





 S
 Schweizerischer Kalibrierdienst

 C
 Service suisse d'étalonnage

 Servizio svizzero di taratura

 S
 Swiss Calibration Service

Accreditation No.: SCS 0108

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

#### 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:

- a) IEC/IEEE 62209-1528, "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)", October 2020.
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### Additional Documentation:

c) DASY 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 source is mounted in a touch configuration below the center marking of the flat phantom.
- Return Loss: This parameter is measured with the source positioned under the liquid filled phantom (as described in the measurement condition clause). 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 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%.

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### **Measurement Conditions**

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

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1900 MHz ± 1 MHz	

#### Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.4 ± 6 %	1.40 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

## SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	10.0 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	40.1 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL SAR measured	condition 250 mW input power	5.22 W/kg

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# Appendix (Additional assessments outside the scope of SCS 0108)

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.9 Ω + 4.8 jΩ
Return Loss	- 26.2 dB

#### **General Antenna Parameters and Design**

Electrical Delay (one direction)	1.201 ns
----------------------------------	----------

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
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### **DASY5 Validation Report for Head TSL**

Date: 15.07.2021

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d101

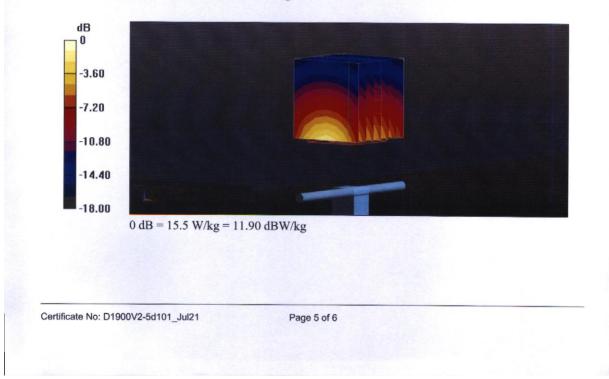
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz;  $\sigma = 1.4$  S/m;  $\varepsilon_r = 40.4$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.43, 8.43, 8.43) @ 1900 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

#### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

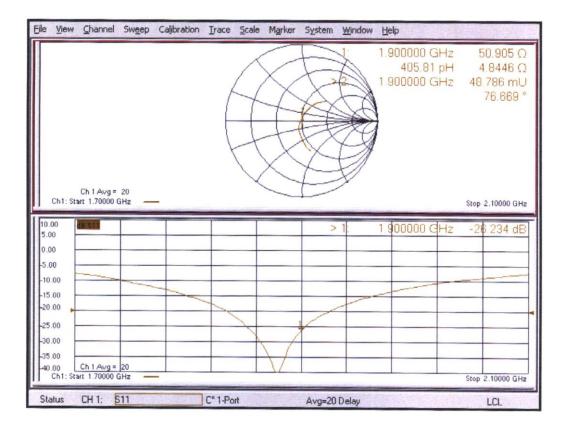
Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 110.1 V/m; Power Drift = 0.05 dB Peak SAR (extrapolated) = 18.4 W/kg SAR(1 g) = 10 W/kg; SAR(10 g) = 5.22 W/kg Smallest distance from peaks to all points 3 dB below = 9.8 mm Ratio of SAR at M2 to SAR at M1 = 54.9% Maximum value of SAR (measured) = 15.5 W/kg







#### Impedance Measurement Plot for Head TSL



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## **3700 MHz Dipole Calibration Certificate**

Calibration Laboratory of Schmid & Partner **Engineering AG** Zeughausstrasse 43, 8004 Zurich, Switzerland





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Certificate No: D3700V2-1004\_Jun21 Client CTTL (Auden) **CALIBRATION CERTIFICATE** Object D3700V2 - SN:1004 Calibration procedure(s) QA CAL-22.v6 Calibration Procedure for SAR Validation Sources between 3-10 GHz Calibration date: June 21, 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 ± 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 09-Apr-21 (No. 217-03291/03292) Apr-22 Power sensor NRP-791 SN: 103244 09-Apr-21 (No. 217-03291) Apr-22 Power sensor NRP-Z91 SN: 103245 09-Apr-21 (No. 217-03292) Apr-22 Reference 20 dB Attenuator SN: BH9394 (20k) 09-Apr-21 (No. 217-03343) Apr-22 Type-N mismatch combination SN: 310982 / 06327 09-Apr-21 (No. 217-03344) Apr-22 Reference Probe EX3DV4 SN: 3503 30-Dec-20 (No. EX3-3503\_Dec20) Dec-21 DAE4 SN: 601 02-Nov-20 (No. DAE4-601 Nov20) Nov-21 Secondary Standards ID # Check Date (in house) Scheduled Check Power meter E4419B SN: GB39512475 30-Oct-14 (in house check Oct-20) In house check: Oct-22 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-20) In house check: Oct-22 07-Oct-15 (in house check Oct-20) Power sensor HP 8481A SN: MY41092317 In house check: Oct-22 RF generator R&S SMT-06 SN: 100972 15-Jun-15 (in house check Oct-20) In house check: Oct-22 Network Analyzer Agilent E8358A SN: US41080477 31-Mar-14 (in house check Oct-20) In house check: Oct-21 Name Function Signature Calibrated by: Jeffrey Katzman Laboratory Technician Approved by: Katja Pokovic Technical Manager Issued: June 22, 2021 This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

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<b>Glossary:</b>
TSL
ConvF

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:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### Additional Documentation:

e) DASY4/5 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.
- Electrical Delay: One-way delay between the SMA connector and the antenna feed point. 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 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%.

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#### **Measurement Conditions**

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

DASY Version	DASY5	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	3700 MHz ± 1 MHz 3800 MHz ± 1 MHz	

### Head TSL parameters at 3700 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	37.7	3.12 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.8 ± 6 %	3.12 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 3700 MHz

100 mW input power	0 74 14/4
ioo inv input power	6.74 W/kg
normalized to 1W	67.1 W/kg ± 19.9 % (k=2)
condition	
	normalized to 1W

SATT averaged over 10 cm (10 g) of thead 13L	condition	
SAR measured	100 mW input power	2.44 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.3 W/kg ± 19.5 % (k=2)

Head TSL parameters at 3800 MHz The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	37.6	3.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.6 ± 6 %	3.20 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

### SAR result with Head TSL at 3800 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	6.57 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	65.4 W/kg ± 19.9 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL SAR measured	condition 100 mW input power	2.41 W/kg

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# Appendix (Additional assessments outside the scope of SCS 0108)

# Antenna Parameters with Head TSL at 3700 MHz

Impedance, transformed to feed point	48.0 Ω - 6.9 jΩ
Return Loss	- 22.7 dB

# Antenna Parameters with Head TSL at 3800 MHz

Impedance, transformed to feed point	58.0 Ω - 4.9 jΩ
Return Loss	- 21.2 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.139 ns

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

Manufacture	
Manufactured by	SPEAG
	SPEAG

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# **DASY5 Validation Report for Head TSL**

Date: 21.06.2021

Test Laboratory: SPEAG, Zurich, Switzerland

# DUT: Dipole 3700 MHz; Type: D3700V2; Serial: D3700V2 - SN:1004

Communication System: UID 0 - CW; Frequency: 3700 MHz, Frequency: 3800 MHz Medium parameters used: f = 3700 MHz;  $\sigma$  = 3.12 S/m;  $\epsilon_r$  = 36.8;  $\rho$  = 1000 kg/m<sup>3</sup>, Medium parameters used: f = 3800 MHz;  $\sigma$  = 3.20 S/m;  $\epsilon_r$  = 36.6;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(7.73, 7.73, 7.73) @ 3700 MHz, ConvF(7.73, 7.73, 7.73) @ 3800 MHz; Calibrated: 30.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm, f=3700MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 71.56 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 18.9 W/kg SAR(1 g) = 6.74 W/kg; SAR(10 g) = 2.44 W/kg Smallest distance from peaks to all points 3 dB below = 8 mm Ratio of SAR at M2 to SAR at M1 = 74% Maximum value of SAR (measured) = 13.0 W/kg

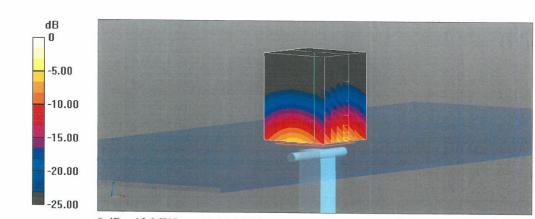
Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm, f=3800MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 68.51 V/m; Power Drift = 0.03 dB Peak SAR (extrapolated) = 18.0 W/kg SAR(1 g) = 6.57 W/kg; SAR(10 g) = 2.41 W/kg Smallest distance from peaks to all points 3 dB below = 8.2 mm Ratio of SAR at M2 to SAR at M1 = 75% Maximum value of SAR (measured) = 12.6 W/kg

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0 dB = 13.0 W/kg = 11.15 dBW/kg

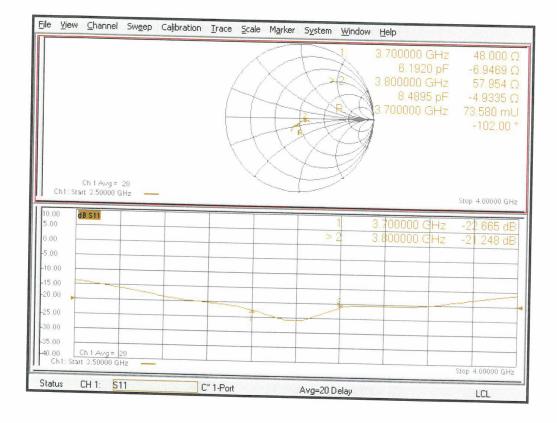
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# Impedance Measurement Plot for Head TSL



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Client Morlab (Auden)

Certificate No: 5G-Veri30-1077\_Dec20

bject	5G Verification	Source 30 GHz - SN: 1077	
Calibration procedure(s)	QA CAL-45.v3 Calibration prod	cedure for sources in air above 6 GHz	2
alibration date:	December 02,	2020	
he measurements and the unce Il calibrations have been condu	artainties with confidence	ational standards, which realize the physical units o e probability are given on the following pages and a tory facility: environment temperature (22 ± 3)°C ar	re part of the certificate.
Salibration Equipment used (M&	H		
himary Standards Reference Probe EUmmWV3	ID # SN: 9374	Cal Date (Certificate No.) 31-Dec-19 (No. EUmmWV3-9374 Dec19)	Scheduled Calibration Dec-20
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:	Name Leif Klysner	Function Laboratory Technician	
Calibrated by: Approved by:			Signature Seef Ilger Mar

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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.
- Hom 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 + λ/4) with a vectorial E-field probe. The E-field value stated as calibration value represents the E-fieldmaxima and the averaged (1cm<sup>2</sup> and 4cm<sup>2</sup>) 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 peak values of the total and normal component of the poynting vector [Re{S}] and n.Re{S} averaged over the surface area of 1 cm<sup>2</sup> (pS<sub>101</sub>avg1cm<sup>2</sup> and pSnavg1cm<sup>2</sup>) and 4cm<sup>2</sup> (pS<sub>101</sub>avg4cm<sup>2</sup> and pSnavg4cm<sup>2</sup>) at the nominal operational frequency of the verification source.

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%.

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

DASY Version	cDASY6 Module mmWave	V2.0
Phantom	5G Phantom	
Distance Horn Aperture - plane	10 mm	
XY Scan Resolution	dx, dy = 2.5 mm	
Number of measured planes	2 (10mm, 10mm + λ/4)	
Frequency	30 GHz ± 10 MHz	

# Calibration Parameters, 30 GHz

Distance Horn Aperture to Measured Plane	Prad' (mW)	Max E-field (V/m)	Uncertainty (k = 2)	n.Re{S)	er Densily , [Re{S}] /m2)	Uncertainty (k = 2)
				1 cm <sup>2</sup>	4 cm <sup>2</sup>	
10 mm	27.0	118	1.27 dB	31.8, 32.2	28.0, 28.4	1.28 dB

<sup>1</sup> derived from far-field data

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#### **DASY Report**

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

lame, Manufacturer iG Verification Source 30	GHz Dimensions (mm	0.001	IMEI SN: 1077	DUT Type	
Exposure Conditions	\$				
Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency (MHz), Channel Number	Conversion Factor
iG -	5.55 mm	Validation band	CW	30000.0, 30000	1.0

Probe, Calibration Date EUmmWV3 - SN9374\_F1-78GHz, 2019-12-31 Phantom mmWave Phantom - 1007 Medium hir

#### Scan Setup

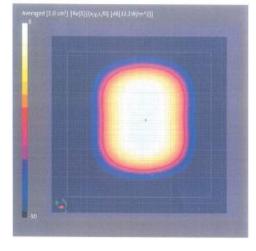
Grid Extents [mm] Grid Stops [lambda] Sensor Surface [mm] MAIA

000	60.0 -
00.0	DOTO X
0,25	D.25 x
5,55	
used	MAIA not

	Measurement Results
n.	
0	Date
5	Avg. Area [cm <sup>2</sup> ]
5	pStot avg [W/m <sup>2</sup> ]
d	p5 <sub>*</sub> avg [W/m <sup>2</sup> ]
	Epost [V/m]
	Power Drift [dB]

56 Scan 2020-12-02, 13:30 1.00 32.2 31.8 118 -0.02

DAE, Calibration Date DAE4ip Sn1602, 2020-08-11



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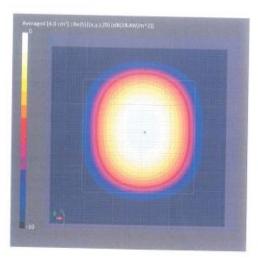




### **DASY Report**

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

Name, Manufacturer 5G Verification Source 3D G		2imensions [mm] 100.0 × 100.0 × 100.0		DUT Type	
Exposure Conditions					
Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency (MHz), Channel Number	Conversion Factor
SG -	5.55 mm	Validation band	CW	30000.0, 30000	1.0
Hardware Setup Phantom mmWave Phantom - 3002	Medium Air	Air		ition Date W9374_F1-78GHz,	DAE, Calibration Date DAE4ip 5n1602, 2020-08-11
Scan Setup			Measurem	ent Results	
Grid Extents [mm] Grid Steps [lambda] Sensor Surface [mm] MAIA	56.5 60.0 x 6 0.25 x 0 5 MAIA not u		1.0 Date 25 Avg. Anea [cm²] 55 p5 <sub>ret</sub> avg [W/m²]		56 Scan 2020-17-02, 13:30 4.00 28.4 28.4 28.0 118 -0.02



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# ANNEX E Accreditation Certificate

