PV Emulator based on Interleaved Buck Converter using Adaptive PI Controller

Mustapha Alaoui, Hattab Maker, Azeddine Mouhsen

IMAT3E'18

International Meeting on Advanced Technologies in Energy and Electrical Engineering

PV Emulator based on Interleaved Buck Converter using Adaptive PI Controller

[1]*ALAOUI Mustapha, [1]MAKER Hattab, [2]MOUHSEN Azeddine.

[1]mu.alaoui@uhp.ac.ma, High School of Technologies, Berrechid, Morocco
[2]Faculty of Sciences and Technologies, Settat, Morocco

This paper presents a modeling, design and simulation of PV array emulator based on Switched Mode Power Supply which consists on an Interleaved DC-DC Buck Converter controlled by an adaptive PI controller, this system is generally used for the purpose of reproducing the electrical behavior of a PV module without needing the use of real PV panels which are very cost and require a large space besides their dependence on weather parameters of irradiance and temperature. For those reasons, the PV emulator has been proposed to overcome these limitations and allow researchers, engineers and manufacturers to carry out tests and experimentation on PV systems such as PV MPPT algorithms and connected PV inverters irrespective of environmental conditions change [2]. The reason behind using interleaved topology is its ability to give a little amount of ripples and reduce conduction losses; in addition, it allows downsizing LC filters, which improves the transient response speed [1]. Simulation results are given and discussed in order to verify the effectiveness of PV emulator system as well as evaluate its performances in terms of accuracy, speed, and overshoot limitation.

The whole PV emulator circuit, as shows in figure 1, contains the power part which concerns the interleaved buck converter, and the control part which consists on the current reference generator where the I-V curve is implemented and the PI controller which tracks the I-V characteristic and ensures the robustness in terms of parameters variation and external disturbances. The subsystem below is used to compare the PV emulator current and voltage outputs with the PV model 'ones.

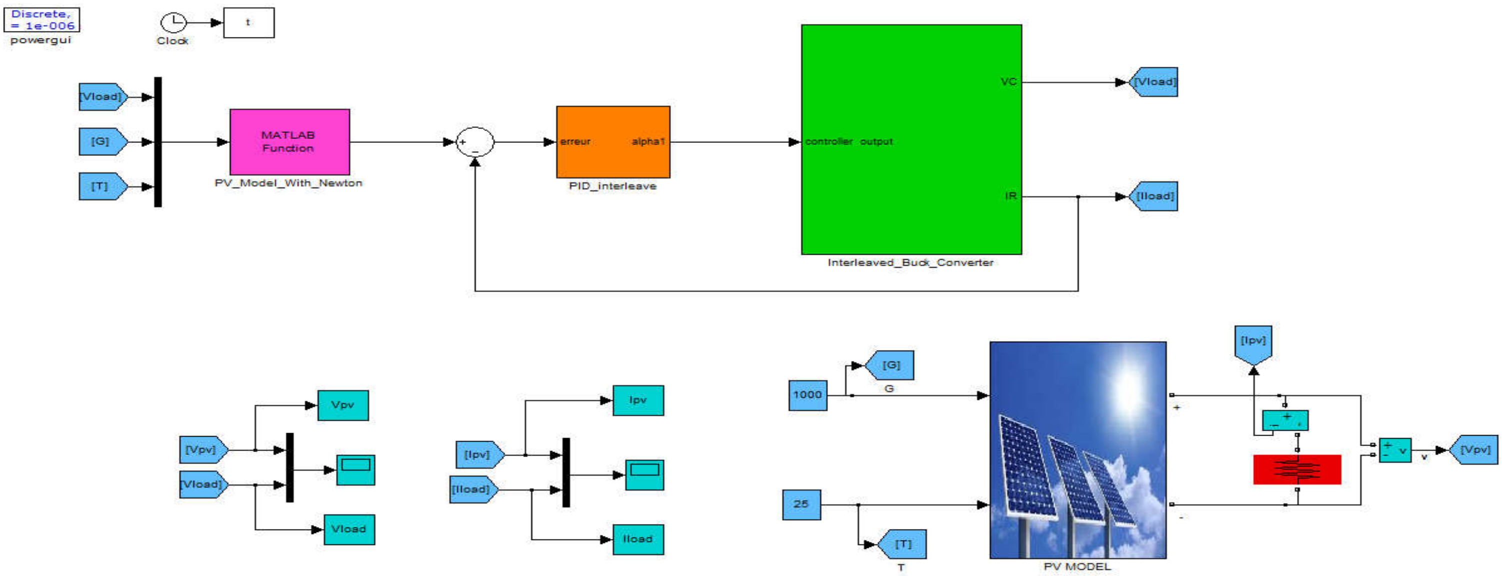

Figure 1: PV Array Emulator Simulink Model

Table 1 : PV emulator parameters

Input voltage Vdc	200 V
Capacitor C	1 µF
Inductors L1 = L2 = L	2 mH
Switching frequency f	100 KHz
Peak rated power	335 W
Open circuit voltage Voc	46.1 V
Short circuit current Isc	9.41 A
Maximum power point voltage Vmpp	37.8 V
Maximum power point current Impp	8.87 A
Temperature coefficient of Isc : ki	0.053
Temperature coefficient of Voc : kv	-0.31
Temperature coefficient of power:kp	-0.41
Cell number Ns	72

The adaptive PI controller parameters are defined using the following equations:

$$Ki(R) = \frac{R}{\tau * Vdc} \tag{1}$$

$$Kp(R) = \frac{Ki * L1}{R} \tag{2}$$

$$Kd(R) = Ki * L * C \tag{3}$$

Where τ is the desired closed loop time constant .The PI parameters are adjusted for any value of resistance (R) in order to maintain the performances of the closed loop system, besides, those parameters are tweaked to make the system over-damped in the voltage region of I-V curve so as to ensure the stability of the PV emulator whereas the current reference changes excessively [3].

It has to be noted that Kd is very low in the order of 1e-6, so it can be neglected.

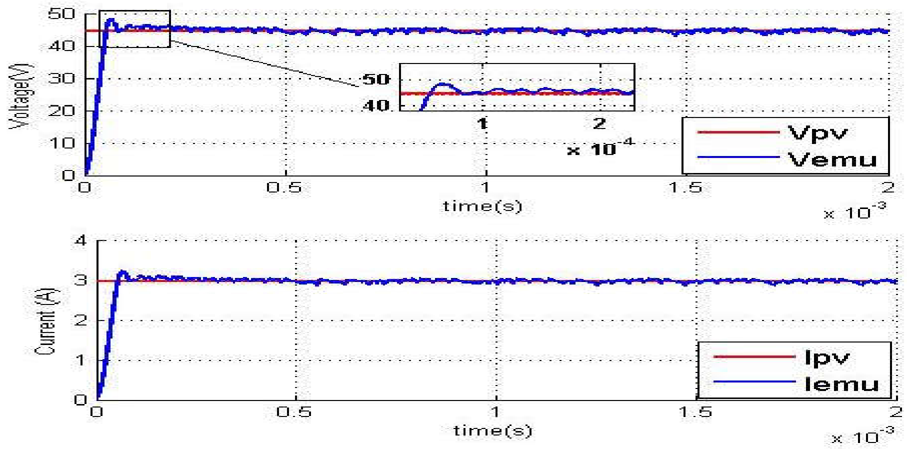

Figure 2: Voltage and Current outputs of the proposed PV emulator for R = 15 Ω under STC conditions

As illustrated in figure 2, the proposed PV emulator is able to track the I-V curve of PV module with accuracy and fast dynamic response; the settling time doesn't exceed 100 µs and the output ripples are very small.

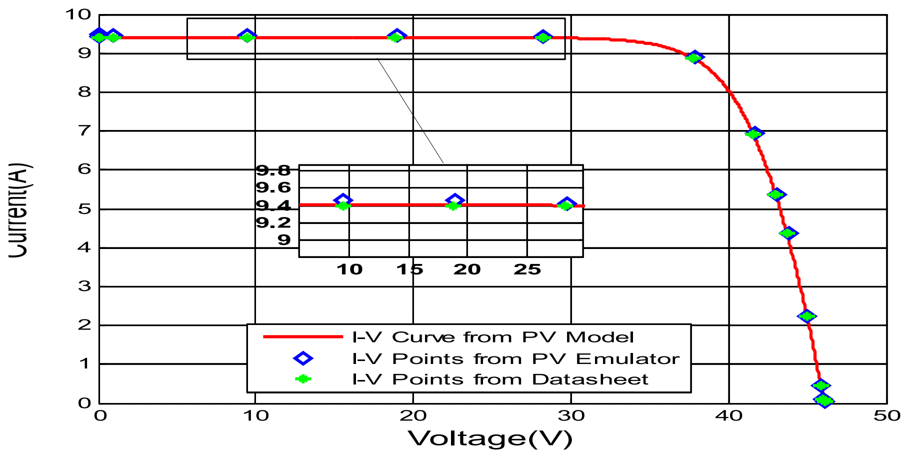

Figure 3: Comparison between I-V curve characteristic of PV model, real PV module and PV emulator under STC conditions.

As shown in figure 3 above, the designed PV emulator can generate accurately the voltage and current outputs of PV module for any operating point in the I-V curve, so it can efficiently mimic the electrical behavior of an actual PV module.

Références

1. K. Billings, T. Morey, Switchmode Power Supply Handbook, 336, 849 (2011).
2. M. C. Di Piazza, G. Vitale, Photovoltaic Sources Modeling and Emulation. 173, 296 (2013).
3. J. Prasanth, H. Manghania, S. Pillaia, T. Sudhaka, M. Miyatakeb, N. Rajasekara, Analysis on solar PV emulators.Rev. 149-160 (2017).