



**Fraunhofer** Institut  
Solare Energiesysteme

## Calibration certificate

**Object:** WPV/S Cell

**Manufacturer:**

**Serial Number:**

**Internal Serial Number:**

**Calibration mark:**

**Customer:**

**Datafile:**

**Number of pages:**

**Date of calibration:**

**Date of receipt:**

**Head of calibration lab:** Freiburg i.B., **Examiner:**

Wolfram Wara

Astrid Ohm

## 1. Description of the calibration object

The device under test is a WPVS-cell package containing a monocrystalline solar cell with a cell area of 4.004 cm<sup>2</sup>, which is covered with a KG5-filter. The front contact, the rear contact and the temperature acquisition are available by a plug contact. The temperature acquisition is realized with a Pt 100 sensor.

## 2. Measurement procedure

The measurement of the relative spectral response on the solar cell was carried out with the DSR method /1/ on a filter monochromator setup according to /2/ with irradiation of the total device area. The relative spectral responsivity was measured under additional bias illumination (EB) under full area irradiation of the complete device using a primary calibrated solar cell as a reference. For this special device, a measurement with partial illumination of the active cell area may cause another characteristic of the spectral response.

Traceability of the reference solar cell:

Identity-Nr.:	Certificate-Nr.:	Traceability:
ISE012	41414-PTB-05	PTB

The entire inspection equipment used is subject to a controlled quality management system according to ISO 9001:2000. All relevant components belonging to the filter monochromator setup external and respectively internal calibration certificates are available.

## 3. Measurement conditions

The operating point of the solar cell is defined by a bias current under short circuit condition.

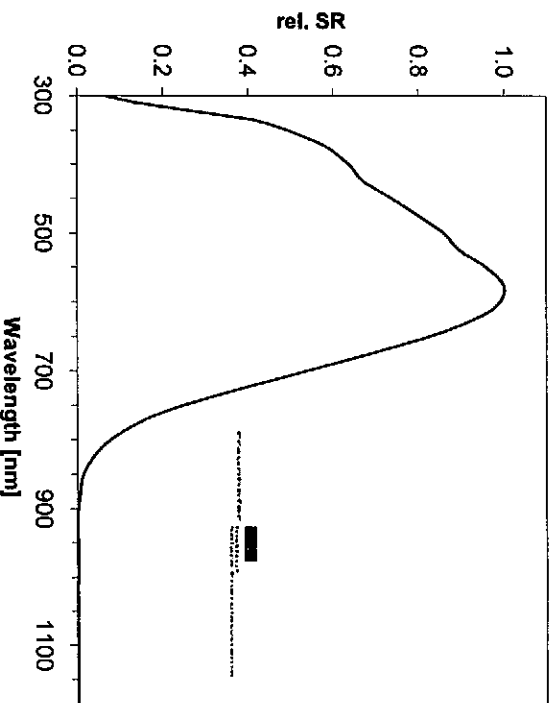
Bias current: 1 mA  
Temperature of the object: 25 °C

The terminal voltage of the solar cell is controlled to below 0.03 V<sub>oc</sub> by a current-to-voltage converter. The frequency of the chopped quasi monochromatic light beam is 125 Hz. The spectral bandwidth (full width at half maximum) of monochromatic light is about 15 nm.

#### 4. Measurement result

Wavelength [nm]	EQE [%]	rel. SR [mA <sup>-1</sup> m <sup>2</sup> W]	rel. SR normalized	*rel. Measurement Uncertainty [%]	Measurement Uncertainty
297,0	6,36	0,0061	0,0419	10,0	0
308,9	18,54	0,0185	0,1267	9	0
320,9	35,77	0,0371	0,2539	9	0
330,6	49,84	0,0532	0,3646	9	0
340,2	59,86	0,0648	0,4440	9	0
369,0	69,81	0,0832	0,5700	9	0
399,0	72,09	0,0929	0,6394	9	0
425,3	71,55	0,0993	0,6733	2	0
452,5	74,53	0,1098	0,7462	2	0
474,1	76,22	0,1187	0,7995	2	0
498,4	77,81	0,1252	0,8391	2	0
523,7	77,16	0,1305	0,8841	2	0
548,4	78,76	0,1395	0,9357	2	0
573,6	78,48	0,1460	1,0000	2	0
601,8	74,21	0,1442	0,9676	2	0
621,4	68,48	0,1375	0,9417	2	0
648,3	58,01	0,1215	0,8321	2	0
698,7	35,26	0,0796	0,5451	3	0
742,2	17,53	0,0420	0,2879	3	0
766,7	10,96	0,0249	0,1708	3	0
791,3	5,95	0,0144	0,0899	3	0
809,7	3,28	0,0096	0,0587	3	0
827,6	1,94	0,0052	0,0355	3	0
847,6	0,85	0,0023	0,0160	3	0
859,6	0,53	0,0015	0,0101	4	0
881,5	0,31	0,0009	0,0060	3	0
905,7	0,06	0,0002	0,0013	10	0
928,1	0,01	0,0000	0,0002	42	0
949,0	0,08	0,0003	0,0018	8	0
974,7	0,06	0,0003	0,0018	9	0
997,2	0,13	0,0004	0,0028	8	0
1016,0	0,05	0,0002	0,0012	12	0
1025,3	0,06	0,0002	0,0013	12	0
1050,3	0,07	0,0003	0,0017	14	0
1058,3	0,03	0,0001	0,0008	12	0
1086,6	0,06	0,0002	0,0014	12	0
1105,5	0,11	0,0004	0,0027	20	0
1118,3	0,03	0,0001	0,0008	20	0
1137,0	0,04	0,0001	0,0008	21	0
1164,5	0,03	0,0001	0,0008	25	0
1185,7	0,03	0,0001	0,0008	208	0

\* For each wavelength the expanded measurement uncertainty resulting of the standard measurement uncertainty multiplied with a factor  $k=2$  is specified. The calculation was carried out according to the "Guide to the expression of Uncertainty in Measurement (ISO, 1995). It corresponds to a Gaussian distribution referring to the deviations of the measurement value within a probability of



## 5. Literature:

/1/ J. Metzdorf, Calibration of Solar Cells. 1: *The Differential Spectral Responsivity Method*, Applied Optics 26 (1987) p.1701-1708

/2/ IEC 60904-8:1998, Photovoltaic devices - Part 8: *Measurement of the spectral response of a photovoltaic (PV) device*

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