Australian Government
Australian Renewable Energy Agency

ARENA

Lessons Learnt

Lessons Learnt Report: *Impact of shading and cell variance on module power*

Project Name: *Photovoltaic Modules for the Australian Environment (PV-MATE)*

Knowledge Category:	Technical
Knowledge Type:	Technology
Technology Type:	Solar PV
State/Territory:	Canberra ACT, Adelaide ACT

Key learning

We have quantitatively studied the impact of partial shading and cell variance on module power. A mismatch tool has been developed to incorporate explicit solutions to both forward and reverse IV characteristics of PV cells. It was found that with a string inverter that maximizes power output of 10 PV modules in series, partial shading of one cell in one module will impact the power output of entire module with shading ratio above 12%. The shading tolerance is about 40% with module maximum power tracking implemented. Investigation on the impact of cell variance on module power output shows 3% of cell short-circuit current standard deviation will lead to about 1% of relative module power output loss, while 10% standard deviation will cause an average 15% of relative power loss.

Implications for future projects

We have developed a cell current mismatch calculator based on MATLAB and Microsoft Excel Spreadsheet that can be included as a component of cell-to-module output calculator. We have also showed the impact of cell I_{sc} on module output to indicate the variance tolerance for sorting cells. Output simulation for partial shading with different maximum power tracking technologies provides a method to evaluate the potential gain of implementing micro inverters on modules.

Knowledge gap

Cell-to-module (CTM) output simulation is conducted to predict PV module power output based on cell design, module configuration and environmental conditions. It includes three components including optical, thermal and electrical simulations. Our analysis quantifies the electrical loss of power due to the variance of the cells. We have used explicit solutions in our calculator for better computational performance when it is incorporated with other simulation components.

Background

Objectives or project requirements

The aim was to develop a calculator to simulate the power output of a module with variance of cell properties. The calculator is required to perform efficiently to be incorporated in a CTM simulator.

Process undertaken

60 commercial PV cells were measured for their forward and reverse IV characteristics. Based on the measurement, mathematical models were established to set the voltage and current relation among cells within a module and the boundary conditions regarding to the designs of bypass diodes and cell strings. We then optimized the computational procedures by implementing explicit solutions to the mathematical models with the Lambert-ω function and the general solution to quadratic functions. The simulation procedures are presented in Fig. 1. By implementing the simulation procedure in MATLAB and Excel, we simulate the relative impact on module power due to cell variance by computing the power output of PV modules, where the cells were parameters had the same average parameters with different cell variance as shown in Fig. 2.

Supporting information

This work can be found in the proceedings of the 2016 APSRC, entitled: “A PV Module Mismatch Simulation Model for Shade Tolerance Analysis”, Jiadong (Harry) Qian, Andrew Thomson, Andrew Blakers, Elissa Tokusato, Marco Ernst, Ingrid Haedrich

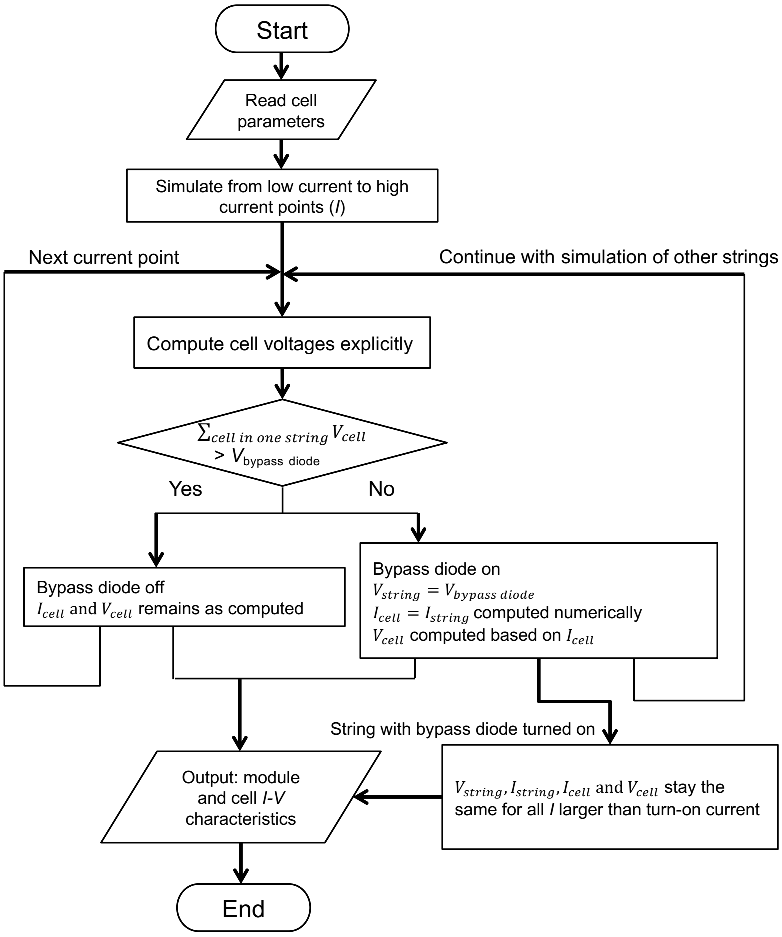

Figure. 1. Flowchart of simulation procedure for cell mismatch in a module

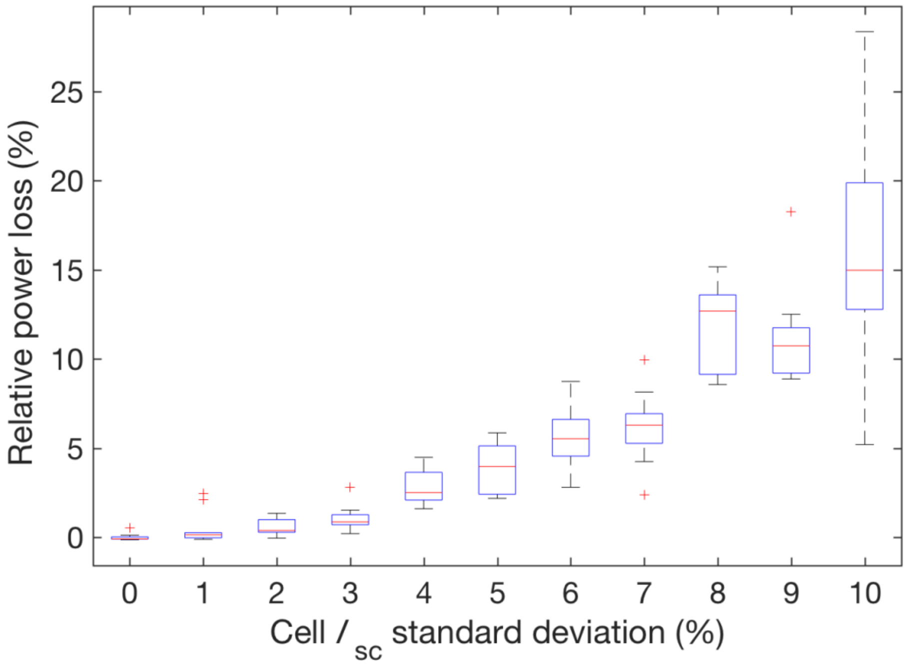

Figure. 2. Relative loss of module power output caused by cell I_{sc} standard deviation based on simulation results of 100 imaginary modules.