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Solar Photovoltaic Emulation under Uniform Irradiance and Partial Shading Conditions using Sliding Mode Control

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Abstract

For the purpose of minimizing greenhouse gas emissions and contributing strongly to the climate change mitigation, many researchers and scientists are making tremendous efforts in order to boost the research and development in renewable energies as an important solution to reduce the use of conventional power generation resources. Solar photovoltaic (PV) energy is widely used and has known a significant interest in last years. However, its dependence on the atmospheric conditions does not allow researchers to perform their experiences at the desired atmospheric parameters especially temperature (T) and irradiance (G). Furthermore, using real PV modules with controllable light source to carry out measurements and tests on PV applications such as Maximum Power Point Tracking (MPPT) and solar connected inverters is considerably inefficient and less flexible. Therefore, PV array emulator were appeared to deal with those limitations and to replace efficiently the use of real PV modules in laboratory tests by delivering similar PV characteristics and mimicking the electrical behavior of PV panels. In addition to the emulation of PV modules under varying environmental conditions, the emulation of PV array under partial shading conditions is an interesting topic especially for the aim of using PV array emulators in testing Global Maximum Power Point Tracking (GMPPT) techniques, which constitute nowadays a huge challenge for PV researchers. This paper presents the design of PV array emulator based on robust sliding mode controller, which is able to emulate accurately the PV array under both uniform solar insolation and partial shading conditions. Simulation results using Matlab Simulink software are presented and discussed so as to investigate the static and dynamic performances of the developed power device.

Keywords: PV Array Emulator, Partial Shading Conditions, PV Characteristics, Robust Sliding Mode Controller, DC-DC Buck Converter, Solar Irradiance.