Solar Photovoltaics (PV) is one of the most promising renewable energy technologies for mitigating the effect of climate change. Reliability of PV modules directly impacts the Levelized Cost of Energy (LCOE), which is a metric for competitiveness of any energy technology. Further reduction in LCOE of PV, through assured long term reliability is necessary in order to facilitate widespread use of solar energy, without having to rely on any subsidies. This dissertation is focused on frameworks for assessing reliability of bypass diodes in PV modules. Bypass diodes are critical components in PV modules that provide protection against shading. Failure of bypass diode in short circuit results in reducing the PV module power by one third, while diode failure in open circuit leaves the module susceptible for extreme hotspot heating and potentially fire hazard. PV modules, along with the bypass diodes are expected to last at least 25 years in field. The various failure mechanisms in bypass diodes such as thermal runaway, high temperature forward bias operation and thermal cycling are discussed. Operation of bypass diode under shading is modeled and method for calculating the module I-V curve under any shading scenario is presented. Frameworks for estimating the diode temperature in field deployed modules based on typical meteorological year data are developed. Model for predicting the susceptibility of bypass diodes for thermal runaway is presented. Diode wear out due to high temperature forward bias operation and thermal cycling is modeled using the activation energies provided by manufacturers. Field equivalents of the common accelerated tests for bypass diodes are calculated and roadmap for improving the existing tests is outlined. Overall, this dissertation has contributed towards estimating the lifetime of bypass diodes in field deployed modules, and therefore, reducing the uncertainty in long term reliability of PV modules.

Major: Electrical Engineering

Educational Career:
Bachelor's of Electrical Engineering, BS, 2011, Indian Institute of Technology Bombay, India
Master's of Electrical Engineering, Microelectronics, MS, 2011, Indian Institute of Technology Bombay, India

Committee in Charge:
Kalpathy Sundaram, Chair, EECS
Winston Schoenfeld, EECS
George Atia , EECS
Reza Abdolvand , EECS
Petros Xanthopoulos, IEMS

Approved for distribution by Kalpathy Sundaram, Committee Chair, on May 27, 2015.

The public is welcome to attend.