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A High Step up DC-DC Converter for AC Photovoltaic Module Application

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Abstract:

This project proposes within the photovoltaic (PV) power-generation market, the ac PV module has shown obvious growth. However, a high voltage gain converter is essential for the module's grid connection through a dc–dc inverter. This paper proposes a converter that employs a floating active switch to isolate energy from the PV panel when the ac module is OFF; this particular design protects installers and users from electrical hazards. Without extreme duty ratios and the numerous turns-ratios of a coupled inductor, this converter achieves a high step-up voltage-conversion ratio; the leakage inductor energy of the coupled inductor is efficiently recycled to the load. These features explain the module's high-efficiency performance. The detailed operating principles and steady-state analyses of continuous, discontinuous, and boundary conduction modes are described. A 6 V input voltage, 60 V output voltage prototype circuit of the proposed converter has been implemented; its maximum efficiency is up to 95% and full-load efficiency is 92%.

***Keywords* — Solar panel, Floating switch, DC-DC Converter, PWM.**

I. INTRODUCTION

PHOTOVOLTAIC (PV) power-generation systems are becoming increasingly important and prevalent in distribution generation systems. A conventional centralized PV array is a serial connection of numerous panels to obtain higher dc-link voltage for main electricity through a dc–ac inverter. Unfortunately, once there is a partial shadow on some panels, the system's energy yield becomes significantly reduced energy. The yield loss by shadow effect,

The power capacity range of a single PV panel is about 100 W to 300 W, and the maximum power point (MPP) voltage range is from 15 V to 40 V, which will be the input voltage of the ac module; in cases with lower input voltage, it is difficult for the ac module to reach high efficiency.

However, employing a high step-up dc–dc converter in the front of the inverter improves power-conversion efficiency and provides a stable dc link to the inverter.

When installing the PV generation system during daylight, for safety reasons, the ac module outputs zero voltage. When installation of the ac module is taking place, this potential difference could pose hazards to both the worker and the facilities. A floating active switch is designed to isolate the dc current from the PV panel, for when the ac module is off-grid as well as in the non-operating condition. This isolation ensures the operation of the internal components without any residential energy being transferred to the output or input terminals, which could be unsafe.

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II. BLOCK DIAGRAM

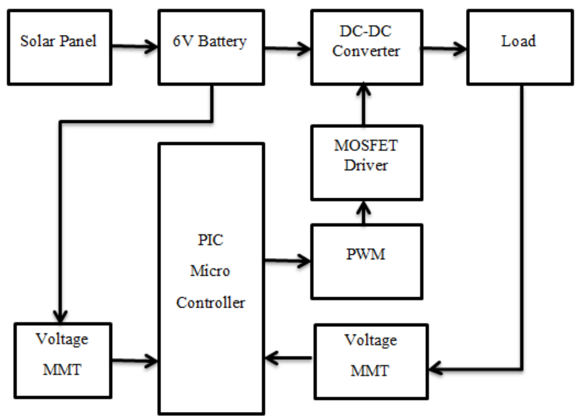

Fig. 1: Block Diagram

III. INPUT SIDE

a) Solar panel

Ac photovoltaic module voltage range is from 15 V to 40 V.

b) Floating switch

A floating active switch is designed to isolate the dc current from the PV panel, for when the ac module is off-grid as well as in the non-operating condition.

IV. OUTPUT SIDE

Constant output voltage

A 6 V input voltage, 60 V output voltage prototype circuit of the proposed converter has been implemented; its maximum efficiency is up to 95.3% and full-load efficiency is 92.3%.

V. EXISTING SYSTEM

Various converters for high step-up applications has included analyses of the switched-inductor and switched-capacitor types transformer less switched-capacitor type the voltage-lift type the capacitor-diode voltage multiplier ; and the boost type integrated with a coupled inductor , these converters by increasing turns ratio of coupled inductor obtain higher voltage gain than conventional boost converter. Some converters successfully combined boost and flyback converters, since various converter combinations are developed to carry out high step-up voltage gain by using the coupled-inductor technique.

Disadvantages:

- The efficiency and voltage gain is less
- parasitic effect of the power switches
- The reverse recovery issue of the diodes.

VI. PROPOSED SYSTEM

The equivalent series resistance (ESR) of the capacitor and the parasitic resistances of the inductor also affect overall efficiency. Use of active clamp technique not only recycles the leakage inductor's energy but also constrains the voltage stress across the active switch, By combining active snubber, auxiliary resonant circuit, synchronous rectifiers, or switched- capacitor-based resonant circuits and so on, these techniques made active switch into zero voltage switching (ZVS) or zero current switching (ZCS) operation and improved converter efficiency. However, when the leakage-inductor energy from the coupled inductor can be recycled, the voltage stress on the active switch is reduced, which means the coupled inductor employed in combination with the voltage-multiplier or voltage-lift technique successfully accomplishes the goal of higher voltage gain.

Advantages:

- Continuous conduction mode
- Low THD
- Less power losses

VII. HARDWARE REQUIREMENTS

The following are the detailed explanation of the hardware used in the project:

- Power MOSFET : IRF840
- Driver IC : IR2112
- Capacitor : 470uF (25V); 1000uF; 4700uF
- Inductor : 100uH; 200uH
- Controller : PIC16F877A
- Regulators : LM7805; LM7812
- Diodes : IN4000; IN5408
- Panel : solar panel

a. PIC Micro-controller:

PIC16F877A Features High-performance RISC CPU 8 K bytes of FLASH Program Memory 368 bytes of Data Memory.

(RAM) 256 bytes of EEPROM Data Memoryo33 I/O pins: (5 ports: A(6), B(8), C(8), D(8) and E(3))o 4-20 MHz operating speed Wide operating voltage range: 2.0V to 5.5V.o Max. 25 mA current from an output pin.

The PIC16F877A features 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPITM) or the 2-wire Inter-Integrated Circuit (I2CTM) bus and a Universal Asynchronous Receiver Transmitter (USART).

High-Performance RISC CPU

- Lead-free; R Ohs-compliant
- Operating speed: 20 MHz, 200 ns instruction cycle
- Operating voltage: 4.0-5.5V
- Industrial temperature range (-40° to +85°C)
- 15 Interrupt Sources
- 35 single-word instructions
- All single-cycle instructions except for program branches (two-cycle)

Special Micro-Controller Features

- Flash Memory: 14.3 K bytes (8192 words)
- Data SRAM: 368 bytes
- Data EEPROM: 256 bytes
- Self-re-programmable under software control
- In-Circuit Serial Programming via two pins (5V)
- Watchdog Timer with on-chip RC oscillator
- Programmable code protection
- Power-saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug via two pins

b. Solar panel:

A solar panel (photovoltaic module or photovoltaic panel) is a packaged interconnected assembly of solar cells, also known as photovoltaic cells.

Solar panels use light energy (photons) from the sun to generate electricity through the photovoltaic effect. The structural (load carrying) member of a module can either be the top layer (superstrate) or the back layer (substrate). The majority of modules use wafer-based crystalline silicon cells or a thin-film cell based on cadmium telluride or silicon. Crystalline silicon, which is commonly used in the wafer form in photovoltaic (PV) modules, is derived from silicon, a commonly used semi-conductor.

- In order to use the cells in practical applications, they must be: connected electrically to one another and to the rest of the system protected from mechanical damage during manufacture, transport, installation and use (in particular against hail impact, wind and snow loads). This is especially important for wafer-based silicon cells which are brittle.
- Protected from moisture, which corrodes metal contacts and interconnects, (and for thin-film cells the transparent conductive oxide layer) thus decreasing performance and lifetime.

c. MOSFET:

The metal-oxide-semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET), is by far the most common field-effect transistor in both digital and analog circuits. The MOSFET is composed of a channel of n-type or p-type semiconductor material (see article on semiconductor devices), and is accordingly called an NMOSFET or a PMOSFET

Here we are using PMOSFET for High Switching Speed. Due to high switching speed the given DC input is converted to related sine wave which is step up through the transformer.

This AC voltage is delivered in the transformer secondary. This AC voltage can be used to drive the AC induction motor. Suppose if you want to drive the DC motor the corresponding AC voltage is rectified through bridge rectifier.

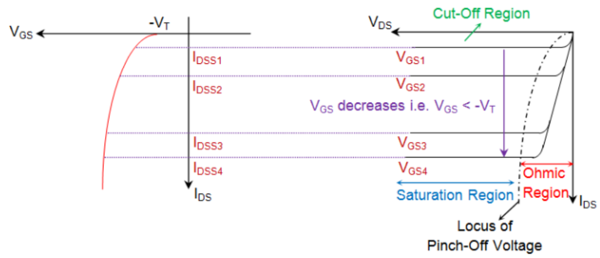

Fig. 2: MOSFET Characteristics

d. DC-DC Converter:

The connection of two pairs of inductors, capacitors and diodes gives a large step-up voltage-conversion ratio. The leakage-inductor energy of the coupled inductor can be recycled. The floating active switch efficiently isolates the PV panel energy during Non-operating conditions.

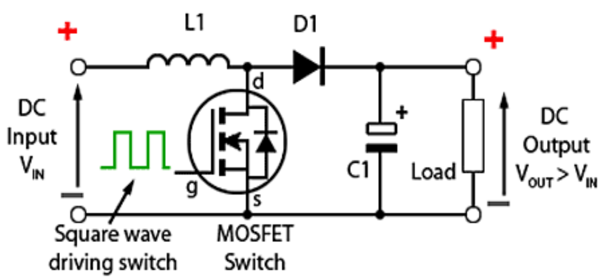

Fig. 3: Schematic Diagram

In this converter there are basically two operations, they are
1) Continuous Conduction Mode of Operation
2) Discontinuous Conduction Mode of Operation

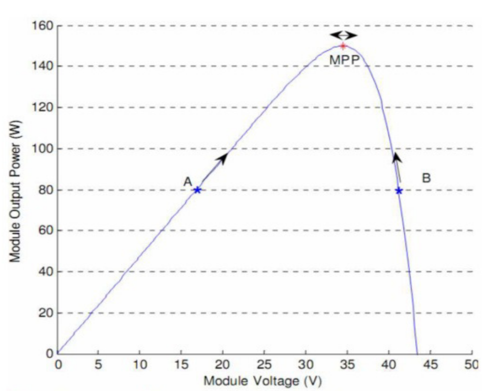

Fig. 4: Characteristics

e. Battery:

Lithium batteries stand apart from other battery chemistries due to their high energy density and low cost per cycle. However, "lithium battery" is an ambiguous term. There are about six common chemistries of lithium batteries, all with their own unique advantages and disadvantages. For renewable energy applications, the predominant chemistry is Lithium Iron Phosphate (LiFePO4). This chemistry has excellent safety, with great thermal stability, high current ratings, long cycle life, and tolerance to abuse.

Here we are using 6V battery to give continuous power supply to the circuit.

CHARGER VOLTAGE SETTINGS (AT 77°F/25°C)				
System Voltage	12V	24V	36V	48V
Daily Charge	14.1 – 14.7	28.2 – 29.4	42.3 – 44.1	56.4 – 58.8
Float	13.5	27	40.5	54

Table 1. Charging Instruction

Fig. 5: 6V 4.5AH Battery

A significant advantage of lithium over lead-acid batteries is that they do not suffer from deficit cycling. Essentially, this is when the batteries cannot be fully charged before being discharged again the next day.

This is a very big problem with lead-acid batteries and can promote significant plate degradation if repeatedly cycled in this manner. LiFePO4 batteries do not need to be fully charged regularly.

This is a very big problem with lead-acid batteries and can promote significant plate degradation if repeatedly cycled in this manner. LiFePO4 batteries do not need to be fully charged regularly.

In fact, it's possible to slightly improve overall life expectancy with a slight partial charge instead of a full charge.

The safety and reliability of lithium batteries is a big concern, thus all assemblies should have an integrated Battery Management System (BMS). The BMS is a system that monitors, evaluates, balances, and protects cells.

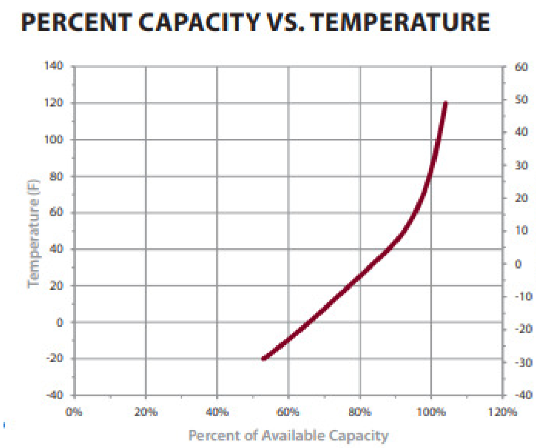

Fig. 6: Battery Characteristics

VIII. WORKING

By taking a continuous feedback from the output side The pic micro controller will change the PWM frequency to the dc to dc converter and make the output as constant by this method shadow effect in that converter

The primary winding N1 of a coupled inductor T1 is similar to the input inductor of the conventional boost converter, and capacitor C1 and diode D1 receive leakage inductor energy from N1. The secondary winding N2 of coupled inductor T1 is connected with another pair of capacitors C2 and diode D2, which are in series with N1 in order to further enlarge the boost voltage. The rectifier diode D3 connects to its output capacitor C . The proposed converter has several features:

1) The connection of the two pairs of inductors, capacitor, and diode gives a large step-up voltage-conversion ratio.
2) The leakage-inductor energy of the coupled inductor can be recycled, thus increasing the efficiency and restraining the voltage stress across the active switch.
3) The floating active switch efficiently isolates the PV panel energy during non-operating conditions, which enhances safety.

IX. RESULTS

Simulation and the output waveform for A High step up DC-DC Converter for AC Photovoltaic module Application is shown in the below figures.

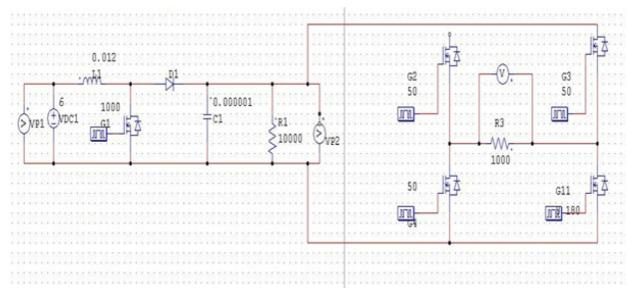

Fig. 6: Simulation for DC-DC Converter

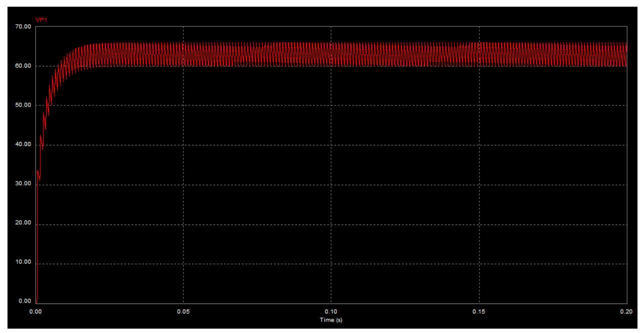

Fig. 7: Voltage Waveform

X. CONCLUSION

Since the energy of the coupled inductor’s leakage inductor has been recycled, the voltage stress across the active switch S1 is constrained, which means low ON-state resistance RDS(ON) can be selected. Thus, improvements to the efficiency of the proposed converter have been achieved. The switching signal action is performed well by the floating switch during system operation; on the other hand, the residential energy is effectively eliminated during the non-operating condition, which improves safety to system technicians. From the prototype converter, the turns ratio n = 5 and the duty ratio D is 55%; thus, without extreme duty ratios and turns ratios, the proposed converter achieves high step-up voltage gain, of up to 13 times the level of input voltage. The experimental results show that the maximum efficiency of 95.3%

is measured at half load, and a small efficiency variation will harvest more energy from the PV module during fading sunlight.

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