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Accreditation No.: **SCS 0108**

Client **Dekra-TW (Auden)**

Certificate No: **D6.5GHzV2-1021_Feb21**

CALIBRATION CERTIFICATE

Object: **D6.5GHzV2 - SN:1021**

Calibration procedure(s): **QA CAL-22.v6
Calibration Procedure for SAR Validation Sources between 3-10 GHz**

Calibration date: **February 09, 2021**

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 | 01-Apr-20 (No. 217-03100/03101) | Apr-21 |
| Power sensor NRP-Z91 | SN: 103244 | 01-Apr-20 (No. 217-03100) | Apr-21 |
| Power sensor NRP-Z91 | SN: 103245 | 01-Apr-20 (No. 217-03101) | Apr-21 |
| Reference 20 dB Attenuator | SN: BH9394 (20k) | 31-Mar-20 (No. 217-03106) | Apr-21 |
| Type-N mismatch combination | SN: 310982 / 06327 | 31-Mar-20 (No. 217-03104) | Apr-21 |
| Reference Probe EX3DV4 | SN: 7405 | 30-Dec-20 (No. EX3-7405_Dec20) | Dec-21 |
| DAE4 | SN: 908 | 14-Aug-20 (No. DAE4-908_Aug20) | Aug-21 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| Power sensor R&S NRP33T | SN: 100967 | 17-Oct-16 (in house check Dec-18) | In house check: Dec-21 |
| RF generator Anapico APSIN20G | SN: 669 | 28-Mar-17 (in house check Dec-18) | In house check: Dec-21 |
| Network Analyzer R&S ZVL13 | SN: 101093 | 10-May-12 (in house check Dec-18) | In house check: Dec-21 |

| | | | |
|----------------|----------------|-----------------------|-----------|
| | Name | Function | Signature |
| Calibrated by: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: February 9, 2021

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Glossary:

| | |
|-------|---------------------------------|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORM x,y,z |
| N/A | not applicable or not measured |

Calibration is Performed According to the Following Standards:

- IEC/IEEE 62209-1528 ED1, "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)", draft 2019

Additional Documentation:

- DASY6 System Handbook

Methods Applied and Interpretation of Parameters:

- Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- SAR measured:* SAR measured at the stated antenna input power.
- SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.
- The absorbed power density (APD):* The absorbed power density is evaluated according to Samaras T, Christ A, Kuster N, "Compliance assessment of the epithelial or absorbed power density above 6 GHz using SAR measurement systems", Bioelectromagnetics, 2021 (submitted). The additional evaluation uncertainty of 0.55 dB (rectangular distribution) is considered.

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 | DASY6 | V6.14 |
| Extrapolation | Advanced Extrapolation | |
| Phantom | Modular Flat Phantom | |
| Distance Dipole Center - TSL | 5 mm | with Spacer |
| Zoom Scan Resolution | dx, dy = 3.4 mm, dz = 1.4 mm | Graded Ratio = 1.4 (Z direction) |
| Frequency | 6500 MHz ± 1 MHz | |

Head TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|--|--------------------|---------------------|---------------------|
| Nominal Head TSL parameters | 22.0 °C | 34.5 | 6.07 mho/m |
| Measured Head TSL parameters | (22.0 ± 0.2) °C | 34.8 ± 6 % | 6.20 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Head TSL

| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
|---|--------------------|--------------------------------|
| SAR measured | 100 mW input power | 29.3 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 293 W/kg ± 24.7 % (k=2) |

| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 5.37 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 53.8 W/kg ± 24.4 % (k=2) |

Appendix

Antenna Parameters with Head TSL

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 51.0 Ω - 1.7 j Ω |
| Return Loss | - 34.1 dB |

APD (Absorber Power Density)

| APD averaged over 1 cm ² | Condition | |
|-------------------------------------|--------------------|--|
| APD measured | 100 mW input power | 293 W/m ² |
| APD measured | normalized to 1W | 2930 W/m² ± 29.2 % (k=2) |

| APD averaged over 4 cm ² | condition | |
|-------------------------------------|--------------------|--|
| APD measured | 100 mW input power | 134 W/m ² |
| APD measured | normalized to 1W | 1340 W/m² ± 28.9 % (k=2) |

*The reported APD values have been derived using psSAR10g. cDASY6 V6.16+ will use psSAR8g resulting in more accurate estimation of the APD values. The estimated offset is less than - 0.15 dB.

General Antenna Parameters and Design

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

| | |
|-----------------|-------|
| Manufactured by | SPEAG |
|-----------------|-------|

DASY6 Validation Report for Head TSL

Measurement Report for D6.5GHz-1021, UID 0 -, Channel 6500 (6500.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|--------------------|--------------------|----------|----------|
| D6.5GHz | 16.0 x 6.0 x 300.0 | SN: 1021 | - |

Exposure Conditions

| Phantom Section, TSL | Position, Test Distance [mm] | Band | Group, UID | Frequency [MHz] | Conversion Factor | TSL Cond. [S/m] | TSL Permittivity |
|----------------------|------------------------------|------|------------|-----------------|-------------------|-----------------|------------------|
| Flat, HSL | 5.00 | Band | CW, | 6500 | 5.75 | 6.20 | 34.8 |

Hardware Setup

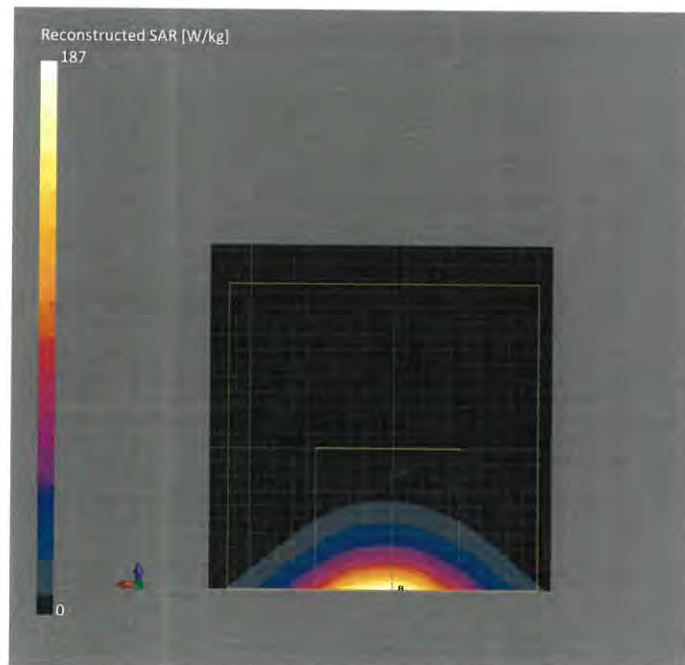
| Phantom | TSL | Probe, Calibration Date | DAE, Calibration Date |
|------------------------|-----------------|-----------------------------|------------------------|
| MFP V8.0 Center - 1182 | HBBL600-10000V6 | EX3DV4 - SN7405, 2020-12-30 | DAE4 Sn908, 2020-08-14 |

Scan Setup

| | Zoom Scan |
|---------------------|--------------------|
| Grid Extents [mm] | 22.0 x 22.0 x 22.0 |
| Grid Steps [mm] | 3.4 x 3.4 x 1.4 |
| Sensor Surface [mm] | 1.4 |
| Graded Grid | Yes |
| Grading Ratio | 1.4 |
| MAIA | N/A |
| Surface Detection | VMS + 6p |
| Scan Method | Measured |

Measurement Results

| | Zoom Scan |
|---------------------|-------------------|
| Date | 2021-02-09, 10:31 |
| psSAR1g [W/Kg] | 29.3 |
| psSAR10g [W/Kg] | 5.37 |
| Power Drift [dB] | 0.00 |
| Power Scaling | Disabled |
| Scaling Factor [dB] | |
| TSL Correction | Enabled |
| M2/M1 [%] | 49.6 |
| Dist 3dB Peak [mm] | 4.8 |

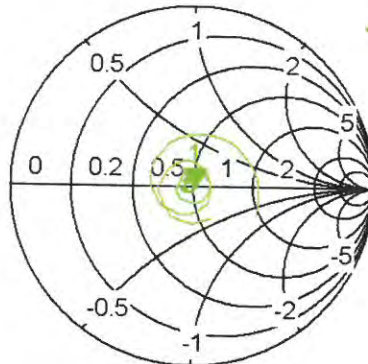


Impedance Measurement Plot for Head TSL



Trc1 S11 Smith Ref 1 U Cal

S11



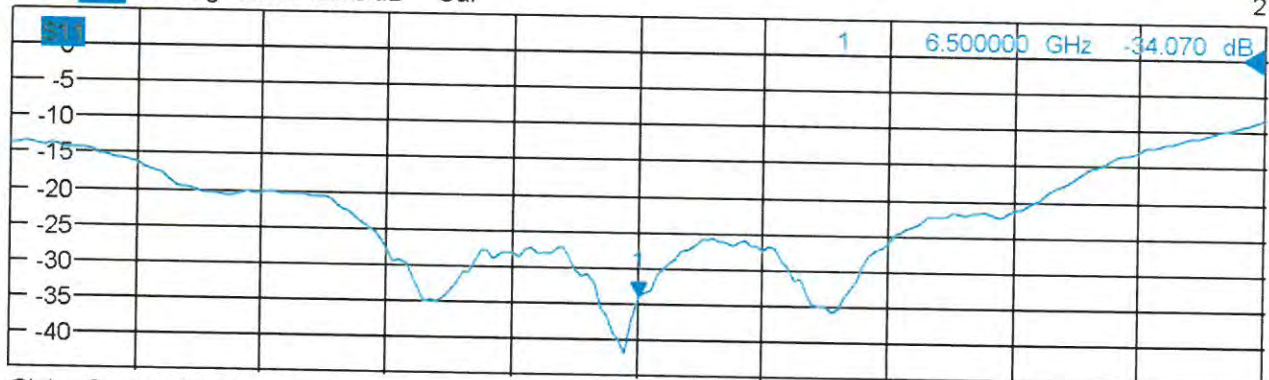
•1 6.500000 GHz 51.013 Ω
 -j1.724 Ω
 14.204 pF

Ch1 Center 6.5 GHz

Pwr 0 dBm

Span 2 GHz

Trc2 S11 dB Mag 5 dB/ Ref 0 dB Cal



Ch1 Center 6.5 GHz

Pwr 0 dBm

Span 2 GHz



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Accreditation No.: **SCS 0108**

Client **Dekra-TW (Auden)**

Certificate No: **5G-Veri10-2006_Apr21**

CALIBRATION CERTIFICATE

Object **5G Verification Source 10 GHz - SN: 2006**

Calibration procedure(s) **QA CAL-45.v3
Calibration procedure for sources in air above 6 GHz**

Calibration date: **April 08, 2021**

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 | 30-Dec-20 (No. EUmmWV3-9374_Dec20) | Dec-21 |
| DAE4ip | SN: 1602 | 11-Aug-20 (No. DAE4ip-1602_Aug20) | Aug-21 |

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

| | Name | Function | Signature |
|----------------|--------------|-----------------------|-----------|
| Calibrated by: | Leif Klysner | Laboratory Technician | |

| | | | |
|--------------|---------------|-------------------|--|
| Approved by: | Katja Pokovic | Technical Manager | |
|--------------|---------------|-------------------|--|

Issued: April 9, 2021

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Glossary

CW Continuous wave

Calibration is Performed According to the Following Standards

- Internal procedure QA CAL-45-5Gsources
- IEC TR 63170 ED1, "Measurement procedure for the evaluation of power density related to human exposure to radio frequency fields from wireless communication devices operating between 6 GHz and 100 GHz", January 2018

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 forward power to the horn antenna is measured prior and after the measurement with a power sensor. 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 | cDASY6 Module mmWave | V2.2 |
| Phantom | 5G Phantom | |
| Distance Horn Aperture - plane | 10 mm | |
| XY Scan Resolution | dx, dy = 7.5 mm | |
| Number of measured planes | 2 (10mm, 10mm + $\lambda/4$) | |
| Frequency | 10 GHz \pm 10 MHz | |

Calibration Parameters, 10 GHz

Circular Averaging

| Distance Horn Aperture to Measured Plane | <i>Prad'</i> (mW) | Max E-field (V/m) | Uncertainty (k = 2) | Avg Power Density Avg ($psPD_{n+}$, $psPD_{tot+}$, $psPD_{mod+}$) (W/m ²) | | Uncertainty (k = 2) |
|--|------------------------------------|------------------------------------|------------------------|--|-------------------|------------------------|
| | | | | 1 cm ² | 4 cm ² | |
| 10 mm | 125 | 264 | 1.27 dB | 184 | 149 | 1.28 dB |

Square Averaging

| Distance Horn Aperture to Measured Plane | <i>Prad'</i> (mW) | Max E-field (V/m) | Uncertainty (k = 2) | Avg Power Density Avg ($psPD_{n+}$, $psPD_{tot+}$, $psPD_{mod+}$) (W/m ²) | | Uncertainty (k = 2) |
|--|------------------------------------|------------------------------------|------------------------|--|-------------------|------------------------|
| | | | | 1 cm ² | 4 cm ² | |
| 10 mm | 125 | 264 | 1.27 dB | 185 | 149 | 1.28 dB |

¹ Assessed ohmic and mismatch loss: 0.85 dB

DASY Report

Measurement Report for 5G Verification Source 10 GHz, UID 0 -, Channel 10000 (10000.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|-------------------------------|-----------------------|----------|----------|
| 5G Verification Source 10 GHz | 100.0 x 100.0 x 172.0 | SN: 2006 | - |

Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| 5G - | 10.0 mm | Validation band | CW | 10000.0, 10000 | 1.0 |

Hardware Setup

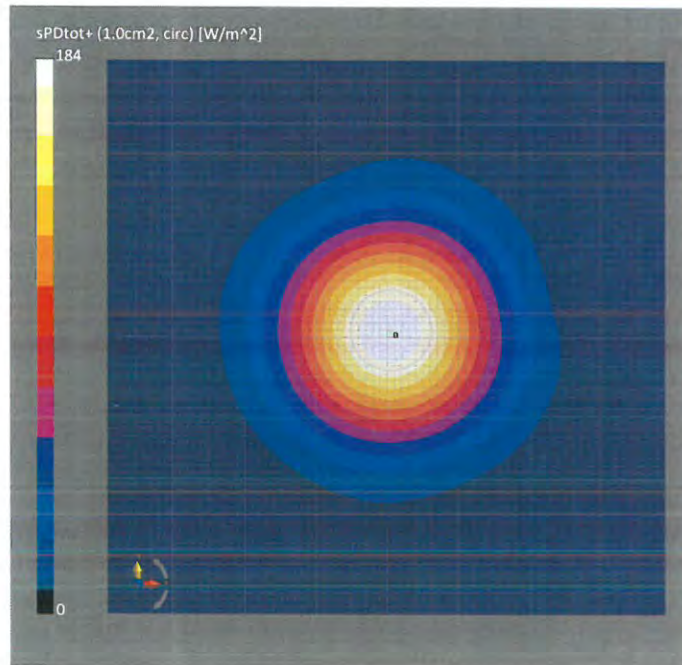
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|-----------------------|--------|---------------------------------------|---------------------------|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F1-78GHz, 2020-12-30 | DAE4ip Sn1602, 2020-08-11 |

Scan Setup

| | 5G Scan |
|---------------------|---------------|
| Grid Extents [mm] | 120.0 x 120.0 |
| Grid Steps [lambda] | 0.25 x 0.25 |
| Sensor Surface [mm] | 10.0 |
| MAIA | MAIA not used |

Measurement Results

| | 5G Scan |
|------------------------------|-------------------|
| Date | 2021-04-08, 11:28 |
| Avg. Area [cm ²] | 1.00 |
| psPDn+ [W/m ²] | 184 |
| psPDtot+ [W/m ²] | 184 |
| psPDmod+ [W/m ²] | 185 |
| E _{max} [V/m] | 264 |
| Power Drift [dB] | -0.04 |



DASY Report

Measurement Report for 5G Verification Source 10 GHz, UID 0 -, Channel 10000 (10000.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|-------------------------------|-----------------------|----------|----------|
| 5G Verification Source 10 GHz | 100.0 x 100.0 x 172.0 | SN: 2006 | - |

Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| 5G - | 10.0 mm | Validation band | CW | 10000.0, 10000 | 1.0 |

Hardware Setup

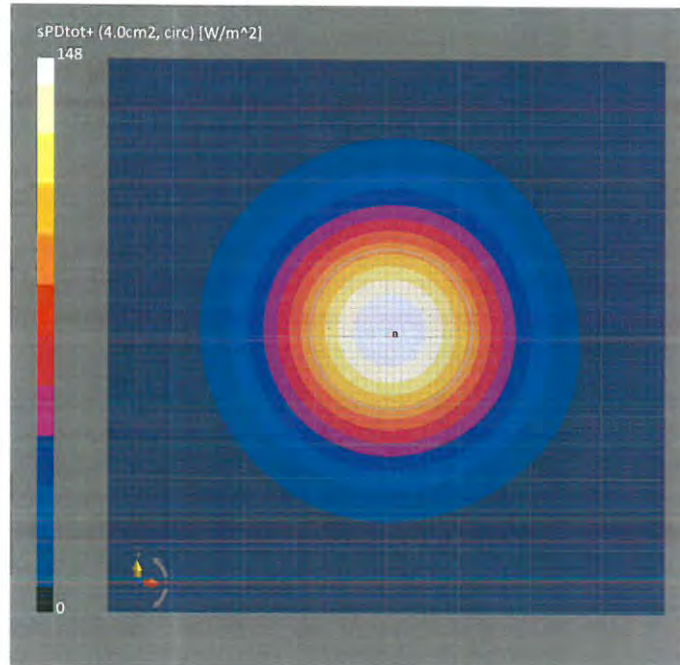
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|-----------------------|--------|---------------------------------------|---------------------------|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F1-78GHz, 2020-12-30 | DAE4ip Sn1602, 2020-08-11 |

Scan Setup

| | 5G Scan |
|---------------------|---------------|
| Grid Extents [mm] | 120.0 x 120.0 |
| Grid Steps [lambda] | 0.25 x 0.25 |
| Sensor Surface [mm] | 10.0 |
| MAIA | MAIA not used |

Measurement Results

| | 5G Scan |
|------------------------------|-------------------|
| Date | 2021-04-08, 11:28 |
| Avg. Area [cm ²] | 4.00 |
| psPDn+ [W/m ²] | 148 |
| psPDtot+ [W/m ²] | 148 |
| psPDmod+ [W/m ²] | 151 |
| E _{max} [V/m] | 264 |
| Power Drift [dB] | -0.04 |



DASY Report

Measurement Report for 5G Verification Source 10 GHz, UID 0 -, Channel 10000 (10000.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|-------------------------------|-----------------------|----------|----------|
| 5G Verification Source 10 GHz | 100.0 x 100.0 x 172.0 | SN: 2006 | - |

Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| 5G - | 10.0 mm | Validation band | CW | 10000.0, 10000 | 1.0 |

Hardware Setup

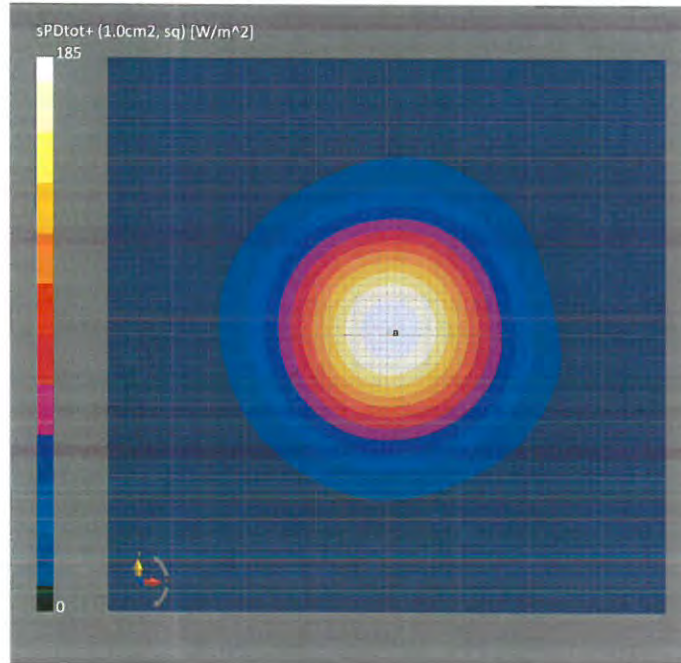
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|-----------------------|--------|---------------------------------------|---------------------------|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F1-78GHz, 2020-12-30 | DAE4ip Sn1602, 2020-08-11 |

Scan Setup

| | 5G Scan |
|---------------------|---------------|
| Grid Extents [mm] | 120.0 x 120.0 |
| Grid Steps [lambda] | 0.25 x 0.25 |
| Sensor Surface [mm] | 10.0 |
| MAIA | MAIA not used |

Measurement Results

| | 5G Scan |
|------------------------------|-------------------|
| Date | 2021-04-08, 11:28 |
| Avg. Area [cm ²] | 1.00 |
| psPDn+ [W/m ²] | 185 |
| psPDtot+ [W/m ²] | 185 |
| psPDmod+ [W/m ²] | 186 |
| E _{max} [V/m] | 264 |
| Power Drift [dB] | -0.04 |



DASY Report

Measurement Report for 5G Verification Source 10 GHz, UID 0 -, Channel 10000 (10000.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|-------------------------------|-----------------------|----------|----------|
| 5G Verification Source 10 GHz | 100.0 x 100.0 x 172.0 | SN: 2006 | - |

Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| 5G - | 10.0 mm | Validation band | CW | 10000.0, 10000 | 1.0 |

Hardware Setup

| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|-----------------------|--------|---------------------------------------|---------------------------|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F1-78GHz, 2020-12-30 | DAE4ip Sn1602, 2020-08-11 |

Scan Setup

Grid Extents [mm]
 Grid Steps [lambda]
 Sensor Surface [mm]
 MAIA

5G Scan
 120.0 x 120.0
 0.25 x 0.25
 10.0
 MAIA not used

Measurement Results

Date
 Avg. Area [cm²]
 psPDn+ [W/m²]
 psPDtot+ [W/m²]
 psPDmod+ [W/m²]
 E_{max} [V/m]
 Power Drift [dB]

5G Scan
 2021-04-08, 11:28
 4.00
 147
 148
 151
 264
 -0.04

