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

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S Swiss Calibration Service

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Accreditation No.: SCS 0108

Client	**UL** **Fremont, USA**	**Certificate No.**	**EX-7810_May26**

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:7810
Calibration procedure(s)	QA CAL-01.v10, QA CAL-12.v10, QA CAL-14.v7, QA CAL-23.v6, QA CAL-25.v8, QA CAL-48.v2 Calibration procedure for dosimetric E-field probes
Calibration date	May 06, 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 ± 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 NRP40T	SN: 101861	22-Apr-26 (No. 2026-007003)	Apr-27
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	Signature
Calibrated by	Henrique Almeida	Laboratory Technician	Henrique Almeida
Approved by	Sven Kühn	Technical Manager	

Issued: May 06, 2026

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Glossary

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,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:

a) 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.
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,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.
- *DCPx,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
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,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 *NORMx,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 *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:7810

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.59	0.70	0.66	±10.1%
DCP (mV) [B]	107.8	105.6	104.2	±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	131.0	±2.2%	±4.7%
		Y	0.00	0.00	1.00		143.0		
		Z	0.00	0.00	1.00		140.9		
10352	Pulse (D=10%, T=5 ms)	X	0.42	61.01	15.31	10.00	23.0	±1.8%	±9.6%
		Y	0.34	59.76	14.68		24.0		
		Z	0.35	60.69	15.04		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.38	64.02	15.44	6.99	46.0	±1.4%	±9.6%
		Y	0.31	62.77	14.75		48.0		
		Z	0.33	63.70	15.10		48.0		
10354	Pulse (D=40%, T=5 ms)	X	0.34	67.03	15.57	3.98	92.0	±1.7%	±9.6%
		Y	0.28	65.78	14.83		96.0		
		Z	0.31	66.71	15.15		96.0		
10355	Pulse (D=60%, T=5 ms)	X	0.31	68.79	15.68	2.22	138.0	±1.9%	±9.6%
		Y	0.26	67.54	14.90		144.0		
		Z	0.29	68.47	15.19		144.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.00	65.91	18.35	0.51	103.0	±1.6%	±9.6%
		Y	0.00	81.89	16.57		108.0		
		Z	0.02	83.02	16.49		109.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	0.51	65.80	15.02	0.00	109.0	±2.9%	±9.6%
		Y	0.55	64.54	14.18		115.0		
		Z	0.66	65.48	14.47		115.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.03	64.74	19.16	1.03	83.0	±1.9%	±9.6%
		Y	0.03	81.62	17.79		88.0		
		Z	0.00	46.08	17.78		88.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	1.81	64.74	13.16	0.00	101.0	±3.8%	±9.6%
		Y	1.66	63.48	12.93		107.0		
		Z	1.76	64.42	13.59		107.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	1.93	62.47	13.11	0.00	71.0	±2.7%	±9.6%
		Y	1.84	61.22	12.86		75.0		
		Z	2.07	62.16	13.53		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 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:7810

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	6.1	43.70	32.65	3.84	0.00	4.90	0.64	0.00	1.00
y	7.0	50.58	33.69	2.90	0.00	4.90	0.28	0.00	1.00
z	7.9	57.41	34.11	2.32	0.00	4.90	0.30	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	46.2°
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:7810

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	9.79	9.49	9.74	0.33	1.27	±11.0%
900	41.5	0.97	9.11	8.83	9.07	0.33	1.27	±11.0%
1450	40.5	1.20	8.34	8.09	8.30	0.34	1.27	±11.0%
1640	40.2	1.31	8.21	7.96	8.17	0.34	1.27	±11.0%
1750	40.1	1.37	8.14	7.89	8.10	0.34	1.27	±11.0%
1900	40.0	1.40	8.03	7.78	7.99	0.34	1.27	±11.0%
2100	39.8	1.49	7.89	7.64	7.85	0.34	1.27	±11.0%
2300	39.5	1.67	7.74	7.50	7.70	0.35	1.27	±11.0%
2450	39.2	1.80	7.62	7.39	7.58	0.35	1.27	±11.0%
2600	39.0	1.96	7.50	7.27	7.47	0.35	1.27	±11.0%
3300	38.2	2.71	6.62	6.42	6.59	0.36	1.27	±13.1%
3500	37.9	2.91	6.69	6.48	6.66	0.36	1.27	±13.1%
3700	37.7	3.12	6.69	6.49	6.66	0.36	1.27	±13.1%
3900	37.5	3.32	6.57	6.37	6.54	0.37	1.27	±13.1%
4100	37.2	3.53	6.45	6.25	6.42	0.37	1.27	±13.1%
4200	37.1	3.63	6.40	6.20	6.37	0.37	1.27	±13.1%
4400	36.9	3.84	6.30	6.10	6.27	0.37	1.27	±13.1%
4600	36.7	4.04	6.21	6.02	6.18	0.38	1.27	±13.1%
4800	36.4	4.25	6.13	5.94	6.10	0.38	1.27	±13.1%
4950	36.3	4.40	6.05	5.87	6.03	0.36	1.27	±13.1%
5250	35.9	4.71	5.59	5.41	5.56	0.33	1.27	±13.1%
5600	35.5	5.07	5.02	4.86	4.99	0.29	1.27	±13.1%
5750	35.4	5.22	5.02	4.86	4.99	0.28	1.27	±13.1%
5850	35.2	5.32	5.11	4.95	5.08	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:7810

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	5.45	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.

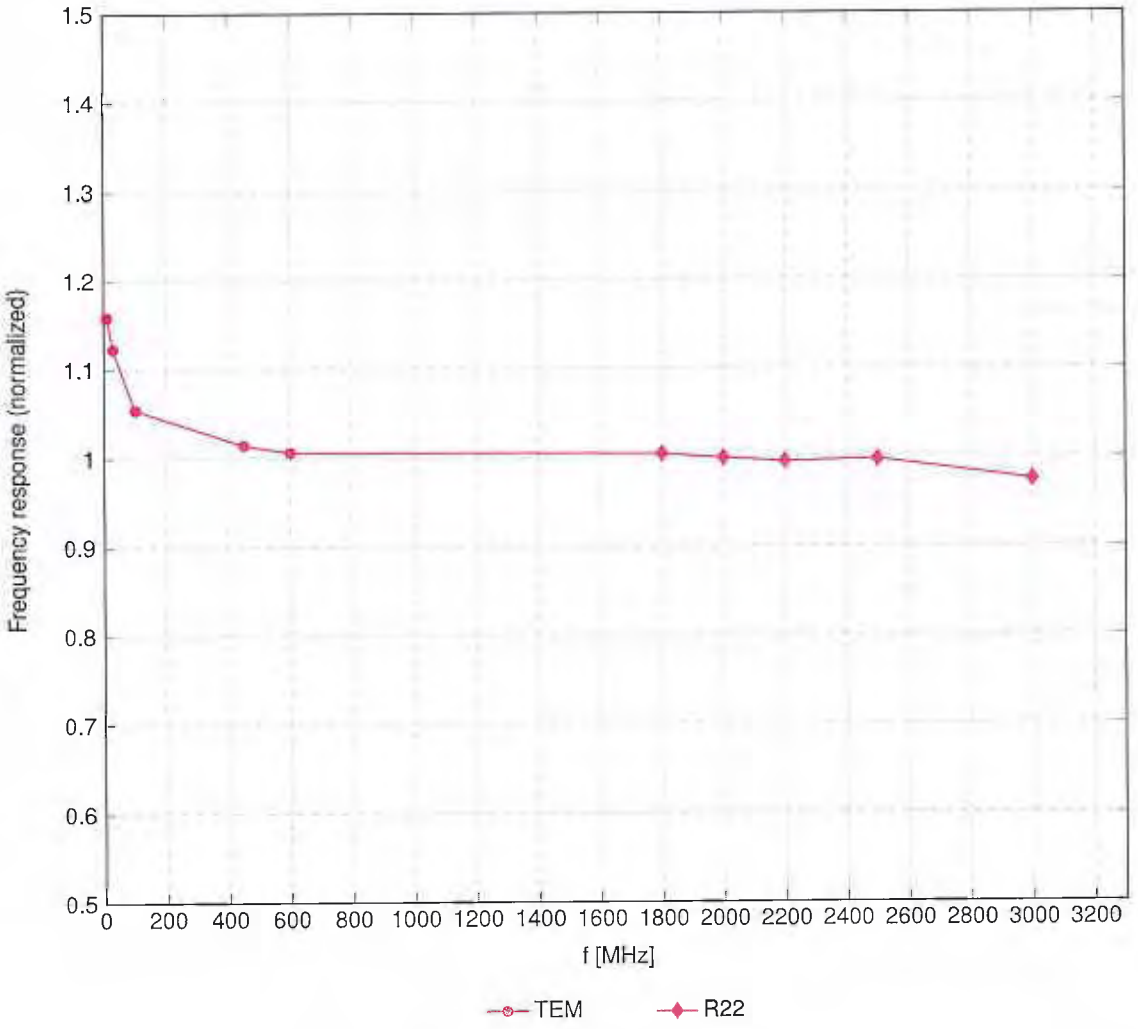
[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±10% from the target values (typically better than ±6%) and are valid for TSL with deviations of up to ±10%.

[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.

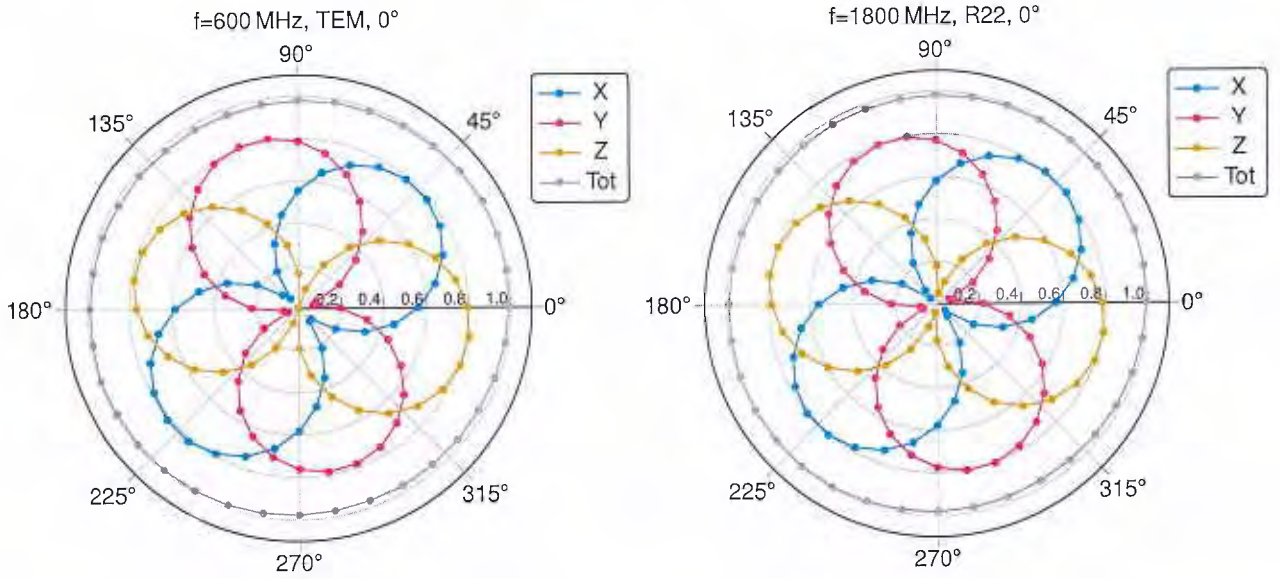
Frequency Response of E-Field

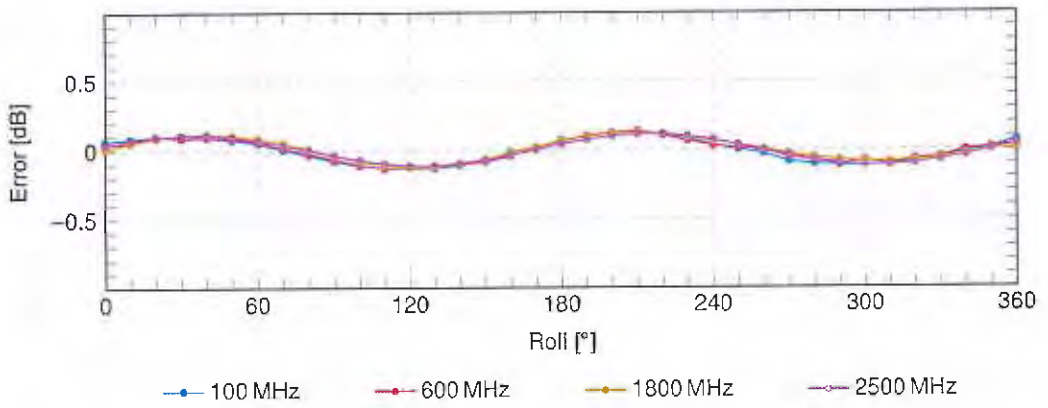
(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$

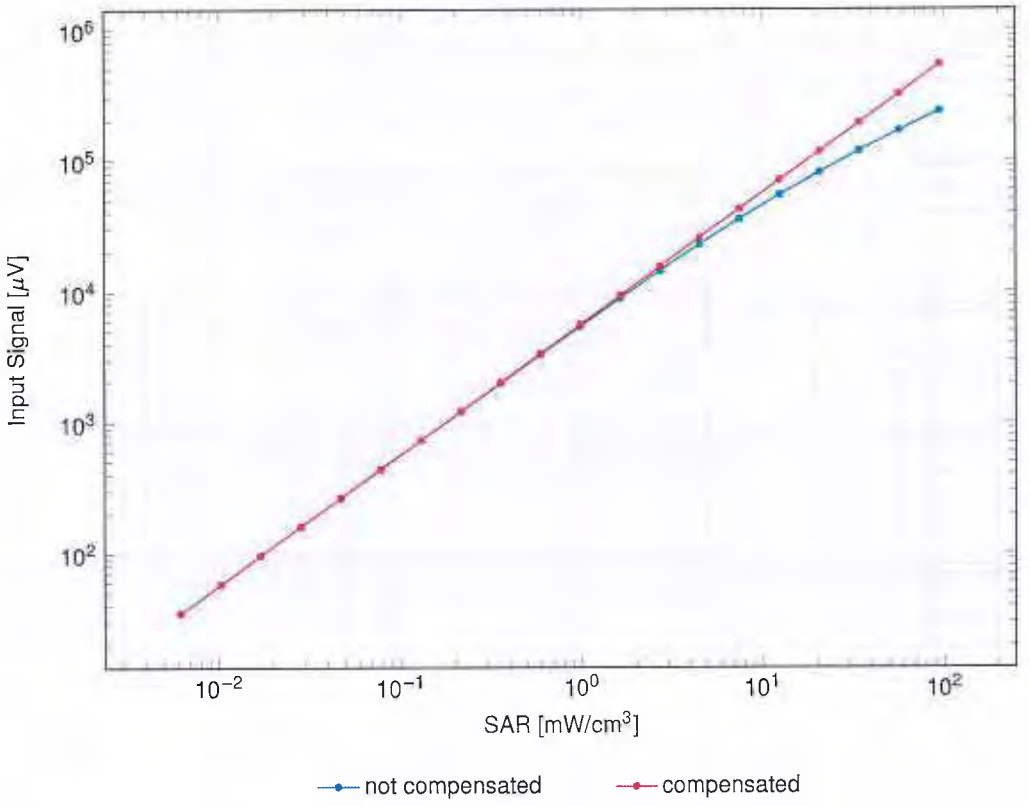


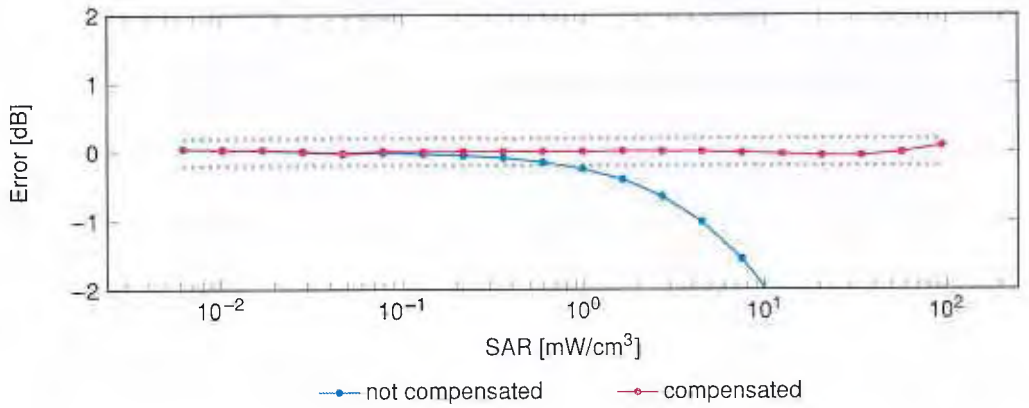


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Dynamic Range f(SAR_{HSL})

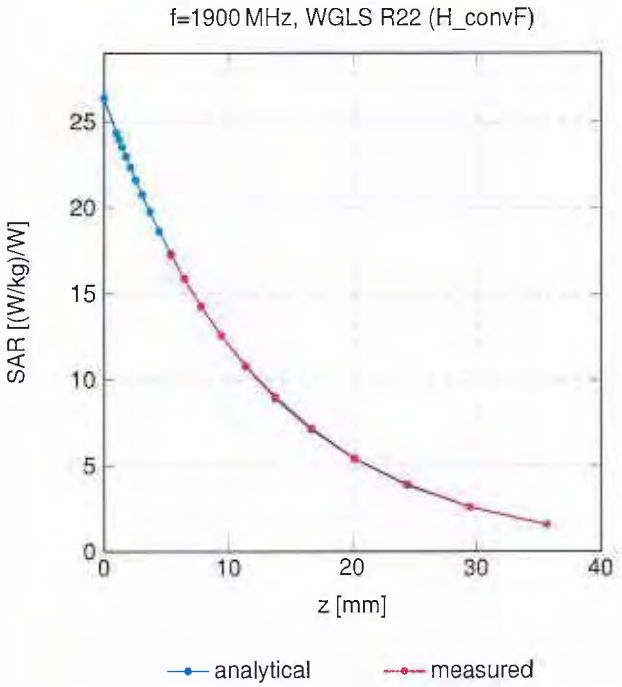
(TEM cell, f_{eval} = 1900 MHz)



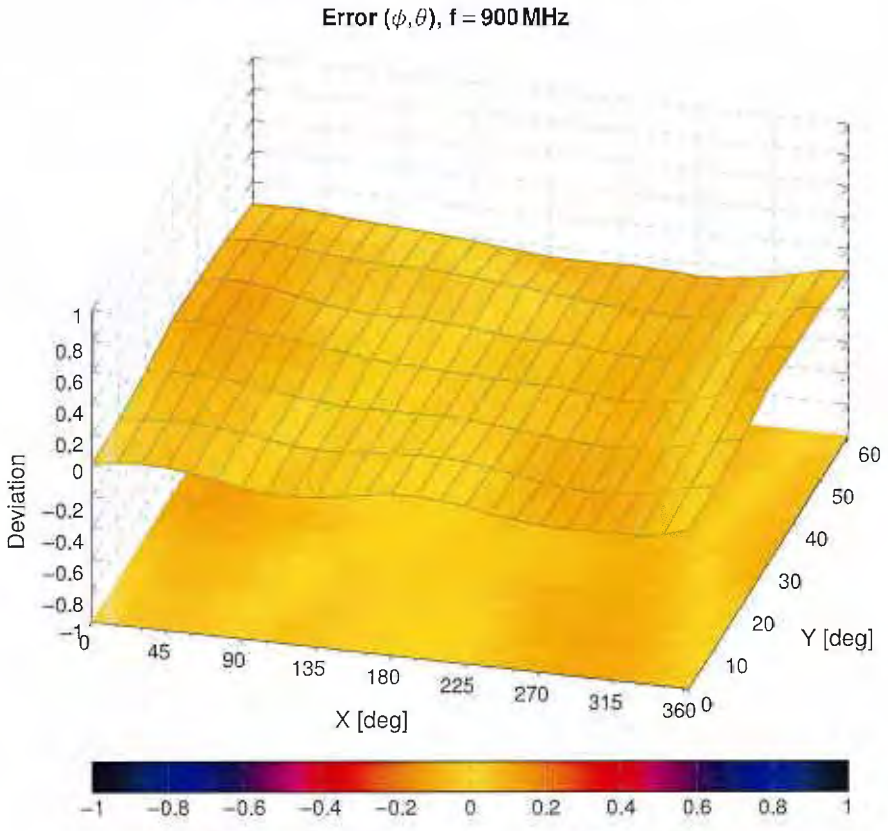


Uncertainty of Linearity Assessment: ±0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: ±2.6% (k=2)

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Accreditation No.: SCS 0108

Client UL
Fremont, USA

Certificate No. EX-7482_Apr26

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:7482
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 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.

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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
Network Analyzer Keysight E5063A	SN: MY54504221	30-Sept-24 (No. 675-CAL18-S4489-Sep24)	Sep-26

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

Issued: April 16, 2026

Glossary

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,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:

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- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
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- *PAR*: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,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 $f \le 800$ 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 *NORMx,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 *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:7482

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.47	0.60	0.61	±10.1%
DCP (mV) [B]	96.8	97.5	98.0	±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	138.6	±1.0%	±4.7%
		Y	0.00	0.00	1.00		125.5		
		Z	0.00	0.00	1.00		128.4		
10352	Pulse (D=10%, T=5 ms)	X	0.72	64.69	15.99	10.00	24.0	±1.4%	±9.6%
		Y	0.63	60.68	13.83		24.0		
		Z	0.61	60.40	13.64		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.66	67.70	15.99	6.99	47.0	±1.2%	±9.6%
		Y	0.57	63.69	13.81		49.0		
		Z	0.56	63.41	13.61		48.0		
10354	Pulse (D=40%, T=5 ms)	X	0.59	70.71	15.99	3.98	93.0	±1.1%	±9.6%
		Y	0.51	66.70	13.78		97.0		
		Z	0.50	66.42	13.58		96.0		
10355	Pulse (D=60%, T=5 ms)	X	0.55	72.48	15.99	2.22	140.0	±1.2%	±9.6%
		Y	0.48	68.46	13.77		145.0		
		Z	0.46	68.18	13.57		144.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.63	69.60	15.99	0.00	114.0	±1.9%	±9.6%
		Y	0.59	65.58	13.81		118.0		
		Z	0.60	65.30	13.63		117.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	1.94	69.48	16.00	0.00	121.0	±1.6%	±9.6%
		Y	1.58	65.47	14.02		126.0		
		Z	1.55	65.18	13.86		125.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.13	68.42	15.94	1.27	83.0	±2.9%	±9.6%
		Y	0.00	64.41	13.06		86.0		
		Z	0.02	64.12	12.78		85.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	3.08	68.42	16.00	0.00	113.0	±3.6%	±9.6%
		Y	2.44	64.41	14.05		118.0		
		Z	2.39	64.12	13.90		117.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	4.64	66.16	16.00	0.00	91.0	±1.3%	±9.6%
		Y	3.66	62.15	14.06		96.0		
		Z	3.63	61.86	13.91		95.0		

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:7482

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	31.9	242.45	36.53	5.80	0.00	4.95	0.33	0.20	1.00
y	36.6	275.65	35.86	7.23	0.00	5.03	0.94	0.22	1.01
z	38.7	291.19	35.76	14.02	0.00	4.95	0.01	0.36	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	78.0°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	12 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

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

Parameters of Probe: EX3DV4 - SN:7482

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	9.33	9.23	10.07	0.34	1.27	±11.0%
900	41.5	0.97	8.64	8.55	9.32	0.34	1.27	±11.0%
1750	40.1	1.37	7.61	7.53	8.21	0.35	1.27	±11.0%
1900	40.0	1.40	7.50	7.43	8.09	0.35	1.27	±11.0%
2300	39.5	1.67	7.22	7.14	7.79	0.36	1.27	±11.0%
2600	39.0	1.96	7.00	6.93	7.55	0.36	1.27	±11.0%
3300	38.2	2.71	6.52	6.45	7.03	0.37	1.27	±13.1%
3500	37.9	2.91	6.39	6.33	6.90	0.37	1.27	±13.1%
3700	37.7	3.12	6.28	6.22	6.78	0.37	1.27	±13.1%
3900	37.5	3.32	6.17	6.11	6.66	0.38	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.

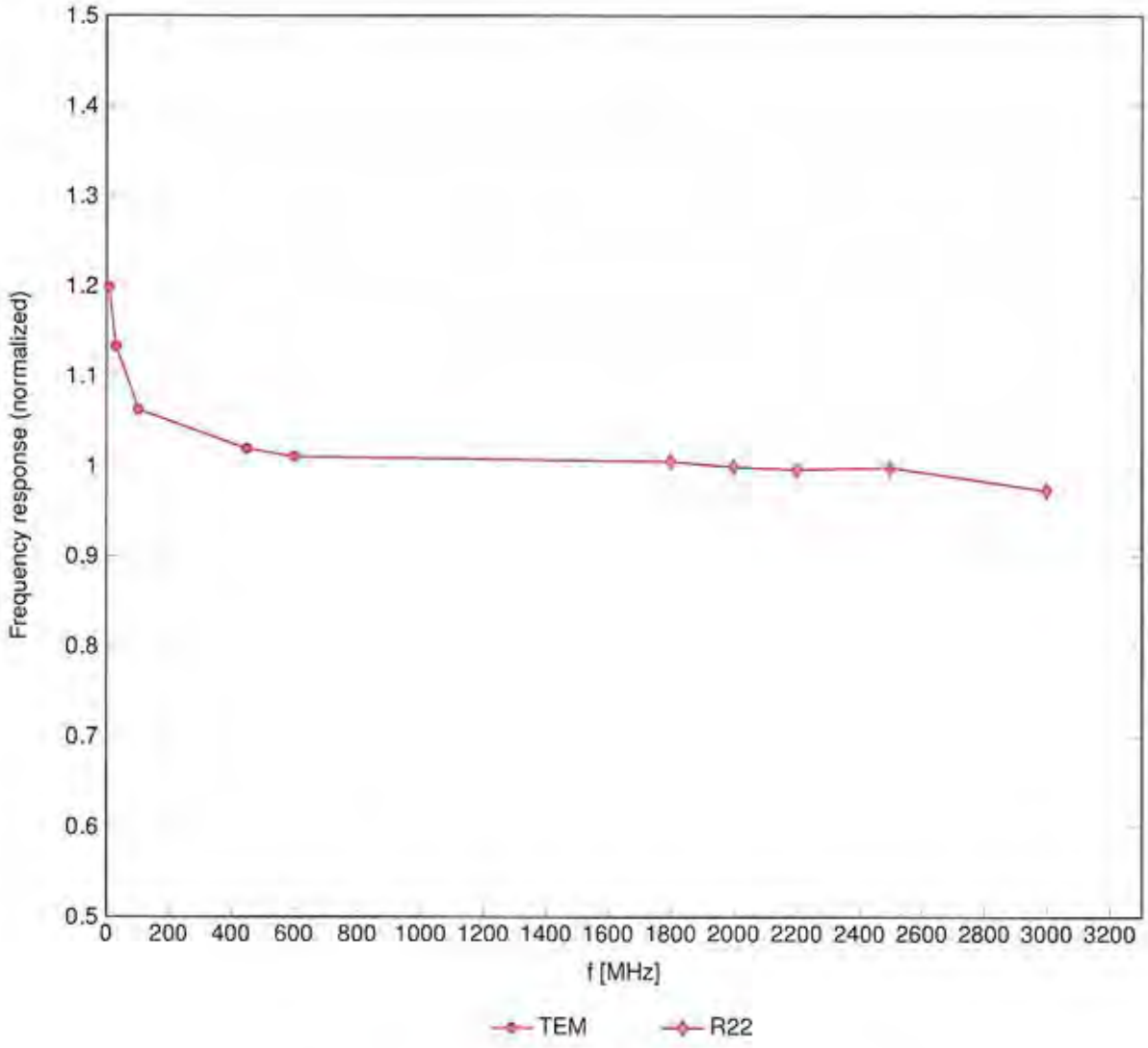
[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

[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.

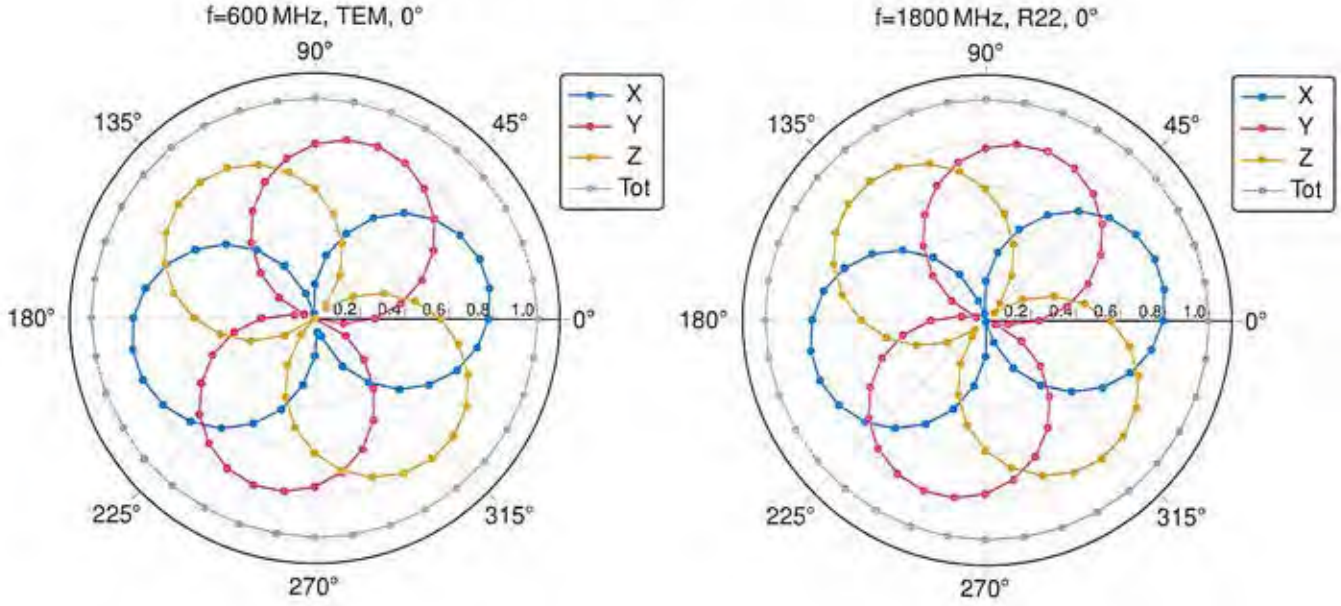
Frequency Response of E-Field

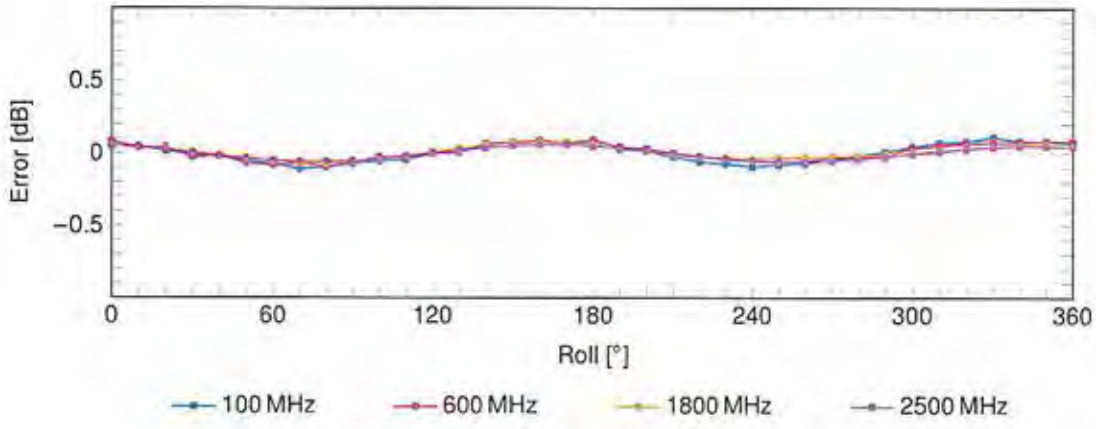
(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$

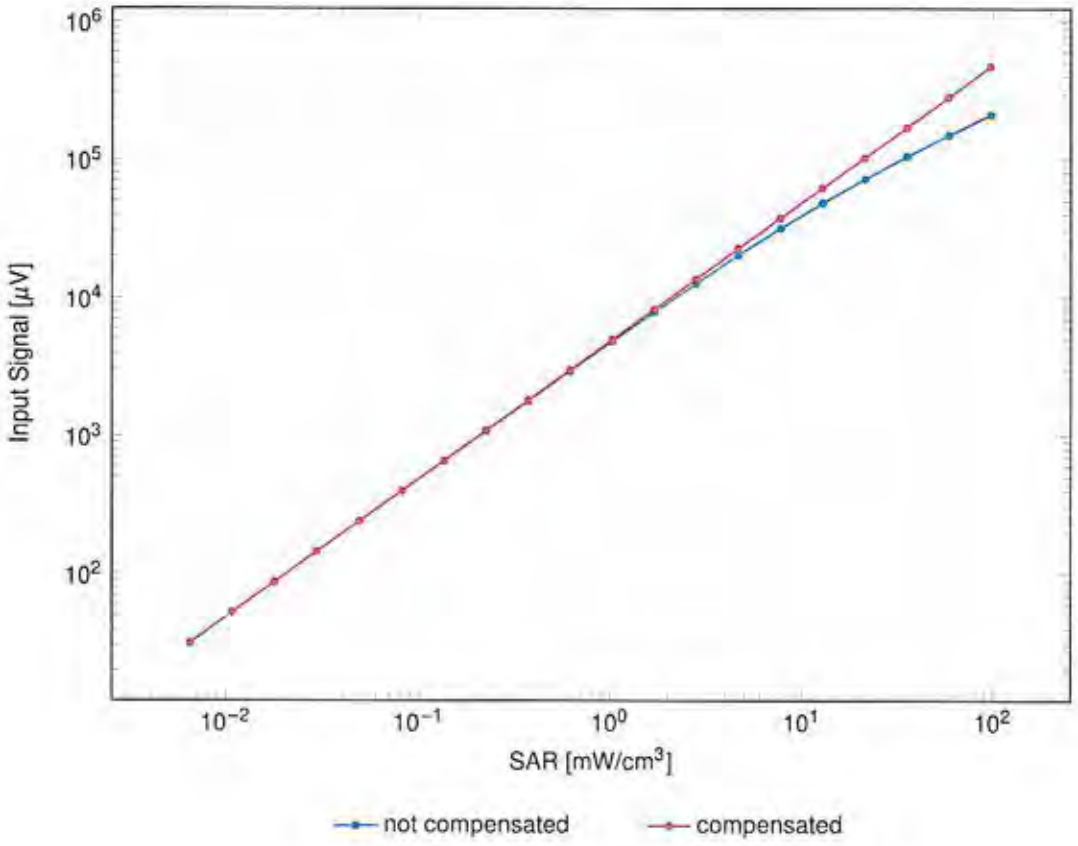


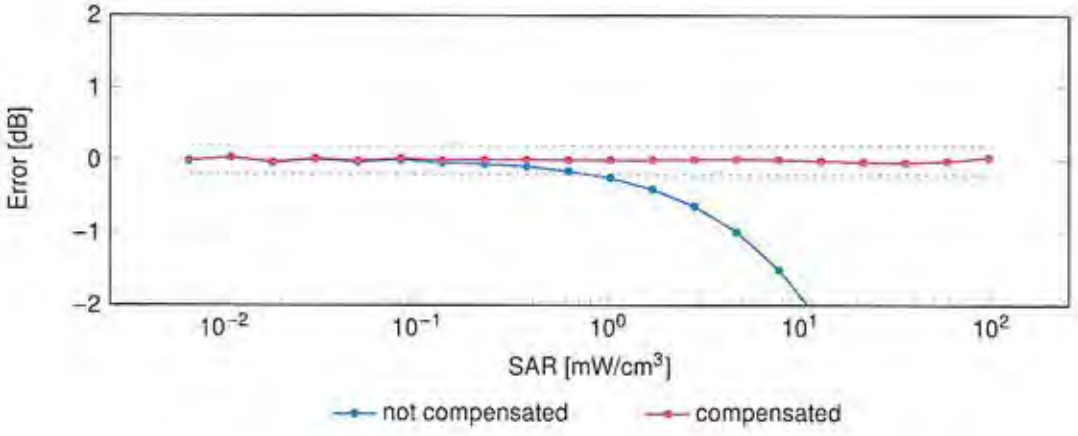


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Dynamic Range f(SAR_{HSL})

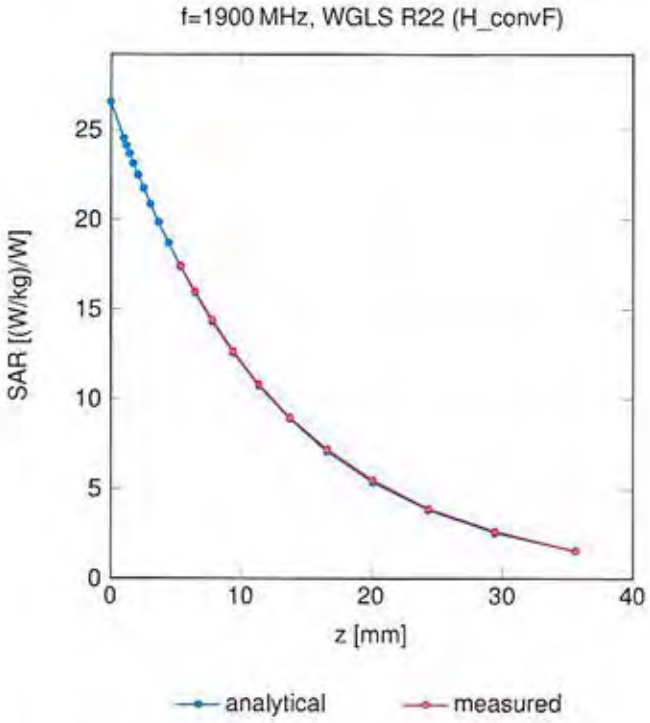
(TEM cell, f_{eval} = 1900 MHz)



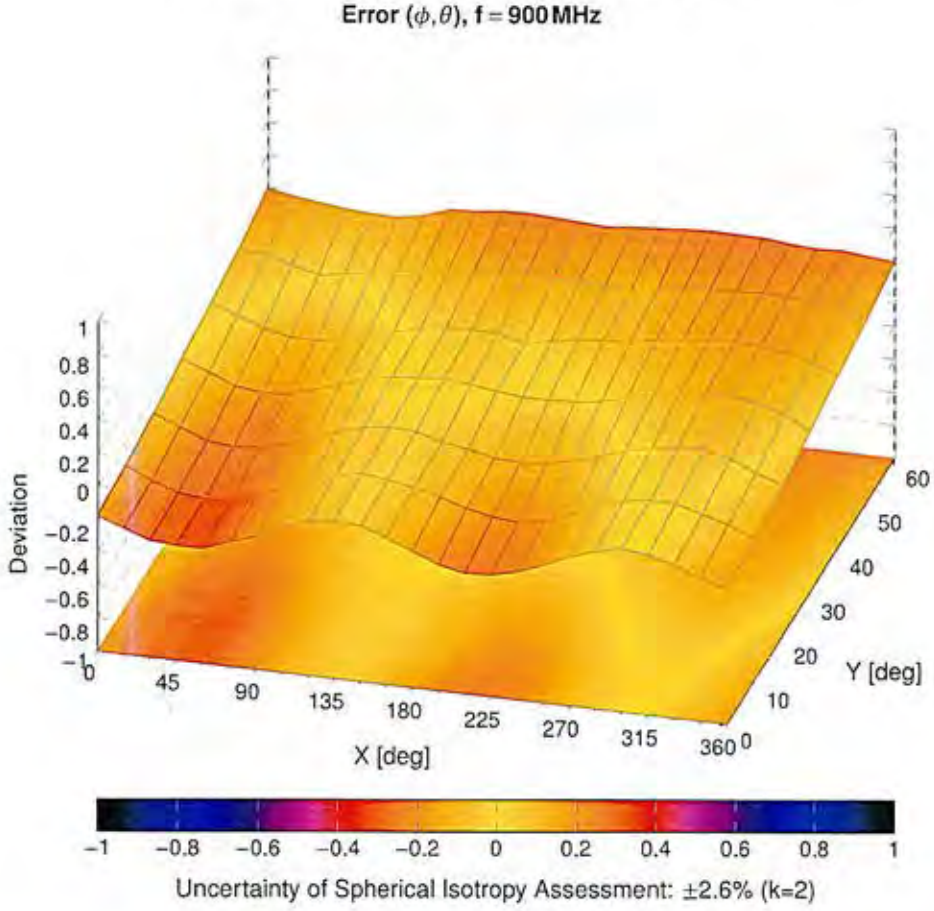


Uncertainty of Linearity Assessment: ±0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid



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S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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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-7569_Apr26

CALIBRATION CERTIFICATE

Object EX3DV4 - SN:7569

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

Issued: April 16, 2026

Glossary

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,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:

a) 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.
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ ($f \le 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,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.
- *DCPx,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
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,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 $f \le 800$ 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 *NORMx,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 *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:7569

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm (μV/(V/m)^2) [A]	0.65	0.60	0.65	±10.1%
DCP (mV) [B]	102.0	100.8	100.4	±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	134.2	±1.1%	±4.7%
		Y	0.00	0.00	1.00		135.4		
		Z	0.00	0.00	1.00		136.3		
10352	Pulse (D=10%, T=5 ms)	X	1.35	66.67	16.71	10.00	24.0	±1.4%	±9.6%
		Y	0.96	61.61	14.25		25.0		
		Z	1.13	64.43	15.84		26.0		
10353	Pulse (D=20%, T=5 ms)	X	1.23	69.68	16.69	6.99	49.0	±1.1%	±9.6%
		Y	0.87	64.62	14.20		50.0		
		Z	1.02	67.44	15.82		51.0		
10354	Pulse (D=40%, T=5 ms)	X	1.11	72.69	16.66	3.98	97.0	±1.5%	±9.6%
		Y	0.78	67.63	14.15		99.0		
		Z	0.91	70.45	15.79		101.0		
10355	Pulse (D=60%, T=5 ms)	X	1.04	74.45	16.65	2.22	144.0	±1.3%	±9.6%
		Y	0.72	69.39	14.12		148.0		
		Z	0.85	72.21	15.77		151.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.99	71.57	16.64	0.00	116.0	±1.7%	±9.6%
		Y	0.74	66.51	14.13		119.0		
		Z	0.86	69.33	15.77		122.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	2.44	71.45	16.78	0.00	124.0	±1.2%	±9.6%
		Y	1.72	66.40	14.44		127.0		
		Z	2.03	69.22	15.94		131.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.09	70.40	15.52	0.92	85.0	±1.9%	±9.6%
		Y	0.02	65.34	12.64		87.0		
		Z	0.00	68.16	14.73		89.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	3.67	70.40	16.79	0.00	114.0	±3.5%	±9.6%
		Y	2.57	65.34	14.49		118.0		
		Z	3.04	68.16	15.96		121.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	5.59	68.13	16.79	0.00	94.0	±1.8%	±9.6%
		Y	3.95	63.08	14.50		97.0		
		Z	4.66	65.90	15.96		100.0		

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:7569

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	39.4	286.38	33.74	26.95	0.00	5.10	1.76	0.12	1.01
y	40.5	295.98	34.02	18.58	0.19	5.10	0.91	0.26	1.01
z	38.9	286.09	34.36	27.45	0.00	5.10	1.14	0.22	1.01

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-88.2°
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:7569

Calibration Parameter Determined in HSL

f (MHz)[C]	Relative Permittivity[F]	Conductivity[F] (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unc[H] ($k = 2$)
750	41.9	0.89	10.61	10.68	9.84	0.32	1.27	±11.0%
900	41.5	0.97	9.71	9.77	9.00	0.32	1.27	±11.0%
1750	40.1	1.37	8.24	8.30	7.64	0.33	1.27	±11.0%
1900	40.0	1.40	8.10	8.15	7.51	0.33	1.27	±11.0%
2300	39.5	1.67	7.73	7.78	7.16	0.33	1.27	±11.0%
2450	39.2	1.80	7.59	7.64	7.04	0.34	1.27	±11.0%
2600	39.0	1.96	7.46	7.51	6.91	0.34	1.27	±11.0%

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

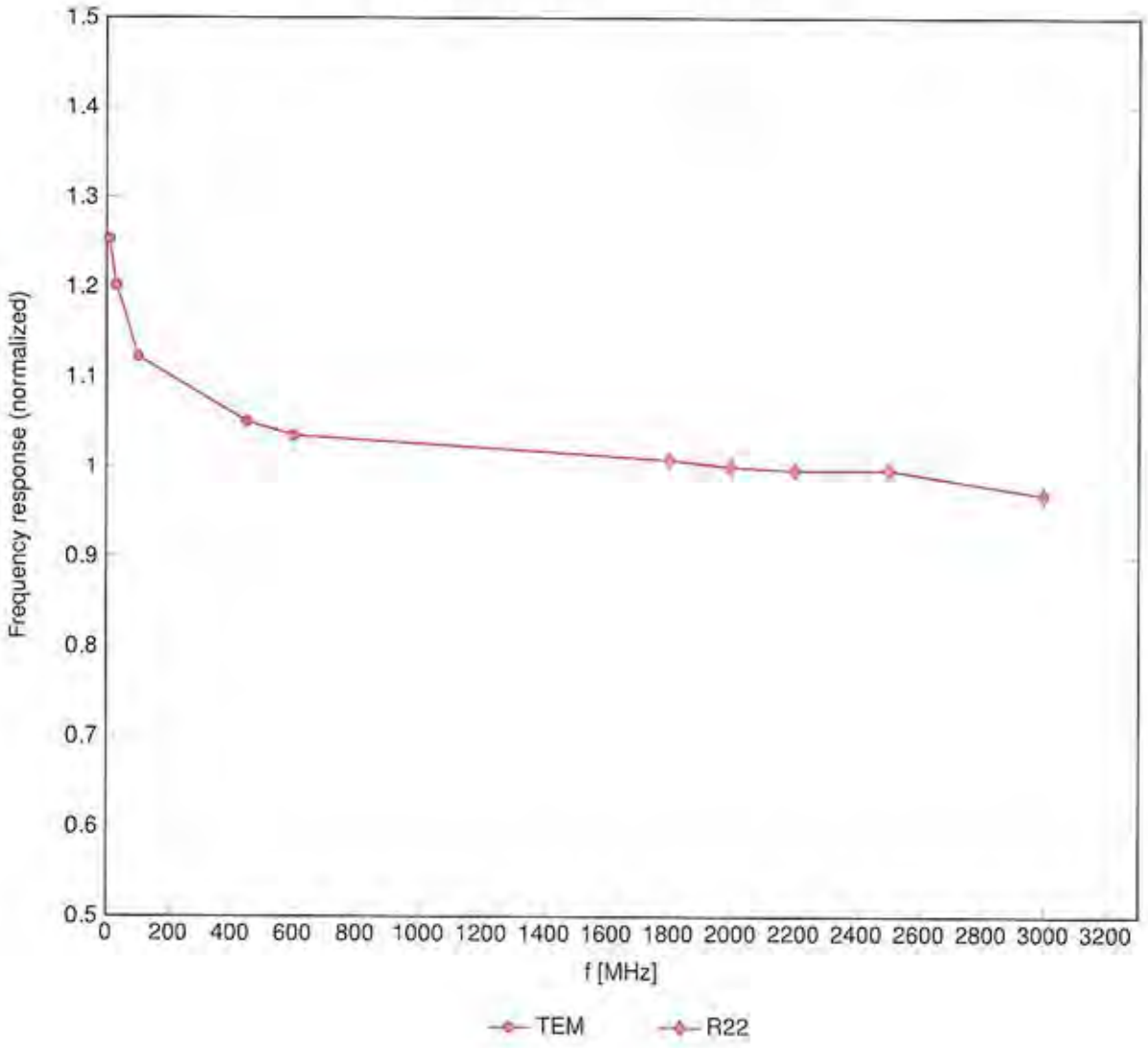
[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

[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.

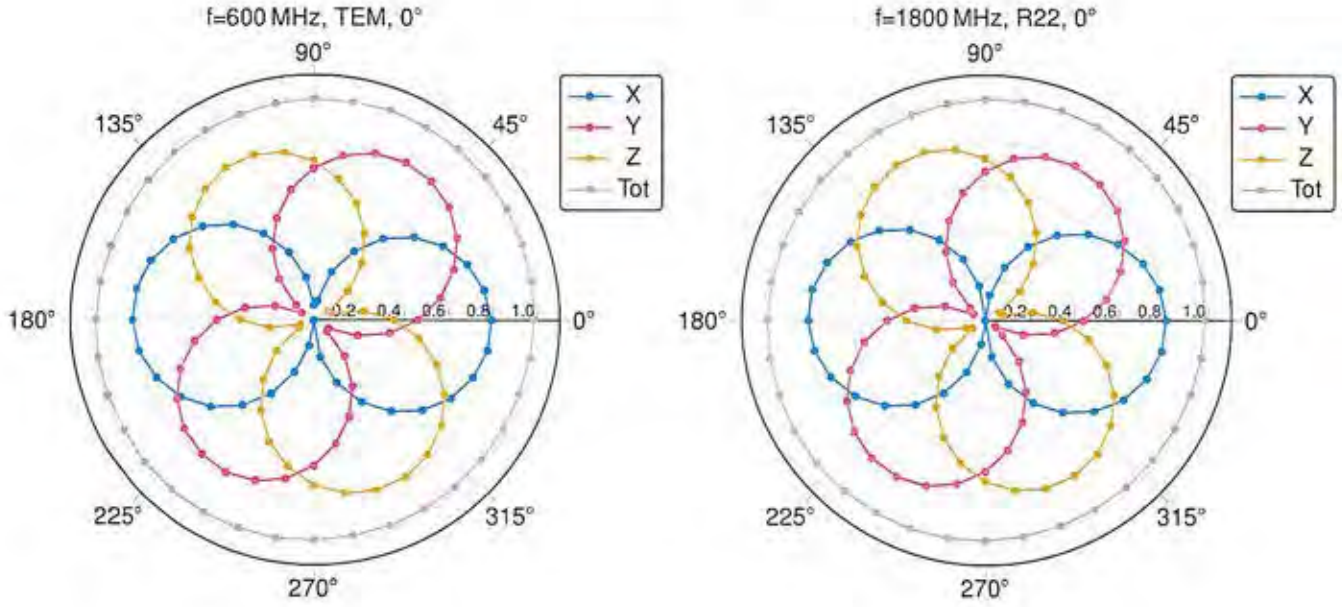
Frequency Response of E-Field

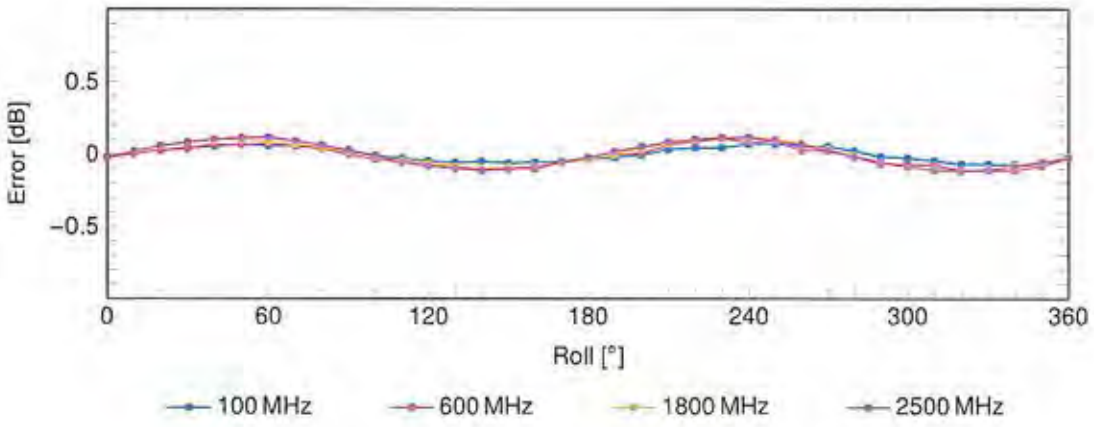
(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$

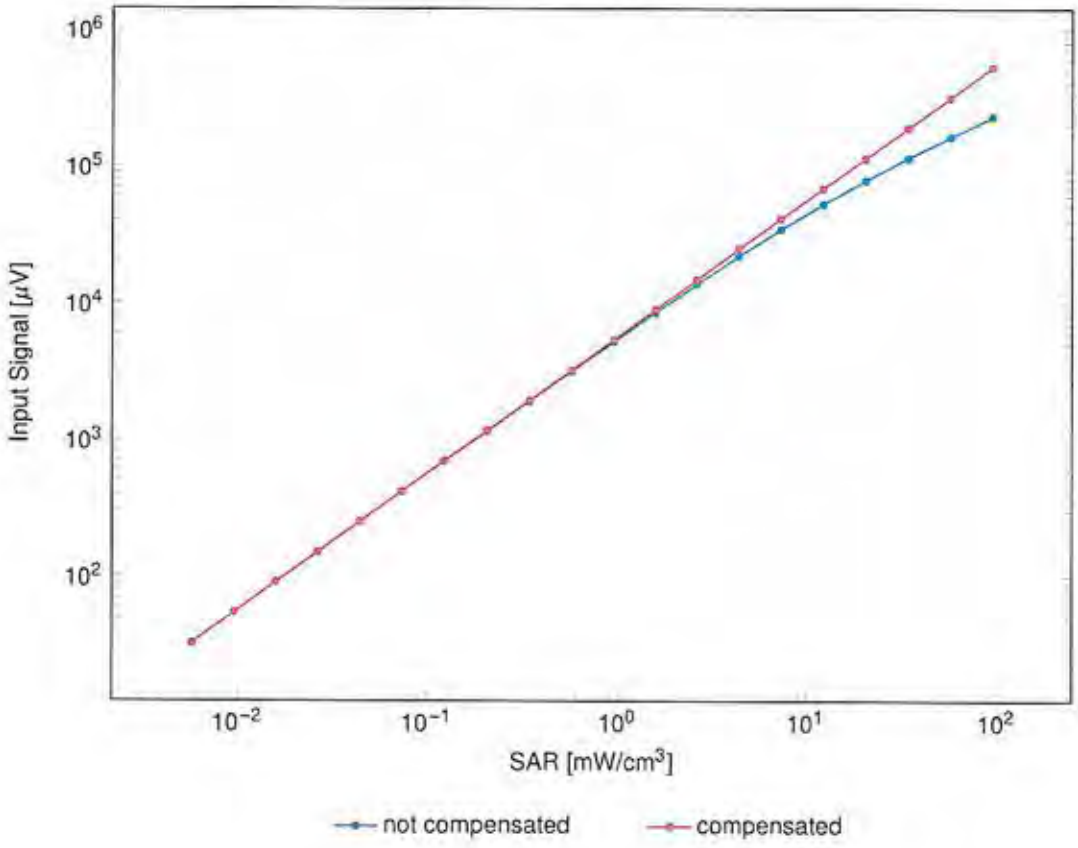


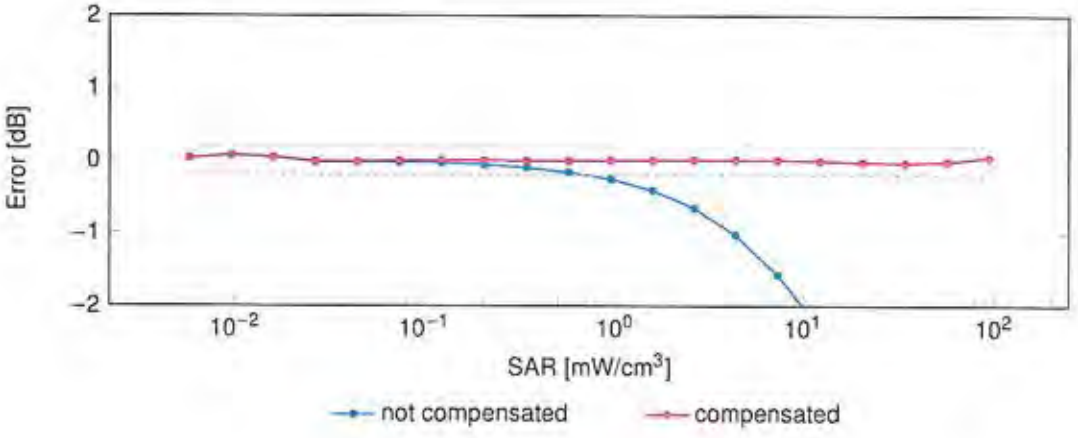


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Dynamic Range f(SAR_{HSL})

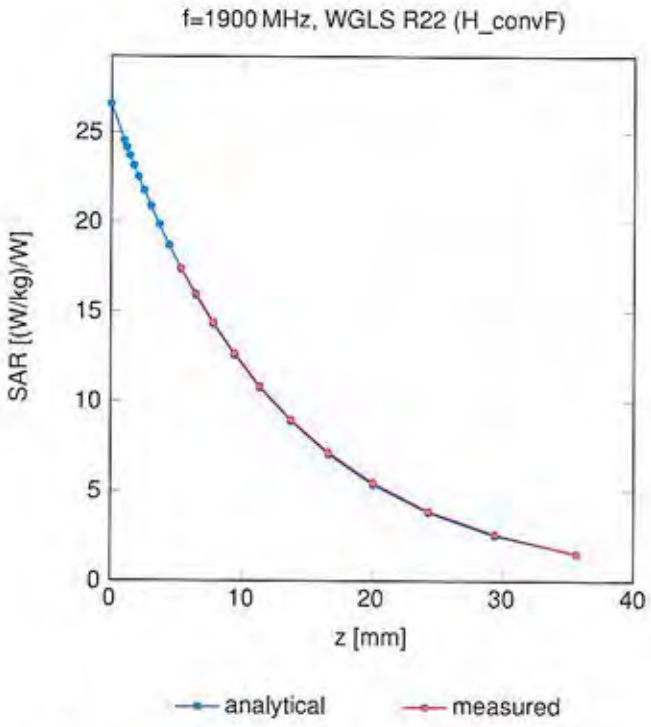
(TEM cell, f_{eval} = 1900 MHz)



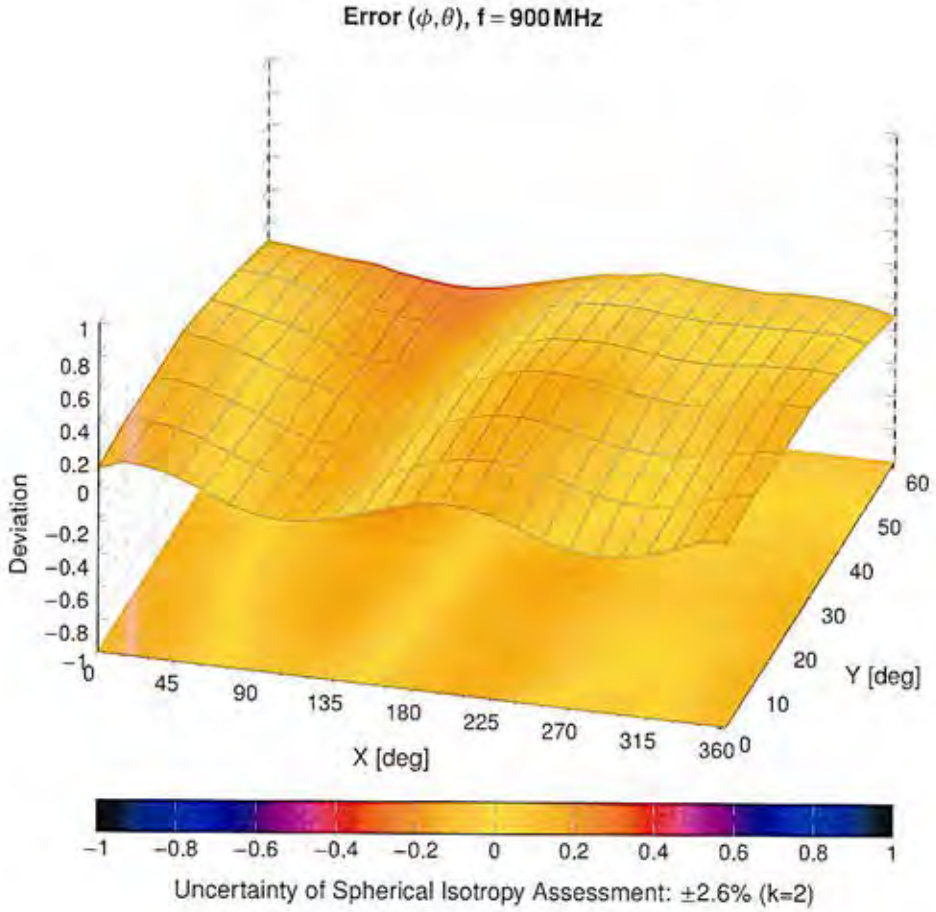


Uncertainty of Linearity Assessment: ±0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: ±2.6% (k=2)

Calibration Laboratory of
Schmid & Partner
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Accreditation No.: SCS 0108

Client UL
Fremont, USA

Certificate No. EX-3885_Oct25

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3885
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	October 16, 2025

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Calibration Date (Certificate No.)	Sched. Cal.
Power Sensor R&S NRP-33T	SN: 100967	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	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	07-Nov-24 (No. DAE4-1301_Nov24)	Nov-25

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: October 16, 2025

Glossary

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,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:

a) 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.
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,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.
- *DCPx,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
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,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 *NORMx,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 *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:3885

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.49	0.38	0.48	±10.1%
DCP (mV) [B]	105.0	106.8	104.8	±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	125.1	±1.9%	±4.7%
		Y	0.00	0.00	1.00		138.1		
		Z	0.00	0.00	1.00		124.0		
10352	Pulse (D=10%, T=5 ms)	X	0.21	59.98	15.27	10.00	23.0	±1.9%	±9.6%
		Y	0.93	70.00	17.42		23.0		
		Z	0.40	59.11	13.76		23.0		
10353	Pulse (D=20%, T=5 ms)	X	0.20	62.99	15.31	6.99	46.0	±1.5%	±9.6%
		Y	0.88	73.01	17.46		46.0		
		Z	0.37	62.12	13.81		47.0		
10354	Pulse (D=40%, T=5 ms)	X	0.18	66.00	15.35	3.98	92.0	±1.3%	±9.6%
		Y	0.82	76.02	17.50		92.0		
		Z	0.35	65.13	13.87		93.0		
10355	Pulse (D=60%, T=5 ms)	X	0.17	67.76	15.38	2.22	138.0	±1.4%	±9.6%
		Y	0.78	77.78	17.53		138.0		
		Z	0.33	66.89	13.90		140.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.00	64.88	16.66	0.32	106.0	±1.2%	±9.6%
		Y	0.01	74.90	18.94		106.0		
		Z	0.00	64.01	15.14		108.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	0.62	64.77	14.23	0.00	113.0	±2.6%	±9.6%
		Y	1.65	74.78	17.14		113.0		
		Z	0.67	63.90	13.28		114.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.00	82.32	18.23	1.54	81.0	±2.8%	±9.6%
		Y	0.03	73.72	19.83		82.0		
		Z	0.00	62.84	16.56		83.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	1.70	63.71	13.09	0.00	104.0	±4.1%	±9.6%
		Y	3.87	73.72	17.04		104.0		
		Z	1.65	62.84	12.46		106.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	2.09	61.45	12.99	0.00	75.0	±2.2%	±9.6%
		Y	4.64	71.46	17.04		76.0		
		Z	1.96	60.57	12.39		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:3885

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	9.2	67.69	34.39	3.29	0.00	4.90	0.02	0.03	1.00
y	9.1	65.79	33.47	4.24	0.00	4.98	0.60	0.00	1.00
z	8.8	63.90	33.84	5.32	0.00	4.90	0.68	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-44.0°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	12 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

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

Parameters of Probe: EX3DV4 - SN:3885

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	9.74	10.25	9.39	0.34	1.27	±11.0%
900	41.5	0.97	9.31	9.79	8.97	0.34	1.27	±11.0%
1750	40.1	1.37	8.06	8.48	7.77	0.34	1.27	±11.0%
1900	40.0	1.40	7.74	8.14	7.46	0.34	1.27	±11.0%
2300	39.5	1.67	7.31	7.69	7.04	0.33	1.27	±11.0%
2600	39.0	1.96	7.05	7.42	6.80	0.33	1.27	±11.0%
3300	38.2	2.71	6.42	6.75	6.19	0.33	1.27	±13.1%
3500	37.9	2.91	6.36	6.69	6.13	0.33	1.27	±13.1%
3700	37.7	3.12	6.30	6.63	6.07	0.33	1.27	±13.1%
3900	37.5	3.32	6.25	6.57	6.02	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.

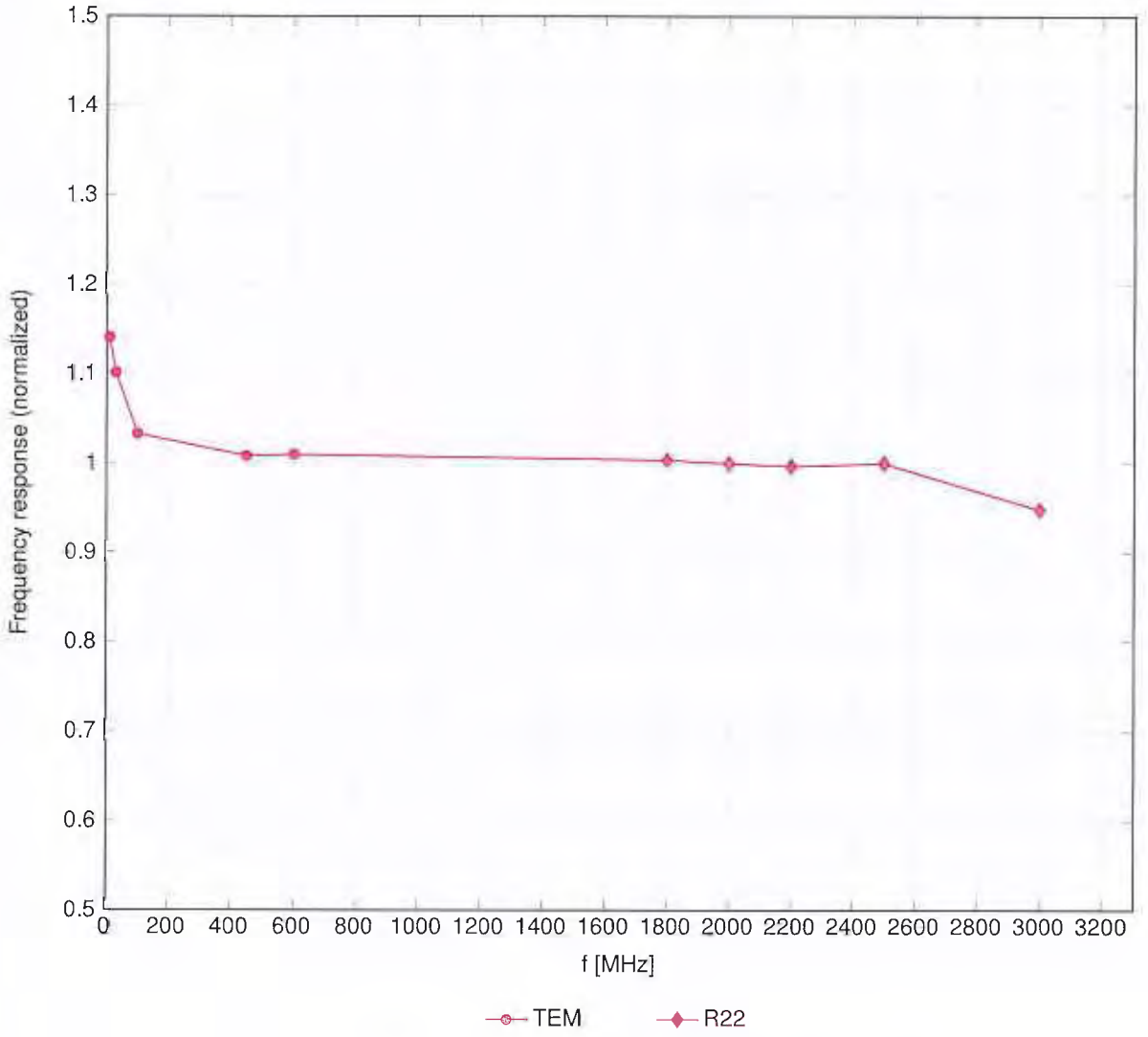
[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

[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.

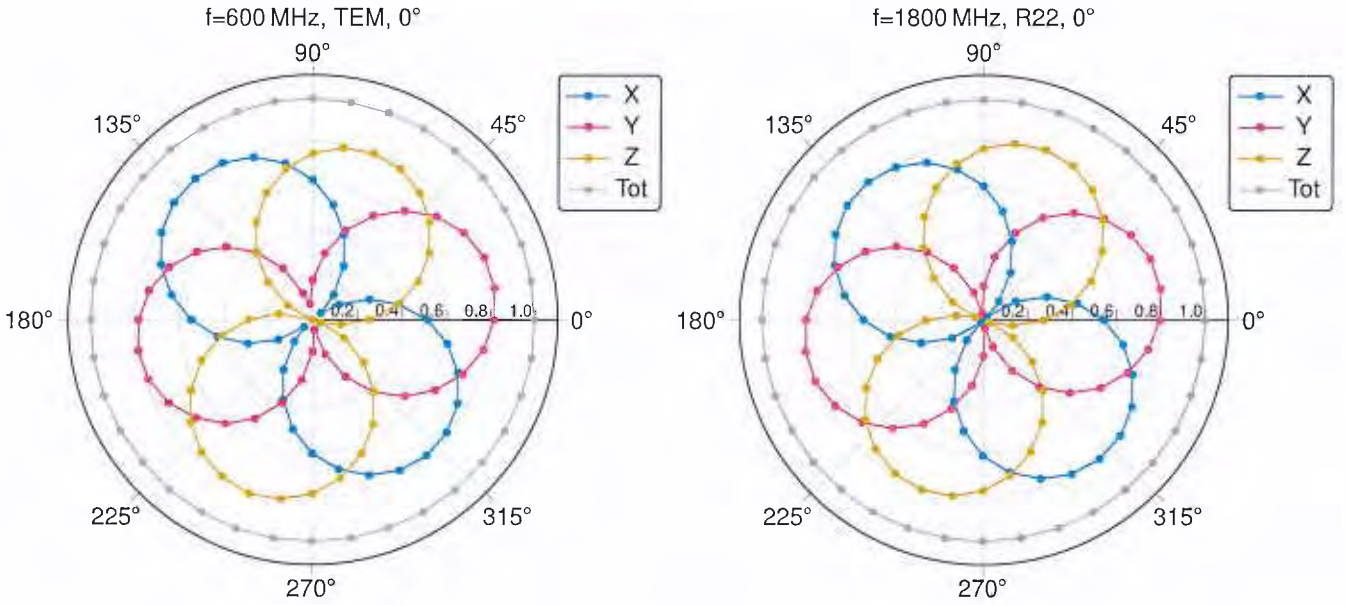
Frequency Response of E-Field

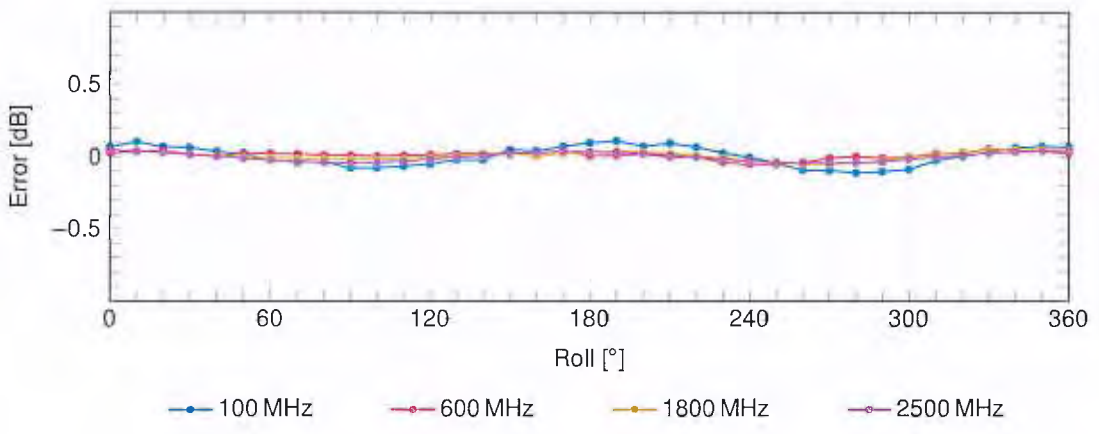
(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$

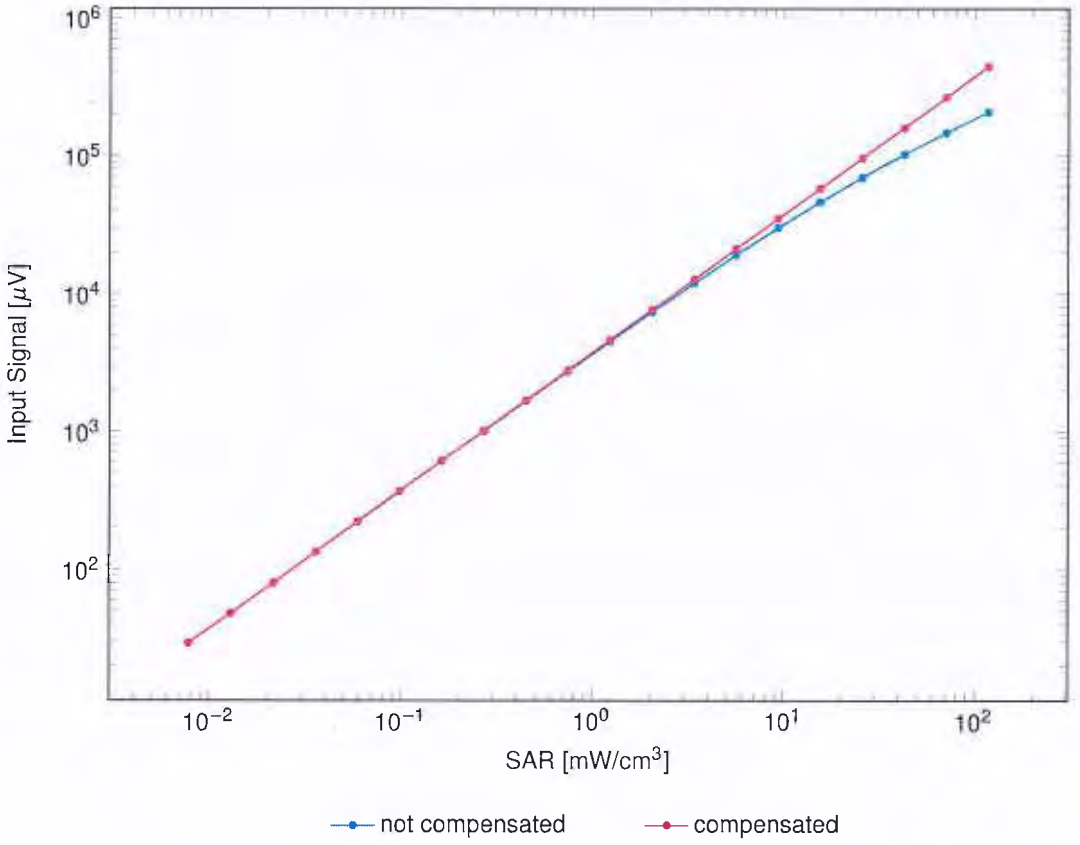


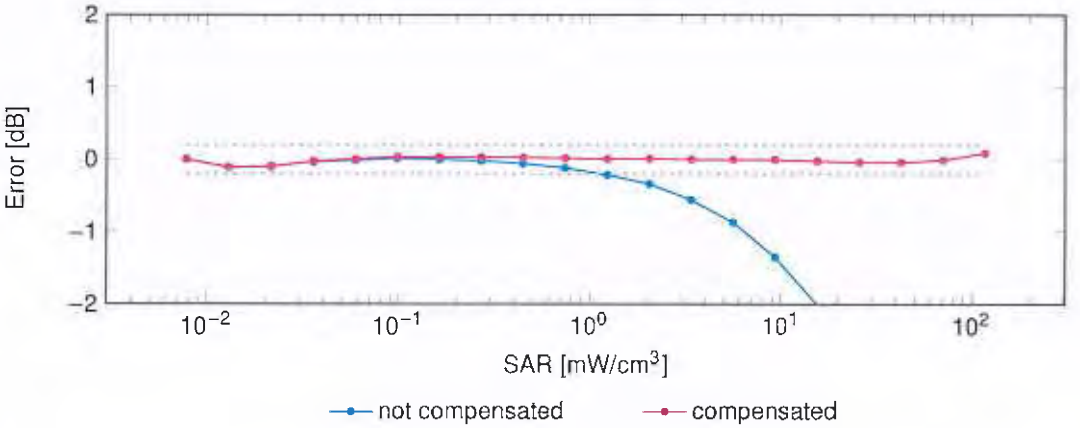


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Dynamic Range f(SAR_{HSL})

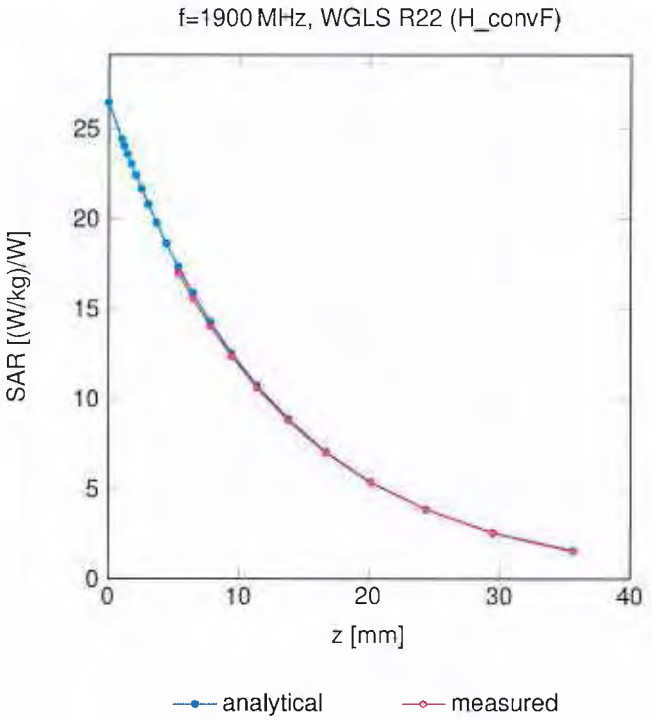
(TEM cell, f_{eval} = 1900 MHz)





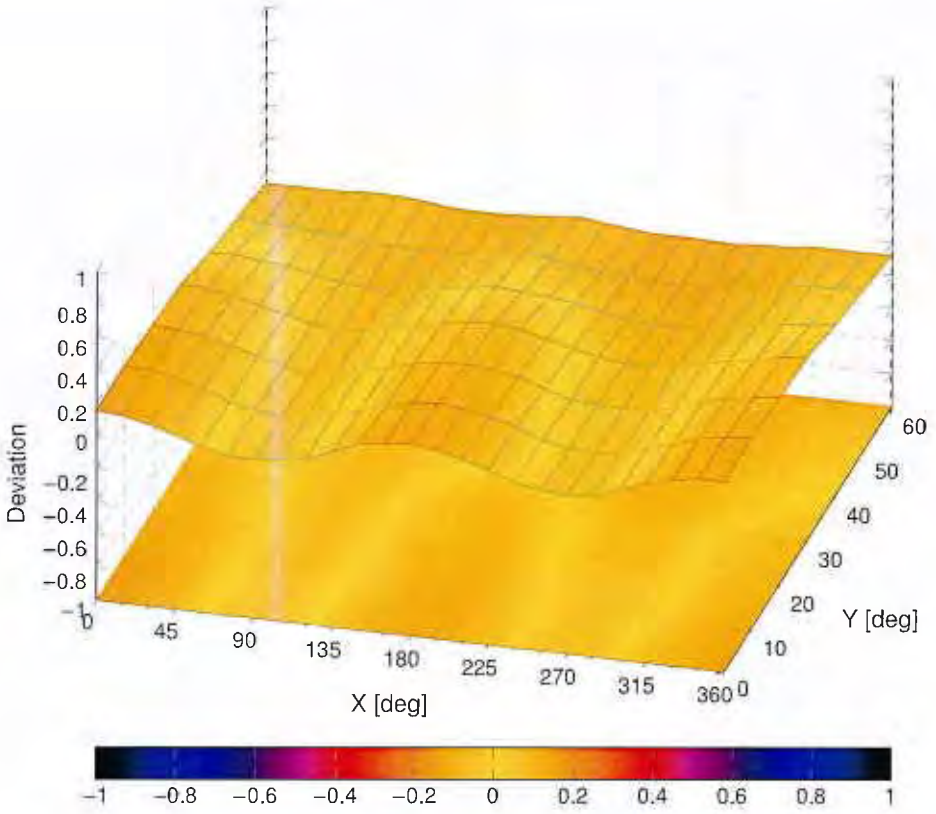
Uncertainty of Linearity Assessment: ±0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: ±2.6% (k=2)

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Accreditation No.: SCS 0108

Client	**UL** **Fremont, USA**	**Certificate No.**	**EX-3686_Jan26**

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3686
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 ± 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 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	Henrique Almeida
Approved by	Sven Kühn	Technical Manager	

Issued: January 15, 2026

Glossary

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,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:

a) 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.
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,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.
- *DCPx,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
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,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 *NORMx,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 *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:3686

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.34	0.38	0.43	±10.1%
DCP (mV) [B]	103.3	98.9	100.2	±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	138.5	±1.0%	±4.7%
		Y	0.00	0.00	1.00		145.1		
		Z	0.00	0.00	1.00		126.2		
10352	Pulse (D=10%, T=5 ms)	X	0.75	58.72	12.50	10.00	24.0	±1.6%	±9.6%
		Y	0.95	59.64	13.17		25.0		
		Z	0.87	59.09	12.84		25.0		
10353	Pulse (D=20%, T=5 ms)	X	0.70	61.73	12.49	6.99	47.0	±1.4%	±9.6%
		Y	0.87	62.65	13.15		50.0		
		Z	0.79	62.10	12.80		50.0		
10354	Pulse (D=40%, T=5 ms)	X	0.64	64.74	12.49	3.98	94.0	±1.3%	±9.6%
		Y	0.78	65.66	13.11		99.0		
		Z	0.72	65.11	12.74		99.0		
10355	Pulse (D=60%, T=5 ms)	X	0.61	66.51	12.48	2.22	141.0	±1.4%	±9.6%
		Y	0.74	67.42	13.10		148.0		
		Z	0.67	66.87	12.71		148.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.45	63.63	12.47	0.00	112.0	±1.5%	±9.6%
		Y	0.70	64.54	13.08		119.0		
		Z	0.65	63.99	12.69		118.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	1.36	63.51	12.53	0.00	119.0	±1.4%	±9.6%
		Y	1.53	64.42	13.30		127.0		
		Z	1.47	63.88	13.08		126.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.17	62.45	12.28	1.29	81.0	±2.0%	±9.6%
		Y	0.02	63.36	12.08		85.0		
		Z	0.05	62.82	11.05		85.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	2.11	62.45	12.54	0.00	109.0	±3.3%	±9.6%
		Y	2.28	63.36	13.35		117.0		
		Z	2.19	62.82	13.17		117.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	3.17	60.19	12.55	0.00	87.0	±1.1%	±9.6%
		Y	3.46	61.10	13.36		94.0		
		Z	3.36	60.56	13.20		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 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:3686

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	31.4	227.27	33.15	10.99	0.82	4.96	2.00	0.04	1.00
y	38.6	283.90	34.28	20.46	0.19	5.10	1.46	0.18	1.01
z	40.2	293.83	34.00	16.17	0.58	5.05	1.04	0.29	1.01

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	66.1°
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:3686

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	15.89	16.64	19.05	0.00	1.25	±13.3%
13	55.0	0.75	13.32	13.95	15.97	0.00	1.25	±13.3%
30	55.0	0.75	12.25	12.83	14.69	0.00	1.25	±13.3%
64	54.2	0.75	11.05	11.58	13.25	0.00	1.25	±13.3%
450	43.5	0.87	9.38	9.38	9.38	0.16	1.30	±13.3%
750	41.9	0.89	8.21	8.32	9.38	0.36	1.27	±11.0%
900	41.5	0.97	7.95	8.05	9.08	0.36	1.27	±11.0%
1450	40.5	1.20	7.27	7.36	8.30	0.36	1.27	±11.0%
1640	40.2	1.31	7.14	7.23	8.15	0.36	1.27	±11.0%
1750	40.1	1.37	7.07	7.16	8.07	0.36	1.27	±11.0%
1900	40.0	1.40	6.86	6.94	7.83	0.36	1.27	±11.0%
2100	39.8	1.49	6.64	6.73	7.58	0.36	1.27	±11.0%
2300	39.5	1.67	6.46	6.54	7.37	0.36	1.27	±11.0%
2450	39.2	1.80	6.33	6.40	7.22	0.36	1.27	±11.0%
2600	39.0	1.96	6.24	6.32	7.12	0.36	1.27	±11.0%
3300	38.2	2.71	5.83	5.90	6.66	0.36	1.27	±13.1%
3500	37.9	2.91	5.76	5.83	6.58	0.36	1.27	±13.1%
3700	37.7	3.12	5.69	5.76	6.49	0.36	1.27	±13.1%
3900	37.5	3.32	5.63	5.70	6.43	0.36	1.27	±13.1%
5250	35.9	4.71	5.10	5.16	5.82	0.32	1.27	±13.1%
5600	35.5	5.07	4.76	4.82	5.43	0.28	1.27	±13.1%
5750	35.4	5.22	4.76	4.82	5.44	0.27	1.27	±13.1%
5850	35.2	5.32	4.60	4.65	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:3686

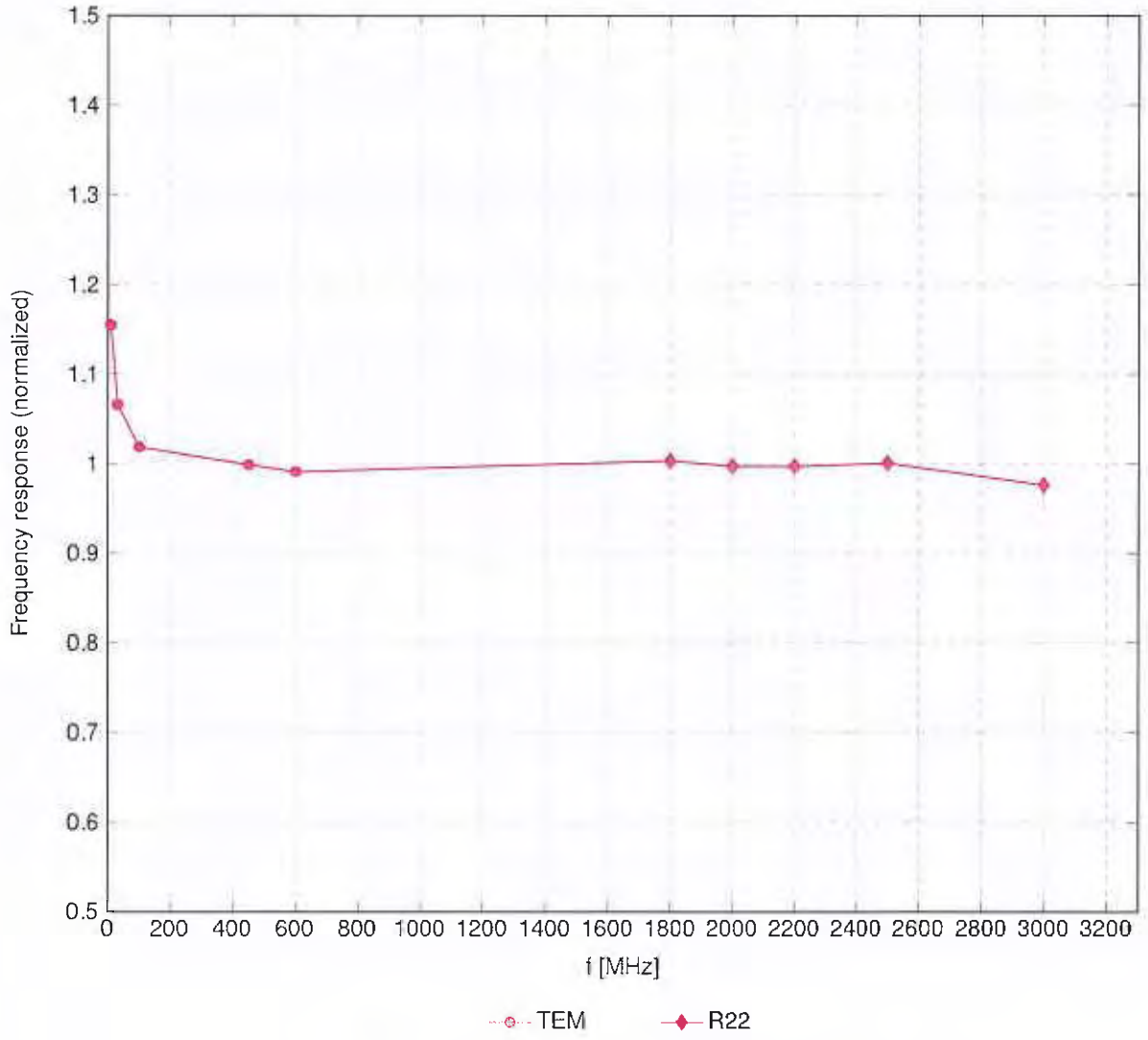
Calibration Parameter Determined in HSL

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	4.96	5.02	5.67	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.

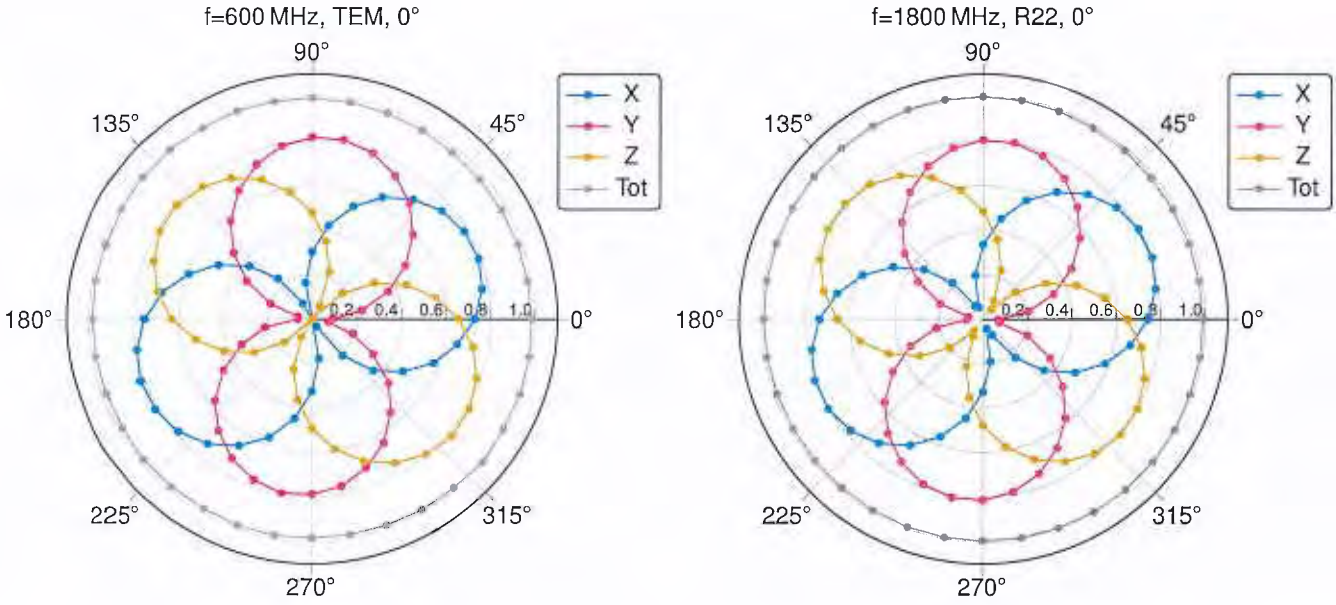
Frequency Response of E-Field

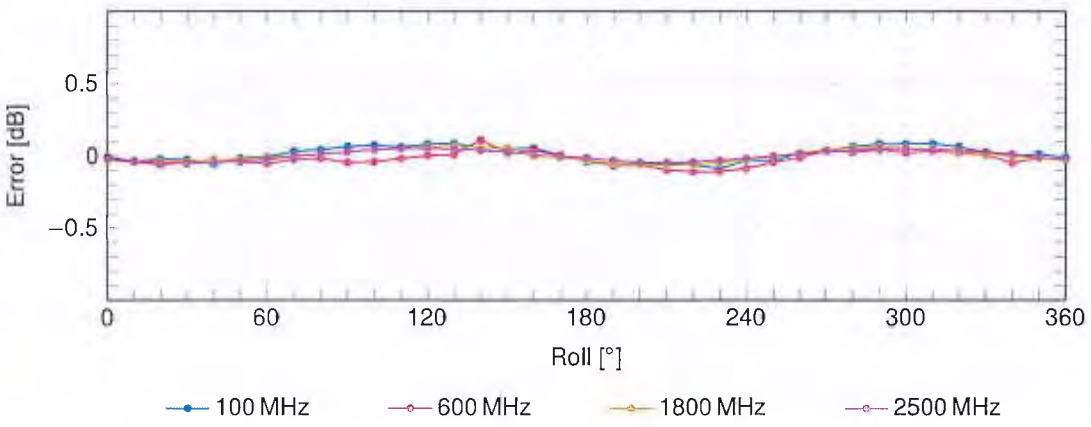
(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$

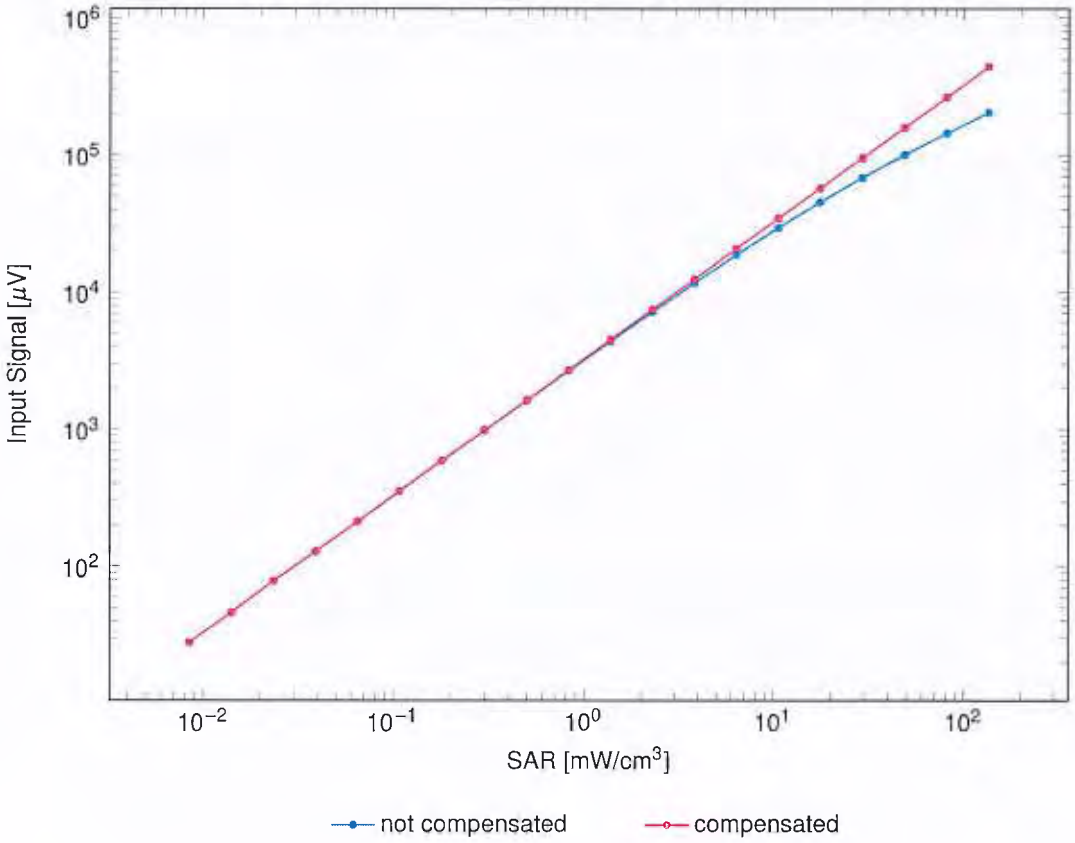


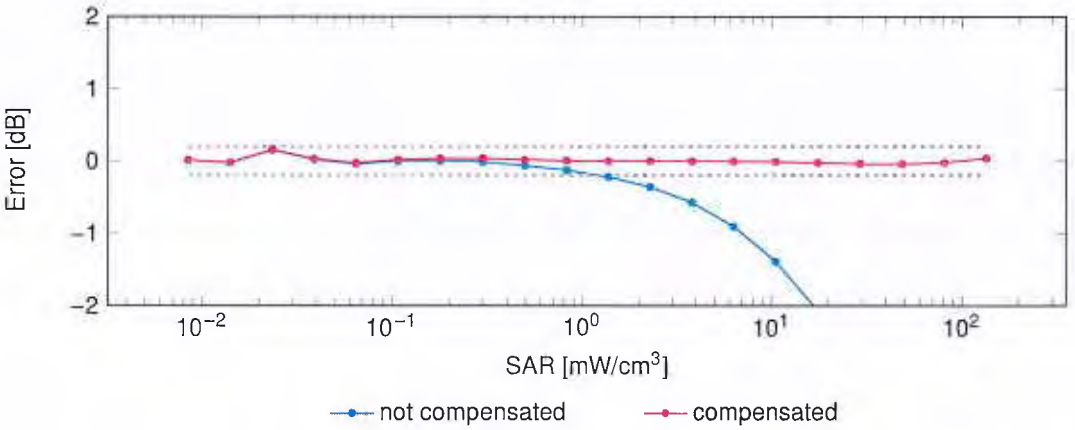


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Dynamic Range f(SAR_{HSL})

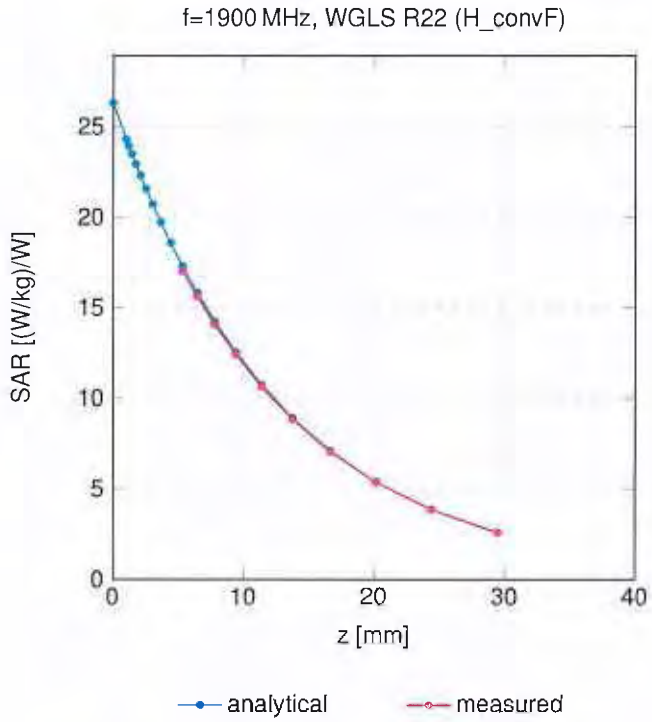
(TEM cell, f_{eval} = 1900 MHz)



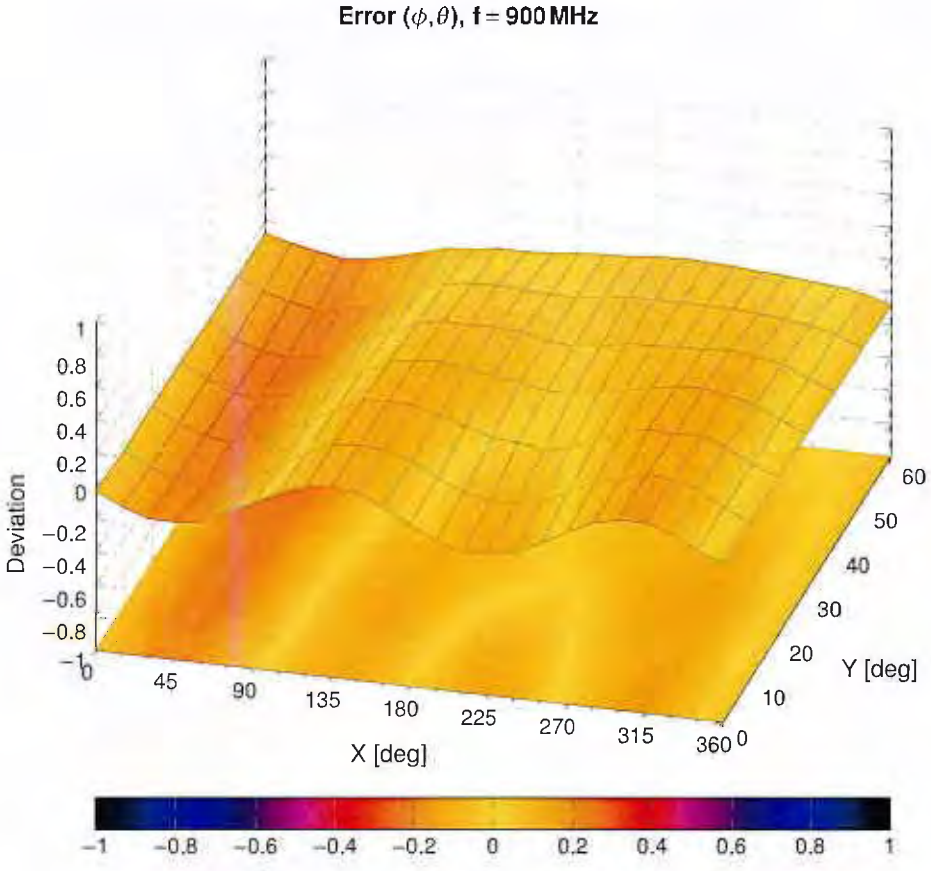


Uncertainty of Linearity Assessment: ±0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: ±2.6% (k=2)

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

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-3749_Jan26

CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:3749

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 ± 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 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	Henrique Almeida
Approved by	Sven Kühn	Technical Manager	

Issued: January 15, 2026

Glossary

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,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:

a) 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.
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,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.
- *DCPx,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
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,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 *NORMx,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 *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:3749

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.47	0.44	0.44	±10.1%
DCP (mV) [B]	102.9	104.2	104.0	±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	129.4	±1.5%	±4.7%
		Y	0.00	0.00	1.00		130.4		
		Z	0.00	0.00	1.00		126.3		
10352	Pulse (D=10%, T=5 ms)	X	1.10	61.37	14.12	10.00	24.0	±1.2%	±9.6%
		Y	1.04	60.29	13.48		25.0		
		Z	0.88	59.19	12.99		25.0		
10353	Pulse (D=20%, T=5 ms)	X	1.02	64.38	14.08	6.99	48.0	±1.0%	±9.6%
		Y	0.96	63.30	13.45		49.0		
		Z	0.81	62.20	12.97		49.0		
10354	Pulse (D=40%, T=5 ms)	X	0.92	67.39	14.04	3.98	95.0	±1.2%	±9.6%
		Y	0.87	66.31	13.41		97.0		
		Z	0.74	65.21	12.94		98.0		
10355	Pulse (D=60%, T=5 ms)	X	0.87	69.15	14.02	2.22	142.0	±1.2%	±9.6%
		Y	0.83	68.07	13.39		145.0		
		Z	0.70	66.98	12.92		146.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.76	66.27	13.95	0.00	114.0	±1.5%	±9.6%
		Y	0.72	65.19	13.33		116.0		
		Z	0.61	64.10	12.87		117.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	1.72	66.15	14.25	0.00	121.0	±1.1%	±9.6%
		Y	1.63	65.07	13.63		124.0		
		Z	1.45	63.98	13.13		124.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.02	65.09	12.42	0.77	84.0	±1.6%	±9.6%
		Y	0.02	64.02	11.93		86.0		
		Z	0.03	62.92	11.86		87.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	2.55	65.09	14.31	0.00	111.0	±3.3%	±9.6%
		Y	2.41	64.02	13.68		114.0		
		Z	2.18	62.92	13.19		114.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	3.89	62.83	14.32	0.00	90.0	±1.7%	±9.6%
		Y	3.64	61.75	13.69		93.0		
		Z	3.25	60.66	13.21		93.0		

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:3749

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	39.0	279.22	32.84	21.21	0.68	5.04	1.86	0.17	1.01
y	39.8	282.93	32.42	22.55	0.39	5.09	1.43	0.22	1.00
z	37.0	264.44	32.71	21.00	0.78	5.04	1.72	0.18	1.01

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-65.7°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	12 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

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

Parameters of Probe: EX3DV4 - SN:3749

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	15.73	17.70	15.15	0.00	1.25	±13.3%
13	55.0	0.75	13.93	15.68	13.42	0.00	1.25	±13.3%
30	55.0	0.75	13.06	14.70	12.59	0.00	1.25	±13.3%
64	54.2	0.75	11.62	13.08	11.20	0.00	1.25	±13.3%
450	43.5	0.87	9.93	9.93	9.93	0.16	1.30	±13.3%
750	41.9	0.89	8.59	9.64	8.30	0.37	1.27	±11.0%
900	41.5	0.97	8.25	9.26	7.98	0.37	1.27	±11.0%
1450	40.5	1.20	7.33	8.22	7.08	0.37	1.27	±11.0%
1640	40.2	1.31	7.19	8.07	6.95	0.36	1.27	±11.0%
1750	40.1	1.37	7.11	7.98	6.87	0.36	1.27	±11.0%
1900	40.0	1.40	6.86	7.70	6.63	0.36	1.27	±11.0%
2100	39.8	1.49	6.67	7.49	6.45	0.36	1.27	±11.0%
2300	39.5	1.67	6.54	7.34	6.33	0.36	1.27	±11.0%
2450	39.2	1.80	6.41	7.19	6.20	0.36	1.27	±11.0%
2600	39.0	1.96	6.28	7.05	6.08	0.36	1.27	±11.0%
3300	38.2	2.71	5.86	6.58	5.67	0.35	1.27	±13.1%
3500	37.9	2.91	5.79	6.50	5.60	0.35	1.27	±13.1%
3700	37.7	3.12	5.76	6.47	5.57	0.35	1.27	±13.1%
3900	37.5	3.32	5.71	6.41	5.52	0.34	1.27	±13.1%
5250	35.9	4.71	5.08	5.70	4.91	0.31	1.27	±13.1%
5600	35.5	5.07	4.71	5.28	4.55	0.28	1.27	±13.1%
5750	35.4	5.22	4.76	5.34	4.60	0.26	1.27	±13.1%
5850	35.2	5.32	4.55	5.11	4.40	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:3749

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	4.95	5.55	4.78	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.

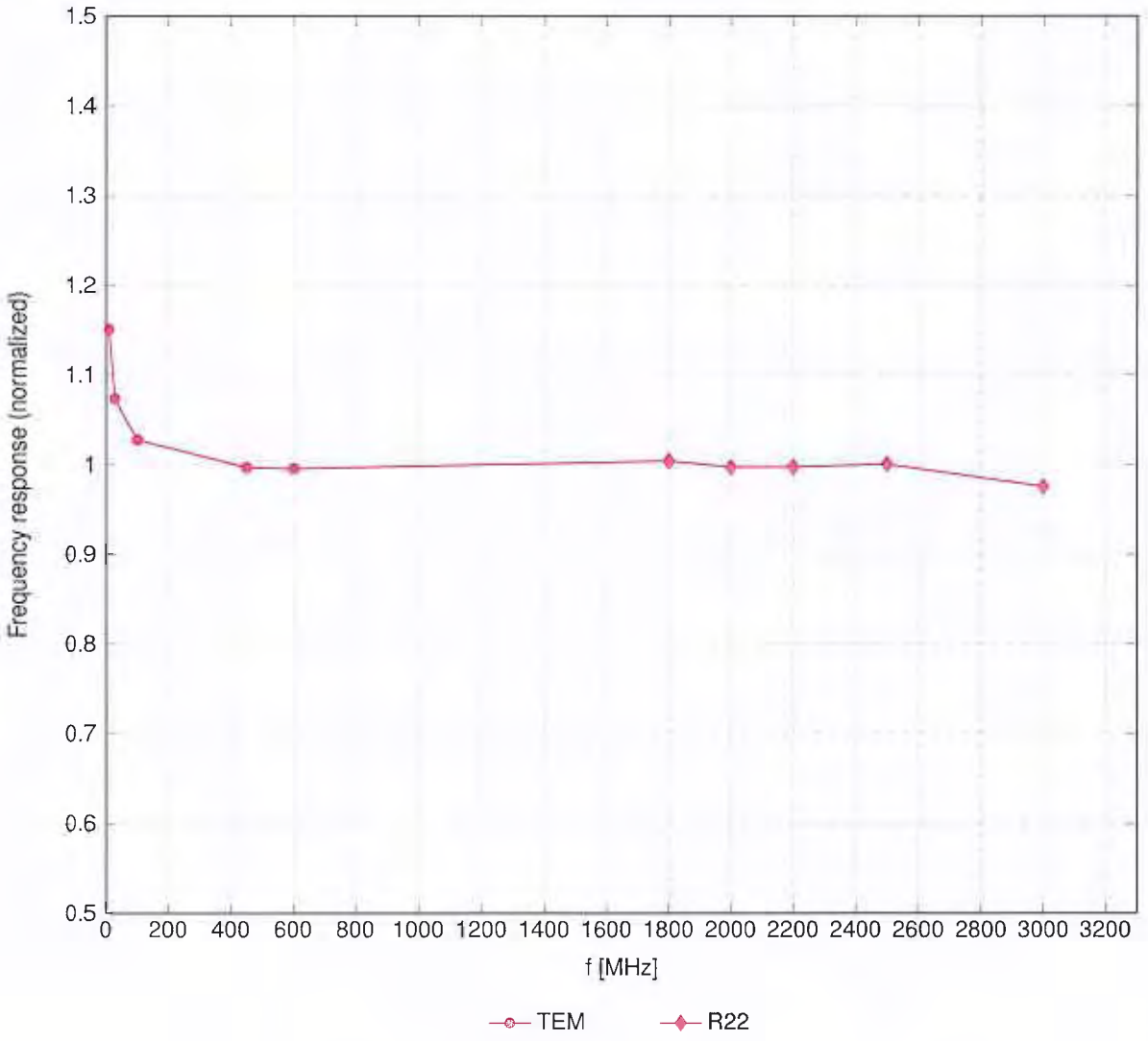
[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±10% from the target values (typically better than ±6%) and are valid for TSL with deviations of up to ±10%.

[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.

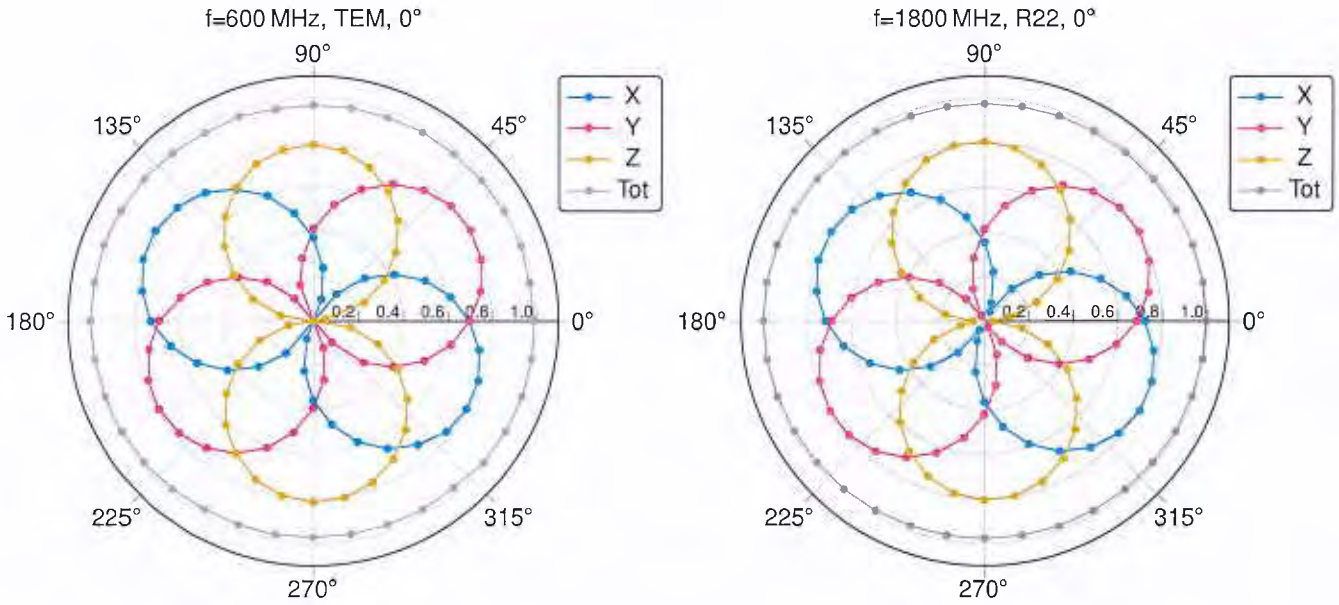
Frequency Response of E-Field

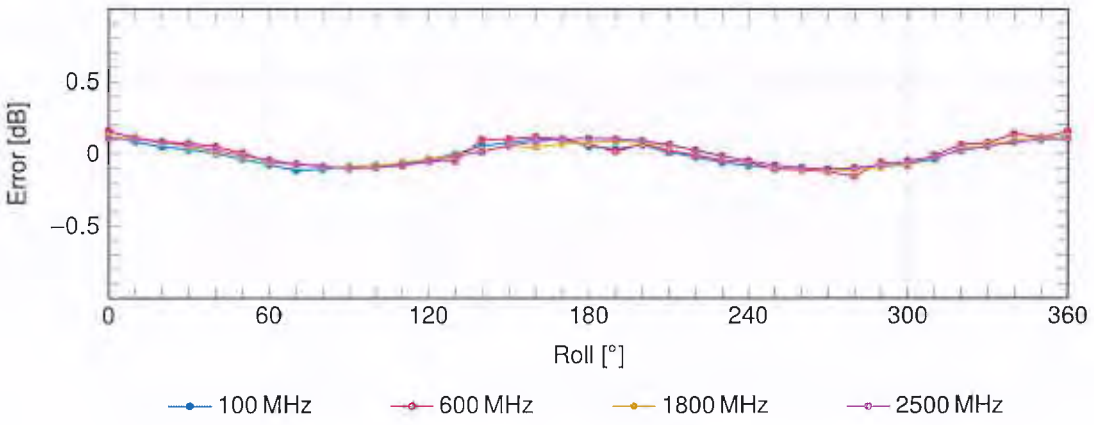
(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$

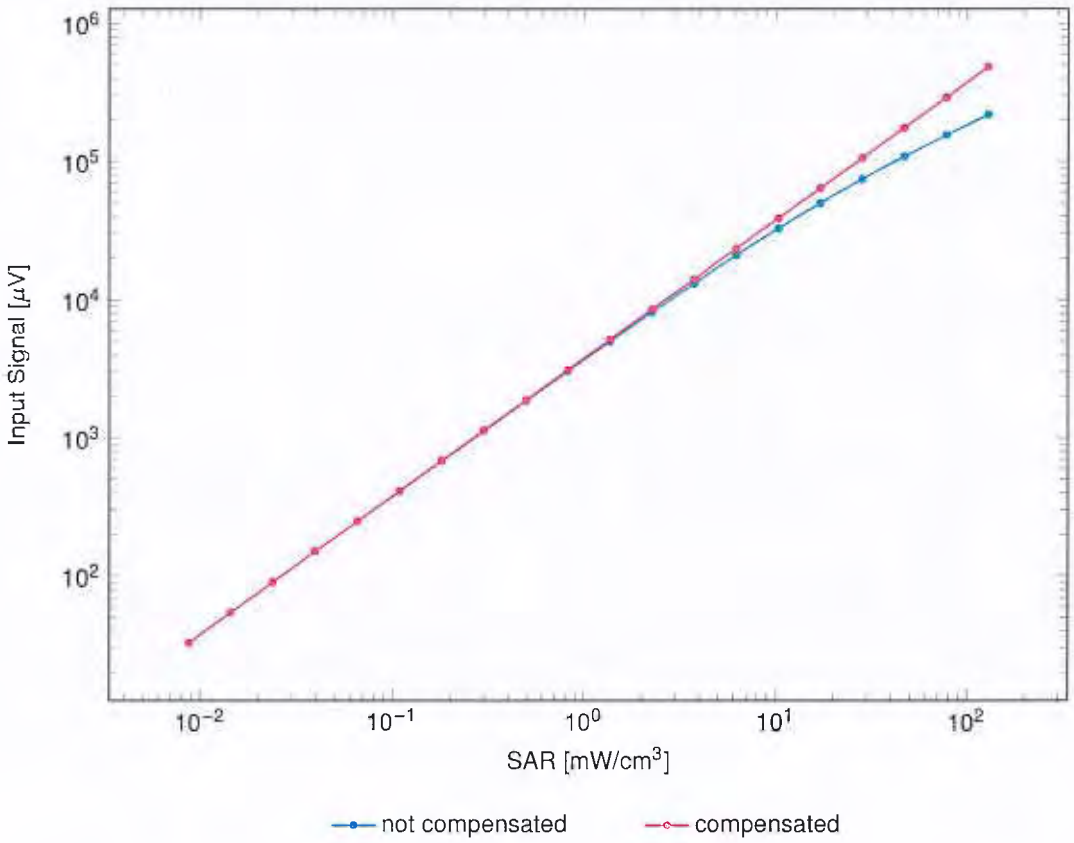


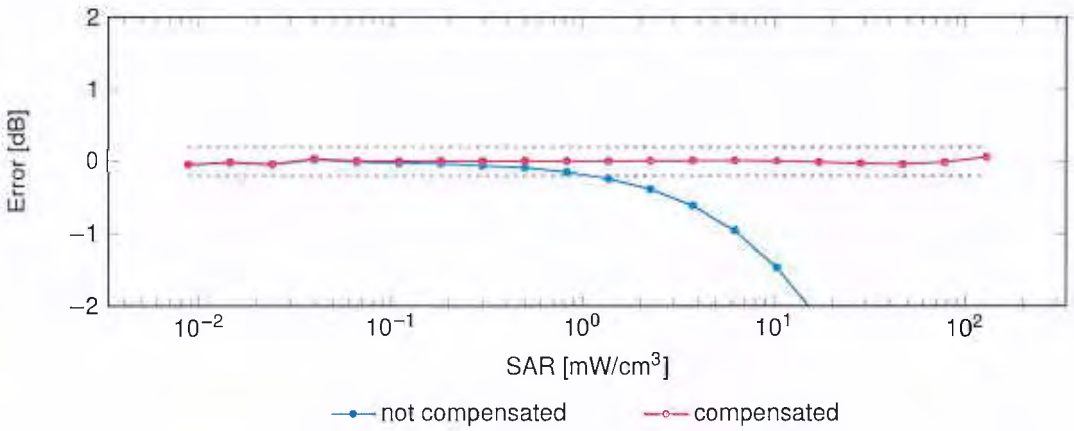


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Dynamic Range f(SAR_{HSL})

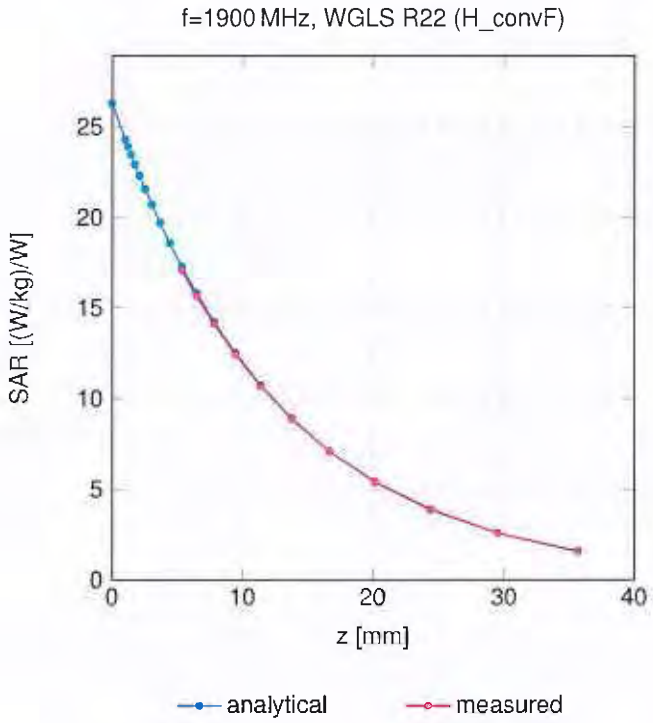
(TEM cell, f_{eval} = 1900 MHz)



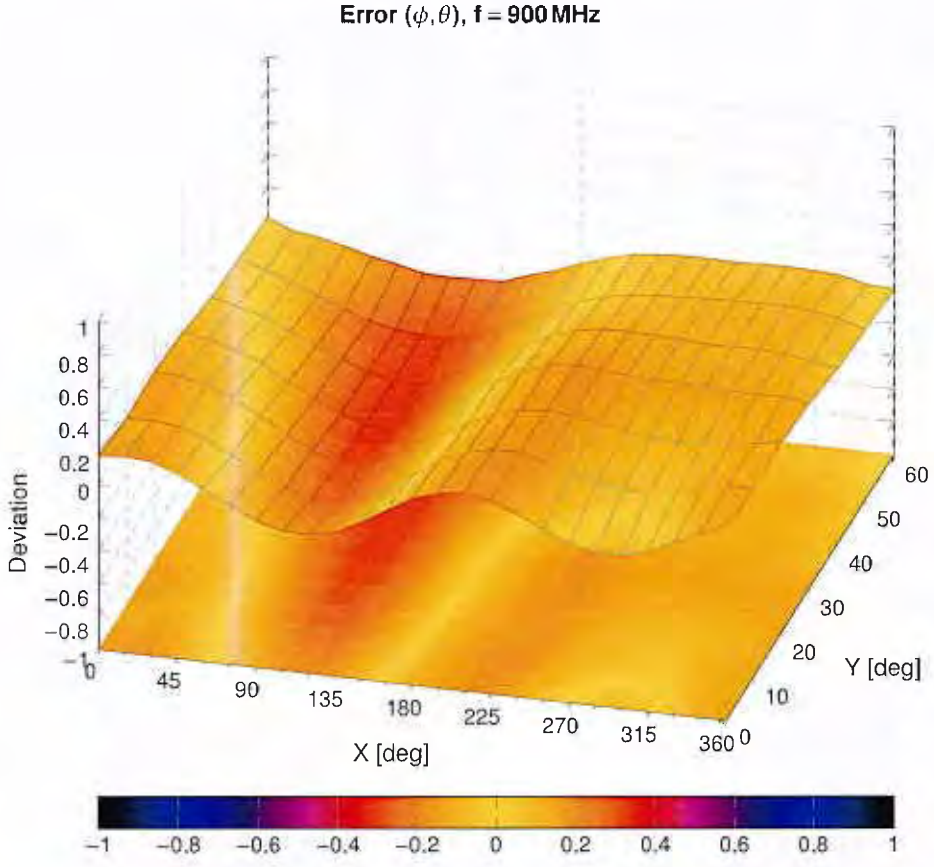


Uncertainty of Linearity Assessment: ±0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: ±2.6% (k=2)

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

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-7448_Feb26

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:7448
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	February 17, 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 ± 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 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
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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	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	Henrique Almeida
Approved by	Sven Kühn	Technical Manager	

Issued: February 17, 2026

Glossary

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,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:

a) 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.
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,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.
- *DCPx,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
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,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 *NORMx,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 *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:7448

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.29	0.38	0.51	±10.1%
DCP (mV) [B]	94.9	100.4	99.9	±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	147.6	±1.0%	±4.7%
		Y	0.00	0.00	1.00		149.3		
		Z	0.00	0.00	1.00		141.3		
10352	Pulse (D=10%, T=5 ms)	X	0.49	60.35	13.92	10.00	23.0	±1.2%	±9.6%
		Y	0.35	63.36	15.87		24.0		
		Z	0.58	63.58	15.44		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.44	63.36	13.89	6.99	46.0	±1.0%	±9.6%
		Y	0.31	66.37	15.89		47.0		
		Z	0.52	66.59	15.43		47.0		
10354	Pulse (D=40%, T=5 ms)	X	0.39	66.37	13.86	3.98	92.0	±0.9%	±9.6%
		Y	0.28	69.38	15.92		94.0		
		Z	0.46	69.60	15.42		94.0		
10355	Pulse (D=60%, T=5 ms)	X	0.36	68.13	13.85	2.22	137.0	±1.0%	±9.6%
		Y	0.26	71.14	15.93		140.0		
		Z	0.42	71.37	15.41		140.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.61	65.25	13.98	0.00	113.0	±2.1%	±9.6%
		Y	0.37	68.26	15.86		116.0		
		Z	0.59	68.49	15.45		116.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	1.57	65.13	14.21	0.00	121.0	±1.5%	±9.6%
		Y	1.64	68.14	15.44		124.0		
		Z	1.81	68.37	15.57		125.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.00	64.07	13.06	0.97	83.0	±1.7%	±9.6%
		Y	0.04	67.08	16.81		84.0		
		Z	0.61	84.01	15.00		85.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	2.40	64.07	14.26	0.00	113.0	±3.3%	±9.6%
		Y	2.74	67.08	15.40		116.0		
		Z	2.86	67.31	15.59		116.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	3.68	61.81	14.27	0.00	93.0	±1.4%	±9.6%
		Y	3.99	64.82	15.39		96.0		
		Z	4.31	65.05	15.59		96.0		

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:7448

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	47.6	365.89	37.29	4.64	0.00	5.00	0.25	0.30	1.00
y	27.4	205.71	35.82	2.57	0.00	4.97	1.14	0.00	1.00
z	34.8	260.96	35.61	10.53	0.00	4.94	1.46	0.11	1.01

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	7.1°
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:7448

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	21.09	19.62	19.78	0.00	1.25	±13.3%
13	55.0	0.75	18.22	16.95	17.09	0.00	1.25	±13.3%
30	55.0	0.75	16.00	14.88	15.01	0.00	1.25	±13.3%
64	54.2	0.75	14.39	13.38	13.49	0.00	1.25	±13.3%
450	43.5	0.87	10.90	10.90	10.90	0.16	1.30	±13.3%
750	41.9	0.89	9.35	9.81	9.91	0.32	1.27	±11.0%
900	41.5	0.97	8.86	9.30	9.39	0.32	1.27	±11.0%
1450	40.5	1.20	7.50	7.88	7.96	0.33	1.27	±11.0%
1640	40.2	1.31	7.71	8.09	8.17	0.33	1.27	±11.0%
1750	40.1	1.37	7.51	7.88	7.96	0.33	1.27	±11.0%
1900	40.0	1.40	7.23	7.59	7.66	0.33	1.27	±11.0%
2100	39.8	1.49	7.42	7.79	7.87	0.33	1.27	±11.0%
2300	39.5	1.67	7.08	7.43	7.51	0.34	1.27	±11.0%
2450	39.2	1.80	6.87	7.21	7.28	0.34	1.27	±11.0%
2600	39.0	1.96	6.85	7.19	7.26	0.34	1.27	±11.0%
3300	38.2	2.71	6.42	6.74	6.80	0.35	1.27	±13.1%
3500	37.9	2.91	6.35	6.67	6.74	0.35	1.27	±13.1%
3700	37.7	3.12	6.35	6.66	6.73	0.35	1.27	±13.1%
3900	37.5	3.32	6.25	6.56	6.63	0.36	1.27	±13.1%
5250	35.9	4.71	5.11	5.36	5.42	0.32	1.27	±13.1%
5600	35.5	5.07	4.73	4.97	5.02	0.28	1.27	±13.1%
5750	35.4	5.22	4.82	5.06	5.11	0.27	1.27	±13.1%
5850	35.2	5.32	4.37	4.58	4.63	0.26	1.27	±13.1%

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

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

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

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

Parameters of Probe: EX3DV4 - SN:7448

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	5.03	5.28	5.33	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.

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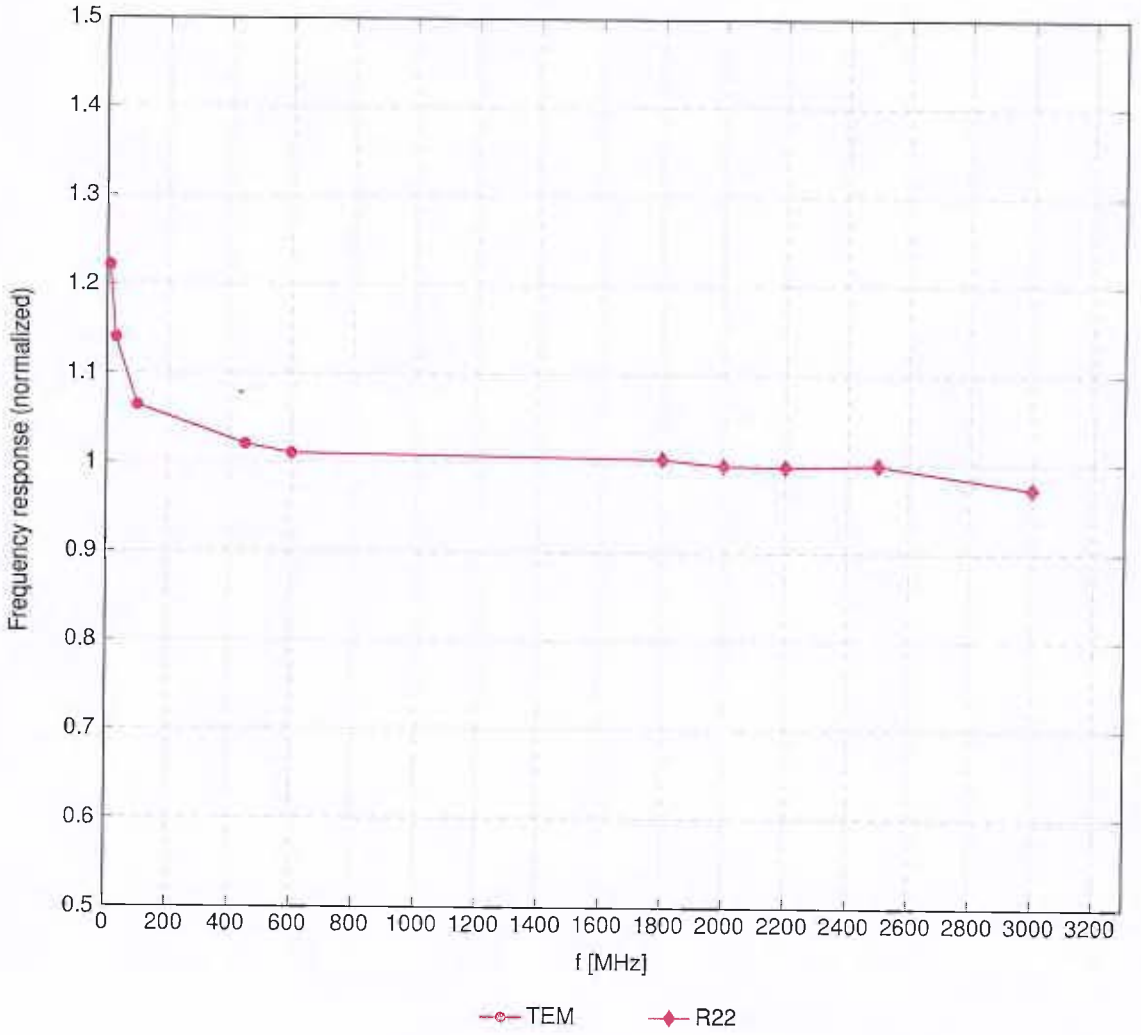
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz; below ±2% for frequencies between 3–6 GHz; and below ±4% for frequencies between 6–10 GHz at any distance larger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

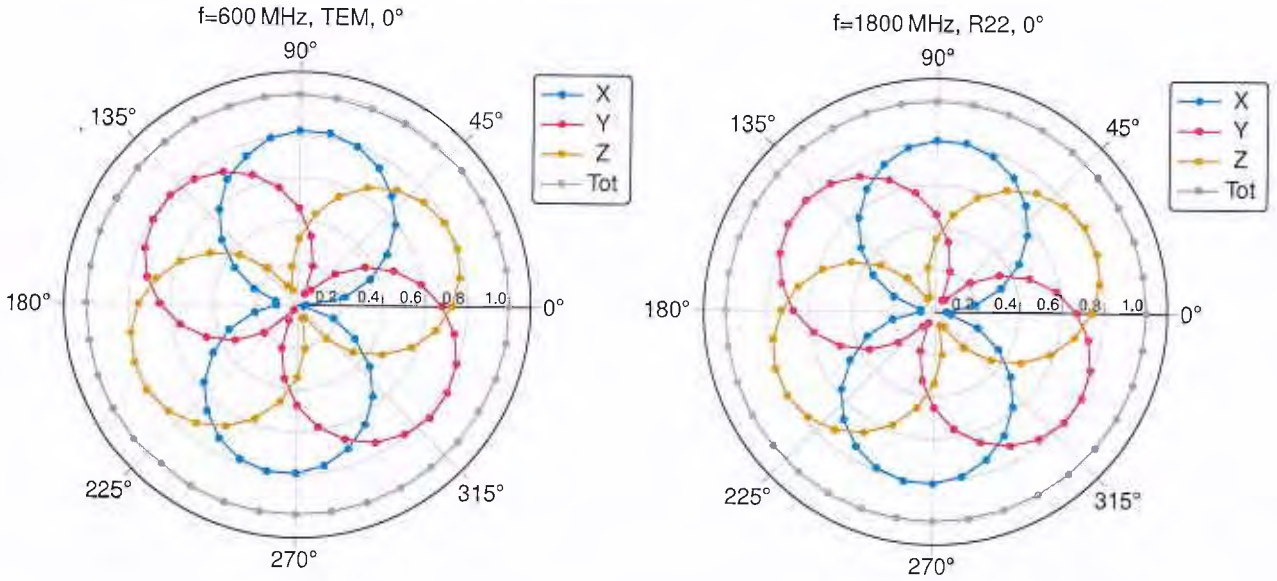
Frequency Response of E-Field

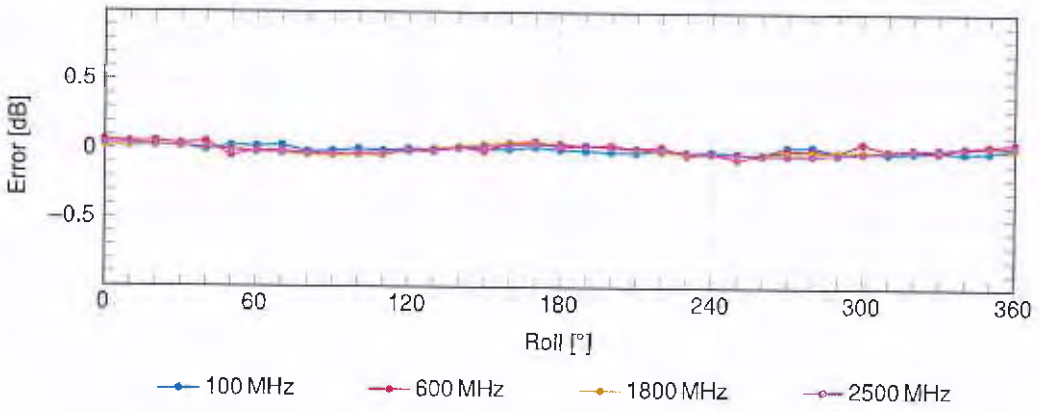
(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$

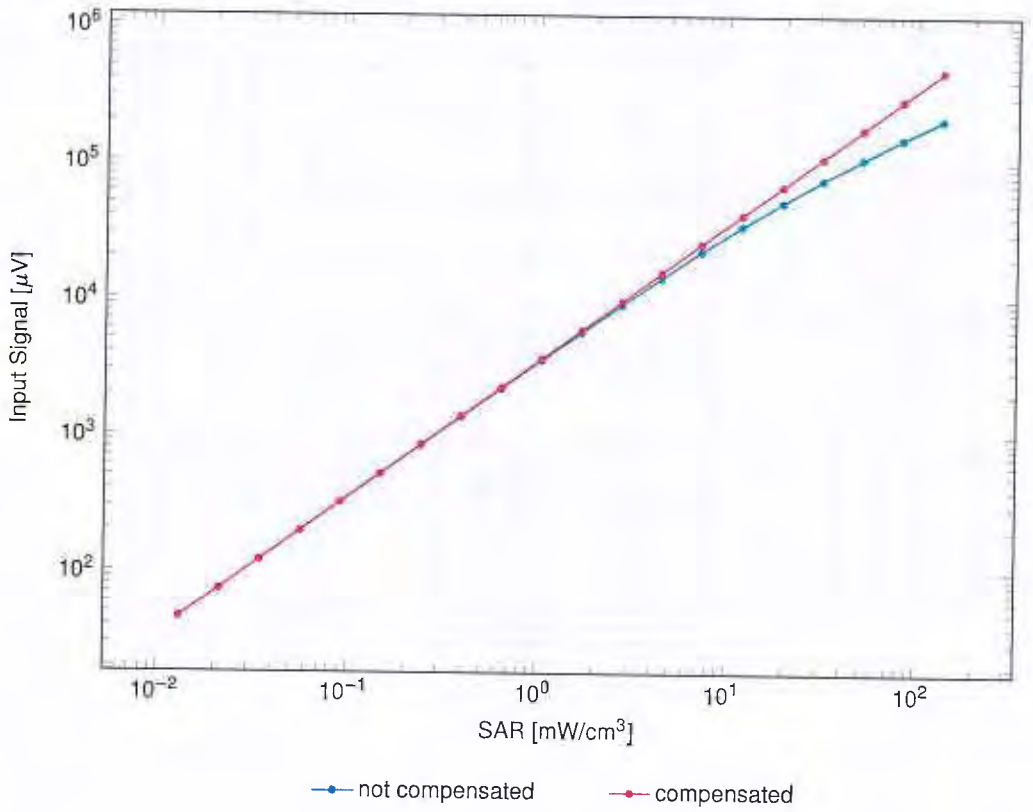


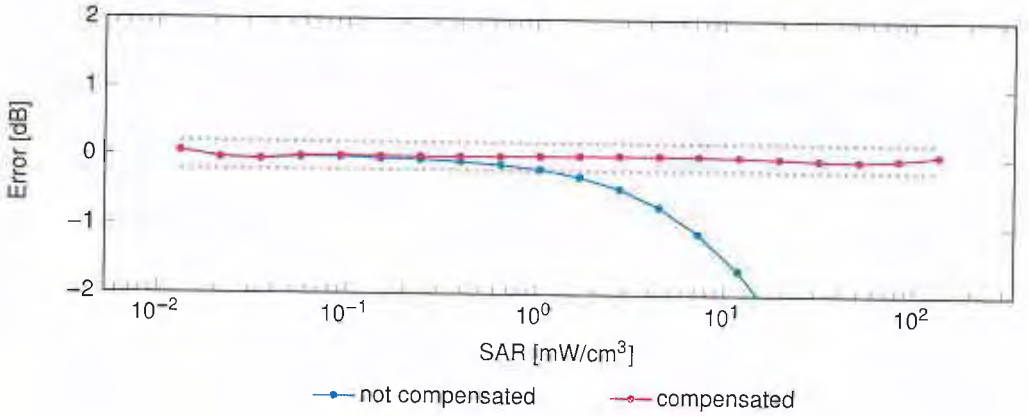


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Dynamic Range f(SAR_{HSL})

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





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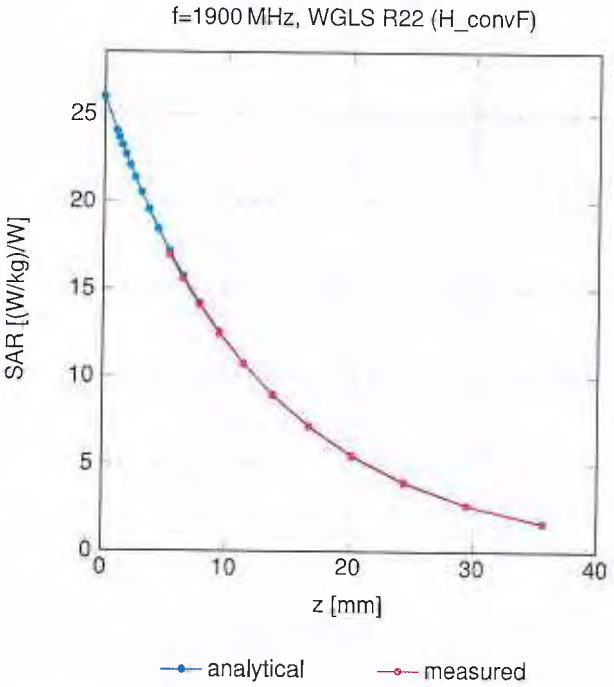

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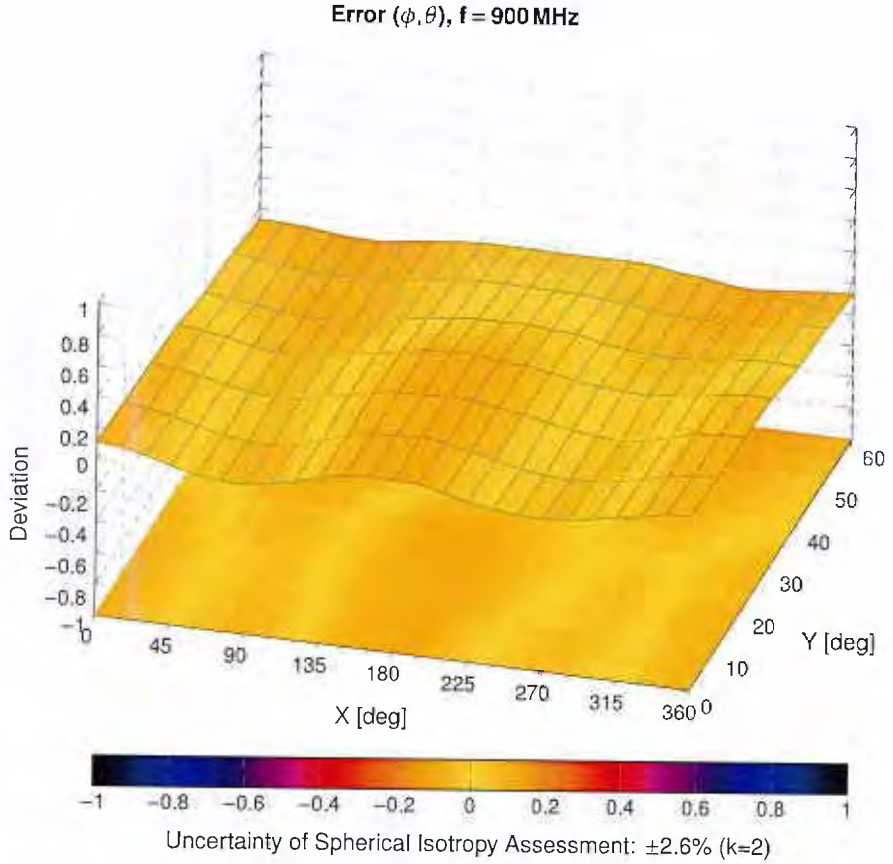

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Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

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-3990_Feb26**

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3990
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	February 17, 2026

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

Issued: February 17, 2026

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- *DCPx,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
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,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 $f \le 800$ 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 *NORMx,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 *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:3990

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.59	0.61	0.62	±10.1%
DCP (mV) [B]	99.8	99.9	99.8	±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	126.9	±1.1%	±4.7%
		Y	0.00	0.00	1.00		127.1		
		Z	0.00	0.00	1.00		132.6		
10352	Pulse (D=10%, T=5 ms)	X	0.95	64.74	15.89	10.00	24.0	±1.3%	±9.6%
		Y	0.87	62.69	14.94		25.0		
		Z	0.71	61.14	14.18		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.87	67.75	15.88	6.99	48.0	±1.0%	±9.6%
		Y	0.80	65.70	14.93		49.0		
		Z	0.65	64.15	14.18		49.0		
10354	Pulse (D=40%, T=5 ms)	X	0.79	70.76	15.87	3.98	95.0	±1.0%	±9.6%
		Y	0.72	68.71	14.92		97.0		
		Z	0.59	67.16	14.17		97.0		
10355	Pulse (D=60%, T=5 ms)	X	0.74	72.52	15.87	2.22	142.0	±1.1%	±9.6%
		Y	0.68	70.47	14.92		145.0		
		Z	0.55	68.92	14.17		145.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.75	69.64	15.87	0.00	115.0	±1.8%	±9.6%
		Y	0.69	67.59	14.92		118.0		
		Z	0.56	66.04	14.17		118.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	2.07	69.52	15.94	0.00	123.0	±1.4%	±9.6%
		Y	1.81	67.48	14.99		126.0		
		Z	1.59	65.92	14.23		126.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.14	68.46	15.51	1.14	84.0	±2.0%	±9.6%
		Y	0.14	66.42	14.60		86.0		
		Z	0.04	50.08	13.95		86.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	3.19	68.46	15.95	0.00	114.0	±3.3%	±9.6%
		Y	2.78	66.42	15.00		117.0		
		Z	2.47	64.87	14.24		117.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	4.72	66.20	15.95	0.00	92.0	±1.2%	±9.6%
		Y	4.14	64.15	15.01		95.0		
		Z	3.66	62.60	14.25		95.0		

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:3990

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	33.3	246.35	34.78	15.50	0.01	5.09	0.95	0.25	1.01
y	34.6	254.75	34.51	18.01	0.00	5.05	0.91	0.24	1.01
z	33.1	244.72	34.74	14.24	0.00	5.10	0.82	0.25	1.01

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-45.3°
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:3990

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	9.66	10.46	9.35	0.36	1.27	±11.0%
900	41.5	0.97	9.32	10.09	9.03	0.36	1.27	±11.0%
1640	40.2	1.31	7.85	8.50	7.60	0.36	1.27	±11.0%
1750	40.1	1.37	7.90	8.55	7.65	0.37	1.27	±11.0%
1900	40.0	1.40	7.79	8.42	7.53	0.37	1.27	±11.0%
2100	39.8	1.49	7.70	8.33	7.45	0.37	1.27	±11.0%
2300	39.5	1.67	7.45	8.07	7.21	0.37	1.27	±11.0%
2450	39.2	1.80	7.17	7.76	6.94	0.37	1.27	±11.0%
2600	39.0	1.96	7.25	7.84	7.01	0.38	1.27	±11.0%
3300	38.2	2.71	6.75	7.30	6.53	0.38	1.27	±13.1%
3500	37.9	2.91	6.63	7.18	6.42	0.38	1.27	±13.1%
3700	37.7	3.12	6.65	7.20	6.44	0.39	1.27	±13.1%
3900	37.5	3.32	6.74	7.29	6.52	0.39	1.27	±13.1%
4100	37.2	3.53	6.62	7.16	6.41	0.39	1.27	±13.1%
4200	37.1	3.63	6.48	7.01	6.27	0.39	1.27	±13.1%
4400	36.9	3.84	6.37	6.89	6.16	0.39	1.27	±13.1%
4600	36.7	4.04	6.10	6.60	5.90	0.40	1.27	±13.1%
4800	36.4	4.25	6.11	6.62	5.92	0.40	1.27	±13.1%
4950	36.3	4.40	6.07	6.57	5.88	0.38	1.27	±13.1%
5250	35.9	4.71	5.49	5.95	5.32	0.35	1.27	±13.1%
5600	35.5	5.07	5.15	5.57	4.98	0.31	1.27	±13.1%
5750	35.4	5.22	5.31	5.74	5.13	0.29	1.27	±13.1%
5850	35.2	5.32	5.04	5.46	4.88	0.28	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:3990

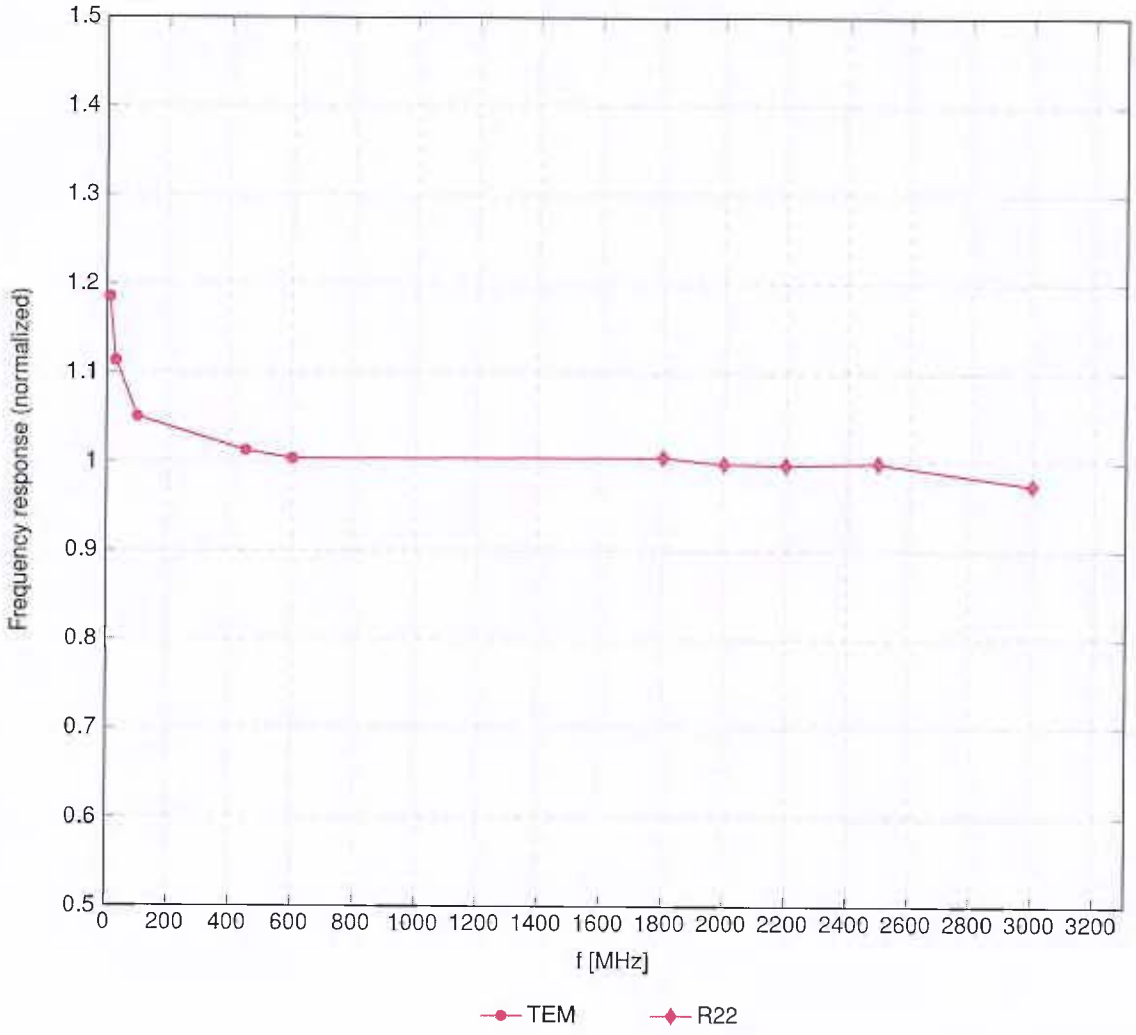
Calibration Parameter Determined in HSL

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	5.35	5.79	5.18	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.

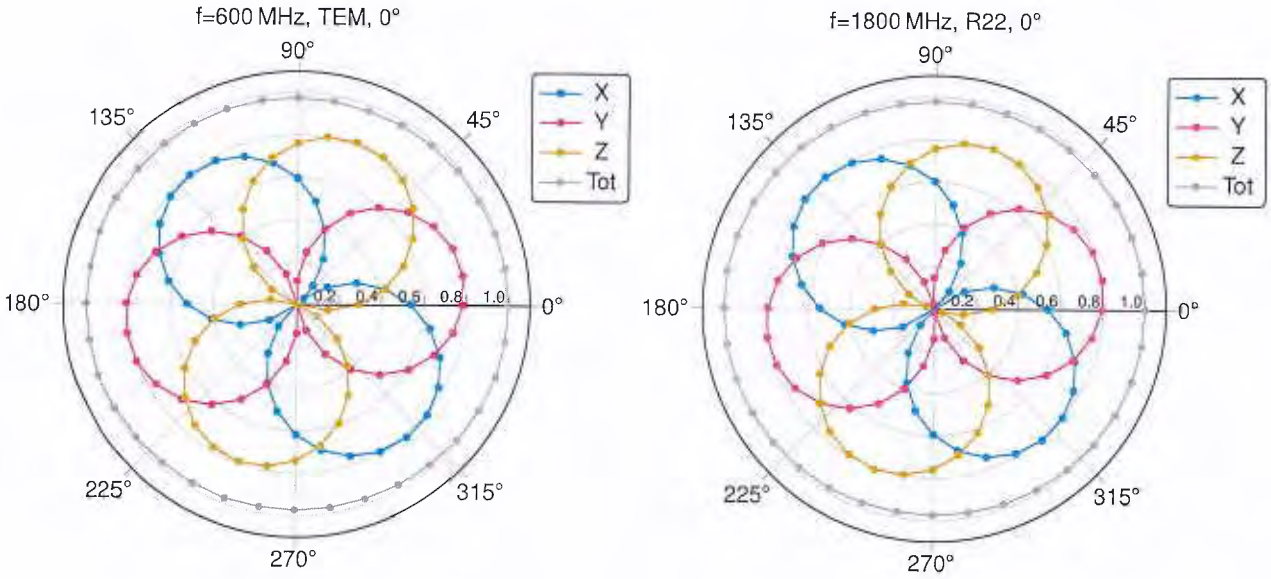
Frequency Response of E-Field

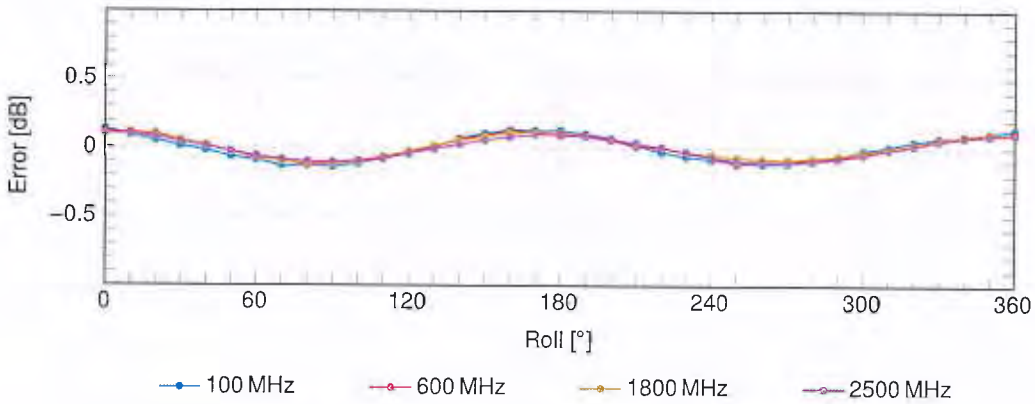
(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$

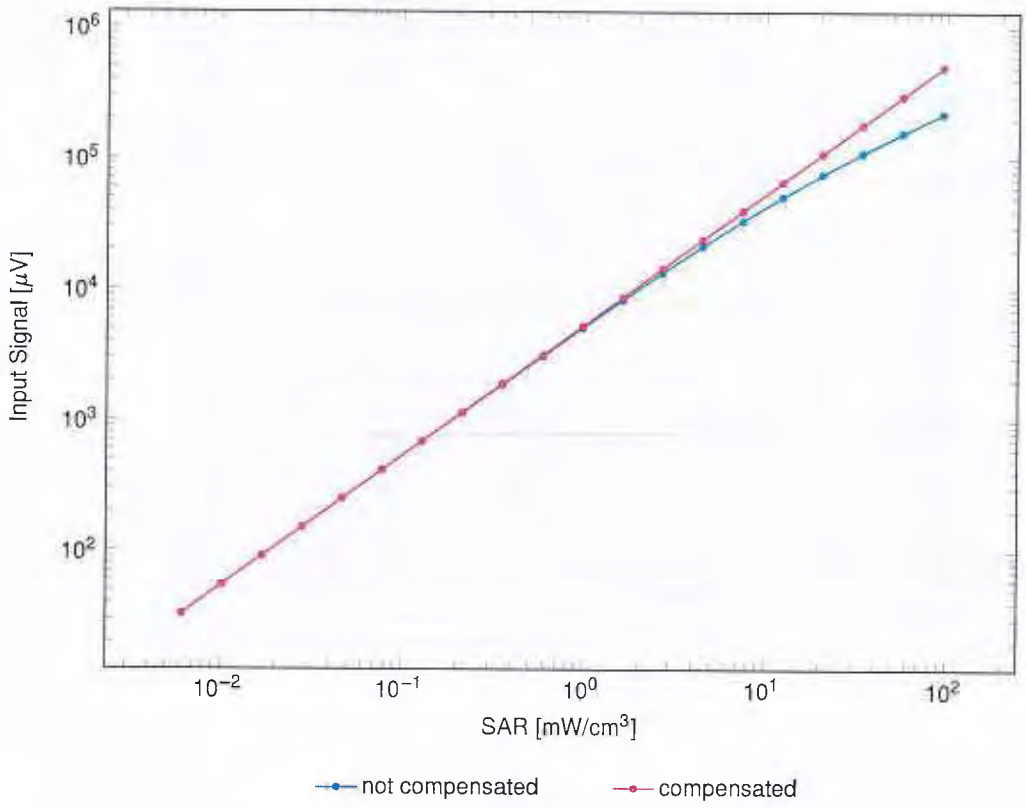


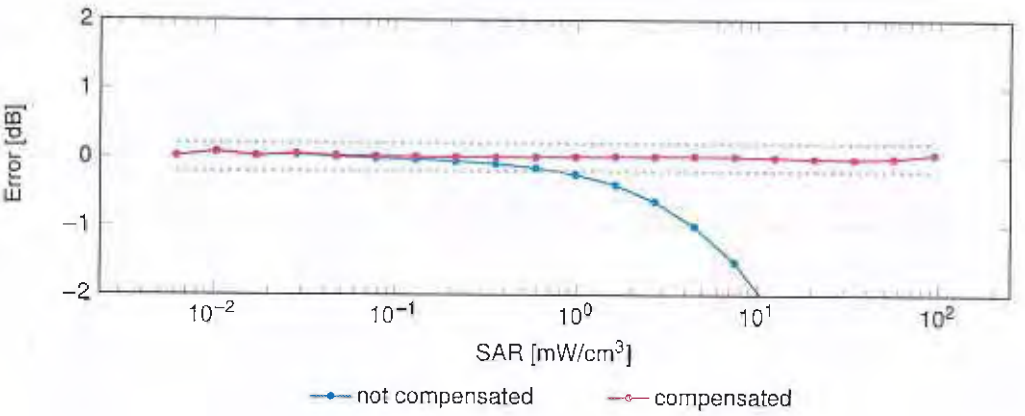


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Dynamic Range f(SAR_{HSL})

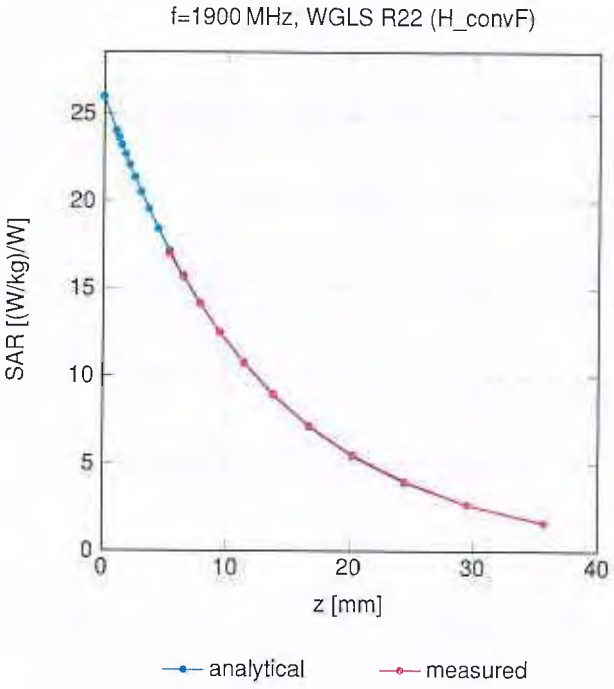
(TEM cell, f_{eval} = 1900 MHz)





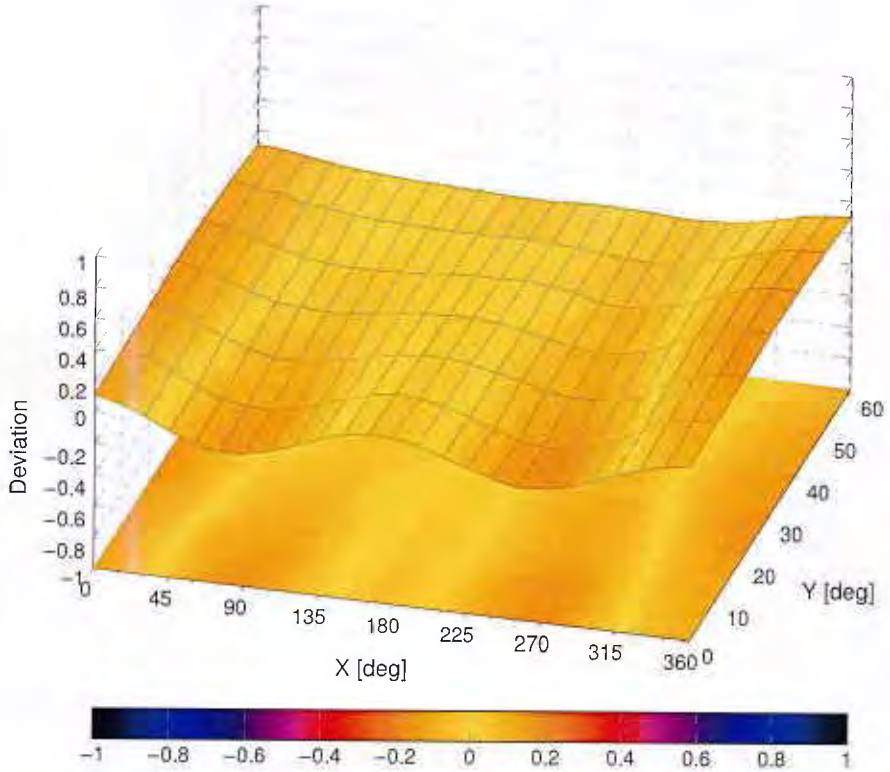
Uncertainty of Linearity Assessment: ±0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: ±2.6% (k=2)

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
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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-7897_Oct25

CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:7897

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: October 14, 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	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	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	07-Nov-24 (No. DAE4-1301_Nov24)	Nov-25

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: October 14, 2025

Glossary

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,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:

a) 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.
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,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.
- *DCPx,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
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,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 *NORMx,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 *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:7897

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.58	0.60	0.60	±10.1%
DCP (mV) [B]	107.0	107.1	107.0	±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	141.2	±2.7%	±4.7%
		Y	0.00	0.00	1.00		149.6		
		Z	0.00	0.00	1.00		142.9		
10352	Pulse (D=10%, T=5 ms)	X	0.29	60.09	14.52	10.00	23.0	±2.0%	±9.6%
		Y	0.63	70.00	18.07		24.0		
		Z	0.56	69.98	17.94		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.27	63.10	14.56	6.99	46.0	±1.6%	±9.6%
		Y	0.60	73.01	18.11		48.0		
		Z	0.52	72.99	17.98		48.0		
10354	Pulse (D=40%, T=5 ms)	X	0.25	66.11	14.60	3.98	93.0	±1.4%	±9.6%
		Y	0.56	76.02	18.16		95.0		
		Z	0.48	76.00	18.03		95.0		
10355	Pulse (D=60%, T=5 ms)	X	0.24	67.87	14.62	2.22	139.0	±1.3%	±9.6%
		Y	0.54	77.78	18.19		143.0		
		Z	0.46	77.76	18.06		143.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.01	64.99	15.76	0.34	106.0	±1.3%	±9.6%
		Y	0.01	74.90	19.59		110.0		
		Z	0.01	80.63	19.44		109.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	0.62	64.87	13.92	0.00	112.0	±2.6%	±9.6%
		Y	1.76	74.78	17.34		116.0		
		Z	1.54	74.76	17.25		116.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.00	63.81	16.97	1.57	81.0	±3.1%	±9.6%
		Y	0.08	73.73	21.03		83.0		
		Z	0.00	81.68	20.43		83.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	1.66	63.81	13.09	0.00	104.0	±4.0%	±9.6%
		Y	3.99	73.73	17.23		107.0		
		Z	3.74	73.71	17.11		107.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	2.01	61.55	13.02	0.00	75.0	±2.0%	±9.6%
		Y	4.85	71.46	17.23		78.0		
		Z	4.64	71.44	17.11		78.0		

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:7897

Sensor Model Parameters

	C1 fF	C2 fF	α V^{-1}	T1 ms V^{-2}	T2 ms V^{-1}	T3 ms	T4 V^{-2}	T5 V^{-1}	T6
x	8.5	61.35	33.62	3.59	0.00	4.90	0.44	0.00	1.00
y	10.7	77.49	33.81	3.88	0.00	4.91	0.48	0.00	1.00
z	9.4	68.52	33.76	2.14	0.00	4.90	0.31	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-59.5°
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:7897

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	9.18	9.47	9.62	0.36	1.27	±11.0%
900	41.5	0.97	8.76	9.04	9.18	0.36	1.27	±11.0%
1640	40.2	1.31	7.68	7.92	8.04	0.36	1.27	±11.0%
1750	40.1	1.37	7.61	7.85	7.97	0.36	1.27	±11.0%
1900	40.0	1.40	7.39	7.63	7.74	0.36	1.27	±11.0%
2100	39.8	1.49	7.21	7.44	7.55	0.36	1.27	±11.0%
2300	39.5	1.67	7.02	7.24	7.35	0.36	1.27	±11.0%
2450	39.2	1.80	6.87	7.09	7.20	0.36	1.27	±11.0%
2600	39.0	1.96	6.74	6.95	7.06	0.36	1.27	±11.0%
3300	38.2	2.71	6.41	6.62	6.72	0.35	1.27	±13.1%
3500	37.9	2.91	6.38	6.58	6.68	0.35	1.27	±13.1%
3700	37.7	3.12	6.31	6.51	6.61	0.35	1.27	±13.1%
3900	37.5	3.32	6.28	6.48	6.58	0.35	1.27	±13.1%
4100	37.2	3.53	6.22	6.42	6.51	0.35	1.27	±13.1%
4200	37.1	3.63	6.15	6.34	6.44	0.35	1.27	±13.1%
4400	36.9	3.84	6.06	6.25	6.35	0.35	1.27	±13.1%
4600	36.7	4.04	5.99	6.18	6.27	0.35	1.27	±13.1%
4800	36.4	4.25	5.93	6.12	6.21	0.35	1.27	±13.1%
4950	36.3	4.40	5.81	5.99	6.09	0.34	1.27	±13.1%
5250	35.9	4.71	5.44	5.61	5.70	0.31	1.27	±13.1%
5600	35.5	5.07	5.06	5.22	5.30	0.28	1.27	±13.1%
5750	35.4	5.22	5.15	5.31	5.39	0.27	1.27	±13.1%
5850	35.2	5.32	4.91	5.07	5.15	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:7897

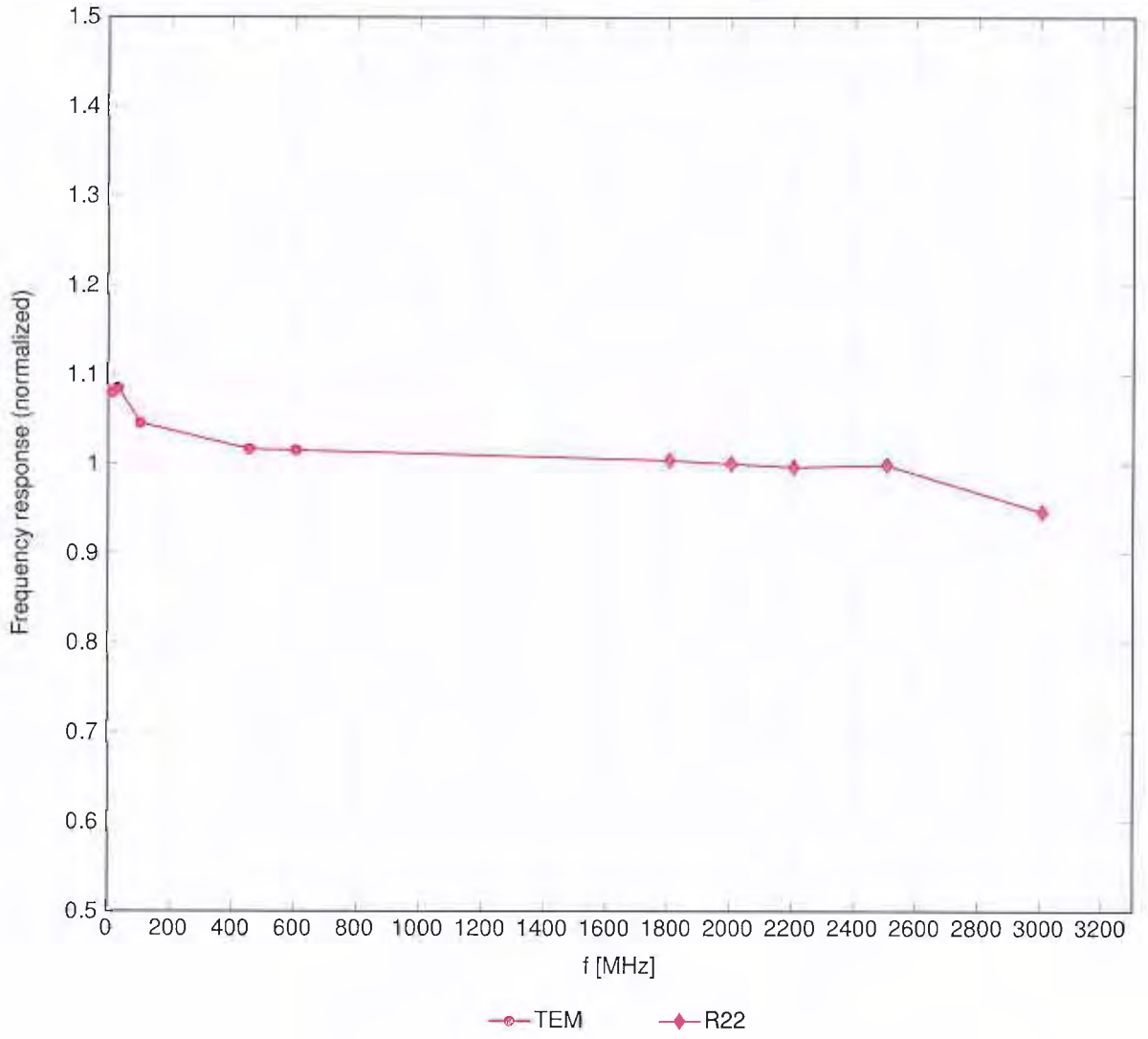
Calibration Parameter Determined in HSL

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	5.29	5.45	5.54	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.

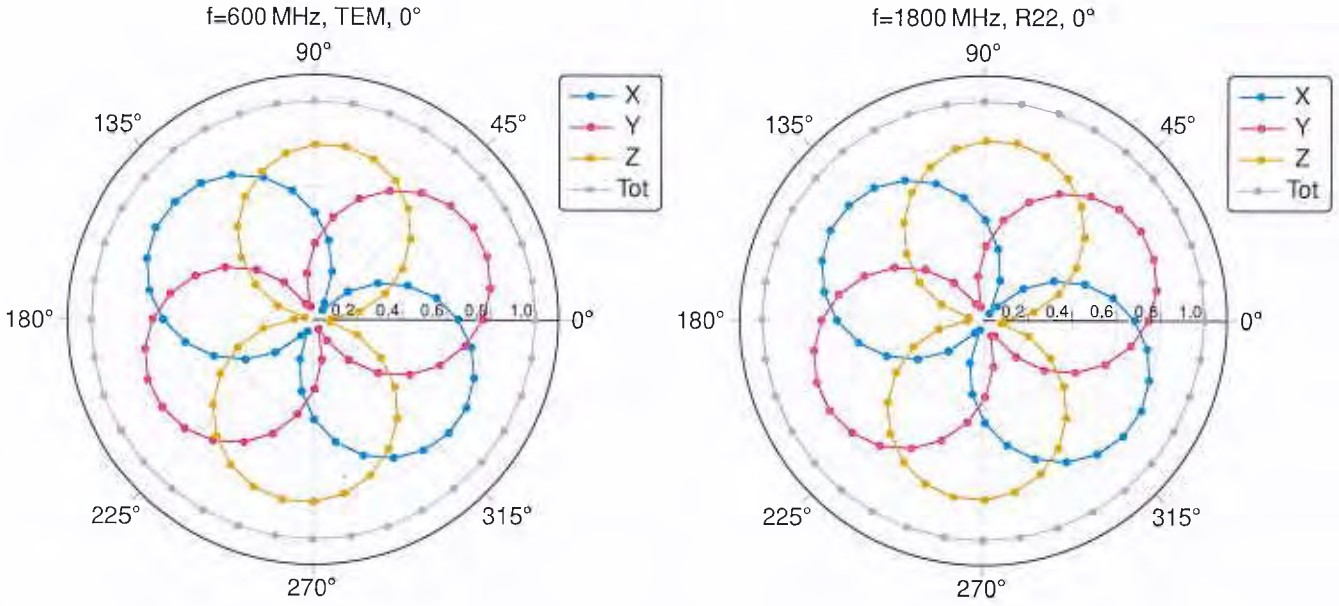
Frequency Response of E-Field

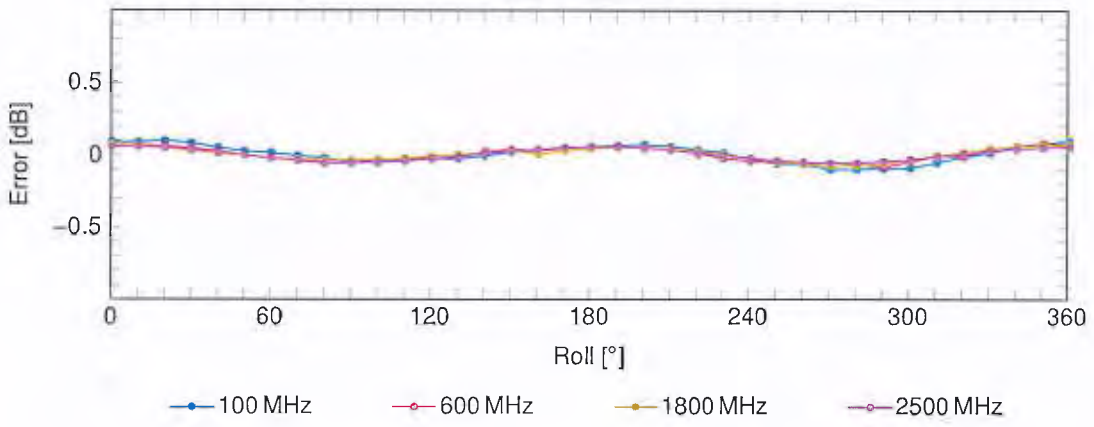
(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$

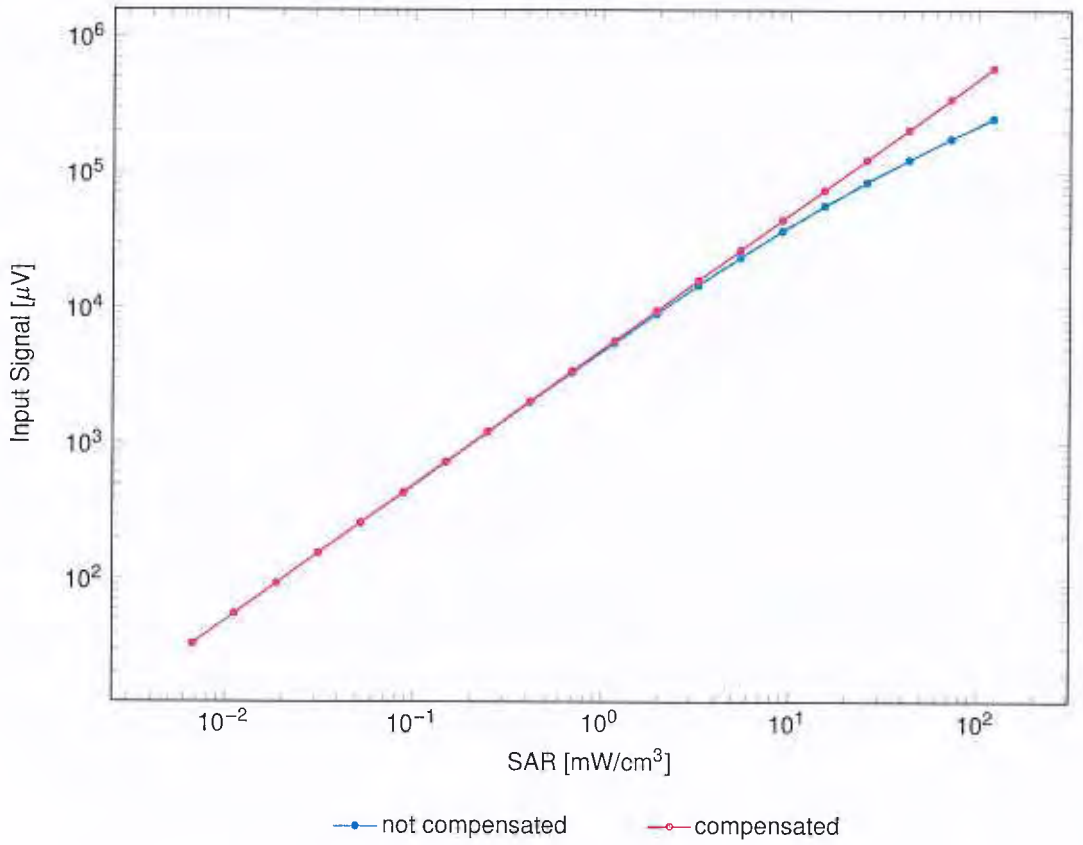


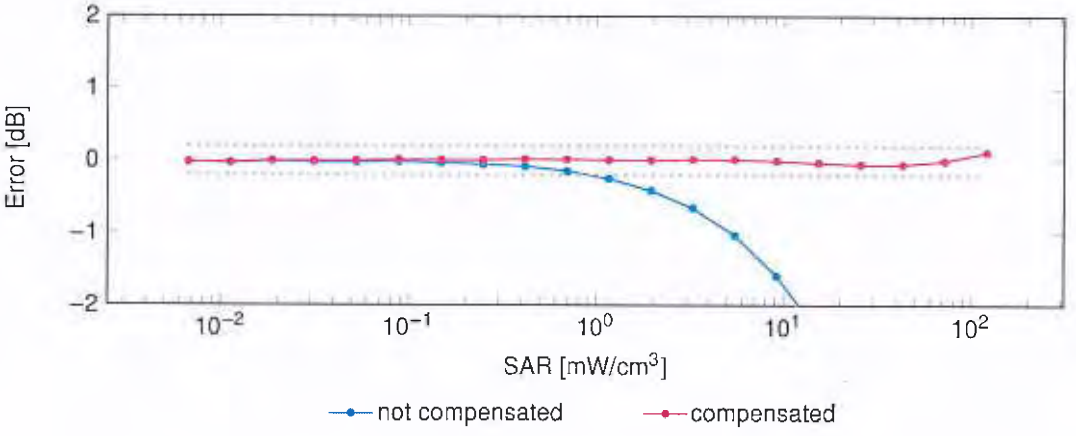


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Dynamic Range f(SAR_{HSL})

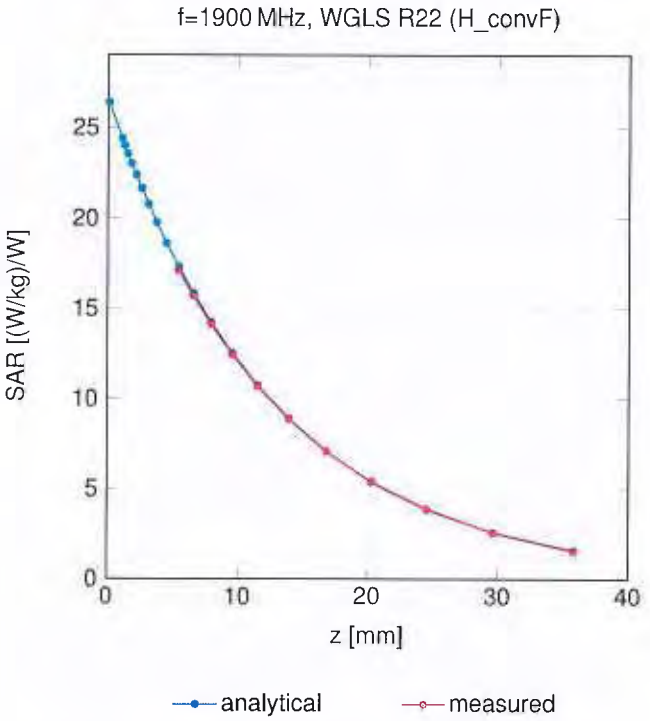
(TEM cell, f_{eval} = 1900 MHz)





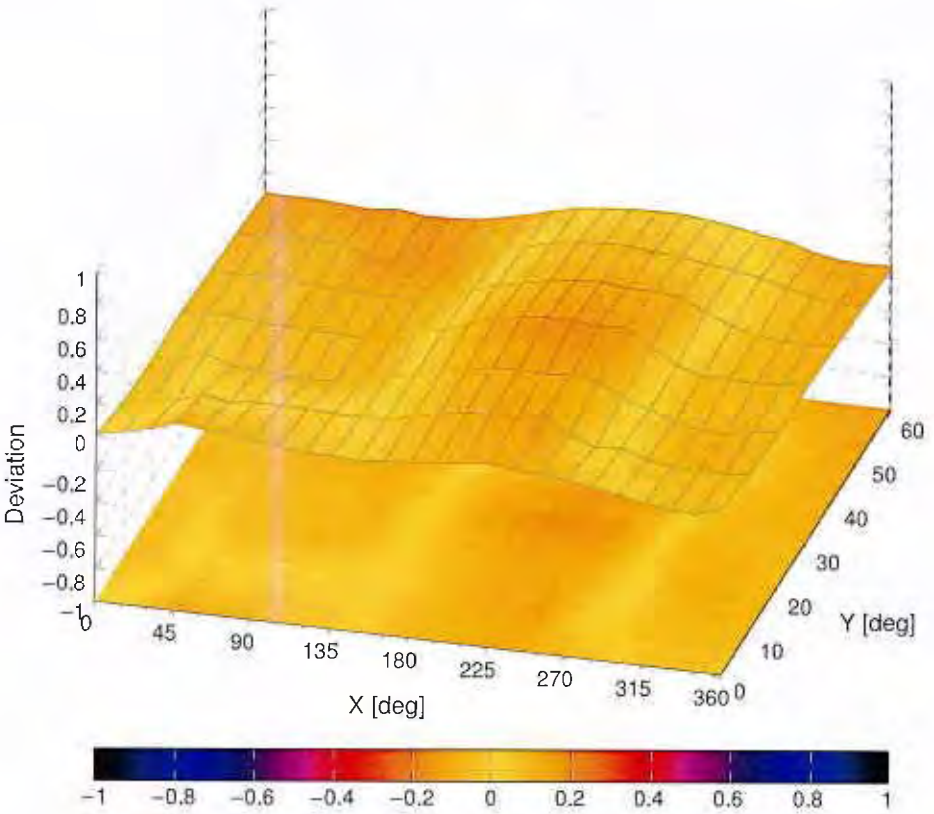
Uncertainty of Linearity Assessment: ±0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: ±2.6% (k=2)

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

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Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client UL
Fremont, USA

Certificate No. EX-7979_Mar26

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:7979
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 03, 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 ± 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 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	Henrique Almeida
Approved by	Sven Kühn	Technical Manager	

Issued: March 03, 2026

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

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Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Glossary

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,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:

a) 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.
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ ($f \le 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,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.
- *DCPx,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
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,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 $f \le 800$ 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 *NORMx,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 *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:7979

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.69	0.61	0.59	±10.1%
DCP (mV) [B]	105.1	104.5	105.0	±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	136.4	±2.0%	±4.7%
		Y	0.00	0.00	1.00		132.1		
		Z	0.00	0.00	1.00		129.4		
10352	Pulse (D=10%, T=5 ms)	X	0.79	70.00	17.87	10.00	23.0	±1.8%	±9.6%
		Y	0.33	60.59	14.88		24.0		
		Z	0.33	61.47	15.37		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.75	73.01	17.90	6.99	46.0	±1.5%	±9.6%
		Y	0.31	63.60	14.93		47.0		
		Z	0.31	64.48	15.42		48.0		
10354	Pulse (D=40%, T=5 ms)	X	0.70	76.02	17.94	3.98	93.0	±1.3%	±9.6%
		Y	0.28	66.61	14.97		94.0		
		Z	0.29	67.49	15.47		96.0		
10355	Pulse (D=60%, T=5 ms)	X	0.67	77.78	17.96	2.22	139.0	±1.3%	±9.6%
		Y	0.27	68.37	15.00		141.0		
		Z	0.27	69.26	15.50		143.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.01	74.90	19.15	0.24	107.0	±1.5%	±9.6%
		Y	0.00	82.66	16.25		109.0		
		Z	0.00	84.45	16.90		110.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	1.51	74.78	17.58	0.00	113.0	±2.7%	±9.6%
		Y	0.76	65.37	14.05		115.0		
		Z	0.67	66.26	14.72		117.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.03	82.16	19.82	1.49	80.0	±3.6%	±9.6%
		Y	0.00	82.68	17.84		82.0		
		Z	0.00	65.20	18.16		83.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	3.66	73.73	17.47	0.00	104.0	±4.0%	±9.6%
		Y	1.87	64.32	13.24		107.0		
		Z	1.86	65.20	13.84		109.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	4.33	71.46	17.47	0.00	75.0	±2.4%	±9.6%
		Y	2.23	62.05	13.18		77.0		
		Z	2.16	62.94	13.78		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:7979

Sensor Model Parameters

	C1 fF	C2 fF	α V^{-1}	T1 ms V^{-2}	T2 ms V^{-1}	T3 ms	T4 V^{-2}	T5 V^{-1}	T6
x	8.5	62.14	34.00	4.15	0.00	4.90	0.50	0.00	1.00
y	9.1	66.64	34.13	2.42	0.00	4.90	0.35	0.00	1.00
z	8.0	58.34	34.15	2.89	0.00	4.90	0.36	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-5.6°
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:7979

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	9.35	9.82	9.21	0.34	1.27	±11.0%
900	41.5	0.97	8.93	9.37	8.80	0.34	1.27	±11.0%
1750	40.1	1.37	7.79	8.18	7.68	0.34	1.27	±11.0%
1900	40.0	1.40	7.46	7.83	7.35	0.34	1.27	±11.0%
2300	39.5	1.67	7.10	7.46	7.00	0.34	1.27	±11.0%
2600	39.0	1.96	6.82	7.16	6.73	0.34	1.27	±11.0%
3300	38.2	2.71	6.32	6.64	6.23	0.35	1.27	±13.1%
3500	37.9	2.91	6.25	6.56	6.16	0.35	1.27	±13.1%
3700	37.7	3.12	6.18	6.49	6.09	0.35	1.27	±13.1%
3900	37.5	3.32	6.12	6.43	6.04	0.35	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.

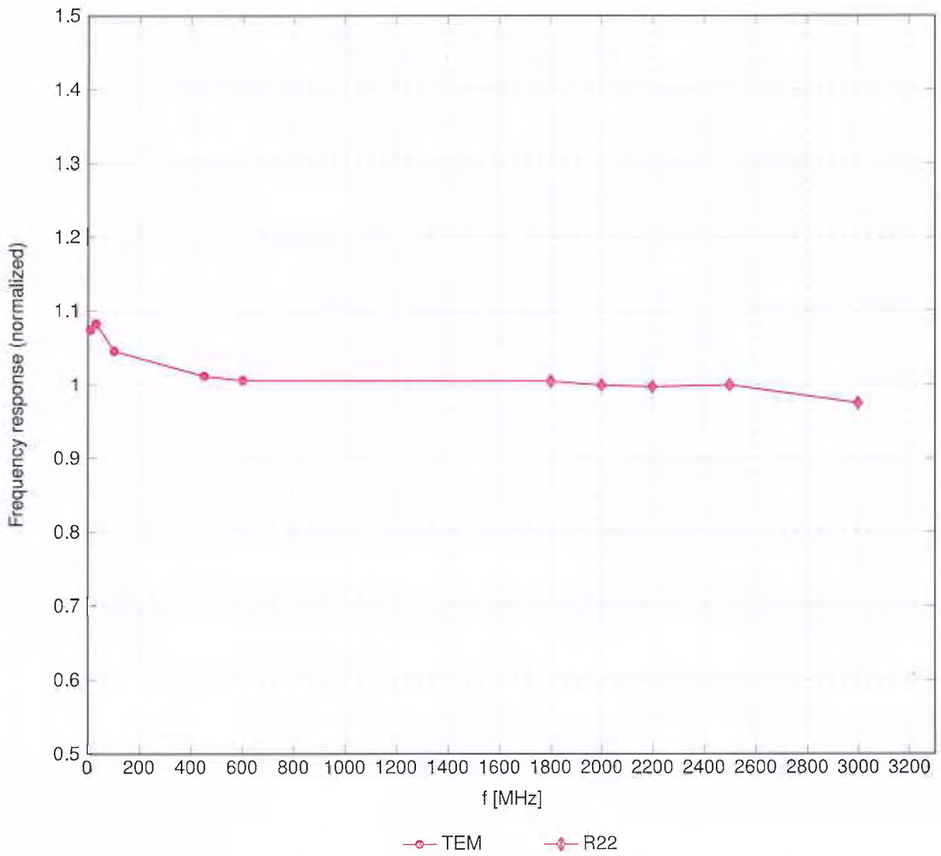
[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

[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.

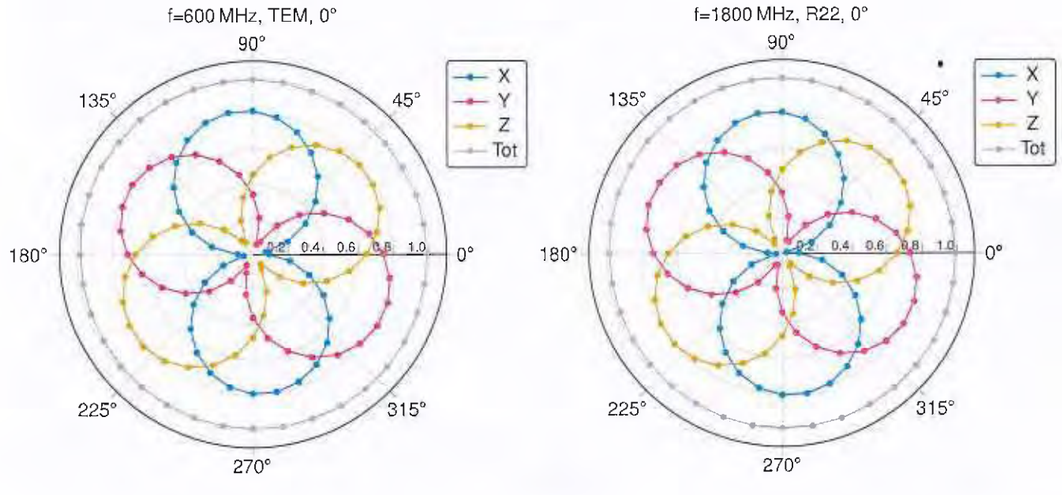
Frequency Response of E-Field

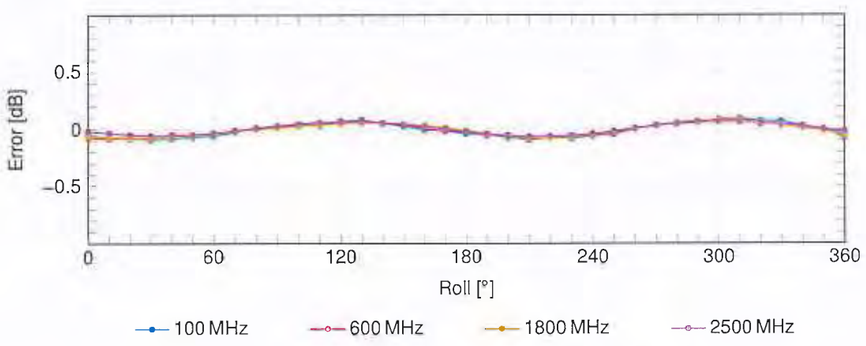
(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$





Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

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S Swiss Calibration Service

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-7981_Mar26

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:7981
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 17, 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 ± 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 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	Henrique Almeida
Approved by	Sven Kühn	Technical Manager	

Issued: March 17, 2026

Glossary

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,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:

a) 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.
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,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.
- *DCPx,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
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,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 *NORMx,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 *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:7981

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.64	0.60	0.54	±10.1%
DCP (mV) [B]	104.6	105.1	104.4	±4.7%

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B $dB\sqrt{\mu V}$	C	D dB	VR mV	Max dev.	Max Unc[E] $k = 2$
0	Continuous Wave	X	0.00	0.00	1.00	0.00	132.1	±1.9%	±4.7%
		Y	0.00	0.00	1.00		132.8		
		Z	0.00	0.00	1.00		121.3		
10352	Pulse (D=10%, T=5 ms)	X	0.91	70.00	17.73	10.00	23.0	±1.6%	±9.6%
		Y	0.34	58.94	13.82		24.0		
		Z	0.34	59.95	14.47		24.0		
10353	Pulse (D=20%, T=5 ms)	X	0.85	73.01	17.75	6.99	46.0	±1.3%	±9.6%
		Y	0.31	61.95	13.86		47.0		
		Z	0.32	62.96	14.52		47.0		
10354	Pulse (D=40%, T=5 ms)	X	0.79	76.02	17.78	3.98	93.0	±1.2%	±9.6%
		Y	0.29	64.96	13.91		94.0		
		Z	0.30	65.97	14.58		95.0		
10355	Pulse (D=60%, T=5 ms)	X	0.75	77.78	17.79	2.22	139.0	±1.3%	±9.6%
		Y	0.28	66.72	13.93		141.0		
		Z	0.28	67.73	14.61		142.0		
10387	Random (BW=1 MHz, MOD=QPSK)	X	0.01	74.90	18.62	0.29	106.0	±1.3%	±9.6%
		Y	0.01	63.84	15.11		107.0		
		Z	0.01	64.85	16.10		108.0		
10388	Random (BW=10 MHz, MOD=QPSK)	X	1.33	74.78	17.63	0.00	112.0	±2.7%	±9.6%
		Y	0.59	63.73	13.35		113.0		
		Z	0.56	64.74	14.00		114.0		
10396	Random (BW=100 kHz, MOD=64QAM)	X	0.07	73.72	18.94	1.41	81.0	±2.3%	±9.6%
		Y	0.00	62.67	16.35		82.0		
		Z	0.00	63.68	17.33		82.0		
10399	Random (BW=40 MHz, MOD=64QAM)	X	3.37	73.72	17.54	0.00	103.0	±4.1%	±9.6%
		Y	1.54	62.67	12.49		105.0		
		Z	1.62	63.68	12.92		106.0		
10414	Random (BW=40 MHz, HIGH PAR)	X	4.00	71.46	17.54	0.00	74.0	±1.8%	±9.6%
		Y	1.82	60.40	12.40		75.0		
		Z	1.90	61.42	12.84		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:7981

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	7.3	53.04	33.93	3.34	0.00	4.90	0.30	0.00	1.00
y	7.8	56.96	33.78	2.29	0.00	4.90	0.37	0.00	1.00
z	7.4	53.86	34.16	2.05	0.00	4.90	0.00	0.00	1.00

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-0.5°
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:7981

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	9.61	10.00	9.36	0.35	1.27	±11.0%
900	41.5	0.97	9.26	9.64	9.02	0.35	1.27	±11.0%
1750	40.1	1.37	7.93	8.25	7.73	0.35	1.27	±11.0%
1900	40.0	1.40	7.61	7.92	7.41	0.35	1.27	±11.0%
2300	39.5	1.67	7.24	7.54	7.06	0.35	1.27	±11.0%
2600	39.0	1.96	7.04	7.33	6.86	0.35	1.27	±11.0%
3300	38.2	2.71	6.65	6.92	6.48	0.34	1.27	±13.1%
3500	37.9	2.91	6.71	6.99	6.54	0.34	1.27	±13.1%
3700	37.7	3.12	6.71	6.98	6.53	0.34	1.27	±13.1%
3900	37.5	3.32	6.66	6.93	6.49	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.

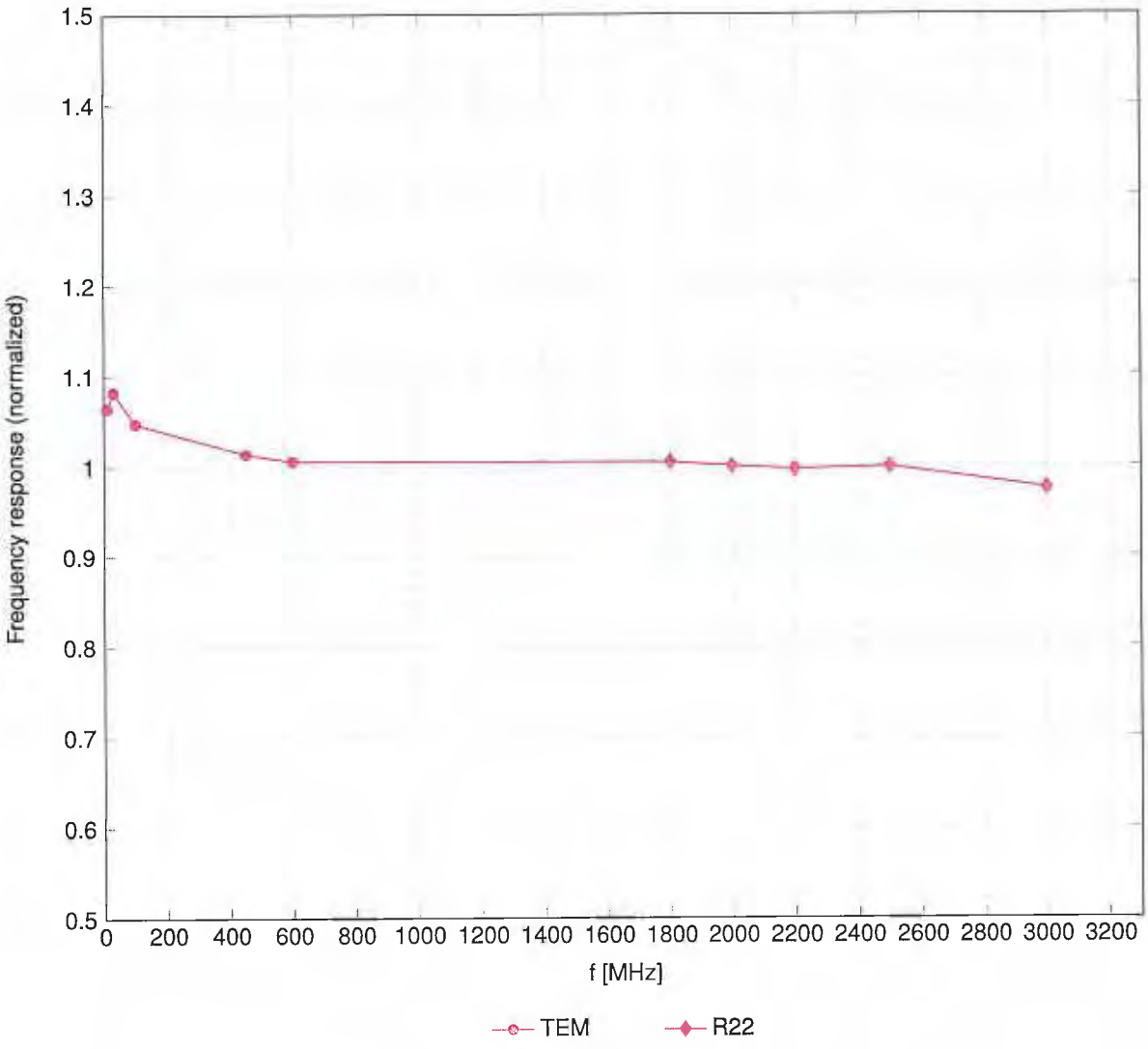
[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10% if SAR correction is applied.

[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.

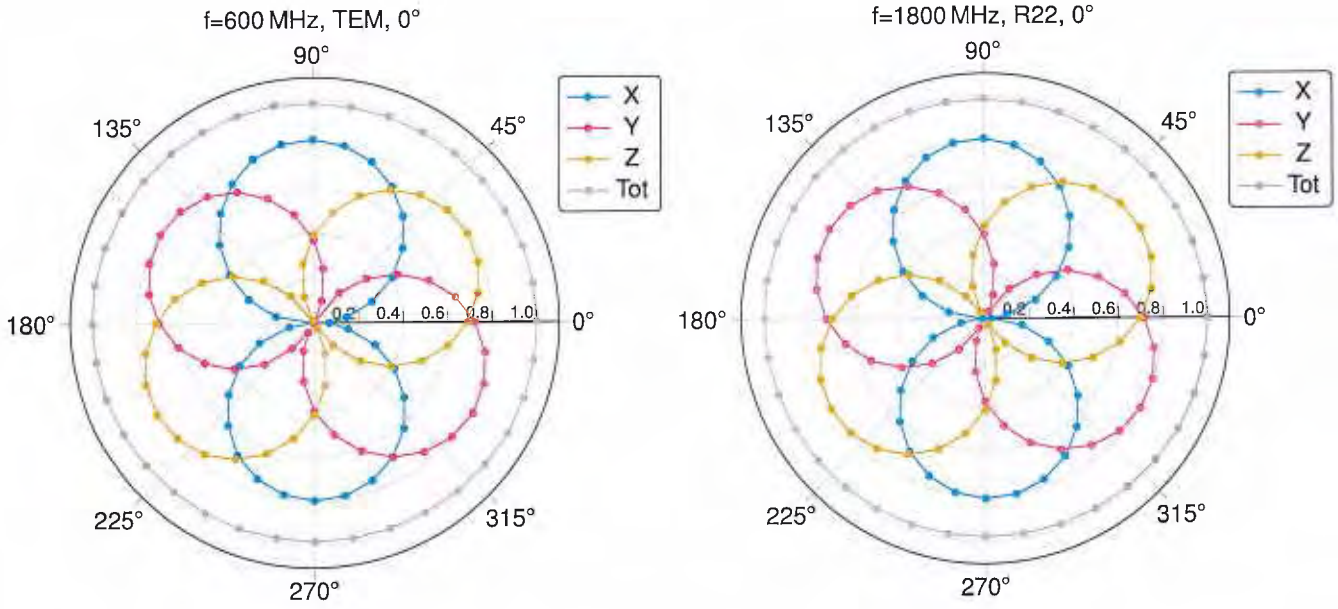
Frequency Response of E-Field

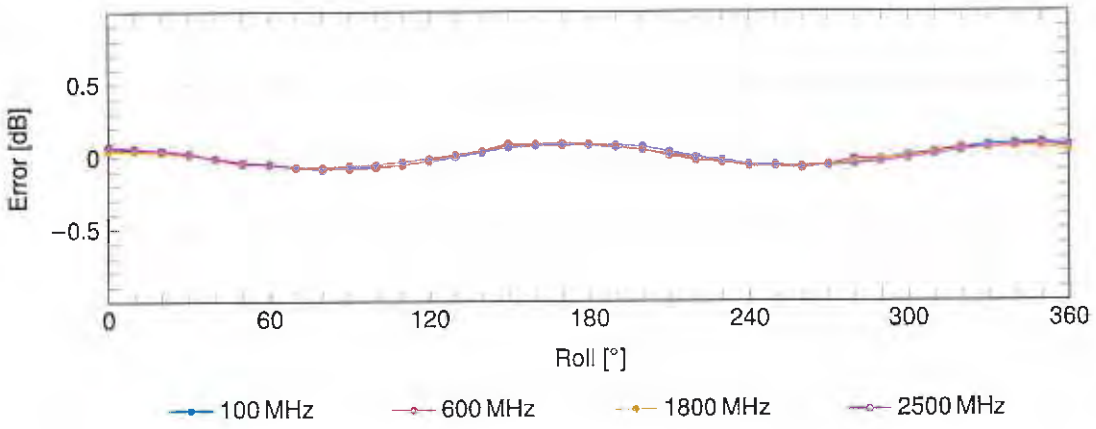
(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$

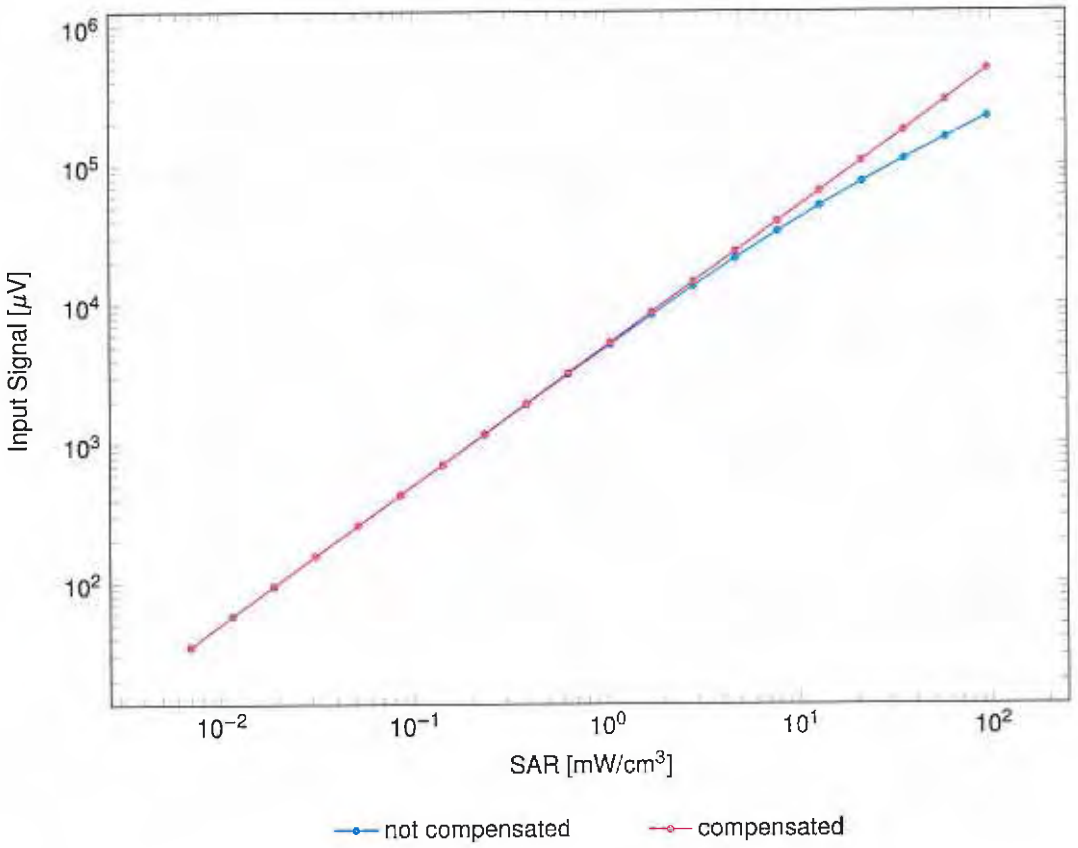


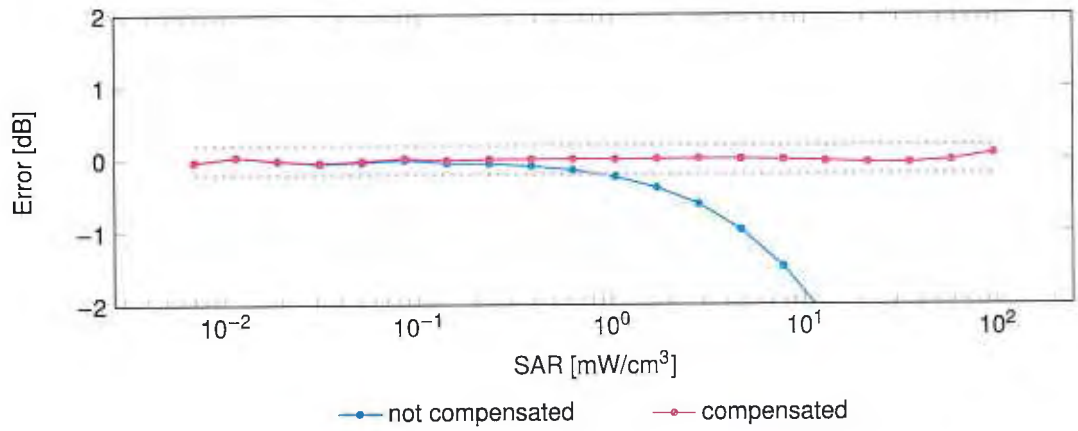


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Dynamic Range f(SAR_{HSL})

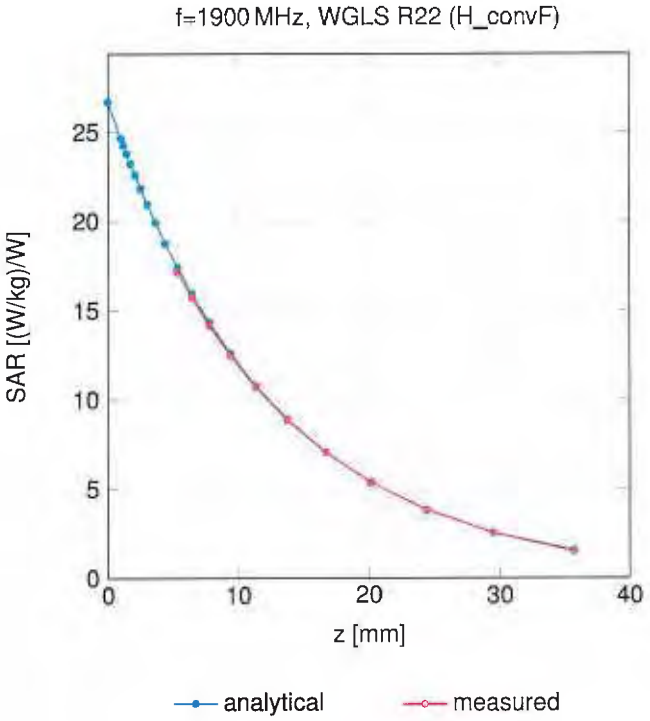
(TEM cell, f_{eval} = 1900 MHz)





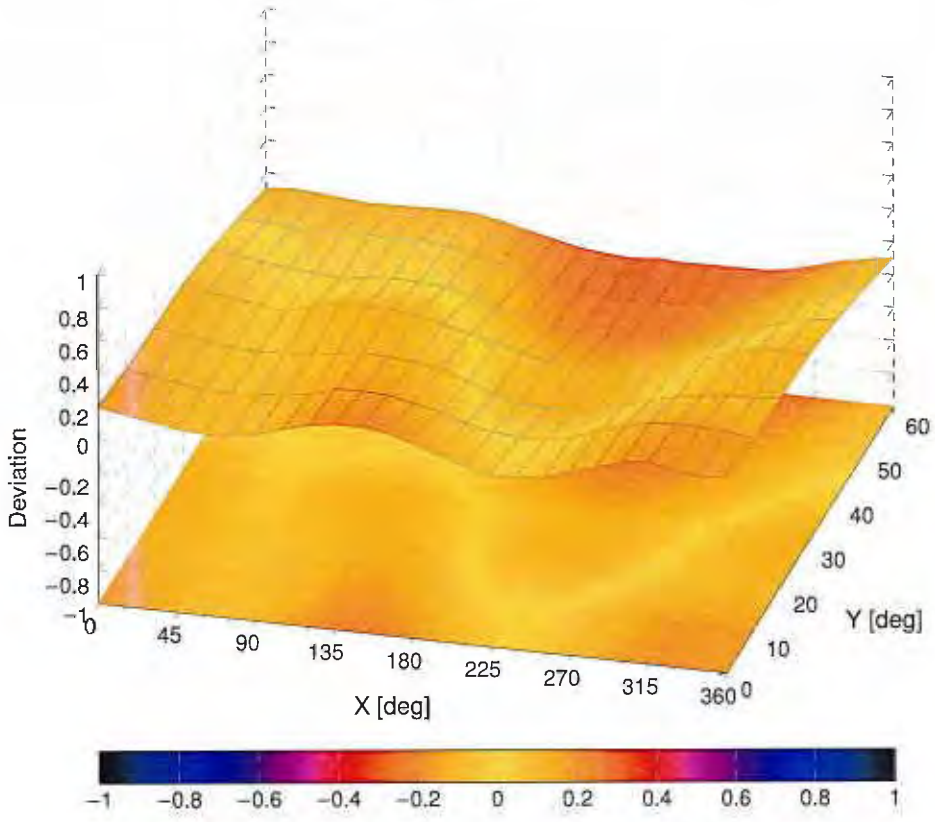
Uncertainty of Linearity Assessment: ±0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: ±2.6% (k=2)