High Temperature Reverse By-Pass Diodes Bias and Failures

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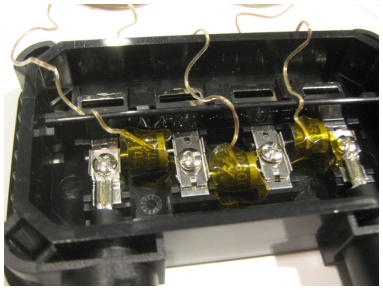
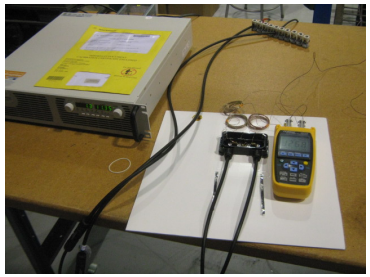
Problem Description

- By-pass diodes generally get "activated" during a shading occurrence in the field.
- For a 72-cell module with 3 by-pass diodes per module, the diodes are typically of the Schottky type and rated 40 to 45 V for maximum reverse voltage and 10 to 20 A for maximum forward current and maximum junction temperature of 150°C.
- Right after a shading occurrence and while the diode is still at high temperature, the diode goes into the normal mode where it sees the operating voltage of 24 cells or roughly 8 to 12 V and that induces a reverse leakage current that can exceed the diode reverse current rating at that temperature with the destruction of that diode most likely in the open mode, although shorted diodes have also been seen.
- We developed a very simple method to test diodes in a j-box or individually in the lab without the need for a sophisticated thermal chamber.

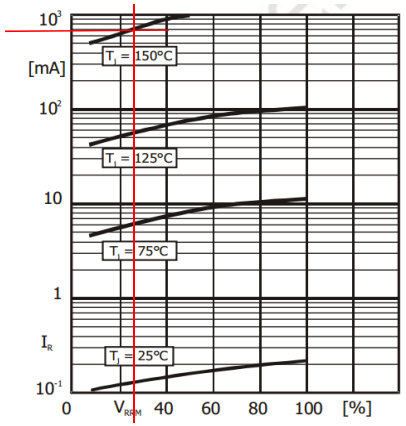




Simple Test Procedure

- 30 A 60 V power supply
- Thermo-couples and Fluke meter
- Connect diodes in forward mode and pass 12 to 15 A (note that the central diode always heats up faster)
- Wait until diodes temperature reaches 150°C
- Quickly reverse polarities and apply 10V per diode while reading the reverse current
- High current diodes fail quickly in a " run-away" mode; i.e. the hotter they get the more current they pass and so forth until the junction melts
- Lower current diodes cool down and stabilize safely at relatively low current.
- Tests were also done on individual diodes as well, outside the j-box with similar results

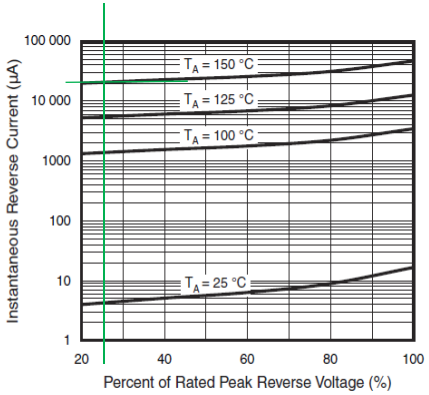
High Reverse Current Diode



Typ. instantaneous leakage current vs. rev. voltage

- Vr = 10V or 25% or Vrmax
- Ir is then 700 mA at 150°C
- P reverse is 7 W
- Diode exceeds 200°C and fails within seconds in the open mode (most of the time)
- A dozen diodes were tested under these conditions and all failed open

Low Reverse Current Diode



Typical Reverse Leakage Characteristics

- Vr = 10V or 25% or Vrmax
- Ir is then 20 mA
- P reverse is 0.2 W
- Diode cools down to less than 100°C within seconds and further down
- No problem with this type of diode

Standards and Certification

- **Field failures of by-pass diodes are most concerning when the diode(s) fail open due to shading conditions as the upcoming shading incident will undermine the cell(s) involved and may lead to cell(s) failure and other related safety problems**
- **An official test procedure needs to be incorporated into the international standards (performance, reliability and safety) and pass/fail criteria included**
- **At a minimum, choose the diodes that have the appropriate reverse characteristics**