A new robust methodology for the identification of parameters on the electrical response of photovoltaic systems through the application of polar coordinates

Carlos Cárdenas-Bravo[1], Sylvain Lespinats[2], and Denys Dutykh[3,4]

[1]Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, LAMA, 73000 Chambéry, France
[2]Univ. Grenoble Alpes, CEA, Liten, INES, 73375 Le Bourget du Lac, France
[3]Mathematics Department, Khalifa University of Science and Technology, PO Box 127788, Abu Dhabi, United Arab Emirates
[4]Causal Dynamics Pty Ltd, Perth, Australia

Abstract: Nowadays, the accurate assessment of the health condition of solar photovoltaic systems is a critical necessity. Typically, mathematical models derived from physical laws serve as tools for this purpose, although often presenting challenges due to their non-linear nature, for example, exponential components. In this study, a new robust methodology for the determination of photovoltaic electrical models using polar coordinates is proposed. Our approach involves transforming the measured electrical data – voltage: V_{pv} and current: I_{pv} – into the polar space – radious: ρ and polar angle φ. Then, using optimization techniques such as the least squares method, the optimal combination of parameters is identified. A schematic overview of the presented methodology, including a pre-processing stage, is depicted in Fig. 1. To validate the proposed method, the well-known single-diode model (SDM) is used. The performance of the computed parameters is measured using the Root Mean Squared Error (RMSE), calculated in terms of the radius as an implicit function of the polar angle. Comparison against three alternative approaches – voltage, current, and non-linear function evaluation – demonstrates the benefits of our method. To ensure consistency despite variations in RMSE units, the V_{pv} and I_{pv} are scaled according to the estimated open-circuit voltage and short-circuit current respectively. Preliminary results highlight the increased performance of our approach, maintaining comparable processing times in all cases.

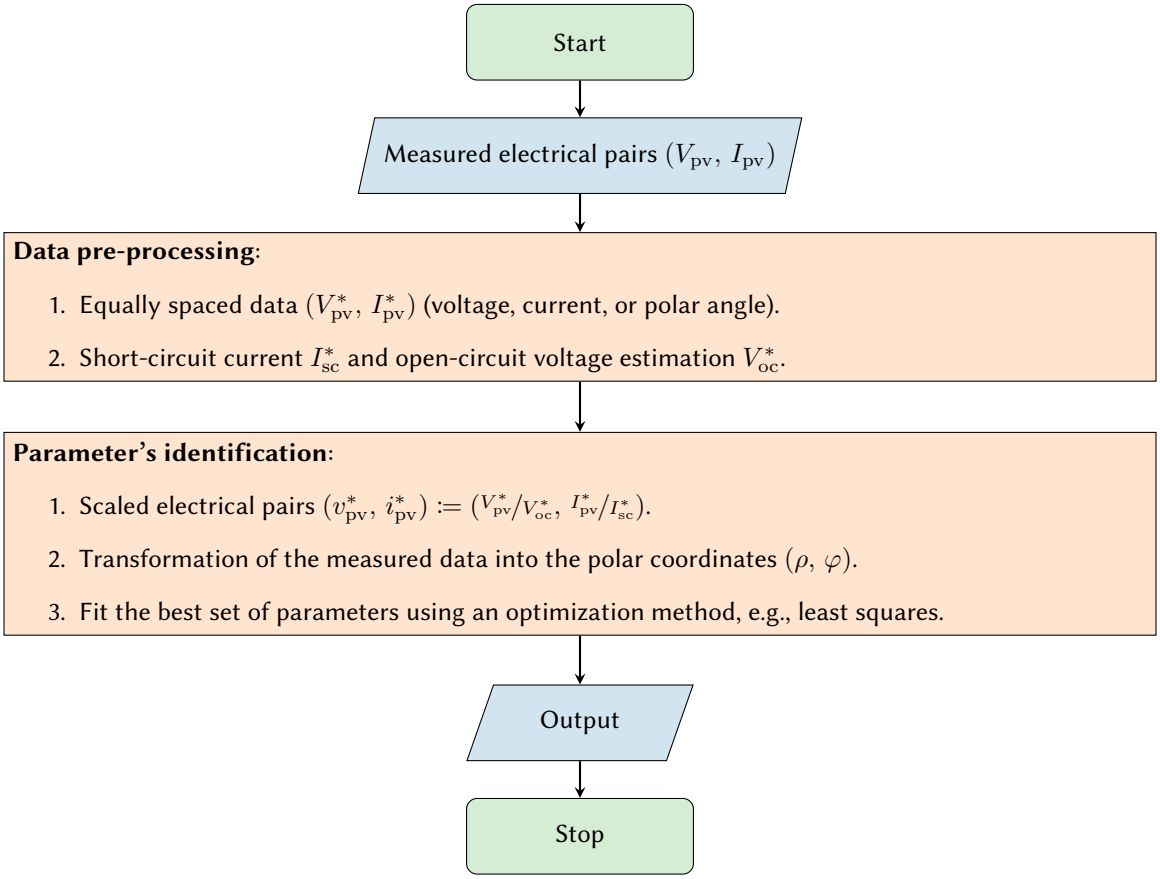

Fig. 1: Flow-chart of the proposed methodology. Here, $(V_{\mathrm{pv}},\, I_{\mathrm{pv}})$ represents the measured voltage and current; I_{sc} and V_{oc} indicates the short-circuit current and the open-circuit voltage, respectively; $(\rho,\, \varphi)$ indicates the measured polar radius and the polar angle; and $(v_{\mathrm{pv}},\, i_{\mathrm{pv}})$ indicates the scaled voltage-current pairs. The superscript "*" stands for variables computed by using the equally spaced data as basis.