Calibration Certificate

Kalibrierschein

issued by the calibration laboratory
erstellt durch das Kalibrierlaboratorium

Calibration and Test Center (CalTeC) Solar Cells
Institut für Solarenergieforschung GmbH
Am Ohrberg 1
31860 Emmerthal
GERMANY

http://caltec.isfh.de/
solarcells@caltec.isfh.de

Deutsche Akkreditierungsstelle D-K-18657-01-00

Calibration mark *Kalibrierzeichen*	005923
	D-K-18657-01-00
	2025-06

Object *Gegenstand*	**Solar irradiance sensor**
Manufacturer *Hersteller*	**SEVEN SENSOR SOLUTIONS Corum, TÜRKIYE**
Type *Typ*	**3S-IS (with modbus interface)**
Serial number *Fabrikat/Serien-Nr.*	**2506009**
Customer *Auftraggeber*	**SEVEN SENSOR SOLUTIONS Corum, TÜRKIYE**
Order No. *Auftragsnummer*	**09125SE**
Date of calibration *Datum der Kalibrierung*	**June 17, 2025**
Place of calibration *Ort der Kalibrierung*	**ISFH CalTeC, 31860 Emmerthal, GERMANY**

Number of pages of the certificate
Anzahl der Seiten des Kalibrierscheins 5

This calibration certificate documents the metrological traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein dokumentiert die metrologische Rückführbarkeit auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
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Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

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Date of issue *Datum der Ausstellung*	Deputy head of the calibration laboratory *Stellvertretender Leiter des Kalibrierlaboratoriums*	Person in charge *Bearbeiter*
June 24, 2025	Dr. David Hinken	Sebastian Denke

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1 Type of calibration

The irradiance sensitivity s of the irradiance sensor is determined for the AM1.5G reference spectrum (1000 W/m^2) and a sensor temperature $T = 25\,^{\circ}\mathrm{C}$ using a class A+A+A+ sun simulator.

2 Calibration object

The calibration object with identifier *2506009* (see Fig. 1) is a digital irradiance sensor. This sensor provides via a digital interface an irradiance value which is correlated to the incident irradiance. In addition, a temperature value is provided.
The front side of the sensor is shown in Fig. 1(a) and the rear side in Fig. 1(b).

Condition of calibration object

The visual examination of the calibration object did not detect any visible damage.

3 Mounting

The irradiance sensor is fixed to the measurement stage using screws. The front surface of the sensor is adjusted to be perpendicular and centrical to the optical axis.
According to manufacturer specifications the height of the solar cell inside the irradiance sensor is located at a height of 40.5 mm (distance from position of solar cell to bottom of housing).

4 Electrical connections

Power supply

The irradiance sensor is connected to a power supply.

a) b)



Fig. 1: Picture of the irradiance sensor with identifier *2506009*.

Digital interface

The irradiance sensor has a Modbus-RS485 interface which is connected to a computer system. A software tool establishes the connection to the irradiance sensor and reads out the irradiance and the temperature value.

5 Irradiance

Sun simulator

The steady-state sun simulator used for calibration of the irradiance sensor is classified as A+A+A+ (spectrum, inhomogeneity of the light field and instability in time) according to the IEC 60904-9:2020 standard. The divergence of the light is smaller than 18 °. The stability of the irradiance over time is controlled with a monitor diode during the whole measurement.

Spectral responsivity measurement

The spectral responsivity of the irradiance sensor is determined using the multi-spectral-responsivity approach [1]. Traceability of this measurement is given by the used spectroradiometer.

Adjustment of irradiance

The irradiance of the sun simulator is adjusted using a WPVS reference cell (primary standard “Irradiance”, see section 7). The short-circuit current of this reference cell and its spectral responsivity was calibrated under standard test conditions (1000 W/m^2, AM1.5G reference spectrum and 25 °C).

Spectral iradiance measurements

The spectral irradiance in the measurement plane is determined using a spectroradiometer covering the wavelength range from 250 nm to 1700 nm. The spectroradiometer is traceable to reference lamps which were calibrated at the Physikalisch-Technische Bundesanstalt PTB (Braunschweig).

Spectral mismatch correction

The spectral correction factor *MM* is calculated and applied as described in the IEC 60904-7:2019 standard.

Light-field inhomogeneity

A correction for the light-field inhomogeneity is applied.

6 Measurement conditions

Irradiance sensor conditioning

The irradiance sensor is conditioned for at least 24 hours in the conditioning storage or in the laboratory.

Ambient conditions

The temperature of the ambient during measurement is

$$T_{\text{room}} = (23.5 \pm 1.0)\,^{\circ}\text{C}. \tag{1}$$

The relative humidity of the ambient during measurement is

$$H_{\text{room}} = (47 \pm 5)\,\%. \tag{2}$$

7 Used primary standards

During measurement the WPVS reference solar cell 50716-PTB-19 (FN001) is used as primary normal. This cell was calibrated at the national metrology institute Physikalisch-Technische Bundesanstalt PTB (Braunschweig, Germany).

8 Sensor adjustment

Before calibration a sensor adjustment is carried out, giving a calibration value of

$$f = 37.0. \tag{3}$$

Please note that no units are given for this calibration value because it is an internal value of the digital sensor. This calibration value is stored within the sensor using the digital programming interface.

9 Calibration result

The following result is obtained:

Irradiance condition	Sensor irradiance reading	Sensor irradiance responsivity
1000 W/m^2	(999 ± 10) W/m^2	(0.999 ± 0.010)

Note that the determined irradiance responsivity only applies to the spectral irradiance and sensor temperature specified in section 1.

10 Additional information

The following parameters are provided as additional information and thus do not necessarily include information about the measurement uncertainty.

Spectral mismatch factor *MM*:	1.0008
Irradiance:	(1000.0 ± 7.0) W/m^2
Sensor temperature during measurement:	$(25.0 \pm 1.0)\,^{\circ}$C
Temperature of reference solar cell during calibration:	$(25.0 \pm 0.2)\,^{\circ}$C

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11 Remarks

- The stability in time of the determined values was not tested.
- Throughout the document a dot is used as decimal separator.
- The calibration date could not be set via the digital programming interface, please refer to the calibration mark sticked at the outside of the sensor.

References

[1] David Hinken, Carsten Schinke, Karsten Bothe, and Rolf Brendel. Multi-spectrum method for the determination of the spectral responsivity and the short-circuit current of photovoltaic devices. *Solar RRL*, 7(13):2300240, 2023.

End of calibration certificate