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Capacitor charging method for $I–V$ curve tracer and MPPT in photovoltaic systems

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Abstract

The capacitor charging method can be used in Photovoltaic (PV) systems for two typical applications: a very simple and cheap way (1) to trace the $I–V$ curve of a PV generator of whatever size and (2) to track the Maximum Power Point (MPP), especially when the partial shading occurs. The problem is the correct sizing of the capacitor in order to achieve accurate, uniform and smooth results. In the first application a simplified calculation to design quickly the capacitor is carried out. This is done only as a function of the main characteristics of the PV array and the most important datasheet parameters of the PV modules. Then, the setup of $I–V$ curve tracers at module, string and array levels is presented: these tracers are useful in the detection of underperformance of PV systems. In the second application a MPPT (MPP Tracker) circuit based on capacitor charging is designed and simulated in partial shading conditions. In these conditions the Power–Voltage ($P–V$) curve of a PV array is characterized by the presence of multiple maxima for the bypass diode action. The PV array is isolated from the load for a negligibly short period and is connected to an external capacitor. During the charging time, the proposed circuit tracks the global $MPP$. This circuit is easy to implement and shortens the duration needed for scanning the $P–V$ curve of the array.

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Keywords: $I–V$ curve tracer; Capacitor sizing; Maximum power point tracker; Partial shading

1. Introduction

Solar energy is one of the most important renewable sources: it is clean, inexhaustible and free. Photovoltaic (PV) power generation exhibits relatively high installation cost (Spertino et al., 2014a) and limited efficiency of solar cells. PV generators are used to directly convert solar into electrical energy. PV arrays are built by connecting many modules in series to form a string, by connecting strings in parallel to form an array, to obtain the desired levels of output voltage, current and power.

The monitoring of its performance during the operation is achievable by the measurement of current–voltage ($I–V$) characteristic curve of the array at the actual solar irradiance and ambient temperature. The Standard (IEC 62446, 2009) is a reference in this topic: it describes “the minimum commissioning tests, inspection criteria and documentation expected to verify the correct operation of the system”. At this aim, the typical size limits, i.e., ≤100 kWp as written in Muñoz et al. (2011), of the commercial