

## CALIBRATION AND PERFORMANCE TESTING OF PHOTOVOLTAIC MODULES



**Fraunhofer Institute for  
Solar Energy Systems ISE**

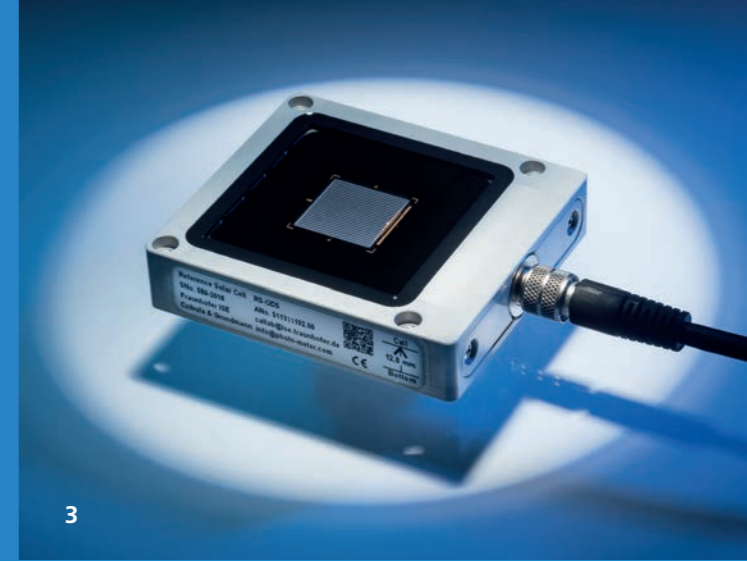
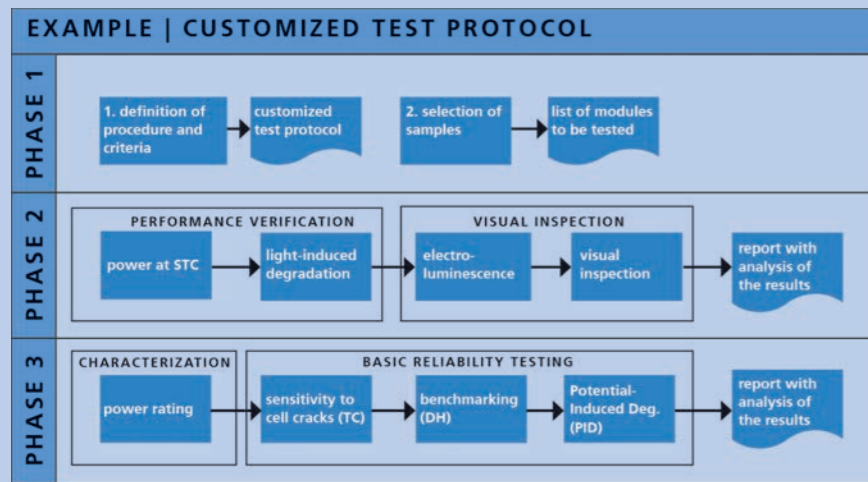
Heidenhofstrasse 2  
79110 Freiburg  
Germany  
Phone +49 761 4588-0  
www.ise.fraunhofer.de

**CalLab PV Modules**

Frank Neuberger  
Phone +49 761 4588-5280  
Mobile +49 170 9247193  
modules@callab.de

**COVER PAGE**

*Calibration of bifacial modules  
in the laboratory CalLab PV  
Modules at Fraunhofer ISE.*



In our accredited calibration laboratory CalLab PV Modules, we combine comprehensive scientific know-how with modern measurement technology. Among our clients are renowned module manufacturers, EPCs (engineering, procurement, construction) and investors with the highest demands on quality. Many years of experience and our excellent reputation in the field of PV module calibration and performance testing ensure reliable measurement results.

Our service offer ranges from the calibration of single cells and modules to customized tasks such as the calibration of bifacial modules. Our measurement uncertainty of only **1.3%** and our quality assurance measures are the basis of our international leadership. Beyond standard testing conditions (STC), we characterize modules comprehensively according to the Power Rating Standard IEC 61853-1 in the lab. Yield properties are also monitored in outdoor operation using high quality reference cells.

#### Accredited Calibration of PV Modules

The calibration laboratory CalLab PV Modules is accredited under DIN EN ISO/IEC 17025:2005 (accreditation certificate D-K-11140-02-00, ILAC-MRA). In addition, CalLab PV Modules is an accredited testing laboratory (accreditation certificate D-PL-11140-03-03). As a result of continuous optimization and research, we have reduced our measurement uncertainty to 1.3%, which is unique worldwide.

An international comparison with leading laboratories around the world has confirmed the excellent reproducibility of our measurements. A low measurement uncertainty affects the measurement accuracy of a module manufacturer positively and thus increases confidence in specifications on labels and data sheets.

Calibration services of CalLab PV Modules include:

- determination of spectral response in the range of 300 nm to 1200 nm
- light stabilization of the module prior to calibration
- image with electroluminescence camera
- accredited calibration according to IEC60904-1
- calibration certificate and calibration mark on the module

For the last four years the variation for our quality assurance modules was less than 0.4% which is outstanding in international comparison. For our customers it is essential to provide a constant calibration level over time.

#### PV Module Performance Testing and Power Rating

Complementary to the accurate measurement of the power at Standard-Test-Conditions (STC), irradiance and temperature performance measurements of the PV modules are important to enable precise yield simulations for PV power plants worldwide. The parameters of the PV modules determined in the laboratory can be used for yield assessments and commercially available simulation tools. The following services are part of our comprehensive performance testing:

- power rating measurement according to IEC 61853-1
- incidence angle modifier (IAM) measurement according to IEC 61853-2
- irradiance performance measurements according to IEC 61853-1
- determination of temperature coefficients according to IEC 60891
- determination of performance at nominal module operating temperature (NMOT) according to IEC61215-2, MQT06.2
- provision of PAN-files for simulation of energy yield

#### Quality Benchmarking of PV Modules

For our international clients using the module measurements for quality control of PV power plants, the improved measurement accuracy also offers advantages. Banks and investors profit from precise measurements because they reduce the uncertainty of the expected return on investment. The measurement uncertainty of the testing laboratory often affects the pass / fail criterion for module power in projects and is thus the decisive parameter for evaluating the modules used. For Quality Benchmarking we developed a procedure which is adaptable according to customer's needs, considering the environmental stress of the power plant location.

#### Highly Precise Reference Cells

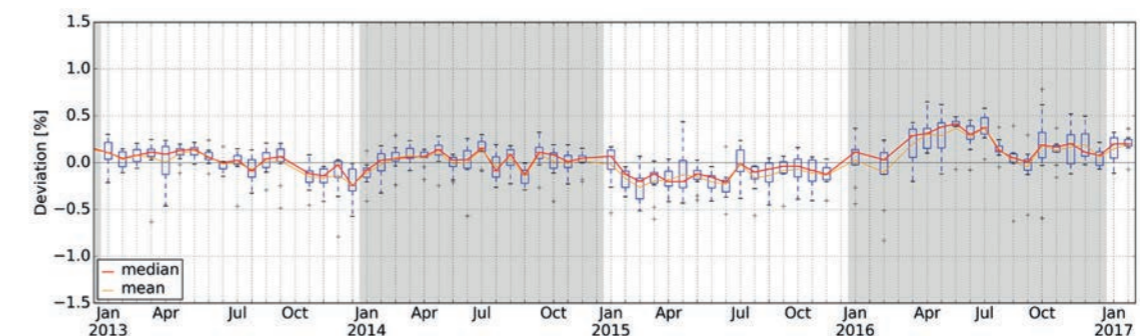
Reference cells of Fraunhofer ISE are cutting-edge equipment for manufacturers of PV modules, laboratories and EPCs worldwide. CalLab PV Modules supplies and calibrates client-specific reference cells that we developed in-house for different applications. A new type of cell based on negatively doped silicon material (n-type) with greater sensitivity in the IR range was successfully integrated and the configuration of the reference cell was optimized at the same time. As a result, adapted reference cells for new cell technology (e.g. PERC) are now available to our clients for the first time.

2 Test set-up for calibration of bifacial PV modules.

3 Outdoor reference cell.

#### PV Module Monitoring

For accurate long-term performance testing of PV modules in outdoor operation, CalLab PV Modules is offering a newly developed data acquisition system. The measurement system has a modular structure and records highly resolved DC measurement data (IV curves) of individual modules. This allows laboratory measurements to be verified and complements comprehensive characterization of modules with respect to the yield properties for new types of technology like bifacial modules. CalLab PV Modules offers this new service worldwide. The data analysis by Fraunhofer ISE can be adapted according to the client's requirements, so that all relevant parameters are available with the highest accuracy.



1 Customized test protocol for quality benchmarking.

4 Constant calibration level at CalLab PV Modules recorded over years.