PV Module Troubleshooting and Measurement

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I declare that this dissertation is my own account

of my research and contains as its main content work which

has not been previously submitted for a degree

at any tertiary institution.

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Abstract

Over the past few years, the solar photovoltaic (PV) industry has taken the lead in the market growth of the Australian renewable energy industry. Due to the steady manufacturing cost reduction and Australian government support, a great number of PV modules have been installed for domestic and commercial use.

It is well known that the performance of PV modules is greatly influenced by many factors, such as solar irradiance, ambient temperature and the angle of incidence. In addition, the output of PV systems gradually degrades over time under exposure to the sun and other environmental conditions, such as a high temperature and moisture. Normally, the limited warranty period of PV modules ranges from 20 to 25 years, which means the rate of degradation should be less than 1% per year. However, we found that some PV modules performed much worse than the normal ones and their outputs dropped much faster than the expected. Therefore, in any PV module troubleshooting, it is important to figure out the causes that result in dramatic power losses and measure the output of the proper PV modules under operating conditions over a long term.

A rated PV module refers to Standard Test Conditions (STC) of 1000 W/m^2 solar irradiance, Air Mass AM1.5, and a cell or module temperature of 25 ^0C measured prior to outdoor exposure. However, module performance in real conditions is

variable. Therefore, it is necessary to provide more information on a module in actual operating conditions over a long term.

This study is divided into two parts. The first part is a theoretical analysis of module degradation and troubleshooting techniques. The second part is mainly practical measurements for module degradation estimation. PV module performance measurements are used to obtain highly accurate output data from four different PV modules representing three different technologies: monocrystalline silicon (mc-Si), polycrystalline silicon (p-Si) and laser grooved buried contact crystalline silicon (LGBC, c-Si). Degradation rate estimation is based on comparisons of three groups of previous test results obtained in three different periods (2002, 2003 and 2007) by three PhD Murdoch University students. Finally, a verification process by a simulator is briefly introduced.

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Glossary

Abbreviation	Definition
EL	Electroluminescence
IGM	Initial Guaranteed Minimum (P_{max} of module)
Isc	Short Circuit Current
I_{mp}	Maximum Power Current
I-V curve	Current-Voltage Characteristic Curve
LGBC	Laser Grooved Buried Contact
MPP	Maximum Power Point
MPPT	Maximum Power Point Tracker
NREL	National Renewable Energy Laboratory-USA
MU	Murdoch University
mc-Si	Monocrystalline silicon
p-Si	Polycrystalline silicon
P_{max}	Maximum Power
POA	Plant of Array
PL	Photoluminescence
PV	Photovoltaic
STC	Standard Test Conditions-1000W/m^2, AM Mass 1.5 and 25 ^{0}C cell Temperature
TC	Temperature Coefficient
V_{mp}	Maximum Power Voltage
V_{oc}	Open Circuit Voltage
W	Watt
Wh	Watt.hour
W_p	Peak Watt
η_c	Module efficiency
κ	Temperature Coefficient of Power
α	Temperature Coefficient of Current
β	Temperature Coefficient of Voltage

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