

High Efficiency DC-DC Boost Converter Using Solar Energy (PV) System

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Abstract- In this paper, conventional boost converter and high efficiency dc-dc boost converter have been taken and designed for solar energy (PV) system. The performance of two dc-dc boost converter topologies in terms of efficiency to the stand-alone PV system application has compared. It has found that the proposed improved boost converter better efficiency than the conventional boost converter. A MATLAB / SIMULINK based model is developed for high efficiency dc-dc boost converter and simulation results are presented.

Keywords- Conventional boost converter, proposed improved boost converter, Photovoltaic (PV) Solar Energy System, MATLAB / SIMULINK.

I. INTRODUCTION

In present Electricity market Renewable Energy Sources (RES) are gaining their importance. The most common Renewable Energy Sources are Photo voltaic (PV), fuel cell (FC) and wind energy systems. PV systems can implement in most of the locations.[1] Due to the critical condition of industrial fuels which include oil, gas and others, the development of renewable energy sources is continuously improving. This is the reason why renewable energy sources have become more important these days. Few other reasons include advantages like abundant availability in nature, eco-friendly and recyclable. Many renewable energy sources like solar, wind, hydel and tidal are there. Among these renewable sources solar and wind energy are the world's fastest growing energy resources. With no emission of pollutants, energy conversion is done through wind and PV cells.

Renewable energy sources with low output voltage, such as the fuel cell stacks and photo-voltaic (PV) generation system, have received a great attention in research fields because they appear to be the possible solutions to the environmental problems [2]-[4].

DC-DC converters are an important component as power electronics interfaces for photovoltaic generators and other renewable energy sources. Most renewable power sources, such as photovoltaic power systems and fuel cells, have quite low-voltage output and require series connection or avoltage booster to provide enough voltage output [5]-[8].

Boost converters are popularly employed in equipments for different applications, as pre-regulators or even integrated with the latter-stage circuits or rectifiers into single-stage circuits [9]-[11].

1.1 DC-DC Converter

A dc/dc converter is an electronic circuit that converts a source of dc from one voltage level to another. Power levels range from very low (batteries) to very high level (high-voltage power transmission). The most common DC/DC converters encountered in low power applications cannot be extended to high power transmission application due to poor performances those converters exhibit. High step-up dc/dc converter involves the following requirements as high step-up voltage gain, low input current and output voltage ripple, high current handling capability and high efficiency. DC-DC converters are mainly classified into isolated converters and non-isolated converters [12].

1.2 Boost Converter

A boost converter is a switch mode dc to dc converter in which the output voltage is greater than the input voltage. It is also called as step up converter. By the law of conservation of energy, the input power has to be equal to output power. The main working principle of boost converter is that the inductor in the input circuit resists sudden variations in input current. When switch is ON, the inductor stores energy in the form of magnetic energy and discharges it when switch is open. The capacitor in the output circuit is assumed large enough that the time constant of RC circuit in the output stage is high [12].

Figure 1 shows a typical block diagram of a standalone PV system.

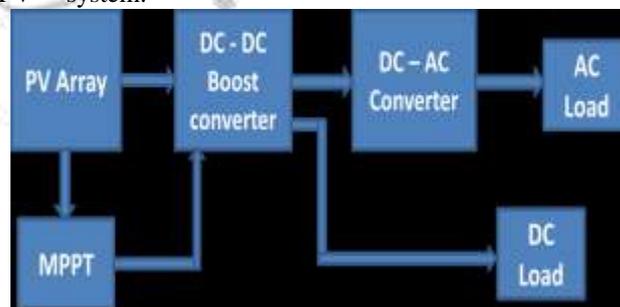


Figure 1: Typical block diagram of a standalone PV system.

In stand-alone PV system applications, it is of much importance that maximum power is extracted from the solar panel and delivered to the load whenever possible. For this reason, a dc-dc power electronic converter is incorporated into the system such that the load is connected to the solar panel through it, controlled by a Maximum Power Point Tracking (MPPT) algorithm. Unfortunately, in practice, the efficiency of the power electronic converter stage is heavily dependent on the operating point of the solar panel which is mainly determined by solar irradiation and temperature

[13]. Nature decides whenever irradiation and temperature changes, hence the output power of the solar panel might change at any time.

Due to the non-linear nature of the PV output power, it is of essential that its maximum power which can be obtained from it is tracked at all times and fed to the load. An MPPT is used for tracking the PV maximum power under any operating condition and the dc-dc boost converter is used to step up the voltage and fed to the load. The two main types of dc-dc converter topologies that are predominantly employed in stand-alone PV system are the conventional dc-dc boost converter and interleaved dc-dc boost converter.

One of the two dc-dc boost converters aforementioned offer better efficiency under weak operating point of the solar panel, whilst the other offer improved efficiency under strong operating point of the solar panel [13]. The standalone PV system developed can be used to power TVs, Compact Disc (CD) players, Laptops, etc.

The classification of high efficient dc-dc converters has shown below:



Figure 2: Efficient DC-DC Converters

II. DESIGN OF A DC-DC BOOST CONVERTER

In a boost converter, the output voltage is greater than the input voltage – hence the name “boost”. A boost converter using a power MOSFET is shown below:

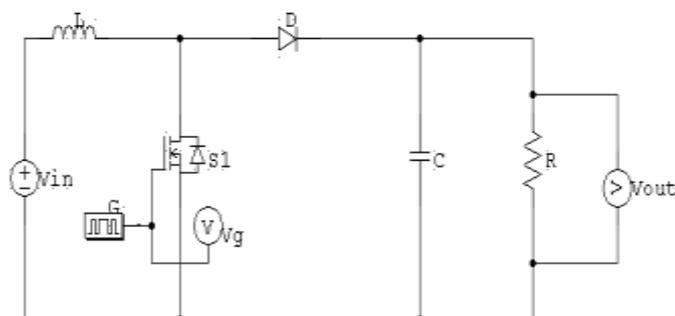


Figure 3: Circuit diagram of Conventional Boost Converter

Power for the boost converter can be taken from any suitable DC sources, such as DC generators, batteries, solar panels and rectifiers. The method that changes one DC voltage to a different DC voltage is called DC to DC conversion. Generally, a boost converter is a DC to DC converter with an output voltage greater than the source voltage. It is sometimes called a step-up converter since it “steps up” the source voltage. Since power ($P = V I$) must be conserved, the output current is lower than the source current. [2]

For high efficiency, the SMPS switch must turn on and off quickly and have low losses. The advent of a commercial semiconductor switch in the 1950s represented a major milestone that made SMPSs such as the boost converter possible. The major DC to DC converters were developed in the early 1960s when semiconductor switches had become available. The aerospace industry’s need for small, lightweight, and efficient power converters led to the converter’s rapid development.

Switched systems such as SMPS are a challenge to design since their models depend on whether a switch is opened or closed. R. D. Middle brook from Caltech in 1977 published the models for DC to DC converters used today. Middle brook averaged the circuit configurations for each switch state in a technique called state-space averaging. This simplification reduced two systems into one. The new model led to insightful design equations which helped the growth of SMPS. [2]

The function of boost converter can be divided into two modes, Mode 1 and Mode 2. Mode 1 begins when transistor M1 is switched on at time $t=0$. The input current rises and flows through inductor L and transistor M1.

Mode 2 begins when transistor M1 is switched off at time $t=t_1$. The input current now flows through L, C, load, and diode D. The inductor current falls until the next cycle. The energy stored in inductor L flows through the load.

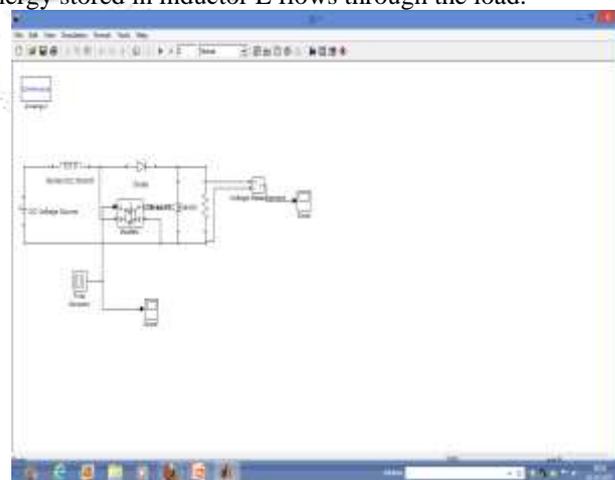


Figure 4: Circuit diagram of boost converter

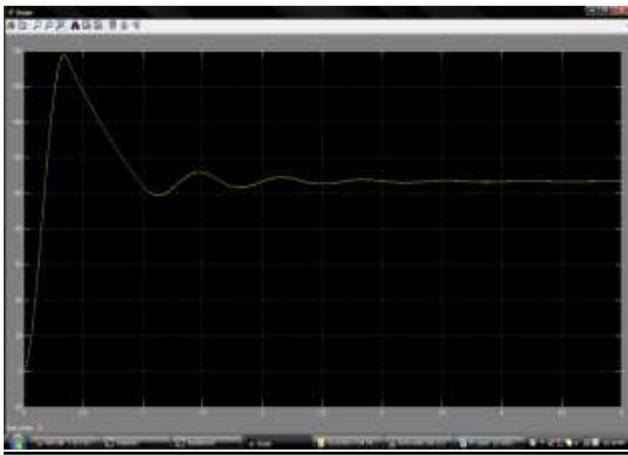


Figure 5: Simulation result of circuit diagram of boost converter

III. DESIGN OF A DC-DC BASIC PROPOSED BOOST CONVERTER

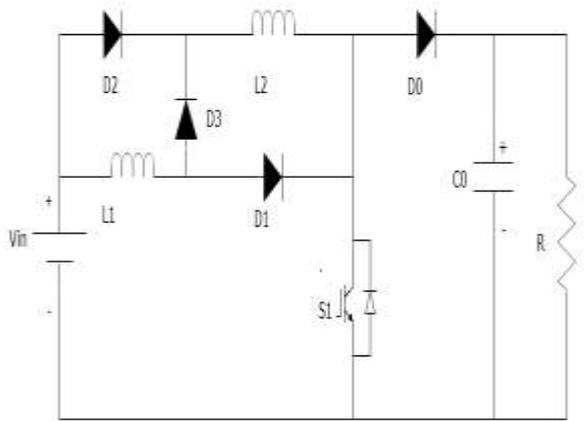


Figure 6: Basic proposed boost converter

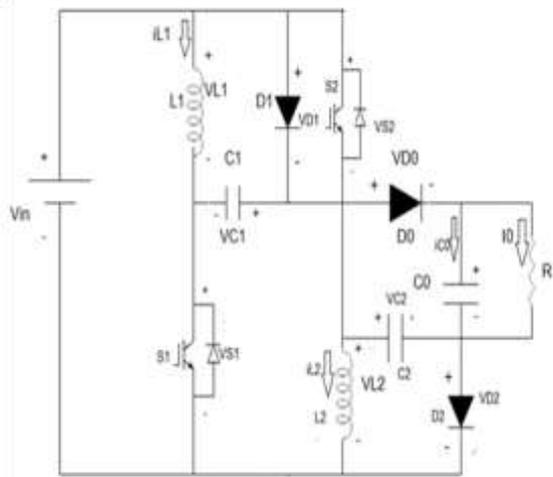


Figure 7: The circuit diagram of improved topology

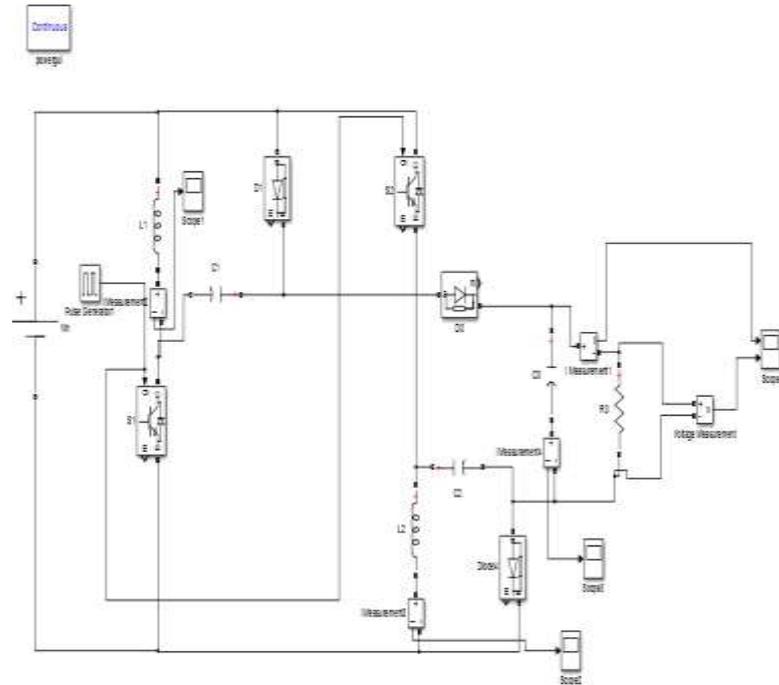


Figure 8: Simulink circuit diagram of improved boost converter topology

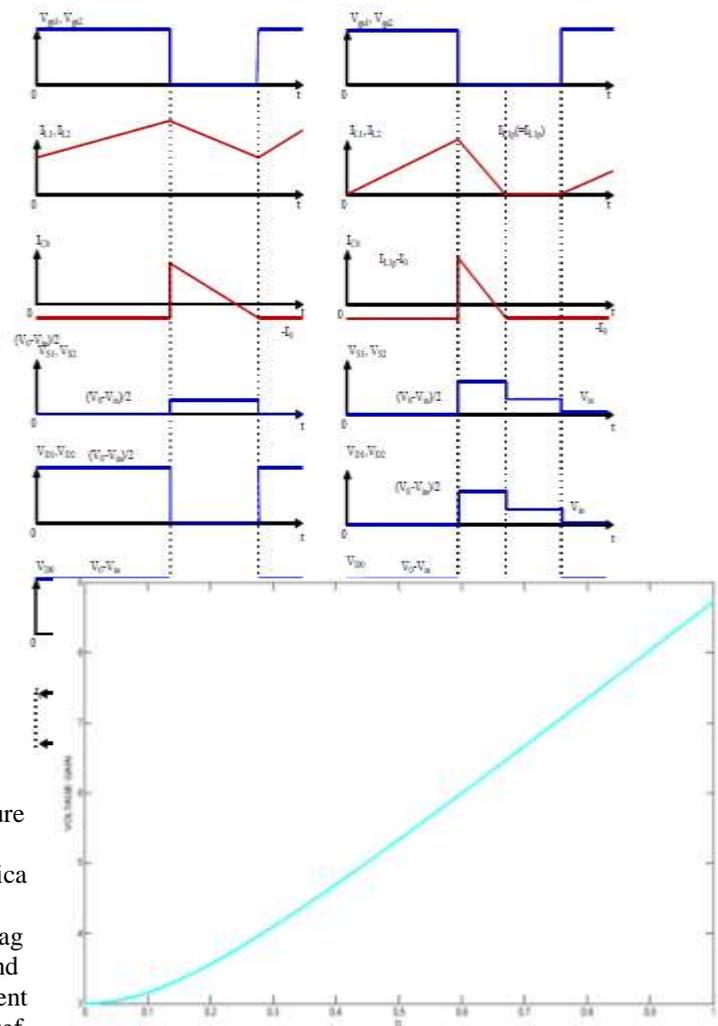


Figure 8: Typical voltage and current wavef

orm for improved topology

IV. SIMULATION RESULT & ANALYSIS

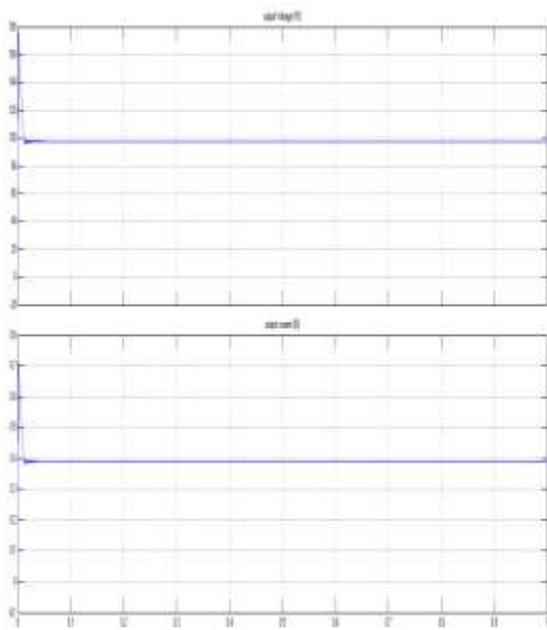


Figure 9: Output Voltage and Current of improved proposed boost topology

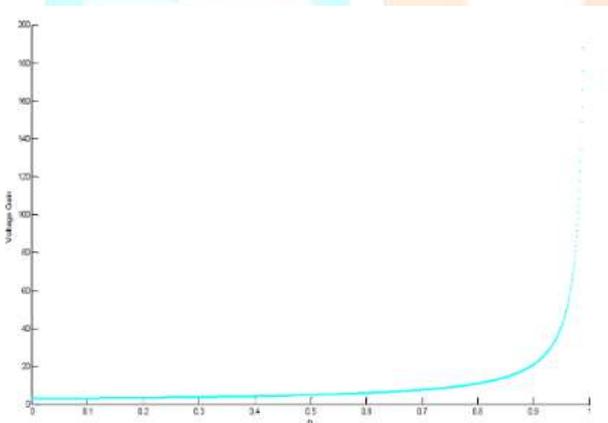


Figure 10: Voltage Gain versus Duty Cycle for the improved Topology in the CCM of the improved topology

Figure 11: Voltage Gain versus Duty Cycle for the improved Topology in the DCM of the improved Topology

Table 1: Comparison with Different Duty Cycle of Improved Proposed Boost Converter

Duty cycle	Vin	Iin	Vout	Iout	Pin	Pout	Efficiency(%)
0.1	12	1.21	37.89	0.155	14.5	5.87	40.54
0.2	12	1.36	41.2	0.172	16.35	7.09	43.38
0.3	12	1.38	45.33	0.18	16.5	8.16	48.98
0.4	12	1.39	50.9	0.21	16.66	10.89	64.8
0.5	12	1.6	58.93	0.24	19.23	14.14	73.5
0.6	12	1.95	70.43	0.29	23.4	20.42	87.9
0.7	12	3.04	91.32	0.37	36.5	33.79	92.7
0.8	12	6.45	130.9	0.55	77.4	71.99	93.8
0.9	12	21.1	251.33	0.99	255.7	248.8	97.3

This comparison chart shows that the efficiency is increasing with varying duty cycle of improved proposed boost topology.

V. CONCLUSION

The simulation result of conventional boost converter and improved proposed boost converter has been shown. The result of improved proposed boost topology has improved efficiency with increasing duty cycle. A study of high efficiency dc-dc boost converter has completed with improving efficiency as shown in the table.

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