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

MERAH Mohamed, BAGHLI Lotfi, BOUMEDIENE Abdelmadjid

Laboratoire d'Automatique de Tlemcen

Université de Tlemcen

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Introduction

- Over the last years the economy of Algeria has negatively been affected by changes in oil prices (from 108 $ to 35 $).

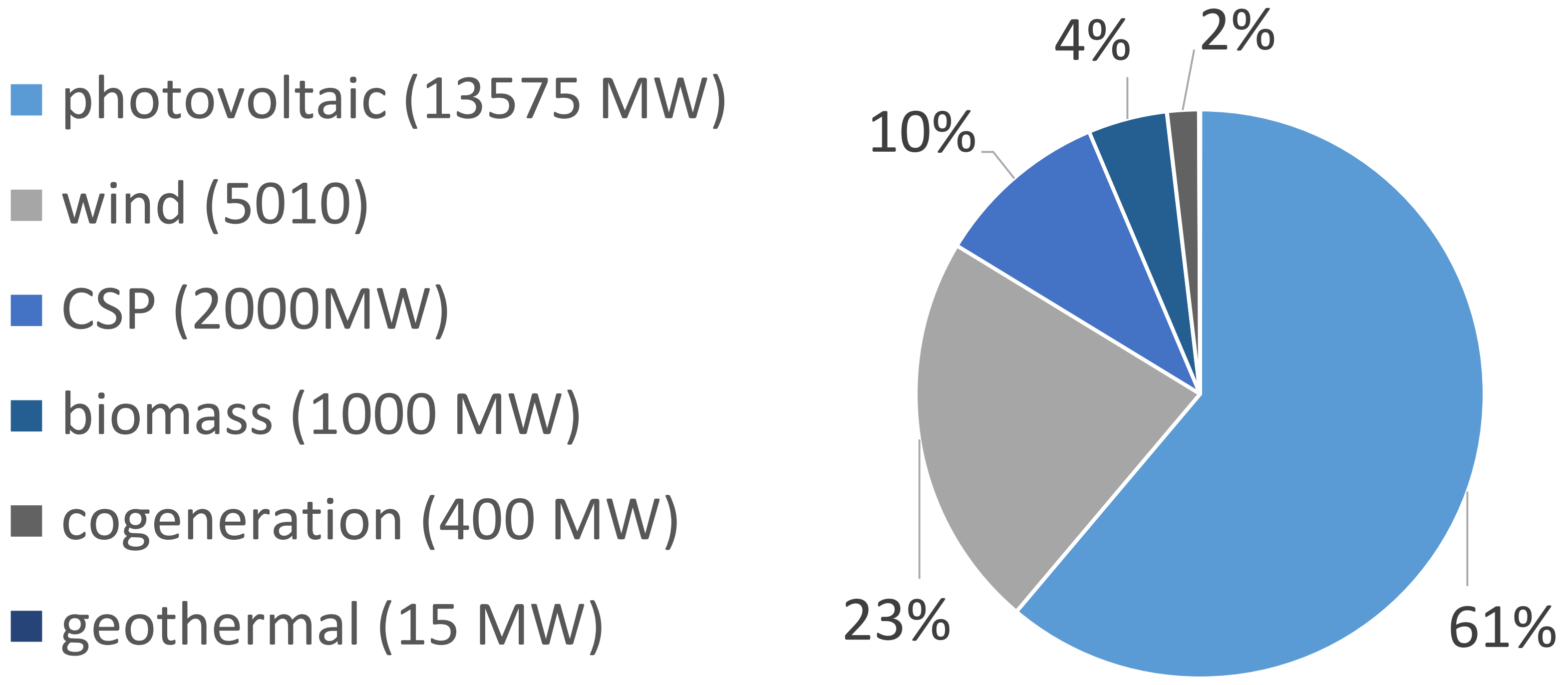
- The price of electricity in Algeria is one of the lowest in the world at 0.04 USD/kWh which is due to the biggest share of the cost being covered by subsidies.

- The latter factors pushed the Algerian government to take austerity measures to mitigate the deficit in the budget.

- The government decided to open the doors to the development and utilization of renewable energy resources.

Introduction

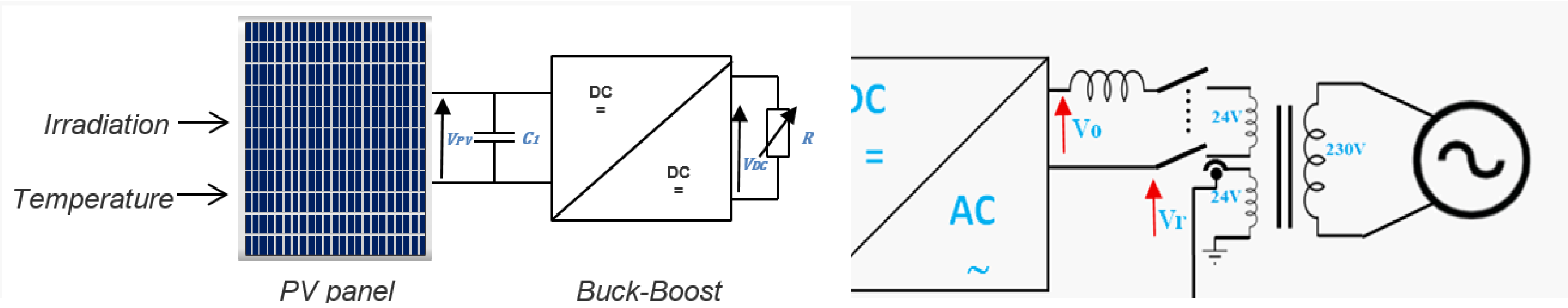
Encouraged by its commitment to the international community to fight against global warming and promoting renewable energies Algeria has drawn a roadmap to reach an installed capacity of 22,000 MW in 2030



Installed power capacity from renewables in 2030 (CDER)

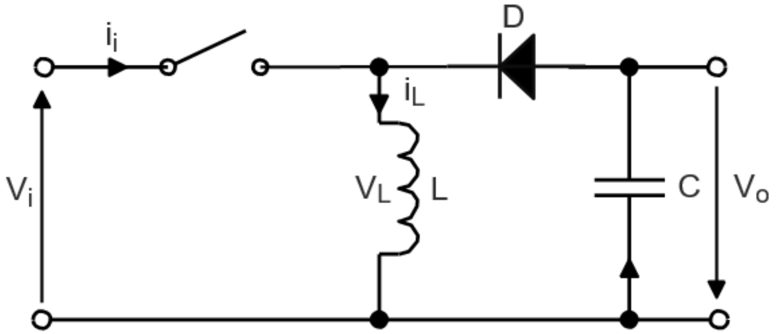
DC/DC stage

- The proposed DC/DC converter is a part of the grid tie PV inverter
- The vast domain of DC-DC power converters has experienced a variety of research
- Interleaved structures are used to lessen the maximum current in power electronics and to avoid high ripple in output voltage

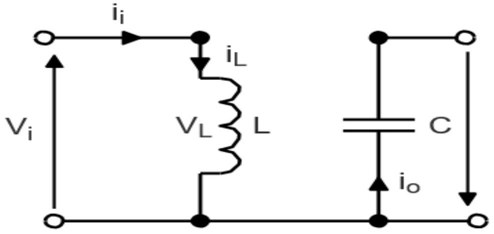


PV system

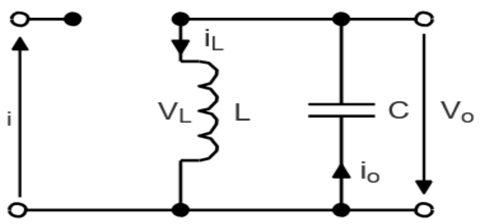
Conventional buck-boost converter (CBBC)



Ideal switch representation of the Buck-Boost DC-to-DC converter.



(a) Switch position at D = 1.



(b) Switch position at D = 0.

Circuits topologies associated with the Buck-Boost converter

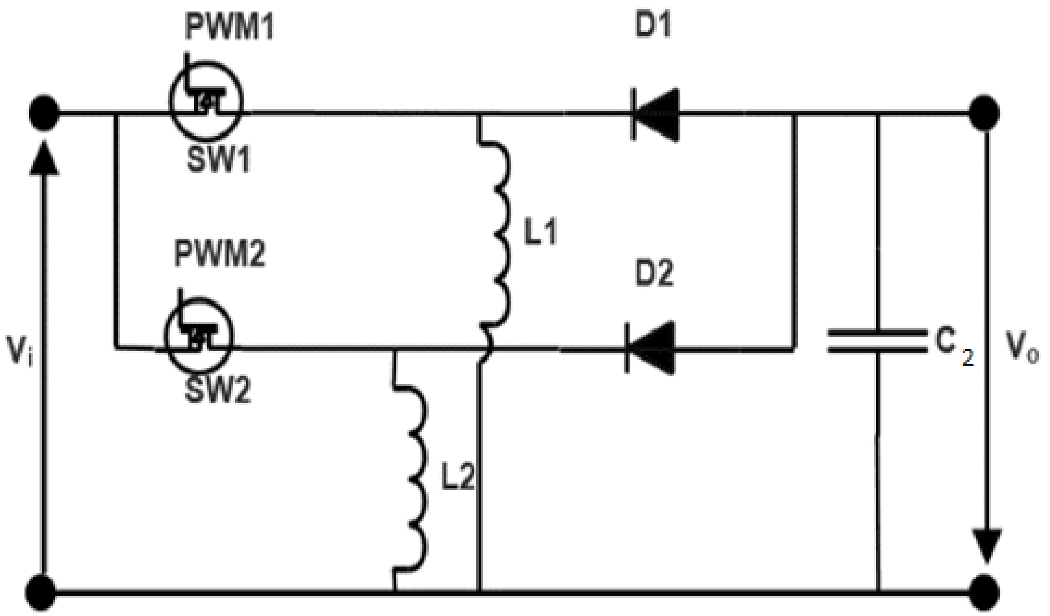
$$V_{DC} = \frac{D}{1-D} V_{pv}$$ where D is the duty cycle of the switch

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

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

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

Interleaved buck boost converter (IBBC)



Scheme of the interleaved Buck-Boost DC-DC converter

Parameters design:

$R = \frac{{V_{DC}}^2}{P_{pv}}$	$L_1 = L_2 = L = \frac{V_{pv} D}{\Delta I_L F_s}$
$C_2 = \frac{V_{DC} D}{\Delta V_{DC} F_s}$	$C_1 = \frac{P_{pv}}{2 * \Delta_{pv} F_s V_{pv\_min}}$

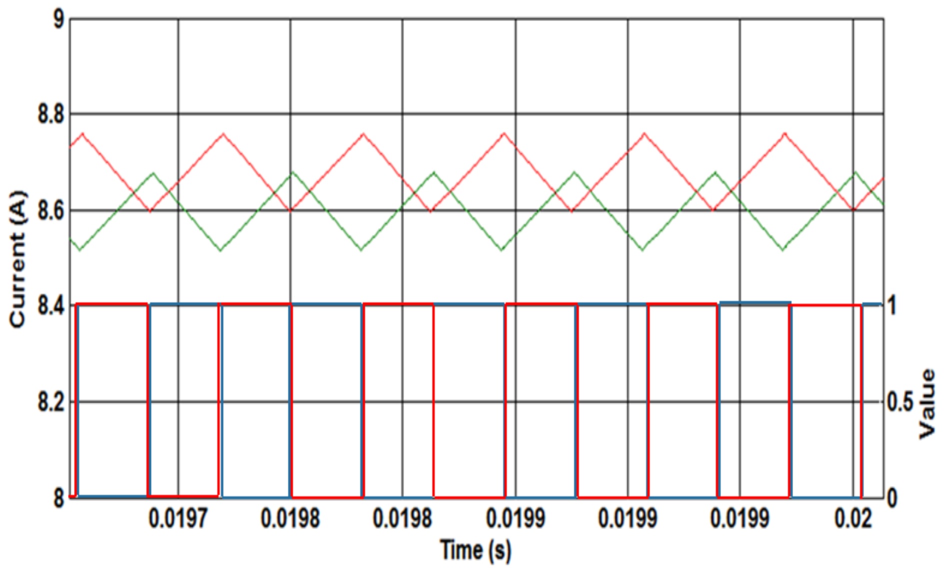
Results and discussion

PV system and DC-DC converter specifications

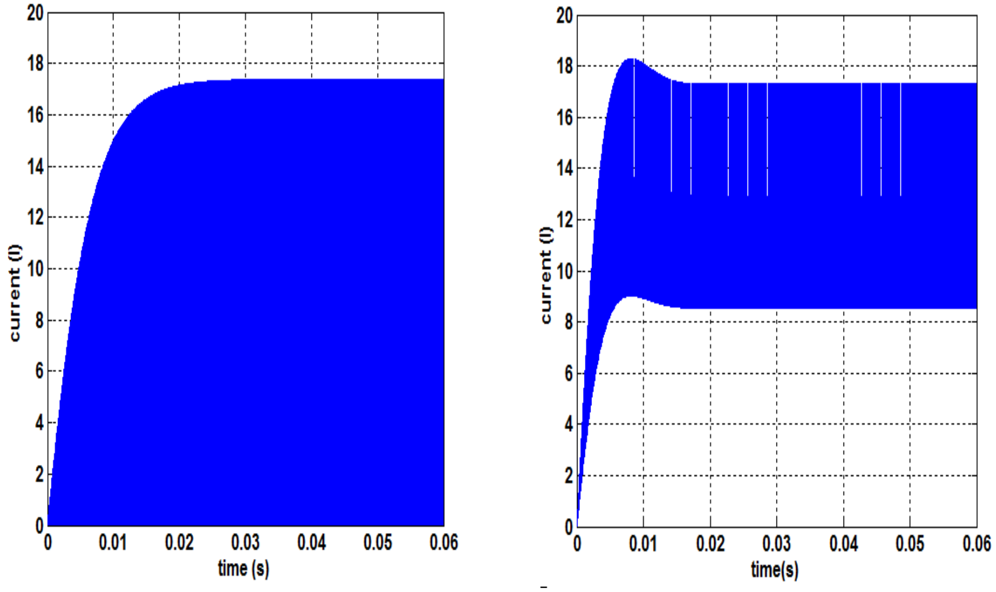
DC-DC input voltage V_{pv}	29.32 V		Capacitor C	>1.1 mF
DC-DC output voltage V_{DC}	33 V		Inductance L1=L2	5.88 mH
DC-DC input current I_i	7.84 A		Capacitor C1	435 µF
DC-DC output current i_o	8.32 A		Resistance	3.73 Ω
Switching frequency F_s	16 KH		Duty cycle D	0.52

Results and discussion

The proposed converters CBBC and IBBC are simulated using Simulink/Matlab environment



IL1 and IL2 current waveform with interleaving control strategy



(a) Conventional BBC	(b) Interleaved BBC
Input current for CBBC and IBBC	

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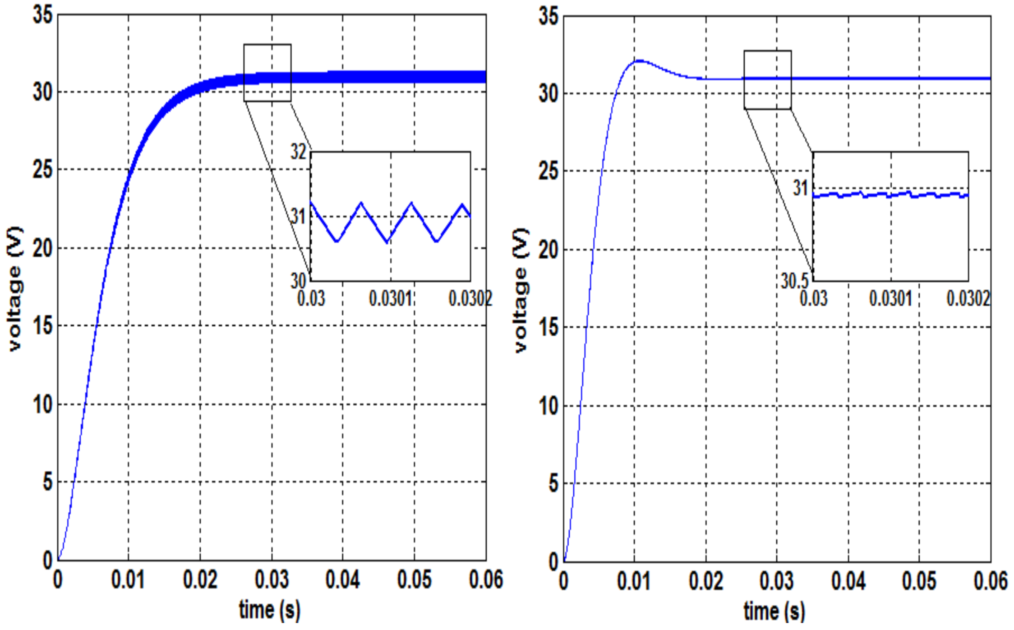
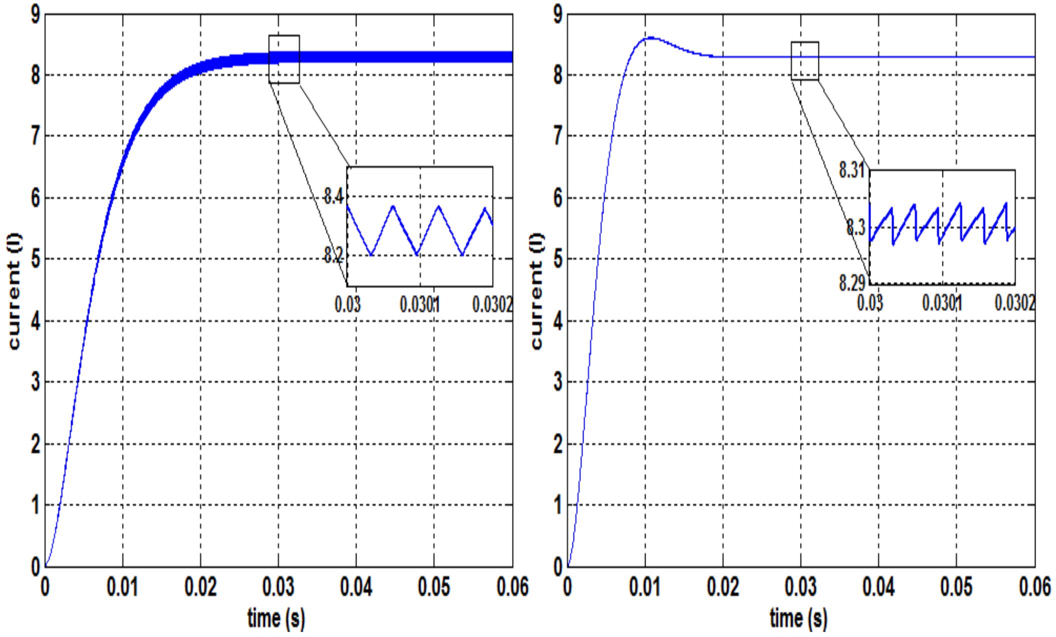
Results and discussion



(a) Conventional BBC	(b) Interleaved BBC
Output voltage	



(a) Conventional BBC	(b) Interleaved BBC
Output current	

Conclusions

- Both input and output voltage and current ripples were reduced, and efficiency was improved.

- 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.

- Having an interleaved structure can cost additional inductors and power switching devices.

As researchers or practitioners what are the possible interactions/collaboration with practitioners resp. researchers to improve/upscale your activities

- Same Lab as PAUWES PhD students

- Build experiments used by:
  - PAUWES PhD students
  - PAUWES Master students

What are the potential aspects of the research that can be transformed into practice?

- Look for partners:
  - Build prototypes
  - Startup
  - Build and sell for Africa
  - Export for EC

Thank you for your attention