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A Dual-Switch Coupled Inductor-Based High Step up DC-DC Converter for Photovoltaic-based Renewable Energy Application

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Abstract –This paper presents a DC-DC boost converter topology for low input and high output voltage applications, such as photovoltaic systems, fuel cell systems, high-intensity discharge lamp (HID), and electric vehicles. The suggested configuration consists of a three-winding coupled-inductor, a single switch and two hybrid voltage multiplier cells. Furthermore, two independent hybrid voltage multiplier cells are in parallel when the single switch S is turned on, and they are in series when the switch S is turned off. So the advantages of the proposed converter structure are summarized as follows: a) A coupled inductor with three windings is introduced in the presented converter structure. The two secondary windings of the coupled inductor are respectively used to form a hybrid multiplier cell on the one hand, on the other hand, it increases the control freedom of the voltage gain, enhances the utility rate of magnetic core and power density, and reduces the stress of power components to provide a stable constant dc output voltage. b) The two hybrid multiplier cells can absorb synchronously the energy of stray inductance, which not only reduces the current stress of corresponding diodes, but also greatly alleviates the spike voltage of the main switch, which improves the efficiency. c) The two hybrid multiplier cells are connected in series to supply power energy for the load, so the voltage gain is extended greatly due to this particular structure.

I. INTRODUCTION

The development of high gain dc-dc converters is important in many applications Such as in uninterrupted power supplies (UPS), the voltage of acid battery is low, however the inverter bus voltage. In the high intensity discharge (HID) lamp ballast system, the dc-dc converter is required to boost the low voltage of the car battery to much higher voltage[1]. Electrical stunning has been used popularly to stun livestock/poultry for alleviating the pain, transforming a low voltage which is safe for person to a high voltage which is enough to stun livestock/poultry. Active-clamp circuits or RCD snubbers can be used to address this issue, but these clamp circuits are complex and costly[2]. In order to achieve high boost conversion ratio with high efficiency, some converters employ the switched-capacitor techniques and the switched-inductor techniques. However, the voltage stress of the switch in these converters are still high, causing serious conduction losses. The diode-capacitor voltage multiplier can be inserted into the conventional boost, sepic, and zeta converters to serve as the built-in voltage gain extension cell. However, several multiplier stages are required to reach a very high voltage gain at the expense of increasing system size and cost, and further, the circuit would be more complex. Recently, some coupled-inductor-based converters have been published in literatures to offer another design freedom rather than the switch duty cycle to satisfy the stringent high step-up voltage gain require. The leakage inductance of the coupled inductor may not only high voltage spikes on the power device when it turns off, but also induce large energy losses. In general, RCD snubbers, which are small networks composed of a resistor, a capacitor and a diode, can control the rate of change of voltage or current and clamp voltage overshoot. So the RCD snubbers are often used to suppress the voltage spike of the switch, but the leakage energy is dissipated. Thus, the converters based on the coupled-inductor technique with an active clamp circuit have also been proposed, However, the number of driven switches increases, resulting in the complexity of the circuit. A passive regenerative snubber has been investigated in reference. The voltage gain of the converter is higher than most converters based on coupled-inductor, and the voltage stresses on all power devices are relatively lower than the output voltage. A single switch high gain converter using a three-winding coupled inductor was proposed. The converter extends the voltage conversion ratio and overcomes the reverse-recovery problem of the output diode, and the leakage energy of coupled inductor can be recycled. This paper proposed a dc-dc boost converter topology based on three-winding coupled-inductor and diode-capacitor technology for high step-up, high power density and high efficiency conversion, which adopts a single switch and two series hybrid voltage multiplier cells. Moreover, two identical passive regenerative snubbers are used for absorbing the energy of stray inductance, clamping the voltage spike of the main switch. Besides, the regenerative snubbers have important role in supplying extra voltage conversion ratio. In laboratory, a prototype circuit with 500W output power was implemented and the simulated and experimental results confirmed the analysis and advantages of the presented topology.

Main highlights of this paper are as follows

- To implement high gain DC-DC boost converter with single switch.
- To reduce the voltage stress across the switch
- To reduce the switching losses in the proposed scheme.

II.PROPOSED SYSTEM

The figure 1 shows the block diagram of the proposed system in mainly consist of a boost coveter with single switch the switch frequency and the duty cycle is controlled by the dspic30f2010 controller. By controlling this the output voltage is booster.

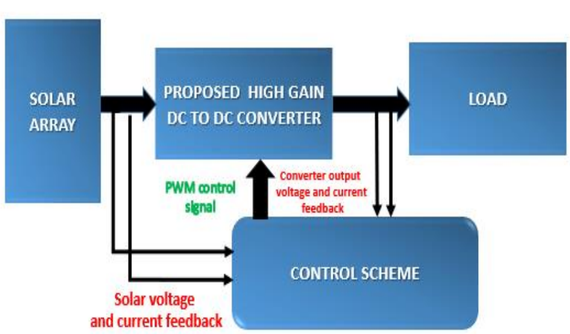

Figure 1: Block Diagram of the proposed topology

The development of the proposed topology is shown in Fig. 2.

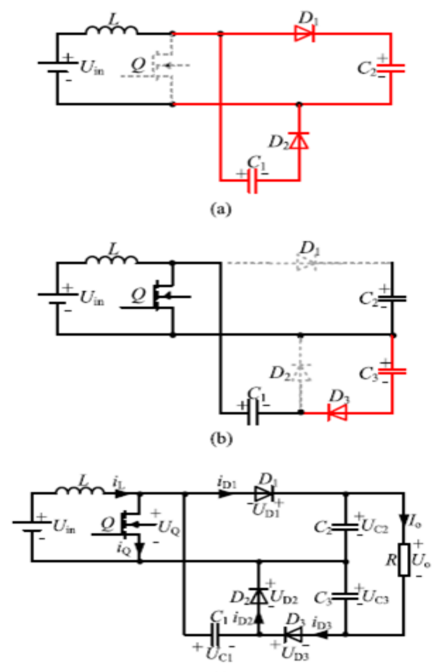

Figure 2: Development of the proposed topology.
(a) Diode-capacitor branches with the common inductor (b) Diode/switch-capacitor branches with the energy transferring (c)Single-switch wide voltage-gain Boost DC-DC converter.

The diode-capacitor branches with the common inductor are in Fig. 2 (a). $D2 - C1$ and $D1 - C2$ are two diode-capacitor modules; they are charged in parallel by the input voltage source Uin and the inductor L. In Fig. 2 (b), $D3 - C3$ is another diode capacitor module, and $Q - C1$ is reconstructed as a switched capacitor module from the diode-capacitor module $D2 - C1$. The energy stored in $C1$ can then be transferred to $C3$ through the active power switch Q and the diode $D3$. Therefore, the total voltage of the output capacitors $C2$ and $C3$ in series is double that of the conventional Boost DC-DC converter. Therefore, a single-switch wide voltage-gain Boost DC-DC converter is created as shown in Fig.2 (c). From Fig. 2(c), it can be seen that the proposed topology is comprised of one inductor, one active power switch and three diode-capacitor modules with $C1 = C2 = C3$. iL is the inductor current of L, iQ is the current through Q, and $iD1$, $iD2$ and $iD3$ are the currents flowing in

*D*1,*D*2 and *D*3, respectively. *U*Qis the blocking voltage across *Q*, *UD1*, *UD*2 and *UD*3 are the voltage stresses across *D*1,*D*2 and *D*3, respectively. *UC*1, *UC*2 and *UC*3 are the voltages across *C*1, *C*2 and *C*3. *U*o is the output voltage, and *I*o is the load current.

III.HARDWARE IMPLEMENTATION

3.1 Power Supply

Power Supply is the device that transfers electric power from a source to a load using electronic circuits. Power supplies are used in many industrial and aerospace applications and in consumer products. Some of the requirements of power supplies are small size, lightweight, low cost, and high-power conversion efficiency.

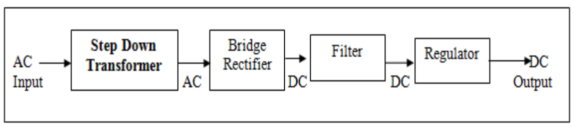

Figure 3: General Block Diagram of Power Supply

In addition to these, some power supplies require the following: electrical isolation between the source and load, low harmonic distortion for the input and output waveforms, and high-power factor (PF) if the source is ac voltage. Some special power supplies require controlled direction of power flow.

3.2 Linear Power Supply

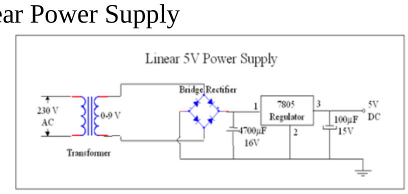

Figure 4: Linear Power Supply Circuit Diagram

A linear power supply is the oldest and simplest type of power supply. In these power supplies, electrical isolation can only be provided by bulky line frequency transformers. The ac source can be rectified with a bridge rectifier to get an uncontrolled dc, and then a dc-to-dc converter can be used to get a controlled dc output. The output voltage is regulated by dropping the extra input voltage across a series transistor (therefore, also referred to as a series regulator).

3.3 Multi Output Power Supply

It is also possible to generate multiple voltages using linear power supplies. In multi output power supply a single voltage must be converted into the required system voltages (for example, +5V, +12V and -12V) with very high power conversion efficiency.

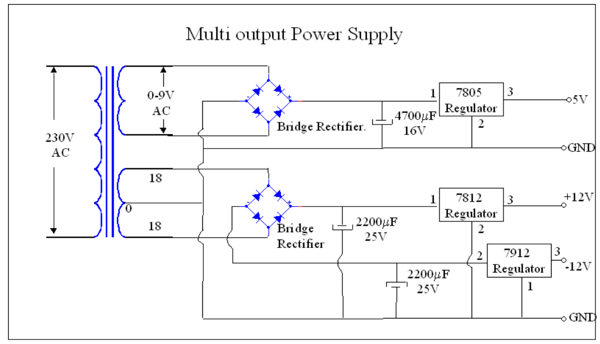

Figure 4: Multi Output Power Supply Circuit Diagram

3.4OPTO COUPLER

The function of Opto Coupler is isolate to the control circuit from power circuit. Pulse width modulation signal (PWM 1 to PWM 12) comes from DSPIC Processor. This signal is not directly fed through a power circuit. Suppose Control Circuit (DSPIC) is connected to power circuit without isolation circuit, the control circuit may get affected. So we need to isolation circuit interface between power circuit and control circuit

3.5OPTO ISOLATOR CIRCUIT DIAGRAM

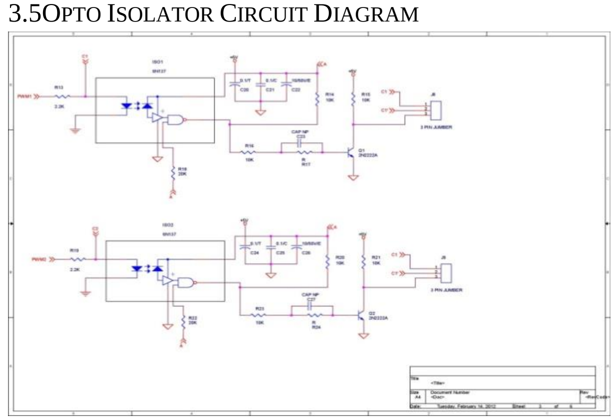

Figure 5: Opto Isolator Circuit Diagram

Pin layout of TLP250 is given below. It is clearly shown in figure that led at input stage and photo detector diode at output stage is used to provide isolation between input and ouput. Pin number 1 and 4 are not connected to any point. Hence they are not in use. Pin 2 is anode point of input stage light emitting diode and pin 3 is cathode point of input stage. Input is provided topin number 2 and 3. Pin number 8 is for supply connection. Pin number 5 is for ground of power supply.

3.7 Motor Contral Pwm Module In Dspic

The dsPIC motor control PWM module is optimized for applications, such as3-phase AC induction motors, 3-phase brushless DC motors, and switched reluctance motors. The motor control PWM module has either 6 or 8 output pins and 3 or 4 PWM generators, depending upon the device.

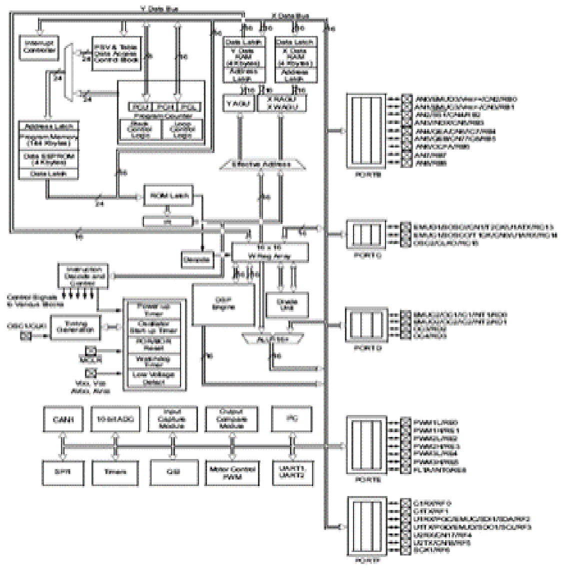

Figure 6: Dspic30f 2010 Architecture Functional Block Diagram

The output pins may be configured as complementary output pairs or as independent outputs. Critical PWM operating parameters, such as output polarity, are programmed in non-volatile memory for safety. The non-volatile options.

3.8 MOSFET

The MOSFET (Metal Oxide Semiconductor Field Effect Transistor) transistor is a semiconductor device which is widely used for switching and amplifying electronic signals in the electronic devices. The MOSFET is a core of integrated circuit and it can be designed and fabricated in a single chip because of these very small sizes. The MOSFET is a four terminal device with source(S), gate (G), drain (D) and body (B) terminals. The body of the MOSFET is frequently connected to the source terminal so making it a three terminal device like field effect transistor. The MOSFET is very far the most common transistor and can be used in both analog and digital circuits. he MOSFET works by electronically varying the width of a channel along which charge carriers flow (electrons or holes). The charge carriers enter the channel at source and exit via the drain. The width of the channel is controlled by the voltage on an electrode is called gate which is located between source and drain. It is insulated from the channel near an extremely.

3.9 IRF840 MOSFET

IRF840 is rated for 8a, 500v, 0.850 ohm, n-channel power mosfet this n-channel enhancement mode silicon gate power field effect transistor is an advanced power mosfet designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation. all of these power mosfets are designed for applications such as switching regulators, switching converters, motor drivers, relay drivers, and drivers for high power bipolar switching transistors requiring high speed and low gate drive power. these types can be operated directly from integrated circuits. Formerly developmental type TA17425.

IV RESULTS AND DISCUSSION

The hardware implementation of the proposed topology is shown in figure 7.

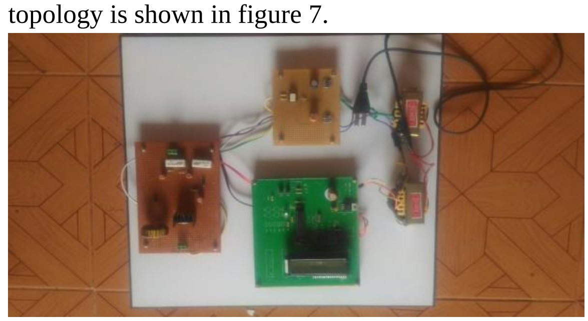

Figure 7:Hardware kit

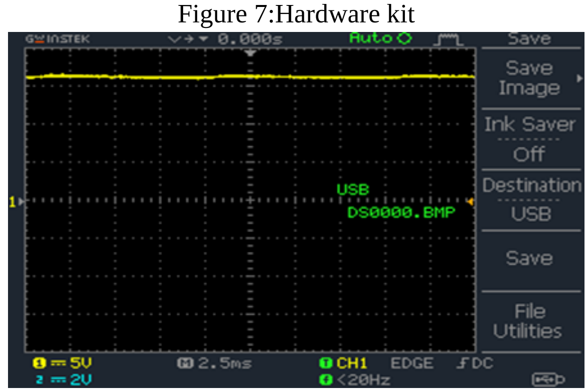

Figure 8: Input Dc Voltage

The input and output voltage waveforms is shown in figure 8 and 9. The output voltage with 10% duty cycle is shown in figure 9.

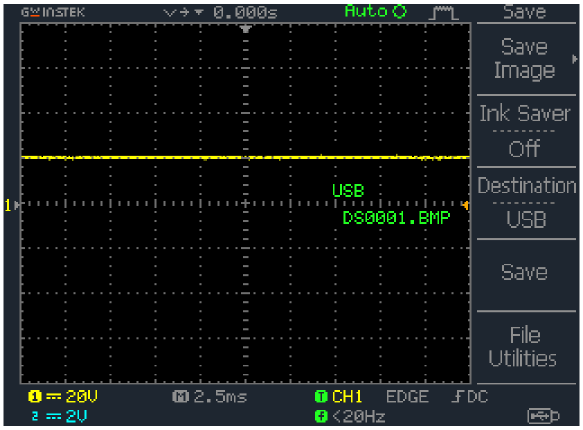

Figure 9: Output Dc voltage At 10% Duty Cycle

V CONCLUSION

A single-switch Boost DC-DC converter with a wide voltage gain range is proposed in this paper. It employs one active power switch and less number of inductors and capacitors to operate over a wide voltage-gain range with the appropriate duty cycle. In addition, the voltage stress across all the semiconductors is as low as 1/n of the output voltage, and the potential difference between the input and the output grounds is constant. It is suitable for the power interface of fuel cell vehicles.

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