SUBMISSION TEMPLATE

Research-2-Practice Forum on Renewable Energy, Water and Climate Security in Africa
16 - 18.04.2018, Tlemcen, Algeria

Category: Research and Scientific Contributions

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Extended abstracts should be written according to structure given in the template below, including the following headings: abstract and keywords, introduction, method, results and discussion, conclusion and recommendations, references. There is flexibility as to the naming of the sections. Sub-headings can be used when necessary.

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Simulation and comparison between conventional and interleaved Buck-boost converter for grid-connected PV system

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Abstract
This paper presents a mathematical modelling of buck boost converter used for grid-connected PV systems. It is related to the optimization of the first input stage of a grid tie inverter PV system. The interleaved buck-boost DC-DC converter is proposed to increase the performance of the entire system. The input current is shared between the inductors. As a result, the current ripples are reduced and a good reliability in power electronic systems is gained. The interleaved buck-boost converter is presented and compared in simulation.
Keywords: DC-DC converter, buck-boost converter, interleaved, PV system.

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1. Introduction

The discovery of solar cells has greatly encouraged researchers to develop the knowledge in this field because the need for an alternating current to power the various devices was an obligation which prompted to concentrate research on the DC-DC and DC-AC converters (Babaei Jan. 2013) (Kumar, V. V. Subrahmanya Kumar Bhajana et Pavel Drabek 2016).
The vast domain of DC-DC power converters has experienced a variety of research: amplification of output voltage of photovoltaic panels, reduction of perturbations due to conversion etc . Generally, one of the main roles of the DC-DC converters is to operate the PV panel at its maximum power point MPP using several control algorithm methods which are called MPP tracking MPPT (Xiao, Xie, Chen et Huang, 2010).
Nowadays, interleaved structures are used extensively to meet this need. But, having an interleaved structure can cost additional inductors and power switching devices. As the size of the inductance increases, the loss of power in a magnetic component decreases, although low volume and low power losses are required (Newlin, Ramalakshmi et Rajasekaran, 2013).

2. Conventional and interleaved Buck-boost DC-DC converter

2.1. Conventional buck-boost converter (CBBC)

The conventional DC-DC buck-boost converter could operate as a buck or boost converter according to the adjusted duty cycle. For continuous current conduction mode (CCM) operation, the voltage gain between input and output voltages is given by Equation {1}, where D is the duty cycle of the switch S*(Bahravar, Mahery, Babaei et Sabahi, 2012)*.

$$V_{DC} = \frac{D}{1-D} V_{pv} \qquad \{1\}$$

The differential equations of the buck-boost converter can be attained when circuit equations are presented in two commutation modes (D=1) and (D=0) *(Bhat et Nagaraja, 2014) (Mashinchi Mahery et Babaei, 2013)*.

The buck-boost converter is operated in continuous conduction mode. For this mode, the inductor current should not fall to zero. For the discontinuous conduction mode, the inductor current attempts to fall below zero and remains there until the beginning of the next switching cycle.

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Circuit equations for each commutation mode of the IGBT S will be derived separately. When the switch S is ON, equations {2} and {3} are obtained as follow:

$$\begin{cases} i_C = C\dfrac{dV_{DC}}{dt} = -i_o & \{2\} \\ V_L = L\dfrac{di_L}{dt} = V_{pv} & \{3\} \end{cases}$$

When the switch S is OFF, equations {4} and {5} are obtained as follow:

$$\begin{cases} i_C = C\dfrac{dV_{DC}}{dt} = -i_L - i_o & \{4\} \\ V_L = L\dfrac{di_L}{dt} = V_{DC} & \{5\} \end{cases}$$

To find a valid dynamic representation for all the period T_s, the following expression is generally used:

$$< \frac{dx}{dt} > T_s = \frac{dx}{dtDT_s} dT_s + \frac{dx}{dt(1-D)T_s}(1-D)T_s \qquad \{6\}$$

When the Kirchoff's voltage and current laws are applied to the two circuit topologies, and the obtained models are combined into valid dynamic representation using equation {6} the resulting system of differential equations describing the Buck-Boost converter is the following:

$$\begin{cases} \dfrac{dV_c}{dt} = \dfrac{1}{C}(-\dfrac{V_c}{R} - (1-D)i_L) & \{7\} \\ \dfrac{di_L}{dt} = \dfrac{1}{L}(V_{pv}D + (1-D)V_{DC}) & \{8\} \end{cases}$$

2.2. Interleaved buck boost converter (IBBC):

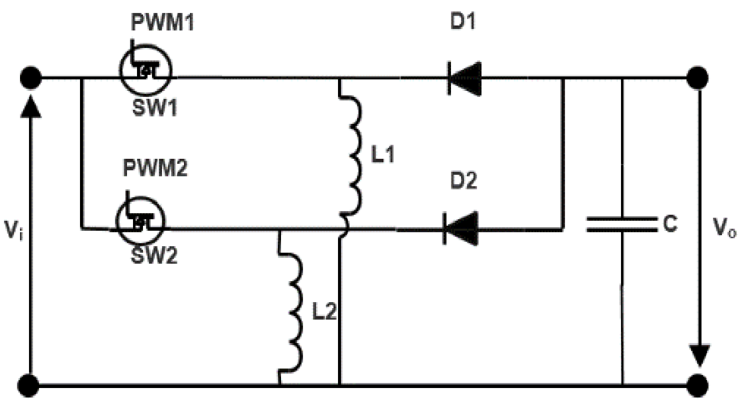

Figure 1: Scheme of the interleaved Buck-Boost DC-DC converter

The interleaved converter shown in Figure 1 is formed by two independent buck-boost switching units and the phase difference in interleaved systems for two switches is 180º *(Hong et al., 2016)*. It exhibits both lower voltage and current ripple at both input and output side. Therefore, the size and losses of the filtering stages can be reduced, and switching losses can be significantly decreased *(Dong-Kurl Kwak, Seung-Ho Lee et Do-Young Jung, 2009) (Abdel-Rahim, Orabi et Ahmed, 2010)*.

The mathematical modelling of the interleaved Buck-Boost converter is the same with that of the conventional Buck-Boost converter taking in consideration two CBBC in parallel *(Vijayalakshmi, Arthika et Priya, 2015)*.

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2.3. Parameters design:

The interleaved parameters are designed as follow *(Newlin, Ramalakshmi et Rajasekaran, 2013 ; Marodkar, Adhau, Sabley et Adhau, 2015)*:

$$R = \frac{{V_{DC}}^2}{P_{pv}} \qquad L_1 = L_2 = L = \frac{V_{pv} D}{\Delta I_L F_s} \qquad \{9\}$$

$$C_2 = \frac{V_{DC} D}{\Delta V_{DC} F_s} \qquad C_1 = \frac{P_{pv}}{2 * \Delta_{pv} F_s V_{pv\_min}} \qquad \{10\}$$

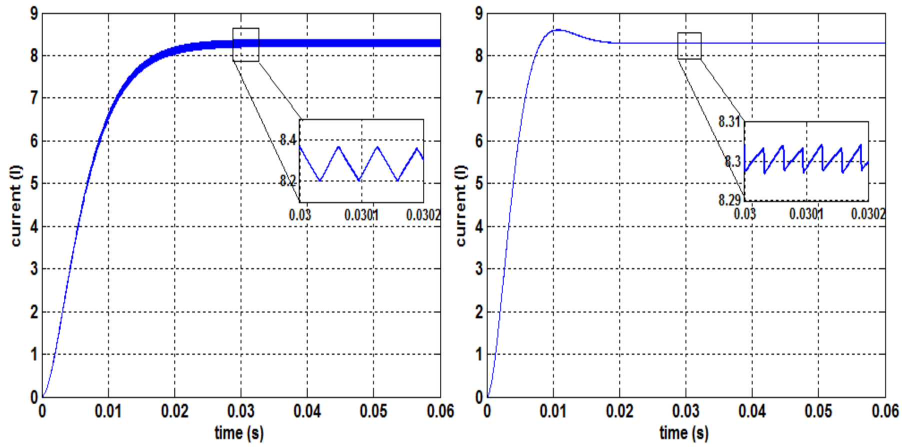
Where: P_{pv} is the PV panel maximum output power, Δ_{pv} is the allowable peak-to-peak voltage ripple at the input of the array, F_s is the switching frequency and V_{pv_min} is the minimum operating value for the input voltage, ΔI_L is the allowable peak-to-peak inductance current ripple.

3. Results and discussion

The proposed converters CBBC and IBBC have been simulated using Simulink/Matlab environment. The considered simulation parameters of the converters are given in Table 1:

Table 1: System PV and DC-DC converter specifications

DC-DC input voltage V_{pv}	29.32 V	Capacitor C	>1.1 mF
DC-DC output voltage V_{DC}	33 V	Inductance L1=L2	5.88 mH
DC-DC input current I_i	7.84 A	Capacitor C1	435 µF
DC-DC output current i_o	8.32 A	Resistance	3.73 Ω
Switching frequency F_s	16 KH	Duty cycle D	0.52



(a) Conventional BBC (b) Interleaved BBC

Figure 2: output current

By comparing the waveform results (a) and (b) shown in Figure 2, current ripples in both input and output side, we notice that the ripples are minimized while using interleaved converter.

4. Conclusion

Modeling and comparison between both CBBC and IBBC have been presented in this paper. Simulation results are obtained using Simulink/Matlab. As a conclusion, by using the interleaved Buck-Boost converter, both input and output voltage and current ripples were reduced, and efficiency was improved. On the other hand, the use of two switches on the circuit involves the reduction of switching losses because of the alternation between these two switches. Also, the size of the inductor can be reduced when using IBBC. The IBBC presents less switching power losses and has a higher efficiency in respect to the CBBC.

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