Parameter Estimation Techniques for Different Diode Models: An Overview and Future Prospects

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From the past few decades, the world has seen many ups and downs in the field of power generation due to many prevailing issues presented by the conventional methods. The conventional fuels are drying out and would be empty very soon, further the amount of pollution contributed by them is huge. They produce a large amount of harmful fumes in the environment directly into the air. Besides they also pollute the water and the soil. As a result of it, people set out for finding an alternative for the production of electricity and came up with renewable energy resources. These energy resources do not pollute the environment and have unlimited availableness. Out of all the energy resources the solar energy has got the maximum potential as it is available to almost all the countries in the world and in an abundant amount. The electricity is generated from solar energy by the use of photovoltaic (PV) technology. PV are the silicon-based semiconductor which when illuminated produces electricity.

For the proper evaluation of the PV panels the knowledge of the appropriate mathematical model is crucial as they lead to the calculation of intrinsic parameters. These parameters are not provided by the manufacturer and if they are not known then the performance parameters including efficiency cannot be determined accurately. The efficiency of the panel may change slightly over the years and depends on its usage as well. It also depends on the environmental conditions the panel is subjected to and the different types of fault which may be internal or external faults that may appear in it. The intrinsic parameters of the PV panel depends on the also depends on the irradiation level and this is being used for the extraction of them. Different conditions which are known from the manufacturers are applied to the mathematical equations formulated from the mathematical model and then they are solved. Hence, an accurate model needs to be chosen for this. The literature has evidence of many such models which are known to give good results for the parameters extracted. Single diode model (SDM) is the simplest amongst the lot, in which the cell is represented with the help of a single diode and accounts for the losses in the quasi-neutral region. It also consists of a series resistance, a parallel resistance and there are overall five parameters which need to extracted from it. This model is the simplest model and provides good results quickly. In order to get clearer image of the PV cell a slight modification was made in the existing single diode model where another diode was added parallel to it and was called the double diode model (DDM). The second diode introduced accounts for the loss in the space charge region and is more accurate than the SDM. With accurateness the complexity and the number of variables to be to be estimated which increases to seven. DDM has proved out to give better results than SDM and is hence preferred over SDM. Together SDM and DDM are the most popular model on which the work of parameter estimation has been done till now. Another slight modification which has been done on the DDM is the addition of a new diode in parallel to it which makes three diode in parallel and hence its name is three diode model (TDM). The third diode represents the losses occurring in the grain boundary and is considered as the most accurate model for a PV cell. It is a recently developed model and is the most sought-after model. The presence of three diode in parallel increases the number of unknown parameters which increase to nine and so is the complexity. Hence, larger time is required by the algorithms to produce results for them. When a resistance is added in series with any of the one diode in the DDM then a new it becomes a new model known as modified two diode model (MDDM). It is also a newly developed and less explored model where the extra series resistance accounts for the losses in the grain boundary region of the diode. There are eight parameters which needs to be estimated from MDDM and has its complexity lying between the TDM and DDM. There is another model which has been developed recently for the extraction of parameters of the organic solar cells and is known as reverse two diode model (RTDM). It consists of a diode and a resistance in parallel in the load side of the model and is the least explored model of all. The need of this model was felt as the conventional models do not produce good results for organic solar panels. It is indeed a very complex model with complex equations and the convergence characteristics is affected badly while extracting parameters.

For solving of the non-linear equations generated from different models, analytical solution techniques cannot be applied on them as they would provide very poor solution and would be tedious in nature. Hence, they are avoided. The numerical methods are also of many types. Hence, for solving the different diode equations metaheuristic algorithms came into limelight. These are population based methods where the firstly the population is initialized randomly and are then updated during the subsequent iterations. They also serve as the optimization methods to obtain the desired accuracy in the solution. These algorithms update the fitness of each of the member during every iteration and judge which one is the closest to the actual global maxima or minima of the problem. They are equipped to handle multimodal functions easily and do not get struck due to the presence of local maxima or minima. Metaheuristic algorithms are advanced algorithms and impose no restrictions in the total number of variables. These algorithms have their history from the early years of 21¬th century and since then advancements have been made constantly towards this and mostly all of them have been explored for the extraction of parameters of different diode modelled PV panels.

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