

Annex A301 – Calibration Data

No. 1-2152-25-01-02_TR1-A301-R01

July 30, 2026

Description

Detailed SAR System calibration data

This test report is electronically signed and valid without handwritten signature.
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Regulatory Services Radio

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1 Calibration report "Probe EX3DV4" – SN: 3944

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Cetecom Advanced**
Saarbrücken, Germany

Certificate No. **EX-3944_May25**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3944**

Calibration procedure(s) **QA CAL-01.v10, QA CAL-12.v10, QA CAL-14.v7, QA CAL-23.v6,
QA CAL-25.v8
Calibration procedure for dosimetric E-field probes**

Calibration date **May 16, 2025**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.
All calibrations have been conducted in the closed laboratory facility; environment temperature (22 ± 3) °C and humidity < 70%.
Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Calibration Date (Certificate No.)	Sched. Cal.
Power Sensor R&S NRP-33T	SN: 100967	26-Mar-25 (No. 217-D4290)	Mar-26
Type-N mismatch combination	SN: L1119	26-Mar-25 (No. 217-D4292)	Mar-26
OCP DAK-12	SN: 1016	24-Sept-24 (No. OCP-DAK12-1016_Sep24)	Sep-25
OCP DAK-3.5	SN: 1249	23-Sept-24 (No. OCP-DAK3.5-1249_Sep24)	Sep-25
Reference Probe EX3DV4	SN: 7349	10-Jan-25 (No. EX3-7349_Jan25)	Jan-26
DAE4	SN: 1301	07-Nov-24 (No. DAE4-1301_Nov24)	Nov-25
Secondary Standards	ID	Check Date (in house)	Sched. Check
ACAP 2020 Setup 1	SN: L1404	30-Sept-24 (No. Report_ACAP2020E-Cave_20240930s)	Sep-25

	Name	Function	Signature
Calibrated by	Aidonia Georgiadou	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	

Issued: May 16, 2025

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No.: EX-3944_May25

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Accreditation No.: SCS 0108

Glossary

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,y,z}
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\theta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

- IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices – Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\theta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E²-field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z} = NORM_{x,y,z} * frequency_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP_{x,y,z}**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal. DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}; A, B, C, D** are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM_{x,y,z} * ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- Spherical isotropy (3D deviation from isotropy)**: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:3944

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.55	0.61	0.42	$\pm 10.1\%$
DCP (mV) ^B	100.9	100.7	103.6	$\pm 4.7\%$

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Max dev.	Max Unc ^E $k = 2$
0	CW	X	0.00	0.00	1.00	0.00	132.4	$\pm 1.6\%$	$\pm 4.7\%$
		Y	0.00	0.00	1.00		147.6		
		Z	0.00	0.00	1.00		141.0		
10352	Pulse Waveform (200Hz, 10%)	X	20.00	91.92	21.33	10.00	60.0	$\pm 2.8\%$	$\pm 9.6\%$
		Y	20.00	95.43	24.04		60.0		
		Z	20.00	87.84	18.52		60.0		
10353	Pulse Waveform (200Hz, 20%)	X	20.00	93.54	21.24	6.99	80.0	$\pm 1.6\%$	$\pm 9.6\%$
		Y	20.00	95.53	22.95		80.0		
		Z	20.00	89.39	18.17		80.0		
10354	Pulse Waveform (200Hz, 40%)	X	20.00	98.48	22.46	3.98	95.0	$\pm 1.3\%$	$\pm 9.6\%$
		Y	20.00	98.33	22.90		95.0		
		Z	20.00	94.54	19.42		95.0		
10355	Pulse Waveform (200Hz, 60%)	X	20.00	106.08	24.80	2.22	120.0	$\pm 1.2\%$	$\pm 9.6\%$
		Y	20.00	103.01	23.76		120.0		
		Z	20.00	104.87	23.07		120.0		
10387	QPSK Waveform, 1 MHz	X	1.76	66.87	15.49	1.00	150.0	$\pm 1.9\%$	$\pm 9.6\%$
		Y	1.78	65.64	15.00		150.0		
		Z	1.73	67.94	15.77		150.0		
10388	QPSK Waveform, 10 MHz	X	2.34	68.80	16.20	0.00	150.0	$\pm 1.1\%$	$\pm 9.6\%$
		Y	2.34	68.08	15.66		150.0		
		Z	2.25	68.78	16.28		150.0		
10396	64-QAM Waveform, 100 kHz	X	2.99	71.00	19.04	3.01	150.0	$\pm 0.8\%$	$\pm 9.6\%$
		Y	3.21	70.51	18.65		150.0		
		Z	2.70	70.82	19.06		150.0		
10399	64-QAM Waveform, 40 MHz	X	3.60	67.58	16.04	0.00	150.0	$\pm 0.8\%$	$\pm 9.6\%$
		Y	3.46	66.56	15.46		150.0		
		Z	3.53	67.55	16.04		150.0		
10414	WLAN CCDF, 64-QAM, 40 MHz	X	4.77	65.33	15.39	0.00	150.0	$\pm 2.0\%$	$\pm 9.6\%$
		Y	4.88	65.23	15.28		150.0		
		Z	4.65	65.42	15.43		150.0		

Note: For details on UID parameters see Appendix

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.

^A The uncertainties of Norm X,Y,Z do not affect the E^2 -field uncertainty inside TSL (see Pages 5 and 6).

^B Linearization parameter uncertainty for maximum specified field strength.

^E Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

EX3DV4 - SN:3944

May 16, 2025

Parameters of Probe: EX3DV4 - SN:3944
Sensor Model Parameters

	C1 fF	C2 fF	α V ⁻¹	T1 ms V ⁻²	T2 ms V ⁻¹	T3 ms	T4 V ⁻²	T5 V ⁻¹	T6
x	45.6	336.45	34.85	20.04	0.00	5.10	1.22	0.22	1.01
y	56.8	421.46	35.17	21.45	0.55	5.10	0.63	0.47	1.01
z	36.7	267.00	34.02	11.07	0.00	5.03	1.65	0.01	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-0.7°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

Note: Measurement distance from surface can be increased to 3–4 mm for an Area Scan job.

Parameters of Probe: EX3DV4 - SN:3944

Calibration Parameter Determined in HSL

f (MHz) ^C	Relative Permittivity ^F	Conductivity ^F (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc ^H (k = 2)
6	55.0	0.75	17.64	18.18	20.60	0.00	1.25	±13.3%
13	55.0	0.75	16.33	16.83	19.07	0.00	1.25	±13.3%
450	43.5	0.87	11.01	11.01	11.01	0.16	1.30	±13.3%
600	42.7	0.88	10.56	10.56	10.56	0.10	1.25	±13.3%
750	41.9	0.89	9.46	9.79	9.67	0.35	1.27	±11.0%
850	41.5	0.92	8.97	9.29	9.17	0.35	1.27	±11.0%
900	41.5	0.97	9.25	9.58	9.47	0.35	1.27	±11.0%
1450	40.5	1.20	8.21	8.50	8.40	0.35	1.27	±11.0%
1640	40.2	1.31	8.01	8.30	8.20	0.35	1.27	±11.0%
1750	40.1	1.37	8.00	8.29	8.19	0.34	1.27	±11.0%
1900	40.0	1.40	7.67	7.94	7.85	0.34	1.27	±11.0%
2150	39.7	1.53	7.70	7.97	7.88	0.34	1.27	±11.0%
2300	39.5	1.67	7.52	7.79	7.69	0.34	1.27	±11.0%
2450	39.2	1.80	7.53	7.80	7.71	0.34	1.27	±11.0%
2600	39.0	1.96	7.31	7.57	7.48	0.34	1.27	±11.0%
3300	36.2	2.71	6.56	6.79	6.71	0.33	1.27	±13.1%
3500	37.9	2.91	6.71	6.95	6.87	0.33	1.27	±13.1%
3700	37.7	3.12	6.77	7.01	6.93	0.33	1.27	±13.1%
5200	36.0	4.66	5.48	5.68	5.61	0.30	1.27	±13.1%
5300	35.9	4.76	5.29	5.47	5.41	0.29	1.27	±13.1%
5500	35.6	4.96	5.11	5.29	5.23	0.28	1.27	±13.1%
5600	35.5	5.07	5.13	5.32	5.25	0.27	1.27	±13.1%
5800	35.3	5.27	5.02	5.20	5.14	0.25	1.27	±13.1%

^C Frequency validity above 300 MHz of ±100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ±50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ±10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4–9 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.

^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for frequencies between 3–6 GHz at any distance larger than half the probe tip diameter from the boundary.

^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

EX3DV4 - SN:3944

May 16, 2025

Parameters of Probe: EX3DV4 - SN:3944

Calibration Parameter Determined in HSL

f (MHz) ^C	Relative Permittivity ^F	Conductivity ^F (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc ^H (k = 2)
6500	34.5	6.07	5.62	5.82	5.75	0.20	1.27	±18.6%

^C Frequency validity is -600/+700 MHz at 6.5 GHz, ±700 MHz at or above 7 GHz, and ±150 MHz at 9.85 GHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

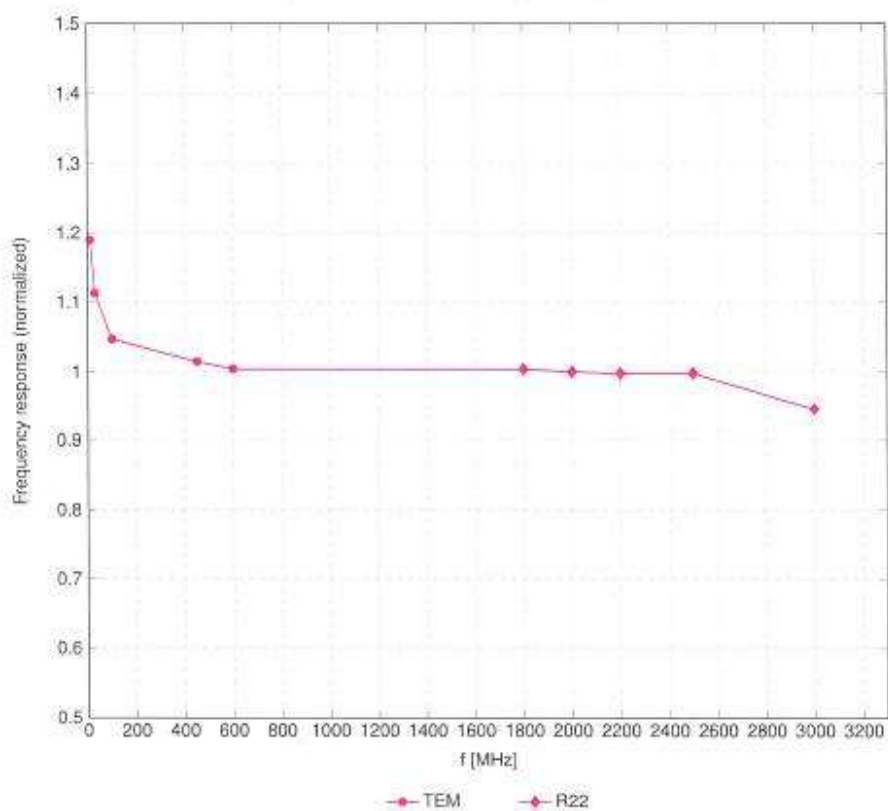
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±10% from the target values (typically better than ±6%) and are valid for TSL with deviations of up to ±10%.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz; below ±2% for frequencies between 3–6 GHz; and below ±4% for frequencies between 6–10 GHz at any distance larger than half the probe tip diameter from the boundary.

^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1526:2020.

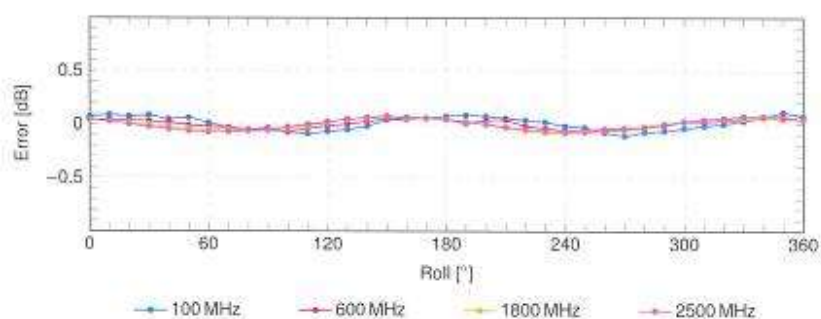
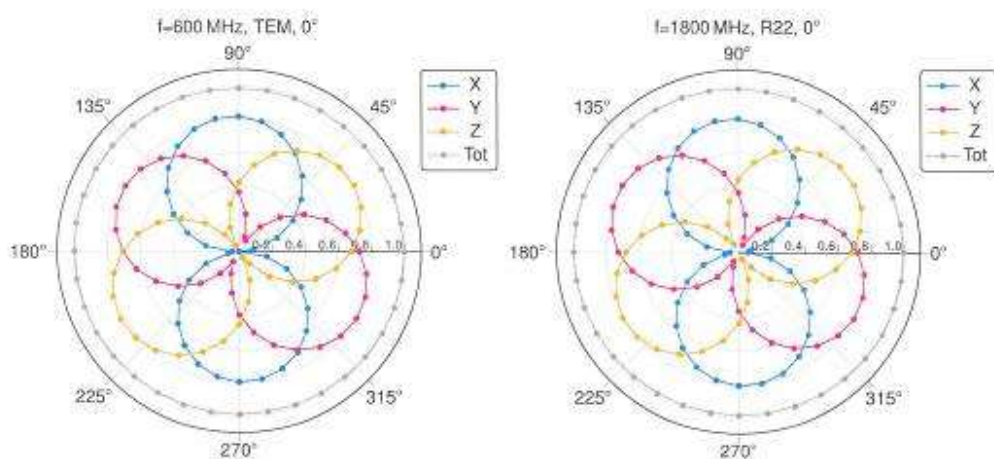
Frequency Response of E-Field

(TEM-Cell:111110 EXX, Waveguide:R22)

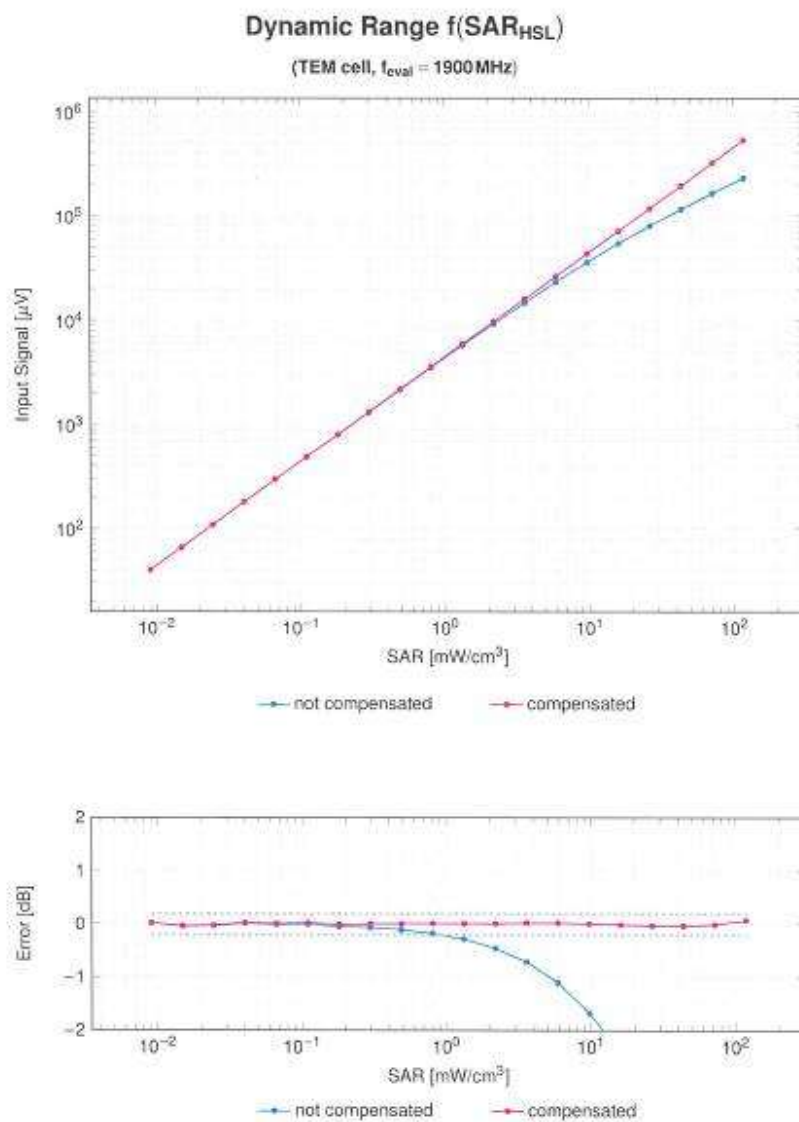


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

Receiving Pattern (ϕ), $\vartheta = 0^\circ$

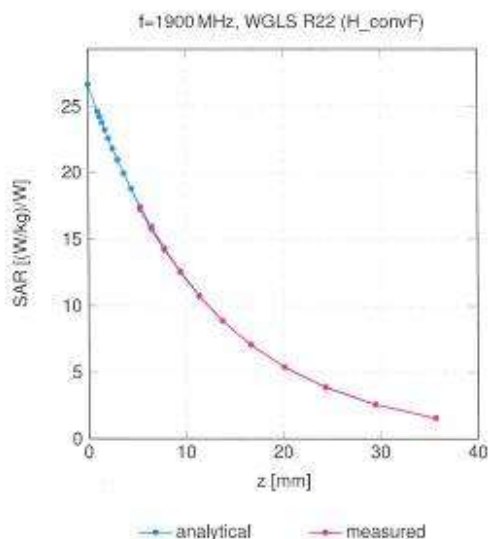


Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

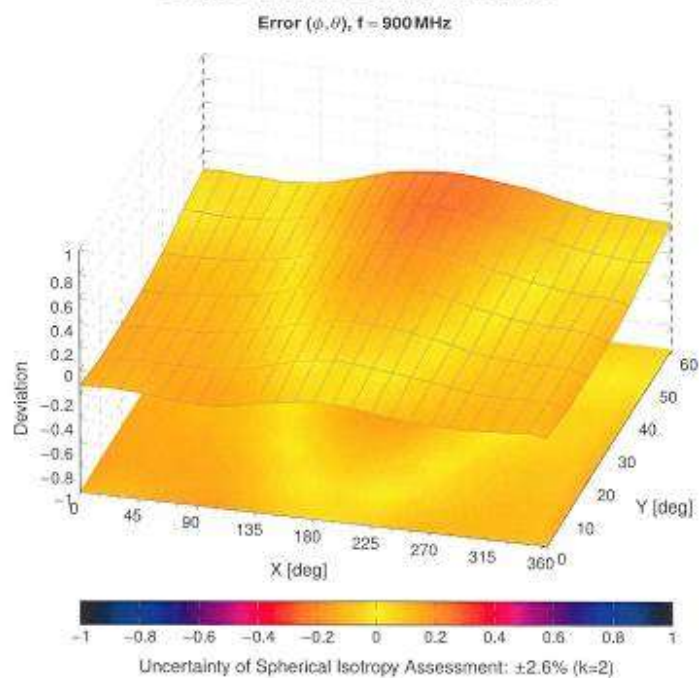


Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid



2 Calibration report "Probe EX3DV4" – SN: 3944

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Accreditation No.: SCS 0108

Client

Cetecom Advanced
Saarbrücken, Germany

Certificate No.

EX-3944_May26

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3944**

Calibration procedure(s) **QA CAL-01.v10, QA CAL-12.v10, QA CAL-14.v7, QA CAL-23.v6,
QA CAL-25.v8, QA CAL-48.v2
Calibration procedure for dosimetric E-field probes**

Calibration date **May 05, 2026**

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The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

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Calibration Equipment used (M&TE critical for calibration)

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OCP DAK-12	SN: 1016	16-Sept-25 (No. OCP-DAK12-1016_Sep25)	Sep-26
OCP DAK-3.5	SN: 1249	16-Sept-25 (No. OCP-DAK3.5-1249_Sep25)	Sep-26
Reference Probe EX3DV4	SN: 7349	29-Jan-26 (No. EX3-7349_Jan26)	Jan-27
DAE4	SN: 1301	22-Jan-26 (No. DAE4-1301_Jan26)	Jan-27

Secondary Standards	ID	Check Date (in house)	Sched. Check
ACAP 2026 Setup 1	SN: L1404	01-Oct-25 (No. IHCK_ACAP2020-1_Oct25)	Oct-26
OCP DAK-12	SN: 1029	24-Feb-26 (No. OCP-DAK12-1029_Feb26)	Feb-27
OCP DAK-3.5	SN: 1336	10-Dec-25 (No. OCP-DAK3.5-1336_Dec25)	Dec-26
Network Analyzer Keysight E5063A	SN: MYS4504221	30-Sept-24 (No. 675-CAL18-S4489-Sept24)	Sep-26

	Name	Function	Signature
Calibrated by	Aldona Georgiadou	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			Issued: May 06, 2026

Certificate No: EX-3944_May26

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Glossary

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A, B, C, D	modulation dependent linearization parameters
Polarization ψ	ψ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\theta = 0$ is normal to probe axis
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- NORM(f)_{x,y,z} = NORM_{x,y,z} * frequency_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
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- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}; A, B, C, D** are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM_{x,y,z} * ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- Spherical isotropy (3D deviation from isotropy)**: In a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:3944

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.56	0.61	0.42	$\pm 10.1\%$
DCP (mV) ^B	99.4	98.1	101.7	$\pm 4.7\%$

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Max dev.	Max Unc ^E k = 2
0	Continuous Wave	X	0.00	0.00	1.00	0.00	145.7	$\pm 1.0\%$	$\pm 4.7\%$
		Y	0.00	0.00	1.00		129.7		
		Z	0.00	0.00	1.00		128.1		
10352	Pulse (D=10%, T=5 ms)	X	0.92	61.53	14.31	10.00	24.0	$\pm 1.3\%$	$\pm 9.6\%$
		Y	1.09	60.61	13.71		25.0		
		Z	0.85	63.80	15.49		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.85	64.54	14.28	6.99	48.0	$\pm 1.0\%$	$\pm 9.6\%$
		Y	1.01	63.62	13.67		49.0		
		Z	0.78	66.81	15.49		48.0		
10354	Pulse (D=40%, T=5 ms)	X	0.77	67.55	14.26	3.98	95.0	$\pm 0.9\%$	$\pm 9.6\%$
		Y	0.93	66.63	13.63		97.0		
		Z	0.71	69.82	15.49		96.0		
10355	Pulse (D=60%, T=5 ms)	X	0.73	69.31	14.25	2.22	142.0	$\pm 1.0\%$	$\pm 9.6\%$
		Y	0.88	68.39	13.60		146.0		
		Z	0.67	71.58	15.49		143.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.66	66.43	14.22	0.00	115.0	$\pm 1.7\%$	$\pm 9.6\%$
		Y	0.83	65.51	13.56		117.0		
		Z	0.57	68.70	15.49		115.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	1.73	66.31	14.43	0.00	123.0	$\pm 1.4\%$	$\pm 9.6\%$
		Y	1.77	65.39	13.90		126.0		
		Z	1.87	68.59	15.49		123.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.01	65.25	13.32	0.94	84.0	$\pm 1.6\%$	$\pm 9.6\%$
		Y	1.12	76.76	11.63		86.0		
		Z	0.12	67.53	15.47		84.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	2.62	65.25	14.46	0.00	113.0	$\pm 3.3\%$	$\pm 9.6\%$
		Y	2.57	64.33	13.96		117.0		
		Z	2.95	67.53	15.49		114.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	3.87	62.99	14.47	0.00	92.0	$\pm 1.2\%$	$\pm 9.6\%$
		Y	3.79	62.07	13.97		95.0		
		Z	4.27	65.26	15.49		92.0		

Note: For details on UID parameters see Appendix

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.

^A The uncertainties of Norm X,Y,Z do not affect the E^2 -field uncertainty inside TSL (see Pages 5 and 6).

^B Linearization parameter uncertainty for maximum specified field strength.

^E Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

EX3DV4 - SN:3944

May 05, 2026

Parameters of Probe: EX3DV4 - SN:3944

Sensor Model Parameters

	C1 fF	C2 fF	α V ⁻¹	T1 ms V ⁻²	T2 ms V ⁻¹	T3 ms	T4 V ⁻²	T5 V ⁻¹	T6
x	34.3	251.75	34.29	20.04	0.00	5.10	1.22	0.22	1.01
y	40.8	298.30	33.98	21.45	0.55	5.10	0.63	0.47	1.01
z	27.9	204.16	34.11	11.07	0.00	5.03	1.65	0.01	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-1.9°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	12 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

Note: Measurement distance from surface can be increased to 3–4 mm for an Area Scan job.

Parameters of Probe: EX3DV4 - SN:3944

Calibration Parameter Determined in HSL

f (MHz) ^C	Relative Permittivity ^F	Conductivity ^F (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc ^H (k = 2)
6	55.0	0.75	17.60	18.66	20.49	0.00	1.25	±13.3%
13	55.0	0.75	16.13	17.10	18.78	0.00	1.25	±13.3%
450	43.5	0.87	11.04	11.04	11.04	0.16	1.30	±13.3%
600	42.7	0.88	10.39	10.39	10.39	0.10	1.25	±13.3%
750	41.9	0.89	9.54	10.22	9.89	0.31	1.27	±11.0%
850	41.5	0.92	9.08	9.72	9.41	0.31	1.27	±11.0%
900	41.5	0.97	8.91	9.55	9.25	0.31	1.27	±11.0%
1450	40.5	1.20	8.17	8.75	8.48	0.32	1.27	±11.0%
1640	40.2	1.31	8.04	8.61	8.34	0.32	1.27	±11.0%
1750	40.1	1.37	7.96	8.53	8.26	0.32	1.27	±11.0%
1900	40.0	1.40	7.86	8.41	8.15	0.32	1.27	±11.0%
2100	39.8	1.49	7.71	8.26	8.00	0.33	1.27	±11.0%
2300	39.5	1.67	7.56	8.10	7.84	0.33	1.27	±11.0%
2450	39.2	1.80	7.45	7.98	7.73	0.33	1.27	±11.0%
2600	39.0	1.96	7.34	7.86	7.61	0.33	1.27	±11.0%
3300	38.2	2.71	6.84	7.33	7.10	0.34	1.27	±13.1%
3500	37.9	2.91	6.72	7.19	6.96	0.34	1.27	±13.1%
3700	37.7	3.12	6.60	7.07	6.84	0.35	1.27	±13.1%
5200	36.0	4.66	5.31	5.68	5.50	0.32	1.27	±13.1%
5300	35.9	4.76	5.22	5.60	5.42	0.31	1.27	±13.1%
5500	35.6	4.96	4.90	5.25	5.08	0.29	1.27	±13.1%
5600	35.5	5.07	4.86	5.21	5.04	0.28	1.27	±13.1%
5800	35.3	5.27	4.96	5.31	5.15	0.27	1.27	±13.1%

^C Frequency validity above 300 MHz of ±100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ±50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ±10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4–9 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.

^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for frequencies between 3–6 GHz at any distance larger than half the probe tip diameter from the boundary.

^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

EX3DV4 - SN:3944

May 05, 2026

Parameters of Probe: EX3DV4 - SN:3944

Calibration Parameter Determined in HSL

f (MHz) ^C	Relative Permittivity ^F	Conductivity ^F (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc ^H (k = 2)
6500	34.5	6.07	5.17	5.54	5.36	0.20	1.27	±18.6%

^C Frequency validity is -600/+700 MHz at 6.5 GHz; ±700 MHz at or above 7 GHz; and ±150 MHz at 9.85 GHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

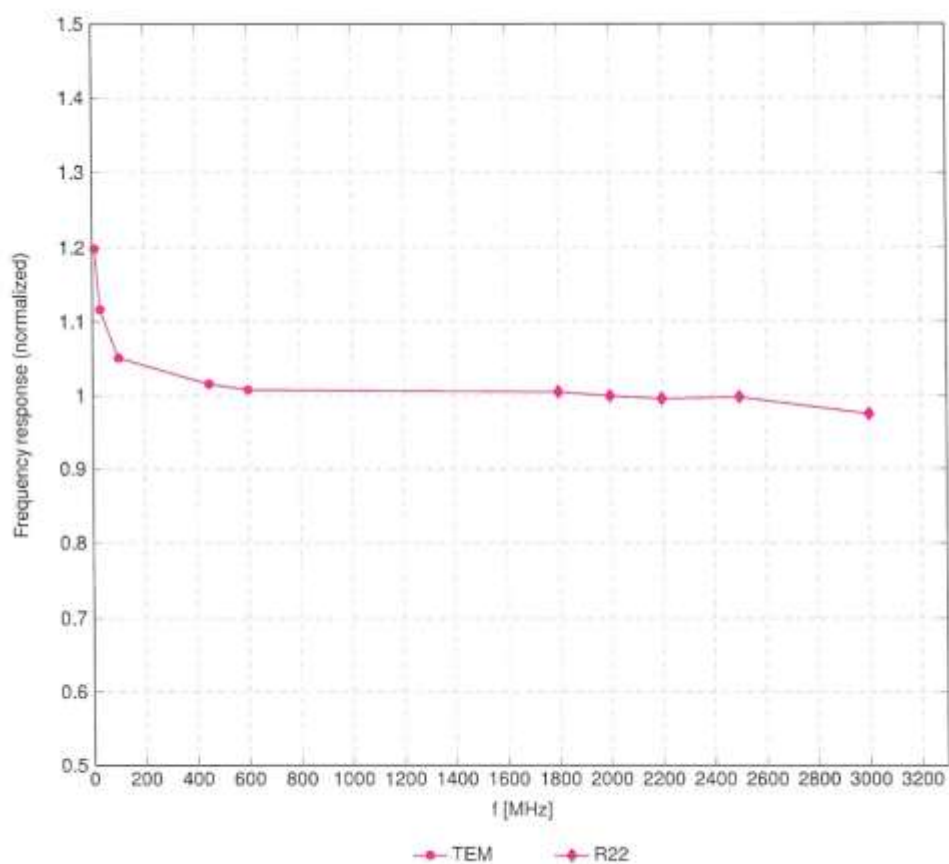
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±10% from the target values (typically better than ±6%) and are valid for TSL with deviations of up to ±10%.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz; below ±2% for frequencies between 3–6 GHz; and below ±4% for frequencies between 6–10 GHz at any distance larger than half the probe tip diameter from the boundary.

^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1525:2020.

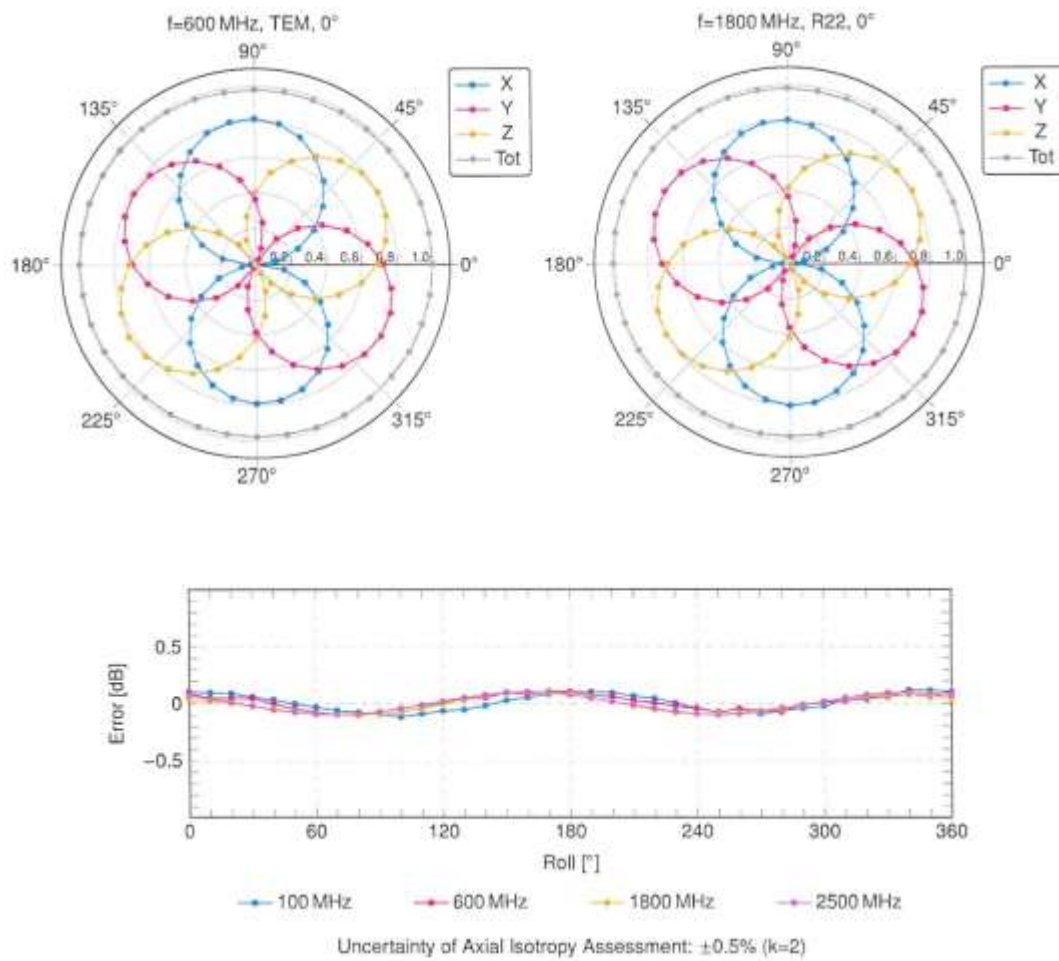
Frequency Response of E-Field

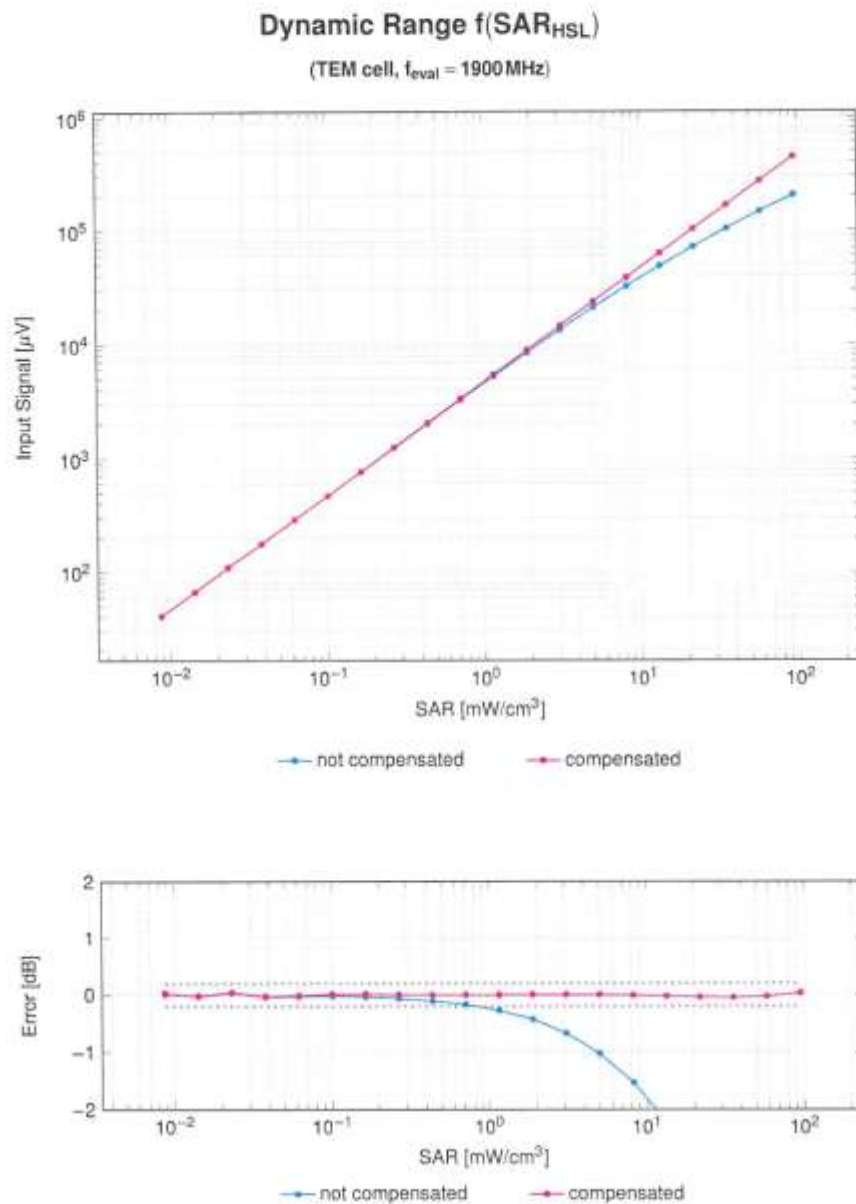
(TEM-Cell:ifl110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

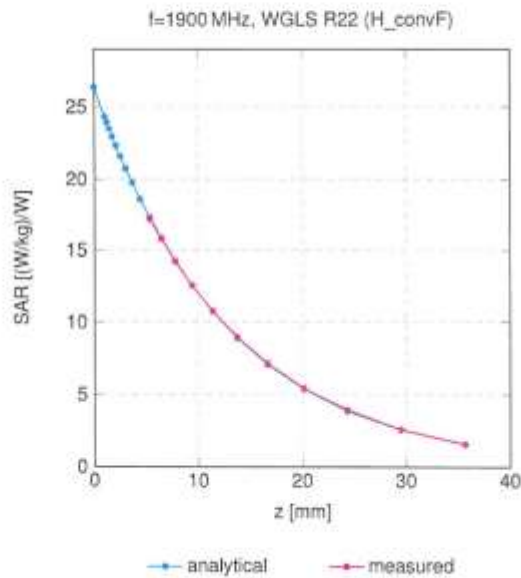
Receiving Pattern (ϕ), $\vartheta = 0^\circ$



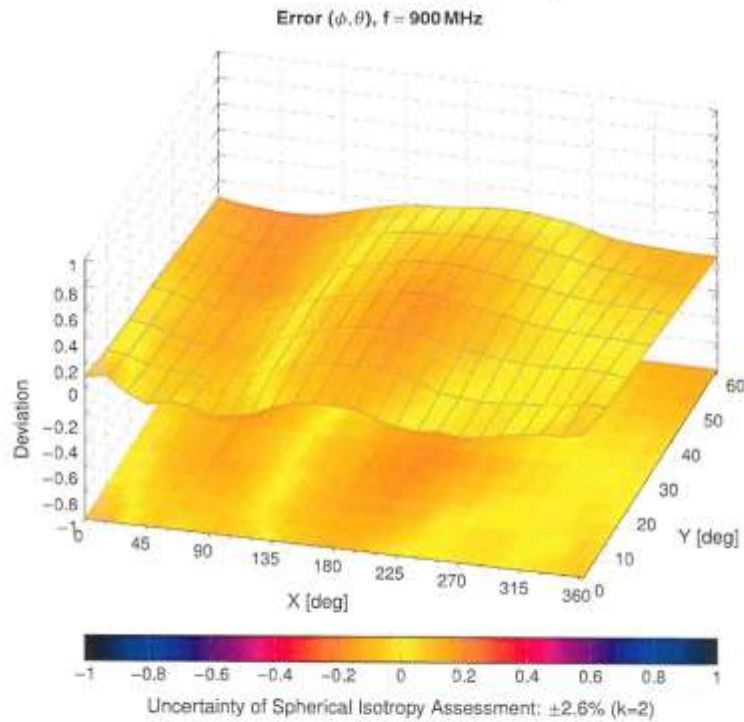


Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid



3 Calibration report "Probe EX3DV4 – SN: 7566"

Calibration Laboratory of
Schmid & Partner
Engineering AG

Zeughausstrasse 43, 8004 Zurich, Switzerland



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
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Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **Cetecom Advanced**
Saarbrücken, Germany

Certificate No. **EX-7566_Aug25**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:7566**

Calibration procedure(s) **QA CAL-01.v10, QA CAL-12.v10, QA CAL-14.v7, QA CAL-23.v6,
QA CAL-25.v8
Calibration procedure for dosimetric E-field probes**

Calibration date **August 07, 2025**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.
All calibrations have been conducted in the closed laboratory facility: environment temperature $(22 \pm 3)^\circ\text{C}$ and humidity $< 70\%$.
Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Calibration Date (Certificate No.)	Sched. Cal.
Power Sensor R&S NRP-33T	SN: 100967	30-Apr-25 (No. 1020-300791769)	Apr-26
N-type mismatch combination	SN: L1119	26-Mar-25 (No. 217-04292)	Mar-26
OCP DAK-12	SN: 1016	24-Sept-24 (No. OCP-DAK12-1016_Sep24)	Sep-25
OCP DAK-3.5	SN: 1249	23-Sept-24 (No. OCP-DAK3.5-1249_Sep24)	Sep-25
Reference Probe EX3DV4	SN: 7349	10-Jan-25 (No. EX3-7349_Jan25)	Jan-26
DAE4	SN: 1301	07-Nov-24 (No. DAE4-1301_Nov24)	Nov-25

Secondary Standards	ID	Check Date (in house)	Sched. Check
ACAP 2020 Setup 1	SN: L1404	30-Sept-24 (No. Report ACAP2020E-Cave_20240930s)	Sep-25
OCP DAK-12	SN: 1029	27-Feb-25 (No. OCP-DAK12-1029_Feb25)	Feb-26
OCP DAK-3.5	SN: 1336	09-Dec-24 (No. OCP-DAK3.5-1336_Dec24)	Dec-25

	Name	Function	Signature
Calibrated by	Joanna Lieshaj	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			
Issued: August 07, 2025			

Certificate No: EX-7566_Aug25

Page 1 of 22

Calibration Laboratory of Schmid & Partner Engineering AG

Zeughausstrasse 43, 8004 Zurich, Switzerland



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Accreditation No.: SCS 0108

Glossary

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,y,z}
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center); i.e., $\theta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

- IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices – Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\theta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E²-field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z} = NORM_{x,y,z} * frequency_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP_{x,y,z}**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal. DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics.
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}**: A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM_{x,y,z} * ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- Spherical isotropy (3D deviation from isotropy)**: In a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:7566

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.68	0.48	0.54	±10.1%
DCP (mV) ^B	100.0	99.8	100.2	±4.7%

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Max dev.	Max Unc ^E k = 2
0	CW	X	0.00	0.00	1.00	0.00	126.2	±0.6%	±4.7%
		Y	0.00	0.00	1.00		122.2		
		Z	0.00	0.00	1.00		136.3		
10352	Pulse Waveform (200Hz, 10%)	X	20.00	92.20	21.53	10.00	60.0	±3.3%	±9.6%
		Y	20.00	90.47	20.32		60.0		
		Z	20.00	91.66	20.73		60.0		
10353	Pulse Waveform (200Hz, 20%)	X	20.00	92.41	20.67	6.99	80.0	±1.9%	±9.6%
		Y	20.00	92.36	20.24		80.0		
		Z	20.00	93.20	20.39		80.0		
10354	Pulse Waveform (200Hz, 40%)	X	20.00	93.17	19.72	3.98	95.0	±1.1%	±9.6%
		Y	20.00	96.35	20.85		95.0		
		Z	20.00	96.01	20.35		95.0		
10355	Pulse Waveform (200Hz, 60%)	X	20.00	93.82	18.74	2.22	120.0	±0.9%	±9.6%
		Y	20.00	99.84	21.14		120.0		
		Z	20.00	96.40	19.18		120.0		
10387	QPSK Waveform, 1 MHz	X	1.57	64.33	13.87	1.00	150.0	±2.6%	±9.6%
		Y	1.57	66.38	14.72		150.0		
		Z	1.61	65.43	14.41		150.0		
10388	QPSK Waveform, 10 MHz	X	2.06	66.21	14.52	0.00	150.0	±1.1%	±9.6%
		Y	2.05	67.25	15.37		150.0		
		Z	2.02	66.35	14.77		150.0		
10396	64-QAM Waveform, 100 kHz	X	2.99	69.66	18.20	3.01	150.0	±1.1%	±9.6%
		Y	2.24	66.43	16.90		150.0		
		Z	2.69	68.36	17.72		150.0		
10399	64-QAM Waveform, 40 MHz	X	3.40	66.27	15.18	0.00	150.0	±1.7%	±9.6%
		Y	3.39	66.76	15.61		150.0		
		Z	3.36	66.27	15.29		150.0		
10414	WLAN CCDF, 64-QAM, 40 MHz	X	4.88	65.37	15.31	0.00	150.0	±3.4%	±9.6%
		Y	4.72	65.47	15.47		150.0		
		Z	4.75	65.11	15.25		150.0		

Note: For details on UID parameters see Appendix

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.

^A The uncertainties of Norm X,Y,Z do not affect the E^2 -field uncertainty inside TSL (see Pages 5 and 6).

^B Linearization parameter uncertainty for maximum specified field strength.

^E Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

EX3DV4 - SN:7566

August 07, 2025

Parameters of Probe: EX3DV4 - SN:7566
Sensor Model Parameters

	C1 IF	C2 IF	α V^{-1}	T1 $ms V^{-2}$	T2 $ms V^{-1}$	T3 ms	T4 V^{-2}	T5 V^{-1}	T6
x	50.9	385.70	36.31	21.51	0.24	5.10	0.86	0.41	1.01
y	38.0	286.59	36.16	16.30	0.04	5.10	0.00	0.34	1.00
z	46.5	353.86	36.62	13.25	0.07	5.10	0.00	0.48	1.01

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-73.7°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	12 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

Note: Measurement distance from surface can be increased to 3–4 mm for an Area Scan job.

Parameters of Probe: EX3DV4 - SN:7566

Calibration Parameter Determined in HSL

f (MHz) ^C	Relative Permittivity ^F	Conductivity ^F (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc ^H (k = 2)
750	41.9	0.89	10.57	10.33	9.61	0.37	1.27	±11.0%
850	41.5	0.92	10.13	9.90	9.21	0.37	1.27	±11.0%
900	41.5	0.97	9.93	9.70	9.02	0.37	1.27	±11.0%
1750	40.1	1.37	8.33	8.13	7.56	0.36	1.27	±11.0%
1900	40.0	1.40	8.03	7.84	7.30	0.36	1.27	±11.0%
2450	39.2	1.80	7.44	7.27	6.76	0.35	1.27	±11.0%
2600	39.0	1.96	7.27	7.10	6.61	0.35	1.27	±11.0%
3300	38.2	2.71	6.78	6.62	6.16	0.34	1.27	±13.1%
3500	37.9	2.91	6.71	6.55	6.09	0.34	1.27	±13.1%
3700	37.7	3.12	6.64	6.48	6.03	0.34	1.27	±13.1%
3900	37.5	3.32	6.57	6.42	5.97	0.34	1.27	±13.1%
5200	36.0	4.66	5.80	5.66	5.27	0.31	1.27	±13.1%
5300	35.9	4.76	5.55	5.42	5.05	0.30	1.27	±13.1%
5500	35.6	4.96	5.10	4.98	4.63	0.28	1.27	±13.1%
5600	35.5	5.07	5.07	4.95	4.60	0.27	1.27	±13.1%
5800	35.3	5.27	5.10	4.98	4.63	0.26	1.27	±13.1%

^C Frequency validity above 300 MHz of ±100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ±50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ±10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4–9 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.

^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for frequencies between 3–6 GHz at any distance larger than half the probe tip diameter from the boundary.

^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

EX3DV4 - SN:7566

August 07, 2025

Parameters of Probe: EX3DV4 - SN:7566

Calibration Parameter Determined in HSL

f (MHz) ^C	Relative Permittivity ^F	Conductivity ^F (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc ^H (k = 2)
6500	34.5	6.07	5.64	5.51	5.12	0.20	1.27	±18.6%

^C Frequency validity is -600/+700 MHz at 6.5 GHz, ±700 MHz at or above 7 GHz, and ±150 MHz at 9.85 GHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

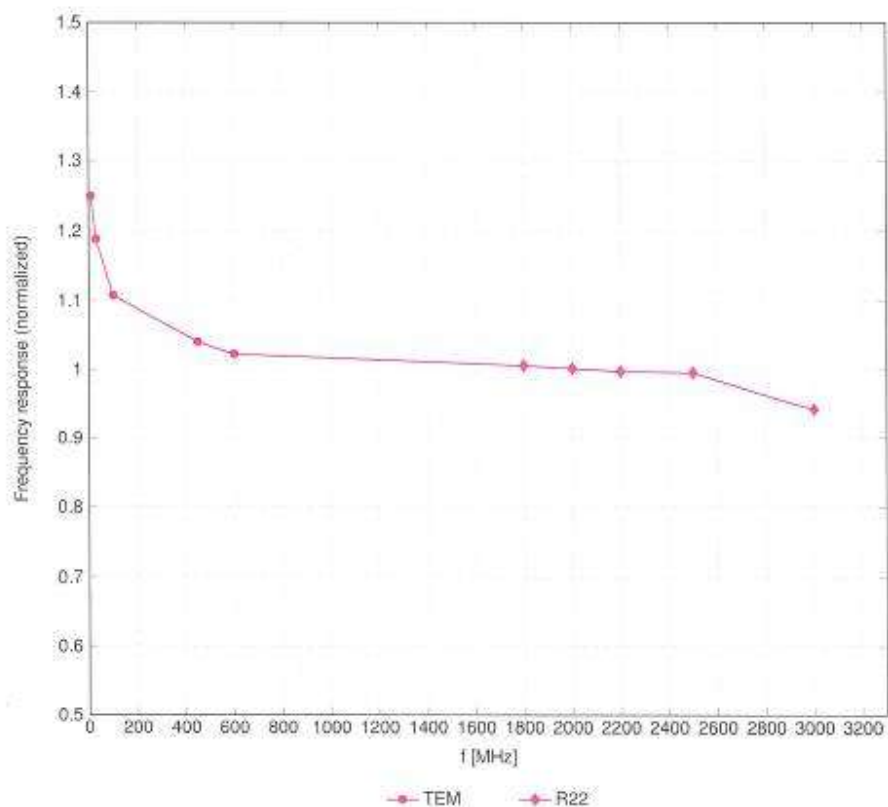
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±10% from the target values (typically better than ±6%) and are valid for TSL with deviations of up to ±10%.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz; below ±2% for frequencies between 3–6 GHz; and below ±4% for frequencies between 6–10 GHz at any distance larger than half the probe tip diameter from the boundary.

^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 6 of IEC/IEEE 62209-1528:2020.

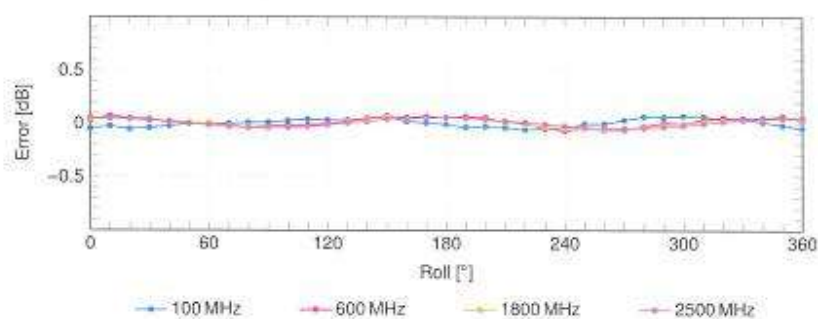
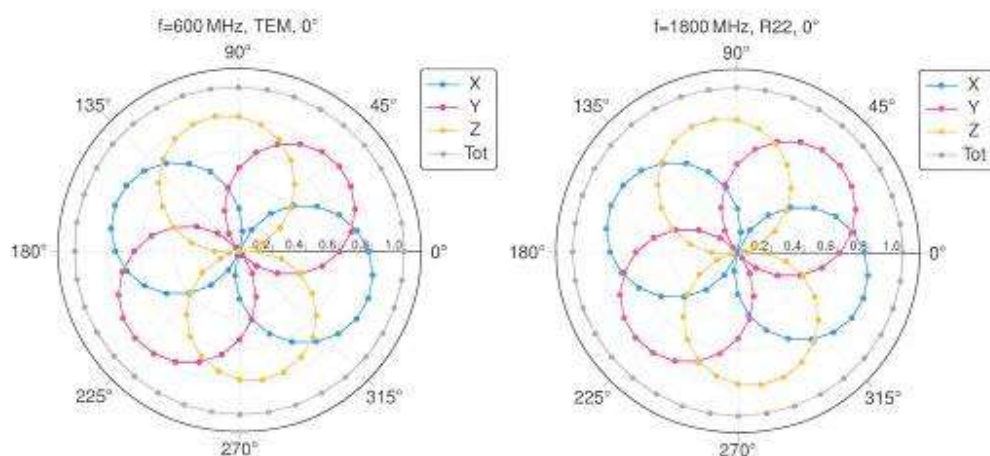
Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide:R22)

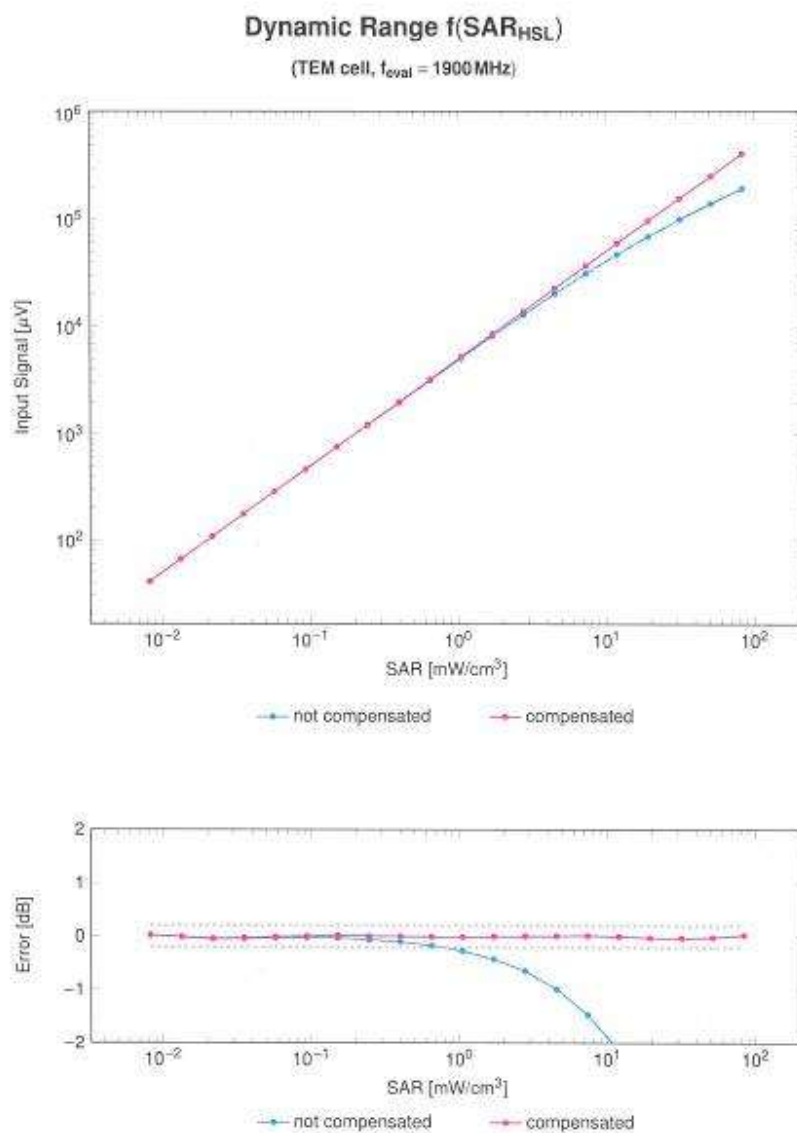


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

Receiving Pattern (ϕ), $\theta = 0^\circ$

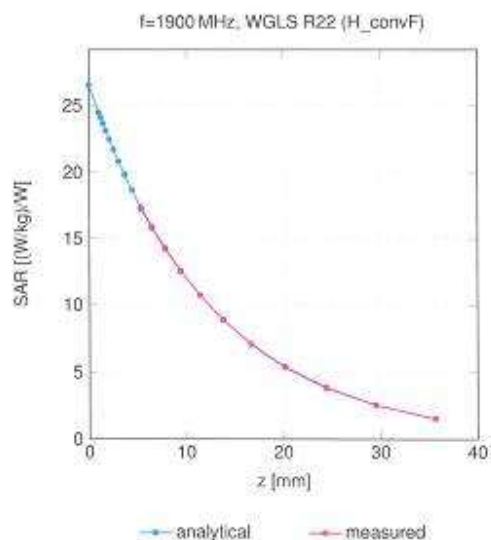


Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

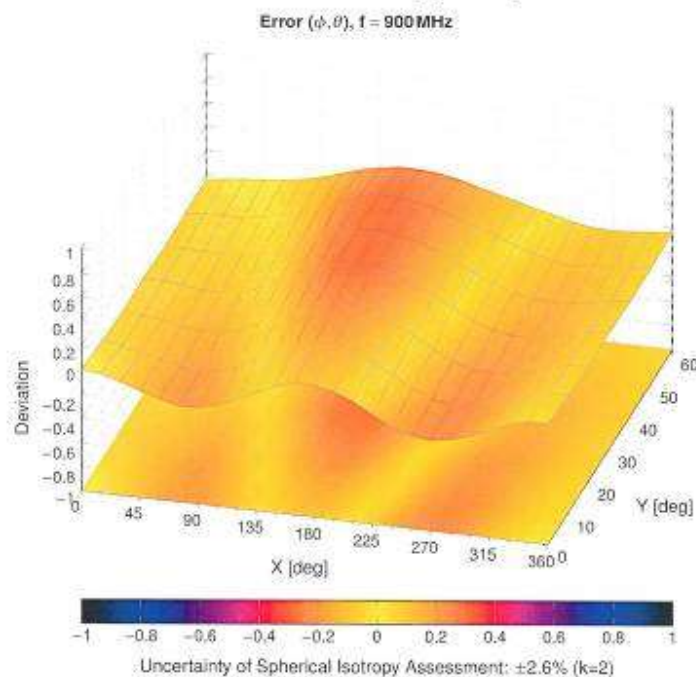


Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid



4 Calibration report "Probe EX3DV4 – SN: 7635"

Calibration Laboratory of
Schmid & Partner
Engineering AG

Zeughausstrasse 43, 8004 Zurich, Switzerland



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Cetecom Advanced**
Saarbrücken, Germany

Certificate No. **EX-7635_Jan26**

CALIBRATION CERTIFICATE

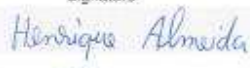
Object: **EX3DV4 - SN:7635**

Calibration procedure(s): **QA CAL-01.v10, QA CAL-12.v10, QA CAL-14.v7, QA CAL-23.v6,
QA CAL-25.v8, QA CAL-48.v2**
Calibration procedure for dosimetric E-field probes

Calibration date: **January 19, 2026**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.
All calibrations have been conducted in the closed laboratory facility; environment temperature $(22 \pm 3)^\circ\text{C}$ and humidity $< 70\%$.
Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Calibration Date (Certificate No.)	Sched. Cal.
Power Sensor R&S NRP40T	SN: 101861	29-Apr-25 (No. 2025-001450)	Apr-26
N-type mismatch combination	SN: L1119	26-Mar-25 (No. 217-04292)	Mar-26
OCP DAK-12	SN: 1016	16-Sept-25 (No. OCP-DAK12-1016_Sep25)	Sep-26
OCP DAK-3.5	SN: 1249	16-Sept-25 (No. OCP-DAK3.5-1249_Sep25)	Sep-26
Reference Probe EX3DV4	SN: 7349	10-Jan-25 (No. EX3-7349_Jan25)	Jan-26
DAE4	SN: 1301	30-Oct-25 (No. DAE4-1301_Oct25)	Oct-26
Secondary Standards	ID	Check Date (in house)	Sched. Check
ACAP 2020 Setup 1	SN: L1404	01-Oct-25 (No. IHCK_ACAP2020-1_Oct25)	Oct-26
OCP DAK-12	SN: 1029	27-Feb-25 (No. OCP-DAK12-1029_Feb25)	Feb-26
OCP DAK-3.5	SN: 1336	10-Dec-25 (No. OCP-DAK3.5-1336_Dec25)	Dec-26

	Name	Function	Signature
Calibrated by	Henrique Almeida	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			
Issued: January 19, 2026			

Certificate No: EX-7635_Jan26

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Accreditation No.: SCS 0108

Glossary

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,y,z}
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\theta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

- IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices – Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\theta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1600$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E²-field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z} = NORM_{x,y,z} * frequency_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP_{x,y,z}**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal. DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}; A, B, C, D** are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM_{x,y,z} * ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- Spherical isotropy (3D deviation from isotropy)**: In a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:7635

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm ($\mu V/(V/m)^2$) ^A	0.65	0.63	0.69	$\pm 10.1\%$
DCP (mV) ^B	111.9	109.5	109.9	$\pm 4.7\%$

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB $\sqrt{\mu V}$	C	D dB	VR mV	Max dev.	Max Unc ^E k = 2
0	Continuous Wave	X	0.00	0.00	1.00	0.00	132.0	$\pm 2.0\%$	$\pm 4.7\%$
		Y	0.00	0.00	1.00		138.4		
		Z	0.00	0.00	1.00		140.4		
10352	Pulse (D=10%, T=5 ms)	X	0.93	69.97	17.40	10.00	23.0	$\pm 2.0\%$	$\pm 9.6\%$
		Y	0.87	70.00	17.68		24.0		
		Z	1.01	69.97	17.51		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.87	72.98	17.44	6.99	47.0	$\pm 1.5\%$	$\pm 9.6\%$
		Y	0.81	73.01	17.71		49.0		
		Z	0.96	72.98	17.54		48.0		
10354	Pulse (D=40%, T=5 ms)	X	0.81	75.99	17.49	3.98	93.0	$\pm 1.3\%$	$\pm 9.6\%$
		Y	0.76	76.02	17.74		97.0		
		Z	0.90	75.99	17.59		96.0		
10355	Pulse (D=60%, T=5 ms)	X	0.78	77.75	17.52	2.22	139.0	$\pm 1.2\%$	$\pm 9.6\%$
		Y	0.73	77.78	17.76		145.0		
		Z	0.87	77.75	17.61		144.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.01	74.87	19.10	0.26	106.0	$\pm 1.3\%$	$\pm 9.6\%$
		Y	0.01	74.90	18.83		111.0		
		Z	0.01	74.87	19.08		110.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	1.42	74.75	17.18	0.00	111.0	$\pm 2.3\%$	$\pm 9.6\%$
		Y	1.42	74.78	17.48		116.0		
		Z	1.70	74.75	17.24		115.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.04	73.69	19.86	1.55	80.0	$\pm 2.8\%$	$\pm 9.6\%$
		Y	0.03	73.72	19.40		84.0		
		Z	0.00	73.69	20.31		83.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	3.55	73.70	17.02	0.00	102.0	$\pm 3.6\%$	$\pm 9.6\%$
		Y	3.49	73.73	17.37		107.0		
		Z	3.82	73.69	17.14		106.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	4.25	71.43	17.02	0.00	73.0	$\pm 1.5\%$	$\pm 9.6\%$
		Y	4.24	71.46	17.37		77.0		
		Z	4.50	71.43	17.13		76.0		

Note: For details on UID parameters see Appendix

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.

^A The uncertainties of Norm X,Y,Z do not affect the E^2 -field uncertainty inside TSL (see Page 5).

^B Linearization parameter uncertainty for maximum specified field strength.

^E Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

EX3DV4 - SN:7635

January 19, 2026

Parameters of Probe: EX3DV4 - SN:7635
Sensor Model Parameters

	C1 fF	C2 fF	α V^{-1}	T1 $ms V^{-2}$	T2 $ms V^{-1}$	T3 ms	T4 V^{-2}	T5 V^{-1}	T6
x	8.4	58.96	31.77	5.38	0.00	4.92	0.61	0.00	1.00
y	8.4	59.81	32.62	5.80	0.00	4.90	0.54	0.00	1.00
z	9.9	69.71	32.18	6.50	0.00	4.93	0.61	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-16.9°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	12 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

Note: Measurement distance from surface can be increased to 3–4 mm for an Area Scan job.

Parameters of Probe: EX3DV4 - SN:7635

Calibration Parameter Determined in HSL

f (MHz) ^C	Relative Permittivity ^F	Conductivity ^F (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc ^H (k = 2)
6	55.0	0.75	19.43	17.83	19.04	0.00	1.25	±13.3%
13	55.0	0.75	18.92	17.36	18.54	0.00	1.25	±13.3%
30	55.0	0.75	18.22	16.73	17.86	0.00	1.25	±13.3%
64	54.2	0.75	15.95	14.64	15.63	0.00	1.25	±13.3%
128	52.8	0.76	15.23	13.96	14.92	0.00	1.25	±13.3%
150	52.3	0.76	14.70	13.49	14.40	0.00	1.25	±13.3%
220	49.0	0.81	14.03	12.88	13.75	0.00	1.25	±13.3%
300	45.3	0.87	12.78	12.78	12.78	0.09	1.00	±13.3%
450	43.5	0.87	11.94	11.94	11.94	0.16	1.30	±13.3%
600	42.7	0.88	11.24	11.24	11.24	0.10	1.25	±13.3%
750	41.9	0.89	10.89	10.13	10.44	0.36	1.27	±11.0%
850	41.5	0.92	10.69	9.95	10.25	0.36	1.27	±11.0%
900	41.5	0.97	10.52	9.79	10.09	0.36	1.27	±11.0%
1450	40.5	1.20	8.99	8.37	8.62	0.36	1.27	±11.0%
1640	40.2	1.31	8.81	8.20	8.45	0.36	1.27	±11.0%
1750	40.1	1.37	8.64	8.05	8.29	0.36	1.27	±11.0%
1900	40.0	1.40	8.35	7.77	8.01	0.36	1.27	±11.0%
2150	39.7	1.53	8.14	7.58	7.81	0.35	1.27	±11.0%
2300	39.5	1.67	8.02	7.47	7.70	0.35	1.27	±11.0%
2450	39.2	1.80	7.88	7.34	7.56	0.35	1.27	±11.0%
2600	39.0	1.96	7.75	7.22	7.44	0.35	1.27	±11.0%

^C Frequency validity above 300 MHz of ±100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ±50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ±10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4–8 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.

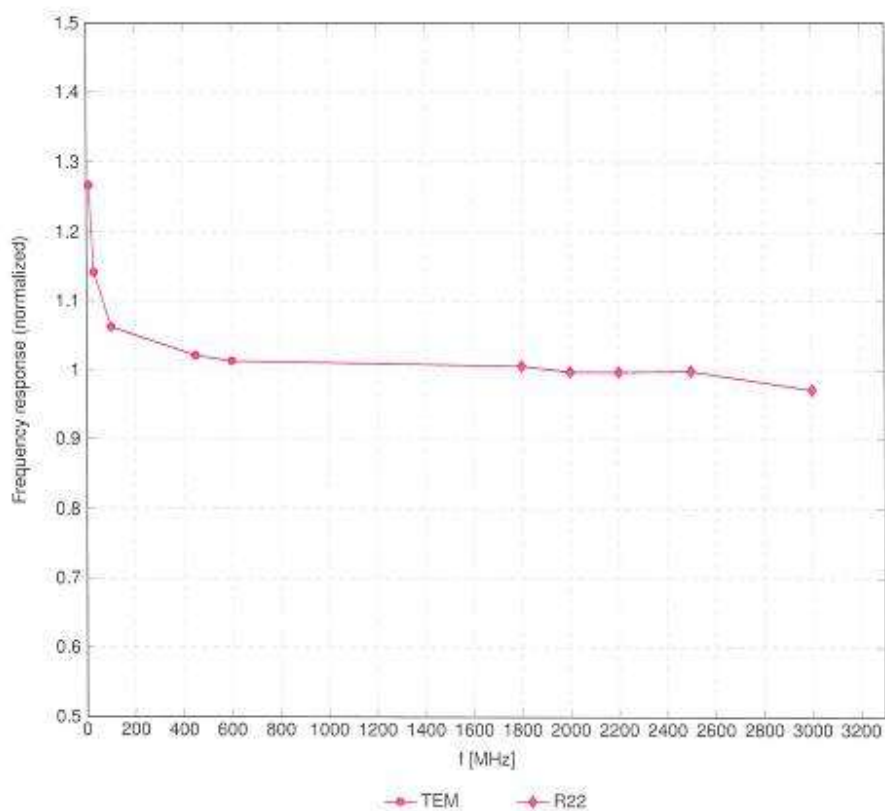
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

^G Alpha/Depth are determined during calibration; SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for frequencies between 3–6 GHz at any distance larger than half the probe tip diameter from the boundary.

^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

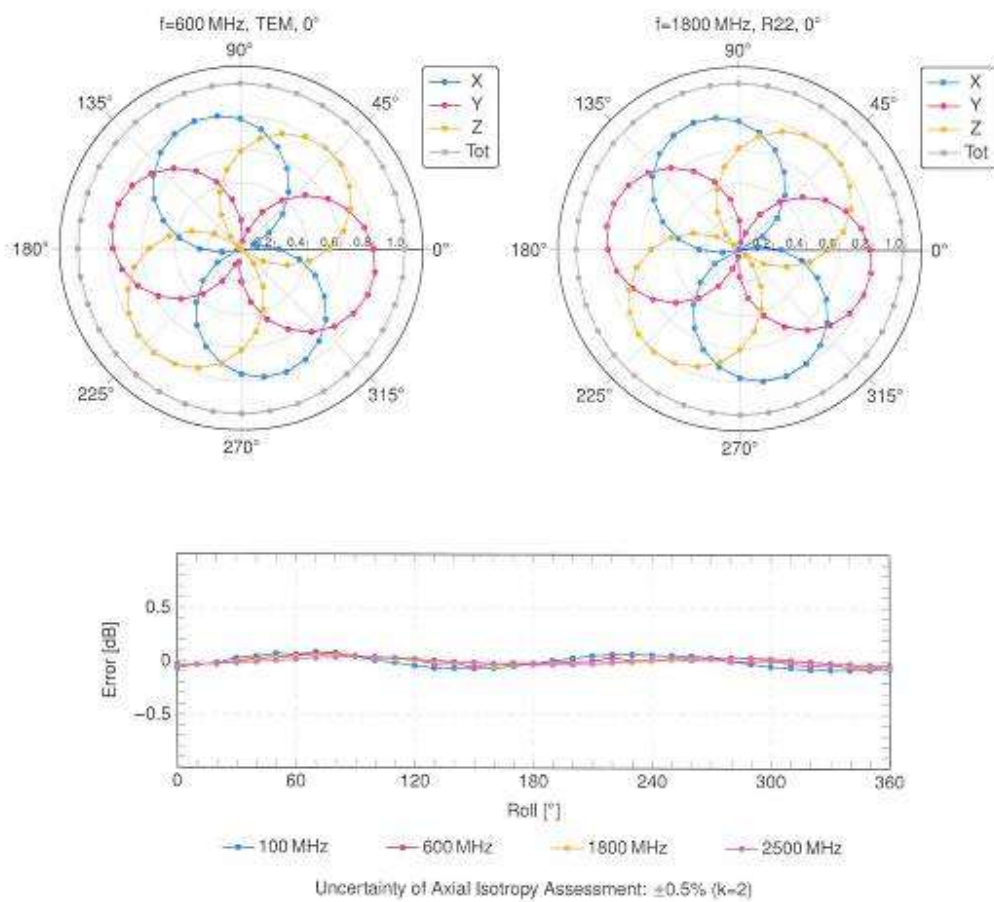
Frequency Response of E-Field

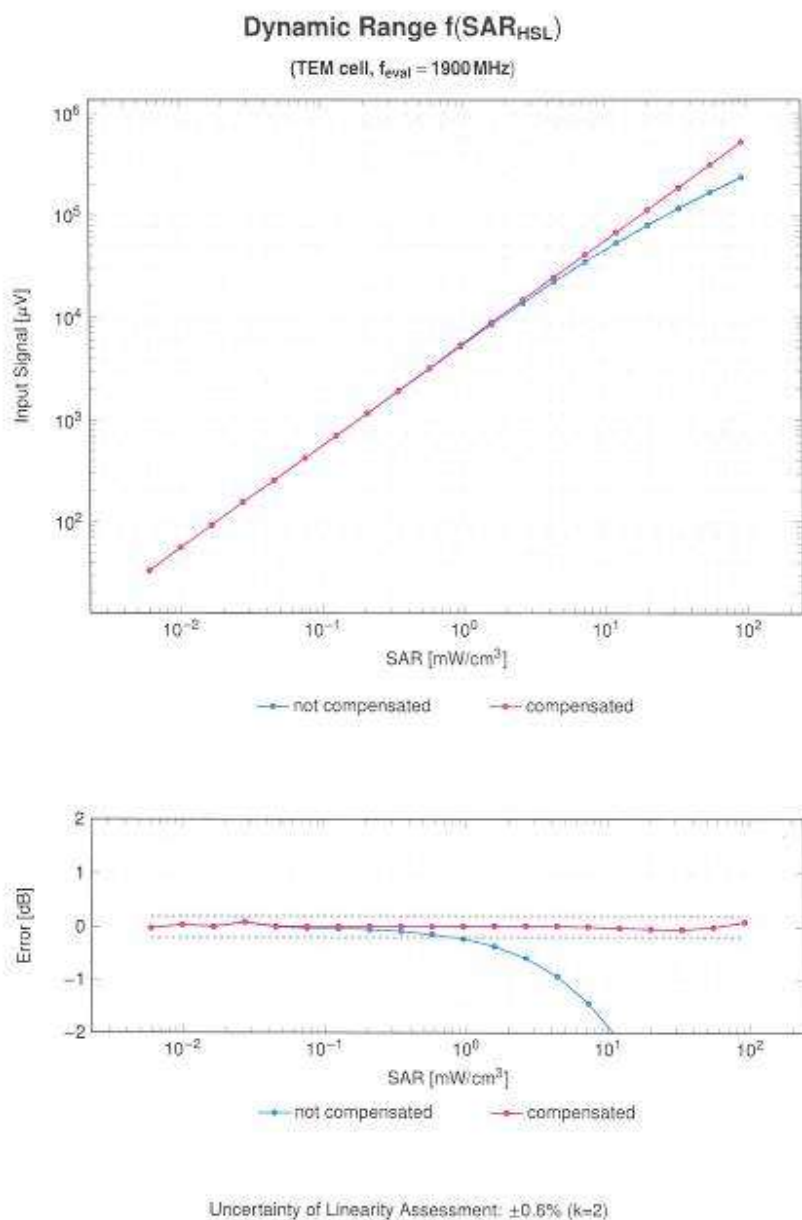
(TEM-Cell:ifi110 EXX, Waveguide:R22)



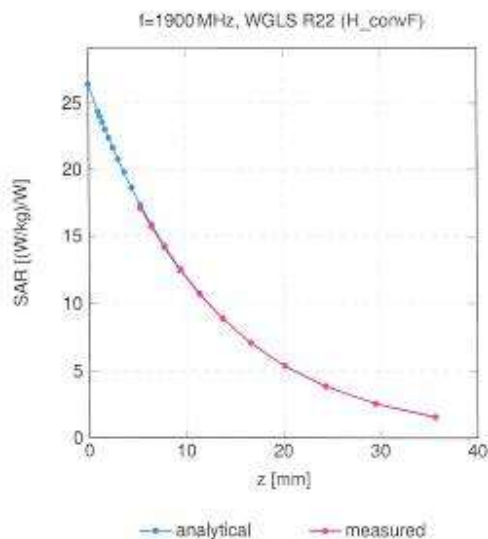
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

Receiving Pattern (ϕ), $\theta = 0^\circ$

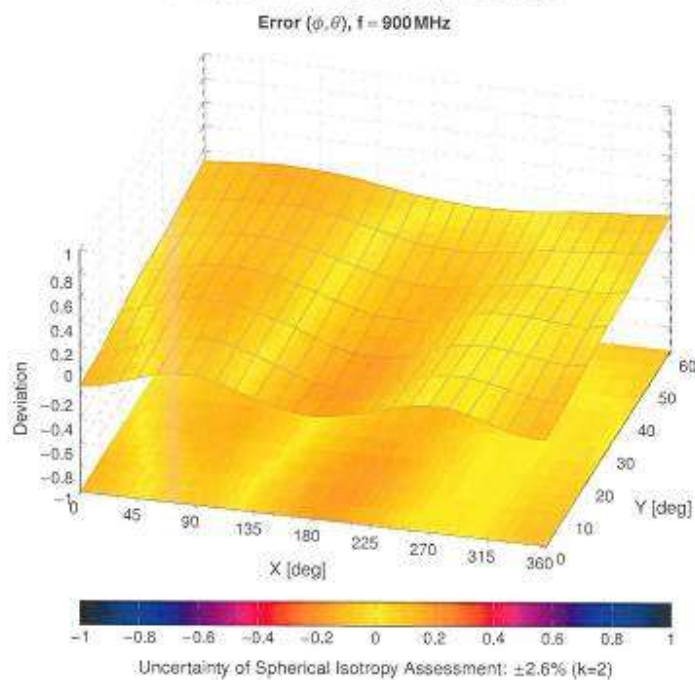




Conversion Factor Assessment



Deviation from Isotropy in Liquid



5 Calibration report "Probe EX3DV4 – SN: 7852"

Calibration Laboratory of

Schmid & Partner
Engineering AG

Zugtraussstrasse 43, 8004 Zurich, Switzerland



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Accreditation No.: **SCS 0108**

Client **Cetecom Advanced**
Saarbrücken, Germany

Certificate No. **EX-7852_Mar26**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:7852**

Calibration procedure(s) **QA CAL-01.v10, QA CAL-12.v10, QA CAL-14.v7, QA CAL-23.v6,
QA CAL-25.v8, QA CAL-48.v2
Calibration procedure for dosimetric E-field probes**

Calibration date **March 12, 2026**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in this closed laboratory facility: environment temperature (22±3) °C and humidity < 70%.

Calibration Equipment used (M&PE critical for calibration)

Primary Standards	ID	Calibration Date (Certificate No.)	Sched. Cal.
Power Sensor R&S NRP4CT	SN: 10186	28-Apr-25 (No. 2025-001450)	Apr-26
N-type mismatch combination	SN: L1116	26-Mar-25 (No. 217-04282)	Mar-26
DCP DAK-12	SN: 1016	16-Sept-25 (No. OCP-DAK12-1016_Sep25)	Sep-26
DCP DAK 3.5	SN: 1740	16-Sept-25 (No. OCP-DAK3-5-1740_Sep25)	Sep-26
Reference Probe EX3DV4	SN: 7346	29-Jan-26 (No. EX3-7346_Jan26)	Jan-27
DAK4	SN: 1301	22-Jan-25 (No. DAK4-1301_Jan25)	Jan-27
Secondary Standards	ID	Check Date (in house)	Sched. Check
ACAP 2020 Setup 1	SN: L-404	01-Oct-25 (No. II-OK-ACAP2020 I Oct25)	Oct-26
DCP DAK-12	SN: 1029	24-Feb-26 (No. OCP-DAK12-1029_Feb26)	Feb-27
DCP DAK-3.5	SN: 1355	13-Dec-25 (No. OCP-DAK3.5-1355_Dec25)	Dec-26

	Name	Function	Signature
Calibrated by	Herrig is Almada	Laboratory Technician	<i>Herrig is Almada</i>
Approved by	Swen Kühn	Technics Manager	<i>Swen Kühn</i>
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			
Issued: March 13, 2026			

Certificate No: EX-7852_Mar26

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Accreditation No.: **SCS 0108**

Glossary

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,y,z}
DCP	diode compression point
CF	crest factor (1/cuty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\theta = 0$ is normal to probe axis
Connector Angle	Information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

- IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices – Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- KDB 865864, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\theta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E²-field uncertainty inside TSL (see below ConvF).
- NORM_{f(x,y,z)} = NORM_{x,y,z} * frequency_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP_{x,y,z}**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal. DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics.
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}; A, B, C, D** are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM_{x,y,z} * ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- Spherical isotropy (3D deviation from isotropy)**: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).

EX3DV4 - SN:7852

March 12, 2026

Parameters of Probe: EX3DV4 - SN:7852

Sensor Model Parameters

	C1 IF	C2 IF	α V^{-1}	T1 $ms V^{-2}$	T2 $ms V^{-1}$	T3 ms	T4 V^{-2}	T5 V^{-1}	T6
x	6.8	48.61	32.98	3.13	0.00	4.90	0.44	0.00	1.00
y	6.2	44.42	32.62	2.71	0.00	4.90	0.48	0.00	1.00
z	5.5	39.39	32.43	3.45	0.00	4.91	0.50	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-30.0°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	12 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

Note: Measurement distance from surface can be increased to 3-4 mm for an Area Scan job.

Parameters of Probe: EX3DV4 - SN:7852

Calibration Parameter Determined in HSL

f (MHz) ^C	Relative Permittivity ^F	Conductivity ^F (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc ^H (k = 2)
750	41.9	0.89	8.75	8.96	9.74	0.39	1.27	±11.0%
850	41.5	0.92	8.50	8.70	9.47	0.39	1.27	±11.0%
900	41.5	0.97	8.42	8.62	9.38	0.39	1.27	±11.0%
1750	40.1	1.37	7.26	7.43	8.09	0.38	1.27	±11.0%
1900	40.0	1.40	6.85	7.01	7.63	0.38	1.27	±11.0%
2450	39.2	1.80	6.19	6.34	6.90	0.38	1.27	±11.0%
2600	39.0	1.96	6.32	6.48	7.04	0.38	1.27	±11.0%
3500	37.9	2.91	5.88	6.03	6.55	0.37	1.27	±13.1%
3700	37.7	3.12	5.83	5.97	6.49	0.37	1.27	±13.1%
3900	37.5	3.32	5.84	5.98	6.50	0.37	1.27	±13.1%
5200	36.0	4.66	4.92	5.04	5.48	0.33	1.27	±13.1%
5300	35.9	4.76	4.85	4.97	5.40	0.32	1.27	±13.1%
5500	35.6	4.96	4.52	4.63	5.04	0.30	1.27	±13.1%
5600	35.5	5.07	4.49	4.60	5.00	0.29	1.27	±13.1%
5800	35.3	5.27	4.43	4.53	4.93	0.27	1.27	±13.1%

^C Frequency validity above 300 MHz of 1100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10 , 25, 40, 50 and 75 MHz for ConvF assessments at 30, 34, 125, 150 and 220 MHz respectively. Validity of ConvF assessed at 5 MHz is 4–9 MHz, and ConvF assessed at 13 MHz is 8–19 MHz. Above 6 GHz frequency validity can be extended to ± 10 MHz.

^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than $\pm 5\%$ from the target values (typically better than $\pm 3\%$) and are valid for TSL with deviations of up to $\pm 10\%$. SAR correction is applied.

^G Alpha/Depth are determined during calibration. SARFAG warrants that the remaining deviation due to the boundary effect after compensation is always less than $\pm 1\%$ for frequencies below 3 GHz and below $\pm 2\%$ for frequencies between 3–6 GHz at any distance larger than half the probe tip diameter from the boundary.

^H The stated uncertainty is the total calibration uncertainty ($k = 2$) of Norm ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62509-1526:2020.

EX3DV4 - SN:7852

March 12, 2026

Parameters of Probe: EX3DV4 - SN:7852

Calibration Parameter Determined in HSL

f (MHz) ^C	Relative Permittivity ^F	Conductivity ^F (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc ^H (k = 2)
6500	34.5	6.07	4.66	4.79	5.21	0.20	1.27	±18.6%

^C Frequency validity: ±800/-700 MHz at 0.5 GHz; +700 MHz at or above 7 GHz; and ±150 MHz at 0.85 GHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

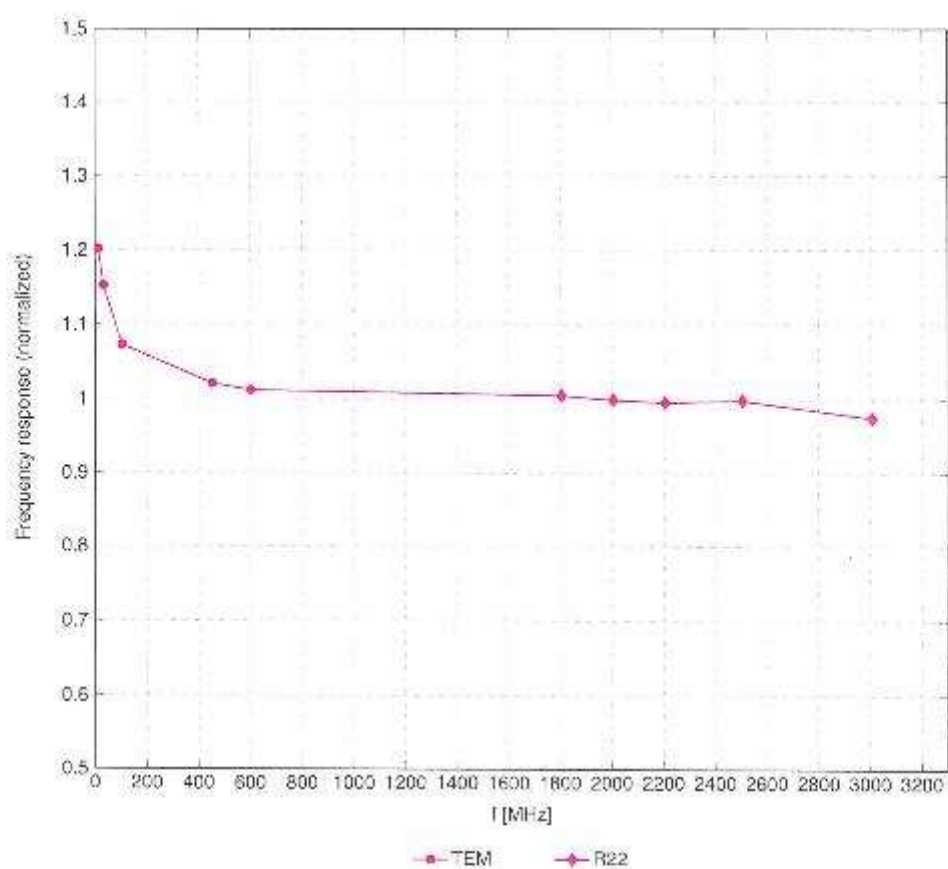
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ' and σ by less than ±10% from the target values (typically better than ±6%) and are valid for TSL with deviations of up to ±13%.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz; below ±2% for frequencies between 3-6 GHz; and below ±4% for frequencies between 6-10 GHz at any distance larger than half the probe tip diameter from the boundary.

^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62259-1529:2020.

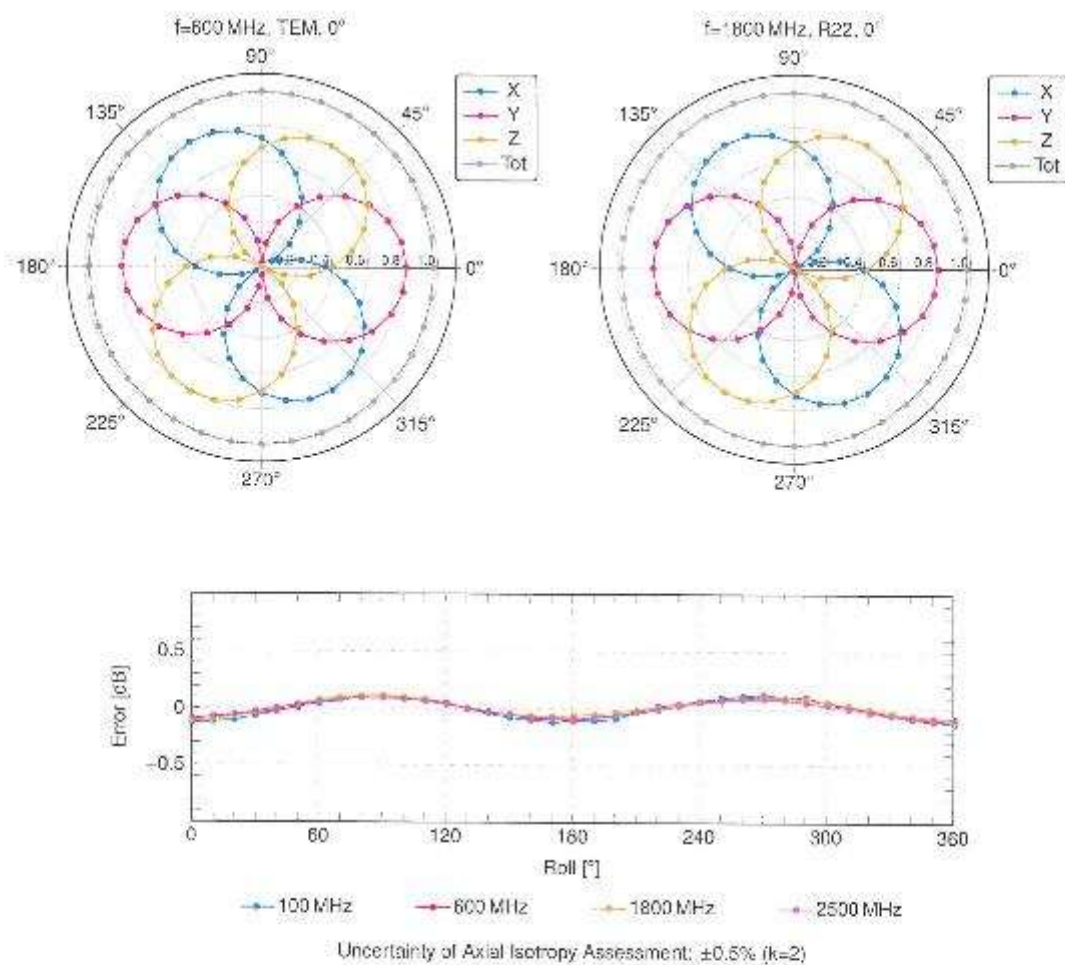
Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide:R22)



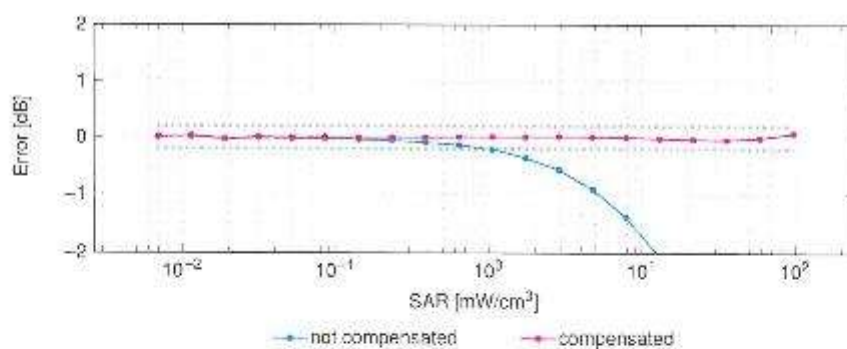
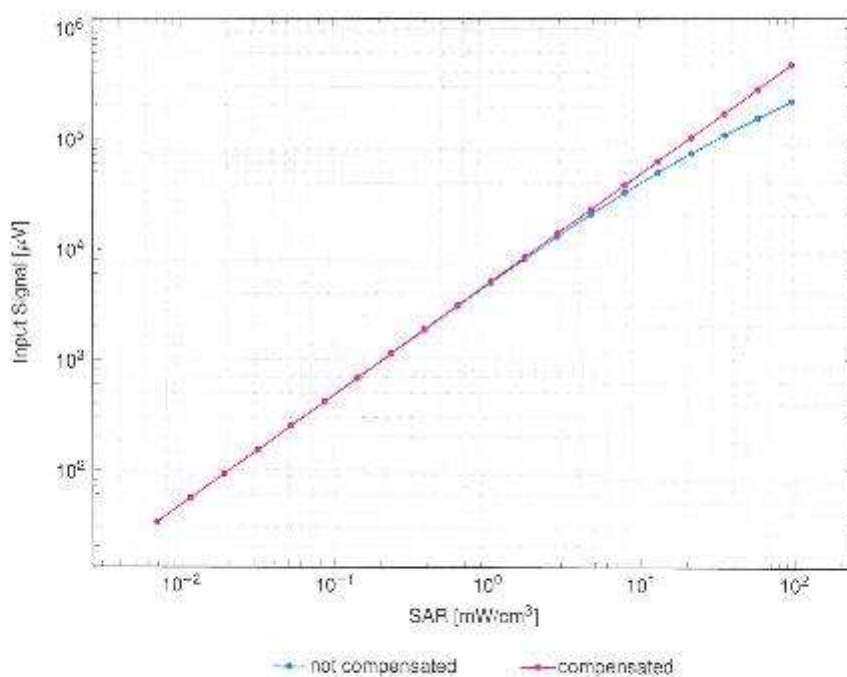
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

Receiving Pattern (ϕ), $\theta = 0^\circ$



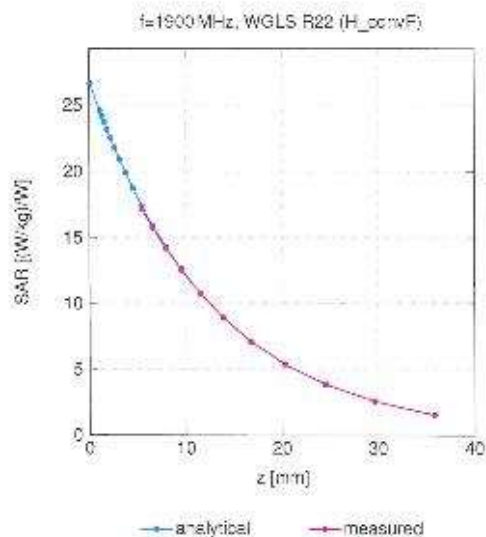
Dynamic Range f(SAR_{HSL})

(TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$)

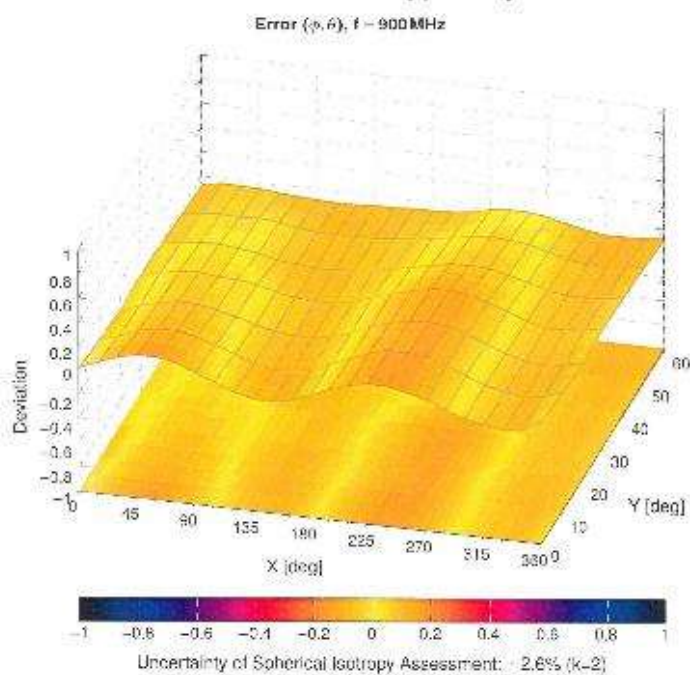


Uncertainty of Linearity Assessment: $\pm 0.6\%$ (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid



6 Calibration report "EUmmWV4 – SN: 9951"

Calibration Laboratory of
Schmid & Partner
Engineering AG

Zeughausstrasse 43, 8004 Zurich, Switzerland



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Cetecom Advanced**
Saarbrücken, Germany

Certificate No. **EUmm-9551_Jul25**

CALIBRATION CERTIFICATE

Object **EUmmWV4 - SN:9551**

Calibration procedure(s) **QA CAL-02.v9, QA CAL-25.v8, QA CAL-42.v3**
Calibration procedure for E-field probes optimized for close near field
evaluations in air

Calibration date **July 08, 2025**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.
All calibrations have been conducted in the closed laboratory facility: environment temperature $(22 \pm 3)^\circ\text{C}$ and humidity $< 70\%$.
Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Calibration Date (Certificate No.)	Sched. Cal.
Power sensor R&S NRP-33T	SN: 100967	26-Mar-25 (No. 217-04290)	Mar-26
Power sensor R&S NRP110T	SN: 101244	24-Mar-25 (No. 1020A300786765)	Mar-26
Spectrum analyzer FSV40	SN: 101832	29-Jan-25 (No. 4030A315009658)	Jan-26
Harmonic Mixer R&S FS-Z75	SN: 101566	20-Mar-25 (No. 1020A300786766)	Mar-26
Harmonic Mixer R&S FS-Z110	SN: 101633	21-Mar-25 (No. 1020A300786769)	Mar-26
Ref. Probe EUmmWV3	SN: 9374	28-Aug-24 (No. EUmm-9374_Aug24)	Aug-25
DAE4ip	SN: 1662	05-Nov-24 (No. DAE4ip-1662_Nov24)	Nov-25

Secondary Standards	ID	Check Date (in house)	Sched. Check
Signal Generator Anapico APSIN26G	SN: 2023	30-Nov-21 (in house check Jul-25)	In house check: Jul-26
Power sensor R&S NRP40T	SN: 101439	08-Nov-21 (in house check Jul-25)	In house check: Jul-26
Power sensor R&S NRP110T	SN: 101226	15-Nov-21 (in house check Jul-25)	In house check: Jul-26

Calibrated by	Name Lelf Klysnar	Function Laboratory Technician	Signature 
Approved by	Name Sven Kühn	Function Technical Manager	Signature 
Issued: July 9, 2025 This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			

Certificate No: EUmm-9551_Jul25

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Calibration Laboratory of

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Accreditation No.: SCS 0108

Glossary

NORM _{x,y}	sensitivity in free space
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\theta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system
Sensor Angles	sensor deviation from the probe axis, used to calculate the field orientation and polarization
$\vec{k}$	is the wave propagation direction

Calibration is Performed According to the Following Standards:

- IEEE Std 1309-2005, "IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005

Methods Applied and Interpretation of Parameters:

- NORM_{x,y}**: Assessed for E-field polarization $\theta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). For frequencies > 6 GHz, the far field in front of waveguide horn antennas is measured for a set of frequencies in various waveguide bands up to 110 GHz.
- DCP_{x,y}**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal. DCP does not depend on frequency nor media.
Note: As the field is measured with a diode detector sensor, it is warranted that the probe response is linear (E^2) below the documented lowest calibrated value.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics.
- The frequency sensor model parameters are determined prior to calibration based on a frequency sweep (sensor model involving resistors R, R_p, inductance L and capacitors C, C_p).
- A_{x,y}; B_{x,y}; C_{x,y}; D_{x,y}; VR_{x,y}**: A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).
- Equivalent Sensor Angle**: The two probe sensors are mounted in the same plane at different angles. The angles are assessed using the information gained by determining the NORM_x (no uncertainty required).
- Spherical isotropy (3D deviation from isotropy)**: in a locally homogeneous field realized using an open waveguide / horn setup.

Parameters of Probe: EUmWV4 - SN:9551

Basic Calibration Parameters

	Sensor X	Sensor Y	Unc (k = 2)
Norm ($\mu\text{V}/(\text{V/m})^2$)	0.01909	0.02098	$\pm 10.1\%$
DCP (mV) ^B	105.0	105.0	$\pm 4.7\%$
Equivalent Sensor Angle	-61.9	34.9	

Calibration Results for Frequency Response (750 MHz – 110 GHz)

Frequency GHz	Target E-Field V/m	Deviation Sensor X dB	Deviation Sensor Y dB	Unc (k = 2) dB
0.75	77.2	-0.22	-0.31	± 0.43
1.8	140.4	-0.02	-0.05	± 0.43
2.0	133.0	0.12	0.13	± 0.43
2.2	124.8	-0.06	-0.04	± 0.43
2.5	123.0	0.08	0.15	± 0.43
3.5	256.2	-0.12	-0.09	± 0.43
3.7	249.8	-0.00	-0.00	± 0.43
6.6	63.4	0.01	-0.38	± 0.98
8.0	58.3	-0.09	-0.14	± 0.98
10.0	57.7	-0.02	0.04	± 0.98
15.0	45.4	0.12	0.17	± 0.98
26.6	115.1	0.23	0.21	± 0.98
30.0	125.1	0.01	-0.00	± 0.98
35.0	123.5	-0.19	-0.16	± 0.98
40.0	101.8	-0.30	-0.27	± 0.98
50.0	60.8	0.11	0.02	± 0.98
55.0	73.7	-0.05	-0.06	± 0.98
60.0	76.4	0.00	0.02	± 0.98
65.0	72.0	0.17	0.17	± 0.98
70.0	68.5	0.15	0.11	± 0.98
75.0	67.9	-0.04	-0.07	± 0.98
75.0	89.9	-0.05	-0.07	± 0.98
80.0	88.2	-0.16	-0.12	± 0.98
85.0	54.3	-0.05	-0.06	± 0.98
90.0	80.6	0.02	0.02	± 0.98
92.0	80.8	0.02	0.03	± 0.98
95.0	73.2	-0.03	-0.02	± 0.98
97.0	65.9	-0.00	-0.03	± 0.98
100.0	63.4	0.04	0.07	± 0.98
105.0	63.2	-0.17	-0.12	± 0.98
110.0	72.1	0.10	0.03	± 0.98

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.

^B Linearization parameter uncertainty for maximum specified field strength.

Parameters of Probe: EUmWV4 - SN:9551
Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB $\sqrt{\mu V}$	C	D dB	VR mV	Max dev.	Max Unc ^E k = 2
0	CW	X	0.00	0.00	1.00	0.00	136.3	$\pm 3.0\%$	$\pm 4.7\%$
		Y	0.00	0.00	1.00		68.7		
10352	Pulse Waveform (200Hz, 10%)	X	2.03	60.00	14.54	10.00	6.0	$\pm 3.4\%$	$\pm 9.6\%$
		Y	1.75	60.00	15.27		6.0		
10353	Pulse Waveform (200Hz, 20%)	X	1.42	60.00	13.38	6.99	12.0	$\pm 1.1\%$	$\pm 9.6\%$
		Y	6.00	76.00	19.00		12.0		
10354	Pulse Waveform (200Hz, 40%)	X	0.87	60.00	12.10	3.98	23.0	$\pm 1.4\%$	$\pm 9.6\%$
		Y	0.72	60.00	13.21		23.0		
10355	Pulse Waveform (200Hz, 60%)	X	0.53	60.00	11.48	2.22	27.0	$\pm 1.0\%$	$\pm 9.6\%$
		Y	0.51	60.00	12.15		27.0		
10387	QPSK Waveform, 1 MHz	X	1.20	60.00	12.07	1.00	22.0	$\pm 2.1\%$	$\pm 9.6\%$
		Y	1.15	60.00	12.01		22.0		
10388	QPSK Waveform, 10 MHz	X	1.29	60.00	11.91	0.00	22.0	$\pm 0.8\%$	$\pm 9.6\%$
		Y	1.36	60.00	11.97		22.0		
10396	64-QAM Waveform, 100 kHz	X	2.30	61.27	14.04	3.01	17.0	$\pm 1.2\%$	$\pm 9.6\%$
		Y	3.82	67.44	16.76		17.0		
10399	64-QAM Waveform, 40 MHz	X	2.10	60.00	12.38	0.00	19.0	$\pm 1.5\%$	$\pm 9.6\%$
		Y	2.10	60.00	12.55		19.0		
10414	WLAN CCDF, 64-QAM, 40 MHz	X	3.23	60.00	12.80	0.00	12.0	$\pm 2.5\%$	$\pm 9.6\%$
		Y	3.12	60.00	13.00		12.0		

Note: For details on UID parameters see Appendix

^E Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

Parameters of Probe: EUmWV4 - SN:9551

Calibration Results for Linearity Response

Frequency GHz	Target E-Field V/m	Deviation Sensor X dB	Deviation Sensor Y dB	Unc (k = 2) dB
0.9	50.0	-0.06	0.13	±0.2
0.9	100.0	-0.02	0.08	±0.2
0.9	500.0	0.02	0.03	±0.2
0.9	1000.0	0.04	0.05	±0.2
0.9	1500.0	0.04	0.06	±0.2
0.9	2100.0	0.03	0.05	±0.2

Sensor Frequency Model Parameters (750 MHz – 55 GHz)

	Sensor X	Sensor Y
R (Ω)	64.52	115.26
R _p (Ω)	88.75	151.27
L (nH)	0.06207	0.09738
C (pF)	0.2453	0.1950
C _p (pF)	0.0983	0.0613

Sensor Frequency Model Parameters (55 GHz – 110 GHz)

	Sensor X	Sensor Y
R (Ω)	40.05	28.87
R _p (Ω)	230.84	159.26
L (nH)	0.13058	0.08989
C (pF)	0.0315	0.0476
C _p (pF)	0.0402	0.0558

Sensor Model Parameters

	C1 fF	C2 fF	α V ⁻¹	T1 ms V ⁻²	T2 ms V ⁻¹	T3 ms	T4 V ⁻²	T5 V ⁻¹	T6
x	58.9	355.10	33.17	2.66	4.27	5.00	0.00	1.39	1.01
y	46.9	292.76	33.27	0.92	3.99	5.02	0.00	1.60	1.01

Other Probe Parameters

Sensor Arrangement	Rectangular
Connector Angle	55.5°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	320 mm
Probe Body Diameter	8 mm
Tip Length	23 mm
Tip Diameter	6.0 mm
Probe Tip to Sensor X Calibration Point	1.5 mm
Probe Tip to Sensor Y Calibration Point	1.5 mm

