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Enhancing Solar PV System Performance Through the Optimization of PV Cell Parameters Using the Puzzle Optimization Algorithm

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***Abstract*—** Accurate estimation of solar photovoltaic (PV) parameters plays a crucial role in achieving optimal performance in PV systems, which is essential for theoretical analysis and real-time applications. This paper introduces the Puzzle Optimization Algorithm (POA) as a novel approach for determining the optimum PV parameters in a PV single-diode model. The primary objective is to show the efficacy of this method by evaluating the root mean square error (RMSE) of the objective function. The investigation involves the analysis of four commercial PV modules, with a comparison of RMSE values against recently published literature. Applying the POA to these PV modules, reveals improved accuracy and minimal error in output current. Moreover, using optimized PV parameters, open-circuit voltage, short-circuit current, and maximum power are determined for all the PV modules in MATLAB and compared with manufacturer data. The obtained results unveil that the percentage relative error in both maximum power and short-circuit current is less than 1% for all of the PV modules. All in all, this investigation establishes the effectiveness of the POA in achieving precise parameter estimation for various PV modules, contributing to improved PV system design and operation.

***Keywords*—** PV module; Optimization; Puzzle optimization algorithm; Performance; Root mean square error.

Nomenclature

K	Boltzmann constant	T_N	Nominal operating temperature
N_s	Number of cells in series	k_i	Temperature coefficient of short circuit current
T	Operating temperature	stc	Standard test condition
q	Electron charge	S	Irradiation in w/m² at operating temperature
I_{sdm}	Single diode module output current	S_{stc}	Irradiation in w/m² at stc
I_{ph}	Photocurrent	I_{sh}	Current through the shunt resistance
I_s	Reference diode saturation current	I_o	Diode saturation current
V_{sdm}	Single diode module output voltage	V_T	Thermal voltage
R_s	Series resistance	AM	Air mass (average solar spectrum)
R_{sh}	Shunt resistance	P_m	Maximum power
n	Ideality factor of the diode	I_{sc}	Short circuit current
$RMSE_{CAL}$	Calculated RMSE	V_{oc}	Open circuit voltage
V_{mp}	Voltage at maximum power	I_{mp}	Current at maximum power

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