3.International Conference on
Theoretical and Applied Computer Science and Engineering
(ICTACSE, 2018)
Ankara, Turkey, November 23-24,2018

Fault Diagnosis Approach of Photovoltaic System Based On Bond Graph Observers

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In recent years, the impact of partial shading on the photovoltaic array performance has been widely discussed [1] - [3]. With a physical photovoltaic module it is difficult to study the effects of partial shading since the field testing is costly, time consuming and depends heavily on the prevailing weather conditions. Moreover, it is difficult to maintain the same shade under varying numbers of shaded and fully illuminated cells throughout the experiment. However it is convenient to carry out the simulation study with the help of a computer model. In most of the studies [4], [5], the effect of partial shading in reducing the output power of the photovoltaic has been discussed. But little attention has been paid to the power dissipated by the shaded cells affecting the array life and utilization of the array for the worst shaded case.

The investigation into mismatch problems of PV arrays can be traced back to as early as late eighties when Bishop [6] proposed a voltage sweeping method to draw the current-voltage (I-V) curve of a PV array with shaded cells. Since then, studies on mismatch of PV arrays, in particular those caused by partial shading, have become active. Shortly later, Abete et al. [7] applied Bishop's method to study the behaviour of a mismatched PV array in presence of bypass diodes. We note that both Bishop [6] and Abete et al. [7] avoided solving nonlinear implicit equations governing PV cell circuits by sweeping the diode voltage to obtain the corresponding I-V curves of PV cells. On the other hand, the Newton-Raphson method, a widely applied iterative numerical method for solving nonlinear equations, was not used for the analysis of PV array networks until the work of Quaschning and Hanitsch [8], subsequent to which Kawamura et al. [9], Alonso-Garcia et al. [10] and Wang and Hsu [11] also adopted the Newton-Raphson method for analyzing mismatched PV arrays.

The present paper deals with a bond graph procedure to design graphical observers for fault detection purpose. First of all, a bond Graph approach to build a graphical proportional observer is shown. The estimators' performance for fault detection purpose is improved using a residual sensitivity analysis to actuator, structural and parametric faults. For uncertain bond graph models in linear fractional transformation (LFT), the method is extended to build a graphical proportional-integral PI observer more robust to the presence of parameter uncertainties. The proposed method