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An Improved PV Modules Modelling Technique

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Abstract. The world's electric power generation is gradually shifting ground from conventional to renewable energy sources (RES) in order to mitigate the negative consequences of the former. Solar photovoltaic energy is regarded as the most attractive of all the RES due to its low installation and maintenance costs, longer lifetime and shorter payback period. As such, an accurate, robust, and flexible modelling of the PV modules is necessary for an improvement in maximum power extraction, partial shading condition (PSC) elimination, accurate and reliable photovoltaic (PV) panel sizing. In this study, MATLAB programming was used to implement the five-parameter single-diode model (SDM) PV modules in the MATLAB/Simulink using the manufacturer's datasheet information. The modules were implemented through the I-V equation parameters estimation of the SDM from the manufacturer's datasheet. The performance of different PV module technologies implemented was evaluated at STC. Analyses of the I-V and P-V curves characteristics of the developed models were carried out. Further models analyses were conducted under various test conditions. Models validation was performed by comparing the results obtained with that of selected in-built PV models. Different factors affecting the modules' performance were also evaluated. Finally, a Simulink model of the PV module was also developed for easy to use with any circuit simulator. The proposed modelling technique meets the key features of minimal differences between the modelled and actual measurements data, most especially at the maximum power points, while exhibiting a fast convergence with good precision.

Keywords; PV modules modelling; MATLAB/Simulink; single-diode model; photovoltaic module

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1. Introduction

PV modules modeling techniques have been continuously modified and improved to find the best approach suitable for current and emerging modules. However, based on the reviewed literature, most of the proposed modelling methods exhibit some level of approximations and estimations of the I-V equation parameters [1], which invariably affect the accuracy and suitability of the techniques [2]. Most importantly, at operating conditions of high solar irradiance and temperature. Therefore, one notable gap, which when filled could improve the modelling accuracy, is the proposition of technique that will eliminate the guess of any of the I-V equation parameters by trial and error while the algorithm is being run. If not eliminated, then the algorithm's accuracy may be affected due to variations in the properties of modules' materials. For ensuring the authenticity of the modelling techniques, all parameters of the I-V equation need to be determined without assuming any constant values. Because it is impractical to introduce any constant values outside the given datasheet information, except for the globally accepted constants.

To address these challenges, an improved modelling technique suitable for the majority of the PV modules technologies utilising only the manufacturer's datasheet information and does not require any initial guess value(s) or finding the I-V equation parameters by trial and error is necessary. Therefore, the proposed PV modelling method presented in this research aims to address these challenges.

2. Methodology

In this study, a five-parameter SDM PV module is modelled by adjusting the I-V equation parameters based on the manufacturer's datasheet information. Then an iterative algorithm technique employing Newton-Raphson iteration is used to implement the module using MATLAB programming in the MATLAB editor window. The performance of different PV module technologies implemented is evaluated at STC. Analyses of the I-V and P-V curves characteristics of the developed models are carried out. Further analyses of the implemented models are conducted by varying the operating temperature and solar irradiance. Models validation is performed by comparing the results obtained with that of the selected in-built PV model using the manufacturer's datasheet. During the model validation, different factors affecting the performance of the module are evaluated. A Simulink version of the proposed modelling algorithm has been developed for easy to use with any type of circuit simulator. Finally, the developed model was used to simulate the traditional P&O MPPT algorithm in the MATLAB/Simulink environment.

3. Conclusion

In this research, a soft modelling method for the PV modules has been proposed, implemented and analysed. MATLAB m-file script and Simulink environment were used for the algorithm implementation and analyses. The primary aim of matching the experimental and the model output curves of PV modules was achieved.

The proposed algorithm in this study was adopted from the research of [3, 4], which were modified and improved to accommodate all the I-V equation parameters necessary for accurate PV module modelling. The use of some parameters' arbitrary values was eliminated, which consequently enhanced the accuracy of other module parameters estimation and overall I-V and P-V characteristics.

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