Abstract

In this thesis two adaptive Maximum Power Point Tracking (MPPT) techniques for PhotoVoltaic (PV) applications, which are based on two different real-time identification procedures are proposed. The algorithms are implemented on the same low-cost Field Programmable Gate Array (FPGA) device in charge of controlling the switching converter that processes the power produced by the PV array.

The Perturb & Observe (P&O) algorithm is the most common MPPT technique. Its efficiency is mainly related to two parameters: the perturbation amplitude and the perturbation period T_p. The optimal values of such parameters depend on the PV array type and on the irradiance and temperature conditions thereof, as well as on the parameters of the power processing circuit. Thus, a method for dynamically adapt the P&O parameters would be very useful for increasing the P&O MPPT performances. Several approaches presented in the current literature are focused on the adaptation of the perturbation amplitude. In this thesis, on the contrary, the on-line optimization of the value of T_p is proposed. The effects of such a parameter on both the tracking speed and the stationary MPPT efficiency are pointed out. Besides, the need for a real-time identification technique for identifying the minimum acceptable value of T_p in the actual PV operating conditions is demonstrated.

Two different identification procedures aimed at developing the aforementioned adaptive MPPT controllers have been studied: the Cross-Correlation Method (CCM) and the Dual Kalman Filter (DKF). The first one belongs to the non-parametric techniques and allows identifying the impulse response and the frequency response of the PV system. Instead, the DKF is a model-based approach which estimates the states and the parameters of the system. One of the aims of this thesis is to demonstrate the usefulness of these identification procedures for the optimization of the PV P&O MPPT performances.

In order to achieve a good trade-off between the desired performances and the cost of the controller, hardware digital solutions, such as FPGA, are adopted. They are able to reduce the execution time by exploiting the intrinsic parallelism of the algorithm to be implemented. Then, in this work, the challenging design of a high performances hardware architecture for the identification algorithms is dealt with. Moreover, the implemented identification techniques are compared in terms of accuracy, identification time and used hardware resources.

Several simulations and experimental tests demonstrate the feasibility of the developed identification procedures. In fact, the proposed adaptive MPPT controllers suitably change in few tens of milliseconds the value of T_p ensuring a stable MPPT behaviour. The developed FPGA-based architectures of both the identification techniques is promising for embedding other functions that are of interest in the field of PV systems, e.g. related to on-line monitoring or diagnostic purposes.

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