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Controller Design Based on Internal Model Applied in a Quadratic Boost Converter with P&O MPPT

E. N. Chaves[1], G. P. Viajante[1], M. A. A. Freitas[1], L. S. Villefort[2], H. T. de Moura[2], L. C. G. de Freitas[2], E. A. A. Coelho[2]

[1] Federal Institute of Education, Science and Technology of Goiás.
Energy Systems Research Center (Núcleo de Pesquisas em Sistemas de Energia - NuPSE)
Phone/Fax number: 55 64 343152005, e-mail A: eric.chaves@ifg.edu.br

[2] Electric Drives Laboratory, Federal University of Uberlândia
Campus Santa Mônica, Uberlândia-MG, Brasil.
Phone/Fax number: 55 34 3239-4411, e-mail: B. ernane@ufu.br

Abstract. This paper presents the controller design used in the inner loop of the Perturb and Observe (P&O) type of maximum power point tracking (MPPT) algorithm to control the output voltage of photovoltaic panels, from a DC-DC quadratic boost converter. The use of such a converter is based on the need to extend the DC-DC conversion range and acquire a quadratic dependence of the output voltage in relation to the duty cycle. In order to investigate a method that improves the controllability of this DC-DC converter, the design of an internal model based controller with 1 degree of freedom is proposed, and its performance is evaluated through experimental results that support the viability of its application.

Keywords

Internal Model Control, Maximum Power Point Tracking, Photovoltaic Generation, Quadratic Boost Converter.

1. Introduction

For most grid-connected photovoltaic systems, a converter that performs Maximum Power Point Tracking (MPPT) of the series and/or parallel arrangement of solar panels is necessary [1]. The converter most commonly used for such applications is the DC-DC boost converter. However, the static gain of the boost converter is limited due to conduction losses suffered when the duty cycle (*D*) approaches that of the unity [2]. By keeping in mind the need to amplify the operating band of DC-DC converters, a quadratic boost converter is presented in [3]. The voltage gain for this converter has a quadratic dependence on duty cycle (D). Other converter topologies with the same features were presented in [4] and [5].

Following on with the line of research for this converter, different control techniques were presented as in [6]-[12]. In these studies, where proposals for control methods of quadratic boost converters are made, the technical difficulties for controlling this DC-DC converter are presented. However, in these studies, as in many others for this converter, control methods for non-MPPT applications are developed.

The quadratic boost converter is characterized through it being a fourth order system. In addition, when this system is modelled for the input voltage control of the converter, typical of MPPT algorithms, its dynamic is marked by the presence of complex conjugate poles close to the imaginary axis of s-plane , and two complex conjugate zeros in the right half-plane. These invert the time response of the system, when under the influence of such compensators.

Therefore, the aim herein is to investigate a method that improves the controllability of this DC-DC converter in MPPT applications. Thus, this paper puts forward a proposal for a control design based on Internal Model Control with one degree of freedom (1-DOF IMC) applied to the quadratic boost converter.

Its performance is evaluated through experimental results, where the corroboration of its viability for MPPT application is sought, according to the needs of a system that can be connected to the grid with respect to the voltage value for the DC bus. Figure 1 presents the structure of the system involving the MPPT, P&O (Perturb and Observe) and the IMC controller, together with the quadratic boost DC-DC converter.

2. Modelling of the Quadratic Boost Converter for the Input Voltage Control

In order to design the controller, the modelling process of the quadratic boost converter was performed through use of state-space averaging [13].