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Modeling and Control of a Photovoltaic Panel with DC-DC Convertor

H. Bencheikh Lehocine*, A. Djoudi Gherbi

Centre de Développement des Energies Renouvelables, CDER, 16340 Algiers, Algeria

*Corresponding author's email: benchikh.ha.16@gmail.com

ABSTRACT

Buck type (DC-DC) converters are used in low power applications, such as mobile applications and renewable energies. This type of converter is studied with the objective of developing its control. We will proceed to the modeling of the closed loop converter in the continuous conduction mode (CCM). A dynamic study is required by transforming the system into an invariant average system, then linearizing around an equilibrium position. The development of the linear model allows the calculation of transfer function to arrive at the control parameters and test the robustness of this controller. The MPPT control implemented using the Arduino board is based on two algorithms, Perturbation and Observation (P&O) and Increment of Conductances INC. The PV system is simulated and studied using Proteus software.

Keywords: DC-DC converter, Buck, CCM, Arduino, Proteus.

1. Introduction

In stand-alone photovoltaic (PV) systems, the main role of the charge controller is the continuous monitoring of the state of charge of the battery to ensure its protection against overcharging and excessive discharge. The GPV system equipped with an MPPT converter is widely studied [1-2]. The direct control of the convertor duty cycle is based on varying the voltage or current at the output of the PV panel using an MPPT algorithm, to operate the system around the point of maximum power. In this systems, no appropriate voltage or current regulation is achieved and the converter is subject to increased switching stress and losses [3]. Therefore, the use of feedback loops with (PI) or (PID) compensators for regulating the current and/or voltage of the converter is preferred. It actuates on the DC-DC converter duty cycle to reduce the converter settling time and also avoids overshoots and oscillations [4], making easier the functioning of MPPT methods [5]. Photovoltaic voltage regulation can be achieved with proportional and integral PI compensators. This article will present an analysis of the PV voltage regulation problem with a Buck converter used as a power conditioning system in the photovoltaic installation. Two algorithms of MPPT control are studied, Perturbation and Observation (P&O) and Increment of Conductances INC. We will proceed to the modeling of the closed loop converter in the continuous conduction mode (CCM). A dynamic study is required by transforming the system into an invariant average system, then linearizing around an operating point to control the input PV voltage. The development of the linear model allows the transfer function calculation to obtain the control parameters and test the robustness of the controller. The analog PI controller was first designed using the standard frequency approach based on linearization, then this analog controller was transformed into a digital controller to be able to implement it in the Arduino.

2. System simulation in Proteus software

Simulate the system using PROTEUS software by developing a detailed diagram containing the control circuit (Arduino and driver) and the power circuit (Buck), as well as the regulation program implemented in the Arduino.

3. Results and Discussion

The results presented in figure 1and 2, are current I(t), voltage V(t), power P(W) under STC conditions and irradiation variations.

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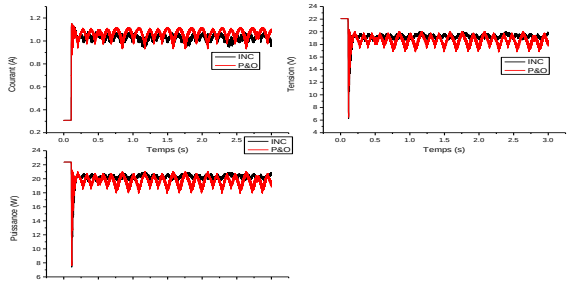

Figure 1: Current I(t), Voltage V(t), Power P(W) under STC conditions.

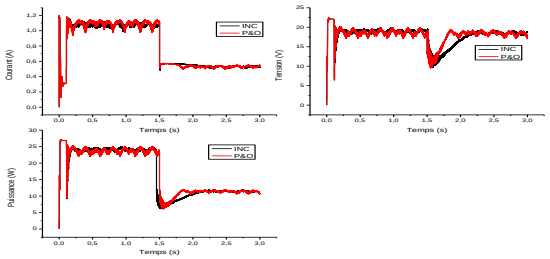

Figure 2: Current I(t), Voltage V(t), Power P(W) under irradiation variations.

Table 1. *Comparison of MPPT P&O and IncCond techniques*.

Algorithms MPPT	P&O	IncCond
Complexity	Low	Average
Convergence speed	Average	Average
Precision	Less precise	more precise

4. Conclusions

Our study focuses on improving the performance and efficiency of a photovoltaic system through the use of an appropriate algorithm for controlling the power interface. The main objective is to find an efficient and optimal algorithm or control law to extract the maximum power available from the photovoltaic generator (GPV). The work presented concerns the control of a DC-DC converter (Buck). The linearized model of the power converter was established and then analyzed. An approach for photovoltaic voltage regulation is used aimed at better robustness and performance, it uses a PI regulator which has been discretized in order to be implemented in the Arduino. The performance of this regulator is based on the correct choice of parameters k_p, k_i, which are calculated from the transfer function of the closed-loop system.

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