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Design of DC to DC Converter for Grid Connected PV System

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ABSTRACT: The photovoltaic standalone system is gaining its high importance mostly for rural application like PV water pumping, solar lighting, battery charging etc. Considering environmental effects and scarcity of fossil fuel the trend has developed towards the use of more and more renewable energy. In this paper a basic circuit of boost converter is designed in MATLAB/Simulink with constant DC source voltage. However, a comparative study has also been done for the converter connected with battery system is connected with R load. All aim, tests, data and conclusions have been documented within this report. Results of simulation show that the switching converter will boost voltage from 12 volts to 24 volts with power conversion efficiency of 94.16 percent

KEYWORDS: Switches, Switching Frequency, R-load

I. INTRODUCTION

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 turns 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.

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%, whereas linear converters are usually 30% efficient. The DC-DC Switching boost converter is designed to provide an efficient method of taking a given DC voltage supply and boosting it to a desired value.

II. CIRCUIT DIAGRAM

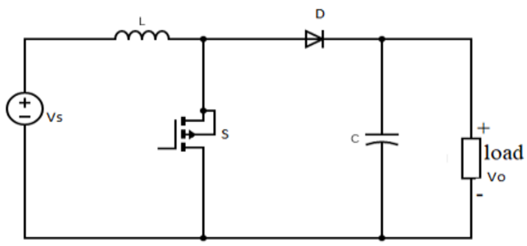

Fig.1 DC-DC converter circuit diagram

It works in two stages; ON and OFF. During the ON state, its Function is to charge the inductor which stores energy in a magnetic field. And during the OFF state, this energy is transferred from the inductor through the diode to the output capacitor.

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The output voltage is usually slightly greater than the desired voltage; hence a zener diode is used to regulate the output in order to have a constant output.

The circuit operation can be divided into two modes.

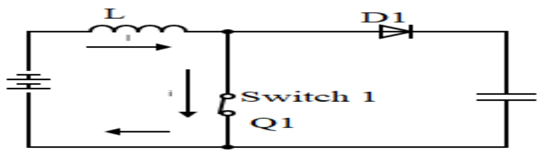

Fig. 1.1 DC-DC converter mode-1 circuit diagram

Mode 1 begins with MOSFET Q1 Switched ON when the Square wave is at its peak Value i.e. at time t=0. The closed loop at the input side consisting of inductor gets charged by the current flowing through the loop using this period. This current will increase till the Switch is Closed.

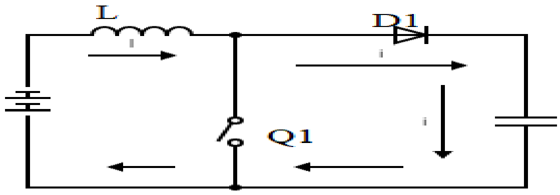

Fig. 1.2 DC-DC converter mode-2 circuit diagram

Mode 2 begins when MOSFET Q1 switch is OFF at time t = t1, i.e. when the square wave is low, there would be a closed loop consisting of power source, inductor L1, diode D1 and capacitor C2. The energy stored in inductor during ON state is discharge to the capacitor through the diode. Thus inductor current is reducing, thereby charging the capacitor.

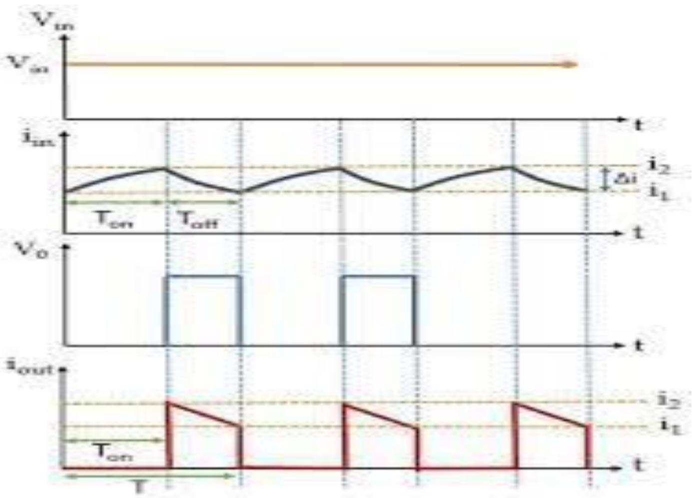

Fig.2 DC-DC converter waveform

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Duty cycle:

$$V_o = \frac{V_S}{(1-D)}$$

Where:

ΔI_L = Peak to peak ripple current.

ΔI_L = requirement taken = 0.01A

Inductor (L):

$$\Delta I_L = \frac{\alpha V_S}{F_l}$$

Capacitor (C)

$$\Delta V_c = \Delta V_o = \frac{\alpha I_o}{F_l}$$

Where:

ΔI_c = Peak to peak ripple current.

ΔI_c = requirement taken = 0.1V

III. DESIGN CALCULATION

V_{in} = 12V, V_{out} = 24V, F = 20kHz, R = 10Ω,

Duty cycle: $V_o = \frac{V_S}{(1-D)}$

(1-D) = 0.5

-α = 0.5-1

α = 0.5

D = 0.5

ΔI_L = Peak to peak ripple current.

ΔI_L = requirement taken = **0.01A**

Inductor (L):

$$\Delta I_L = \frac{\alpha V_S}{F_l}$$

$$0.01 = \frac{0.5*12}{20*10^{3*} L}$$

$$L = \frac{0.5*12}{20*10^3*0.01}$$

L = 30mH.

Capacitor (C)

$$\Delta V_c = \Delta V_o = \frac{\alpha I_o}{F_l}$$

$$\Delta V_c = \frac{0.5*1}{20*10^3*C} = \mathbf{0.1V}$$

ΔI_c = Peak to peak ripple current.

ΔI_c = requirement taken = 0.1V

$$C = \frac{0.5*1}{0.1*20*10^3}$$

C = 2.5mF

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IV. SIMULATION OF DC-DC CONVERTER

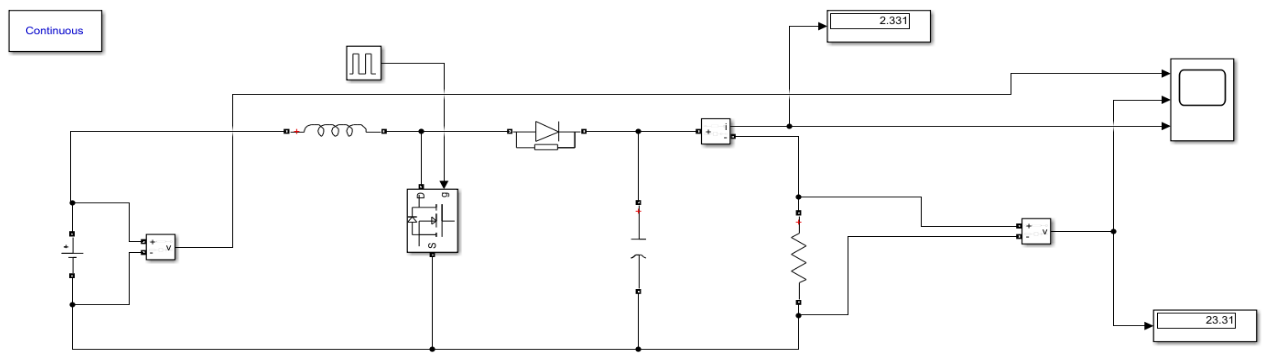

Fig: 3

Using Parameter:

- Inductor $L = 30\mu H$
- Capacitor $C = 25\mu F$
- Diode = U1560
- Resistance R = 10Ω
- MOSFET Switch

4.1 Output Voltage(V) & Current(I) vs Time(sec) Graph

The output voltage is nearly equals to 230V at the time of steady state where as output current is 0.75A. To analyse output waveforms, we have defined two different states those are Transient State and Steady State. In order to get fast response (Damping Factor(ζ) is nearly equals to 1) all, the closed loop poles are real in nature for that reason Time Constant (Critically)decreases hence Settling Time for the system (Ts) also decreases.

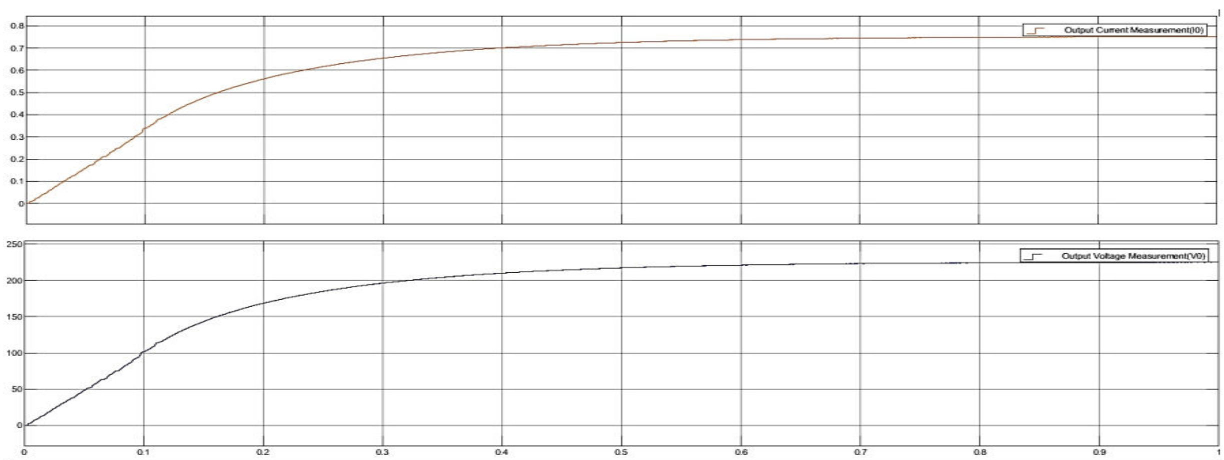

Fig 4 Output Current and Output Voltage Waveform

4.2 Input & Output Power vs Time Graph

The power quality injected into the grid and the performance of the converter system depend on the quality of the input power control. The output power for the PV panel has the undershoot and there are multiple maxima which makes the closed loop system unstable by the addition of unexpected Imaginary Poles in the system and the system becomes Undamped. In order to overcome such dubious situation, we have integrated MPPT technique and as a result the input

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power for the buck-boost converter has a smooth characteristic at the time of both steady state as well as Transient State.

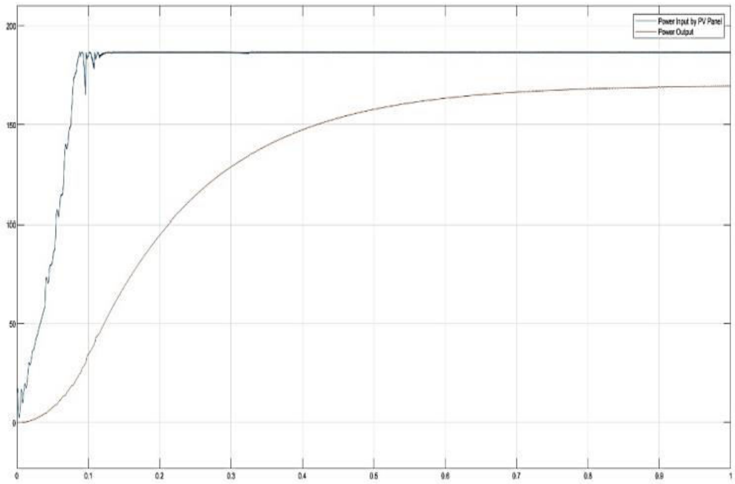

Fig: 5. Power Input & Output Characteristics

4.3 Capacitor Voltages(V) vs Time(sec) Graph

Capacitor voltage characteristics are depicted at the time of Steady State. The output voltage is nearly equals to 230V at the time of steady state whereas input voltage for the 27 buck-boost converter is 48V. A voltmeter is connected across the load side (Capacitor) in order to get output voltage from the system.

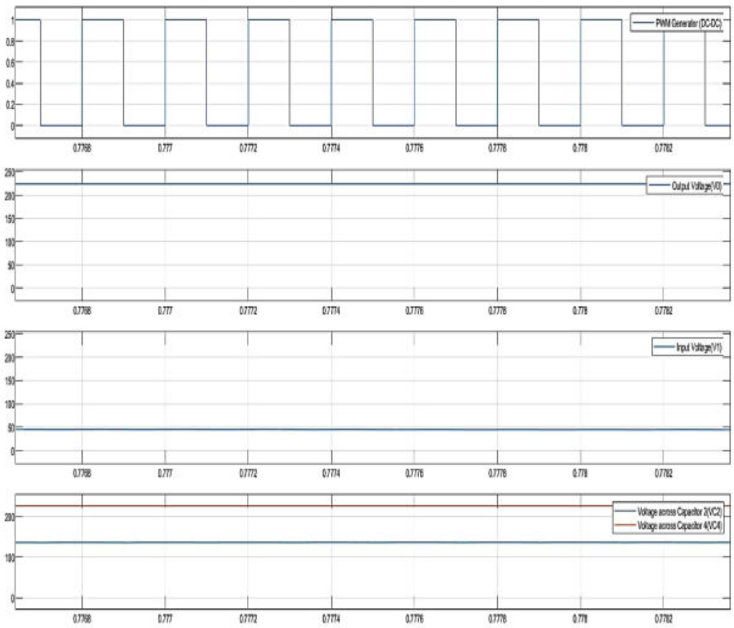

Fig:6 Capacitor Voltage Characteristics at the Time of Steady State

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V. CONCLUSION

In this paper, a High Gain Step-Up DC-DC converter with Controller is proposed. The first stage of the converter is integrated with PV Array. The second stage is a high step-up converter with voltage multiplier cells. The output of the first stage and the input source together are the input of the second stage Thus, a low on-resistance (RDS-on) switch could be used which decreases conduction loss. The steady-state analysis of the proposed converter is presented in the paper. Finally, the buck boost converter is designed and simulated using MATLAB/SIMULINK.

The future scope for this project can be the design of circuit in micro grid system and use of step up boost converter in electric vehicle charging stations.

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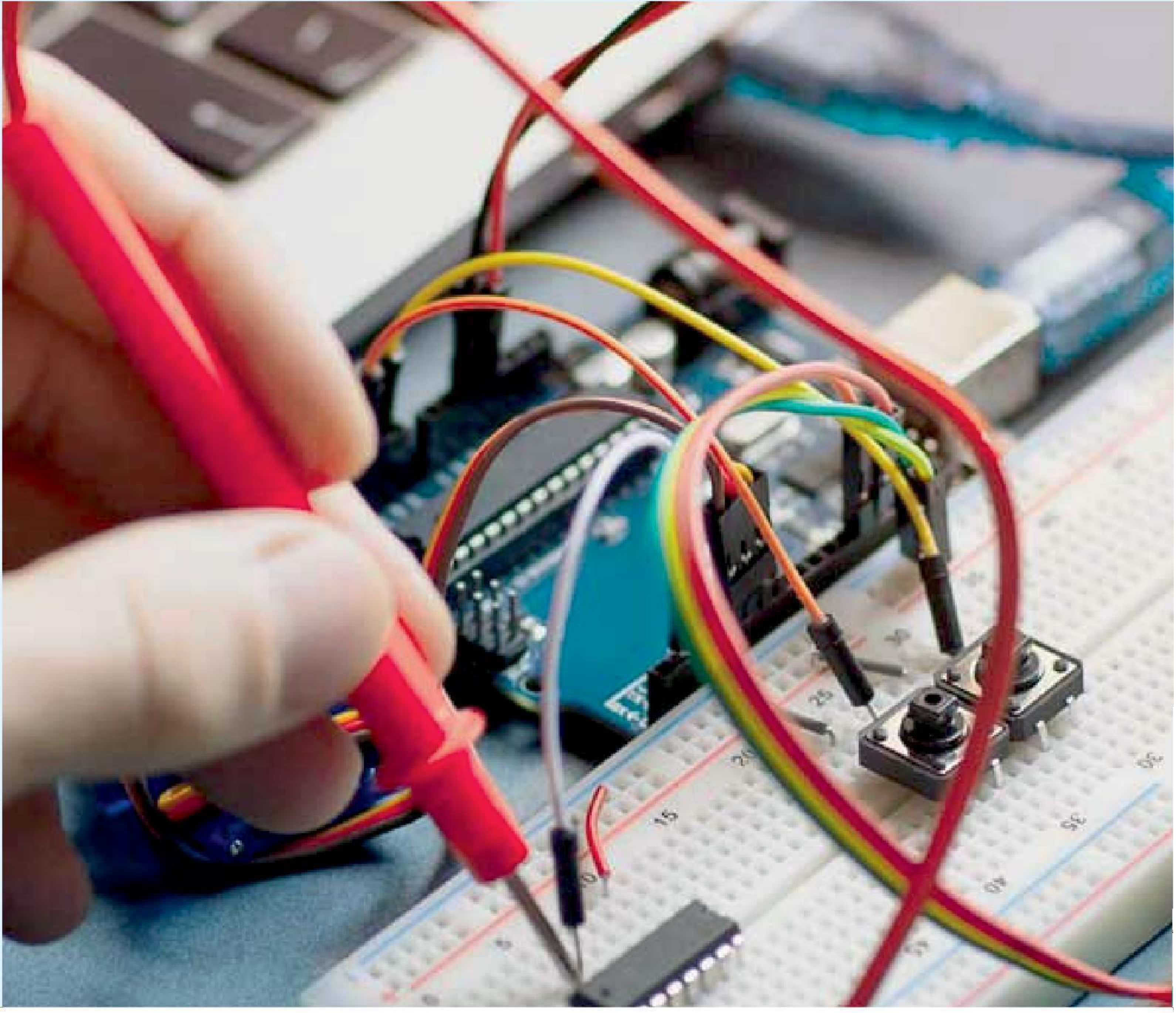

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