Design & Implementation of Boost Converter for PV Cell

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Abstract— In many technical applications, it is required to translate a set voltage DC source into a variable-voltage DC output. A DC-DC switching converter converts voltage straight from DC to DC and is simply recognized as a DC Converter. A DC converter is equivalent to an AC transformer through an incessantly variable turn's ratio. It can be used to step down or step up a DC voltage source, because a transformer. DC converters are widely used for traction motor control in electric automobiles, trolley cars, marine hoists, forklifts trucks, and mine haulers. They supply high efficiency, good acceleration control and fast dynamic response. They can be used in regenerative braking of DC motors to return energy back into the supply. This attribute results in energy savings for transportation systems with frequent steps. DC converters are used in DC voltage regulators; and also are used, with an inductor in conjunction, to generate a DC current source, specifically for the current source inverter.

Key words: Boost Converter, Coupled Inductor, Parallel Capacitor, High Voltage Gain

I. INTRODUCTION

High step up dc-dc converters are used in many applications, such as renewable energy conversion, uninterruptible power supplies (UPS) and high intensity discharge lamp for automobile headlamps. A basic boost converters can achieve high step up voltage gain with an extremely high duty ratio [1]-[2], but extremely high duty ratio results in a serious reverse recovery problem. A dc-dc flyback converter [3] is a very simple structure with a high step up voltage gain, but the active switch of this converter will suffer a high voltage stress due to the leakage inductance of the transformer. A dc–dc flyback converter is a very simple structure with a high step-up voltage gain and an electrical isolation, but the active switch of this converter will suffer a high voltage stress due to the leakage inductance of the transformer. Literature includes some research of the transformer less dc–dc converters, which include the cascade boost type, the quadratic boost, [4]- [5], however these types are all Complex. This paper proposes a transformer less dc-dc converter the high step up voltage gain can be achieved by switched inductor technique without an extremely high duty ratio and with reduced voltage stresses in the active switches. The boost converter is shown in fig.1. The Voltage stress in the active switch S is equal to the output voltage and the duty ratio is high. The structure of this converter is very simple. Several soft-switching techniques, gaining the features of zero-voltage switching (ZVS) or zero-current switching (ZCS) for DC-DC converters, have been proposed to substantially reduce switching losses, hence, attain high efficiency at increased frequencies. There are many resonant or quasi-resonant converters with the advantages of ZVS or ZCS [7]. The main problem with these kinds of converters is that the voltage stresses on the power switches are too high in the resonant converters. Passive snubbers achieving ZVS are attractive [3]-[4], since no extra active switches are needed, and therefore, feature a simpler control scheme and lower cost. Converters with interleaved operation are fascinating techniques nowadays. An interleaved converter with a coupled winding is proposed to provide a lossless clamp [5]. Additional active switches are also appended to provide soft -switching characteristics. These converters are able to provide higher output power and lower output ripple

II. RESEARCH OBJECT

Efficiency, size, and cost are the primary advantages of switching power converters when compared to linear converters. The switching power converter efficiencies can run between 70- 80%, while linear converters are frequently 30% efficient. The DC-DC Switching Boost Converter is designed to make available an efficient method of taking a given DC voltage supply and boosting it to a needed value.

III. PHOTOVOLTAIC SYSTEM & EFFICIENT BOOST CONVERTER CIRCUIT CONFIGURATION

Solar cells produce current when sunlight falls on them. In this paper the solar cell is simulated for whichever ambient temperature, sun light intensity and other internal parameters. A corresponding circuit is developed for easy analysis of solar cell. The PV cell is electrical device, which produces electrical power when exposed to sunlight and they are connected to boost converter. In proposed model the current is considered as controlled constant current source, and the voltage changes based on the irradiation level. So the equivalent model contains a constant current source. The equivalent model is shown in Fig 1.

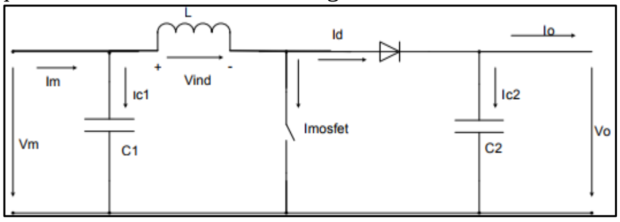

Fig. 1: Boost Converter Model [2]

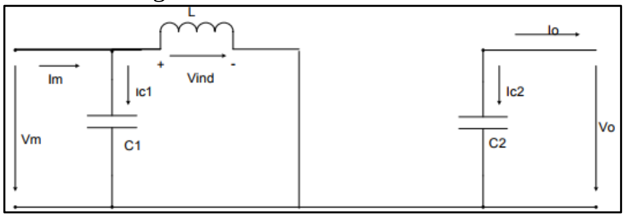

Fig. 2: Equivalent Circuit Of A Boost Converter At "On Mode"[2]

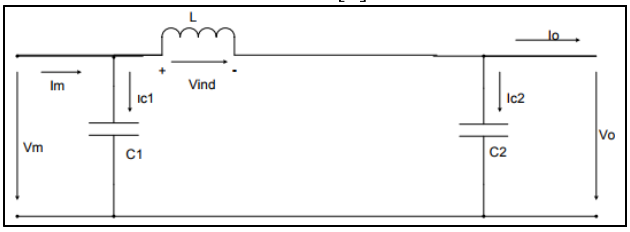

Fig. 3: Equivalent Circuit of a Boost Converter at "Off Mode"[2]

Function of switch position. Shown in figure 4.9[5] When the switch is in "on mode" and operating at t = ton= DTs, the input current rises and flows through inductor L and the switch. The magnetic energy stored in the inductor can build up. The output stage is completely isolated because the diode is reverse biased, as shown in Figure 4.8. When the switch is in "off mode", at t = toff = D'Ts, the current flowing through the switch will now flow through towards the output stage because the diode becomes forward biased, as seen in Figure Moreover, the energy stored in the inductor will be released to the load The boost converter plays very important role as it varies the PV array terminal voltage with the change of the duty cycle. The duty cycle will be determined depending on the signal of the maximum power point tracker whether it is P&O as it is discussed in the following sections Output capacitor. Buck converters are commonly used when the input voltage is too high and needs to be lowered to an appropriate level. A step down converter produces a lower average output voltage than the DC input voltage $V_{d.}$

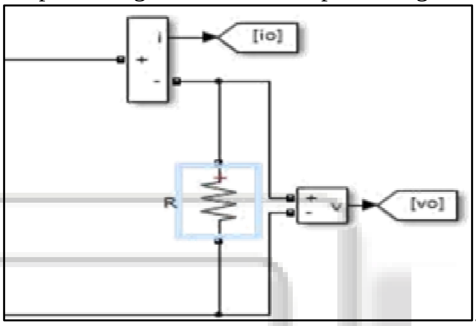

Fig. 5: Output Load Resistor with Measurement Blocks Connected

In many technical applications, it is required to convert a set voltage DC source into a variable-voltage DC output. A DC-DC switching converter converts voltage directly from DC to DC and is simply known as a DC Converter. A DC converter is equivalent to an AC transformer with a continuously variable turn's ratio. It can be used to step down or step up a DC voltage source, as a transformer. DC converters are widely used for traction motor control in electric automobiles, trolley cars, marine hoists, forklifts trucks, and mine haulers. They provide high efficiency, good acceleration control and fast dynamic response. They can be used in regenerative braking of DC motors to return energy back into the supply. This attribute results in energy savings for transportation systems with frequent steps. DC converters are used in DC voltage regulators; and also are used, with an inductor in conjunction, to generate a DC current source, specifically for the current source inverter. [1]

IV. General Boost Converter Configuration

In a boost converter, the output voltage is greater than the input voltage – hence the name "boost". Fig. 3.1.1 Circuit diagram of Boost Converter. [1] 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=t1. The input current now flows through L, C, load, and diode Dm. The inductor current falls until the next cycle. The energy stored in inductor L flows through the load.

A. Specifications

Engineers working in today's high tech environment have to deal with a rapidly changing market of electronic products and equipments. As new technologies are invented, integrated circuits function faster and are smaller in size and shape. But, many integrated circuits still require a voltage of 15 volts to function. The DC-DC Switching Boost Converter will take a 5 Volt DC voltage 10 % tolerance and deliver 15 Volts to the load. The maximum current delivered to±supply with the load will be 0.4 A. The circuit will operate with a minimum efficiency of 94.16%. [7] The inductor shown in Fig. 3.1.1 acts as the magnetic field storage element shown in Fig.. It stores energy in its core material. The ideal PWM functions as the switch control and the transistor acts as the switch element. The diode and the capacitor are used to perform the function of the output rectifier and filter block

V. Boost DC-DC Converter Implementation

The Boost DC-DC Converter A boost converter is used also as an electronic power DC-DC device interfacing the solar panel and the battery load to perform good matching. It uses the output voltage of the solar module as the input parameter and sets it to the desired level while keeping its output voltage fixed. The output voltage of a boost chopper is always greater than or equal to its input voltage. For better comparison, it uses the same components as the buck converter. The boost converter study includes the steady-state and dynamic analyses for ideal and non-ideal circuits.

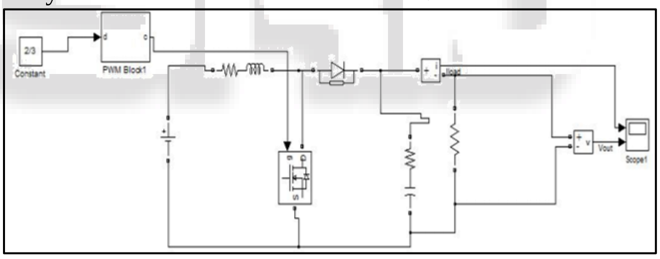

Fig. 5: Implementation of Boost Converter

A. Operation of Boost Converter

Previous to probing on the circuit, the subsequent assumptions are presumed.

1) The output capacitor C0 should be large enough to neglect the output voltage ripple.
2) The forward voltage drops across MOSFET $S1$, $S2$ and diodes $D1$, $D2$ are neglected.
3) Inductors $L1$, $L2$ have large inductance and their currents are identical constants, i.e., $L1 = L2 = IL$.
4) Output capacitances of switches Cs1 and Cs2 have the same values, i.e. $CS1 = CS2 = CS$
5) The two active switches S1 and S2 are operated with pulse width modulation (PWM) control techniques. They are triggered with identical frequencies and duty ratios. Rising edges of the two gating signals are separated apart for half of the switching cycles. The complete operation of the converter can be divided into eight modes, the equivalent circuits and theoretical waveforms are shown in Fig 3 and Fig 4 respectively

Power Output	100W
Voltage Output	24V
Output Current	4.2A
Switching Frequency	24Khz
Input Voltage	6-23V

Table 1: Specification of Proposed Boost Converter

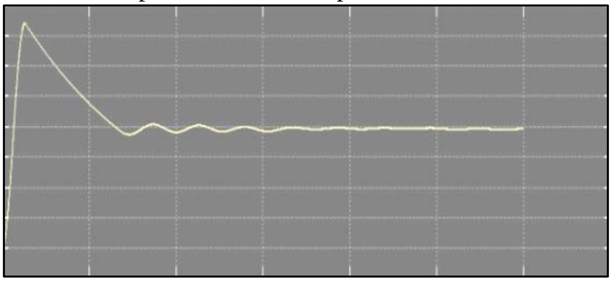

Fig. 6: Output Voltage Waveform

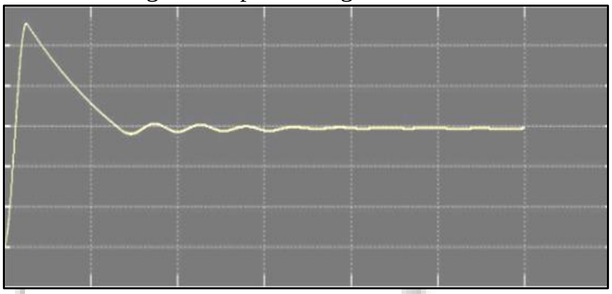

Fig. 7: Output Current Waveform

VI. CONCLUSION

All of the specifications stated previously have been met by this boost converter design. MATLAB and PSPICE simulations using calculated parameters were performed and corresponding waveforms were obtained. The output voltage across the output capacitor is 15Vwith a maximum output ripple of 1.6%. The power efficiency of the circuit exceeds 94 %. However an additional constraint needs to be put on the load. The load must not exceed 0.75kΩ. This will cause the efficiency to fall below the specified value of 94.16%. Hardware design of Boost Converter was done. It is observed, by varying duty cycle output voltage also changes.

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