

# TECHNICAL SPECIFICATION

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**Photovoltaic (PV) modules and cells – Measurement of diode ideality factor by quantitative analysis of electroluminescence images**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**PHOTOVOLTAIC (PV) MODULES AND CELLS –  
MEASUREMENT OF DIODE IDEALITY FACTOR BY QUANTITATIVE  
ANALYSIS OF ELECTROLUMINESCENCE IMAGES**

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The text of this Technical Specification is based on the following documents:

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82/1955/DTS	82/1992/RVDTS

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

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

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- withdrawn,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

## INTRODUCTION

EL (Electroluminescence) diagnosis technique has been widely used for the evaluation of photovoltaic cells and modules photographically. EL images can identify various kinds of deficiencies, such as cracks and pin-holes in substrates, breakdown and detachment of electrodes, etc. In addition to these qualitative inspections, the quantitative analysis of EL intensity can reveal the electronic performance of photovoltaic cells [1] to [7]<sup>1</sup>. The EL intensity is proportional to the total number of minority carriers in photovoltaic cell bodies. The injection of minority carriers is governed by the  $I$ - $V$  characteristics of pn junctions following the diode rectification formula, which yields that the EL intensity dependence upon the injection current will derive the diode ideality factor [8].

The proposed analysis method is not intended to give the criteria for the diagnosis of cells and modules, but the measured values of  $n$  are informative for stakeholders to share a common view about degradation phenomena among themselves. This standard measurement technique may be useful for the following stakeholders:

- a) Manufacturers – checking validity of samples for both development and quality control (refer to Annex C).
- b) Power producers – checking suspicious modules for potential failures (refer to Annex B).
- c) Reuse – evaluation of value of second-hand modules (refer to Annex B).

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<sup>1</sup> Numbers in square brackets refer to the Bibliography.

# PHOTOVOLTAIC (PV) MODULES AND CELLS – MEASUREMENT OF DIODE IDEALITY FACTOR BY QUANTITATIVE ANALYSIS OF ELECTROLUMINESCENCE IMAGES

## 1 Scope

This document specifies a method to measure the diode ideality factor of photovoltaic cells and modules by quantitative analysis of electroluminescence (EL) images.

This document provides a definition of the term diode ideality factor  $n$ , as the inverse of increment ratio of natural logarithm of current as a function of applied voltage, which is related to the fill factor  $FF$ , and is useful as an effective indicator to represent the output efficiency of photovoltaic cells and modules with the other key parameters open circuit voltage  $V_{oc}$  and short circuit current  $I_{sc}$ .

This document is only applicable to crystalline silicon photovoltaic cells and modules.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC TS 60904-13:2018, *Photovoltaic devices – Part 13: Electroluminescence of photovoltaic modules*

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*