. Thus, iL1 still increases continuously and iL2 decreases linearly.
3) Mode 3 (t2 ≤ t < t3 ): For this operation mode, as can be observed from Figures, both S1 and S2 are turned ON. The Corresponding equivalent circuit turns out to be the same as Fig.4.2.1.
4) Mode 4 (t3 ≤ t < t4): For this operation mode, switch S2 remains conducting and S1 is turned OFF. Diodes D1a and D1b become conducting. The corresponding equivalent circuit is shown in Fig.4.2.3. It is seen from Fig.4.2.3 that the part of stored energy in inductor L1 as well as the stored energy of CB is now released to output capacitor C2 and load. Meanwhile, part of stored energy in inductor L1 is stored in CA. In this mode, the output capacitor voltage VC2 is equal to VCB plus VCA. Thus, iL2 still increases continuously and iL1 decreases linearly, increases continuously and iL1 decreases linearly.

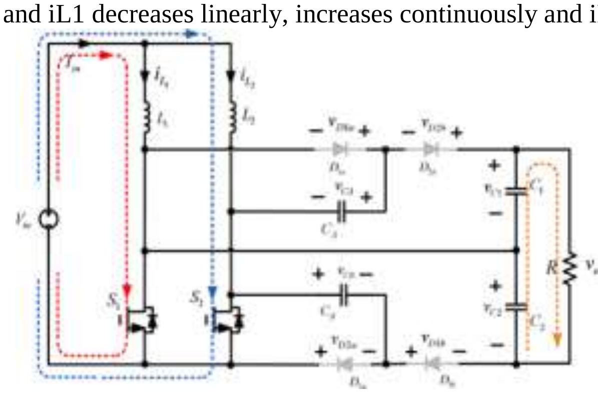

Fig. 4.2.1: When Both Switches $S_1$ & $S_2$ Are Turned On

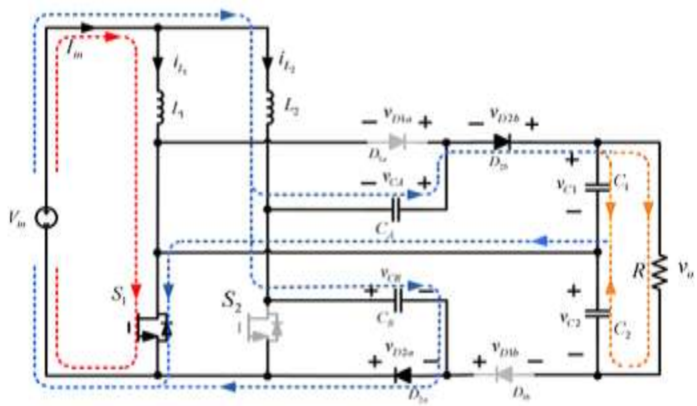

Fig. 4.2.2: When $S_1$ Is Conducting & $S_2$ Is Off

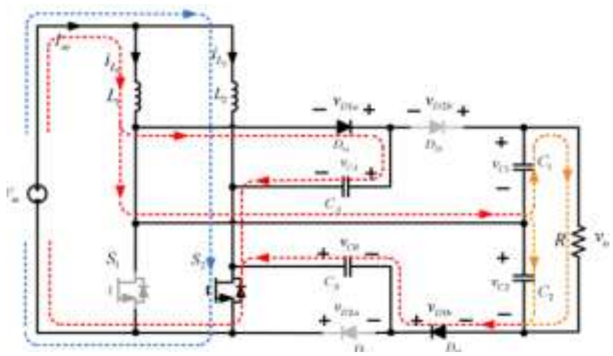

Fig. 4.2.3: When $S_1$ Is Off & $S_2$ Is Conducting

The basic simulated model of base paper voltage quadruple dc-dc converter is shown in below fig.4.3.

 

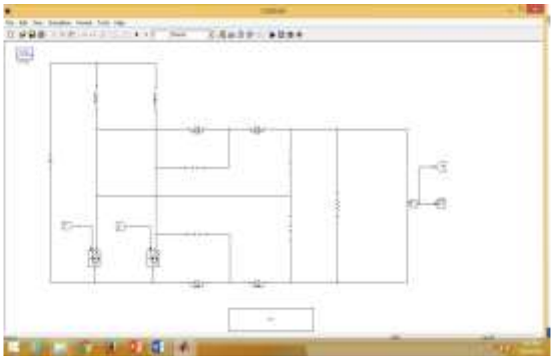

Fig. 4.3: Basic Simulated Model Of Transformer-Less Voltage Quadruple Dc-Dc Converter

Here we applied 25-v input dc value and finally we will get 400-v dc output. This output waveform can be shown in result and discussion part.

In order to increase the output efficiency we use FLC (Fuzzy Logic Controller), by changing the input of the FLC we will get variable output. In the proposed simulated model we use solar system at the input which are having lots of advantages, and also connected a PMSM (Permanent Magnet Synchronous Motor) at the output terminal, which is used for appliance purpose. Fig.4.4 shows the proposed model of transformer less solar-dc converter by using FLC.

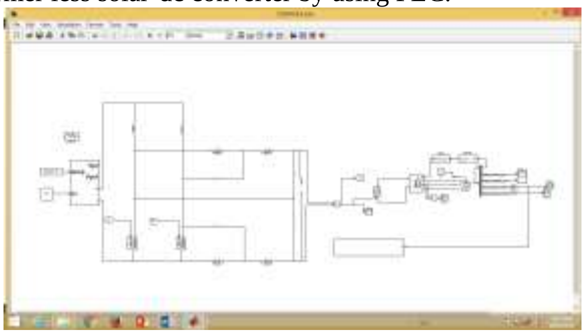

Fig. 4.4: Proposed simulated model Of solar-dc converter by using FLC

## V. RESULT AND DISCUSSIONS

In this converter when we provide solar input then it will produces 440-v dc output at 0.12 sec settling time, whereas in the previous converter when we applied 25-v input dc then we will get 400-v dc output at 0.2 sec settling time. So that we will get more output at less settling time by using proposed converter. This comparison can be shown by the below waveforms which are shown in fig.5.1 and fig. 5.2.

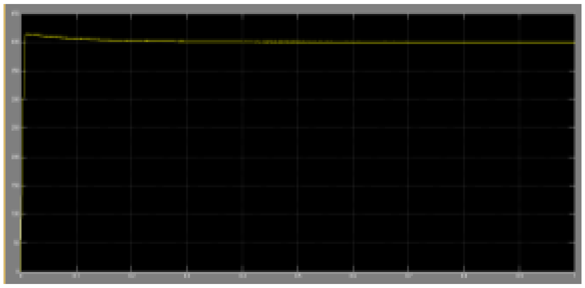

Fig. 5.1: Waveform Of The Output Voltage Of Previous Converter

Fig. 5.2: Waveform Of The Output Voltage Of Proposed Converter

So that from the above comparison we see that the proposed converter is more efficient than previous one.
From the above fig.4.4,we also find the stator current and torque speed of the PMSM motor, which can be shown in the below fig. 5.3 and fig. 5.4.

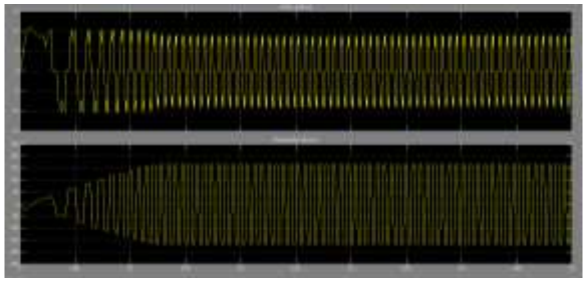

Fig. 5.3: Waveform Of The Stator Current Of PMSM Motor

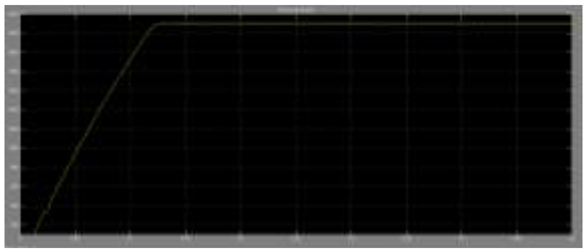

Fig. 5.4: Waveform Of The rotor Speed Of The PMSM Motor

From the above fig the rotor speed calculated is 2300rpm.

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