

## **APPENDIX B. – Dipole Calibration Data**





Client

#### Calibration Laboratory of Schmid & Partner

Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland

DT&C (Dymstec)



Schweizerischer Kalibrierdienst Service suisse d'étalonnage Servizio svizzero di taratura Swiss Calibration Service

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

Certificate No: D750V3-1049 Jan21

Accreditation No.: SCS 0108

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#### **CALIBRATION CERTIFICATE** Object D750V3 - SN:1049 Calibration procedure(s) QA CAL-05.v11 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz Calibration date: January 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 Cal Date (Certificate No.) ID# 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: 7349 28-Dec-20 (No. EX3-7349 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 Power sensor HP 8481A SN: MY41092317 07-Oct-15 (in house check Oct-20) 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: Claudio Leubler Laboratory Technician Approved by: Katja Pokovic Technical Manager Issued: January 21, 2021 This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: D750V3-1049\_Jan21

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

Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



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Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS)

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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:

- 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	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	750 MHz ± 1 MHz	

#### Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.9	0.89 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	41.4 ± 6 %	0.90 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	2.12 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	8.39 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	5.47 W/kg ± 16.5 % (k=2)

#### **Body TSL parameters**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.5 ± 6 %	0.95 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

#### SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.17 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	8.75 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL SAR measured	condition 250 mW input power	1.43 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	53.1 Ω - 1.7 jΩ
Return Loss	- 29.3 dB

#### Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.1 Ω - 4.6 jΩ
Return Loss	- 26.5 dB

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

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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: 21.01.2021

Test Laboratory: SPEAG, Zurich, Switzerland

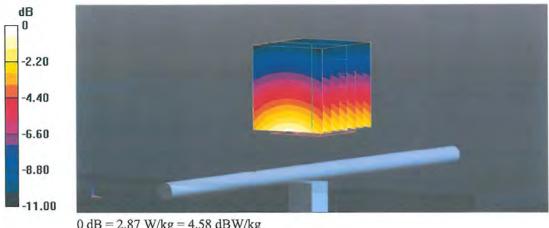
## DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1049

Communication System: UID 0 - CW; Frequency: 750 MHz Medium parameters used: f = 750 MHz;  $\sigma = 0.9 \text{ S/m}$ ;  $\varepsilon_r = 41.4$ ;  $\rho = 1000 \text{ kg/m}^3$ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(10.11, 10.11, 10.11) @ 750 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection) .
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 59.59 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 3.25 W/kg SAR(1 g) = 2.12 W/kg; SAR(10 g) = 1.38 W/kg Smallest distance from peaks to all points 3 dB below = 18.9 mm Ratio of SAR at M2 to SAR at M1 = 65.1% Maximum value of SAR (measured) = 2.87 W/kg



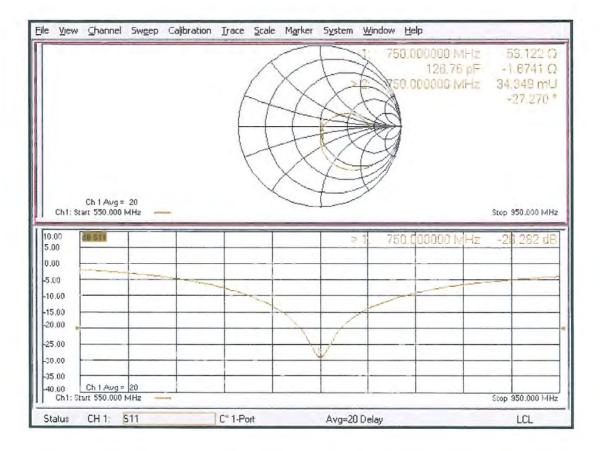
0 dB = 2.87 W/kg = 4.58 dBW/kg

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## Impedance Measurement Plot for Head TSL



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## DASY5 Validation Report for Body TSL

Date: 21.01.2021

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1049

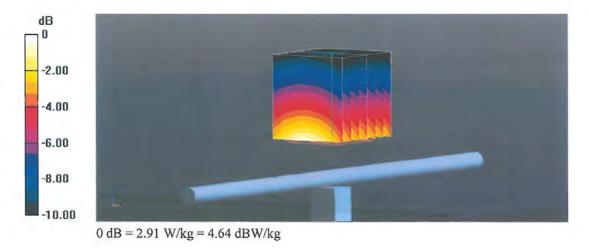
Communication System: UID 0 - CW; Frequency: 750 MHz Medium parameters used: f = 750 MHz;  $\sigma = 0.95$  S/m;  $\epsilon_r = 55.5$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(10.23, 10.23, 10.23) @ 750 MHz; Calibrated: 28.12.2020
- · Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

#### Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 55.81 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 3.32 W/kg SAR(1 g) = 2.17 W/kg; SAR(10 g) = 1.43 W/kg Smallest distance from peaks to all points 3 dB below = 16 mm Ratio of SAR at M2 to SAR at M1 = 65.9% Maximum value of SAR (measured) = 2.91 W/kg

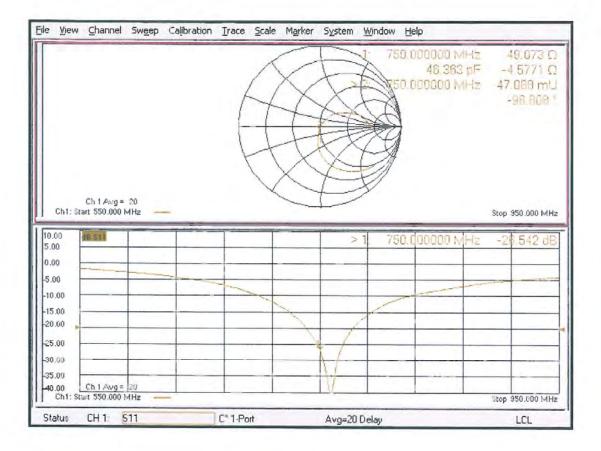


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## Impedance Measurement Plot for Body TSL

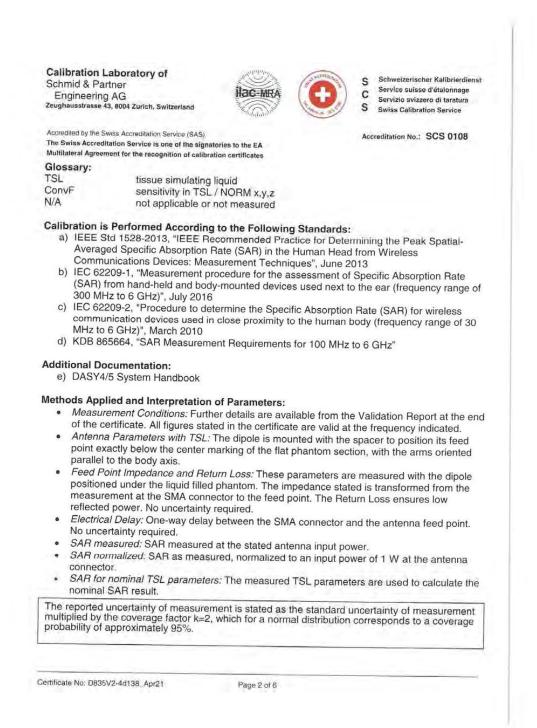


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# **Dt&C**

Engineering AG eughausstrasse 43, 8004 Zuric	h, Switzerland	Hac-MRA	S Schweizerischer Kalibrierdiens C Service suisse d'étalonnage Servizio svizzero di taratura S swiss Calibration Service
Accredited by the Swiss Accreditation Service	e is one of the signator	ies to the EA	Accreditation No.: SCS 0108
Multilateral Agreement for the re	ecognition of calibratio	n certificates	
Client SGS Korea (Dy	(meter)		
and the second second second			No: D835V2-4d138_Apr21
CALIBRATION C	ERTIFICAT	E	
Object	D835V2 - SN:40	1138	[2] = 11
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Calibration procedure(s)	QA CAL-05.v11		170
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Calibration date:	April 22, 2021		
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#### **Measurement Conditions**

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

DASY5	V52.10.4
Advanced Extrapolation	
Modular Flat Phantom	
15 mm	with Spacer
dx, dy, dz = 5 mm	
835 MHz ± 1 MHz	
	Advanced Extrapolation Modular Flat Phantom 15 mm dx, dy, dz = 5 mm

Head TSL parameters The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.5	0.90 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	42.2 ± 6 %	0.92 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	2.47 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.75 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	1.59 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	50.3 Ω - 2.0 jΩ	
Return Loss	- 33.9 dB	

## General Antenna Parameters and Design

Electrical Delay (one direction)	1 200 mg	
(in a controlly	1.398 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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Date: 22.04.2021

## DASY5 Validation Report for Head TSL

Test Laboratory: SPEAG, Zurich, Switzerland

## DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d138

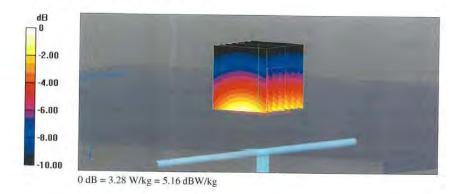
Communication System: UID 0 - CW; Frequency: 835 MHz Medium parameters used: f = 835 MHz;  $\sigma$  = 0.92 S/m;  $\epsilon_r$  = 42.2;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(9.69, 9.69, 9.69) @ 835 MHz: Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

## Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 63.47 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 3.74 W/kg **SAR(1 g) = 2.47 W/kg; SAR(10 g) = 1.59 W/kg Smallest distance from peaks to all points 3 dB below = 16.3 mm Ratio of SAR at M2 to SAR at M1 = 66\% Maximum value of SAR (measured) = 3.28 W/kg** 

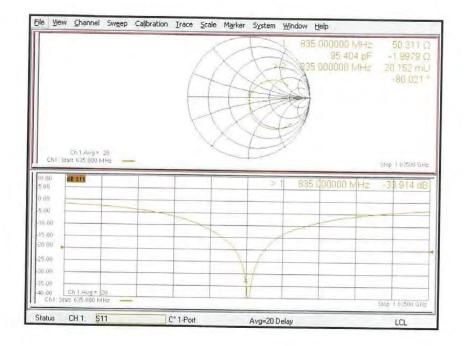


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# **Dt&C**

## Impedance Measurement Plot for Head TSL



Certificate No: D835V2-4d138\_Apr21

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Johent     D1900V2 - SN:5G158       Calibration procedure(s)     CA CAL-05.v11 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz       Salibration date     April 22, 2021       This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (S), the measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.       It calibration Equipment used (M&TE critical for calibration)       Imary Standards     ID #       Over meter NRP     SN: 104778       Over sensor NRP-291     SN: 104778       SN: 103244     09-Apr:21 (No. 217-03291)       Over sensor NRP-291     SN: 103244       SN: 103245     09-Apr:21 (No. 217-03291)       Apr:22     Apr:22       Oper-20 (No. DAF-201)     Apr:22       Over sensor NRP-291     SN: 103244       SN: 103245     09-Apr:21 (No. 217-03291)       Apr:22     Apr:22       Oper-20 (No. DAF-601 Nov20)     Nov:21       efference Probe EX3DV4     SN: 08924 (0832 OP-Apr:21 (No. 217-03343)       Apr:22     Apr:22       over meter F4419B     SN: 601     02-Nov-20 (No. DAF-601 Nov20)       over enter E4419B     SN: 601     02-Nov-20 (No. DAF-601 Nov20)       over enter F4419B     SN: US37292783     07-Oct-14 (in house check Oct-20)       over enter F4419B <th>CALIBRATION C</th> <th>ERTIFICATI</th> <th></th> <th></th>	CALIBRATION C	ERTIFICATI		
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The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.         Violable and the uncertainties with confidence probability environment temperature (22 ± 3)°C and humidity < 70%.         Calibration Equipment used (M&TE critical for calibration)         Scheduled Calibration         Ymmary Standards       ID #       Cal Date (Certificate No.)       Scheduled Calibration         Yower meter NRP       SN: 104778       09-Apr-21 (No. 217-03291)       Apr-22         Yower sensor NRP-Z91       SN: 103245       09-Apr-21 (No. 217-03292)       Apr-22         Yower sensor NRP-Z91       SN: 103245       09-Apr-21 (No. 217-03343)       Apr-22         Yower sensor NRP-Z91       SN: 103245       09-Apr-21 (No. 217-03344)       Apr-22         Yower sensor NRP-Z91       SN: 103082 (208)       09-Apr-21 (No. 217-03344)       Apr-22         Yower sensor NRP-Z91       SN: 310982 (208327       09-Apr-20 (No. EX3-7349_Dec20)       Dec-21         Yower sensor NRP Standards       SN: 601       02-Nov-20 (No. DAE4-601_Nov20)       Nov-21         Apr-42       SN: 601       02-Nov-20 (No. DAE4-601_Nov20)       In house check. Oct-22         Yower sensor HP 8481A       SN: US37292783       07-Oct-14 (in house check Oct-20)       In house ch	Calibration date:	April 22, 2021		
Power meter NRP         SN: 104778         09-Apr-21 (No. 217-03291/03292)         Apr-22           Power sensor NRP-Z91         SN: 103244         09-Apr-21 (No. 217-03291)         Apr-22           Power sensor NRP-Z91         SN: 103244         09-Apr-21 (No. 217-03291)         Apr-22           Power sensor NRP-Z91         SN: 103244         09-Apr-21 (No. 217-03292)         Apr-22           Power sensor NRP-Z91         SN: 103245         09-Apr-21 (No. 217-03243)         Apr-22           Vpe-N mismatch combination         SN: 310982 / 06327         09-Apr-21 (No. 217-03344)         Apr-22           Vpe-N mismatch combination         SN: 310982 / 06327         09-Apr-21 (No. 217-03344)         Apr-22           Vpe-N mismatch combination         SN: 310982 / 06327         09-Apr-21 (No. 217-03349)         Apr-22           Vpe-N mismatch combination         SN: 310982 / 06327         09-Apr-21 (No. 217-03349)         Apr-22           Vpe-N mismatch combination         SN: 310982 / 06327         09-Apr-21 (No. 217-03291)         Apr-22           Vpe-N mismatch combination         SN: 310982 / 06327         09-Apr-21 (No. 217-03249)         Dec-21           VAE4         SN: 601         02-Nov-20 (No. DAE4-601_Nov20)         Nov-21           Veecondary Standards         ID #         Check Date (In house)         Scheduled Check <th>The measurements and the uncer</th> <th></th> <th></th> <th></th>	The measurements and the uncer			
ower sensor NRP-Z91         SN: 103244         09-Apr-21 (No. 217-03291)         Apr-22           ower sensor NRP-Z91         SN: 103244         09-Apr-21 (No. 217-03291)         Apr-22           eferance 20 dB Attenuator         SN: 103245         09-Apr-21 (No. 217-03282)         Apr-22           open resensor NRP-Z91         SN: 103245         09-Apr-21 (No. 217-03243)         Apr-22           open resensor NRP Z91         SN: 109324 (20k)         09-Apr-21 (No. 217-03343)         Apr-22           open resensor NRP Z91         SN: 10982 / 06327         09-Apr-21 (No. 217-03344)         Apr-22           solver meter EX3DV4         SN: 7349         28-Dec-20 (No. EX3-7349 Dec20)         Dec-21           SN: 601         02-Nov-20 (No. DAE4-601_Nov20)         Nov-21           econdary Standards         ID #         Check Date (in house)         Scheduled Check           ower sensor HP 8481A         SN: US37292783         07-Oct-15 (in house check Oct-20)         In house check: Oct-22           ower sensor HP 8481A         SN: US41080477         31-Mar-16 (in house check Oct-20)         In house check: Oct-22           etwork Analyzer Aglient E8358A         SN: US41080477         31-Mar-14 (in house check Oct-20)         In house check: Oct-21           name         Function         Signature         Juf444	he measurements and the uncer Il calibrations have been conduct alibration Equipment used (M&TI	ed in the closed laborato E critical for calibration)		
Ower sensor NRP-Z91         SN: 103245         09-Apr-21 (No. 217-03292)         Apr-22           eference 20 dB Attenuator         SN: 103245         09-Apr-21 (No. 217-03343)         Apr-22           gerence 20 dB Attenuator         SN: 8H9394 (20k)         09-Apr-21 (No. 217-03343)         Apr-22           gerence 20 dB Attenuator         SN: 310982 / 06327         09-Apr-21 (No. 217-03343)         Apr-22           gerence Probe EX3DV4         SN: 601         02-Nov-20 (No. DAE4-601 Nov20)         Dec-21           AE4         SN: 601         02-Nov-20 (No. DAE4-601 Nov20)         Nov-21           econdary Standards         ID #         Check Date (in house)         Scheduled Check           ower sensor HP 8481A         SN: US37292783         07-Oct-14 (in house check Oct-20)         In house check: Oct-22           sh: 00972         15-Jun-15 (in house check Oct-20)         In house check: Oct-22         In house check: Oct-22           sh: 00972         15-Jun-15 (in house check Oct-20)         In house check: Oct-22         In house check: Oct-22           sh: 00972         15-Jun-15 (in house check Oct-20)         In house check: Oct-21         In house check: Oct-22           sh: 00972         15-Jun-15 (in house check Oct-20)         In house check: Oct-21         In house check: Oct-22           sh: Work Analyzer Aglient E8358A         SN: US41080	he measurements and the uncer Il calibrations have been conduct alibration Equipment used (M&TI rimary Standards	ed in the closed laborato E critical for calibration)	ry facility: environment temperature (22 ± 3 Cal Date (Certificate No.)	)°C and flumidity < 70%. Scheduled Calibration
eference 20 dB Attenuator ype-N mismatch combination eference Probe EX3DV4     SN: BH9394 (20k)     09-Apr-21 (No. 217-03343)     Apr-22       SN: 310982 / 06327     09-Apr-21 (No. 217-03343)     Apr-22       SN: 7349     28-Dec-20 (No. EX3-7349_Dec-20)     Dec-21       SN: 601     02-Nov-20 (No. DAE4-601_Nov20)     Nov-21       econdary Standards     ID #     Check Date (in house)       swer sensor HP 8481A     SN: G839512475     30-Oct-14 (in house check Oct-20)     In house check: Oct-22       swer sensor HP 8481A     SN: US37292783     07-Oct-15 (in house check Oct-20)     In house check: Oct-22       Swer sensor HP 8481A     SN: M109721     15-Jun-15 (in house check Oct-20)     In house check: Oct-22       Swer sensor HP 8481A     SN: US37292783     07-Oct-15 (in house check Oct-20)     In house check: Oct-22       Swer sensor HP 8481A     SN: W109721     15-Jun-16 (in house check Oct-20)     In house check: Oct-22       Swer sensor HP 8481A     SN: US37292783     07-Oct-15 (in house check Oct-20)     In house check: Oct-22       Swer sensor HP 8481A     SN: W10972     15-Jun-16 (in house check Oct-20)     In house check: Oct-22       SN: US41080477     31-Mar-14 (in house check Oct-20)     In house check: Oct-21       Name     Function     Signature       Jaibrated by:     Jaffrey Katzman     Laboratory Technician     JMAAAA <td>he measurements and the uncer Il calibrations have been conduct alibration Equipment used (M&amp;T) rimary Standards ower meter NRP</td> <td>ed in the closed laborato E critical for calibration) ID # SN: 104778</td> <td>ry facility: environment temperature (22 ± 3 Cal Date (Certificate No.) 09-Apr-21 (No. 217-03291/03292)</td> <td>)°C and flumidity &lt; 70%. Scheduled Calibration Apr-22</td>	he measurements and the uncer Il calibrations have been conduct alibration Equipment used (M&T) rimary Standards ower meter NRP	ed in the closed laborato E critical for calibration) ID # SN: 104778	ry facility: environment temperature (22 ± 3 Cal Date (Certificate No.) 09-Apr-21 (No. 217-03291/03292)	)°C and flumidity < 70%. Scheduled Calibration Apr-22
pe-N mismatch combination (ferrince Probe EX3DV4 NE4     SN: 310982 / 06327 SN: 7349     09-Apr-21 (No. 217-03344)     Apr-22 Dec-20)       SN: 7349     28-Dec-20 (No. EX3-7349_Dec20)     Dec-21 Nov-21       icondary Standards     ID #     Check Date (in house)     Scheduled Check       wer sensor HP 8481A wer sensor HP 8481A     SN: (B39512475)     30-Oct-14 (in house check Oct-20) In house check: Oct-22 In house check: Oct-22 SN: 1037292783     In house check Oct-20) SN: US37292783     In house check Oct-20) In house check: Oct-22 SN: 10372       igenerator RAS SMT-06 twork Analyzer Agilent E8358A     SN: US41080477     31-Mar-14 (in house check Oct-20) In house check: Oct-21       Name     Function     Signature       Jeffrey Katzman     Laboratory Technician     Juttation	e measurements and the uncer I calibrations have been conduct alibration Equipment used (M&T) imary Standards ower meter NRP ower sensor NRP-Z91	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 103244	ry facility: environment temperature (22 ± 3 Cal Date (Certificate No.) 09-Apr-21 (No. 217-03291/03292) 09-Apr-21 (No. 217-03291)	)°C and flumidity < 70%. Scheduled Calibration Apr-22 Apr-22
efereinde Probe EX3DV4     SN: 7349     28-Dec-20 (No. EX3-7349_Dec20)     Dec-21       AE4     SN: 601     02-Nov-20 (No. DAE4-601_Nov20)     Nov-21       econdary Standards     ID #     Check Date (in house)     Scheduled Check       ower meter E4419B     SN: GB39512475     30-Oct-14 (in house check Oct-20)     In house check: Oct-22       ower sensor HP 8481A     SN: US37292783     07-Oct-15 (in house check Oct-20)     In house check: Oct-22       ower sensor HP 8481A     SN: W141092317     07-Oct-15 (in house check Oct-20)     In house check: Oct-22       generator RAS SMT-05     SN: 100972     15-Jun-15 (in house check Oct-20)     In house check: Oct-22       generator RAS SMT-05     SN: US41080477     31-Mar-14 (in house check Oct-20)     In house check: Oct-21       Name     Function     Signature       Alibrated by:     Jeffrey Katzman     Laboratory Technician     Jume4	he measurements and the uncer II calibrations have been conduct alibration Equipment used (M&T) many Standards wer meter NRP wer sensor NRP-Z91 ower sensor NRP-Z91	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245	ry facility: environment temperature (22 ± 3 Cal Date (Certificate No.) 09-Apr-21 (No. 217-03291/03292) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03292)	)°C and flumidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22
ID-#         Check Date (in house)         Scheduled Check           econdary Standards         ID-#         Check Date (in house)         Scheduled Check           ower mater E4419B         SN: G839512475         30-Oct-14 (in house check Oct-20)         In house check: Oct-22           ower sensor HP 8481A         SN: US37292783         07-Oct-15 (in house check Oct-20)         In house check: Oct-22           wer sensor HP 8481A         SN: W109271         07-Oct-15 (in house check Oct-20)         In house check: Oct-22           F generator R&S SMT-06         SN: US41080477         15-Jun-15 (in house check Oct-20)         In house check: Oct-22           stwork Analyzer Agilent E8358A         SN: US41080477         31-Mar-14 (in house check Oct-20)         In house check: Oct-21           Name         Function         Signature         Jumoter           alibrated by:         Jeffrey Katzman         Laboratory Technician         JMddddddddddddddddddddddddddddddddddd	he measurements and the uncer Il calibrations have been conduct alibration Equipment used (M&T) rimary Standards ower sensor NRP-291 ower sensor NRP-291 eferonce 20 dB Attenuator	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 104778 SN: 103245 SN: 103245 SN: 6H9394 (20k)	ry facility: environment temperature (22 ± 3 <u>Cal Date (Certificate No.)</u> 09-Apr-21 (No. 217-03291/03292) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03292) 09-Apr-21 (No. 217-03343)	)°C and humidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22
bwer meter E4119B         SN: GB39512475         30-Oct-14 (in house check Oct-20)         In house check Oct-22           bwer sensor HP 8481A         SN: US37292783         07-Oct-15 (in house check Oct-20)         In house check: Oct-22           bwer sensor HP 8481A         SN: MY41092317         07-Oct-15 (in house check Oct-20)         In house check: Oct-22           generator RAS SMT-05         SN: 100972         15-Jun-15 (in house check Oct-20)         In house check: Oct-22           generator RAS SMT-05         SN: US41080477         31-Mar-14 (in house check Oct-20)         In house check: Oct-21           atwork Analyzer Agitent E8358A         SN: US41080477         31-Mar-14 (in house check Oct-20)         In house check: Oct-21           Name         Function         Signature         Juffrey Katzman         Laboratory Technician	he measurements and the uncer II calibrations have been conduct alibration Equipment used (M&T) immary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 eference 20 dB Attenuator rpe-N mismatch combination eference Probe EX3DV4	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327	ry facility: environment temperature (22 ± 3 Cal Date (Certificate No.) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03292) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03344)	)°C and flumidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22
Wer meter E4419B         SN: GB39512475         30-Oct-14 (in house check Oct-20)         In house check Oct-22           Wer sensor HP 8481A         SN: US37292783         07-Oct-15 (in house check Oct-20)         In house check: Oct-22           Wer sensor HP 8481A         SN: MY41092317         07-Oct-15 (in house check Oct-20)         In house check: Oct-22           Wer sensor HP 8481A         SN: MY41092317         07-Oct-15 (in house check Oct-20)         In house check: Oct-22           generator RAS SMT-05         SN: ID0972         15-Jun-15 (in house check Oct-20)         In house check: Oct-22           twork Analyzer Agilent E8358A         SN: US41080477         31-Mar-14 (in house check Oct-20)         In house check: Oct-21           Name         Function         Signature           Hibrated by:         Jeffrey Katzman         Laboratory Technician         Juttation	e measurements and the uncer I calibrations have been conduct alibration Equipment used (M&T) imary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 eference 20 dB Attenuator ree-N mismatch combination eference Probe EX3DV4	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 104274 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 7349	ry facility: environment temperature (22 ± 3 Cal Date (Certificate No.) 09-Apr-21 (No. 217-03291/03292) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03344) 28-Dec-20 (No. EX3-7349_Dec20)	)°C and flumidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Dec-21
ower sensor HP 8481A     SN: US37292783     07-Oct-15 (in house check Oct-20)     In house check: Oct-22       ower sensor HP 8481A     SN: MY41092317     07-Oct-15 (in house check Oct-20)     In house check: Oct-22       F generator R&S SMT-06     SN: 100972     15-Jun-15 (in house check Oct-20)     In house check: Oct-22       SN: US3129277     31-Mar-14 (in house check Oct-20)     In house check: Oct-22       SN: US41080477     31-Mar-14 (in house check Oct-20)     In house check: Oct-21       Name     Function     Signature       Jaibrated by:     Jeffrey Katzman     Laboratory Technician     Juttable	he measurements and the uncer alibration Equipment used (M&TI many Standards ower sensor NRP-Z91 ower sensor NRP-Z91 over sensor NRP-Z91 eference 20 dB Attenuator ppe-N mismatch combination eference Probe EX3DV4 AE4	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 104778 SN: 103245 SN: 013245 SN: 013245 SN: 013245 SN: 310982 / 06327 SN: 7349 SN: 601	ry facility: environment temperature (22 ± 3 <u>Cal Date (Certificate No.)</u> 09-Apr-21 (No. 217-03291/03292) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03344) 28-Dec-20 (No. EX3-7349_Dec20) 02-Nov-20 (No. DAE4-601_Nov20)	9°C and humidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Dec-21 Nov-21
F generator R&S SMT-06 stwork Analyzer Agilient E8358A SN: 100972 15-Jun-15 (in house check Oct-20) In house check: Oct-20 SN: US41080477 31-Mar-14 (in house check Oct-20) In house check: Oct-21 Name Function Signature Jeffrey Katzman Laboratory Technician	he measurements and the uncer Il calibrations have been conduct alibration Equipment used (M&T) rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 eference 20 dB Attenuator ope-N mismatch combination eference Probe EX3DV4 AE4 econdary Standards	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 103244 SN: 03245 SN: 03245 SN: 03245 SN: 03245 SN: 03245 SN: 03245 SN: 03245 SN: 03245 SN: 0326 SN: 0327 SN: 7349 SN: 601 ID #	ry facility: environment temperature (22 ± 3 Cal Date (Certificate No.) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03243) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03344) 28-Dec-20 (No. EX3-7349_Dec20) 02-Nov-20 (No. DAE4-601_Nov20) Check Date (in house)	)°C and humidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Dec-21 Nov-21 Scheduled Check
etwork Analyzer Agilent EB358A SN: US41080477 31-Mar-14 (in house check Oct-20) In house check: Oct-21 Name Function Signature Alibrated by: Jeffrey Katzman Laboratory Technician	he measurements and the uncer Il calibrations have been conduct alibration Equipment used (M&T) imary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 oference 20 dB Attenuator ype-N mismatch combination eference Probe EX3DV4 AE4 econdary Standards ower meter E4198 ower sensor HP 8481A	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 103245 SN: 6103245 SN: 619394 (20k) SN: 310962 / 06327 SN: 7349 SN: 601 ID # SN: 601 SN: 601 SN: 601	ry facility: environment temperature (22 ± 3 <u>Cal Date (Certificate No.)</u> 09-Apr-21 (No. 217-03291/03292) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03343) 09-Apr-22 (No. 2X3-7349_Dec20) 02-Nov-20 (No. DAE4-601_Nov20) <u>Check Date (in house</u> 30-Oct-14 (in house check Oct-20) 07-Oct-15 (in house check Oct-20)	b)°C and flumidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Dec-21 Nov-21 Scheduled Check In house check: Oct-22
Name Function Signature alibrated by: Jeffrey Katzman Laboratory Technician	he measurements and the uncer alibration Equipment used (M&TI many Standards ower meter NRP ower sensor NRP-Z91 eference 20 dB Attenuator ype-N mismatch combination eference Probe EX3DV4 AE4 econdary Standards ower meter E4419B ower sensor HP 8481A ower sensor HP 8481A	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 103245 SN: 013245 SN: 013245 SN: 013245 SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: G839512475 SN: US37292783 SN: US37292783 SN: MY41092317	ry facility: environment temperature (22 ± 3 Cal Date (Certificate No.) 09-Apr-21 (No. 217-03291/03292) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03293) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03344) 28-Dec-20 (No. EX3-7349_Dec20) 02-Nov-20 (No. DAE4-601_Nov20) Check Date (in house 30-Oct-14 (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 07-Oct-15 (in house check Oct-20)	b)°C and humidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Dec-21 Nov-21 Scheduled Check In house check: Oct-22 In house check: Oct-22
alibrated by: Jeffrey Katzman Laboratory Technician	he measurements and the uncer alibrations have been conduct alibration Equipment used (M&T) rimary Standards ower meter NRP ower sensor NRP-Z91 eference 20 dB Attenuator ype-N mismatch combination eference Probe EX3DV4 AE4 econdary Standards ower meter E4419B ower sensor HP 8481A power sensor HP 8481A F generator R&S SMT-06	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 103245 SN: 103245 SN: 8H9394 (20k) SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: 6039512475 SN: US37292783 SN: M341092317 SN: 100972	ry facility: environment temperature (22 ± 3 Cal Date (Certificate No.) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03243) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03344) 28-Dec-20 (No. EX3-7349_Dec20) 02-Nov-20 (No. DAE4-601_Nov20) Check Date (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 15-Jun-15 (in house check Oct-20)	b)°C and humidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Dec-21 Nov-21 Scheduled Check In house check: Oct-22 In house check: Oct-22
J. Koto	he measurements and the uncer alibrations have been conduct alibration Equipment used (M&T) rimary Standards ower meter NRP ower sensor NRP-Z91 eference 20 dB Attenuator ype-N mismatch combination eference Probe EX3DV4 AE4 econdary Standards ower meter E4419B ower sensor HP 8481A power sensor HP 8481A F generator R&S SMT-06	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 103245 SN: 103245 SN: 8H9394 (20k) SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: 6039512475 SN: US37292783 SN: M341092317 SN: 100972	ry facility: environment temperature (22 ± 3 Cal Date (Certificate No.) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03243) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03344) 28-Dec-20 (No. EX3-7349_Dec20) 02-Nov-20 (No. DAE4-601_Nov20) Check Date (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 15-Jun-15 (in house check Oct-20)	b)°C and humidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Dec-21 Nov-21 Scheduled Check In house check: Oct-22 In house check: Oct-22
oproved by: Kalja Pokovic Technical Manager	The measurements and the uncer calibration Equipment used (M&T) trimary Standards tower meter NRP tower sensor NRP-Z91 tower sensor NRP-Z91 tower sensor NRP-Z91 teleference 20 dB Attenuator ype-N mismatch combination teleference Probe EX3DV4 AE4 econdary Standards ower meter E4419B ower sensor HP 8481A F generator R&S SMT-06 etwork Analyzer Aglient E8358A	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 8149394 (206) SN: 310982 / 06327 SN: 310982 / 06327 SN: 5N: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317 SN: 100972 SN: US41080477	ry facility: environment temperature (22 ± 3 <u>Cal Date (Certificate No.)</u> 09-Apr-21 (No. 217-03291/03292) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03243) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-0344) 09-Apr-21 (No. 217-0324) 09-Apr-21 (No	b)°C and humidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Dec-21 Nov-21 Scheduled Check In house check: Oct-22 In house check: Oct-21
recinical monager	The measurements and the uncer All calibrations have been conduct Calibration Equipment used (M&T) Primary Standards Power sensor NRP-Z91 Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator ype-N mismatch combination Reference Probe EX3DV4 VAE4 Sover sensor HP 8481A Power sensor HP 8481A F generator R&S SMT-06 retwork Analyzer Agilent E8358A	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 103245 SN: 013245 SN: 013245 SN: 013245 SN: 013245 SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: G839512475 SN: US37292783 SN: WY41092317 SN: 100972 SN: US41080477 Name	ry facility: environment temperature (22 ± 3 Cal Date (Certificate No.) 09-Apr-21 (No. 217-03291/03292) 09-Apr-21 (No. 217-03291) 09-Apr-21 (No. 217-03343) 09-Apr-21 (No. 217-03344) 28-Dec-20 (No. EX3-7349_Dec20) 02-Nov-20 (No. DAE4-601_Nov20) Check Date (in house) 30-Oct-14 (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 15-Jun-15 (in house check Oct-20) 31-Mar-14 (in house check Oct-20) Function	b)°C and humidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Dec-21 Nov-21 Scheduled Check In house check: Oct-22 In house check: Oct-21
	The measurements and the uncer All calibrations have been conduct Calibration Equipment used (M&T) Primary Standards "ower meter NRP "ower sensor NRP-Z91 "ower sensor NRP-Z91 Reference 20 dB Attenuator ype-N mismatch combination Reference Probe EX3DV4 VAE4 Recondary Standards Power sensor HP 8481A rower sensor HP 8481A rower sensor HP 8481A (Figuenerator R&S SMT-06 Retwork Analyzer Agilent E8358A salibrated by:	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 013245 SN: 0130245 SN: 0140627 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: WY41092317 SN: US37292783 SN: WY41092317 SN: US3129277 SN: US31080477 Name Jeffrey Katzman	Cal Date (Certificate No.)           09-Apr-21 (No. 217-03291/03292)           09-Apr-21 (No. 217-03291)           09-Apr-21 (No. 217-03292)           09-Apr-21 (No. 217-03292)           09-Apr-21 (No. 217-03292)           09-Apr-21 (No. 217-03292)           09-Apr-21 (No. 217-03294)           28-Dec-20 (No. EX3-7349_Dec20)           02-Nov-20 (No. DAE4-601_Nov20)           Check Date (in house)           30-Cat-14 (in house check Oct-20)           07-Oct-15 (in house check Oct-20)           07-Oct-15 (in house check Oct-20)           07-Oct-15 (in house check Oct-20)           15-Jun-15 (in house check Oct-20)           15-Jun-15 (in house check Oct-20)           Function           Laboratory Technician	b)°C and humidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Dec-21 Nov-21 Scheduled Check In house check: Oct-22 In house check: Oct-21
Issued: April 23, 2021 his calibration certificate shall not be reproduced except in full without written approval of the laboratory.	The measurements and the uncer VI calibrations have been conduct Calibration Equipment used (M&T) Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Veterence 20 dB Attenuator ype-N mismatch combination Veterence Probe EX3DV4 VAE4 Vecondary Standards Cower meter E4419B Yower sensor HP 8481A Presensor HP 8481A Figuremetor R&S SMT-06 Vetwork Analyzer Agilent E8358A alibrated by:	ed in the closed laborato E critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 013245 SN: 0130245 SN: 0140627 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: WY41092317 SN: US37292783 SN: WY41092317 SN: US3129277 SN: US31080477 Name Jeffrey Katzman	Cal Date (Certificate No.)           09-Apr-21 (No. 217-03291/03292)           09-Apr-21 (No. 217-03291)           09-Apr-21 (No. 217-03292)           09-Apr-21 (No. 217-03292)           09-Apr-21 (No. 217-03292)           09-Apr-21 (No. 217-03292)           09-Apr-21 (No. 217-03294)           28-Dec-20 (No. EX3-7349_Dec20)           02-Nov-20 (No. DAE4-601_Nov20)           Check Date (in house)           30-Cat-14 (in house check Oct-20)           07-Oct-15 (in house check Oct-20)           07-Oct-15 (in house check Oct-20)           07-Oct-15 (in house check Oct-20)           15-Jun-15 (in house check Oct-20)           15-Jun-15 (in house check Oct-20)           Function           Laboratory Technician	b)°C and humidity < 70%. Scheduled Calibration Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Apr-22 Dec-21 Nov-21 Scheduled Check In house check: Oct-22 In house check: Oct-21



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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:

- 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 car (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%.

Certificate No: D1900V2-5d158\_Apr21

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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	
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	40.9 ± 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	10.2 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	41.0 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	5.30 W/kg

Certificate No: D1900V2-5d158\_Apr21

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

Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.3 Ω + 5.9 jΩ	
Return Loss	- 24.2 dB	

#### General Antenna Parameters and Design

Electrical Deleu (ene direction)	to refer the same
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

Certificate No: D1900V2-5d158\_Apr21

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

Date: 22.04.2021

Test Laboratory: SPEAG, Zurich, Switzerland

## DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d158

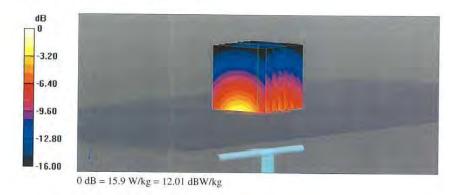
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz;  $\sigma$  = 1.40 S/m;  $\epsilon_r$  = 40.9;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

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(1527); SEMCAD X 14.6.14(7483)

## 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 = 111.1 V/m; Power Drift = -0.00 dB Peak SAR (extrapolated) = 18.8 W/kg SAR(1 g) = 10.2 W/kg; SAR(10 g) = 5.30 W/kg Smallest distance from peaks to all points 3 dB below = 10 mm Ratio of SAR at M2 to SAR at M1 = 54.5% Maximum value of SAR (measured) = 15.9 W/kg

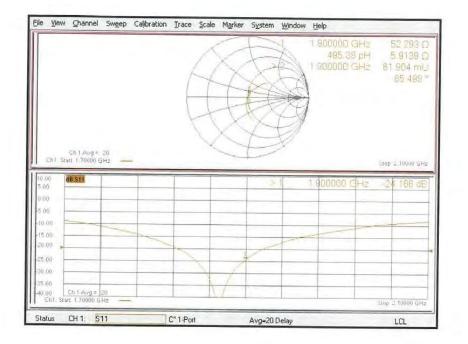


Certificate No: D1900V2-5d158\_Apr21

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# **Dt&C**

#### Impedance Measurement Plot for Head TSL



Certificate No: D1900V2-5d158\_Apr21

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



S Schweizerischer Kalibrierdienst

C Service suisse d'étalonnage Servizio svizzero di taratura

S Swiss Calibration Service

Accreditation No.: SCS 0108

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Client DT&C (Dymstec)

Certificate No: D2450V2-920\_Aug20

Dbject	D2450V2 - SN:92	20	
Calibration procedure(s)	QA CAL-05.v11 Calibration Proce	dure for SAR Validation Sources	between 0.7-3 GHz
Calibration date:	August 18, 2020		
		onal standards, which realize the physical un robability are given on the following pages an	
All calibrations have been conducte	ed in the closed laborator	ry facility: environment temperature (22 ± 3)°C	C and humidity < 70%.
Calibration Equipment used (M&TE	E 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
	SN: BH9394 (20k)	31-Mar-20 (No. 217-03106)	Apr-21
Reference 20 dB Attenuator	A contraction of the contract		
Type-N mismatch combination	SN: 310982 / 06327	31-Mar-20 (No. 217-03104)	Apr-21
Type-N mismatch combination Reference Probe EX3DV4	SN: 310982 / 06327 SN: 7349	31-Mar-20 (No. 217-03104) 29-Jun-20 (No. EX3-7349_Jun20)	Jun-21
	SN: 310982 / 06327	31-Mar-20 (No. 217-03104)	
Type-N mismatch combination Reference Probe EX3DV4	SN: 310982 / 06327 SN: 7349	31-Mar-20 (No. 217-03104) 29-Jun-20 (No. EX3-7349_Jun20)	Jun-21
Type-N mismatch combination Reference Probe EX3DV4 DAE4	SN: 310982 / 06327 SN: 7349 SN: 601	31-Mar-20 (No. 217-03104) 29-Jun-20 (No. EX3-7349_Jun20) 27-Dec-19 (No. DAE4-601_Dec19)	Jun-21 Dec-20
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	SN: 310982 / 06327 SN: 7349 SN: 601 ID #	31-Mar-20 (No. 217-03104) 29-Jun-20 (No. EX3-7349_Jun20) 27-Dec-19 (No. DAE4-601_Dec19) Check Date (in house)	Jun-21 Dec-20 Scheduled Check In house check: Oct-20 In house check: Oct-20
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter E4419B	SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317	31-Mar-20 (No. 217-03104) 29-Jun-20 (No. EX3-7349_Jun20) 27-Dec-19 (No. DAE4-601_Dec19) Check Date (in house) 30-Oct-14 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 07-Oct-15 (in house check Oct-18)	Jun-21 Dec-20 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317 SN: 100972	31-Mar-20 (No. 217-03104) 29-Jun-20 (No. EX3-7349_Jun20) 27-Dec-19 (No. DAE4-601_Dec19) Check Date (in house) 30-Oct-14 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 07-Oct-15 (in house check Oct-18) 15-Jun-15 (in house check Oct-18)	Jun-21 Dec-20 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A	SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317	31-Mar-20 (No. 217-03104) 29-Jun-20 (No. EX3-7349_Jun20) 27-Dec-19 (No. DAE4-601_Dec19) Check Date (in house) 30-Oct-14 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 07-Oct-15 (in house check Oct-18)	Jun-21 Dec-20 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317 SN: 100972	31-Mar-20 (No. 217-03104) 29-Jun-20 (No. EX3-7349_Jun20) 27-Dec-19 (No. DAE4-601_Dec19) Check Date (in house) 30-Oct-14 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 07-Oct-15 (in house check Oct-18) 15-Jun-15 (in house check Oct-18)	Jun-21 Dec-20 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317 SN: 100972 SN: US41080477	31-Mar-20 (No. 217-03104) 29-Jun-20 (No. EX3-7349_Jun20) 27-Dec-19 (No. DAE4-601_Dec19) Check Date (in house) 30-Oct-14 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 07-Oct-15 (in house check Oct-18) 15-Jun-15 (in house check Oct-18) 31-Mar-14 (in house check Oct-19)	Jun-21 Dec-20 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A	SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317 SN: 100972 SN: US41080477 Name	31-Mar-20 (No. 217-03104) 29-Jun-20 (No. EX3-7349_Jun20) 27-Dec-19 (No. DAE4-601_Dec19) Check Date (in house) 30-Oct-14 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 07-Oct-15 (in house check Oct-18) 15-Jun-15 (in house check Oct-18) 31-Mar-14 (in house check Oct-19) Function	Jun-21 Dec-20 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A	SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317 SN: 100972 SN: US41080477 Name	31-Mar-20 (No. 217-03104) 29-Jun-20 (No. EX3-7349_Jun20) 27-Dec-19 (No. DAE4-601_Dec19) Check Date (in house) 30-Oct-14 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 07-Oct-15 (in house check Oct-18) 15-Jun-15 (in house check Oct-18) 31-Mar-14 (in house check Oct-19) Function	Jun-21 Dec-20 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A Calibrated by:	SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317 SN: 100972 SN: US41080477 Name Jeffrey Katzman	31-Mar-20 (No. 217-03104) 29-Jun-20 (No. EX3-7349_Jun20) 27-Dec-19 (No. DAE4-601_Dec19) Check Date (in house) 30-Oct-14 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 07-Oct-15 (in house check Oct-18) 15-Jun-15 (in house check Oct-18) 31-Mar-14 (in house check Oct-19) Function Laboratory Technician	Jun-21 Dec-20 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20

Certificate No: D2450V2-920\_Aug20

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



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Schweizerischer Kallbrierdienst Service suisse d'étalonnage Servizio svizzero di taratura 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) 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%.

Certificate No: D2450V2-920\_Aug20

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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	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.9 ± 6 %	1.84 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	13.2 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.0 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
	oonanion	
SAR measured	250 mW input power	6.11 W/kg

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.5 ± 6 %	2.03 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	No.	

## SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.0 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	50.6 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL SAR measured	condition 250 mW input power	6.08 W/kg

Certificate No: D2450V2-920\_Aug20



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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	56.1 Ω + 1.9 jΩ	
Return Loss	- 24.4 dB	

#### Antenna Parameters with Body TSL

Impedance, transformed to feed point	51.8 Ω + 4.6 jΩ	
Return Loss	- 26.3 dB	

#### General Antenna Parameters and Design

Electrical Delay (one direction)	1.154 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

Certificate No: D2450V2-920\_Aug20

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

Date: 18.08.2020

Test Laboratory: SPEAG, Zurich, Switzerland

## DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:920

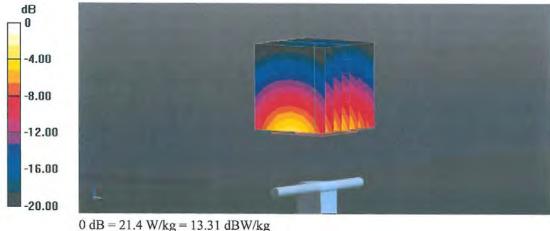
Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz;  $\sigma$  = 1.84 S/m;  $\epsilon_r$  = 38.9; p = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.74, 7.74, 7.74) @ 2450 MHz; Calibrated: 29.06.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- 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=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 114.7 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 25.5 W/kg SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.11 W/kg Smallest distance from peaks to all points 3 dB below = 9 mm Ratio of SAR at M2 to SAR at M1 = 51.5% Maximum value of SAR (measured) = 21.4 W/kg

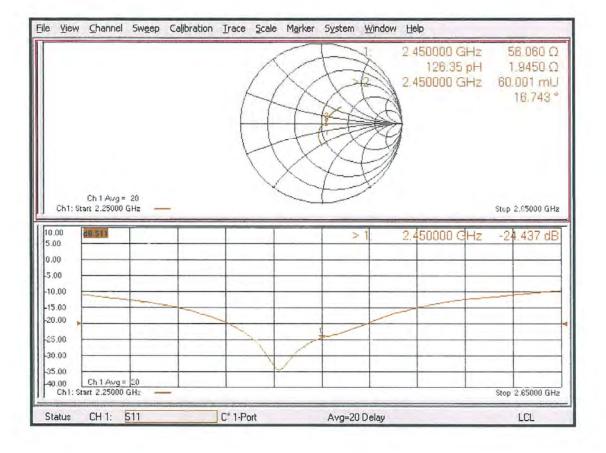


Certificate No: D2450V2-920\_Aug20

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## Impedance Measurement Plot for Head TSL



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## **DASY5 Validation Report for Body TSL**

Date: 18.08.2020

Test Laboratory: SPEAG, Zurich, Switzerland

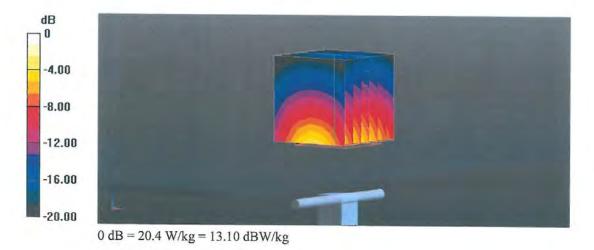
### DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:920

Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz;  $\sigma = 2.03$  S/m;  $\epsilon_r = 51.5$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.82, 7.82, 7.82) @ 2450 MHz; Calibrated: 29.06.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 107.5 V/m; Power Drift = -0.08 dB Peak SAR (extrapolated) = 24.5 W/kg SAR(1 g) = 13.0 W/kg; SAR(10 g) = 6.08 W/kg Smallest distance from peaks to all points 3 dB below = 8.9 mm Ratio of SAR at M2 to SAR at M1 = 53.8% Maximum value of SAR (measured) = 20.4 W/kg

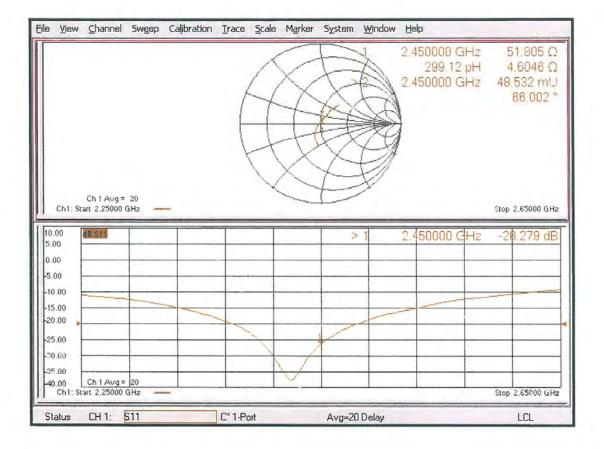


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## Impedance Measurement Plot for Body TSL



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## **APPENDIX C. – SAR Tissue Specifications**



The brain and muscle mixtures consist of a viscous gel using hydrox-ethylcellulose (HEC) gelling agent and saline solution (see Table C.1). Preservation with a bactericide is added and visual inspection is made to make sure air bubbles are not trapped during the mixing process. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. The mixture characterizations used for the brain and muscle tissue simulating liquids are according to the data by C. Gabriel and G. Harts grove.



Figure C.1 Simulated Tissue

Ingredients	Frequency (MHz)									
(% by weight)	835		1900		2450		5200 ~ 5800			
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body		
Water	40.19	50.75	55.24	70.23	71.88	73.40	65.52	80.00		
Salt (NaCl)	1.480	0.940	0.310	0.290	0.160	0.060	-	-		
Sugar	57.90	48.21	-	-	-	-	-	-		
HEC	0.250	-	-	-	-	-	-	-		
Bactericide	0.180	0.100	-	-	-	-	-	-		
Triton X-100	-	-	-	-	19.97	-	17.24	-		
DGBE	-	-	44.45	29.48	7.990	26.54	-	-		
Diethylene glycol hexyl ether	-	-	-	-	-	-	17.24	-		
Polysorbate (Tween) 80	-	-	-	-	-	-		20.00		
Target for Dielectric Constant	41.5	55.2	40.0	53.3	39.2	52.7	-	-		
Target for Conductivity (S/m)	0.90	0.97	1.40	1.52	1.80	1.95	-	-		

### Table C.1 Composition of the Tissue Equivalent Matter

Salt:	99 % Pure Sodium Chloride	Sugar:	98 % Pure Sucrose			
Water:	De-ionized, 16M resistivity	HEC:	Hydroxyethyl Cellulose			
DGBE:	99 % Di(ethylene glycol) butyl ether,[2-(2-butoxyethoxy) ethanol]					
Triton X-100(ultra pure):	Polyethylene glycol mono[4-(1,1,3,3-tetramethylbutyl)phenyl] ether					

Item	Head Tissue Simulation Liquids HSL750					
nem	Muscle (body) Tissue Simulation Liquids MSL750					
Туре No	SL AAH 075, SL AAM 075					
Manufacturer	SPEAG					
The item is composed of the following ingredients:						
H <sup>2</sup> O	Water, 35 – 58%					
Sucrose	Sucrose, 40 – 60%					
NaCl	Sodium Chloride, 0 – 6%					
Hydroxyethyl-cellulose	Medium Viscosity (CAS# 9004-62-0), < 0.3%					
Preventol-D7	Preservative: aqueous preparation, (CAS# 55965-84-9), containing 5- chloro-2-methyl-3(2H)-isothiazolone and 2-methyyl-3(2H)-isothiazolone, 0.1 – 0.6%					

## Table C.2 HSL/MSL750 (Head and Body liquids for 700 – 800 MHz)



## **APPENDIX D. – SAR SYSTEM VALIDATION**

## **SAR System Validation**

Per FCC KDB 865664 D02v01r02, SAR system validation status should be documented to confirm measurement accuracy. The SAR systems (including SAR probes, system components and software versions) used for this device were validated against its performance specifications prior to the SAR measurements. Reference dipoles were used with the required tissue- equivalent media for system validation, according to the procedures outlined in FCC KDB 865664 D01v01r04 and IEEE 1528-2013.Since SAR probe calibrations are frequency dependent, each probe calibration point was validated at a frequency within the valid frequency range of the probe calibration point, using the system that normally operates with the probe for routine SAR measurements and according to the required tissue-equivalent media.

A tabulated summary of the system validation status including the validation date(s), measurement frequencies, SAR probes and tissue dielectric parameters has been included.

SAR	Freq.	Date	Probe	Probe	Proba CAL Boint		Probe CAL. Point		PERM.	COND.		CW Validatio	on	мс	D. Validatio	n
Syster	n [MHz]	Date	SN	Туре	FIDDe C	AL. FOIII	(ɛr)	(σ)	Sensi- tivity	Probe Linearity	Probe Isortopy	MOD. Type	Duty Factor	PAR		
С	750	2020.12.07	7368	EX3DV4	750	Head	41.437	0.874	PASS	PASS	PASS	N/A	N/A	N/A		
С	835	2020.12.08	7368	EX3DV4	835	Head	41.032	0.912	PASS	PASS	PASS	GMSK	PASS	N/A		
D	1900	2020.10.21	3933	EX3DV4	1900	Head	38.602	1.366	PASS	PASS	PASS	GMSK	PASS	N/A		
D	2450	2020.10.22	3933	EX3DV4	2450	Head	38.158	1.821	PASS	PASS	PASS	OFDM/TDD	PASS	PASS		

#### Table D.1 SAR System Validation Summary

NOTE: While the probes have been calibrated for both a CW and modulated signals, all measurements were performed using communication systems calibrated for CW signals only. Modulations in the table above represent test configurations for which the measurement system has been validated per FCC KDB Publication 865664 D01v01r04 for scenarios when CW probe calibrations are used with other signal types. SAR systems were validated for modulated signals with a periodic duty cycle, such as GMSK, or with a high peak to average ratio (>5 dB), such as OFDM according to KDB 865664.



## **APPENDIX E. – Description of Test Equipment**



## E.1 SAR Measurement Setup

Measurements are performed using the DASY5 automated dosimetric assessment system. The DASY5 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, desktop computer, near-field probe, probe alignment sensor, and the generic twin phantom containing the brain equivalent material. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF) (see Fig. E.1.1).

A cell controller system contains the power supply, robot controller each pendant (Joystick), and a remote control used to drive the robot motors. The PC consists of the Intel Core i7-3 770 3.40 GHz desktop computer with Windows 7 system and SAR Measurement Software DASY5,A/D interface card, monitor, mouse, and keyboard. The Staubli Robotis connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.

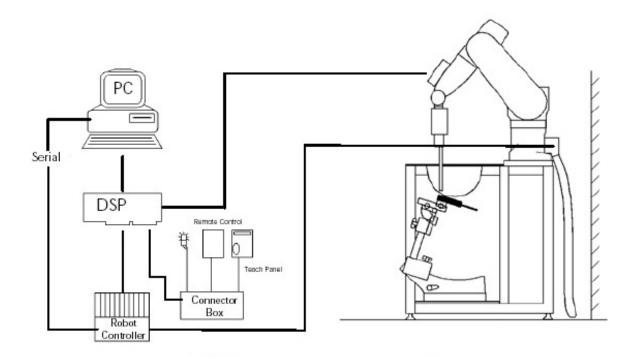


Figure E.1.1 SAR Measurement System Setup

The DAE4 consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer. The system is described in detail.

## **E.2 Probe Specification**

Frequency	10 MHz to 6 GHz					
Linearity	±0.2 dB(30 MHz to	±0.2 dB(30 MHz to 6 GHz)				
Dynamic	10 µW/g to > 100 mW/g					
Range	Linearity :	±0.2 dB				
Dimensions	Overall length :	337 mm				
Tip length	20 mm					
Body diameter	12 mm					
Tip diameter	3.9 mm					
Distance from pr	obe tip to sensor	center 1.0 mm				
Application	SAR Dosimetry To Compliance tests	esting of mobile phones				

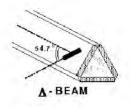


Figure E.2.1 Triangular Probe Configurations



Figure E.2.2 Probe Thick-Film Technique



DAE System

The SAR measurements were conducted with the dosimetric probe EX3DV4 designed in the classical triangular configuration(see E.2.1) and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multitier line ending at the front of the probe tip. It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY5 software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting. The approach is stopped at reaching the maximum.



#### **Dosimetric Assessment Procedure**

Each probe is calibrated according to a dosimetric assessment procedure with accuracy better than ±10%. The

spherical isotropy was evaluated with the procedure and found to be better than ±0.25 dB. The sensitivity parameters (Norm X, Norm Y, Norm Z), the diode compression parameter (DCP) and the conversion factor (Conv F) of the probe is tested.

#### Free Space Assessment

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies below 1 GHz, and in a waveguide above 1GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity at the proper orientation with the field. The probe is then rotated 360 degrees.

#### **Temperature Assessment \***

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The measured free space E-field in the medium, correlates to temperature rise in a dielectric medium. For temperature correlation calibration a RF transparent the remits or based temperature probe is used in conjunction with the E-field probe.

SAR = 
$$C\frac{\Delta T}{\Delta t}$$

where:

where:

$$\mathsf{SAR} = \frac{\left|\mathsf{E}\right|^2 \cdot \sigma}{\rho}$$

simulated tissue conductivity, σ

Tissue density (1.25 g/cm<sup>3</sup> for brain tissue) =

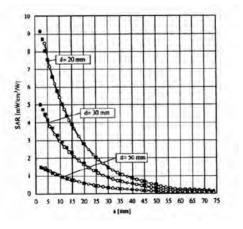
 $\Delta t$ =

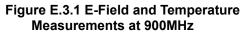
С

= heat capacity of tissue (brain or muscle),

 $\Delta T$ = temperature increase due to RF exposure.

possible to quantify the electric field in the simulated tissue by





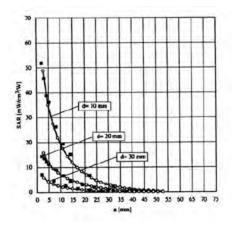


Figure E.3.2 E-Field and Temperature Measurements at 1800MHz

exposure time (30 seconds),

SAR is proportional to  $\Delta T / \Delta t$ , the initial rate of tissue heating, before thermal diffusion takes place. Now it's equating the thermally derived SAR to the E- field;



## E.4 Data Extrapolation

The DASY5 software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given like below;

$V_i = U_i + U_i^2 \cdot \frac{df}{dcp_i}$	with	$V_i$ = compensated signal of channel i $U_i$ = input signal of channel i cf = crest factor of exciting field	(i=x,y,z) (DASY parameter)
acp i		dcp <sub>i</sub> = diode compression point	(DASY parameter)

From the compensated input signals the primary field data for each channel can be evaluated:

with

E-field probes:

$$E_{i} = \sqrt{\frac{V_{i}}{Norm_{i} \cdot ConvF}}$$
Norm\_{i} = sensor sensitivity of channel i (i = x,y,z)  

$$\mu V/(V/m)^{2} \text{ for E-field probes}$$
ConvF = sensitivity of enhancement in solution  
E\_{i} = electric field strength of channel i in V/m

= compensated signal of channel i (i = x,y,z)

The RSS value of the field components gives the total field strength (Hermetian magnitude):

$$E_{tot} = \sqrt{E_{x}^{2} + E_{y}^{2} + E_{z}^{2}}$$

The primary field data are used to calculate the derived field units.

$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$	with		<ul> <li>= local specific absorption rate in W/g</li> <li>= total field strength in V/m</li> <li>= conductivity in [mho/m] or [Siemens/m]</li> </ul>
		•	
		ρ	= equivalent tissue density in g/cm <sup>3</sup>

The power flow density is calculated assuming the excitation field to be a free space field.

$P_{pur} = \frac{E_{tot}^2}{3770}$	with		<ul> <li>= equivalent power density of a plane wave in W/cm<sup>2</sup></li> <li>= total electric field strength in V/m</li> </ul>
1 pur = 3770		Etot	= total electric field strength in V/m



## E.5 SAM Twin Phantom

The SAM Twin Phantom V5.0 is constructed of a fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents the evaporation of the liquid.

Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. (see Fig. E.5.1)

## SAM Twin Phantom Specification:



Figure E.5.1 SAM Twin Phantom

Construction	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin
	(SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation
	of left and right hand phone usage as well as body mounted usage at the flat phantom region.
	A cover prevents evaporation of the liquid. Reference markings on the phantom allow the
	complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.
	Twin SAM V5.0 has the same shell geometry and is manufactured from the same material
	as Twin SAM V4.0, but has reinforced top structure.
Shell Thickness	(2 ± 0.2) mm
Filling Volume	Approx. 25 liters
Dimensions	Length: 1000 mm
	Width: 500 mm
	Height: adjustable feet

## Specific Anthropomorphic Mannequin (SAM) Specifications:

The phantom for handset SAR assessment testing is a low-loss dielectric shell, with shape and dimensions derived from the anthropometric data of the 90th percentile adult male head dimensions as tabulated by the US Army. The SAM Twin Phantom shell is bisected along the mid-sagittal plane into right and left halves (see Fig. E.5.2). The perimeter sidewalls of each phantom halves are extended to allow filling with liquid to a depth that is sufficient to minimized reflections from the upper surface. The liquid depth is maintained at a minimum depth of 15cm to minimize reflections from the upper surface.



Figure E.5.2 Sam Twin Phantom shell



## E.6 Device Holder for Transmitters

In combination with the Twin SAM Phantom V4.0/V4.0c, V5.0 or ELI4, the Mounting Device enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to IEC, IEEE, FCC or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).

Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produce infinite number of configurations. To produce the warst case, condition (the hand absorb, antenna autout power), the hand is emitted

worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

Figure E.6.1 Mounting Device



## E.7 Automated Test System Specifications

## **Positioner**

Robot Repeatability No. of axis	Stäubli Unimation Corp. Robot Model: TX90XL 0.02 mm 6			
Data Acquisition Electro	onic (DAE) System			
<u>Cell Controller</u> Processor Clock Speed Operating System Data Card	Intel Core i7-3770 3.40 GHz Windows 7 Professional DASY5 PC-Board			
<u>Data Converter</u> Features Software Connecting Lines	Signal, multiplexer, A/D converter. & control logic DASY5 Optical downlink for data and status info Optical uplink for commands and clock			
<u>PC Interface Card</u> Function	24 bit (64 MHz) DSP for real time processing Link to DAE 4 16 bit A/D converter for surface detection system serial link to robot direct emergency stop output for robot			
<u>E-Field Probes</u> Model Construction Frequency Linearity	EX3DV4 S/N: 3933, 7368 Triangular core fiber optic detection system 10 MHz to 6 GHz ±0.2 dB (30 MHz to 6 GHz)			
<u>Phantom</u> Phantom Shell Material Thickness	SAM Twin Phantom (V5.0) Composite (2.0 ± 0.2) mm			



Figure E.7.1 DASY5 Test System