



REPORT No.: SZ23040024S02

## Annex E DASY Calibration Certificate



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA  
 Multilateral Agreement for the recognition of calibration certificates

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  $(22 \pm 3)^{\circ}\text{C}$  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 |

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

Issued: July 21, 2022

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



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

### Glossary:

|                          |                                                                                                                                                      |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| NORM <sub>x,y,z</sub>    | 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 $\varphi$   | $\varphi$ rotation around probe axis                                                                                                                 |
| Polarization $\vartheta$ | $\vartheta$ 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:

- IEEE Std 1309-2005, "IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005
- CTIA Test Plan for Hearing Aid Compatibility, Rev 3.1.1, May 2017

### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: 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)<sub>x,y,z</sub>** = NORM<sub>x,y,z</sub> \* frequency\_response (see Frequency Response Chart).
- DCP<sub>x,y,z</sub>**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal. DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A<sub>x,y,z</sub>; B<sub>x,y,z</sub>; C<sub>x,y,z</sub>; D<sub>x,y,z</sub>; VR<sub>x,y,z</sub>**: 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 NORM<sub>x</sub> (no uncertainty required).

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

### Basic Calibration Parameters

|                                              | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|----------------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) | 1.62     | 1.79     | 1.68     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                        | 99.8     | 97.9     | 99.6     | $\pm 4.7 \%$  |

### 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%                    | $\pm 5.1 \%$ |
| 100           | 77.0               | 78.4                      | 1.8%                    | 77.8                      | 1.0%                    | $\pm 5.1 \%$ |
| 450           | 77.1               | 78.7                      | 2.0%                    | 77.9                      | 1.0%                    | $\pm 5.1 \%$ |
| 600           | 77.2               | 78.3                      | 1.5%                    | 77.6                      | 0.6%                    | $\pm 5.1 \%$ |
| 750           | 77.2               | 78.1                      | 1.2%                    | 77.5                      | 0.4%                    | $\pm 5.1 \%$ |
| 1800          | 143.1              | 142.8                     | -0.2%                   | 142.3                     | -0.6%                   | $\pm 5.1 \%$ |
| 2000          | 135.0              | 132.5                     | -1.8%                   | 131.9                     | -2.3%                   | $\pm 5.1 \%$ |
| 2200          | 127.6              | 127.6                     | -0.1%                   | 129.1                     | 1.1%                    | $\pm 5.1 \%$ |
| 2500          | 125.4              | 123.8                     | -1.3%                   | 125.3                     | -0.1%                   | $\pm 5.1 \%$ |
| 3000          | 79.4               | 78.8                      | -0.7%                   | 81.7                      | 3.0%                    | $\pm 5.1 \%$ |

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%.

<sup>B</sup> Linearization parameter uncertainty for maximum specified field strength.

<sup>E</sup> 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<br>dB | B<br>dB $\sqrt{\mu V}$ | C     | D<br>dB | VR<br>mV | Max<br>dev.  | Max<br>Unc <sup>E</sup><br>(k=2) |
|-----------|-----------------------------|---|---------|------------------------|-------|---------|----------|--------------|----------------------------------|
| 0         | CW                          | X | 0.00    | 0.00                   | 1.00  | 0.00    | 147.0    | $\pm 2.2 \%$ | $\pm 4.7 \%$                     |
|           |                             | 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     | $\pm 2.1 \%$ | $\pm 9.6 \%$                     |
|           |                             | 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     | $\pm 2.3 \%$ | $\pm 9.6 \%$                     |
|           |                             | 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     | $\pm 3.5 \%$ | $\pm 9.6 \%$                     |
|           |                             | 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    | $\pm 3.4 \%$ | $\pm 9.6 \%$                     |
|           |                             | 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    | $\pm 2.2 \%$ | $\pm 9.6 \%$                     |
|           |                             | 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    | $\pm 1.1 \%$ | $\pm 9.6 \%$                     |
|           |                             | 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    | $\pm 0.6 \%$ | $\pm 9.6 \%$                     |
|           |                             | 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    | $\pm 1.6 \%$ | $\pm 9.6 \%$                     |
|           |                             | 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    | $\pm 3.7 \%$ | $\pm 9.6 \%$                     |
|           |                             | 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%.

<sup>B</sup> Linearization parameter uncertainty for maximum specified field strength.

<sup>E</sup> 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

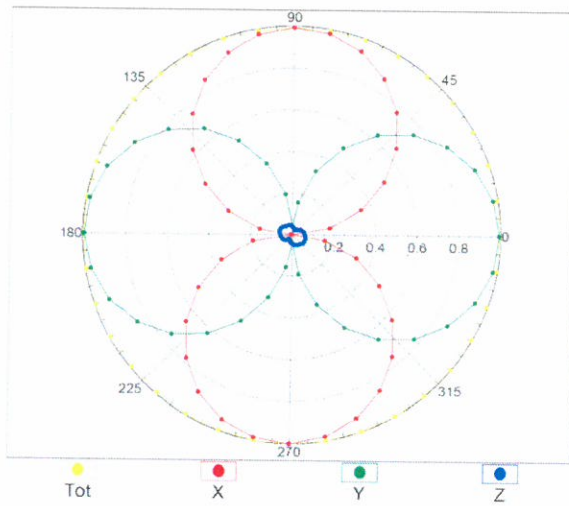
|   | C1<br>fF | C2<br>fF | $\alpha$<br>$V^{-1}$ | T1<br>$ms.V^{-2}$ | T2<br>$ms.V^{-1}$ | T3<br>ms | T4<br>$V^{-2}$ | T5<br>$V^{-1}$ | T6   |
|---|----------|----------|----------------------|-------------------|-------------------|----------|----------------|----------------|------|
| X | 95.2     | 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

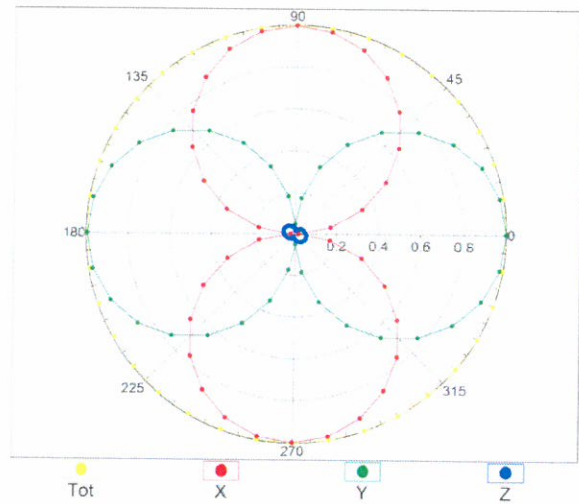
|                                         |             |
|-----------------------------------------|-------------|
| Sensor Arrangement                      | Rectangular |
| Connector Angle (°)                     | 162.1       |
| Mechanical Surface Detection Mode       | enabled     |
| Optical Surface 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 ( $\phi$ ), $\vartheta = 0^\circ$

f=600 MHz,TEM,0°

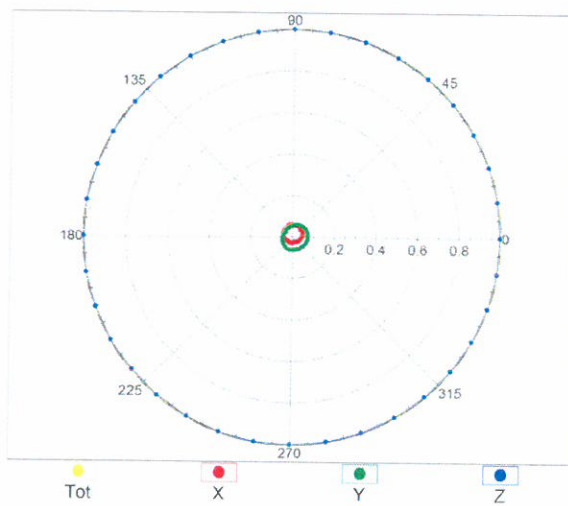


f=2500 MHz,R22,0°

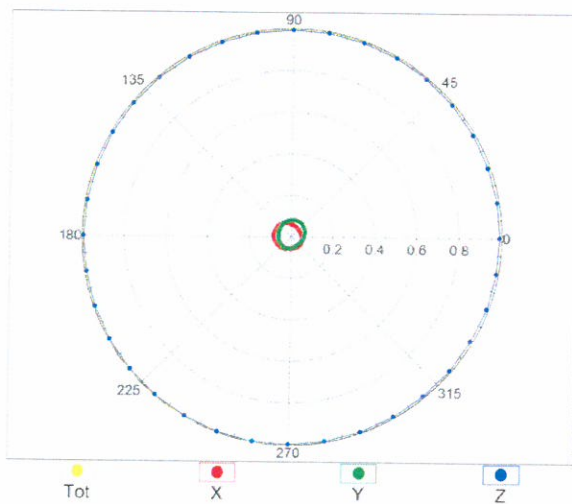


## Receiving Pattern ( $\phi$ ), $\vartheta = 90^\circ$

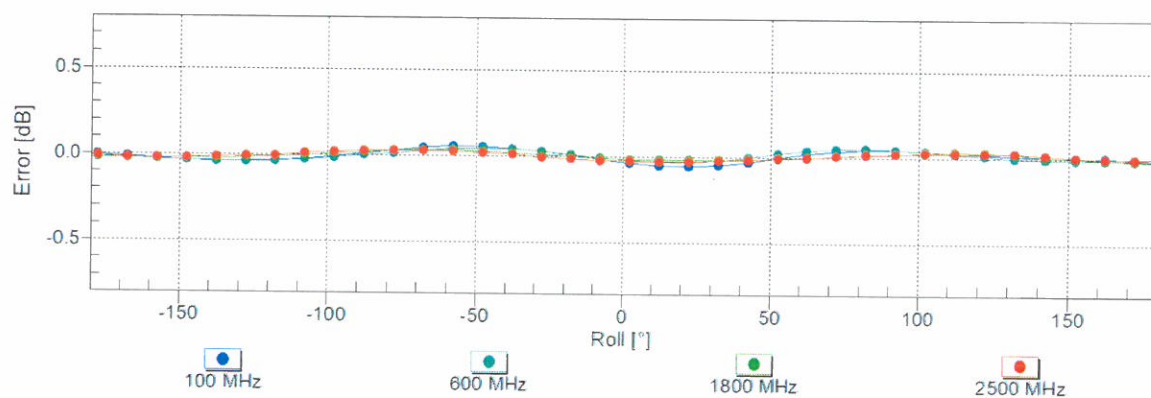
f=600 MHz,TEM,90°



f=2500 MHz,R22,90°

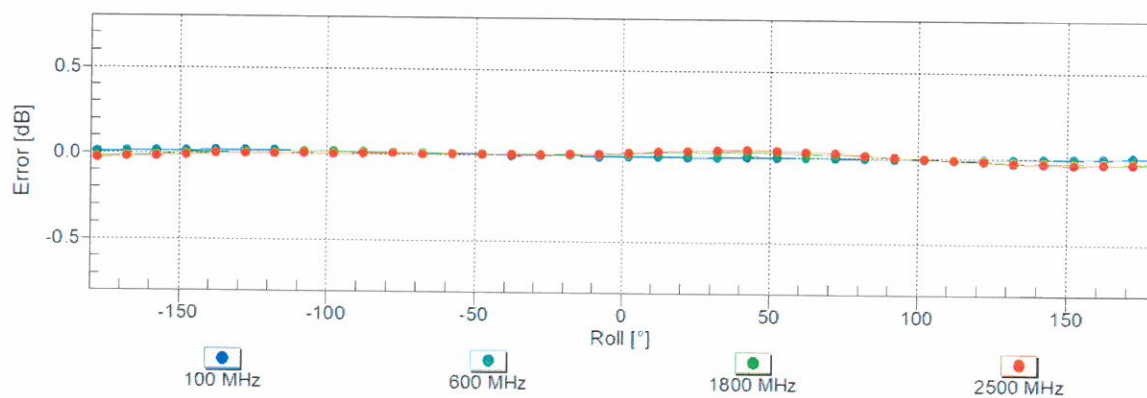


## Receiving Pattern ( $\phi$ ), $\vartheta = 0^\circ$



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

## Receiving Pattern ( $\phi$ ), $\vartheta = 90^\circ$



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