Solar Photo-Voltaic Modelling using Intelligent Algorithms

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Abstract:

The modelling of Solar Photovoltaic (PV) plays an important task in the calculation of the predictable power from a solar PV module. The precise modelling of Solar PV is a tedious task since certain parameters are not given in Manufacturer's datasheet. These unknown parameters such as diode saturation current (I_0), shunt resistance (R_p), series resistance (R_s), ideality factor (a), and Photo generated current (I_{pv}) are used to estimate the electrical characteristics from the Solar PV under different conditions of temperature and irradiance. Intelligent Algorithms have employed to optimize the unknown parameters in the Solar PV Module under different environmental conditions.

Introduction:

The exhausting nature of non-renewable energy sources has driven the world into the energy crisis. As an outcome, the practice of renewable energy sources like solar, wind, and tidal are providing a better solution for the problem [1]-[2]. Among the renewable energy sources, solar energy has identified as favourite due to inexhaustibility, non-polluting nature, and maintenance free. Most solar cells are manufactured using crystalline silicon; it can be able to convert 14-20% of sunlight into electricity. The correct modelling of solar PV Module is required before the hardware implementation part. The worldwide researchers found that MATLAB and PSPICE is appropriate software for solar PV modelling [3]. A Solar PV manufacturers have given inadequate model parameters such as open circuit voltage (V_{oc}), short circuit current (I_{sc}),the voltage at maximum power point (V_{mp}), and current at maximum power point(I_{mp}), Current temperature coefficient, Voltage temperature coefficient. For modelling the solar panel using single diode model, the model parameters such as shunt resistance (R_{sh}), series resistance (R_s), ideality factor (a), diode saturation current (I_0), Photo generated current(Iph) are mandatory. However, these parameters are not given in manufacturer's datasheets. The calculation of precise values of model parameters is crucial owing to nonlinearity in the PV characteristics [4]-[6]. Initially, Conventional Techniques such as Gauss Seidel and Newton Raphson method have been employed for parameters optimization. However, these methods are tedious and time consuming [7]-[8]. Hence, considering the above facts, intelligent algorithms such as Particle Swarm optimization, bacterial foraging algorithm, and several other algorithms have been applied recently to extract the unknown parameters.

Basic Elements of Solar PV Modelling:

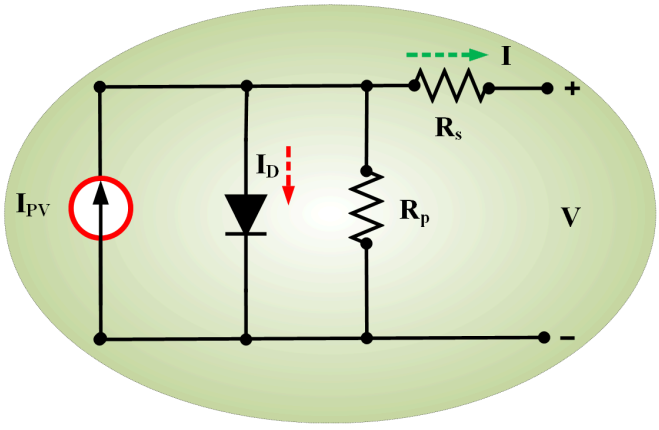

Figure 1. Single diode solar cell model

The single diode PV cell consists of a current source along with an anti-parallel diode, series resistance, and shunt resistance. The Equivalent circuit defines the entire V-I curve of a PV Cell, Module or an Array as a function of operating conditions. The Operating Conditions implies Irradiance and Temperature. A precise model predicts the V-I curve as accurate as a real time graph at a particular point. Short circuit current and Maximum Power Point (MPP) of the PV modules varies linearly with solar irradiance. The open-circuit voltage and MPP point of the PV module will vary according to temperature changes. The values of parallel and series resistance are an important factor to fix the MPP point of the PV module.

Advantages of Intelligent Algorithms compared to the conventional techniques:

The solar PV Module unknown parameters are extract using various Intelligent Algorithms.

Computation Time: The intelligent algorithms have taken less time to achieve the convergence point compared to the conventional techniques such as Gauss Seidel and Newton-Raphson Method.

Accuracy: The convergence accuracy is high in intelligent algorithms compared to conventional techniques.

Iterations: The number of iterations to reach the optimum point is very less in Intelligent Algorithms compared to the conventional techniques.

Local optima: The problem of local optimum is lesser in intelligent algorithms due to random search.

Error: The percent error is lesser in Intelligent Algorithms compared to conventional techniques.

Numerous intelligent algorithms in literature have tried to extract exact PV parameters since the convergence to the global optimum has not been assured with these techniques. Thereby, in recent years, an additional concept such as hybrid bee pollinator, predator-prey is incorporated with the existing intelligent algorithms to optimize the unknown parameters with global optimum conditions.

Conclusion

This paper provides a wide observation towards the advantages of accurate solar PV modelling before the installation part. It has been attained with the help of intelligent algorithms, which optimize the unknown parameters in the solar PV module with high accuracy and convergence speed, without sub optimal traps. These parameters decide the current and voltage from the solar PV module under different environmental conditions.

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