

# Update on the activities of PVQAT Group

## 4: Diodes, Shading and Reverse Bias

Vivek Gade — Jabil, representing the Americas

Paul Robusto — Miasole, representing the Americas

Yasunori Uchida — JET, representing Japan

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# US Task Group 4 Update

## IEC Technical Specification on ESD

- A technical specification/Guideline: IEC 62916 was approved in early 2014
- IEC 62916 was sent out Jan 21, 2015 for final review and will become a draft technical specification

## Model for Predicting Vulnerability of Diodes to Thermal Runaway

- Vivek Gade and Narendra Shiradkar have developed a theoretical framework for assessing the vulnerability of bypass diodes for thermal runaway based on the diode datasheet parameters.
- Currently options of incorporating this into NWIP on thermal runaway proposed by Japanese group are being explored.

## Thermal Runaway Testing at SunEdison

- Kent Whitfield and Shuying Yang at SunEdison tested various diodes for thermal runaway at ambient temperatures of 50 C and 90 C and forward current equal to  $1.25 \times I_{sc}$
- It was concluded from the experiments that the condition of ambient temperature= 90 C and short circuit current equal to  $1.25 \times I_{sc}$  in the thermal runaway test draft maybe too harsh and a somewhat lower ambient temperature maybe better.

# US Task Group 4 Update Continued..

## Estimating Field Stressors Affecting Bypass Diodes

- Models are being developed at Jabil to estimate the field stressors (TJ and  $\Delta T_J$ ) during service life of bypass diodes as a function of shading configuration and TMY data of various locations.
- Outdoor experiments are being performed on a rooftop array in Florida to monitor the diode junction temperature for model verification.

## Thermal Resistance Measurement of Bypass Diodes / Junction Boxes

- Thermal resistance (Junction  $\rightarrow$  Ambient) has been measured using 1-Dimensional heat conduction model for 9 different types of bypass diode / junction box samples at various ambient temperatures and forward currents.
- It is shown that the thermal resistance (Junction  $\rightarrow$  Ambient) at standard conditions (say  $T_{\text{ambient}} = 25 \text{ C}$ ,  $I_f = 10 \text{ A}$ ), can be used to quantify heat dissipation properties of various junction box designs (Poster #32 at PVMRW 2015)

## Extended Bypass Diode Test According to Qualification Plus

- Extended bypass diode test as described in the Qualification Plus Standard ( Ambient temperature = 75 C,  $I = I_{sc}$ , Duration = 96 hours) is being carried out at Jabil on 9 different types of bypass diodes / junction boxes.
- This test is expected to generate useful representative data for describing the effect of Extended Bypass Diode Test on various sample types.

## Thermal Cycling With Current Through the Diodes

- It was proposed that during thermal cycling test, current should be cycled through the diodes for last 50 thermal cycles
- Experiments have been initiated at Jabil to understand the effect of such thermal /current cycling on diodes.

# Japanese Task Group 4 Update

- **NWIP on Thermal Runaway**
- Diodes can undergo thermal runaway during forward bias to reverse bias transition when the shading is suddenly removed.
- NWIP draft for "Thermal runaway test for bypass diodes" was submitted by team from Japan to TC82/WG2 and it has been accepted.
- Preparation of special measuring equipment for establishing Vf-Tj relation to calculate Tj has been undertaken by the team from Japan
- It has been shown that the VF-TJ method is more elaborate and accurate method of junction temperature measurement.
- The difference between the junction temperatures measured using VF-TJ method and Tlead method could be close to 10 C. (Poster # 46 at PVMRW 2015)

# European Task Group 4 Update

- Hubert Volz has proposed a method for characterizing the forward I-V properties of the bypass diodes in a junction box in design phase.
- This method can be used for determining the current rating of the new junction box designs.
- The method involves holding the junction box at various temperatures in oven and passing known amount of current through the diode for a short duration to measure the forward voltage.
- Data is then extrapolated to get the I-V characteristics of diodes at other temperatures.
- They have also proposed a thermal model for junction box based on various thermal resistances.

# Chinese Task Group 4 Update

- The Chinese regional Task Group 4 was started in July 2014, with 22 participant organizations, including diode manufacturers, junction-box manufacturers, module manufacturers, system installers, universities, and testing and auditing organizations.
- The Chinese Group has initiated efforts to:
  - Define a diode test to be used to confirm that a diode is good, since sometimes the diodes increase in resistance without failing completely in the open or shorted configuration.
  - Define a high temperature durability test for diodes.
  - Support international efforts already underway on ESD and thermal runaway associated with the transition between the forward and reverse bias conditions.
- It has been decided to arrange quarterly conference calls between the Chinese group and the US group in order to coordinate the efforts.

# Goals of Task Group 4

<b>PVQAT Task Group</b>	<b>2014 Status</b>	<b>2015 Goals</b>	<b>2016 Goals</b>
Task Group 4	<ol style="list-style-type: none"><li>1. ESD Technical Specification IEC 62916 is under review</li><li>2. NWIP on Thermal Runaway was approved</li></ol>	<ol style="list-style-type: none"><li>1. Complete IEC 62916</li><li>2. Revise thermal runaway test specification</li><li>3. Experiments to support TG2 initiative of diode thermal cycling testing in leg #1</li><li>4. Submit NWIP on high temperature, reverse bias endurance testing of cells</li></ol>	<ol style="list-style-type: none"><li>1. Complete the test standard for Thermal Runaway</li><li>2. Complete the test standard for high temperature, reverse bias endurance testing of cells</li></ol>