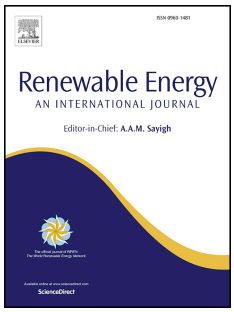
Accepted Manuscript



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PII: S0960-1481(18)30453-1

DOI: 10.1016/j.renene.2018.04.045

Reference: RENE 10003

To appear in: *Renewable Energy*

Received Date: 14 January 2018

Revised Date: 12 March 2018

Accepted Date: 12 April 2018

Please cite this article as: Bressan M, Gutierrez A, Garcia Gutierrez L, Alonso C, Development of a real-time hot-spot prevention using an emulator of partially shaded PV systems, *Renewable Energy* (2018), doi: 10.1016/j.renene.2018.04.045.

Development of a real-time hot-spot prevention using an emulator of partially shaded PV systems

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Abstract: This work presents an emulation in real-time of the shaded PV systems with a hot-spot prevention. The PV model takes into account the photo-induced current contributions from unshaded and shaded sides thanks to parameters such as the shadow transmittance and the percentage area of the shadows. The use of shadow fault detection in real time is employed avoiding all form of hot-spot formation and PV cells power dissipation. The calculation uses a simple derivative equation able to give the area of detection in function of the PV module voltage. The implementation of the emulator in FPGA takes advantages as a result of their features of adaptability and parallel processing suitable for emulation of complex shading visible on PV systems. The emulation of the proposed PV model and the hot-spot prevention are validated through two experimental tests on PV modules.

Keywords: PV system, partial shading, bypass diode, shading factor, real-time emulation, hot-spot prevention

Nomenclature

δ	Shadow coefficient	I	Cell current
δ_L	Lowest shadow coefficient	I_0	Dark saturation current
δ_n	Calculated shadow coefficient	I_{dv}	Divergence current
τ	Shadow transmittance	I_{ph}	Photogenerated current
a	Constant	I_{ph_i}	Illuminated I_{ph}
a_i	Percentage of illuminated area	I_{ph_s}	Shaded I_{ph}
a_n	Calculated area	I_{ph_T}	Total I_{ph}
a_s	Percentage of shaded area	$I_{ph_{T_i}}$	Completely illuminated I_{ph}
a_{s_L}	Lowest percentage of shaded area	$I_{sc_{STC}}$	Short circuit current for STC
k	Boltzmann constant	J	Density current
m	Constant	J_{ph}	Photocurrent density
n	Ideality factor of the diode	J_{ph_i}	Illuminated J_{ph}
q	Magnitude of the electron charge	MSE	Mean Square Error
p_b	Black pixel	R_s	Series resistance
p_w	White pixel	R_{sh}	Shunt resistance
A_c	Cell area	S_f	Shading factor
A_i	Illuminated area	STC	Standard Test Conditions
A_s	Shaded area	T_c	Cell temperature