SOFT SWITCHING BOOST CONVERTER OPERATION USING PUSH-PULL TOPOLOGY

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ABSTRACT

A new soft switching boost converter is proposed in this paper. The conventional boost converter generates switching losses at turn ON and turns OFF, and this causes a reduction in the whole system's efficiency. The proposed boost converter utilizes a soft switching method using an auxiliary circuit with a resonant inductor and capacitor, auxiliary switch and diodes. Therefore, the proposed soft switching boost converter reduces switching losses more than the conventional hard switching converter. The efficiency which is about 91% in hard switching increases to about 97% in the proposed soft switching converter using proposed method work on efficiency and switching speed for different solar applications.

Key words: Boost converter, soft switching, efficiency

I. INTRODUCTION

Boost converter is a DC to DC power converter. This converter is Capable of giving higher voltages at the load than the input voltage, so Boost converter is called Step up chopper**.** Boost converter contains at least two semiconductors (a diode and a transistor) and at least one energy storage element (a capacitor , inductor or the two in combination).

The main working principle of boost converter is that the inductor in the input circuit resists sudden variations in input current. When switch is OFF the inductor stores energy in the form of magnetic energy and discharges it when switch is closed. The capacitor in the output circuit is assumed large enough that the time constant of RC circuit in the output stage is high. The large time constant compared to switching period ensures a constant output.

Problems of Hard-Switching

- Switching losses
- Device stress, thermal management
- EMI due to high di/dt and dv/dt
- Energy loss in stray L and C

Possible Solutions (combination)

1.Snubbers to reduce di/dt and dv/dt
- usually no change in losses (unless loss recovery)

2. Circuit layout to reduce stray inductances
3. Gate drive
- circuit layout
- turn on / off speeds

4. Soft switching to achieve ZVS and/or ZCS

Soft switching technique

The term “soft switching” is actually defined as “The operation of power electronic switches as Zero voltage switches (ZVS) or Zero current switches (ZCS). Soft switching is a convenient alternative of reducing losses in switches of Power electronics. We can get reduced switching losses and stress occurred in switch. The thermal operation gets easy and possibly low values of EMI can be achieved.
It is done by two methods:

Zero Voltage Switching (ZVS)
Zero Current Switching (ZCS)

Advantages of soft switching

- Lower losses (may be!)
- Allows high frequency operation
- Low EMI (may be!)

Single Output Primary soft switching Push Pull converter

Resonance is introduced in the primary switching circuit of the puh-pull converter to reduce the switching losses in hard switched converters operating at high frequencies. Soft switching push-pull converters used for powering applications like CMOS circuits, TTL logic circuits, robotic arm motor.

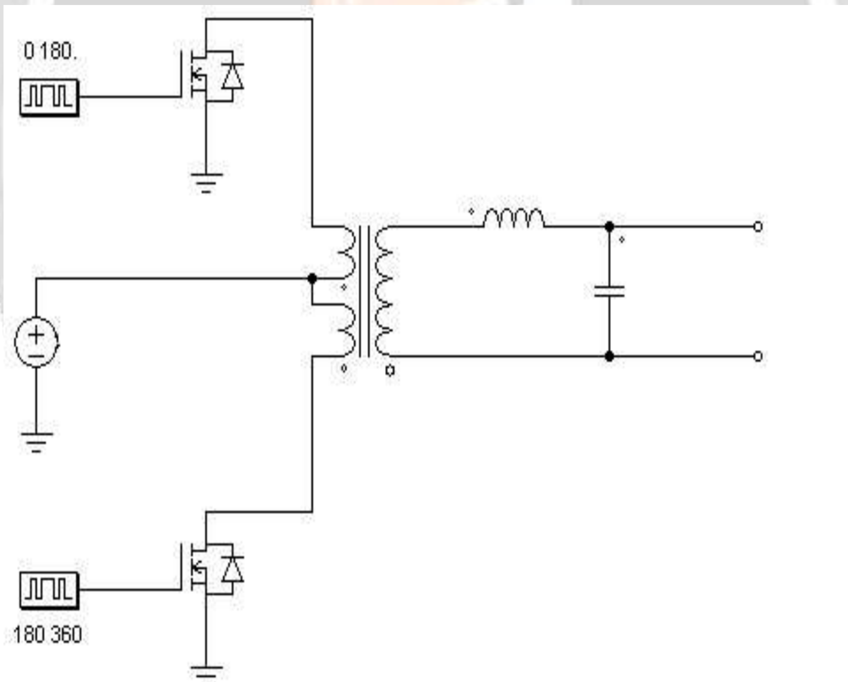

Figure: 1 – Proposed Push-pull topology to be used in boost converter operation

The operation of the converter is explained in 6 modes. The assumptions made are:

- All semiconductor switches are ideal
- Magnetizing inductance is larger than resonant inductor
- Analysis is carried out at steady state

- Lossless capacitors and inductors
- Supply and load are maintained constant
- Output filter capacitor value is assumed to be larged

II. RELATED WORK

Now-a-days using increased switching frequencies are a better way to get efficient output in DC-DC converters. The advancements in technology of semiconductor fabrication is the reason behind the significant improvement in not only the capabilities of voltage and current but also the switching. The faster semiconductors working at high frequencies result in the passive components of converters like capacitors, inductors and transformers becoming smaller thereby reducing the total size and weight of the equipment and hence to increase power density.

In [1] a modular switched capacitor (SC) dc-dc converter based electrical drive system for battery electric vehicles is presented. It is noticed that due to high energy density of capacitors, SC converters can enable improved power density compared to conventional inductor based power- converters. From the results of this paper, it is shown that the SC converter topology based system is more efficient at heavy load. The SC converters reduce hardware space required. No additional cooling equipment is necessary.

In [2] it represents a new design procedure for a bidirectional DC-DC LCL converter for potential MW range applications. Instead of a traditional high frequency transformer, two DC/AC converters and a passive LCL filter is used. By using soft switching operation, switching losses are minimized. Robust and stable operation by this proposed system. The main objective was to achieve higher voltage-step ratio to impose a strict limit on the capacitor voltage, to limit the fault currents and to propose a simple and effective way to control the LCL DC-DC converter.

In [3] It is shown that with the advent of SiC technology, MOSFET ON-state resistance is reduced drastically. MOSFET device manufacturing for higher voltage and current has been encouraging. Due to wider band gap of silicon carbide compared to Silicon (Si), MOSFET made in SiC has considerably lower drift region resistance.

In [4] a detailed experimental hard switching characteristics of 15 kV SiC MOSFET is presented. These high voltage SiC devices enable simple two level converters for medium voltage (MV) voltage source converter topology. This paper shows the switching loss comparison of 15 kV SiC MOSFET with 15 kV SiC IGBT for the same dv/dt condition.

In [5] the paper presents a high gain dc-dc converter which is derived from a traditional SEPIC (single-ended primary-inductor) converter. These distributed generation systems are powered by sources such as fuel cell, photovoltaic (PV) systems and batteries. This consists of two conversion stages, in the first stage the low level voltage from the PV cell is converted to high level voltage by using a dc-dc converter. In the second stage the high level dc voltage is converted into AC voltage by using inverter. The main advantage of the SEPIC converter is continuous input current, which can be helpful in accurate PowerPoint tracking of solar cell The inductor less regenerative snubber that reduces switching losses and helps to attain soft switching (zero voltage and zero current

III. SIMULATION ENVIRONMENT AND RESULT ANALYSIS

Closed loop Hard switching Boost converter circuit uing Push-pull topology

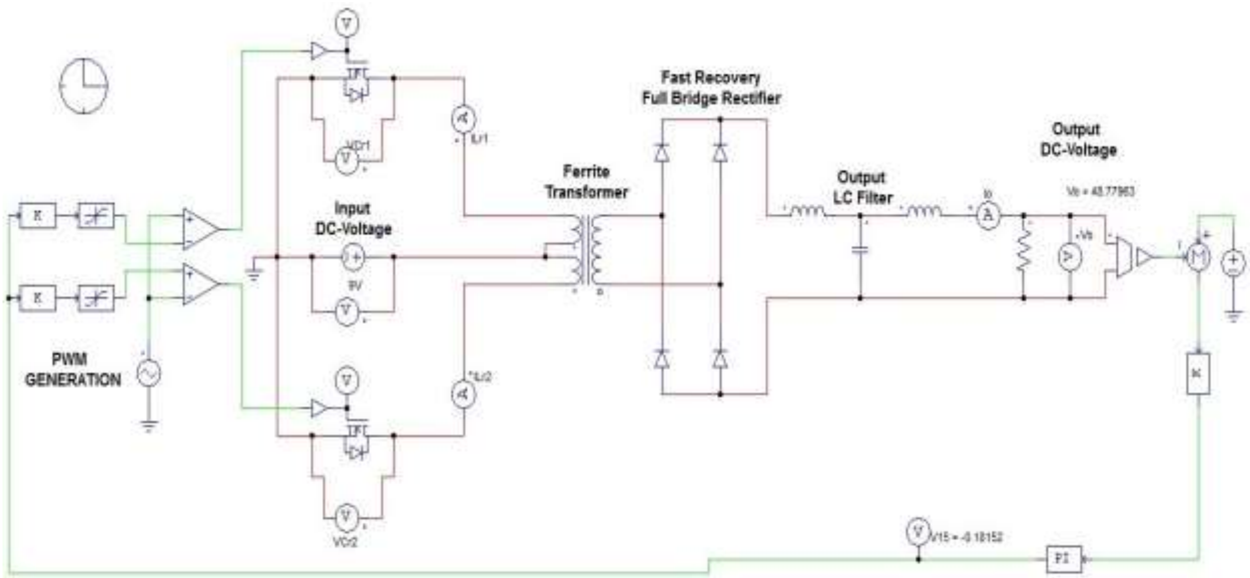

Figure: 2 – closed loop circuit of hard switching operation of boost converter using push-pull topology

Input side waveforms

Figure: 3- Input side waveforms

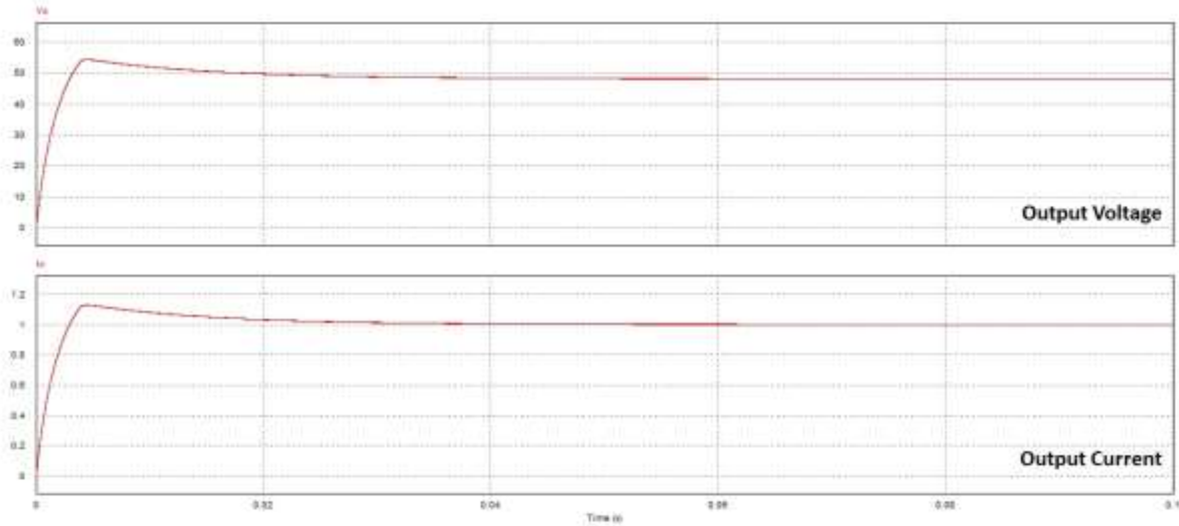

Figure: 4 – Output side waveforms

Closed loop soft switching Boost converter circuit uing Push-pull topology

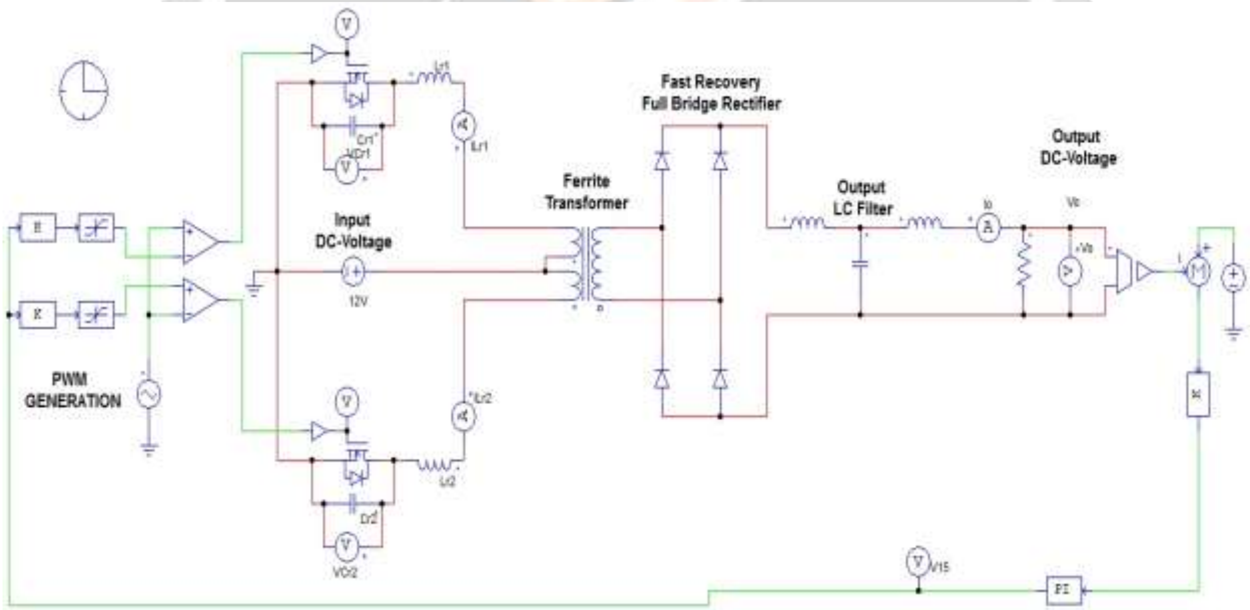

Figure:5 - closed loop circuit of soft switching operation of boost converter using push-pull topology

Input side waveforms

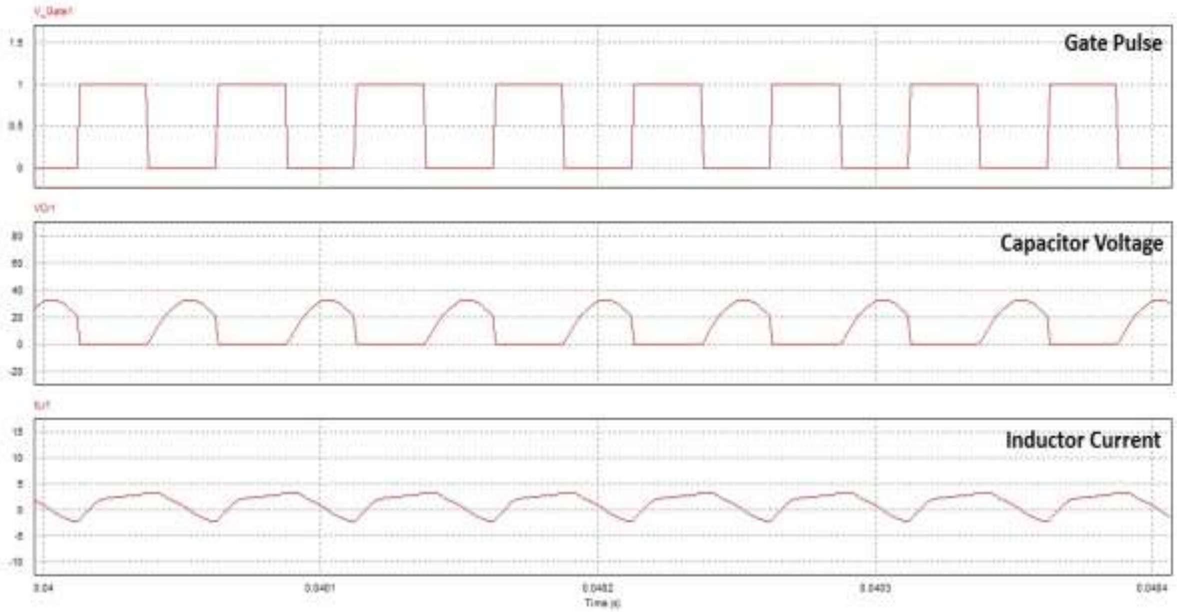

Figure: 6 – Input side waveforms

Output side waveforms

Figure: 7 – output side waveforms

IV. Hardware Testing

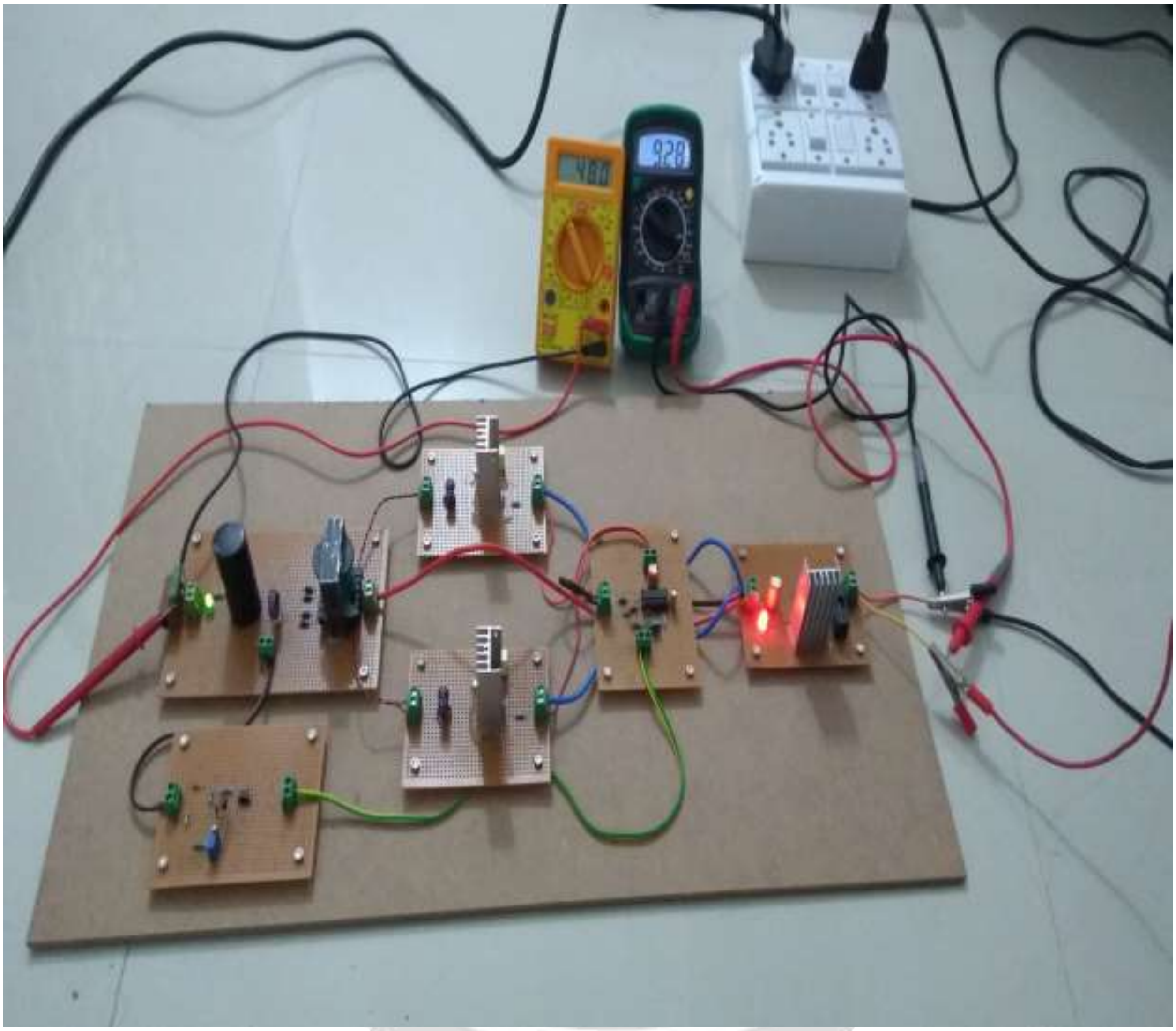

Figure: 8 – Hardware circuit testing

- IRFZ44N MOSFET is used in the circuit
- Input = 9 V
- Output = 48 V
- Resonance capacitance = 0.1 µF
- Resonance inductor = 10 µF
- Resonance frequency = 60 kHz

V. Conclusion

From this analysis it is concluded that the overall output performance of boost converter circuit using push-pull topology can be improved using soft switching technique. The operation of the circuit gets smoother and faster by operating the power semiconductor switches at zero Voltage Switching (ZVS) or Zero Current Switching (ZCS).

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