

| UID   | Rev | Communication System Name                          | Group         | PAR (dB) | Unc <sup>E</sup> $k = 2$ |
|-------|-----|----------------------------------------------------|---------------|----------|--------------------------|
| 10983 | AAC | 5G NR DL (CP-OFDM, TM 3.1, 40 MHz, 64-QAM, 15 kHz) | 5G NR FR1 TDD | 9.31     | ±9.6                     |
| 10984 | AAB | 5G NR DL (CP-OFDM, TM 3.1, 50 MHz, 64-QAM, 15 kHz) | 5G NR FR1 TDD | 9.42     | ±9.6                     |
| 10985 | AAC | 5G NR DL (CP-OFDM, TM 3.1, 40 MHz, 64-QAM, 30 kHz) | 5G NR FR1 TDD | 9.54     | ±9.6                     |
| 10986 | AAB | 5G NR DL (CP-OFDM, TM 3.1, 50 MHz, 64-QAM, 30 kHz) | 5G NR FR1 TDD | 9.50     | ±9.6                     |
| 10987 | AAC | 5G NR DL (CP-OFDM, TM 3.1, 60 MHz, 64-QAM, 30 kHz) | 5G NR FR1 TDD | 9.53     | ±9.6                     |
| 10988 | AAB | 5G NR DL (CP-OFDM, TM 3.1, 70 MHz, 64-QAM, 30 kHz) | 5G NR FR1 TDD | 9.38     | ±9.6                     |
| 10989 | AAC | 5G NR DL (CP-OFDM, TM 3.1, 80 MHz, 64-QAM, 30 kHz) | 5G NR FR1 TDD | 9.33     | ±9.6                     |
| 10990 | AAB | 5G NR DL (CP-OFDM, TM 3.1, 90 MHz, 64-QAM, 30 kHz) | 5G NR FR1 TDD | 9.52     | ±9.6                     |
| 11003 | AAA | 5G NR DL (CP-OFDM, TM 3.1, 30 MHz, 64-QAM, 15 kHz) | 5G NR FR1 TDD | 10.24    | ±9.6                     |
| 11004 | AAA | 5G NR DL (CP-OFDM, TM 3.1, 30 MHz, 64-QAM, 30 kHz) | 5G NR FR1 TDD | 10.73    | ±9.6                     |
| 11005 | AAA | 5G NR DL (CP-OFDM, TM 3.1, 25 MHz, 64-QAM, 15 kHz) | 5G NR FR1 FDD | 8.70     | ±9.6                     |
| 11006 | AAA | 5G NR DL (CP-OFDM, TM 3.1, 30 MHz, 64-QAM, 15 kHz) | 5G NR FR1 FDD | 8.55     | ±9.6                     |
| 11007 | AAA | 5G NR DL (CP-OFDM, TM 3.1, 40 MHz, 64-QAM, 15 kHz) | 5G NR FR1 FDD | 8.46     | ±9.6                     |
| 11008 | AAA | 5G NR DL (CP-OFDM, TM 3.1, 50 MHz, 64-QAM, 15 kHz) | 5G NR FR1 FDD | 8.51     | ±9.6                     |
| 11009 | AAA | 5G NR DL (CP-OFDM, TM 3.1, 25 MHz, 64-QAM, 30 kHz) | 5G NR FR1 FDD | 8.76     | ±9.6                     |
| 11010 | AAA | 5G NR DL (CP-OFDM, TM 3.1, 30 MHz, 64-QAM, 30 kHz) | 5G NR FR1 FDD | 8.95     | ±9.6                     |
| 11011 | AAA | 5G NR DL (CP-OFDM, TM 3.1, 40 MHz, 64-QAM, 30 kHz) | 5G NR FR1 FDD | 8.96     | ±9.6                     |
| 11012 | AAA | 5G NR DL (CP-OFDM, TM 3.1, 50 MHz, 64-QAM, 30 kHz) | 5G NR FR1 FDD | 8.68     | ±9.6                     |
| 11013 | AAB | IEEE 802.11be (320 MHz, MCS1, 99pc duty cycle)     | WLAN          | 8.47     | ±9.6                     |
| 11014 | AAB | IEEE 802.11be (320 MHz, MCS2, 99pc duty cycle)     | WLAN          | 8.45     | ±9.6                     |
| 11015 | AAB | IEEE 802.11be (320 MHz, MCS3, 99pc duty cycle)     | WLAN          | 8.44     | ±9.6                     |
| 11016 | AAB | IEEE 802.11be (320 MHz, MCS4, 99pc duty cycle)     | WLAN          | 8.44     | ±9.6                     |
| 11017 | AAB | IEEE 802.11be (320 MHz, MCS5, 99pc duty cycle)     | WLAN          | 8.41     | ±9.6                     |
| 11018 | AAB | IEEE 802.11be (320 MHz, MCS6, 99pc duty cycle)     | WLAN          | 8.40     | ±9.6                     |
| 11019 | AAB | IEEE 802.11be (320 MHz, MCS7, 99pc duty cycle)     | WLAN          | 8.29     | ±9.6                     |
| 11020 | AAB | IEEE 802.11be (320 MHz, MCS8, 99pc duty cycle)     | WLAN          | 8.27     | ±9.6                     |
| 11021 | AAB | IEEE 802.11be (320 MHz, MCS9, 99pc duty cycle)     | WLAN          | 8.46     | ±9.6                     |
| 11022 | AAB | IEEE 802.11be (320 MHz, MCS10, 99pc duty cycle)    | WLAN          | 8.36     | ±9.6                     |
| 11023 | AAB | IEEE 802.11be (320 MHz, MCS11, 99pc duty cycle)    | WLAN          | 8.09     | ±9.6                     |
| 11024 | AAB | IEEE 802.11be (320 MHz, MCS12, 99pc duty cycle)    | WLAN          | 8.42     | ±9.6                     |
| 11025 | AAB | IEEE 802.11be (320 MHz, MCS13, 99pc duty cycle)    | WLAN          | 8.37     | ±9.6                     |
| 11026 | AAB | IEEE 802.11be (320 MHz, MCS0, 99pc duty cycle)     | WLAN          | 8.39     | ±9.6                     |

<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.

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

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

Client

**BTL Inc.**  
Guangdong

Certificate No.

**EUmm-9561\_Jun25****CALIBRATION CERTIFICATE**

Object

**EUmmWV4 - SN:9561**

Calibration procedure(s)

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

Calibration date

**June 18, 2025**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature  $(22 \pm 3)^\circ\text{C}$  and humidity  $< 70\%$ .

Calibration Equipment used (M&TE critical for calibration)

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

| Secondary Standards               | ID         | Check Date (in house)             | Sched. Check           |
|-----------------------------------|------------|-----------------------------------|------------------------|
| Signal Generator Anapico APSIN26G | SN: 2023   | 30-Nov-21 (in house check Jun-24) | In house check: Jun-25 |
| Power sensor R&S NRP40T           | SN: 101439 | 08-Nov-21 (in house check Jun-24) | In house check: Jun-25 |
| Power sensor R&S NRP110T          | SN: 101226 | 15-Nov-21 (in house check Jun-24) | In house check: Jun-25 |

|                                                                                                                 | Name           | Function              | Signature |
|-----------------------------------------------------------------------------------------------------------------|----------------|-----------------------|-----------|
| Calibrated by                                                                                                   | Joanna Lleshaj | Laboratory Technician |           |
| Approved by                                                                                                     | Sven Kühn      | Technical Manager     |           |
| Issued: June 18, 2025                                                                                           |                |                       |           |
| This calibration certificate shall not be reproduced except in full without written approval of the laboratory. |                |                       |           |

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Accreditation No.: **SCS 0108**

## Glossary

|                          |                                                                                                                                                      |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| NORM <sub>x,y</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                                                                                                        |
| 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                                                               |
| Sensor Angles            | sensor deviation from the probe axis, used to calculate the field orientation and polarization                                                       |
| $\vec{k}$                | is the wave propagation direction                                                                                                                    |

## Calibration is Performed According to the Following Standards:

- 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

## Methods Applied and Interpretation of Parameters:

- **NORM<sub>x,y</sub>**: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). For frequencies  $> 6$  GHz, the far field in front of waveguide horn antennas is measured for a set of frequencies in various waveguide bands up to 110 GHz.
- **DCP<sub>x,y</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.  
Note: As the field is measured with a diode detector sensor, it is warranted that the probe response is linear ( $E^2$ ) below the documented lowest calibrated value.
- **PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- The frequency sensor model parameters are determined prior to calibration based on a frequency sweep (sensor model involving resistors R, R<sub>p</sub>, inductance L and capacitors C, C<sub>p</sub>).
- **A<sub>x,y</sub>; B<sub>x,y</sub>; C<sub>x,y</sub>; D<sub>x,y</sub>; VR<sub>x,y</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.
- **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).
- **Equivalent Sensor Angle**: The two probe sensors are mounted in the same plane at different angles. The angles are assessed using the information gained by determining the **NORM<sub>x</sub>** (no uncertainty required).
- **Spherical isotropy (3D deviation from isotropy)**: in a locally homogeneous field realized using an open waveguide / horn setup.

## Parameters of Probe: EUmmWV4 - SN:9561

### Basic Calibration Parameters

|                                              | Sensor X | Sensor Y | Unc ( $k = 2$ ) |
|----------------------------------------------|----------|----------|-----------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) | 0.01783  | 0.01956  | $\pm 10.1\%$    |
| DCP (mV) <sup>B</sup>                        | 105.0    | 105.0    | $\pm 4.7\%$     |
| Equivalent Sensor Angle                      | -61.4    | 38.0     |                 |

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

| Frequency GHz | Target E-Field V/m | Deviation Sensor X dB | Deviation Sensor Y dB | Unc ( $k = 2$ ) dB |
|---------------|--------------------|-----------------------|-----------------------|--------------------|
| 0.75          | 77.2               | -0.21                 | -0.31                 | $\pm 0.43$         |
| 1.8           | 140.4              | -0.02                 | -0.04                 | $\pm 0.43$         |
| 2.0           | 133.0              | 0.13                  | 0.14                  | $\pm 0.43$         |
| 2.2           | 124.8              | -0.07                 | -0.03                 | $\pm 0.43$         |
| 2.5           | 123.0              | 0.07                  | 0.14                  | $\pm 0.43$         |
| 3.5           | 256.2              | -0.10                 | -0.08                 | $\pm 0.43$         |
| 3.7           | 249.8              | 0.01                  | 0.01                  | $\pm 0.43$         |
|               |                    |                       |                       |                    |
| 6.6           | 63.4               | 0.07                  | -0.24                 | $\pm 0.98$         |
| 8.0           | 58.4               | 0.00                  | -0.12                 | $\pm 0.98$         |
| 10.0          | 57.7               | -0.03                 | 0.01                  | $\pm 0.98$         |
| 15.0          | 45.5               | 0.08                  | 0.18                  | $\pm 0.98$         |
|               |                    |                       |                       |                    |
| 26.6          | 115.1              | 0.20                  | 0.25                  | $\pm 0.98$         |
| 30.0          | 125.1              | 0.02                  | 0.02                  | $\pm 0.98$         |
| 35.0          | 123.5              | -0.15                 | -0.19                 | $\pm 0.98$         |
| 40.0          | 101.8              | -0.25                 | -0.33                 | $\pm 0.98$         |
|               |                    |                       |                       |                    |
| 50.0          | 60.8               | 0.04                  | -0.05                 | $\pm 0.98$         |
| 55.0          | 73.7               | -0.08                 | -0.05                 | $\pm 0.98$         |
| 60.0          | 76.4               | 0.02                  | 0.04                  | $\pm 0.98$         |
| 65.0          | 72.0               | 0.17                  | 0.15                  | $\pm 0.98$         |
| 70.0          | 68.5               | 0.12                  | 0.07                  | $\pm 0.98$         |
| 75.0          | 67.9               | -0.05                 | -0.08                 | $\pm 0.98$         |
|               |                    |                       |                       |                    |
| 75.0          | 89.9               | -0.09                 | -0.07                 | $\pm 0.98$         |
| 80.0          | 88.2               | -0.16                 | -0.12                 | $\pm 0.98$         |
| 85.0          | 54.3               | -0.03                 | -0.08                 | $\pm 0.98$         |
| 90.0          | 80.6               | 0.02                  | 0.02                  | $\pm 0.98$         |
| 92.0          | 80.8               | 0.02                  | 0.02                  | $\pm 0.98$         |
| 95.0          | 73.2               | -0.01                 | -0.01                 | $\pm 0.98$         |
| 97.0          | 65.9               | -0.02                 | -0.03                 | $\pm 0.98$         |
| 100.0         | 63.4               | 0.05                  | 0.07                  | $\pm 0.98$         |
| 105.0         | 63.2               | -0.22                 | -0.12                 | $\pm 0.98$         |
| 110.0         | 72.1               | 0.14                  | 0.02                  | $\pm 0.98$         |

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

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

## Parameters of Probe: EUmmWV4 - SN:9561

### 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    | 113.5    | ±2.5%       | ±4.7%                            |
|       |                             | Y | 0.00    | 0.00                   | 1.00  |         | 93.7     |             |                                  |
| 10352 | Pulse Waveform (200Hz, 10%) | X | 2.35    | 60.00                  | 14.43 | 10.00   | 6.0      | ±1.3%       | ±9.6%                            |
|       |                             | Y | 2.61    | 60.00                  | 15.01 |         | 6.0      |             |                                  |
| 10353 | Pulse Waveform (200Hz, 20%) | X | 1.60    | 60.00                  | 13.36 | 6.99    | 12.0     | ±1.2%       | ±9.6%                            |
|       |                             | Y | 1.78    | 60.00                  | 13.98 |         | 12.0     |             |                                  |
| 10354 | Pulse Waveform (200Hz, 40%) | X | 0.94    | 60.00                  | 12.22 | 3.98    | 23.0     | ±1.5%       | ±9.6%                            |
|       |                             | Y | 1.05    | 60.00                  | 12.87 |         | 23.0     |             |                                  |
| 10355 | Pulse Waveform (200Hz, 60%) | X | 0.57    | 60.00                  | 11.58 | 2.22    | 27.0     | ±1.0%       | ±9.6%                            |
|       |                             | Y | 0.64    | 60.00                  | 12.26 |         | 27.0     |             |                                  |
| 10387 | QPSK Waveform, 1 MHz        | X | 1.19    | 60.00                  | 12.28 | 1.00    | 22.0     | ±1.3%       | ±9.6%                            |
|       |                             | Y | 1.16    | 60.00                  | 12.59 |         | 22.0     |             |                                  |
| 10388 | QPSK Waveform, 10 MHz       | X | 1.27    | 60.00                  | 12.08 | 0.00    | 22.0     | ±0.7%       | ±9.6%                            |
|       |                             | Y | 1.23    | 60.00                  | 12.42 |         | 22.0     |             |                                  |
| 10396 | 64-QAM Waveform, 100 kHz    | X | 2.81    | 63.57                  | 15.22 | 3.01    | 17.0     | ±0.6%       | ±9.6%                            |
|       |                             | Y | 4.11    | 67.99                  | 17.00 |         | 17.0     |             |                                  |
| 10399 | 64-QAM Waveform, 40 MHz     | X | 2.06    | 60.00                  | 12.53 | 0.00    | 19.0     | ±0.8%       | ±9.6%                            |
|       |                             | Y | 2.00    | 60.00                  | 12.82 |         | 19.0     |             |                                  |
| 10414 | WLAN CCDF, 64-QAM, 40 MHz   | X | 3.17    | 60.00                  | 12.94 | 0.00    | 12.0     | ±0.9%       | ±9.6%                            |
|       |                             | Y | 3.05    | 60.00                  | 13.21 |         | 12.0     |             |                                  |

Note: For details on UID parameters see Appendix

<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.

## Parameters of Probe: EUmmWV4 - SN:9561

### Calibration Results for Linearity Response

| Frequency<br>GHz | Target E-Field<br>V/m | Deviation Sensor X<br>dB | Deviation Sensor Y<br>dB | Unc ( $k = 2$ )<br>dB |
|------------------|-----------------------|--------------------------|--------------------------|-----------------------|
| 0.9              | 50.0                  | 0.01                     | 0.05                     | $\pm 0.2$             |
| 0.9              | 100.0                 | -0.08                    | 0.03                     | $\pm 0.2$             |
| 0.9              | 500.0                 | 0.00                     | 0.01                     | $\pm 0.2$             |
| 0.9              | 1000.0                | 0.02                     | 0.04                     | $\pm 0.2$             |
| 0.9              | 1500.0                | 0.03                     | 0.03                     | $\pm 0.2$             |
| 0.9              | 2100.0                | 0.01                     | 0.02                     | $\pm 0.2$             |

### Sensor Frequency Model Parameters (750 MHz – 55 GHz)

|                             | Sensor X | Sensor Y |
|-----------------------------|----------|----------|
| R ( $\Omega$ )              | 66.57    | 75.62    |
| R <sub>p</sub> ( $\Omega$ ) | 91.17    | 100.52   |
| L (nH)                      | 0.06285  | 0.06413  |
| C (pF)                      | 0.2490   | 0.3009   |
| C <sub>p</sub> (pF)         | 0.0971   | 0.0928   |

### Sensor Frequency Model Parameters (55 GHz – 110 GHz)

|                             | Sensor X | Sensor Y |
|-----------------------------|----------|----------|
| R ( $\Omega$ )              | 10.11    | 31.19    |
| R <sub>p</sub> ( $\Omega$ ) | 56.91    | 172.00   |
| L (nH)                      | 0.03244  | 0.09628  |
| C (pF)                      | 0.1295   | 0.0445   |
| C <sub>p</sub> (pF)         | 0.1609   | 0.0514   |

### Sensor Model Parameters

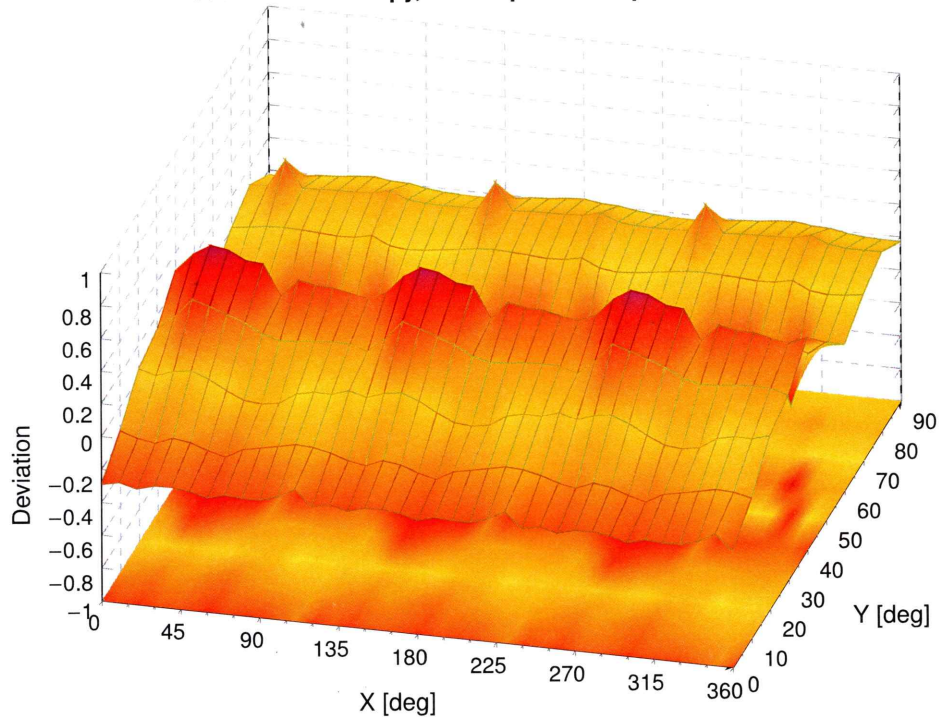
|   | C1<br>fF | C2<br>fF | $\alpha$<br>$V^{-1}$ | T1<br>$ms V^{-2}$ | T2<br>$ms V^{-1}$ | T3<br>ms | T4<br>$V^{-2}$ | T5<br>$V^{-1}$ | T6   |
|---|----------|----------|----------------------|-------------------|-------------------|----------|----------------|----------------|------|
| x | 52.1     | 374.82   | 33.19                | 0.92              | 5.31              | 4.98     | 0.00           | 1.62           | 1.01 |
| y | 52.4     | 379.20   | 33.64                | 2.66              | 6.85              | 4.99     | 0.00           | 1.84           | 1.01 |

### Other Probe Parameters

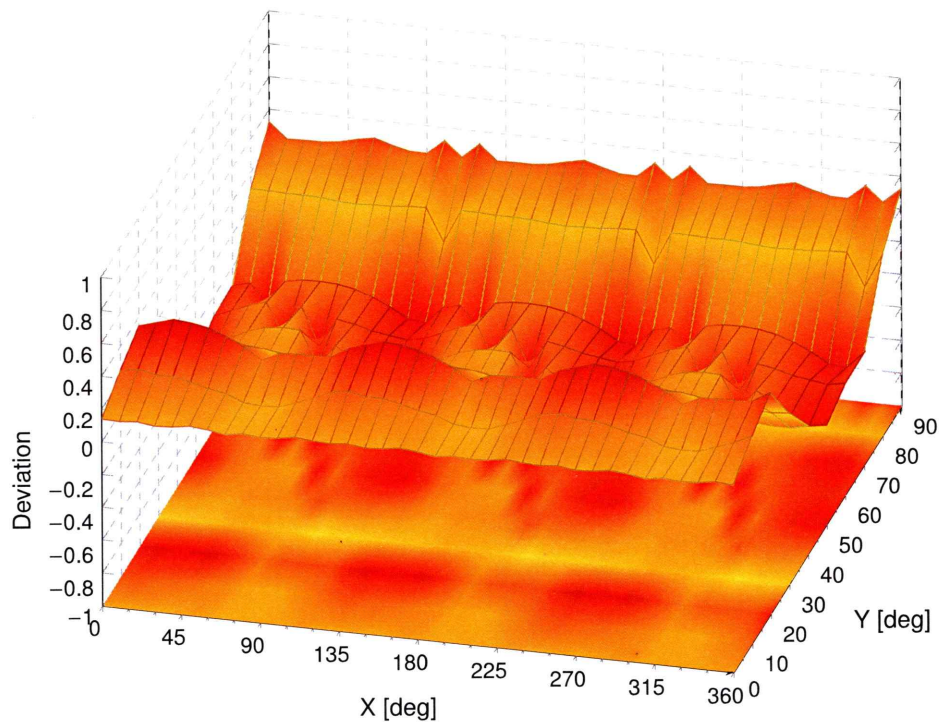
|                                         |             |
|-----------------------------------------|-------------|
| Sensor Arrangement                      | Rectangular |
| Connector Angle                         | 148.8°      |
| Mechanical Surface Detection Mode       | enabled     |
| Optical Surface Detection Mode          | disabled    |
| Probe Overall Length                    | 320 mm      |
| Probe Body Diameter                     | 8 mm        |
| Tip Length                              | 23 mm       |
| Tip Diameter                            | 8.0 mm      |
| Probe Tip to Sensor X Calibration Point | 1.5 mm      |
| Probe Tip to Sensor Y Calibration Point | 1.5 mm      |

## Deviation from Isotropy in Air

30GHz: 3D isotropy, E-field parallel to probe axis



60GHz: 3D isotropy, E-field parallel to probe axis



Probe isotropy for  $E_{\text{tot}}$ : probe rotated  $\phi = 0^\circ$  to  $360^\circ$ , tilted from field propagation direction  $\vec{k}$   
 Parallel to the field propagation ( $\psi = 0^\circ - 90^\circ$ ) at 30 GHz: deviation within  $\pm 0.42$  dB  
 Parallel to the field propagation ( $\psi = 0^\circ - 90^\circ$ ) at 60 GHz: deviation within  $\pm 0.42$  dB