EMPIR Call 2018 – Health, SI Broader Scope, Normative and Research Potential

Selected Research Topic number: **SRT-n06**
Version: 1.0

Title: Precision space solar cell calibration

Abstract

The accurate determination of the energy output of solar power generators in space is crucial for performing space missions. ISO 15387:2005 describes different calibration methods divided into atmospheric methods and synthetic methods such as the differential spectral responsivity method. For the validation of both methods the definition of the extra-terrestrial spectral irradiance is crucial. The revision of the standard intends to set a new Air Mass Zero (AM0) spectrum and a new solar irradiance of 1361 W/m² (the solar constant). The validation requires the Synthetic methods to be compared and validated against a balloon flight performed in 2017. Measurement uncertainties should be evaluated, and scientific input should be provided for the finalisation of the revision of the ISO 15387.

Keywords

Standardisation, ISO 15387, Multi Junction Solar Cells, Balloon flight calibration, synthetic component cell calibration, traceable calibration chain, angular dependency, spectral responsivity, inter-comparison, validation

Background to the Metrological Challenges

ISO 15387 specifies the requirements for primary and secondary calibration procedures of single-junction and multi-junction space solar cells at Air Mass Zero (AM0) conditions. This standard is the basis for quality control in European multi-junction solar cell (MJSC) manufacturers, suppliers and end users (e.g. the European Space Agency) in order to guarantee a precise determination of the energy output of solar power generators in space. In ISO 15387 different calibration procedures are described that should lead to consistent calibration results for primary reference devices. However, up to now traceability is solely realised by the rarely performed high altitude methods and not by the more reliable ground based methods, since a direct comparison and of both methods has never been done satisfactory.

During the EMRP project SolCell the Differential Spectral Responsivity (DSR) method for laboratory based calibrations of MJSC component cells was significantly improved. It is now possible to calibrate such devices with measurement uncertainties comparable to the state of the art balloon flight measurements. To further convince the community to trust “synthetic” laboratory measurements, direct comparisons to balloon flight measurements are necessary.

A major concern in the laboratory calibrations of MJSC is the influence of the angular distribution and polarisation of the incident light. Interference patterns in the spectral responsivity of the germanium bottom junction are strongly dependent on the spectral bandwidth used, as well as its angular distribution, and further characterisation measurements are necessary. The revision of ISO 15387 will introduce a new AM0 spectrum and a solar irradiance of 1361 W/m². However, there is no underlying uncertainty analysis on the impact of using these spectra on the photocurrent density. This is required.

Reliable uncertainty assessments in the measurement of the electrical performance (EP) of solar cells, especially for MJSC, is also required. The understanding of the measurement uncertainty of the EP measurement is of major importance for manufacturers and end-users alike, since this impacts the total cost of ownership as well as putting additional constraints on the overall design of the solar energy generator (in terms of the number of required cells). So far, this uncertainty is almost always a pure estimation without a detailed uncertainty analysis and is typically evaluated to be in the order of 2 – 3 %. It is known, however, that the uncertainty evaluation is strongly dependent on the measurement procedure, the test facility and the reference cells.

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Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on metrology research necessary to support standardisation in synthetic and atmospheric calibration methods for primary reference solar cells for space applications.

The specific objectives are

1. To generate a fundamental understanding of unique reference solar cell properties that determine the calibration results gained from multiple atmospheric and ground based measurement methods, through characterisation of current and next generation reference solar cells enabling the identification and quantification of as yet unknown sources of measurement uncertainties.
2. To demonstrate the reliability and competitiveness of laboratory based solar cell calibrations by comparing them with balloon flight calibrations, which are performed at high altitudes.
3. To evaluate and provide reliable uncertainties in the measurement of the electrical performance of solar cells, including the uncertainty contribution of the Air Mass Zero spectral irradiance composition.
4. To undertake a round robin comparison between all stakeholders along the calibration chain (including SDO) in order to verify the consequences of changing the calibration chain from balloon flights to a laboratory based calibration.
5. To contribute to a revision of ISO 15387:2005 by providing the data, validated methods, guidelines and recommendations, which are necessary for the standardisation of single-junction solar cells, to ISO/TC 20/SC 14. Outputs should be in a form that can be incorporated into the standards at the earliest opportunity and communicated through a variety of media to the standards community and to end users.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this.

In particular, proposers should outline the achievements of the EMRP project SolCell and how their proposal will build on this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.6 M€, and has defined an upper limit of 0.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,

- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the space sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.