

Performance Evaluation of Hysteresis Controlled SEPIC Converter for EV Battery Charging System

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Abstract — The Quality of power is improved by using SEPIC converter with a Cascaded PI controller, which is utilized in battery charging of EV (Electric Vehicles) applications. The cascaded PI controller improves the voltage gain with minimum switching losses. The presented topology will work in buck mode and boost mode of operation reliant on the rectified voltage at the input side and battery voltage at the load side. The steady-state switching frequency is estimated by the hysteresis-controlled PWM generator. The overall performance of the proposed converter is validated using MATLAB simulation.

Keywords: Hysteresis Controlled SEPIC Converter, EV Battery, Charging System

I. INTRODUCTION

Now a days the demand of electricity generation from renewable energy is increasing for domestic to industrial applications. The electricity generated from fossil fuels cause rising of toxic gases in the atmosphere. These fossil fuels are decreasing bit by bit in the environment. Solar energy is one of the most abundant renewable energy resources, eco-friendly, and pollution free. Sunlight is converted into electricity via solar cell using the photovoltaic effect [1]-[3]. For solar energy, system installation cost only is needed, if once installed it can run for a long duration and it can also save the overall maintenance cost. As Solar energy is versatile in nature, it can be used for different power applications from tiny torch to satellite.

Lossless, eco-friendly power generation is the emerging technique in modern civilization. The role of renewable energy becomes more popular, as they do not violate the environment and surroundings. They consume less area for installation and processing. Some of the renewable power resources are listed below: Solar, wind, tidal, hydro, biogas, geothermal, etc.

Depending upon the location and resource availability, the power plants are located. Among the all, nearly half of the power generation in India completely depends upon PV system. This system uses the natural sunlight to generate electricity.

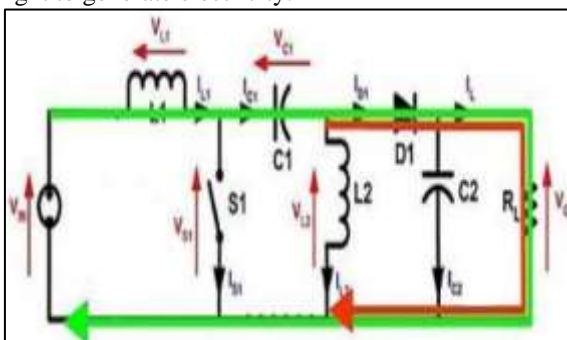


Fig. 1: Schematic SEPIC Converter

Some topologies for power generation to satisfy the load requirement are converters, control techniques, switching actions, filters, etc. These techniques determine the power quality and satisfy the load requirement. The output power is stepped-up or stepped-down in accordance with the load.

The evolution of dc-dc converters for renewable power generation has been growing day-to-day. Lot of dc-dc converters are available. Some converters perform both buck and boost operation in a single track. Cuk Converters, Buck Boost Converters, Sepic Converters and the Zeta Converters are some of the boost and buck converters. The operation of SEPIC converters, its merits and demerits are more are also discussed.

II. CONFIGURATION OF PROPOSED CONVERTER

A. Sepic Converter

Fig. 2(a) displays the SEPIC converter MODE 1. SEPIC converter performs both buck and boost operation. L acts as a filter for input current directly feeding the resistive load and C acts as filter for the output voltage. The coupling capacitor transfers energy from input to output.

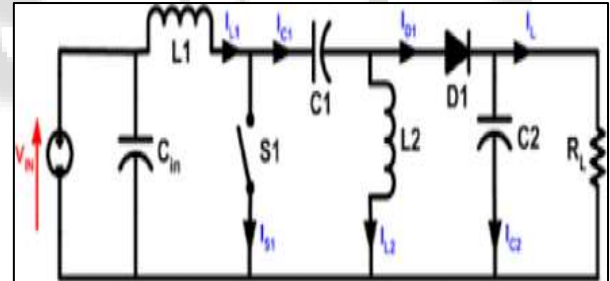


Fig. 2(a): SEPIC Converter Mode 1

The proposed SEPIC converter topology features two modes of operation:

- 1) Switch in ON condition
- 2) Switch in OFF condition

Mode 1: Switch is turned on; input voltage charges the L1 and C1.C2 energies the inductor L2. Diode D1 becomes reversed-biased and output is controlled by the C2.

Mode 2: The switches are placed off and the diode is forward-biased. The L1 discharges while the power in the L2 is sent to the respective loads.

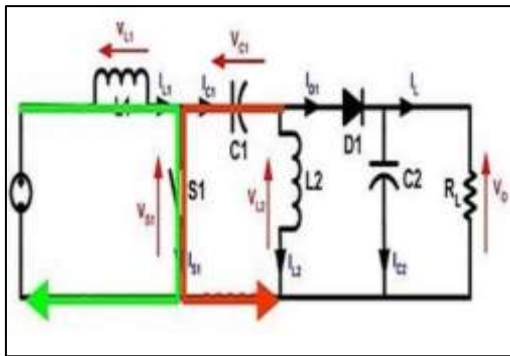


Fig: 2(b): SEPIC converter Mode 2.

Based on the output power requirement the converters have been designed and modelled in MATLAB/SIMULINK. The SEPIC converter can either increase or decrease an input voltage by controlling the Duty Cycle of a pulse to the MOSFET. One way to do that is to directly control the Duty cycle using a potentiometer. [13-15]

The SEPIC converter is essentially a boost converter followed by an inverted buck-boost converter. Therefore it is similar to a traditional buck-boost converter, but has the advantage of having non-inverted output (the output has the same voltage polarity as the input), using a series capacitor to couple energy from the input [16-18].

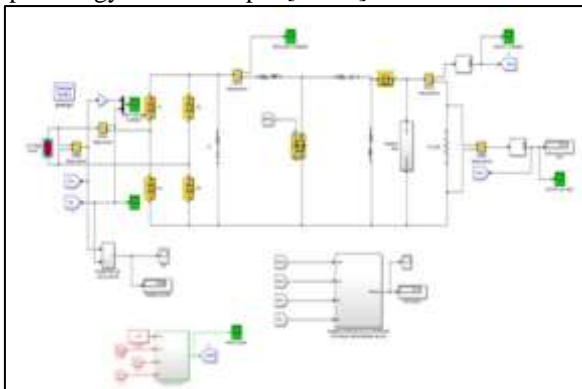


Fig. 3: Simulink Circuit of SEPIC Converter

Fig. 3. shows the Simulink circuit of the SEPIC converter based on the ON or OFF state of the static switch S.

If the capacitor impedance is minimum when comparing to the resistance R2 at a switching frequency f_s , then

$$1/(2\pi [f_s C]_{-1}) \ll R2 \quad (1)$$

The capacitor voltage C1 changes linearly and the voltage slope is generally estimated by the time constant (TC) [19-20] and maximum output level V_P . The switching frequency is given by,

$$f_s = \frac{DV_{CP}}{V_{HTC}} \quad (2)$$

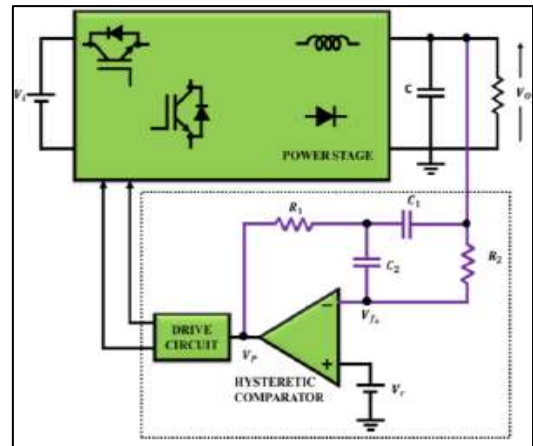


Fig. 4: Hysteresis-controlled PWM circuit

III. RESULTS AND DISCUSSION

To demonstrate the effectiveness of the proposed converter, the above discussed is simulated in MATLAB. The converter is tested under open loop mode. Fig.5 indicates the current and fixed voltage waveform of the AC source, which varies from +2.5A to -2.5A and gradually decreases from +2A to -2A.

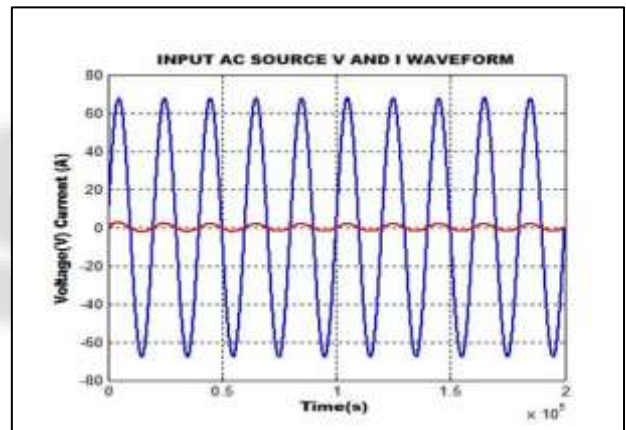


Fig. 5: Input AC source V and I waveform

Both waveforms are sinusoidal in nature. The range of voltage is Fixed from +60V to -60V. Fig. 6(a) and 6(b) represent the PWM pulse waveform to switch 1 and switch 2.

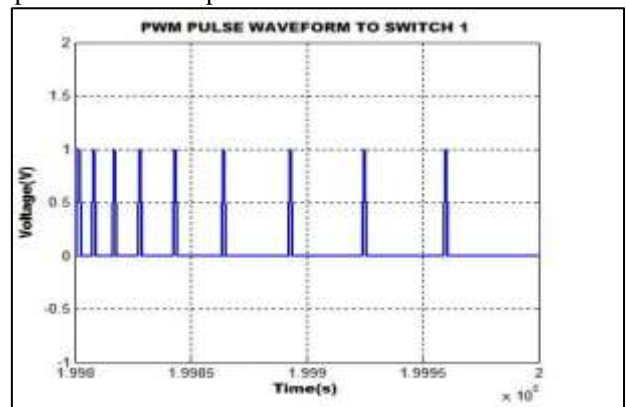


Fig. 6(a): PWM pulse waveform to switch 1

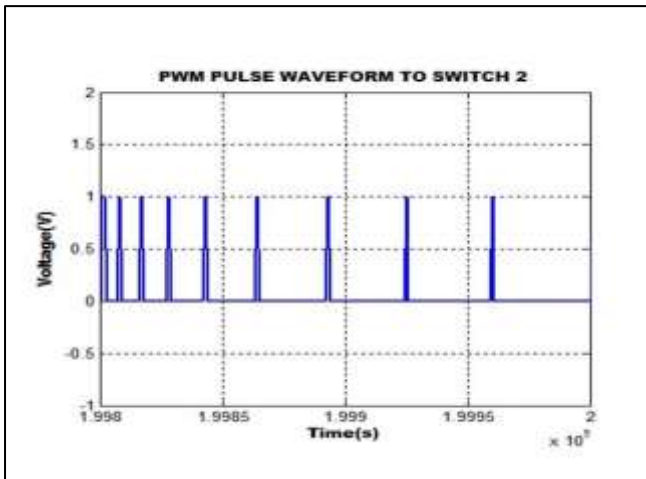


Fig. 6(b): PWM pulse waveform to switch 2

Fig. 7(a) and 7(b) represents the Load current and Load voltage waveform.

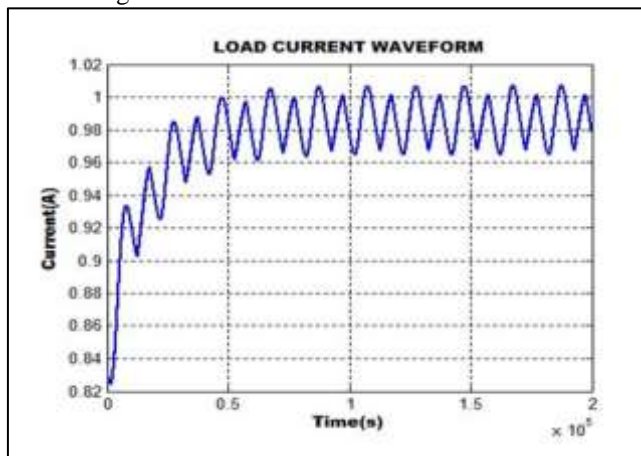


Fig. 7(a): Load current waveform

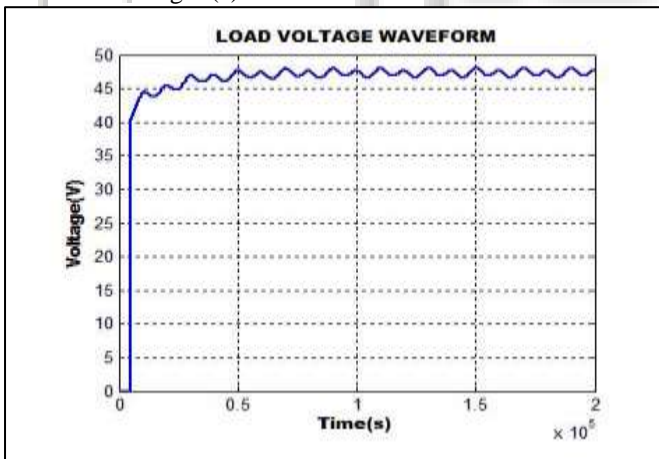


Fig.7(b): Load voltage waveform

Fig.8 indicates the Output power waveform and Fig.9. Represents the power factor waveform of the converter and the unity power factor is approximately maintained.

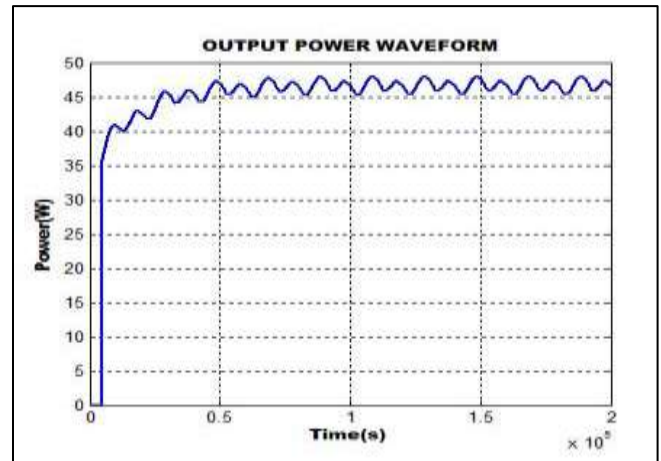


Fig. 8: Output power waveform

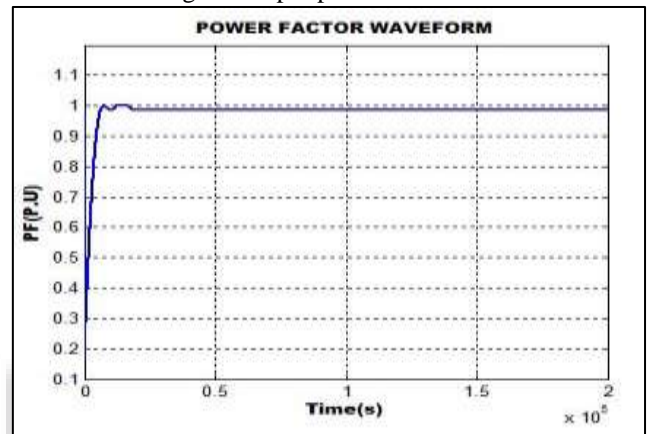


Fig. 9: Power factor waveform

IV. CONCLUSION

The proposed SEPIC based DC-DC converter is designed for solar application. The converter was controlled by Hysteresis-controlled PWM circuit. The output of the proposed converter is presented and analyzed.

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