82/1141/CDV

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PROJET DE COMITÉ POUR VOTE (CDV)

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Also of interest to the following committees Intéresse également les comités suivants		Supersedes document Remplace le document 82/1025/CD, 82/1083A/CC
Proposed horizontal standard Norme horizontale suggérée ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the TC/SC secretary Les autres CE/SC sont requis d'indiquer leur intérêt, si nécessaire, dans ce CDV à l'intention du secrétaire du CE/SC		
Functions concerned Fonctions concernées ☒ Safety / Sécurité ☐ EMC / CEM ☐ Environment / Environnement ☒ Quality assurance / Assurance qualité		

Title: IEC 62979:

Photovoltaic module bypass diode thermal runaway test

Introductory note

ATTENTION
IEC – CENELEC
PARALLEL VOTING

The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) for an International Standard is submitted for parallel voting.
The CENELEC members are invited to vote through the CENELEC online voting system.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PHOTOVOLTAIC MODULE BYPASS DIODE THERMAL RUNAWAY TEST

FOREWORD

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International Standard IEC 62979 has been prepared by WG2 of IEC technical committee TC82: Solar photovoltaic energy systems.

The text of this standard is based on the following documents:

FDIS	Report on voting
82/XX/FDIS	82/XX/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The National Committees are requested to note that for this publication the stability date is 2019.

THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

INTRODUCTION

During the normal operation of PV modules the bypass diodes are reverse biased. When the PV module is partially shaded (for example by utility poles, buildings, or leaves), some of the cells in the PV module may not be able to produce the current being produced by the other cells in the series string. The shaded cells are then driven into reverse biased so the bypass diode of the shaded cell-string becomes forward biased protecting the shaded cells.

Under these circumstances, the temperature of the bypass diode increases due to the forward current flowing through the diode. It is in this condition that the diodes are tested in accordance with IEC 61215 10.18 Bypass Diode Thermal Test. When the shade is removed, operating conditions return to normal and the bypass diode is again reversed biased.

Some of the diodes utilized as bypass diodes in PV modules have characteristics where the reverse bias leakage current increases with the diode temperature. So if the diode is already at an elevated temperature when reverse biased, there will be a substantial leakage current and the diode junction temperature can increase considerably. The worst case occurs when this heating exceeds the cooling capability of the junction box in which the diode is installed. As a result of this increasing temperature and leakage current, the diode can break down. These phenomena are called “thermal runaway”. The thermal design of the bypass diode in the junction box must be verified to ensure that thermal runaway does not occur.

BYPASS DIODE THERMAL RUNAWAY TEST

1 Scope

This international standard provides a method for evaluating whether a bypass diode (BD) as mounted in the module is susceptible to thermal runaway or if there is sufficient cooling for it to survive the transition from forward bias operation to reverse bias operation without overheating.

This test methodology is particularly suited for testing of Schottky Barrier Diodes (SBD), which have the characteristic of increasing leakage current as a function of reverse bias voltage at high temperature, making them more susceptible to thermal runaway.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 17025: General requirements for the competence of testing and calibration laboratories

IEC/TS 61836: Solar photovoltaic energy systems Terms, definitions and symbols

3 Terms and definitions

For the purposes of this document, definitions from IEC 61836 together with the following, apply.

3.1 Leakage current
Leakage current flowing in the opposite direction to the polarity of the BD.

3.2 Reverse bias voltage
Voltage applied to the opposite direction to the polarity of the BD.

3.3 Tlead
Tlead means the temperature of the lead-wire of the BD measured by thermocouple.

4 Thermal runaway test

4.1 Diode Thermal Runaway

Some of the diodes utilized as bypass diodes in PV modules have characteristics where the reverse bias leakage current increases with the diode temperature. So if the diode is already at an elevated temperature when reverse biased, there may be a substantial leakage current and the diode junction temperature can increase considerably. The worst case occurs when this heating exceeds the cooling capability of the junction box in which the diode is installed. As a result of this increasing temperature and leakage current, the diode can break down. These phenomena are called “thermal runaway”. The thermal design of the bypass diode in the junction box must be verified to ensure that thermal runaway does not occur.

How the thermal runaway does or does not occur is illustrated simply in Figure 1.
The curve “R” indicates the relation of the energy injected by the reverse bias voltage vs the junction temperature. As shown, the energy injected will rapidly increase at the higher junction temperature. The cooling capability of the junction box is indicated by the curve “Heat dissipation” and the critical temperature “Tc” is the crossing point of the curve “R” and the curve “Heat dissipation”

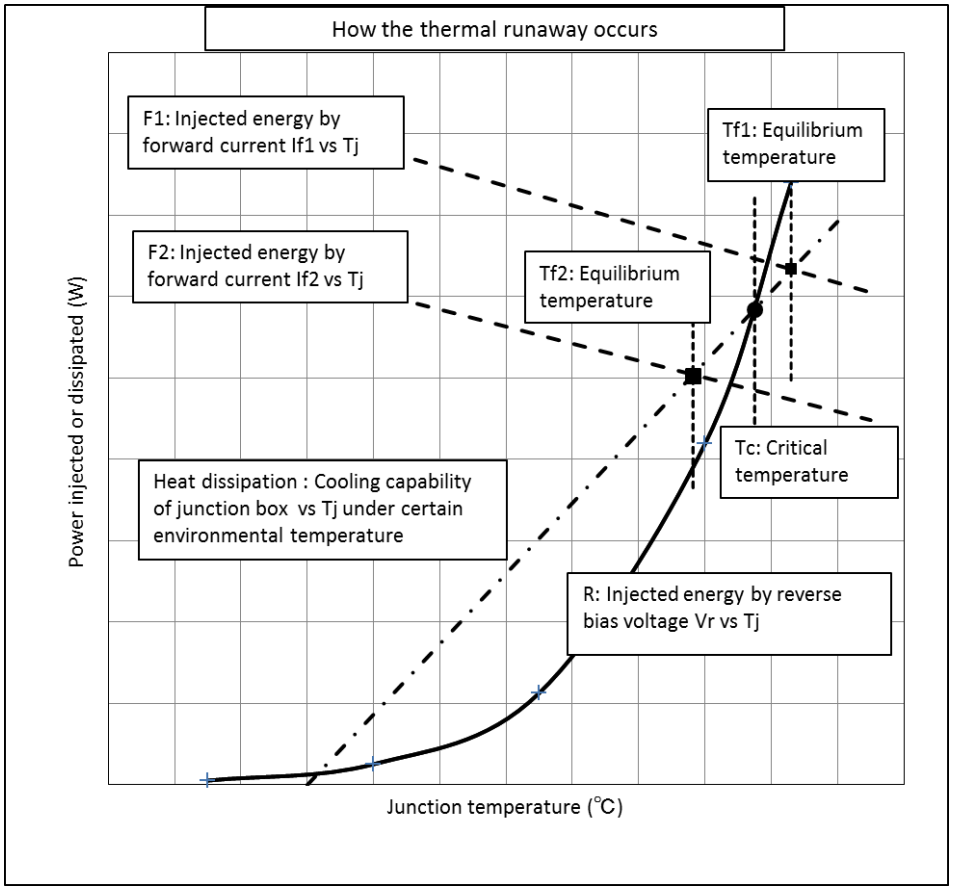


Figure 1 – Illustration of how thermal runaway occurs

If the reverse bias voltage is applied at a junction temperature higher than the critical temperature “Tc”, the injected energy will be more than the cooling capability and the junction temperature will keep increasing until the diode undergoes thermal runway.

On the other hand, if the reverse bias voltage is applied at a junction temperature lower than the critical temperature “Tc”, the injected energy will be less than the cooling capability and the junction temperature will gradually decrease toward the environmental temperature.

The curve “F1” and “F2” show the relationship of the energy injected by the forward current If1 and If2 vs the junction temperature. The crossing points of these curves and the cooling capability “Heat dissipation” show the equilibrium temperature when the forward current is applied.

The equilibrium temperature “Tf1” corresponding to the curve “F1” is higher than “Tc” and the thermal runaway may occur when the diode is reverse biased. The equilibrium temperature “Tf2” corresponding to the curve “F2” is lower than “Tc” and the thermal runaway will not occur when the diode is reverse biased.

Note: The test specimen which employs P/N diodes as bypass diodes could be exempted from the thermal runaway test required herein, because the capability of P/N diodes to withstand the reverse bias is sufficiently high.

4.2 Test conditions

The test conditions under which the thermal runaway test should be performed are as follows;

a) Initial Module temperature:

90 ± 2 °C for roof mount module

75 ± 2 °C for open rack mount module

As the occurrence of thermal runaway is related to the temperature at the instance of the reverse bias voltage application, the thermal runaway test is to be performed under the highest environmental temperature the module could encounter during the normal operation. The module temperature may be measured by Tlead.

b) Specified forward current: 1,25 × “Short circuit current (Isc) at STC” of the PV module for test BD

c) Specified reverse bias voltage: Open circuit voltage (Voc) at STC of the cell string of the module protected by BD to be tested.

4.3 Preparation of test specimen

The test specimen should be the actual module or the special sample having the same construction of the actual module.

In case of using of special sample, the special sample means the Junction box bonded by an adhesive onto a suitable glass-substrate laminated with the back-sheet in order to simulate the actual module. Because the occurrence of thermal runaway depends upon cooling of the BD, the test must be performed with the diode mounted in the same way as in the actual module. The special sample may be provided by the module or junction box manufacturer.

The test specimen must be provided with original connection cables for the test module.

In order to measure Tlead and voltage of each BD, connections of the lead-wires and thermocouples are required to be provided with the test specimen as shown in Figure 2.

Thermocouple should be mounted on the cathode lead as close as possible to the diode body.

Care should be taken to minimize any alteration of the properties of the diode or its heat transfer path.

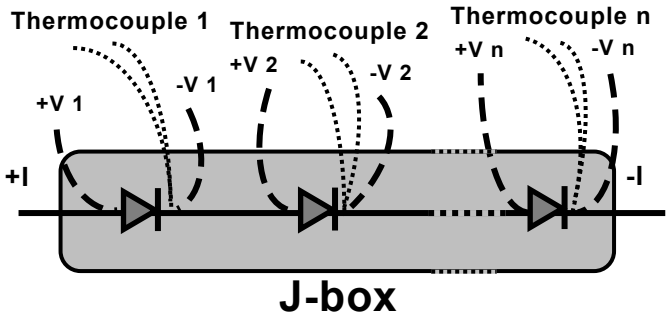


Figure 2 – Circuit for measurement of Tlead and forward voltage

Note 1: Commonly used T-type thermocouple (copper-constantan) with soldering joint is permissible for this test, though it has a limitation about the measureable temperature at around 200 ℃ to 250 ℃, because this limitation would be above the temperature observed when the thermal runaway does not occur. When the thermal runaway occurs, the temperature will go up beyond the limitation, but by

190 measuring the reverse current flowing through the diode the thermal runaway phenomena will be
191 caught.

192 Note 2: In case that the diodes are mounted somewhere else – like in the laminate and so on,
193 the BD having the highest temperature should be tested.

194

195 **4.4 Test equipment**

196 a) Chamber for heating the test specimen to the temperature specified in 4.2 a. Means for
197 monitoring the chamber temperature.

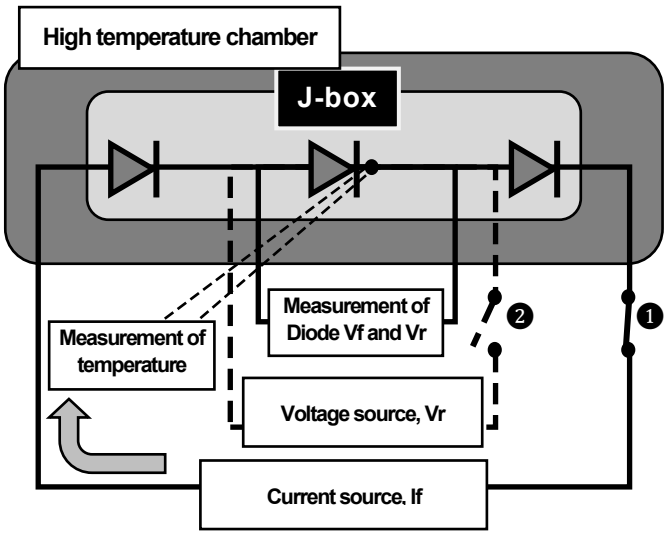
198 b) Means for measuring and recording the Tlead of the test specimen to an accuracy of ±
199 1°C. Care should be taken to minimize any alteration of the properties of the BD or its
200 heat transfer path.

201 c) Means for applying the forward current specified in 4.2 b. Means for monitoring the
202 forward current through the module and the forward voltage, throughout the test.

203 d) Means for applying the reverse bias voltage specified in 4.2 c to the BD with capability of
204 supplying the current equal to 1,25 X Isc of the test module under the specified reverse
205 voltage. Means for measuring the leakage current and the reverse voltage of the BD.

206 e) Means for making the swift switching (within 10 ms) from forward current injection to
207 reverse bias voltage application as illustrated in the test circuit of Figure 3.

208 .



❶**Forward current test circuit**
❷**Reverse bias test circuit**

209
210 **Figure 3-1 – Circuit for flowing a forward current to the BD.**
211

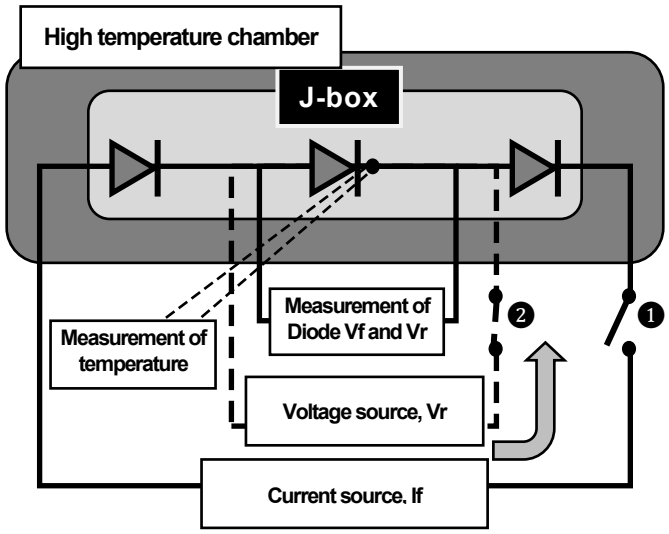


Figure 3-2 – Circuit for applying a reverse bias voltage to the BD.

Note: If necessary, the measuring equipment must be designed so that harmful voltage peaks are avoided.

4.5 Test procedure

a) To obtain initial characteristics of BD and to make sure that BD functions correctly, measure the reverse characteristics of BD at room temperature (25 ℃±5 ℃), covering the forward current and reverse voltage specified in 4.2 b and c.

b) For the selection of the BD to be tested, apply the specified forward current (4.2 b) to all the BDs in series in the test specimen at 25 °C ± 5 °C. Select the BD which shows the highest temperature.

c) After putting the test specimen(s) with necessary measuring and monitoring equipment into the test chamber, heat them to the initial module temperature specified in 4.2 a.

d) Apply the specified forward current (4.2 b) to the BDs for at least 40 minutes and until the range of Tlead change during 10 minutes becomes within 0.3 °C.

Shut-off the forward current. Within 10 ms after that apply the reverse bias voltage specified in “clause 4.2 c” to the BD to be tested. Continue to observe the leakage current and temperature of the reverse biased BD.

In most of the cases the leakage current and the Tlead are expected either to rise (as indicated in the Figure 4a) or to decrease (as indicated in the Figure 4b) soon without staying at a fixed temperature. In some borderline cases some time is needed to see the final direction of the change. In such a case, the test should be continued for at least 2 minutes.

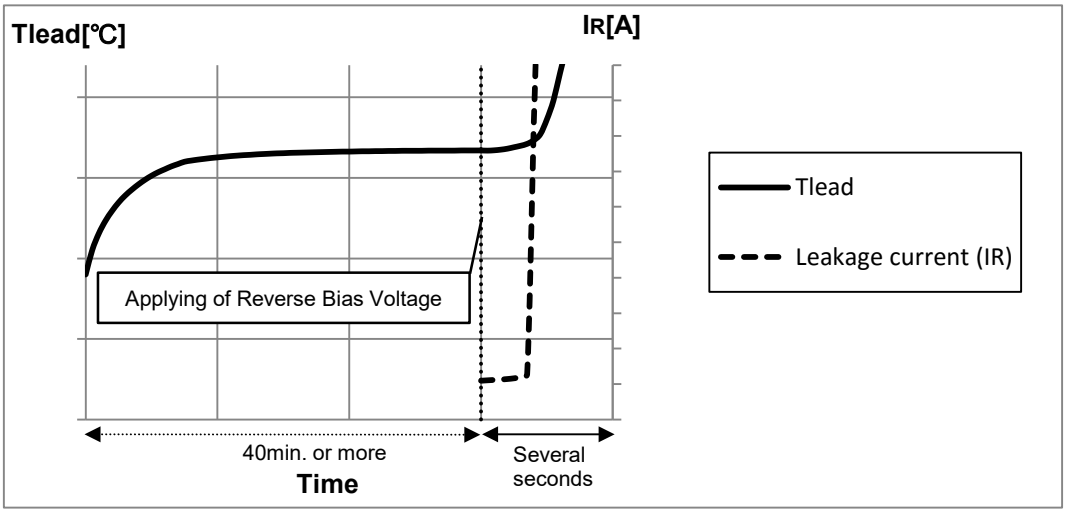


Figure 4a: The typical pattern of thermal runaway

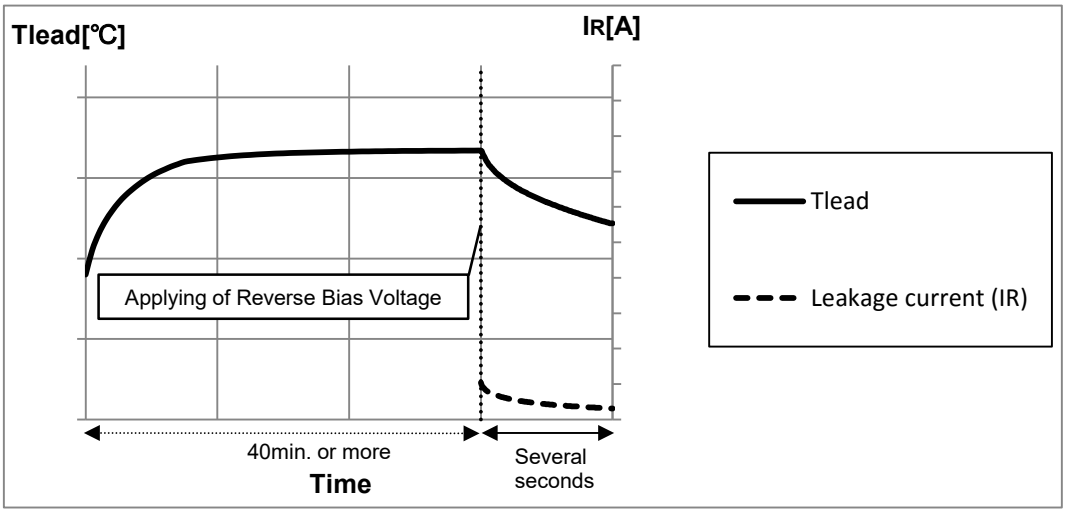


Figure 4b: The pattern of non-thermal runaway

e) Remove the test specimen from the chamber.

f) In order to check the diode performance, the reverse characteristic of the BD should be measured at room temperature (25 ℃±5 ℃). Then compare the results with the initial measurements.

5 Pass or fail criteria

a) In case that Tlead and leakage current decrease, and if the reverse leakage current at -10 V after the test does not increase to more than 5 times of the initial value, the BD is considered safe from the possibility of thermal runaway and pass the test.

b) In other case, namely if Tlead and leakage current increase or if the reverse leakage current at -10 V after the test increases to more than 5 times of the initial value, the BD is considered to have failed.

6 Test Report

A report of the tests shall be prepared by the test agency in accordance with ISO/IEC 17025. The report shall contain information necessary to reproduce test results and the details of the sample tested, specifically, make note of the following:

a) a title;

b) name and address of the test laboratory and location where the tests were carried out;

c) unique identification of the report and of each page;

d) name and address of client, where appropriate;

e) detail specification, description and identification of the item(s) tested;

f) date of receipt of test item and date(s) of test, where appropriate;

g) identification of test method used and test instruments and other equipment used;

h) reference to sampling procedure, where relevant;

i) the values of the specified test conditions with any deviations from, additions to, or exclusions from, the test method and any other information relevant to a specific test, measurements, examinations and derived results supported by tables, graphs, sketches and photographs as appropriate including

- Forward current injected for BD
- The Tlead measured after applying of the forward current for one hour or until Tlead stabilises.
- The duration for which the forward current was applied.
- The switching time until the applying of reverse bias voltage from the interception of forward current.
- Reverse bias voltage applied for BD.
- The application time of specified reverse bias voltage
- Records of the Tlead after the application of reverse bias voltage.
- Records of the leakage current of the diode after the application of reverse bias voltage
- Photos and a description of the of the specimens tested
- Diode characteristics measured before and after the thermal runaway test

j) a statement of the estimated uncertainty of the test results (where relevant);

k) a signature and title, or equivalent identification of the person(s) accepting responsibility for the content of the certificate or report, and the date of issue;

l) where relevant, a statement to the effect that the results relate only to the items tested;

m) a statement that the certificate or report should not be reproduced except in full, without the written approval of the laboratory.