



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. **5G-Veri30-1117_Sep23**

CALIBRATION CERTIFICATE

Object **5G Verification Source 30 GHz - SN: 1117**

Calibration procedure(s) **QA CAL-45.v4
Calibration procedure for sources in air above 6 GHz**

Calibration date: **September 20, 2023**

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 |
|-------------------------|----------|-----------------------------------|-----------------------|
| Reference Probe EUmmWV3 | SN: 9374 | 22-May-23 (No. EUmm-9374_May23) | May-24 |
| DAE4ip | SN: 1602 | 05-Jul-23 (No. DAE4ip-1602_Jul23) | Jul-24 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---------------------|------|-----------------------|-----------------|
| | | | |

| | Name | Function | Signature |
|----------------|----------------|-----------------------|-----------|
| Calibrated by: | Joanna Lloohaj | Laboratory Technician | |
| Approved by: | Sven Kühn | Technical Manager | |

Issued: September 21, 2023

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



Accredited by the Swiss Accreditation Service (SAS)

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

Accreditation No.: **SCS 0108**

Glossary

CW Continuous wave

Calibration is Performed According to the Following Standards

- Internal procedure QA CAL-45, Calibration procedure for sources in air above 6 GHz.
- IEC/IEEE 63195-1, "Assessment of power density of human exposure to radio frequency fields from wireless devices in close proximity to the head and body (frequency range of 6 GHz to 300 GHz)", May 2022

Methods Applied and Interpretation of Parameters

- *Coordinate System:* z-axis in the waveguide horn boresight, x-axis is in the direction of the E-field, y-axis normal to the others in the field scanning plane parallel to the horn flare and horn flange.
- *Measurement Conditions:* (1) 10 GHz: The radiated power is the forward power to the horn antenna minus ohmic and mismatch loss. During the measurements, the horn is directly connected to the cable and the antenna ohmic and mismatch losses are determined by far-field measurements. (2) 30, 45, 60 and 90 GHz: The verification sources are switched on for at least 30 minutes. Absorbers are used around the probe cub and at the ceiling to minimize reflections.
- *Horn Positioning:* The waveguide horn is mounted vertically on the flange of the waveguide source to allow vertical positioning of the EUmmW probe during the scan. The plane is parallel to the phantom surface. Probe distance is verified using mechanical gauges positioned on the flare of the horn.
- *E-field distribution:* E field is measured in two x-y-plane (10mm, 10mm + $\lambda/4$) with a vectorial E-field probe. The E-field value stated as calibration value represents the E-field-maxima and the averaged (1cm² and 4cm²) power density values at 10mm in front of the horn.
- *Field polarization:* Above the open horn, linear polarization of the field is expected. This is verified graphically in the field representation.

Calibrated Quantity

- Local peak E-field (V/m) and average of peak spatial components of the poynting vector (W/m²) averaged over the surface area of 1 cm² and 4cm² at the nominal operational frequency of the verification source. Both square and circular averaging results are listed.

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%.

Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---------------------------------------|-------------------------------|------|
| DASY Version | DASY8 Module mmWave | V3.2 |
| Phantom | 5G Phantom | |
| Distance Horn Aperture - plane | 10 mm | |
| Number of measured planes | 2 (10mm, 10mm + $\lambda/4$) | |
| Frequency | 30 GHz \pm 10 MHz | |

Calibration Parameters, 30 GHz

Circular Averaging

| Distance Horn Aperture to Measured Plane | <i>Prad</i> ¹ (mW) | Max E-field (V/m) | Uncertainty (k = 2) | Avg Power Density Avg (psPDn+, psPDtot+, psPDmod+) (W/m ²) | | Uncertainty (k = 2) |
|--|-------------------------------|-------------------|---------------------|--|-------------------|---------------------|
| | | | | 1 cm ² | 4 cm ² | |
| 10 mm | 74.1 | 201 | 1.27 dB | 92.3 | 80.4 | 1.28 dB |

| Distance Horn Aperture to Measured Plane | <i>Prad</i> ¹ (mW) | Max E-field (V/m) | Uncertainty (k = 2) | Power Density psPDn+, psPDtot+, psPDmod+ (W/m ²) | | Uncertainty (k = 2) |
|--|-------------------------------|-------------------|---------------------|--|-------------------|---------------------|
| | | | | 1 cm ² | 4 cm ² | |
| 10 mm | 74.1 | 201 | 1.27 dB | 91.5, 92.6, 92.8 | 79.4, 80.7, 81.0 | 1.28 dB |

Square Averaging

| Distance Horn Aperture to Measured Plane | <i>Prad</i> ¹ (mW) | Max E-field (V/m) | Uncertainty (k = 2) | Avg Power Density Avg (psPDn+, psPDtot+, psPDmod+) (W/m ²) | | Uncertainty (k = 2) |
|--|-------------------------------|-------------------|---------------------|--|-------------------|---------------------|
| | | | | 1 cm ² | 4 cm ² | |
| 10 mm | 74.1 | 201 | 1.27 dB | 92.5 | 80.1 | 1.28 dB |

| Distance Horn Aperture to Measured Plane | <i>Prad</i> ¹ (mW) | Max E-field (V/m) | Uncertainty (k = 2) | Power Density psPDn+, psPDtot+, psPDmod+ (W/m ²) | | Uncertainty (k = 2) |
|--|-------------------------------|-------------------|---------------------|--|-------------------|---------------------|
| | | | | 1 cm ² | 4 cm ² | |
| 10 mm | 74.1 | 201 | 1.27 dB | 91.7, 92.8, 93.0 | 79.1, 80.5, 80.7 | 1.28 dB |

Max Power Density

| Distance Horn Aperture to Measured Plane | <i>Prad</i> ¹ (mW) | Max E-field (V/m) | Uncertainty (k = 2) | Max Power Density Sn, Stot, Stot (W/m ²) | Uncertainty (k = 2) |
|--|-------------------------------|-------------------|---------------------|--|---------------------|
| 10 mm | 74.1 | 201 | 1.27 dB | 105, 106, 106 | 1.28 dB |

¹ Derived from far-field data

DASY Report

Measurement Report for 5G Verification Source 30 GHz, UID 0 -, Channel 30000 (30000.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|-------------------------------|-----------------------|----------|----------|
| 5G Verification Source 30 GHz | 100.0 x 100.0 x 100.0 | SN: 1117 | |

Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| 5G - | 5.55 mm | Validation band | CW | 30000.0, 30000 | 1.0 |

Hardware Setup

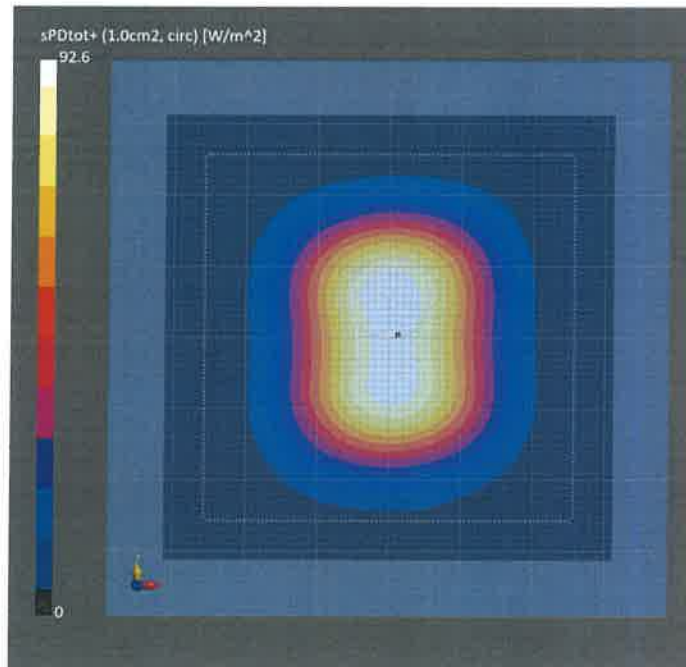
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|-----------------------|--------|-------------------------------------|---------------------------|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F30GHz, 2023-05-22 | DAE4ip Sn1602, 2023-07-05 |

Scan Setup

| | 5G Scan |
|---------------------|---------------|
| Sensor Surface [mm] | 5.55 |
| MAIA | MAIA not used |

Measurement Results

| | 5G Scan |
|---------------------------------|--------------------|
| Date | 2023-09-20, 16:02 |
| Avg. Area [cm ²] | 1.00 |
| Avg. Type | Circular Averaging |
| psPDn+ [W/m ²] | 91.5 |
| psPDtot+ [W/m ²] | 92.6 |
| psPDmod+ [W/m ²] | 92.8 |
| Max(Sn) [W/m ²] | 105 |
| Max(Stot) [W/m ²] | 106 |
| Max(Stot) [W/m ²] | 106 |
| E _{max} [V/m] | 201 |
| Power Drift [dB] | -0.04 |



DASY Report

Measurement Report for 5G Verification Source 30 GHz, UID 0 -, Channel 30000 (30000.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|-------------------------------|-----------------------|----------|----------|
| 5G Verification Source 30 GHz | 100.0 x 100.0 x 100.0 | SN: 1117 | - |

Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| 5G - | 5.55 mm | Validation band | CW | 30000.0, 30000 | 1.0 |

Hardware Setup

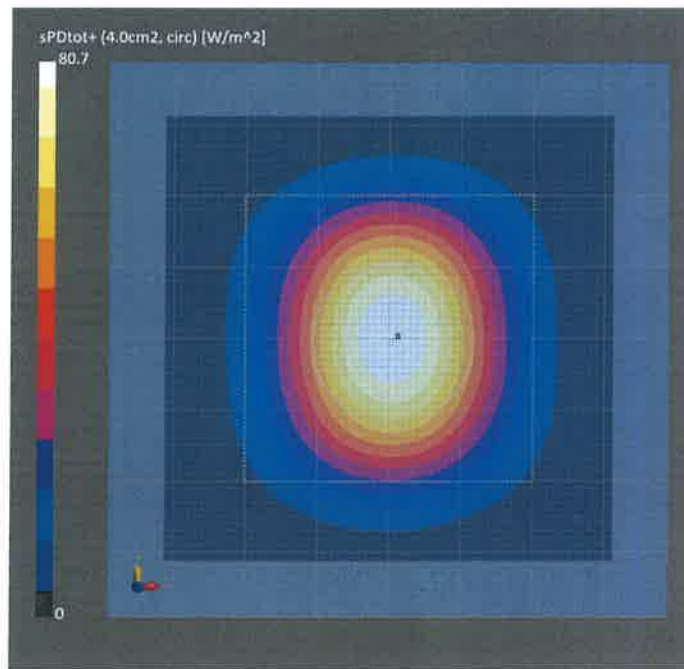
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|-----------------------|--------|-------------------------------------|---------------------------|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F30GHz, 2023-05-22 | DAE4ip Sn1602, 2023-07-05 |

Scan Setup

| Sensor Surface [mm] | 5G Scan |
|---------------------|-----------------------|
| MAIA | 5.55 MAIA not used |

Measurement Results

| | 5G Scan |
|---------------------------------|--------------------|
| Date | 2023-09-20, 16:02 |
| Avg. Area [cm ²] | 4.00 |
| Avg. Type | Circular Averaging |
| psPDn+ [W/m ²] | 79.4 |
| psPDtot+ [W/m ²] | 80.7 |
| psPDmod+ [W/m ²] | 81.0 |
| Max(Sn) [W/m ²] | 105 |
| Max(Stot) [W/m ²] | 106 |
| Max(Stot) [W/m ²] | 106 |
| E _{max} [V/m] | 201 |
| Power Drift [dB] | -0.04 |



DASY Report

Measurement Report for 5G Verification Source 30 GHz, UID 0 -, Channel 30000 (30000.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|-------------------------------|-----------------------|----------|----------|
| 5G Verification Source 30 GHz | 100.0 x 100.0 x 100.0 | SN: 1117 | - |

Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| 5G - | 5.55 mm | Validation band | CW | 30000.0, 30000 | 1.0 |

Hardware Setup

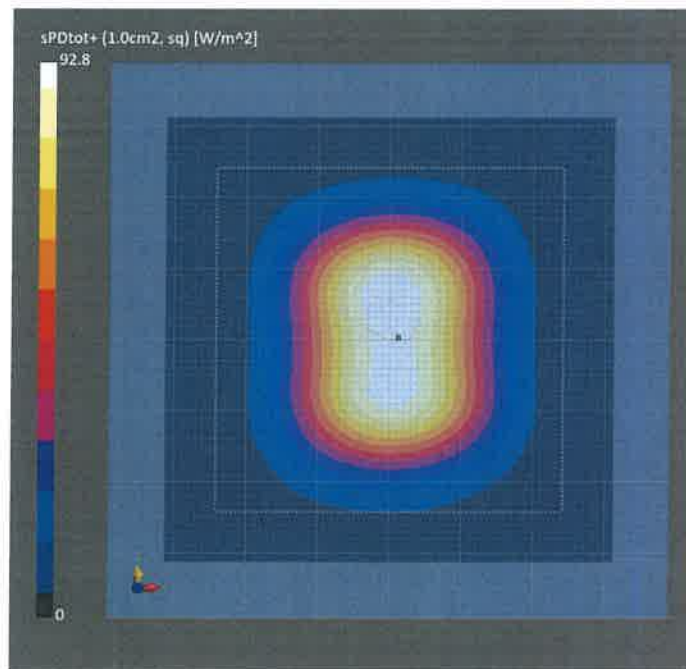
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|-----------------------|--------|-------------------------------------|---------------------------|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F30GHz, 2023-05-22 | DAE4ip Sn1602, 2023-07-05 |

Scan Setup

| Sensor Surface [mm] | 5G Scan |
|---------------------|-----------------------|
| MAIA | 5.55 MAIA not used |

Measurement Results

| | 5G Scan |
|---------------------------------|-------------------|
| Date | 2023-09-20, 16:02 |
| Avg. Area [cm ²] | 1.00 |
| Avg. Type | Square Averaging |
| psPDn+ [W/m ²] | 91.7 |
| psPDtot+ [W/m ²] | 92.8 |
| psPDmod+ [W/m ²] | 93.0 |
| Max(Sn) [W/m ²] | 105 |
| Max(Stot) [W/m ²] | 106 |
| Max(Stot) [W/m ²] | 106 |
| E _{max} [V/m] | 201 |
| Power Drift [dB] | -0.04 |



DASY Report

Measurement Report for 5G Verification Source 30 GHz, UID 0 -, Channel 30000 (30000.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|-------------------------------|-----------------------|----------|----------|
| 5G Verification Source 30 GHz | 100.0 x 100.0 x 100.0 | SN: 1117 | - |

Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| 5G - | 5.55 mm | Validation band | CW | 30000.0, 30000 | 1.0 |

Hardware Setup

| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|-----------------------|--------|-------------------------------------|---------------------------|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F30GHz, 2023-05-22 | DAE4ip Sn1602, 2023-07-05 |

Scan Setup

| Sensor Surface [mm] | 5G Scan |
|---------------------|-----------------------|
| MAIA | 5.55 MAIA not used |

Measurement Results

| | 5G Scan |
|---------------------------------|-------------------|
| Date | 2023-09-20, 16:02 |
| Avg. Area [cm ²] | 4.00 |
| Avg. Type | Square Averaging |
| psPDn+ [W/m ²] | 79.1 |
| psPDtot+ [W/m ²] | 80.5 |
| psPDmod+ [W/m ²] | 80.7 |
| Max(Sn) [W/m ²] | 105 |
| Max(Stot) [W/m ²] | 106 |
| Max(Stot) [W/m ²] | 106 |
| E _{max} [V/m] | 201 |
| Power Drift [dB] | -0.04 |

