

Calibration Laboratory ofSchmid & Partner
Engineering AG

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Multilateral Agreement for the recognition of calibration certificates**Accreditation No.: **SCS 0108**

Client

UL

Fremont, USA

Certificate No.

EX-7983_Mar26**CALIBRATION CERTIFICATE**

Object

EX3DV4 - SN:7983

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 24, 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	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 2020 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

	Name	Function	Signature
Calibrated by	Henrique Almeida	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	

Issued: March 24, 2026

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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., $\vartheta = 0$ 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 $\vartheta = 0$ ($f \leq 900$ 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 E^2 -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:7983

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.56	0.65	0.64	$\pm 10.1\%$
DCP (mV) ^B	105.7	105.8	106.2	$\pm 4.7\%$

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	149.7	$\pm 2.0\%$	$\pm 4.7\%$
		Y	0.00	0.00	1.00		140.9		
		Z	0.00	0.00	1.00		137.7		
10352	Pulse (D=10%, T=5 ms)	X	0.19	60.34	15.41	10.00	23.0	$\pm 1.5\%$	$\pm 9.6\%$
		Y	0.24	59.70	14.71		24.0		
		Z	0.25	60.05	14.53		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.18	63.35	15.45	6.99	47.0	$\pm 1.5\%$	$\pm 9.6\%$
		Y	0.22	62.71	14.76		47.0		
		Z	0.23	63.06	14.57		48.0		
10354	Pulse (D=40%, T=5 ms)	X	0.16	66.36	15.50	3.98	93.0	$\pm 1.6\%$	$\pm 9.6\%$
		Y	0.21	65.72	14.80		94.0		
		Z	0.21	66.07	14.62		95.0		
10355	Pulse (D=60%, T=5 ms)	X	0.15	68.12	15.53	2.22	139.0	$\pm 1.6\%$	$\pm 9.6\%$
		Y	0.20	67.48	14.83		141.0		
		Z	0.20	67.83	14.64		143.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.00	65.24	17.05	0.47	106.0	$\pm 1.9\%$	$\pm 9.6\%$
		Y	0.00	64.60	16.09		107.0		
		Z	0.00	64.95	15.66		109.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	0.45	65.12	14.75	0.00	112.0	$\pm 2.6\%$	$\pm 9.6\%$
		Y	0.57	64.49	13.96		114.0		
		Z	0.66	64.84	13.73		115.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.00	45.49	18.11	1.34	84.0	$\pm 2.8\%$	$\pm 9.6\%$
		Y	0.00	81.26	17.49		84.0		
		Z	0.00	63.78	17.10		86.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	1.53	64.06	13.33	0.00	104.0	$\pm 4.1\%$	$\pm 9.6\%$
		Y	1.57	63.43	12.88		105.0		
		Z	1.67	63.78	12.90		107.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	1.82	61.80	13.22	0.00	74.0	$\pm 2.2\%$	$\pm 9.6\%$
		Y	1.92	61.16	12.78		75.0		
		Z	2.10	61.51	12.81		77.0		

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.

Parameters of Probe: EX3DV4 - SN:7983

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	7.0	51.31	34.61	0.92	0.00	4.90	0.32	0.00	1.00
y	8.4	61.80	34.21	4.33	0.00	4.90	0.20	0.00	1.00
z	9.2	66.86	33.85	3.39	0.00	4.90	0.28	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-46.3°
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:7983

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	9.36	9.44	9.44	0.37	1.27	±11.0%
900	41.5	0.97	8.96	9.04	9.03	0.37	1.27	±11.0%
1750	40.1	1.37	7.66	7.73	7.73	0.37	1.27	±11.0%
1900	40.0	1.40	7.46	7.52	7.52	0.37	1.27	±11.0%
2300	39.5	1.67	7.15	7.21	7.21	0.37	1.27	±11.0%
2600	39.0	1.96	6.90	6.96	6.96	0.37	1.27	±11.0%
3300	38.2	2.71	6.42	6.47	6.47	0.36	1.27	±13.1%
3500	37.9	2.91	6.38	6.43	6.43	0.36	1.27	±13.1%
3700	37.7	3.12	6.34	6.39	6.39	0.36	1.27	±13.1%
3900	37.5	3.32	6.31	6.36	6.36	0.36	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.

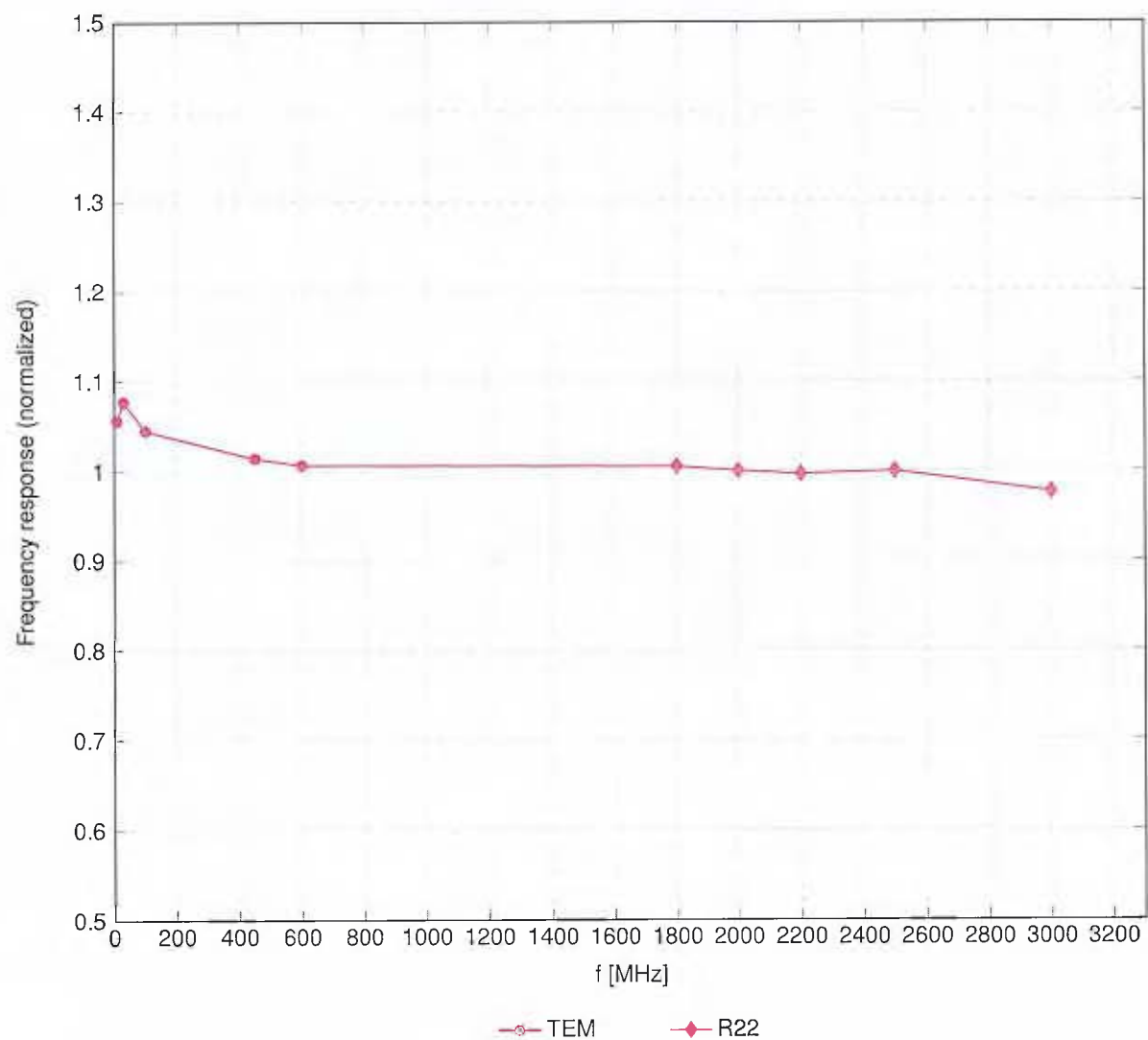
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

^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.

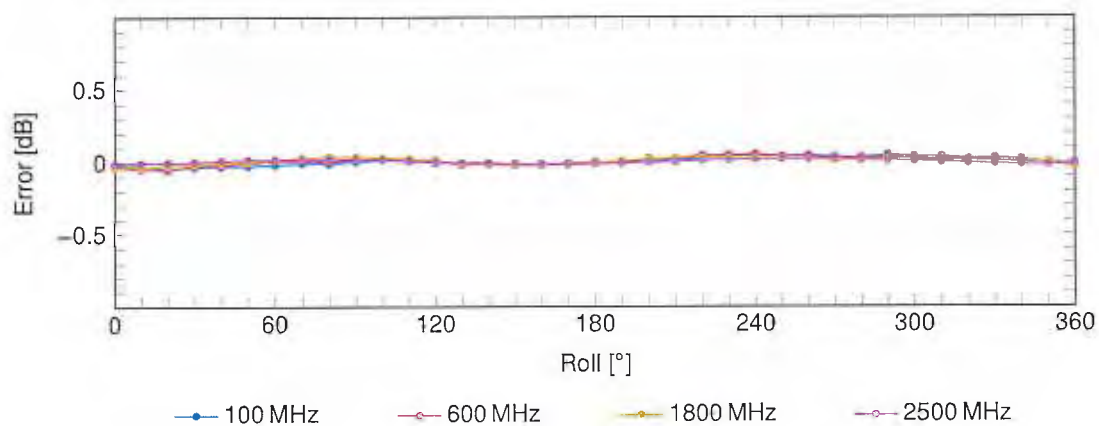
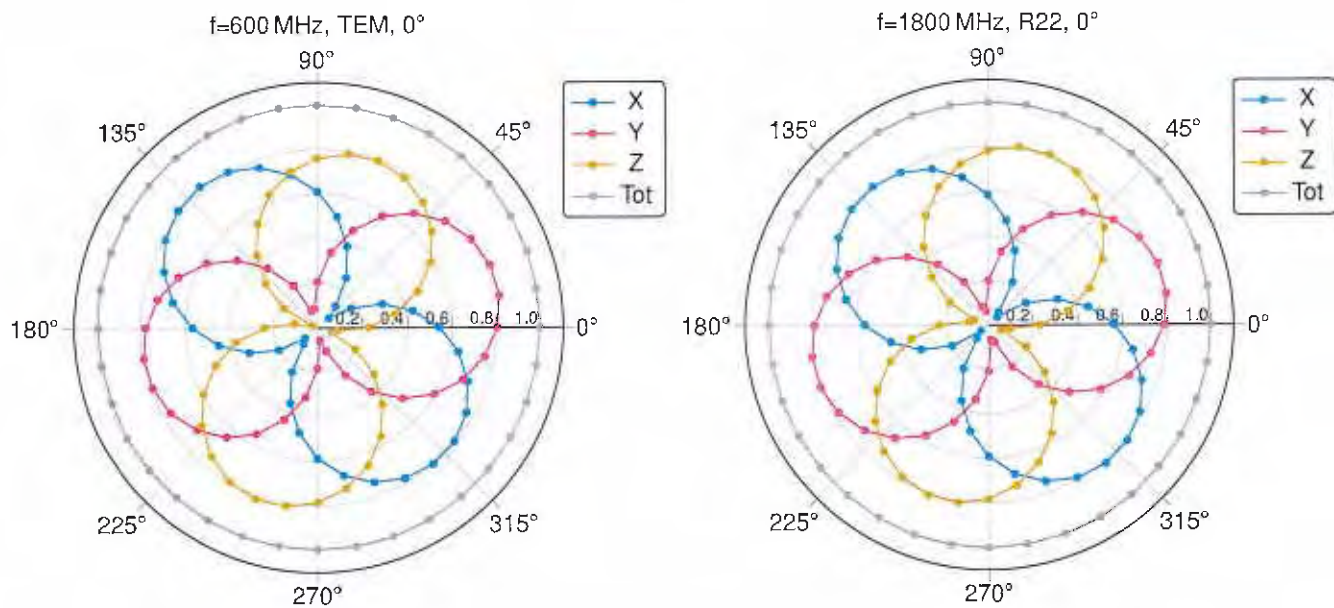
^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

Frequency Response of E-Field

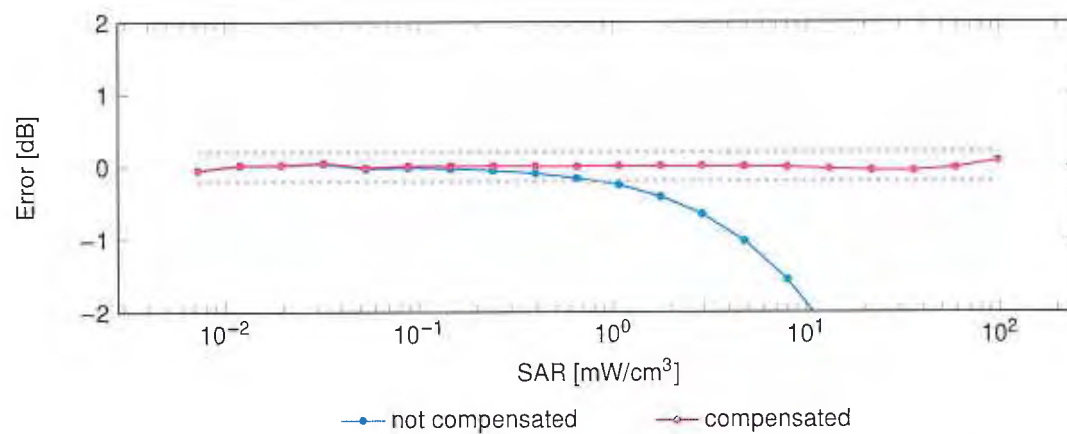
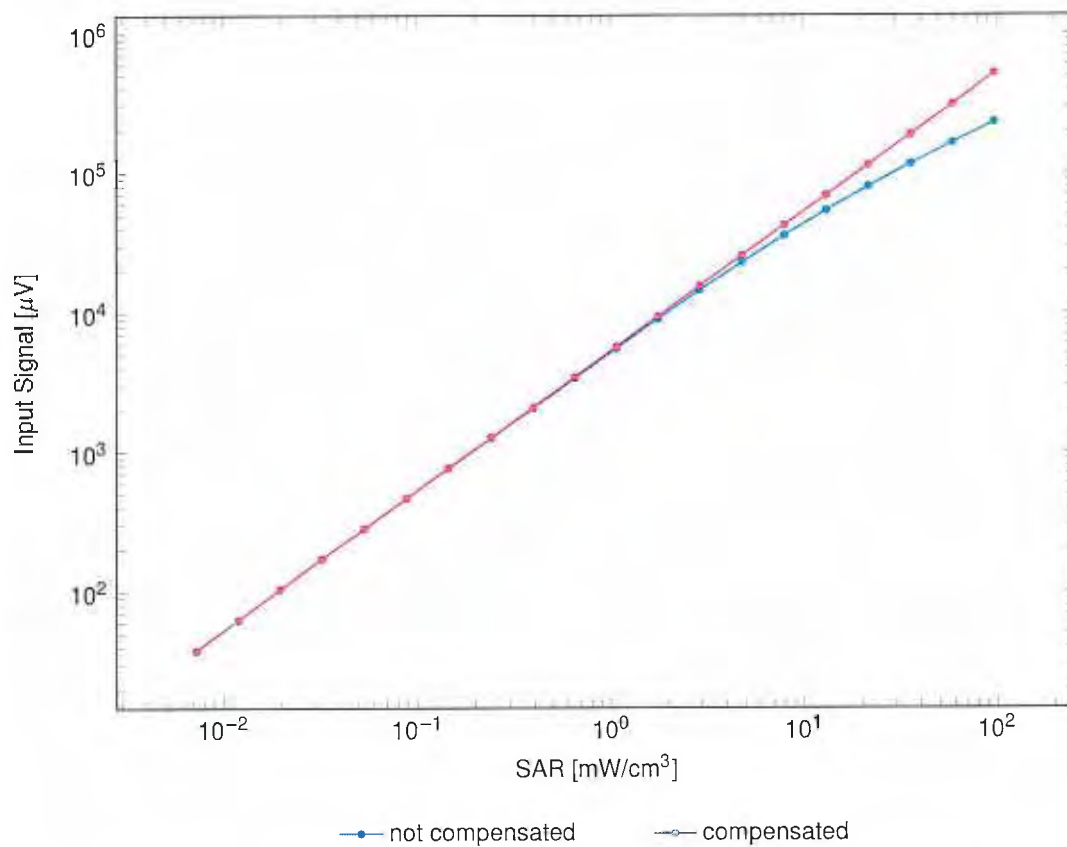
(TEM-Cell:ifi110 EXX, Waveguide:R22)



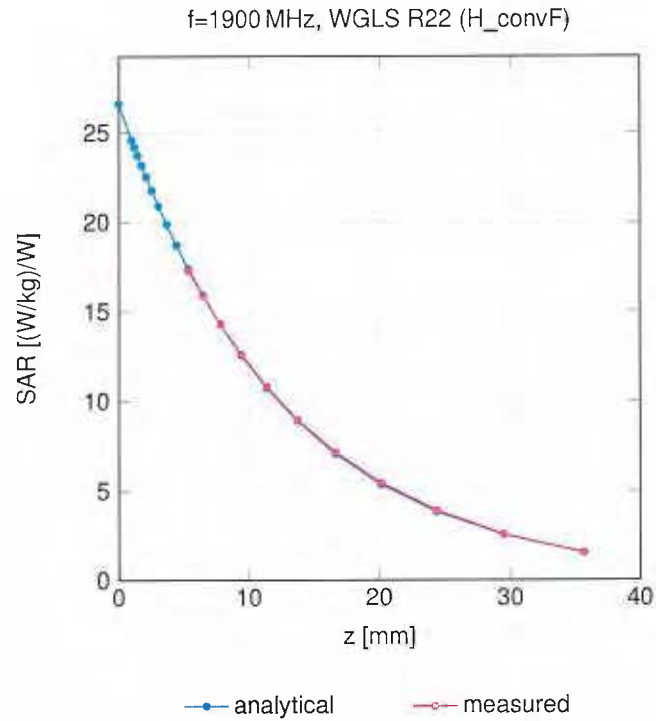
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

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

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

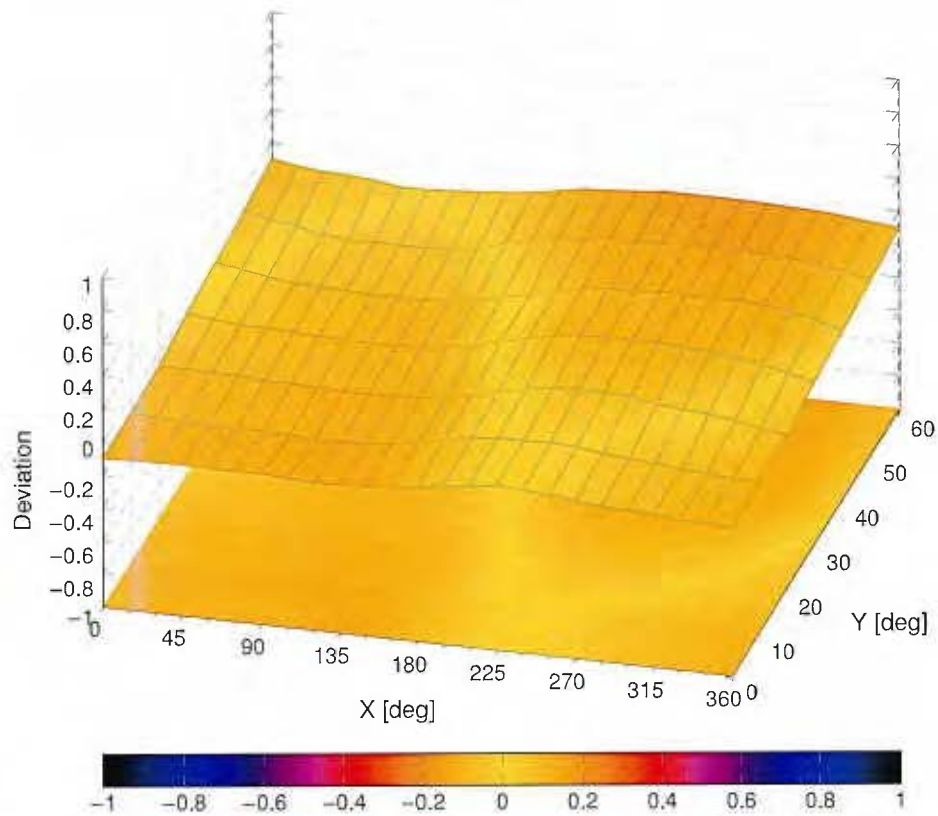
Dynamic Range f(SAR_{HSL})(TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$)Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz



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Client

UL

Fremont, USA

Certificate No.

EX-7977_Mar26**CALIBRATION CERTIFICATE**

Object

EX3DV4 - SN:7977

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 02, 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-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 2020 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

	Name	Function
Calibrated by	Krešimir Franjić	Laboratory Technician
Approved by	Sven Kühn	Technical Manager

Signature

Issued: March 02, 2026

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Glossary

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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., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

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- 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 $\vartheta = 0$ ($f \leq 900$ 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:7977

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.56	0.58	0.59	±10.1%
DCP (mV) ^B	106.8	102.8	103.7	±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	147.0	±1.1%	±4.7%
		Y	0.00	0.00	1.00		124.1		
		Z	0.00	0.00	1.00		121.6		
10352	Pulse (D=10%, T=5 ms)	X	0.24	60.49	14.94	10.00	23.0	±2.1%	±9.6%
		Y	0.47	70.00	18.61		24.0		
		Z	0.38	69.40	18.44		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.22	63.50	14.98	6.99	46.0	±1.7%	±9.6%
		Y	0.45	73.01	18.66		48.0		
		Z	0.34	72.41	18.49		48.0		
10354	Pulse (D=40%, T=5 ms)	X	0.21	66.51	15.01	3.98	92.0	±1.5%	±9.6%
		Y	0.42	76.02	18.72		96.0		
		Z	0.31	75.42	18.53		96.0		
10355	Pulse (D=60%, T=5 ms)	X	0.20	68.27	15.03	2.22	138.0	±1.4%	±9.6%
		Y	0.40	77.78	18.76		144.0		
		Z	0.29	77.18	18.56		144.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.01	65.39	16.12	0.31	106.0	±1.7%	±9.6%
		Y	0.00	74.90	20.12		111.0		
		Z	0.00	74.30	19.42		111.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	0.70	65.27	14.07	0.00	113.0	±2.5%	±9.6%
		Y	1.80	74.78	17.36		118.0		
		Z	1.54	74.19	17.57		118.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.01	64.21	17.54	1.72	80.0	±5.0%	±9.6%
		Y	0.11	80.24	22.11		84.0		
		Z	0.00	73.13	20.56		84.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	1.78	64.22	13.26	0.00	104.0	±4.0%	±9.6%
		Y	4.07	73.73	17.23		109.0		
		Z	3.47	73.13	17.44		109.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	2.21	61.95	13.19	0.00	75.0	±1.9%	±9.6%
		Y	5.01	71.46	17.23		80.0		
		Z	4.41	70.86	17.43		80.0		

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 E²-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.

Parameters of Probe: EX3DV4 - SN:7977

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	9.5	69.38	33.93	4.16	0.00	4.90	0.49	0.00	1.00
y	11.3	83.95	35.16	1.29	0.00	4.90	0.17	0.00	1.00
z	10.8	80.53	35.21	2.25	0.00	4.90	0.26	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-52.3°
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:7977

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	9.58	9.62	9.01	0.36	1.27	±11.0%
900	41.5	0.97	9.18	9.22	8.64	0.36	1.27	±11.0%
1750	40.1	1.37	8.03	8.07	7.56	0.35	1.27	±11.0%
1900	40.0	1.40	7.67	7.70	7.21	0.35	1.27	±11.0%
2300	39.5	1.67	7.37	7.40	6.93	0.35	1.27	±11.0%
2600	39.0	1.96	7.12	7.15	6.70	0.34	1.27	±11.0%
3300	38.2	2.71	6.64	6.67	6.25	0.34	1.27	±13.1%
3500	37.9	2.91	6.57	6.60	6.18	0.34	1.27	±13.1%
3700	37.7	3.12	6.50	6.52	6.11	0.33	1.27	±13.1%
3900	37.5	3.32	6.44	6.47	6.06	0.33	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.

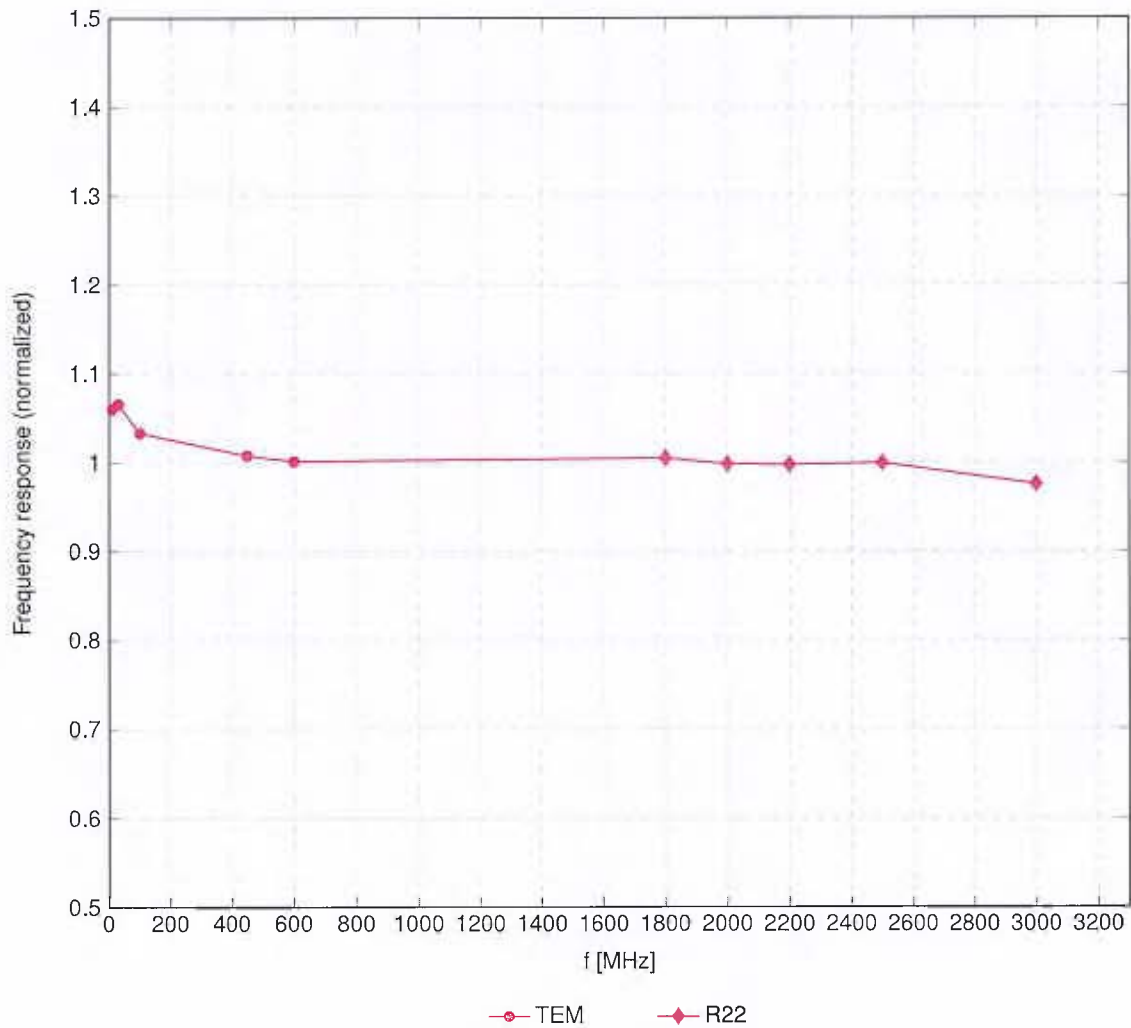
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

^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.

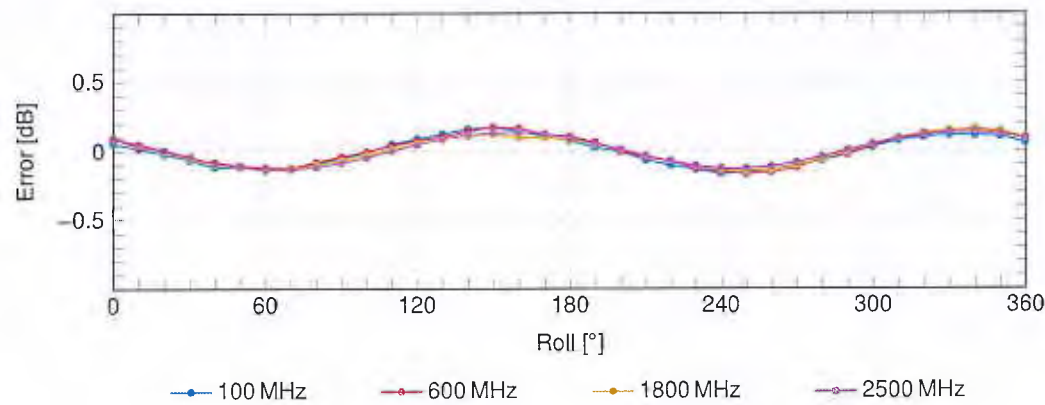
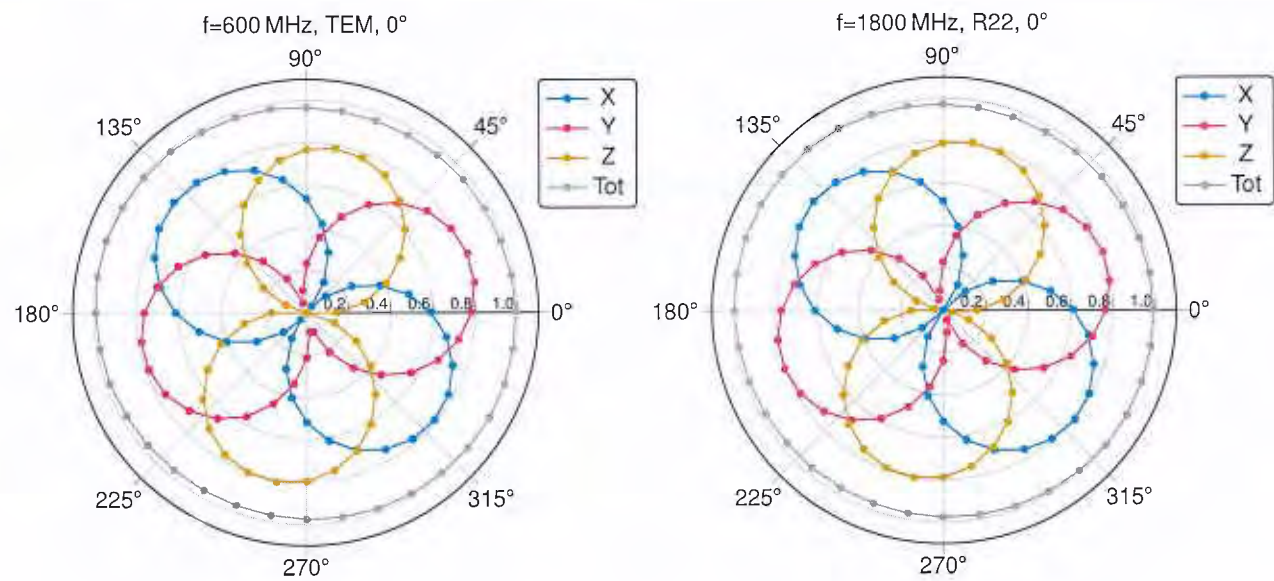
Frequency Response of E-Field

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



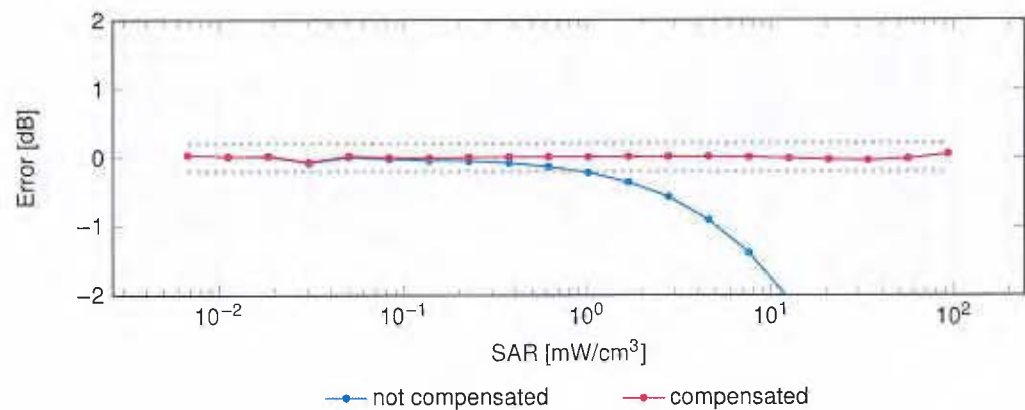
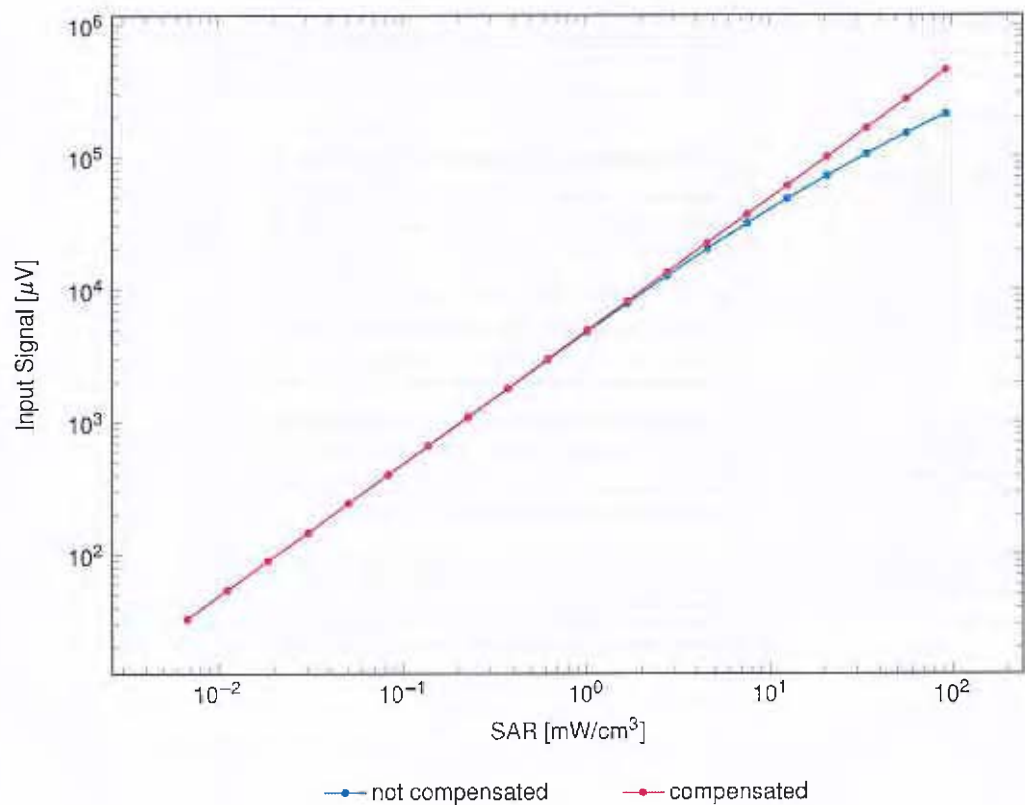
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

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



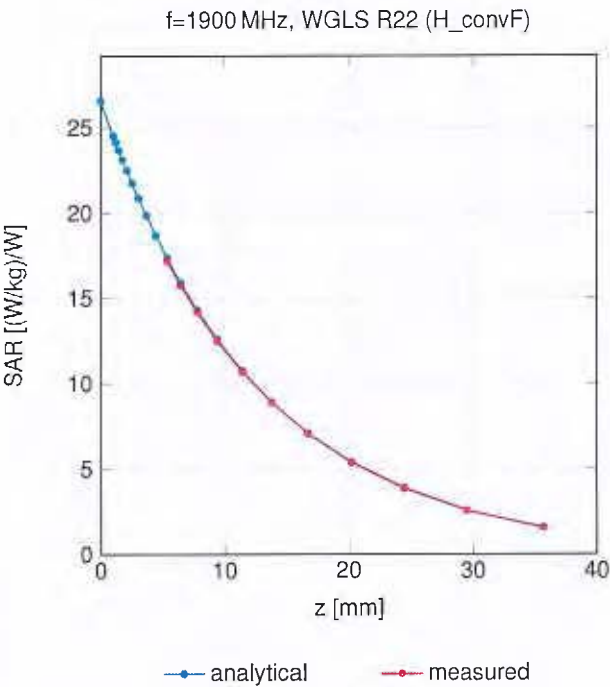
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

Dynamic Range f(SAR_{HSL})
(TEM cell, f_{eval} = 1900 MHz)



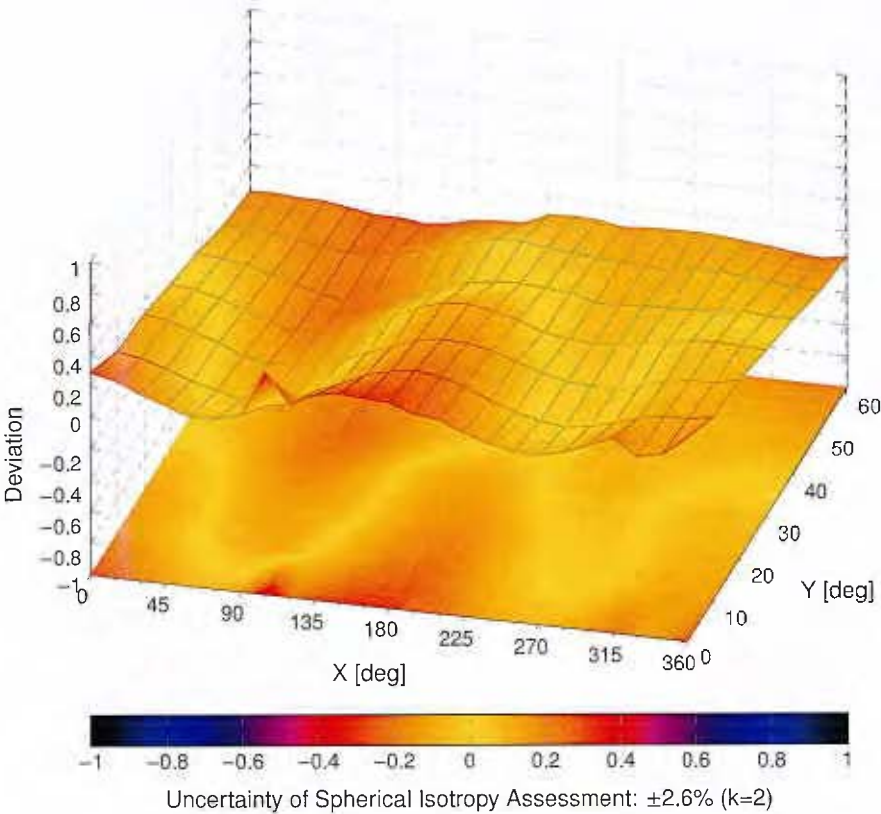
Uncertainty of Linearity Assessment: $\pm 0.6\%$ (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz



Calibration Laboratory of**Schmid & Partner
Engineering AG**

Zeughausstrasse 43, 8004 Zurich, Switzerland

**S** Schweizerischer Kalibrierdienst
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**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

UL

Fremont, USA

Certificate No.

EX-7982_Mar26**CALIBRATION CERTIFICATE**

Object

EX3DV4 - SN:7982

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 24, 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	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 2020 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

	Name	Function	Signature
Calibrated by	Henrique Almeida	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	

Issued: March 24, 2026

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



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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:7982

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.53	0.60	0.57	$\pm 10.1\%$
DCP (mV) ^B	105.9	106.3	107.0	$\pm 4.7\%$

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B $\text{dB}\sqrt{\mu\text{V}}$	C	D dB	VR mV	Max dev.	Max Unc ^E $k = 2$
0	Continuous Wave	X	0.00	0.00	1.00	0.00	121.6	$\pm 1.9\%$	$\pm 4.7\%$
		Y	0.00	0.00	1.00		129.0		
		Z	0.00	0.00	1.00		130.4		
10352	Pulse (D=10%, T=5 ms)	X	1.09	70.00	17.49	10.00	23.0	$\pm 1.7\%$	$\pm 9.6\%$
		Y	0.39	60.00	14.50		24.0		
		Z	0.34	60.93	15.55		24.0		
10353	Pulse (D=20%, T=5 ms)	X	1.03	73.01	17.51	6.99	46.0	$\pm 1.6\%$	$\pm 9.6\%$
		Y	0.36	63.01	14.59		47.0		
		Z	0.31	63.94	15.67		47.0		
10354	Pulse (D=40%, T=5 ms)	X	0.96	76.02	17.53	3.98	92.0	$\pm 1.5\%$	$\pm 9.6\%$
		Y	0.32	66.02	14.69		94.0		
		Z	0.27	66.95	15.79		95.0		
10355	Pulse (D=60%, T=5 ms)	X	0.93	77.78	17.54	2.22	139.0	$\pm 1.6\%$	$\pm 9.6\%$
		Y	0.30	67.78	14.76		142.0		
		Z	0.25	68.71	15.88		142.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.02	81.31	18.54	0.25	105.0	$\pm 1.8\%$	$\pm 9.6\%$
		Y	0.01	82.21	16.58		108.0		
		Z	0.00	65.83	18.51		108.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	1.54	74.78	17.39	0.00	111.0	$\pm 2.7\%$	$\pm 9.6\%$
		Y	0.62	64.79	13.91		114.0		
		Z	0.45	65.71	15.15		114.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.06	82.86	18.96	1.41	80.0	$\pm 2.6\%$	$\pm 9.6\%$
		Y	0.00	63.73	18.10		82.0		
		Z	0.00	64.65	19.35		82.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	3.74	73.73	17.32	0.00	103.0	$\pm 3.9\%$	$\pm 9.6\%$
		Y	1.76	63.73	12.66		106.0		
		Z	1.70	64.65	13.07		106.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	4.32	71.46	17.32	0.00	74.0	$\pm 2.4\%$	$\pm 9.6\%$
		Y	2.01	61.46	12.59		76.0		
		Z	1.87	62.39	12.99		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.

Parameters of Probe: EX3DV4 - SN:7982

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	7.8	56.14	33.25	2.54	0.00	4.90	0.53	0.00	1.00
y	8.0	57.93	33.16	3.16	0.00	4.90	0.44	0.00	1.00
z	6.2	44.37	33.22	4.24	0.00	4.92	0.55	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	20.2°
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:7982

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	9.21	9.53	9.29	0.36	1.27	±11.0%
900	41.5	0.97	8.83	9.14	8.91	0.36	1.27	±11.0%
1750	40.1	1.37	7.60	7.87	7.67	0.36	1.27	±11.0%
1900	40.0	1.40	7.35	7.61	7.42	0.36	1.27	±11.0%
2300	39.5	1.67	6.99	7.24	7.06	0.35	1.27	±11.0%
2600	39.0	1.96	6.73	6.97	6.79	0.35	1.27	±11.0%
3300	38.2	2.71	6.28	6.50	6.34	0.34	1.27	±13.1%
3500	37.9	2.91	6.22	6.44	6.28	0.34	1.27	±13.1%
3700	37.7	3.12	6.17	6.39	6.23	0.34	1.27	±13.1%
3900	37.5	3.32	6.12	6.34	6.18	0.34	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.

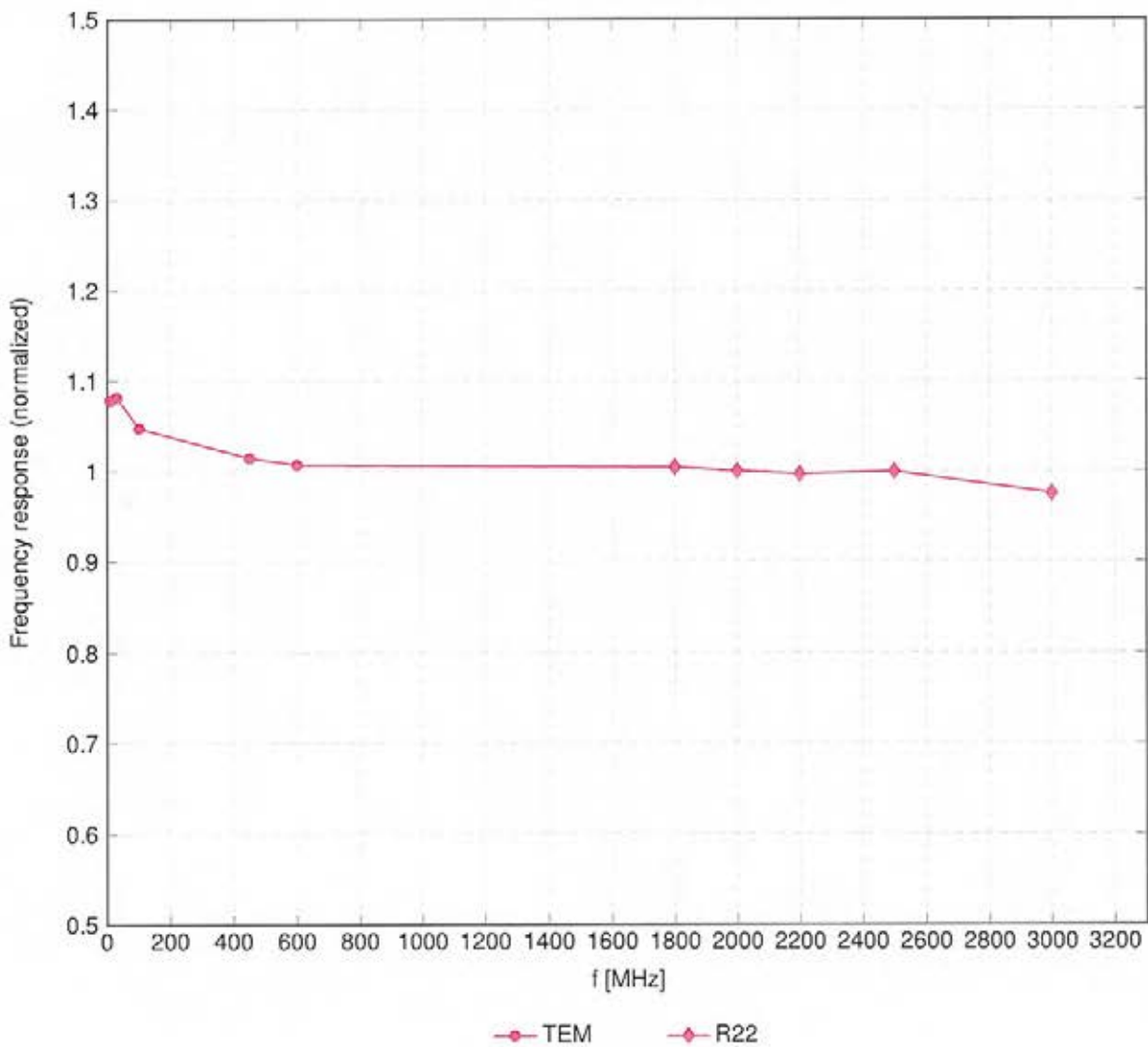
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

^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.

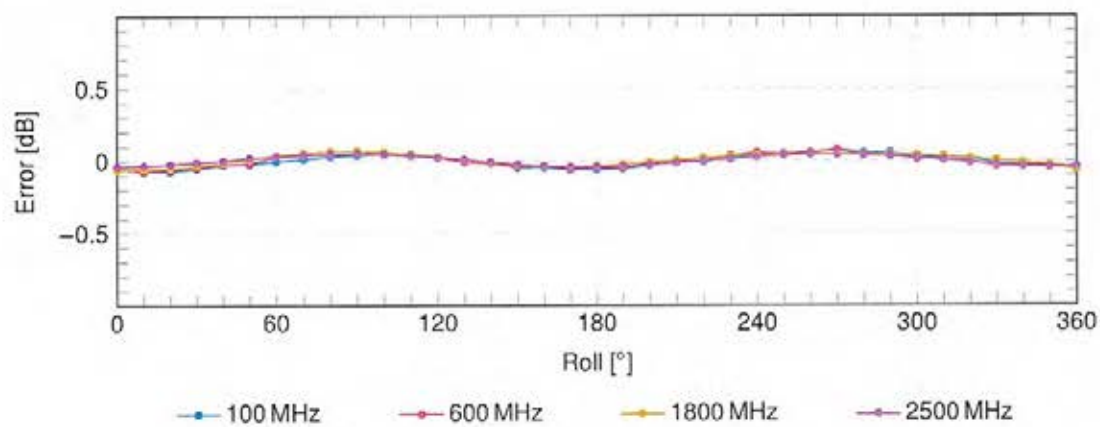
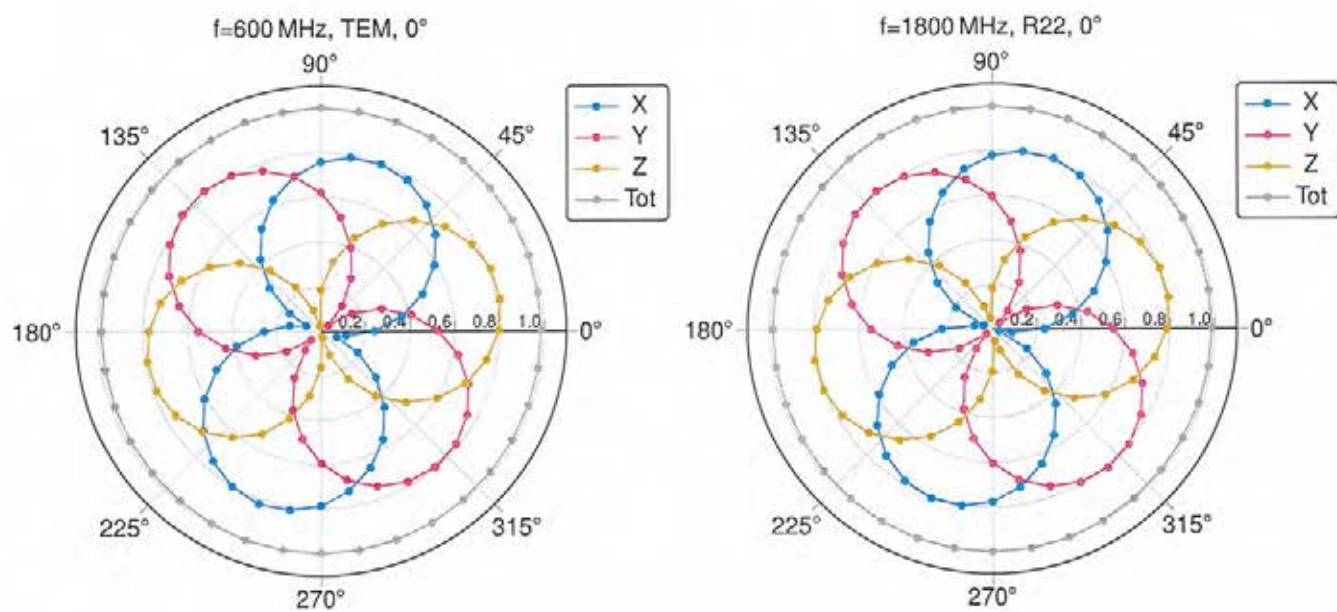
^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

Frequency Response of E-Field

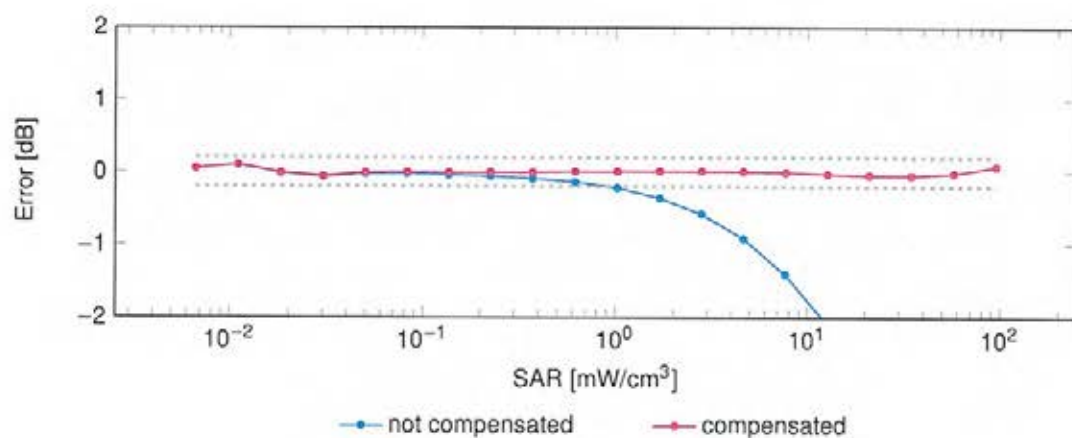
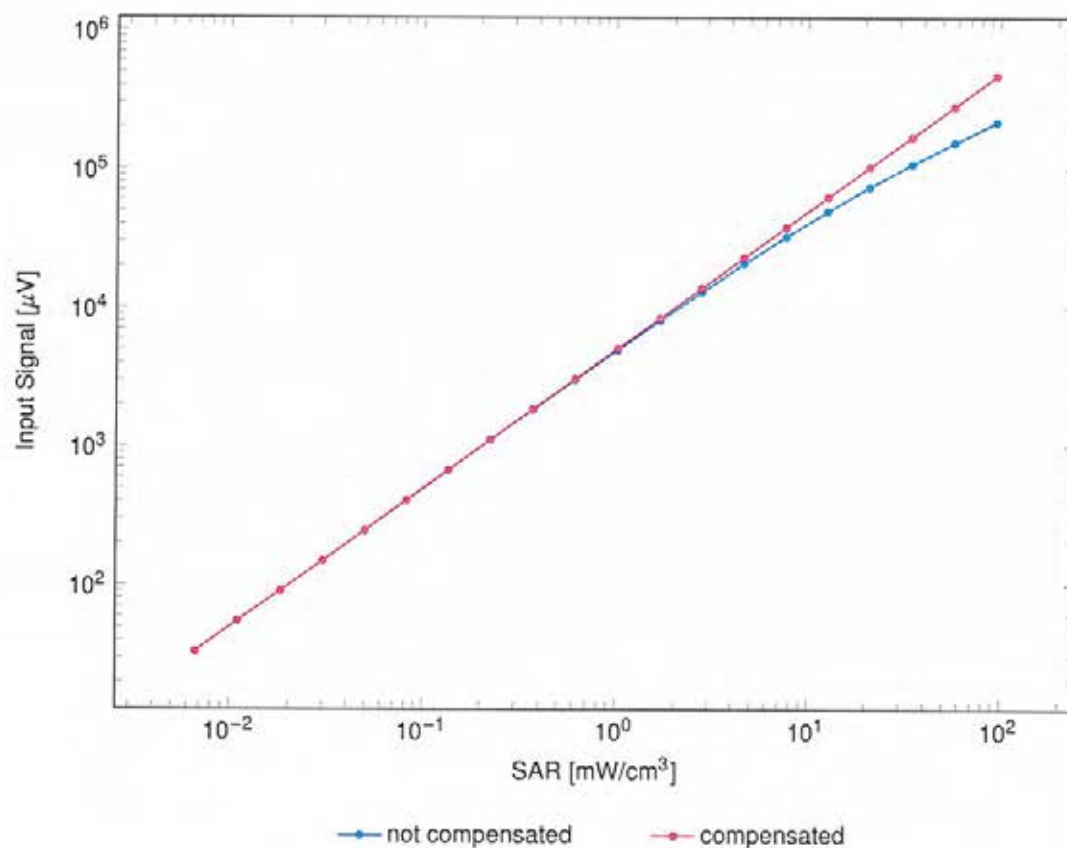
(TEM-Cell:ifi110 EXX, Waveguide:R22)



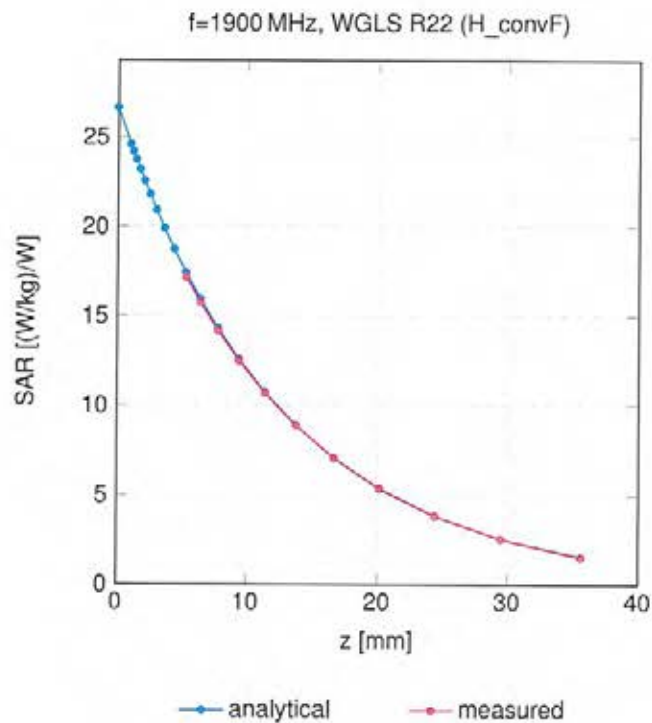
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

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

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

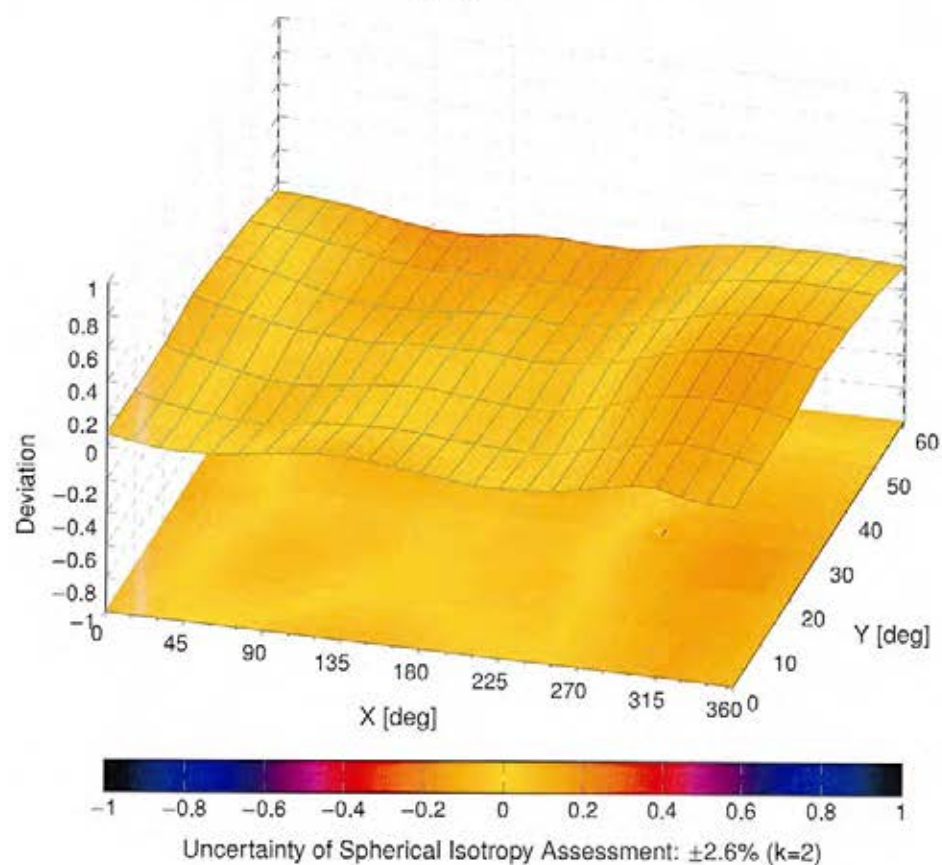
Dynamic Range $f(\text{SAR}_{\text{HSL}})$ (TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$)Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), $f = 900\text{ MHz}$





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Accreditation No.: **SCS 0108**

Client

UL

Research Triangle Park, USA

Certificate No.

EX-7710_Jan26

CALIBRATION CERTIFICATE

Object

EX3DV4 - SN:7710

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 15, 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	

Issued: January 18, 2026

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Calibration Laboratory of

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Multilateral Agreement for the recognition of calibration certificates

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:7710

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.58	0.58	0.67	±10.1%
DCP (mV) ^B	104.7	103.0	104.5	±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	149.8	±1.5%	±4.7%
		Y	0.00	0.00	1.00		125.2		
		Z	0.00	0.00	1.00		133.1		
10352	Pulse (D=10%, T=5 ms)	X	0.69	70.00	18.12	10.00	23.0	±1.9%	±9.6%
		Y	0.28	60.53	15.17		24.0		
		Z	0.45	69.99	18.59		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.65	73.01	18.18	6.99	46.0	±1.5%	±9.6%
		Y	0.26	63.54	15.22		48.0		
		Z	0.41	73.00	18.64		48.0		
10354	Pulse (D=40%, T=5 ms)	X	0.60	76.02	18.24	3.98	92.0	±1.3%	±9.6%
		Y	0.24	66.55	15.26		95.0		
		Z	0.38	76.01	18.70		96.0		
10355	Pulse (D=60%, T=5 ms)	X	0.58	77.78	18.27	2.22	139.0	±1.3%	±9.6%
		Y	0.23	68.31	15.29		142.0		
		Z	0.36	77.77	18.73		144.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.01	74.90	19.64	0.11	108.0	±1.6%	±9.6%
		Y	0.00	82.91	16.60		111.0		
		Z	0.01	80.24	19.90		112.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	1.77	74.78	17.47	0.00	114.0	±2.5%	±9.6%
		Y	0.61	65.32	14.49		117.0		
		Z	1.58	74.78	17.65		119.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.09	73.73	21.14	1.73	80.0	±4.2%	±9.6%
		Y	0.00	64.26	17.85		82.0		
		Z	0.03	73.72	21.24		83.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	3.94	73.73	17.36	0.00	105.0	±3.7%	±9.6%
		Y	1.72	64.26	13.51		109.0		
		Z	3.66	73.72	17.50		111.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	4.81	71.46	17.36	0.00	77.0	±1.7%	±9.6%
		Y	2.03	61.99	13.44		80.0		
		Z	4.61	71.45	17.49		81.0		

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 E²-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.

Parameters of Probe: EX3DV4 - SN:7710

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	10.4	75.76	34.20	3.41	0.00	4.90	0.47	0.00	1.00
y	7.7	56.92	34.72	0.92	0.00	4.90	0.22	0.00	1.00
z	10.0	74.11	34.89	3.06	0.00	4.90	0.51	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	54.6°
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:7710

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)
13	55.0	0.75	16.43	14.36	16.71	0.00	1.25	±13.3%
450	43.5	0.87	11.50	11.50	11.50	0.16	1.30	±13.3%
750	41.9	0.89	10.17	9.64	10.36	0.35	1.27	±11.0%
900	41.5	0.97	9.89	9.38	10.08	0.35	1.27	±11.0%
1750	40.1	1.37	8.36	7.93	8.52	0.35	1.27	±11.0%
1900	40.0	1.40	8.10	7.67	8.25	0.35	1.27	±11.0%
2100	39.8	1.49	8.11	7.69	8.27	0.34	1.27	±11.0%
2300	39.5	1.67	7.79	7.39	7.94	0.34	1.27	±11.0%
2450	39.2	1.80	7.59	7.19	7.73	0.34	1.27	±11.0%
2600	39.0	1.96	7.75	7.35	7.90	0.34	1.27	±11.0%
3300	38.2	2.71	6.82	6.46	6.94	0.34	1.27	±13.1%
3500	37.9	2.91	6.84	6.48	6.96	0.34	1.27	±13.1%
3700	37.7	3.12	6.92	6.56	7.05	0.33	1.27	±13.1%
3900	37.5	3.32	6.78	6.42	6.90	0.33	1.27	±13.1%
4100	37.2	3.53	6.66	6.31	6.78	0.33	1.27	±13.1%
4200	37.1	3.63	6.54	6.20	6.66	0.33	1.27	±13.1%
4400	36.9	3.84	6.29	5.96	6.41	0.33	1.27	±13.1%
4600	36.7	4.04	6.40	6.07	6.52	0.33	1.27	±13.1%
4800	36.4	4.25	6.54	6.20	6.66	0.33	1.27	±13.1%
4950	36.3	4.40	6.49	6.15	6.61	0.32	1.27	±13.1%
5250	35.9	4.71	5.76	5.46	5.87	0.29	1.27	±13.1%
5400	35.8	4.86	5.46	5.18	5.56	0.28	1.27	±13.1%
5600	35.5	5.07	5.49	5.20	5.59	0.27	1.27	±13.1%
5750	35.4	5.22	5.63	5.34	5.74	0.26	1.27	±13.1%
5850	35.2	5.32	5.29	5.02	5.39	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.

Parameters of Probe: EX3DV4 - SN:7710

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	5.53	5.25	5.64	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.

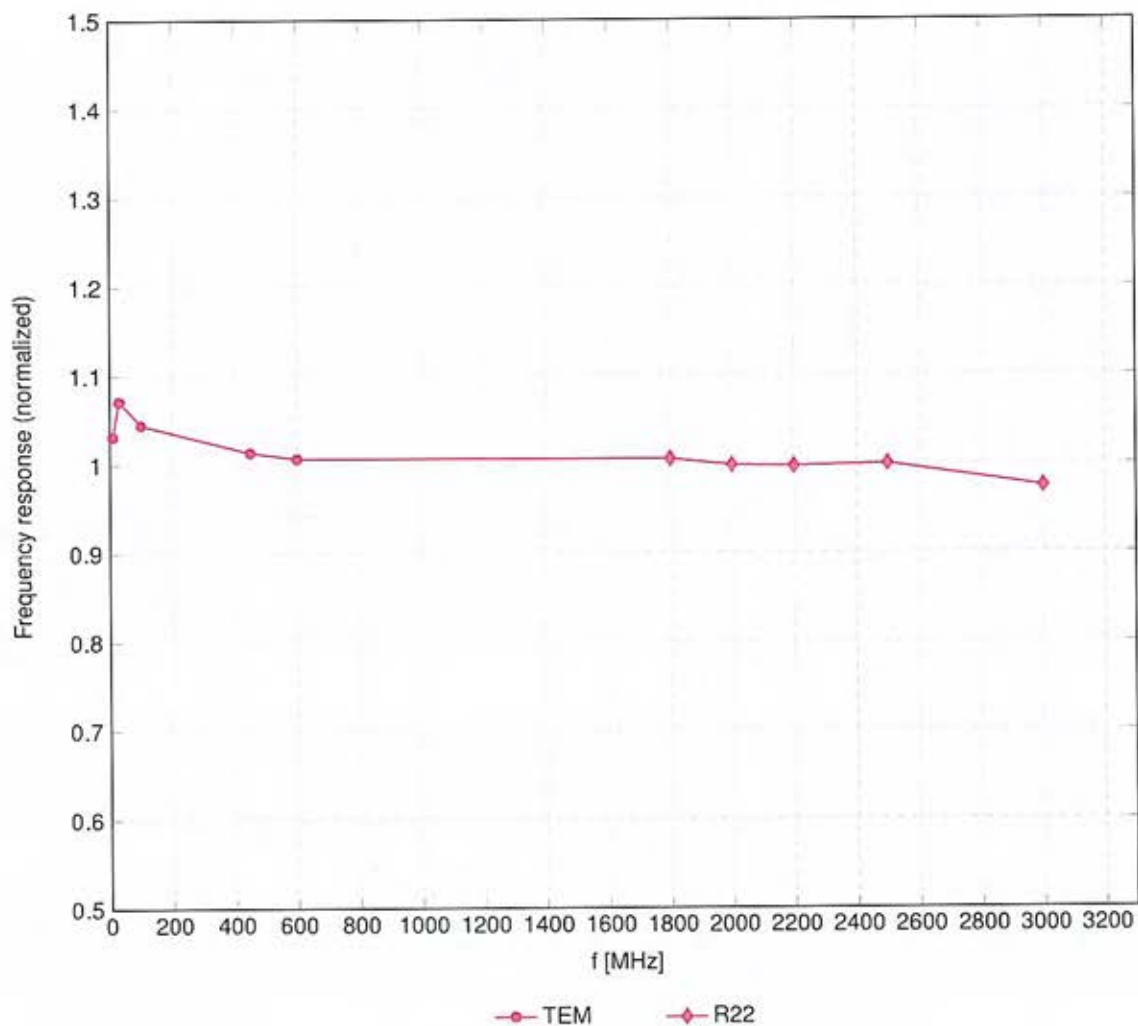
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±10% from the target values (typically better than ±6%) and are valid for TSL with deviations of up to ±10%.

^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.

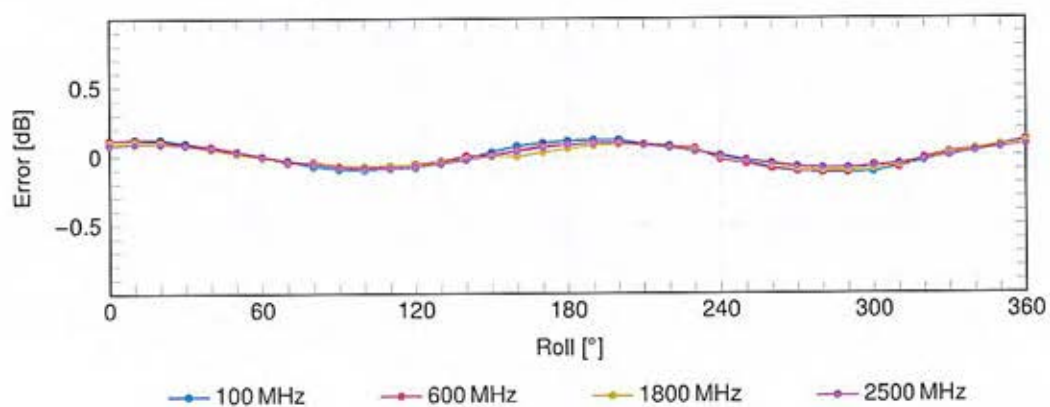
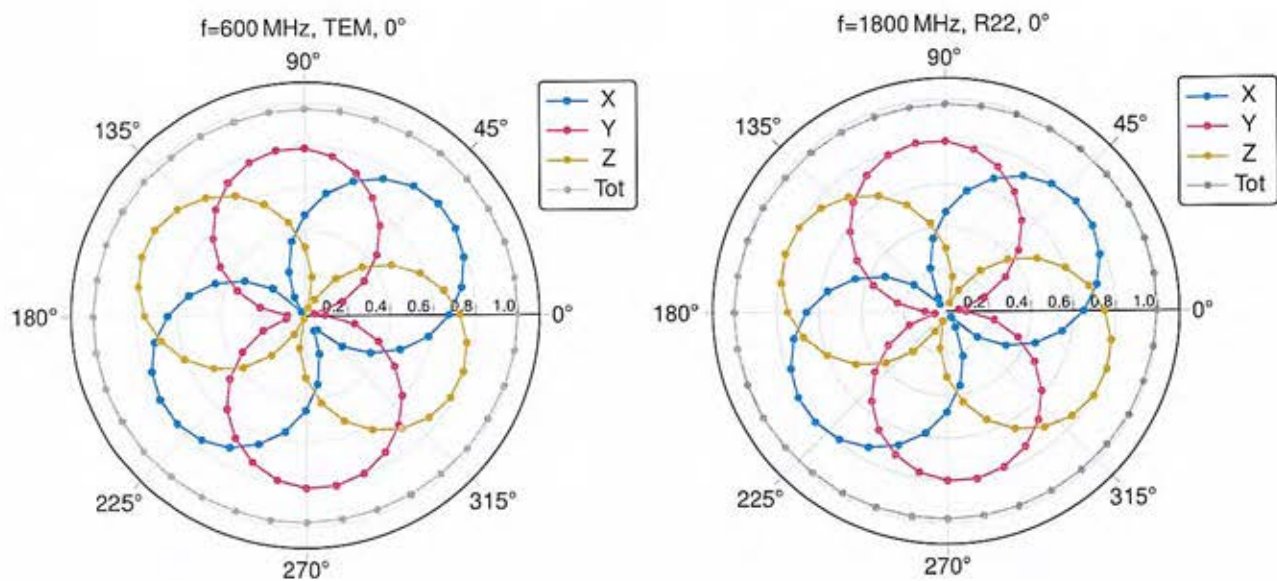
^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

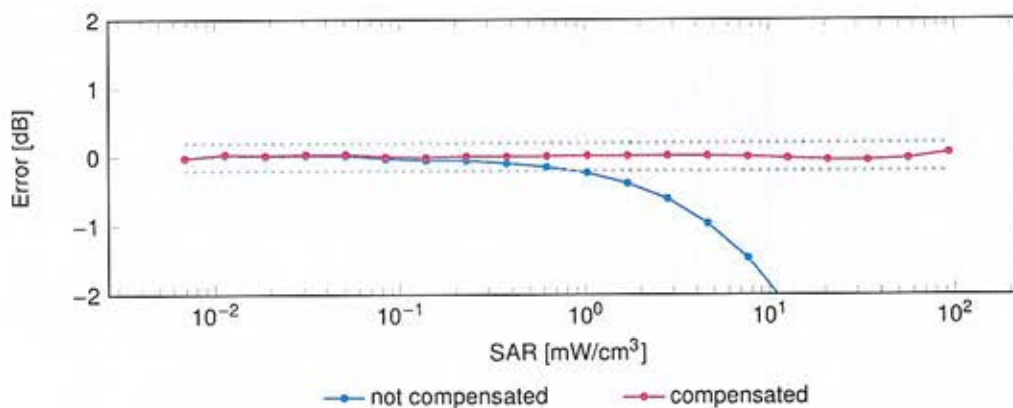
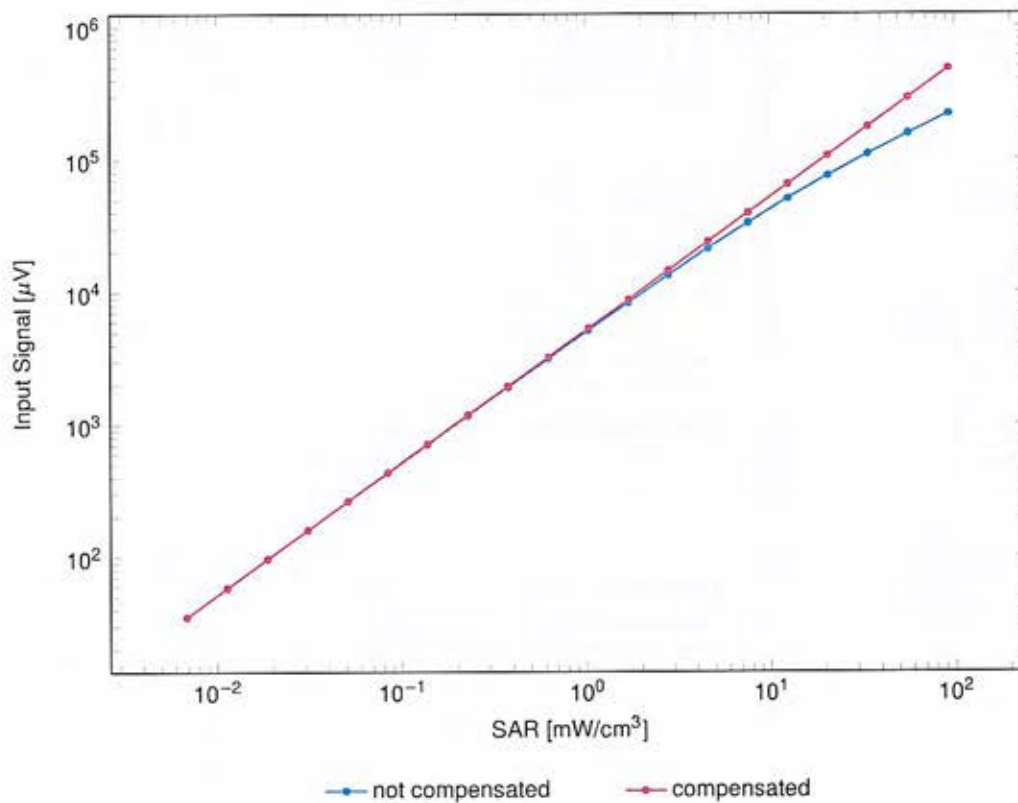
Frequency Response of E-Field

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

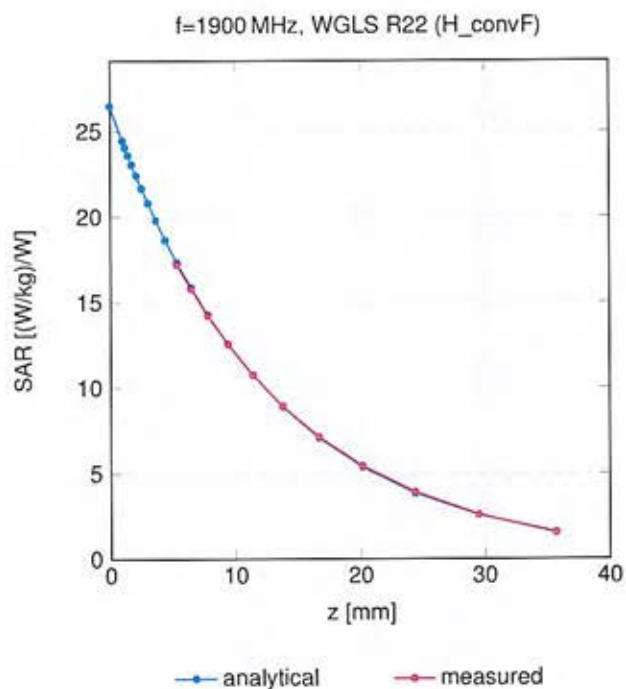


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

Receiving Pattern (ϕ), $\vartheta = 0^\circ$ Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

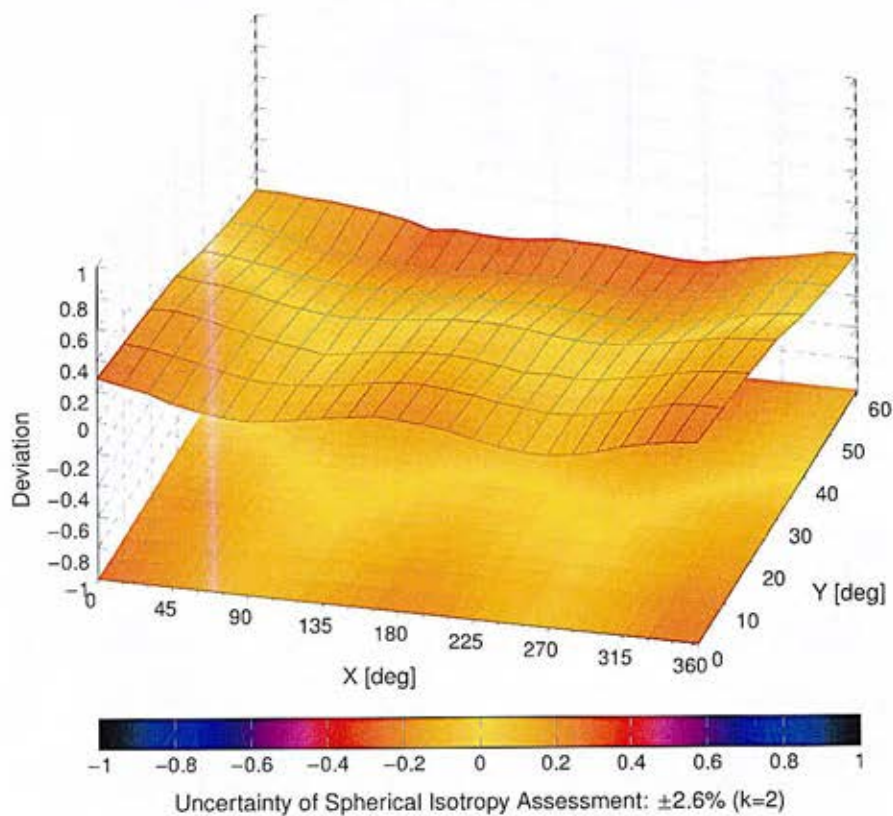
Dynamic Range f(SAR_{HSL})(TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$)Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz





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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

UL
Gyeonggi-do, Republic of Korea

Certificate No.

EX-7947_Sep25

CALIBRATION CERTIFICATE

Object EX3DV4 - SN:7947

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 September 10, 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. 1020-300791789)	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	Jeffrey Katzman	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	

Issued: September 10, 2025

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

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., $\vartheta = 0$ 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 $\vartheta = 0$ ($f \leq 900$ 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:7947

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) ^A	0.54	0.57	0.58	$\pm 10.1\%$
DCP (mV) ^B	106.2	107.1	107.7	$\pm 4.7\%$

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	134.0	$\pm 2.3\%$	$\pm 4.7\%$
		Y	0.00	0.00	1.00		144.5		
		Z	0.00	0.00	1.00		140.5		
10352	Pulse (D=10%, T=5 ms)	X	0.22	59.36	14.50	10.00	22.0	$\pm 1.9\%$	$\pm 9.6\%$
		Y	0.29	61.55	15.46		22.0		
		Z	0.25	59.94	14.94		22.0		
10353	Pulse (D=20%, T=5 ms)	X	0.21	62.37	14.53	6.99	45.0	$\pm 1.5\%$	$\pm 9.6\%$
		Y	0.27	64.56	15.51		45.0		
		Z	0.23	62.95	14.98		45.0		
10354	Pulse (D=40%, T=5 ms)	X	0.20	65.38	14.56	3.98	90.0	$\pm 1.3\%$	$\pm 9.6\%$
		Y	0.25	67.57	15.56		90.0		
		Z	0.21	65.96	15.03		90.0		
10355	Pulse (D=60%, T=5 ms)	X	0.19	67.14	14.58	2.22	135.0	$\pm 1.4\%$	$\pm 9.6\%$
		Y	0.24	69.34	15.59		134.0		
		Z	0.20	67.72	15.05		134.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.01	64.26	15.83	0.40	102.0	$\pm 1.3\%$	$\pm 9.6\%$
		Y	0.01	66.46	16.93		102.0		
		Z	0.01	81.97	16.41		102.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	0.51	64.15	13.90	0.00	108.0	$\pm 2.9\%$	$\pm 9.6\%$
		Y	0.73	66.34	14.58		108.0		
		Z	0.60	64.73	14.12		108.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.00	80.35	16.97	1.47	79.0	$\pm 2.3\%$	$\pm 9.6\%$
		Y	0.00	65.28	18.41		79.0		
		Z	0.00	45.46	17.82		79.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	1.50	63.09	12.81	0.00	100.0	$\pm 4.1\%$	$\pm 9.6\%$
		Y	1.92	65.28	13.70		99.0		
		Z	1.66	63.67	13.01		99.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	1.79	60.82	12.72	0.00	71.0	$\pm 2.2\%$	$\pm 9.6\%$
		Y	2.31	63.02	13.64		71.0		
		Z	1.98	61.41	12.92		71.0		

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.

Parameters of Probe: EX3DV4 - SN:7947

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	7.8	57.02	34.01	3.42	0.00	4.90	0.54	0.00	1.00
y	9.3	67.70	33.61	3.61	0.00	4.97	0.48	0.03	1.00
z	8.9	64.67	33.44	4.67	0.00	4.90	0.74	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-38.9°
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:7947

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	9.02	9.17	9.42	0.40	1.27	±11.0%
900	41.5	0.97	8.63	8.77	9.01	0.40	1.27	±11.0%
1810	40.0	1.40	7.41	7.53	7.74	0.39	1.27	±11.0%
1950	40.0	1.40	7.18	7.30	7.50	0.39	1.27	±11.0%
2450	39.2	1.80	6.80	6.91	7.10	0.38	1.27	±11.0%
2600	39.0	1.96	6.91	7.02	7.21	0.38	1.27	±11.0%
3500	37.9	2.91	6.22	6.32	6.50	0.37	1.27	±13.1%
3700	37.7	3.12	6.17	6.27	6.44	0.37	1.27	±13.1%
5200	36.0	4.66	5.41	5.49	5.65	0.33	1.27	±13.1%
5300	35.9	4.76	5.22	5.30	5.45	0.32	1.27	±13.1%
5500	35.6	4.96	4.93	5.01	5.15	0.30	1.27	±13.1%
5600	35.5	5.07	4.95	5.03	5.17	0.29	1.27	±13.1%
5800	35.3	5.27	4.92	5.00	5.14	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.

Parameters of Probe: EX3DV4 - SN:7947

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	5.20	5.28	5.43	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.

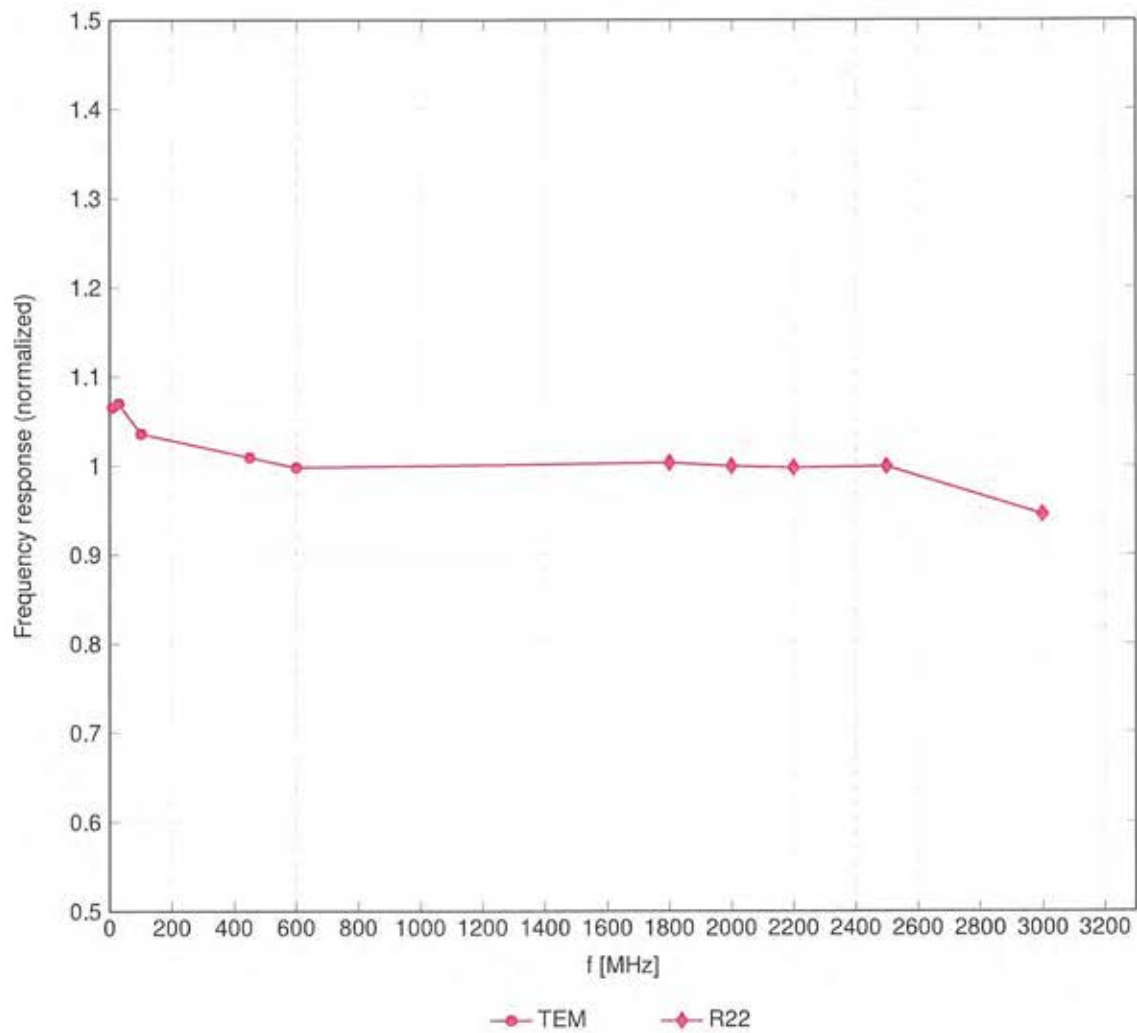
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±10% from the target values (typically better than ±6%) and are valid for TSL with deviations of up to ±10%.

^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.

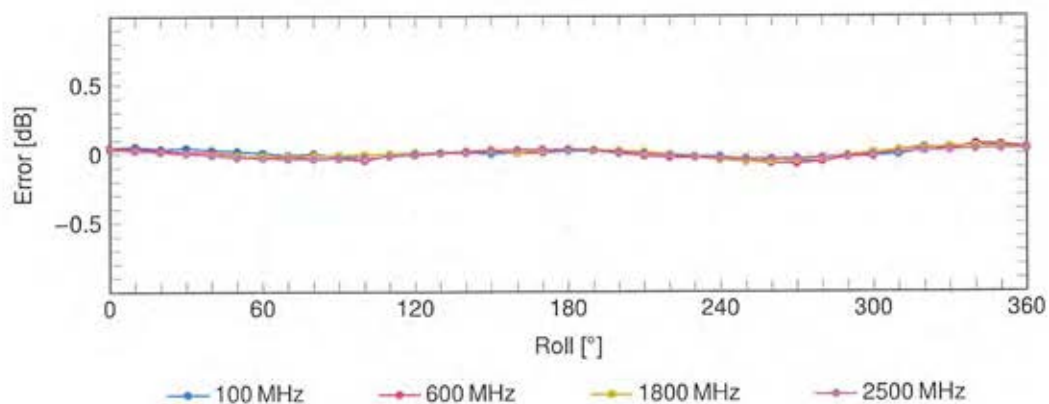
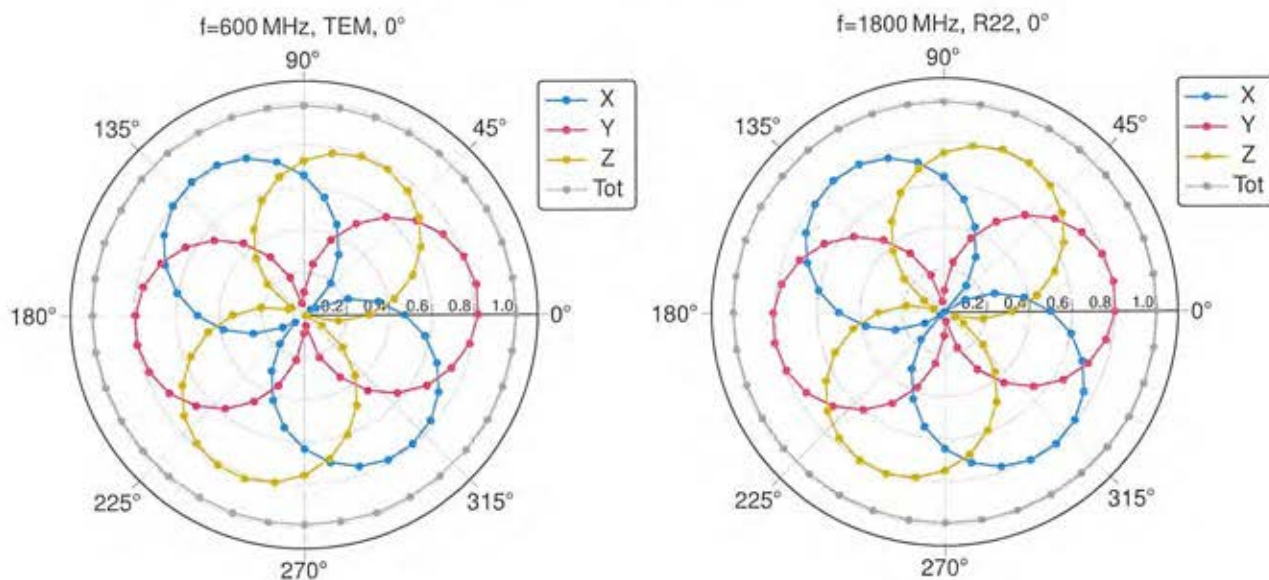
^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

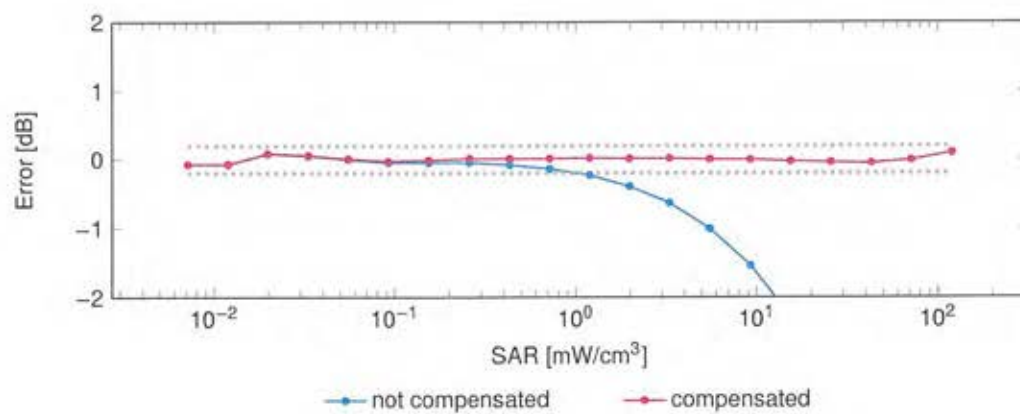
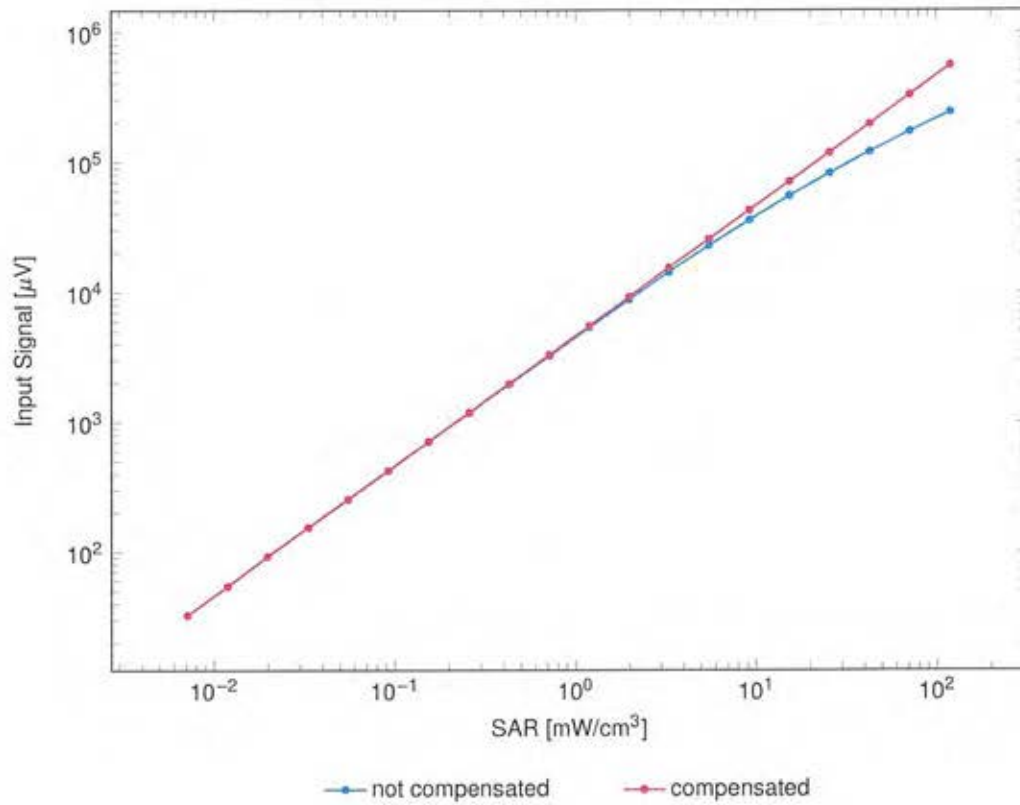
Frequency Response of E-Field

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

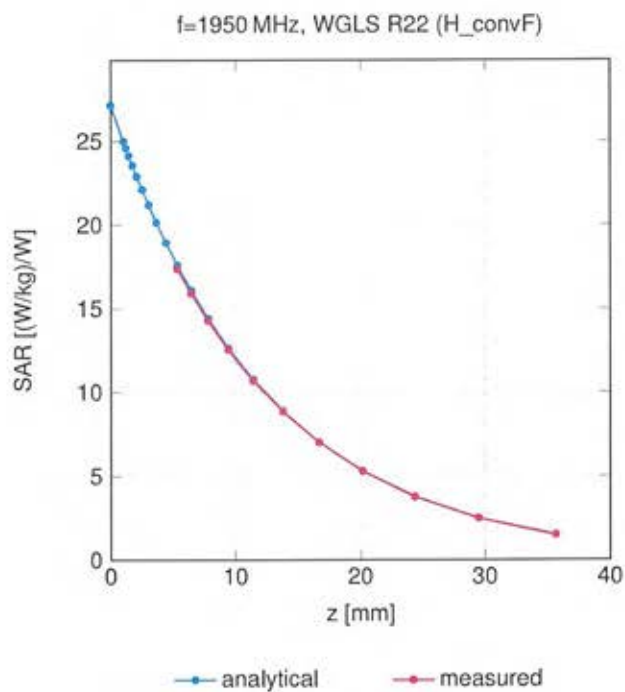


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

Receiving Pattern (ϕ), $\vartheta = 0^\circ$ Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

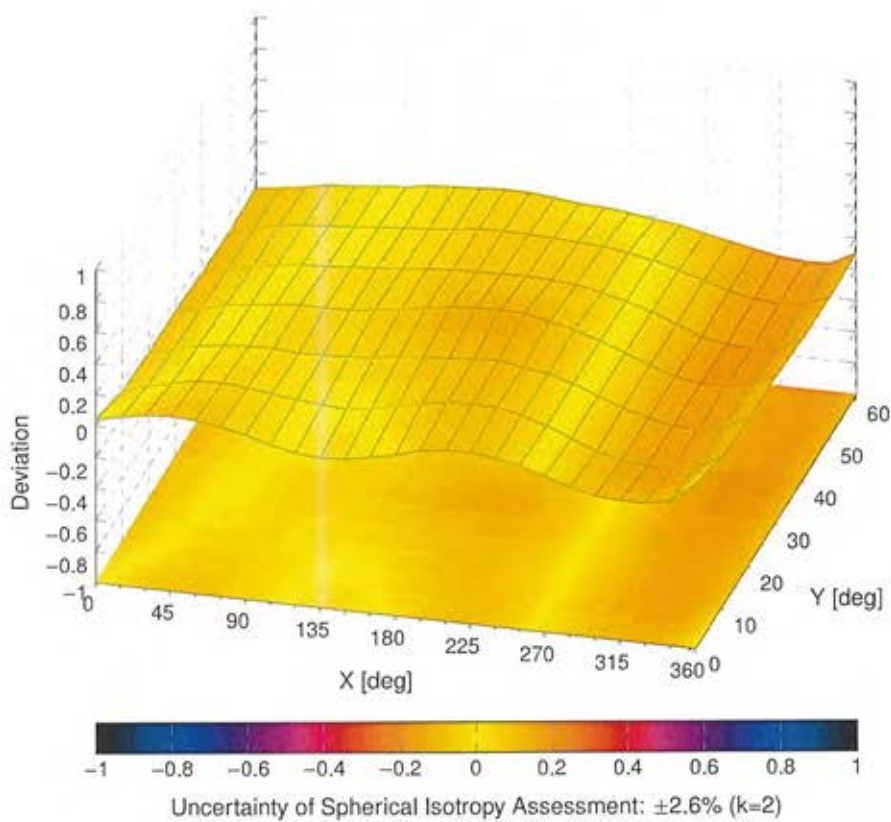
Dynamic Range f(SAR_{HSL})(TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$)Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz





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

UL
Fremont, USA

Certificate No.

EX-7463_Apr26

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:7463**

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 **April 24, 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-26 (No. 2026-005592)	Mar-27
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 2020 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: MY54504221	30-Sept-24 (No. 675-CAL18-S4489-Sep24)	Sep-26

	Name	Function
Calibrated by	Krešimir Franjić	Laboratory Technician
Approved by	Sven Kühn	Technical Manager

Signature

[Signature]
IA A. Kühn

Issued: April 24, 2026

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



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**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., $\vartheta = 0$ 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 $\vartheta = 0$ ($f \leq 900$ 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:7463

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.56	0.54	0.51	±10.1%
DCP (mV) ^B	104.1	104.8	108.2	±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	Continuous Wave	X	0.00	0.00	1.00	0.00	121.3	±1.3%	±4.7%
		Y	0.00	0.00	1.00		122.0		
		Z	0.00	0.00	1.00		148.8		
10352	Pulse (D=10%, T=5 ms)	X	0.26	59.07	14.65	10.00	23.0	±1.9%	±9.6%
		Y	0.19	58.78	14.61		24.0		
		Z	0.17	60.67	16.22		23.0		
10353	Pulse (D=20%, T=5 ms)	X	0.24	62.08	14.71	6.99	46.0	±1.6%	±9.6%
		Y	0.18	61.79	14.64		47.0		
		Z	0.15	63.68	16.29		47.0		
10354	Pulse (D=40%, T=5 ms)	X	0.22	65.09	14.76	3.98	93.0	±1.7%	±9.6%
		Y	0.17	64.80	14.68		94.0		
		Z	0.13	66.69	16.35		93.0		
10355	Pulse (D=60%, T=5 ms)	X	0.21	66.86	14.79	2.22	139.0	±1.8%	±9.6%
		Y	0.16	66.56	14.69		141.0		
		Z	0.12	68.45	16.41		140.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.00	63.98	16.30	0.37	106.0	±1.5%	±9.6%
		Y	0.00	63.68	15.96		108.0		
		Z	0.00	65.57	18.47		107.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	0.54	63.86	13.92	0.00	113.0	±2.6%	±9.6%
		Y	0.46	63.56	13.92		115.0		
		Z	0.37	65.45	15.50		113.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.00	44.86	17.71	1.45	82.0	±2.2%	±9.6%
		Y	0.01	62.51	17.26		84.0		
		Z	0.04	64.40	19.31		83.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	1.56	62.80	12.62	0.00	104.0	±4.4%	±9.6%
		Y	1.37	62.51	12.65		106.0		
		Z	1.52	64.40	13.35		105.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	1.84	60.54	12.51	0.00	75.0	±2.5%	±9.6%
		Y	1.70	60.24	12.49		76.0		
		Z	1.77	62.13	13.22		75.0		

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 to 7).

^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.

Parameters of Probe: EX3DV4 - SN:7463

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	7.9	58.07	34.60	3.20	0.00	4.90	0.50	0.00	1.00
y	7.8	57.66	34.44	2.24	0.00	4.90	0.44	0.00	1.00
z	6.4	46.43	33.58	4.86	0.00	4.90	0.62	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	44.9°
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:7463

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	13.96	13.98	15.92	0.00	1.25	±13.3%
13	55.0	0.75	14.76	14.78	16.84	0.00	1.25	±13.3%
30	55.0	0.75	13.23	13.25	15.09	0.00	1.25	±13.3%
64	54.2	0.75	11.92	11.94	13.60	0.00	1.25	±13.3%
450	43.5	0.87	10.01	10.01	10.01	0.16	1.30	±13.3%
750	41.9	0.89	9.01	8.72	10.21	0.31	1.27	±11.0%
900	41.5	0.97	8.32	8.05	9.42	0.31	1.27	±11.0%
1450	40.5	1.20	7.53	7.29	8.53	0.32	1.27	±11.0%
1640	40.2	1.31	7.41	7.17	8.40	0.32	1.27	±11.0%
1750	40.1	1.37	7.35	7.11	8.32	0.32	1.27	±11.0%
1900	40.0	1.40	7.26	7.02	8.22	0.33	1.27	±11.0%
2100	39.8	1.49	7.13	6.90	8.08	0.33	1.27	±11.0%
2300	39.5	1.67	7.00	6.78	7.93	0.33	1.27	±11.0%
2450	39.2	1.80	6.90	6.68	7.82	0.33	1.27	±11.0%
2600	39.0	1.96	6.80	6.58	7.70	0.33	1.27	±11.0%
3300	38.2	2.71	6.33	6.12	7.17	0.34	1.27	±13.1%
3500	37.9	2.91	6.20	6.00	7.02	0.35	1.27	±13.1%
3700	37.7	3.12	6.08	5.88	6.89	0.35	1.27	±13.1%
3900	37.5	3.32	5.97	5.78	6.76	0.35	1.27	±13.1%
4100	37.2	3.53	5.86	5.67	6.64	0.35	1.27	±13.1%
4200	37.1	3.63	5.81	5.63	6.59	0.35	1.27	±13.1%
4400	36.9	3.84	5.72	5.54	6.48	0.36	1.27	±13.1%
4600	36.7	4.04	5.64	5.46	6.39	0.36	1.27	±13.1%
4800	36.4	4.25	5.56	5.38	6.30	0.36	1.43	±13.1%
4950	36.3	4.40	5.50	5.32	6.23	0.35	1.42	±13.1%
5250	35.9	4.71	5.12	4.96	5.80	0.32	1.39	±13.1%
5600	35.5	5.07	4.53	4.38	5.13	0.29	1.35	±13.1%
5750	35.4	5.22	4.56	4.41	5.17	0.27	1.34	±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.

Parameters of Probe: EX3DV4 - SN:7463

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)
5850	35.2	5.32	4.60	4.46	5.22	0.26	1.33	±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 $\pm 5\%$ from the target values (typically better than $\pm 3\%$) and are valid for TSL with deviations of up to $\pm 10\%$ 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 $\pm 1\%$ 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 62209-1528:2020.

Parameters of Probe: EX3DV4 - SN:7463

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	4.81	4.65	5.45	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.

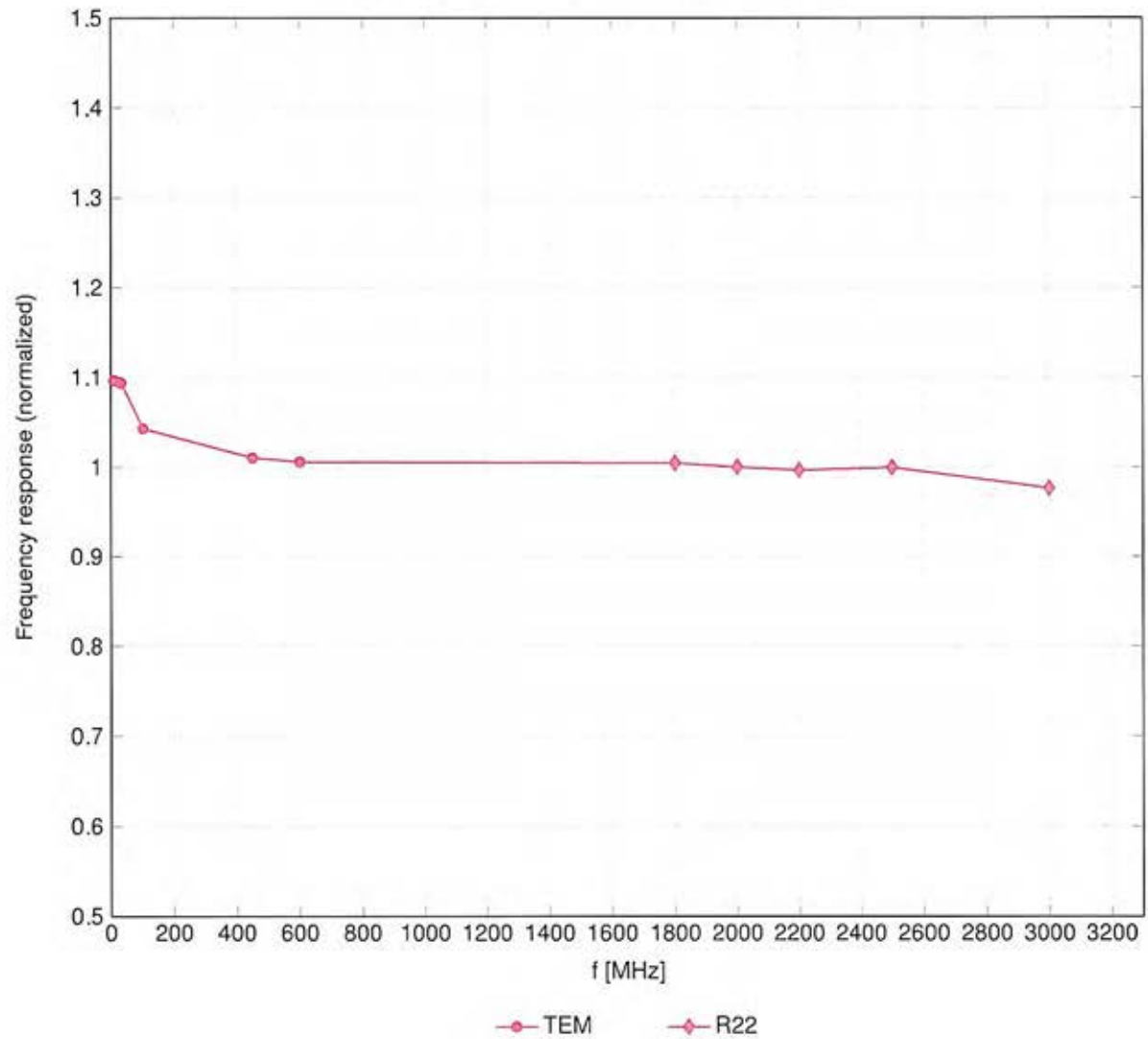
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±10% from the target values (typically better than ±6%) and are valid for TSL with deviations of up to ±10%.

^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.

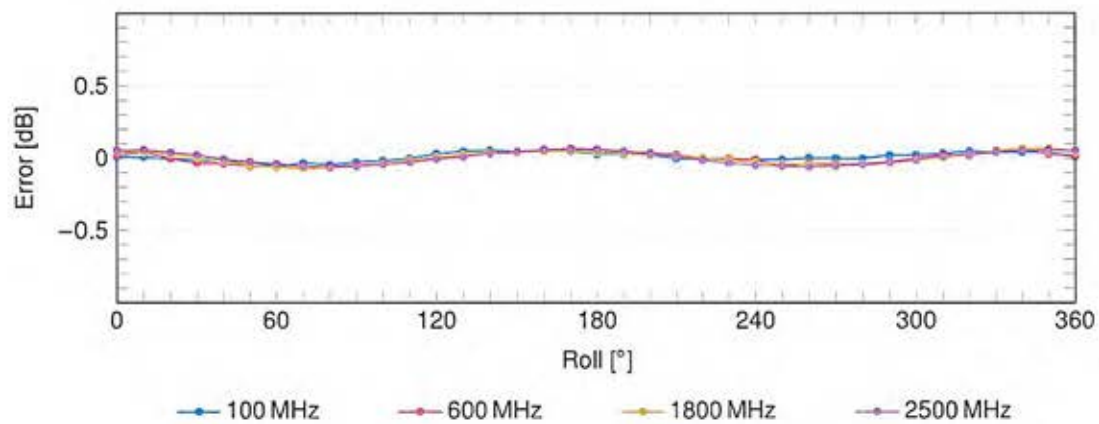
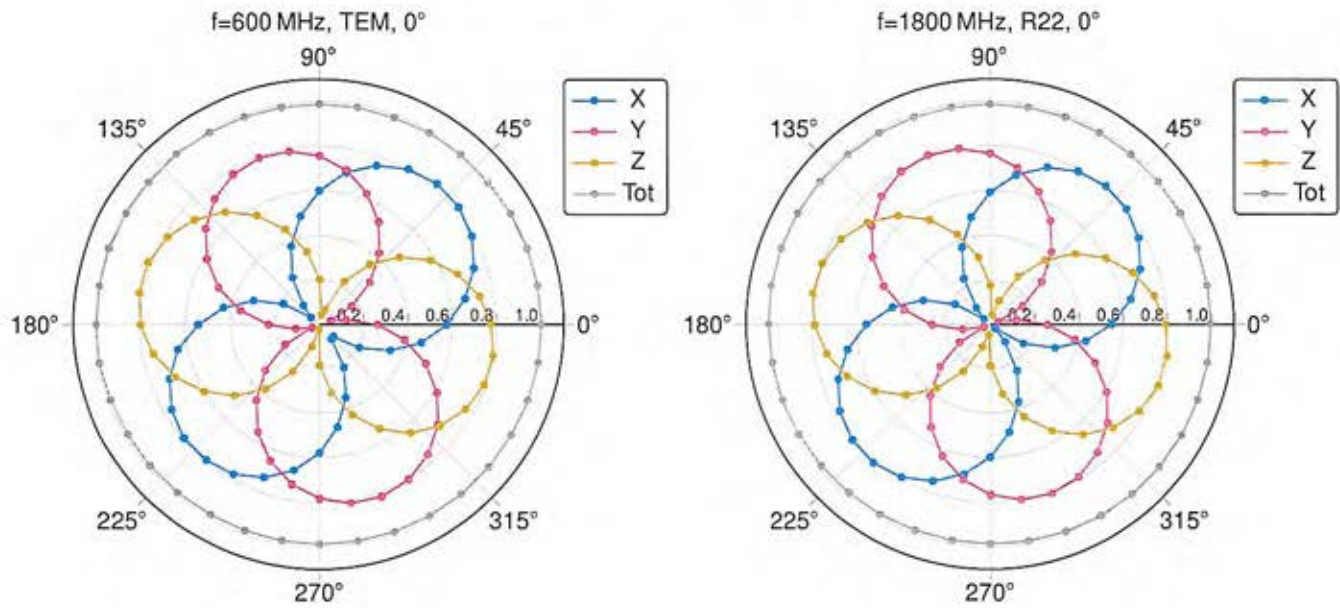
^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

Frequency Response of E-Field

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

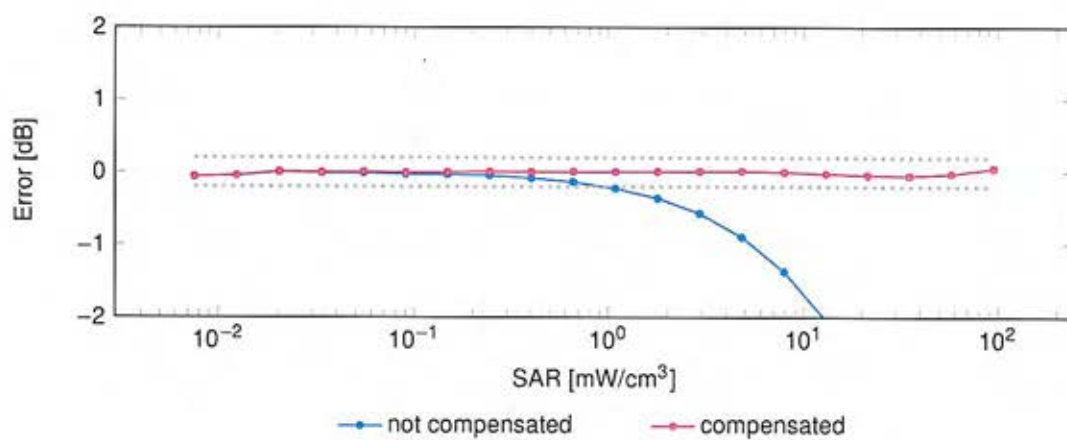
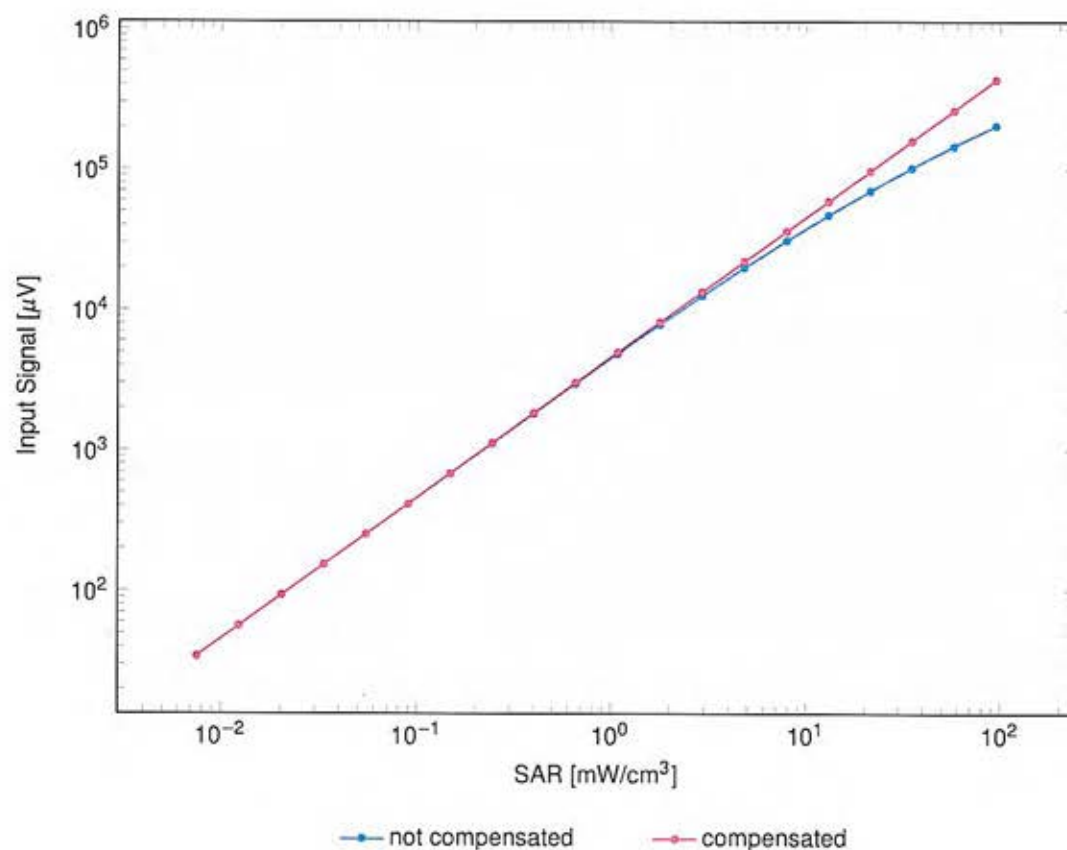


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

Receiving Pattern (ϕ), $\vartheta = 0^\circ$ Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

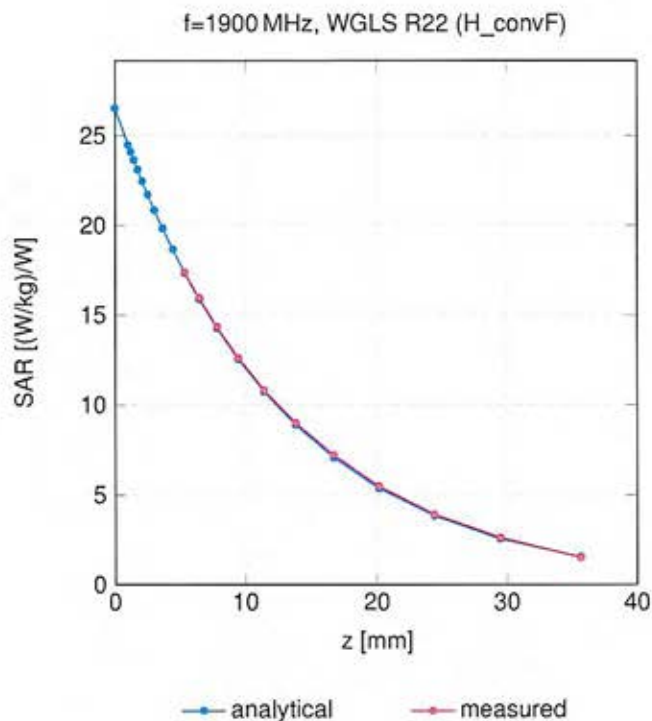
Dynamic Range f(SAR_{HSL})

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



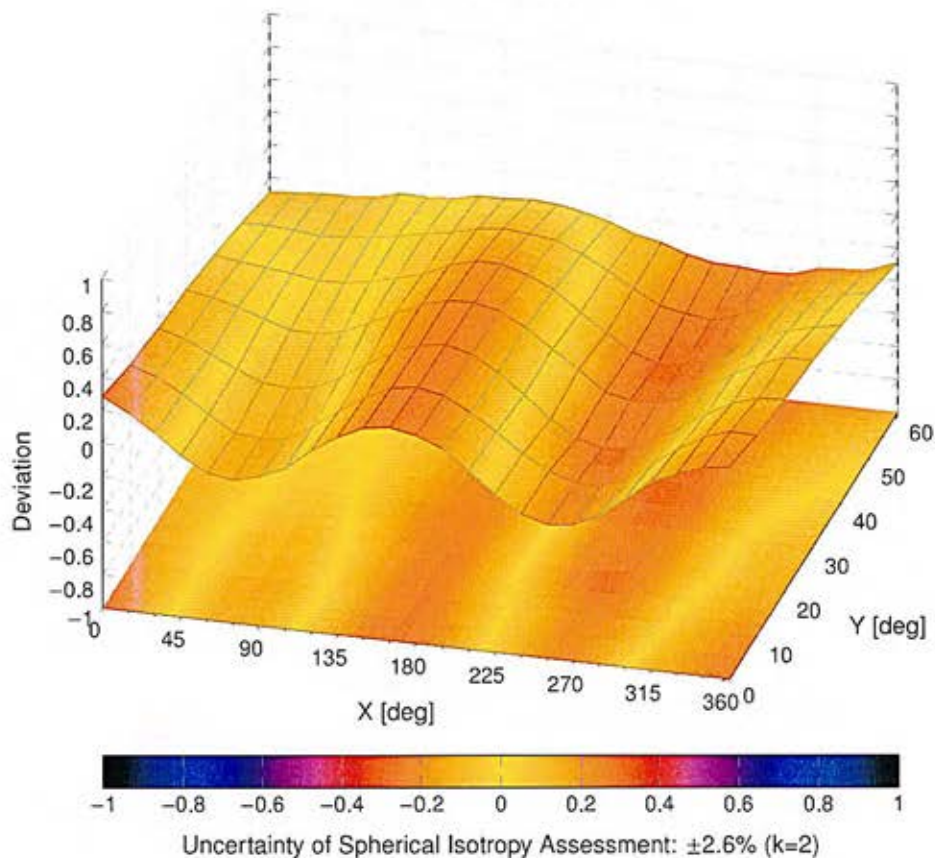
Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz



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Engineering AG**

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**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****UL**

Fremont, USA

Certificate No.**EX-7915_Nov25****CALIBRATION CERTIFICATE****Object**

EX3DV4 - SN:7915

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

November 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	29-Oct-25 (No. Part of L1407)	Oct-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	09-Dec-24 (No. OCP-DAK3.5-1336_Dec24)	Dec-25

	Name	Function	Signature
Calibrated by	Joanna Lleshaj	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	
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Issued: November 11, 2025

Calibration Laboratory of

Schmid & Partner
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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., $\vartheta = 0$ 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 $\vartheta = 0$ ($f \leq 900$ 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:7915

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.65	0.58	0.61	±10.1%
DCP (mV) ^B	103.5	104.9	106.0	±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	137.7	±1.9%	±4.7%
		Y	0.00	0.00	1.00		132.5		
		Z	0.00	0.00	1.00		136.0		
10352	Pulse (D=10%, T=5 ms)	X	0.36	69.97	18.92	10.00	23.0	±1.6%	±9.6%
		Y	0.25	63.96	16.57		24.0		
		Z	0.38	69.99	18.59		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.33	72.98	18.97	6.99	47.0	±1.4%	±9.6%
		Y	0.23	66.97	16.61		47.0		
		Z	0.35	73.00	18.63		47.0		
10354	Pulse (D=40%, T=5 ms)	X	0.31	75.99	19.02	3.98	93.0	±1.2%	±9.6%
		Y	0.21	69.98	16.65		94.0		
		Z	0.33	76.01	18.68		94.0		
10355	Pulse (D=60%, T=5 ms)	X	0.29	77.75	19.05	2.22	139.0	±1.2%	±9.6%
		Y	0.20	71.75	16.67		141.0		
		Z	0.31	77.77	18.71		141.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.00	74.87	20.31	0.19	109.0	±1.6%	±9.6%
		Y	0.00	49.07	17.69		110.0		
		Z	0.00	74.89	20.00		110.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	1.52	74.76	17.73	0.00	115.0	±2.4%	±9.6%
		Y	0.90	68.75	15.57		116.0		
		Z	1.52	74.77	17.51		116.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.03	73.70	21.74	1.76	81.0	±4.4%	±9.6%
		Y	0.00	67.69	19.02		82.0		
		Z	0.02	73.71	21.25		82.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	3.60	73.70	17.54	0.00	107.0	±3.9%	±9.6%
		Y	2.25	67.69	15.02		108.0		
		Z	3.66	73.71	17.33		108.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	4.52	71.43	17.54	0.00	78.0	±1.7%	±9.6%
		Y	2.82	65.43	14.99		79.0		
		Z	4.58	71.45	17.33		79.0		

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.

Parameters of Probe: EX3DV4 - SN:7915

Sensor Model Parameters

	C1 fF	C2 fF	α V ⁻¹	T1 msV ⁻²	T2 msV ⁻¹	T3 ms	T4 V ⁻²	T5 V ⁻¹	T6
x	10.1	75.11	35.12	1.74	0.00	4.90	0.33	0.00	1.00
y	9.4	69.68	34.76	2.42	0.00	4.90	0.24	0.00	1.00
z	10.1	74.71	34.66	2.09	0.00	4.90	0.26	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-1.1°
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:7915

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	9.73	9.52	9.63	0.36	1.27	±11.0%
900	41.5	0.97	9.54	9.34	9.45	0.36	1.27	±11.0%
1750	40.1	1.37	8.25	8.07	8.17	0.35	1.27	±11.0%
1900	40.0	1.40	7.82	7.66	7.74	0.35	1.27	±11.0%
2300	39.5	1.67	7.51	7.35	7.44	0.34	1.27	±11.0%
2450	39.2	1.80	7.13	6.98	7.06	0.34	1.27	±11.0%
2600	39.0	1.96	7.24	7.09	7.17	0.34	1.27	±11.0%
5250	35.9	4.71	5.89	5.76	5.83	0.30	1.27	±13.1%
5600	35.5	5.07	5.34	5.23	5.29	0.27	1.27	±13.1%
5750	35.4	5.22	5.37	5.26	5.32	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.

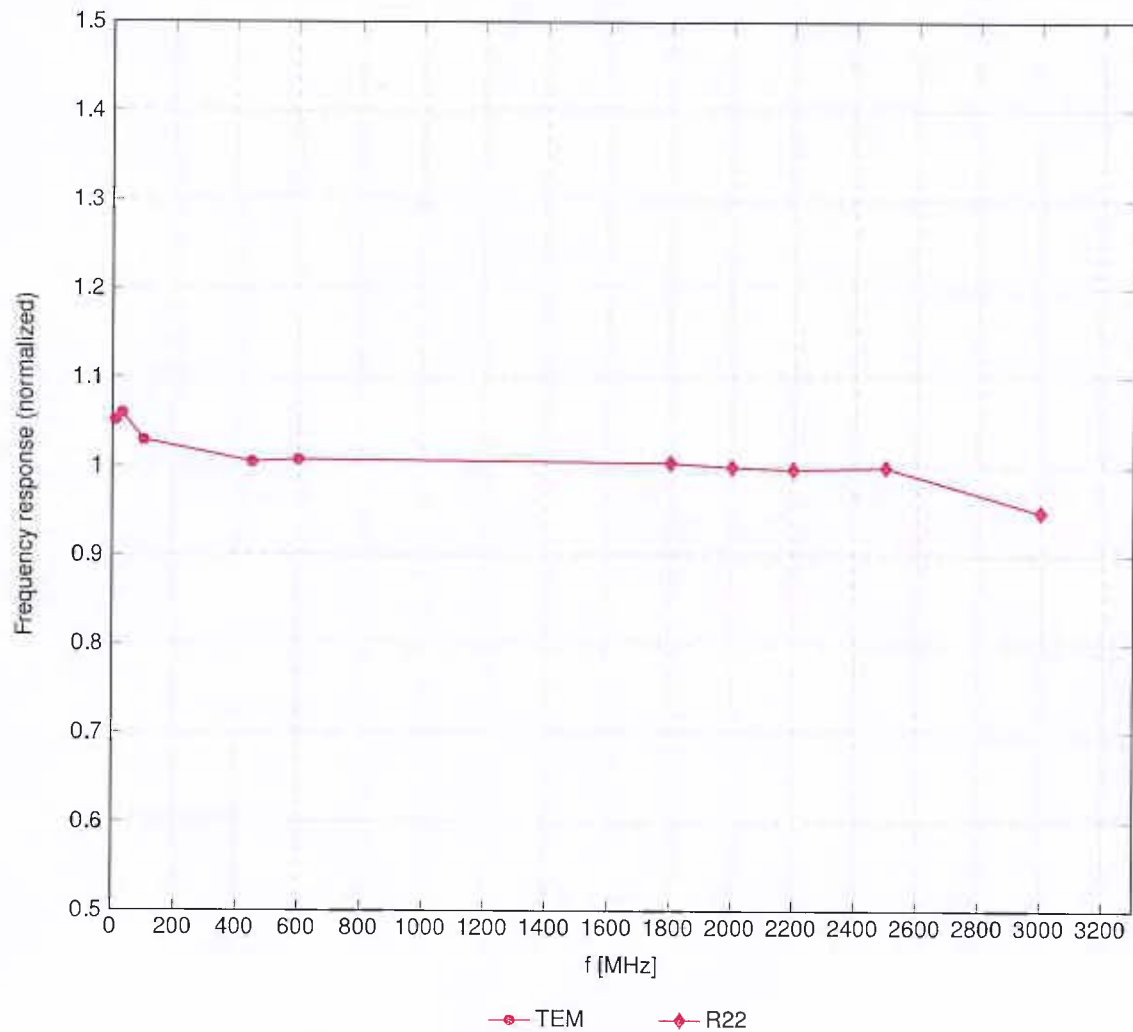
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

^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.

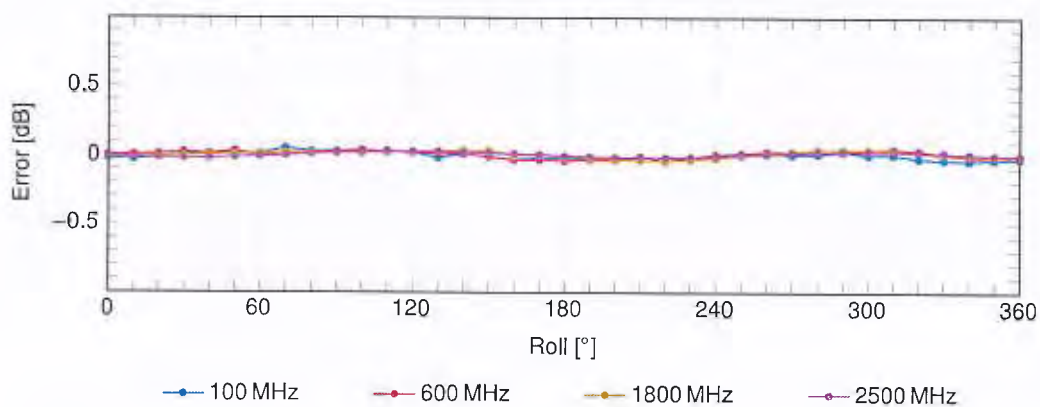
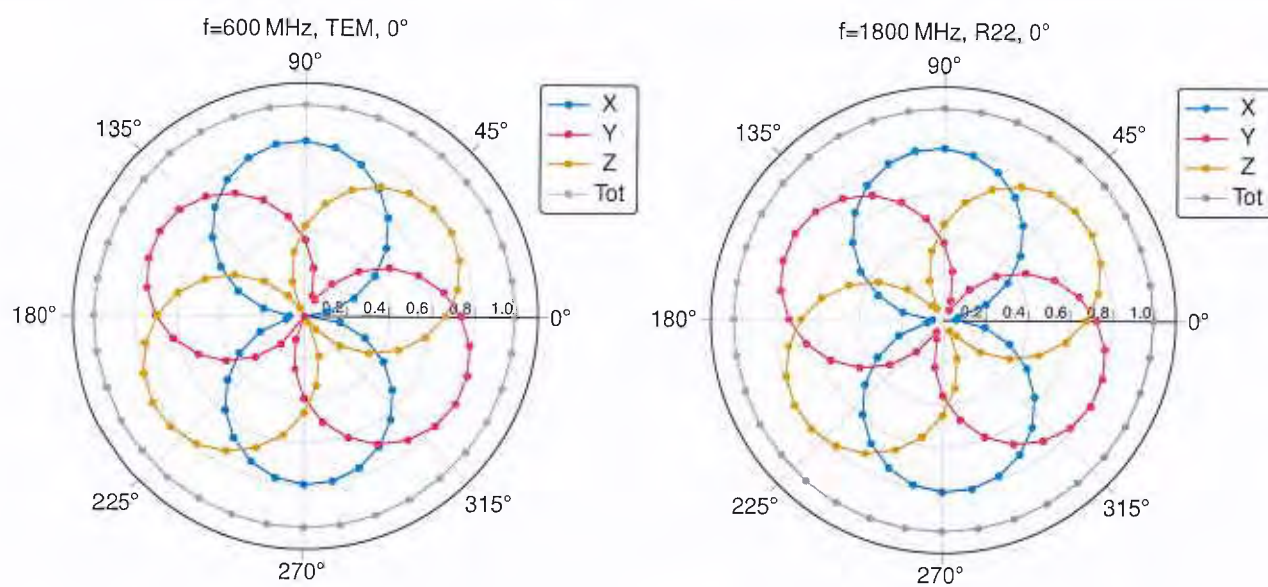
^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

Frequency Response of E-Field

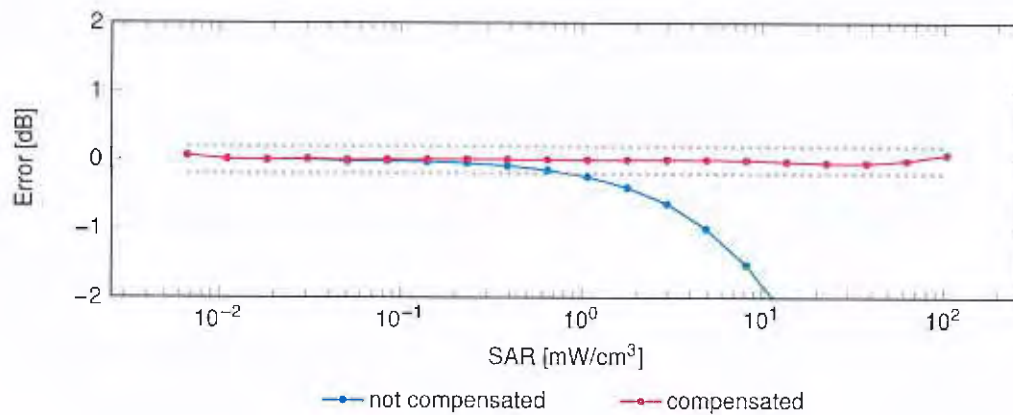
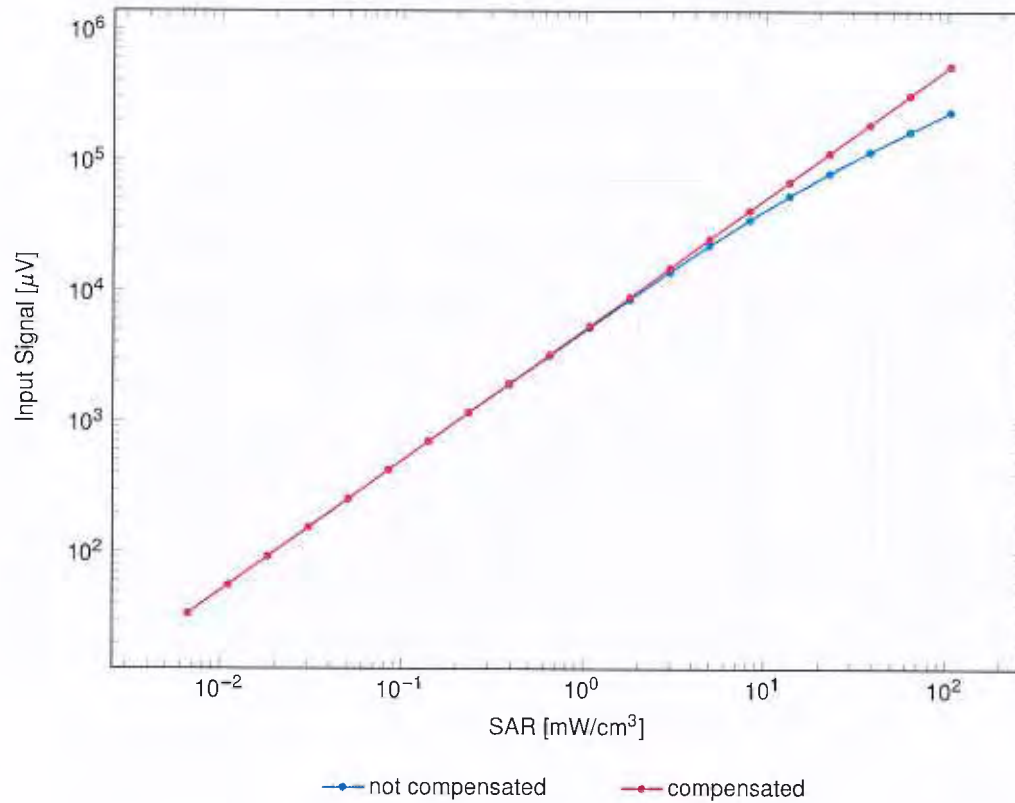
(TEM-Cell:ifi110 EXX, Waveguide:R22)



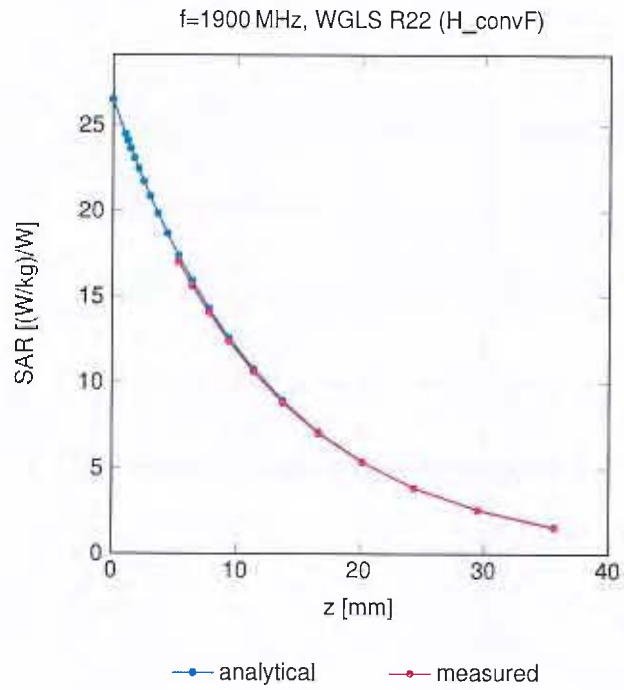
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

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

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

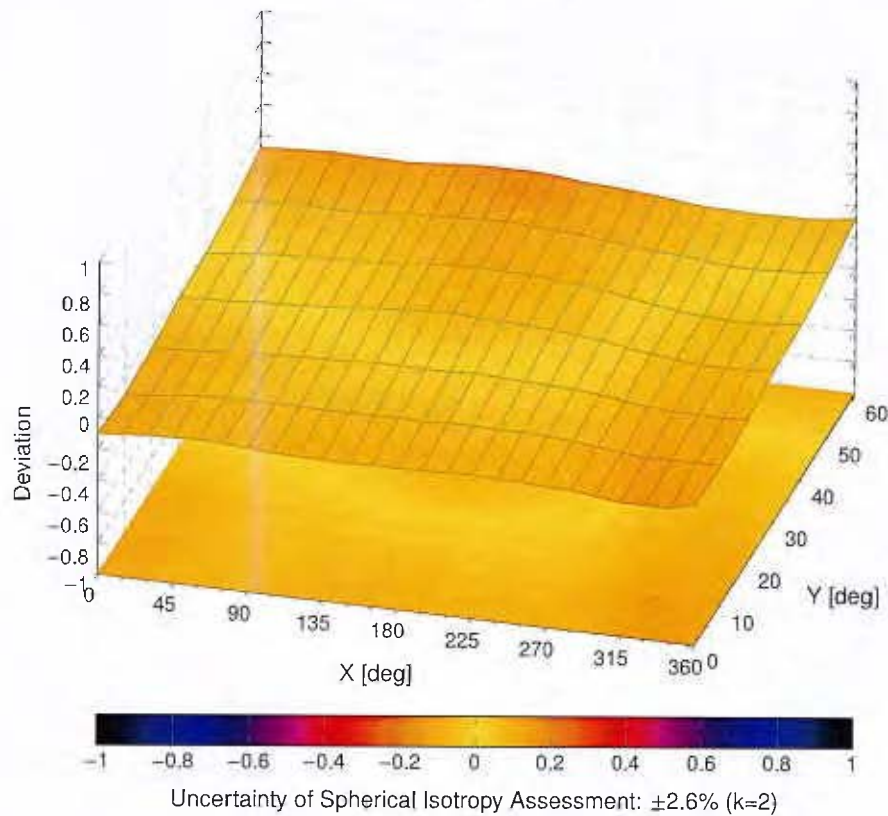
Dynamic Range $f(\text{SAR}_{\text{HSL}})$ (TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$)Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz





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Accreditation No.: SCS 0108

Client
UL
Fremont, USA

Certificate No.
EX-7914_Nov25

CALIBRATION CERTIFICATE

Object
EX3DV4 - SN:7914

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
November 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 ± 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	29-Oct-25 (No. Part of L1407)	Oct-26
N-type mismatch combination	SN: L1119	26-Mar-25 (No. 217-04292)	Mar-26
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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	09-Dec-24 (No. OCP-DAK3.5-1336_Dec24)	Dec-25

	Name	Function	Signature
Calibrated by	Joanna Lleshaj	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	

Issued: November 10, 2025

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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., $\vartheta = 0$ 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 $\vartheta = 0$ ($f \leq 900$ 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:7914

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.62	0.58	0.62	$\pm 10.1\%$
DCP (mV) ^B	106.2	105.5	106.4	$\pm 4.7\%$

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	135.7	$\pm 2.2\%$	$\pm 4.7\%$
		Y	0.00	0.00	1.00		134.5		
		Z	0.00	0.00	1.00		138.2		
10352	Pulse (D=10%, T=5 ms)	X	0.23	59.82	14.67	10.00	23.0	$\pm 1.8\%$	$\pm 9.6\%$
		Y	0.63	70.00	18.17		24.0		
		Z	0.59	69.99	18.19		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.21	62.83	14.71	6.99	46.0	$\pm 1.6\%$	$\pm 9.6\%$
		Y	0.59	73.01	18.22		47.0		
		Z	0.55	73.00	18.25		48.0		
10354	Pulse (D=40%, T=5 ms)	X	0.20	65.84	14.74	3.98	93.0	$\pm 1.4\%$	$\pm 9.6\%$
		Y	0.55	76.02	18.28		95.0		
		Z	0.52	76.02	18.31		95.0		
10355	Pulse (D=60%, T=5 ms)	X	0.19	67.60	14.77	2.22	139.0	$\pm 1.5\%$	$\pm 9.6\%$
		Y	0.53	77.78	18.31		142.0		
		Z	0.49	77.78	18.35		142.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.01	64.72	15.81	0.30	107.0	$\pm 1.4\%$	$\pm 9.6\%$
		Y	0.01	74.90	19.70		109.0		
		Z	0.01	74.90	19.87		110.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	0.66	64.61	13.84	0.00	113.0	$\pm 2.6\%$	$\pm 9.6\%$
		Y	1.71	74.78	17.45		116.0		
		Z	1.75	74.78	17.26		117.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.00	81.15	17.23	1.67	81.0	$\pm 3.8\%$	$\pm 9.6\%$
		Y	0.09	73.73	21.09		83.0		
		Z	0.09	80.68	21.60		83.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	1.68	63.55	12.99	0.00	105.0	$\pm 4.2\%$	$\pm 9.6\%$
		Y	3.91	73.73	17.33		108.0		
		Z	3.98	73.72	17.13		108.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	2.08	61.28	12.90	0.00	76.0	$\pm 2.0\%$	$\pm 9.6\%$
		Y	4.75	71.46	17.33		78.0		
		Z	4.88	71.46	17.12		79.0		

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.

Parameters of Probe: EX3DV4 - SN:7914

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	9.4	68.47	34.07	3.66	0.00	4.90	0.50	0.00	1.00
y	10.4	76.11	34.16	3.73	0.00	4.90	0.40	0.00	1.00
z	10.8	78.46	33.99	4.22	0.00	4.90	0.30	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-20.4°
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:7914

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	9.49	9.32	9.99	0.37	1.27	±11.0%
900	41.5	0.97	9.30	9.14	9.80	0.36	1.27	±11.0%
1750	40.1	1.37	8.12	7.98	8.55	0.35	1.27	±11.0%
1900	40.0	1.40	7.68	7.54	8.09	0.35	1.27	±11.0%
2300	39.5	1.67	7.36	7.23	7.75	0.35	1.27	±11.0%
2450	39.2	1.80	7.02	6.90	7.39	0.35	1.27	±11.0%
2600	39.0	1.96	7.09	6.96	7.47	0.34	1.27	±11.0%
5250	35.9	4.71	5.78	5.68	6.09	0.31	1.27	±13.1%
5600	35.5	5.07	5.30	5.20	5.58	0.28	1.27	±13.1%
5750	35.4	5.22	5.46	5.37	5.75	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 4–8 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.

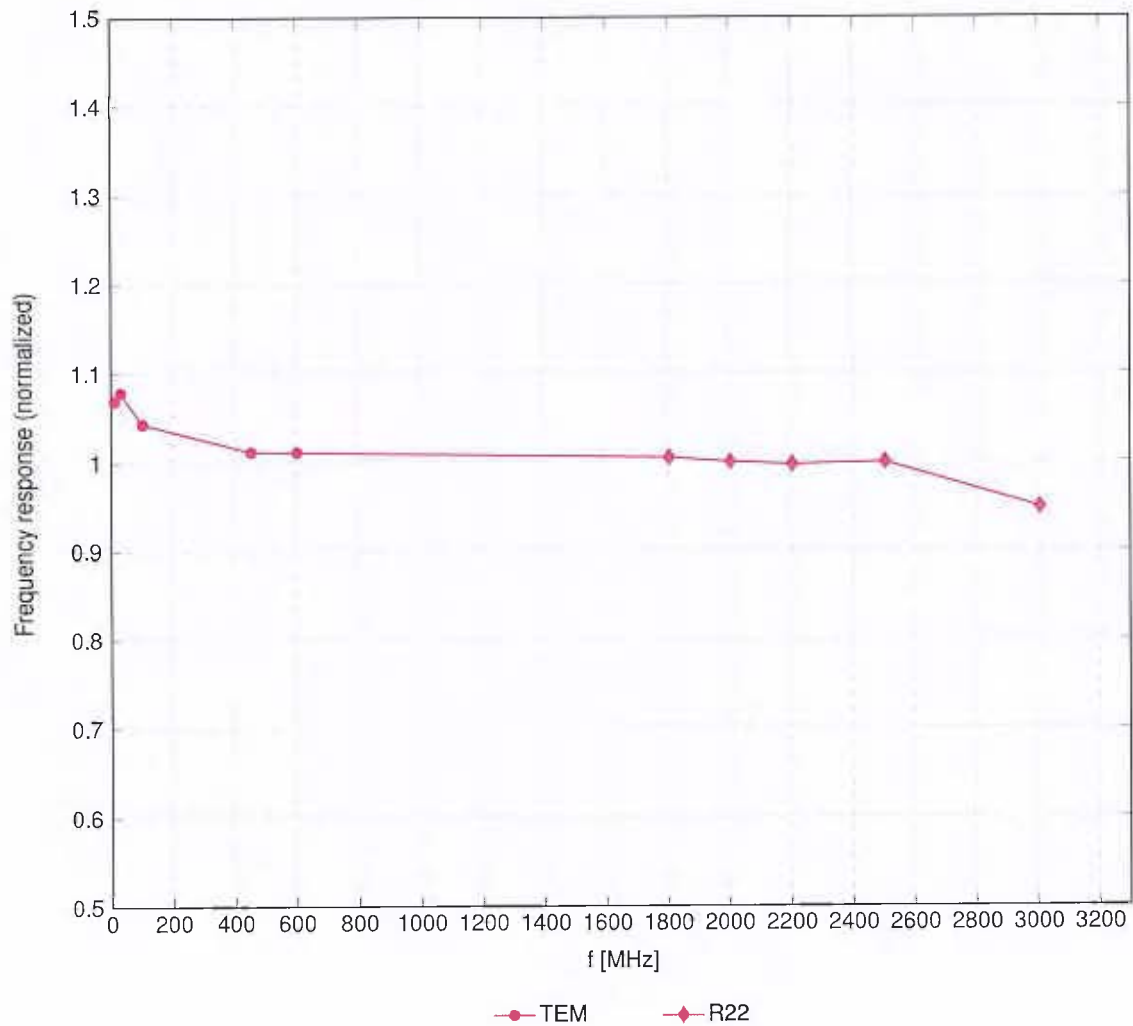
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

^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.

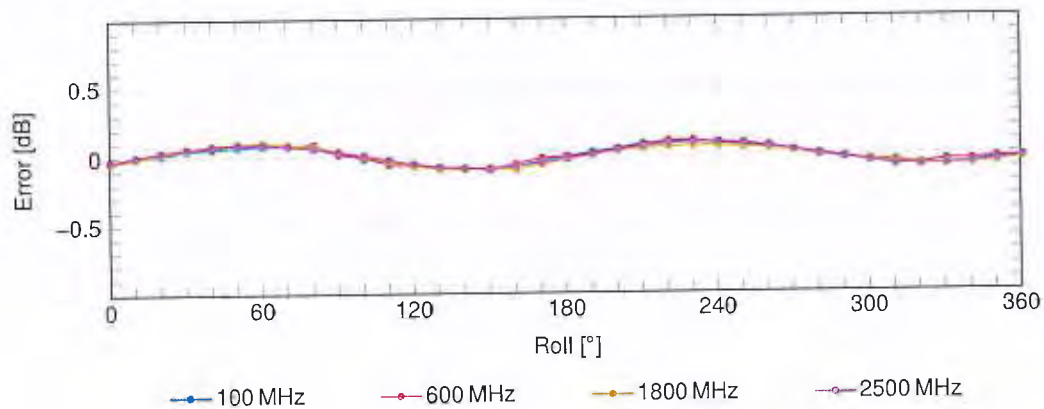
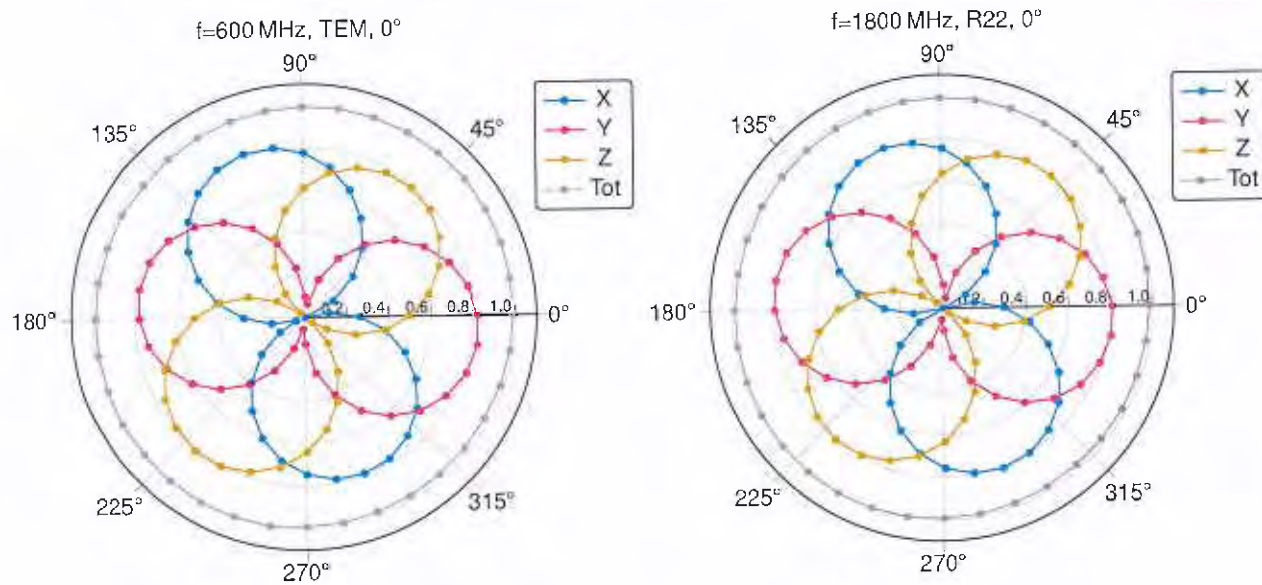
^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

Frequency Response of E-Field

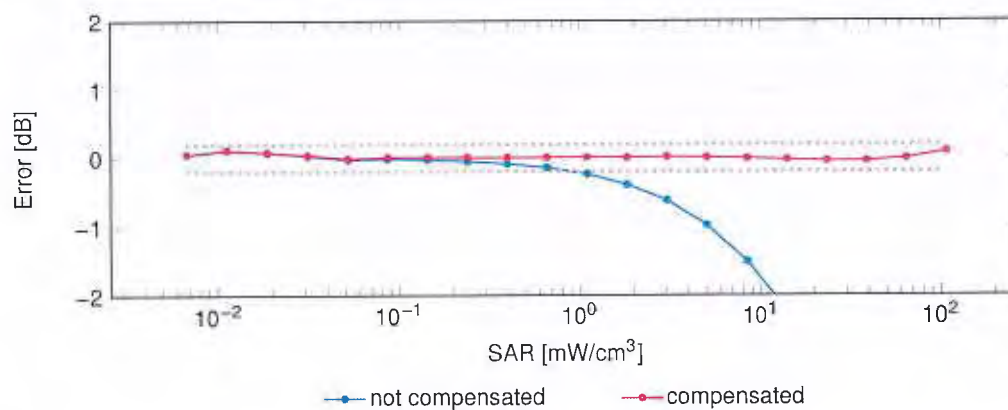
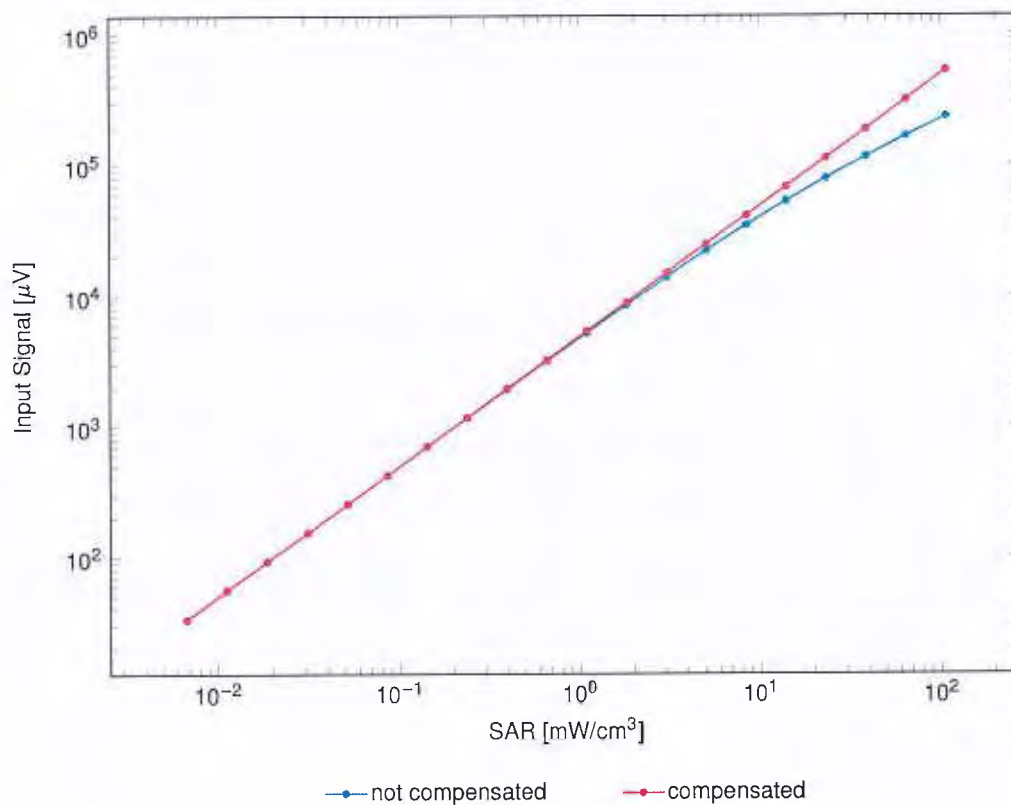
(TEM-Cell:ifi110 EXX, Waveguide:R22)



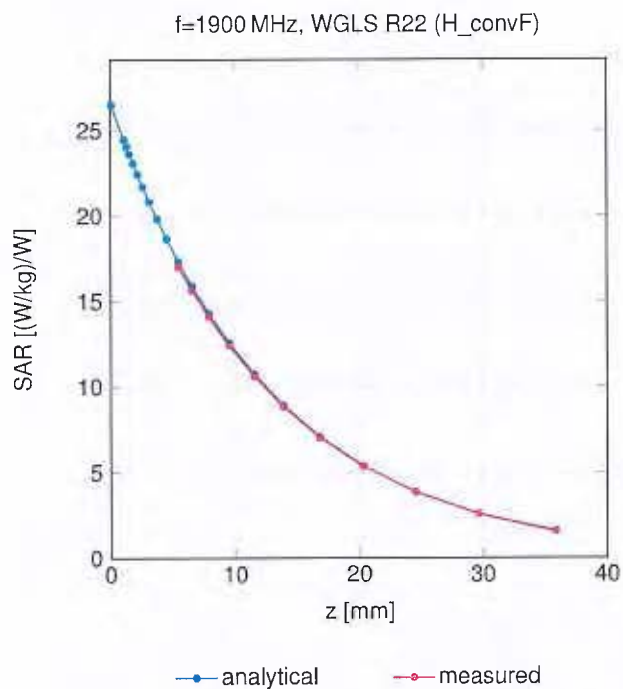
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

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

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

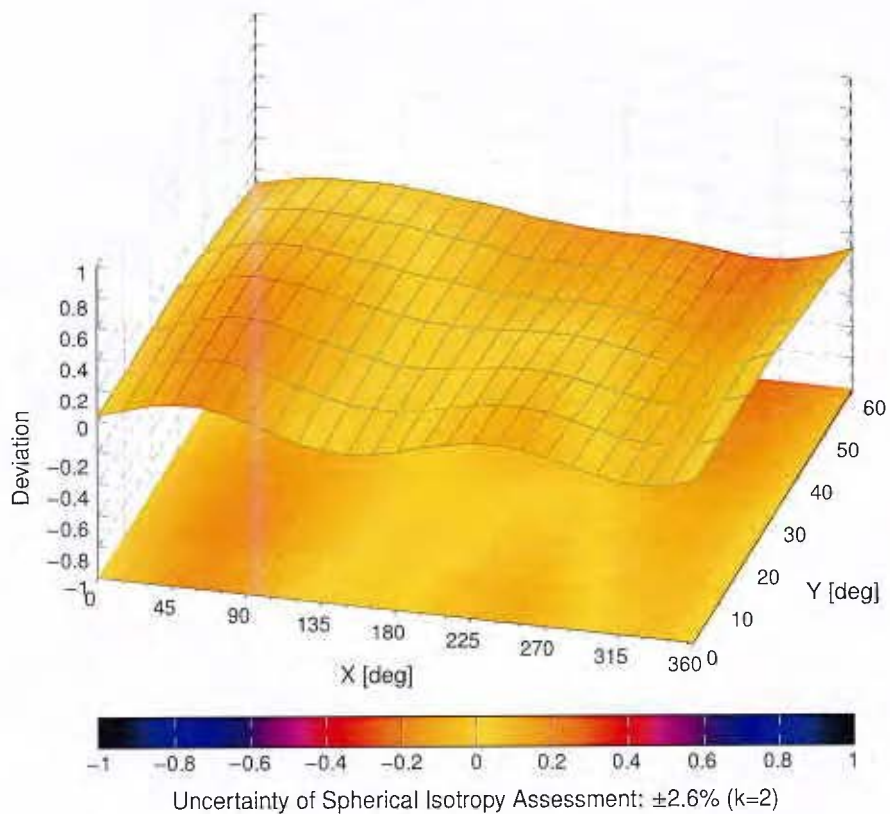
Dynamic Range $f(\text{SAR}_{\text{HSL}})$ (TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$)Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz



Calibration Laboratory ofSchmid & 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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**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

UL

Fremont, USA

Certificate No.

EX-3989_Jan26**CALIBRATION CERTIFICATE**

Object

EX3DV4 - SN:3989

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 15, 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	
Issued: January 15, 2026			
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			



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**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., $\vartheta = 0$ 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 $\vartheta = 0$ ($f \leq 900$ 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:3989

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.53	0.53	0.48	±10.1%
DCP (mV) ^B	101.7	99.3	101.6	±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	145.9	±1.7%	±4.7%
		Y	0.00	0.00	1.00		141.0		
		Z	0.00	0.00	1.00		138.6		
10352	Pulse (D=10%, T=5 ms)	X	0.76	60.78	13.73	10.00	24.0	±1.4%	±9.6%
		Y	0.85	60.40	13.53		25.0		
		Z	0.74	60.82	13.93		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.70	63.79	13.71	6.99	48.0	±1.2%	±9.6%
		Y	0.78	63.41	13.49		49.0		
		Z	0.68	63.83	13.91		49.0		
10354	Pulse (D=40%, T=5 ms)	X	0.63	66.80	13.68	3.98	95.0	±1.2%	±9.6%
		Y	0.70	66.42	13.43		98.0		
		Z	0.62	66.84	13.89		97.0		
10355	Pulse (D=60%, T=5 ms)	X	0.59	68.56	13.67	2.22	142.0	±1.3%	±9.6%
		Y	0.66	68.19	13.40		147.0		
		Z	0.58	68.60	13.87		145.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.62	65.68	13.68	0.00	115.0	±1.7%	±9.6%
		Y	0.74	65.30	13.46		119.0		
		Z	0.62	65.72	13.89		117.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	1.62	65.56	13.89	0.00	123.0	±1.4%	±9.6%
		Y	1.64	65.19	13.82		127.0		
		Z	1.61	65.60	14.09		125.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.01	64.51	12.86	0.96	84.0	±1.5%	±9.6%
		Y	0.05	64.13	11.72		87.0		
		Z	0.00	64.54	13.11		85.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	2.48	64.51	13.92	0.00	113.0	±3.4%	±9.6%
		Y	2.44	64.13	13.88		118.0		
		Z	2.46	64.54	14.12		116.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	3.76	62.24	13.93	0.00	92.0	±1.5%	±9.6%
		Y	3.74	61.87	13.90		96.0		
		Z	3.67	62.28	14.13		94.0		

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 E²-field uncertainty inside TSL (see Pages 5 to 7).

^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.

Parameters of Probe: EX3DV4 - SN:3989

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	38.1	279.21	34.12	15.46	0.26	5.04	1.43	0.18	1.01
y	44.1	326.02	34.70	19.28	0.00	5.09	0.97	0.29	1.01
z	37.4	274.58	34.24	11.19	0.35	5.04	1.89	0.11	1.01

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	79.9°
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:3989

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	22.02	20.69	21.98	0.00	1.25	±13.3%
13	55.0	0.75	19.44	18.26	19.40	0.00	1.25	±13.3%
30	55.0	0.75	17.66	16.59	17.62	0.00	1.25	±13.3%
64	54.2	0.75	15.35	14.42	15.31	0.00	1.25	±13.3%
450	43.5	0.87	11.34	11.34	11.34	0.16	1.30	±13.3%
750	41.9	0.89	10.30	9.74	9.84	0.39	1.27	±11.0%
900	41.5	0.97	9.95	9.41	9.51	0.39	1.27	±11.0%
1450	40.5	1.20	8.81	8.33	8.42	0.38	1.27	±11.0%
1640	40.2	1.31	8.60	8.14	8.23	0.38	1.27	±11.0%
1750	40.1	1.37	8.52	8.06	8.14	0.38	1.27	±11.0%
1900	40.0	1.40	8.18	7.74	7.82	0.38	1.27	±11.0%
2100	39.8	1.49	7.96	7.53	7.61	0.38	1.27	±11.0%
2300	39.5	1.67	7.74	7.32	7.40	0.38	1.27	±11.0%
2450	39.2	1.80	7.62	7.21	7.29	0.38	1.27	±11.0%
2600	39.0	1.96	7.52	7.11	7.19	0.38	1.27	±11.0%
3300	38.2	2.71	7.03	6.65	6.72	0.37	1.27	±13.1%
3500	37.9	2.91	6.98	6.61	6.68	0.37	1.27	±13.1%
3700	37.7	3.12	6.94	6.56	6.63	0.37	1.27	±13.1%
3900	37.5	3.32	6.83	6.46	6.53	0.37	1.27	±13.1%
4100	37.2	3.53	6.75	6.38	6.45	0.37	1.27	±13.1%
4200	37.1	3.63	6.70	6.34	6.40	0.37	1.27	±13.1%
4400	36.9	3.84	6.59	6.23	6.30	0.36	1.27	±13.1%
4600	36.7	4.04	6.53	6.18	6.25	0.36	1.27	±13.1%
4800	36.4	4.25	6.48	6.13	6.20	0.36	1.27	±13.1%
4950	36.3	4.40	6.38	6.03	6.10	0.35	1.27	±13.1%
5250	35.9	4.71	6.13	5.80	5.86	0.32	1.27	±13.1%
5600	35.5	5.07	5.65	5.34	5.40	0.29	1.27	±13.1%
5750	35.4	5.22	5.73	5.42	5.48	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.

Parameters of Probe: EX3DV4 - SN:3989

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)
5850	35.2	5.32	5.49	5.19	5.25	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.

Parameters of Probe: EX3DV4 - SN:3989

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	5.91	5.59	5.65	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.

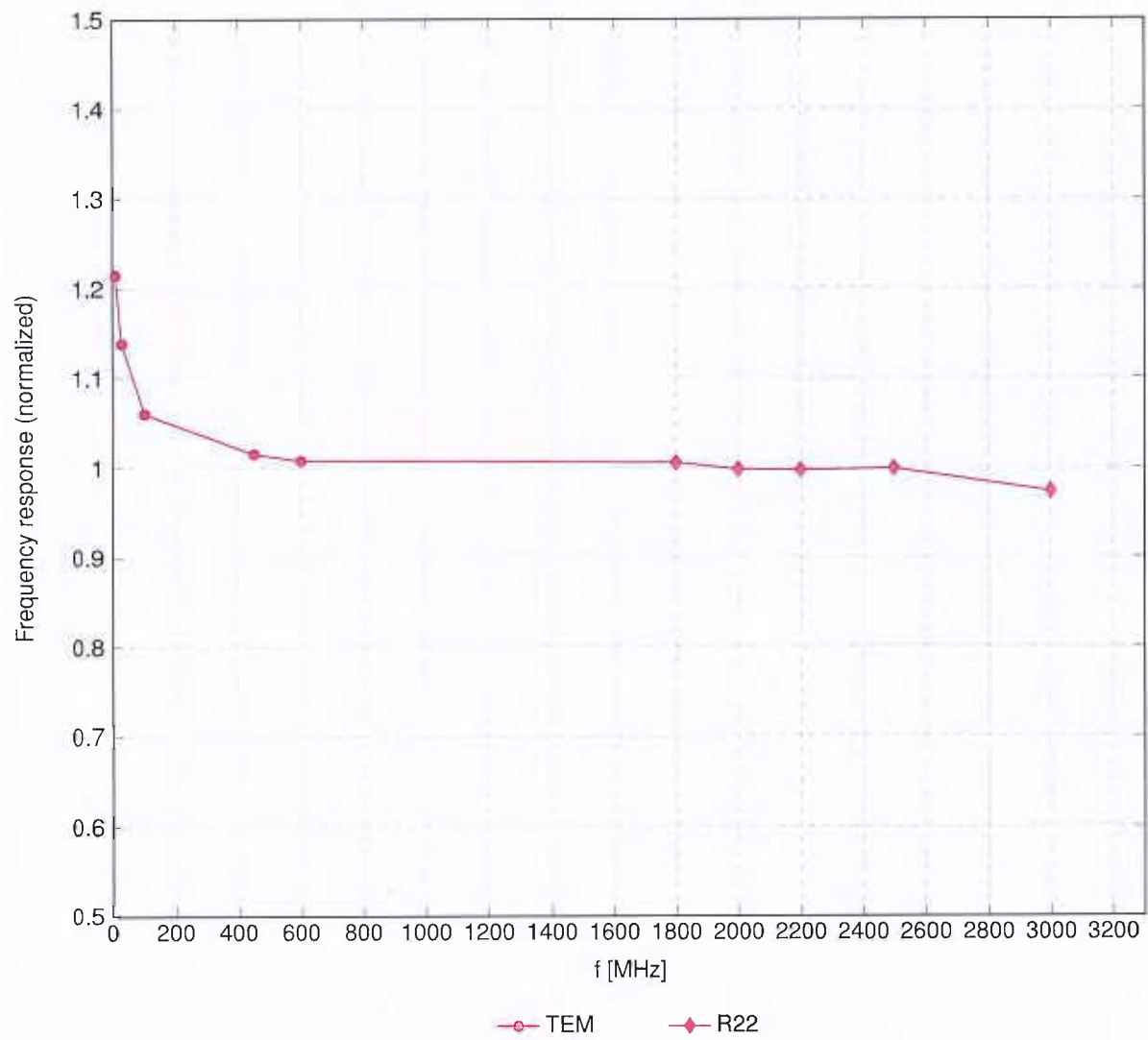
^F The probes are calibrated using tissue simulating liquids (TSL) that deviate for ϵ and σ by less than ±10% from the target values (typically better than ±6%) and are valid for TSL with deviations of up to ±10%.

^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.

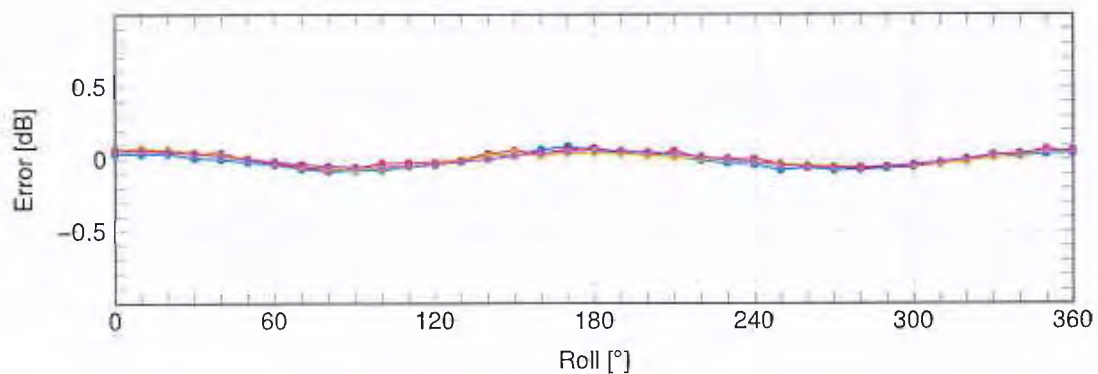
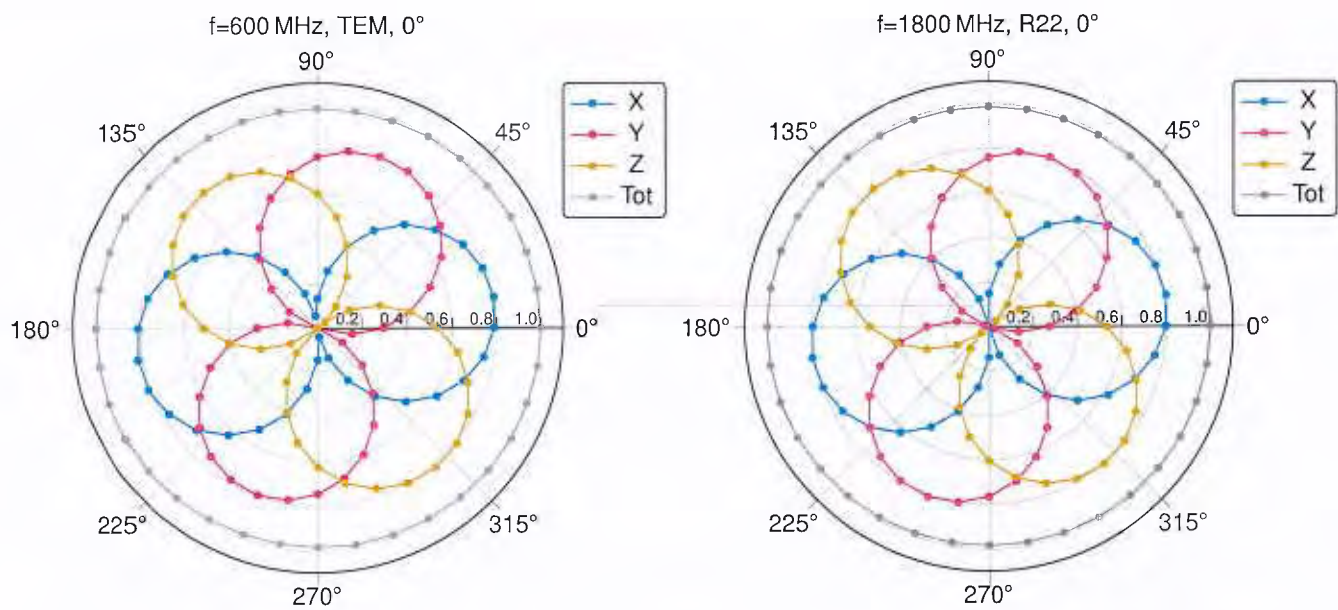
^H The stated uncertainty is the total calibration uncertainty (k = 2) of Norm-ConvF. This is equivalent to the uncertainty component with the symbol CF in Table 9 of IEC/IEEE 62209-1528:2020.

Frequency Response of E-Field

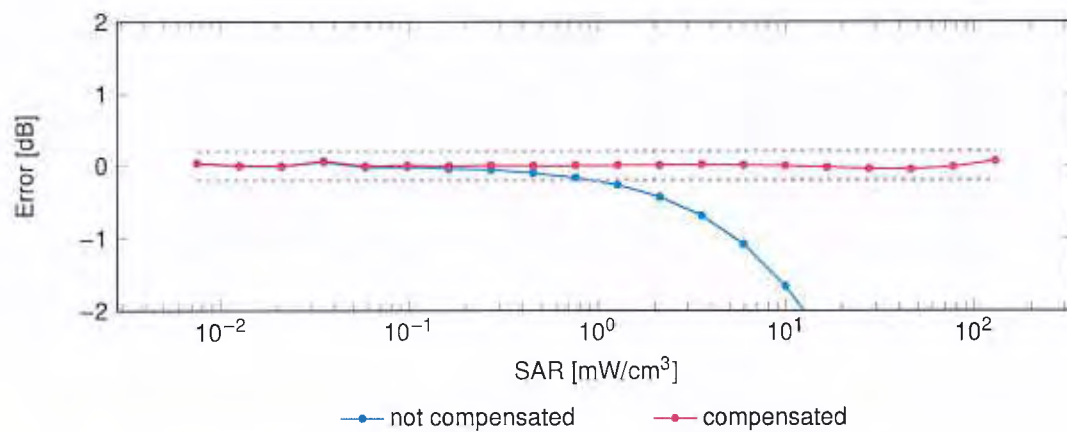
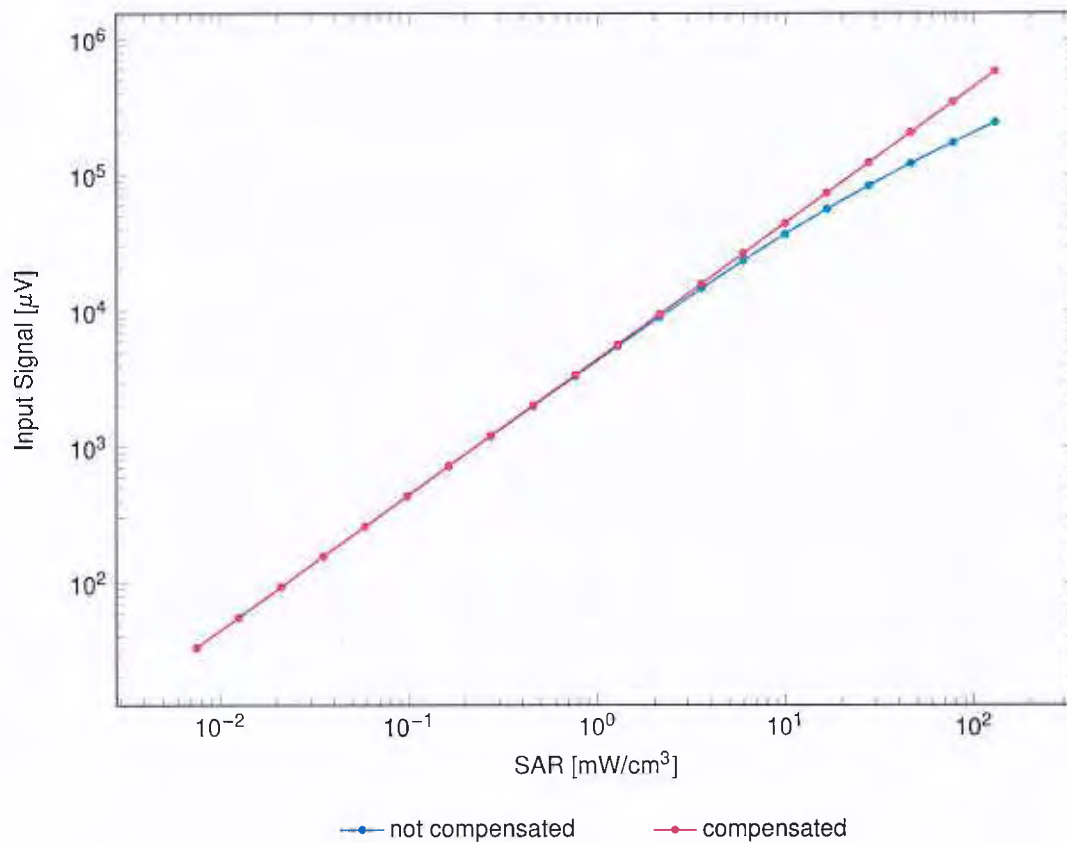
(TEM-Cell:ifi110 EXX, Waveguide:R22)



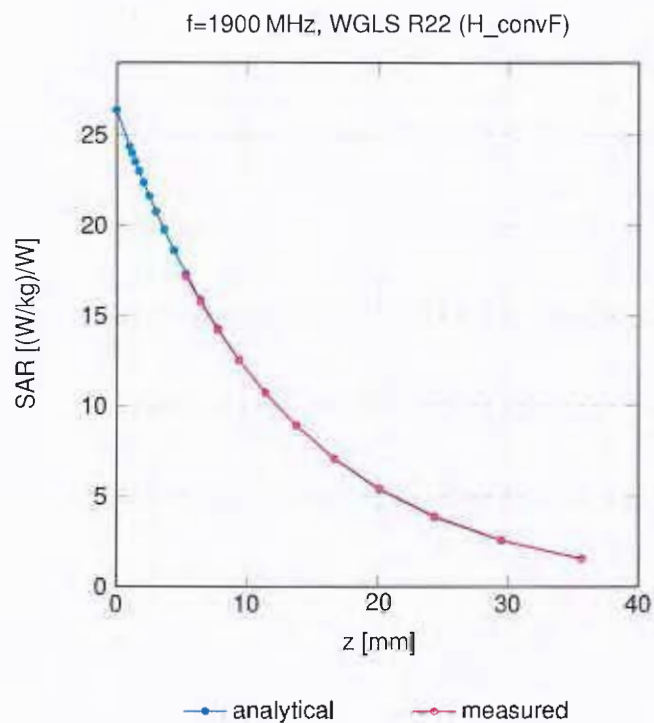
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

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

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

Dynamic Range $f(\text{SAR}_{\text{HSL}})$ (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

Error (ϕ, θ), f = 900 MHz

