Annex E DASY Calibration Certificate

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S Schweizerischer Kalibrierdienst
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Accreditation No.: SCS 0108

Client Auden

Certificate No: ER3-2344_Jul22

CALIBRATION CERTIFICATE

Object: ER3DV6- SN:2344

Calibration procedure(s): QA CAL-02.v9, QA CAL-25.v7
Calibration procedure for E-field probes optimized for close near field evaluations in air

Calibration date: July 15, 2022

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	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-22 (No. 217-03525/03524)	Apr-23
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23
Power sensor NRP-Z91	SN: 103245	04-Apr-22 (No. 217-03525)	Apr-23
Reference 20 dB Attenuator	SN: CC2552 (20x)	04-Apr-22 (No. 217-03527)	Apr-23
DAE4	SN: 789	24-Dec-21 (No. DAE4-789_Dec21)	Dec-22
Reference Probe ER3DV6	SN: 2328	08-Oct-21 (No. ER3-2328_Oct21)	Oct-22
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-22)	In house check: Jun-24
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-22

	Name	Function	Signature
Calibrated by:	Jeffrey Katzman	Laboratory Technician	
Approved by:	Sven Kühn	Technical Manager	

Issued: July 21, 2022

Glossary:

NORMx,y,z	sensitivity in free space
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
En	incident E-field orientation normal to probe axis
Ep	incident E-field orientation parallel to probe axis
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) IEEE Std 1309-2005, " IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005
b) CTIA Test Plan for Hearing Aid Compatibility, Rev 3.1.1, May 2017

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization $\vartheta = 0$ for XY sensors and $\vartheta = 90$ for Z sensor ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart).
- *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.
- *Spherical isotropy (3D deviation from isotropy)*: in a locally homogeneous field realized using an open waveguide setup.
- *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).

DASY/EASY - Parameters of Probe: ER3DV6 - SN:2344

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)	1.62	1.79	1.68	± 10.1 %
DCP (mV)[B]	99.8	97.9	99.6	± 4.7 %

Calibration results for Frequency Response (30 MHz – 3 GHz)

Frequency MHz	Target E-Field V/m	Measured E-field (En) V/m	Deviation E-normal in %	Measured E-field (Ep) V/m	Deviation E-normal in %	Unc (k=2) %
30	77.2	76.5	-0.9%	77.3	0.1%	± 5.1 %
100	77.0	78.4	1.8%	77.8	1.0%	± 5.1 %
450	77.1	78.7	2.0%	77.9	1.0%	± 5.1 %
600	77.2	78.3	1.5%	77.6	0.6%	± 5.1 %
750	77.2	78.1	1.2%	77.5	0.4%	± 5.1 %
1800	143.1	142.8	-0.2%	142.3	-0.6%	± 5.1 %
2000	135.0	132.5	-1.8%	131.9	-2.3%	± 5.1 %
2200	127.6	127.6	-0.1%	129.1	1.1%	± 5.1 %
2500	125.4	123.8	-1.3%	125.3	-0.1%	± 5.1 %
3000	79.4	78.8	-0.7%	81.7	3.0%	± 5.1 %

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

[B] Linearization parameter uncertainty for maximum specified field strength.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

DASY/EASY - Parameters of Probe: ER3DV6 - SN:2344

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Max dev.	Max Unc[E] (k=2)
0	CW	X	0.00	0.00	1.00	0.00	147.0	± 2.2 %	± 4.7 %
		Y	0.00	0.00	1.00		164.4		
		Z	0.00	0.00	1.00		142.1		
10352-AAA	Pulse Waveform (200Hz, 10%)	X	10.73	83.78	21.24	10.00	60.0	± 2.1 %	± 9.6 %
		Y	10.31	82.69	21.32		60.0		
		Z	10.56	82.76	22.19		60.0		
10353-AAA	Pulse Waveform (200Hz, 20%)	X	11.28	85.28	20.35	6.99	80.0	± 2.3 %	± 9.6 %
		Y	10.17	83.59	20.19		80.0		
		Z	12.47	86.89	22.17		80.0		
10354-AAA	Pulse Waveform (200Hz, 40%)	X	20.00	93.22	21.05	3.98	95.0	± 3.5 %	± 9.6 %
		Y	20.00	93.53	21.54		95.0		
		Z	20.00	94.89	22.80		95.0		
10355-AAA	Pulse Waveform (200Hz, 60%)	X	20.00	93.24	19.49	2.22	120.0	± 3.4 %	± 9.6 %
		Y	20.00	94.03	20.14		120.0		
		Z	20.00	95.96	21.55		120.0		
10387-AAA	QPSK Waveform, 1 MHz	X	1.91	66.58	15.40	1.00	150.0	± 2.2 %	± 9.6 %
		Y	1.95	66.69	15.60		150.0		
		Z	1.82	66.60	15.34		150.0		
10388-AAA	QPSK Waveform, 10 MHz	X	2.54	69.19	15.94	0.00	150.0	± 1.1 %	± 9.6 %
		Y	2.60	69.48	16.10		150.0		
		Z	2.45	69.11	16.07		150.0		
10396-AAA	64-QAM Waveform, 100 kHz	X	4.61	77.04	22.04	3.01	150.0	± 0.6 %	± 9.6 %
		Y	4.83	77.89	22.74		150.0		
		Z	4.72	76.32	21.55		150.0		
10399-AAA	64-QAM Waveform, 40 MHz	X	3.65	67.39	15.79	0.00	150.0	± 1.6 %	± 9.6 %
		Y	3.68	67.49	15.88		150.0		
		Z	3.56	67.18	15.77		150.0		
10414-AAA	WLAN CCDF, 64-QAM, 40MHz	X	4.91	65.18	15.25	0.00	150.0	± 3.7 %	± 9.6 %
		Y	5.17	65.99	15.72		150.0		
		Z	4.98	65.70	15.58		150.0		

Note: For details on UID parameters see Appendix

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

[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.

DASY/EASY - Parameters of Probe: ER3DV6 - SN:2344

Sensor Frequency Model Parameters

	Sensor X	Sensor Y	Sensor Z
Frequency Corr. (LF)	-1.67	-1.71	0.32
Frequency Corr. (HF)	0.00	0.00	0.00

Sensor Model Parameters

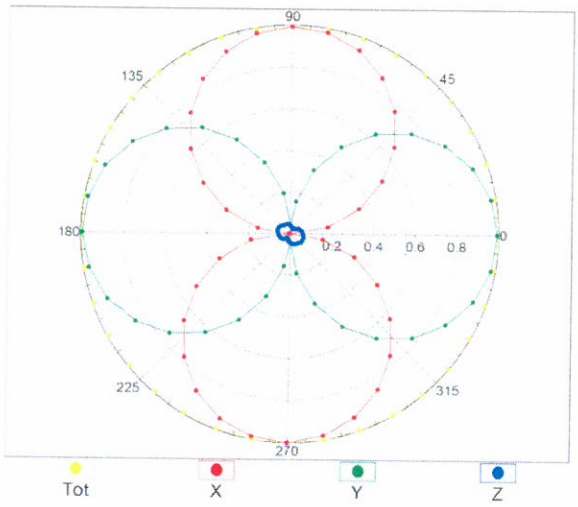
	C1 fF	C2 fF	α V^{-1}	T1 $ms.V^{-2}$	T2 $ms.V^{-1}$	T3 ms	T4 V^{-2}	T5 V^{-1}	T6
X	95.2	456.81	36.41	27.38	1.81	5.10	0.00	0.66	1.02
Y	102.2	494.15	36.85	28.81	2.38	5.10	0.00	0.69	1.02
Z	82.1	393.79	36.51	29.73	3.32	5.10	0.00	0.83	1.02

Other Probe Parameters

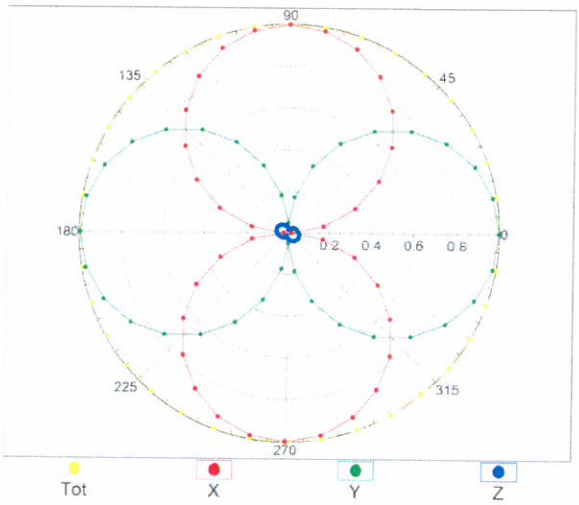
Sensor Arrangement	Rectangular
Connector Angle (°)	162.1
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	8 mm
Probe Tip to Sensor X Calibration Point	2.5 mm
Probe Tip to Sensor Y Calibration Point	2.5 mm
Probe Tip to Sensor Z Calibration Point	2.5 mm

Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM,0°

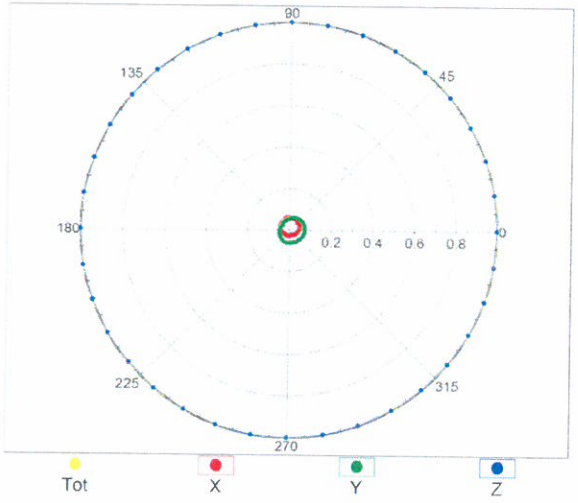


f=2500 MHz,R22,0°

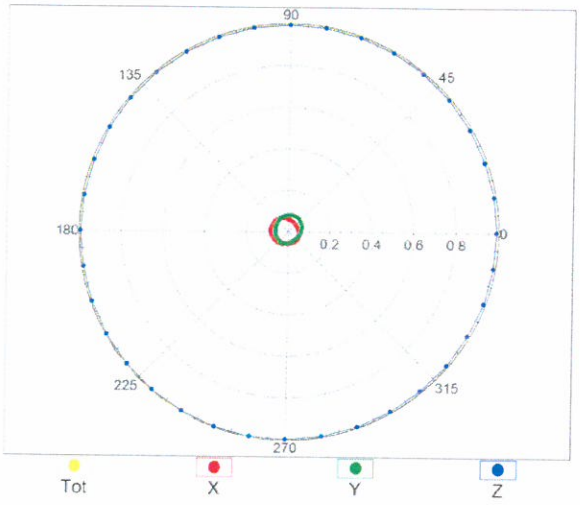


Receiving Pattern (ϕ), ϑ = 90°

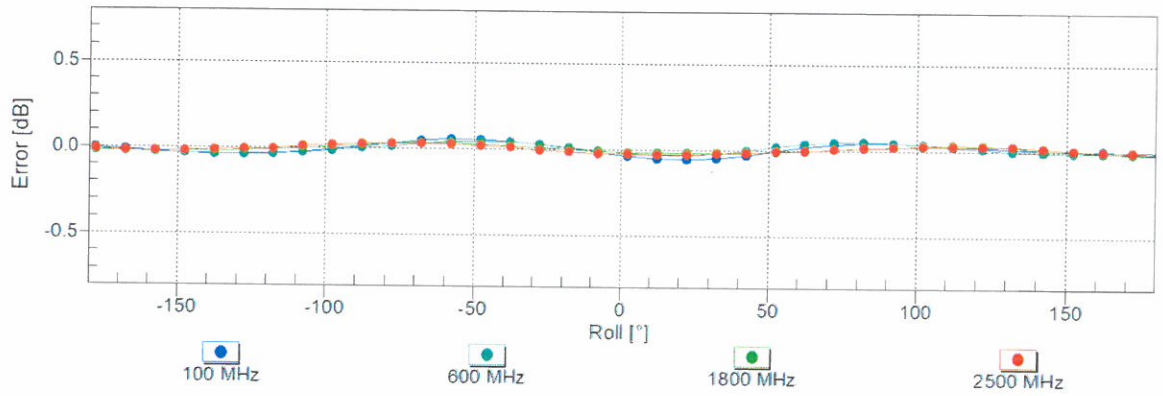
f=600 MHz,TEM,90°



f=2500 MHz,R22,90°

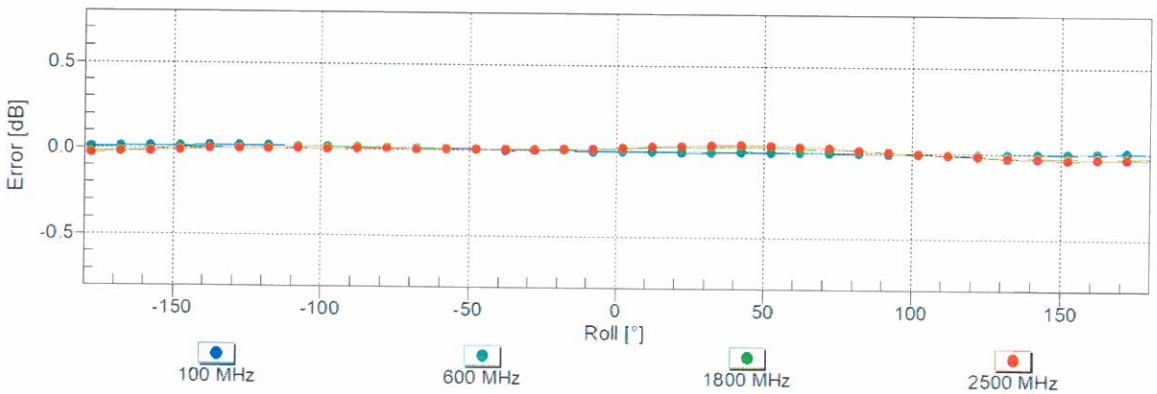


Receiving Pattern (ϕ), ϑ = 0°



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

Receiving Pattern (ϕ), ϑ = 90°



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