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





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Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates Accreditation No.: SCS 0108

Client PC Test		C	ertilicate No: D19D0V2-5d030_Jun19
CALIBRATION C	ERNIEIGANE		
Dbjeot	D1900V2 - SN:50	1030	/ ATH 6128/19
Cailbration procedure(s)	QA CAL-05.v11 Calibration Proce	dure for SAR Validation	(7.3)/// Sources between 0.7-3 GHz
Calibration date:	June 19, 2019		AIM 7/3/20
This calibration certificate documer The measurements and the uncert	nts the traceability to nati aintles with confidence p	onal standards, which realize the robability are given on the follow	e physical units of measurements (SI). Ing pages and are part of the certificate.
All calibrations have been conducte Calibration Equipment used (M&TE		ry facility: environment temperate	ure (22 $\pm$ 3)°C and humidity < 70%. 7/10/202
Primary Standards	1D#	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	03-Apr-19 (No. 217-02892/02	893) Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probe EX3DV4	SN: 7349	29-May-19 (No. EX3-7349_M	av19) May-20
DAE4	SN: 601	30-Apr-19 (No. DAE4-601_Ap	
Secondary Standards	ID #	Check Date (In house)	Scheduled Check
Power meter E4419B	SN: GB39512476	30-Oct-14 (in house check Fe	eb-19) In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check O	ol-18) In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check O	ct-18) In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check O	ct-18) In house check: Oct-20
Network Analyzer Agllent E8358A	SN: US41080477	31-Mar-14 (in house check O	ct-18) In house check: Oct-19
Calibrated by:	Name Claudic Leubler	Function Laboratory Techi	nician:
Approved by:	Kalja Pokovic	Technical Manag	jer (1997)
Appiovea by.			Al 45

#### **Calibration Laboratory of**

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





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#### Glossarv:

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. 6 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%.

Accreditation No.: SCS 0108

#### **Measurement Conditions**

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

DASY Version	DASY5	V52.10.2
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	41.4 ± 6 %	1.39 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	9.85 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	39.9 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	5.19 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	20.9 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	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.2 ± 6 %	1.50 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	9.86 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.9 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.24 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.1 W/kg ± 16.5 % (k=2)

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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.0 Ω + 4.2 jΩ
Return Loss	- 27.6 dB

#### Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.0 Ω + 5.4 jΩ
Return Loss	- 24.0 dB

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

Electrical Delay (one direction)	1.191 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

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

Date: 19.06.2019

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d030

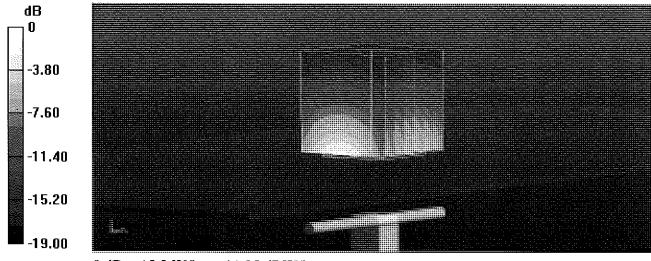
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz;  $\sigma = 1.39$  S/m;  $\varepsilon_r = 41.4$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

#### DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.44, 8.44, 8.44) @ 1900 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

#### 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 = 109.2 V/m; Power Drift = 0.03 dB Peak SAR (extrapolated) = 18.2 W/kg SAR(1 g) = 9.85 W/kg; SAR(10 g) = 5.19 W/kg Maximum value of SAR (measured) = 15.3 W/kg



## Impedance Measurement Plot for Head TSL

<u>File Vie</u> i	w <u>C</u> hannel	Sw <u>e</u> ep C	alibration	<u>T</u> race <u>S</u> cale	e M <u>a</u> rker	System	<u>W</u> indow	<u>H</u> elp		
	Ch 1 Avg =	20		A	XXX		A	1.900000 GH 351.42 pt 1.900000 GH	H 4 Iz 41.	0.050 Ω .1953 Ω 898 mU 86.911 °
Ch1:	Start 1.70000	GHz							Stop ;	2.10000 GHz
10.00 5.00	dB S11					> `	1.	1.900000 GH	lz -2	7.556 dB
5.00 0.00						> `		1.900000 GH	.z -27	'.556 dB
5.00								1.900000 GH	z -27	'.556 dB
5.00 0.00 -5.00 -10.00 -15.00								1.900000 CH	z -2	'.556 dB
5.00 0.00 -5.00 -10.00 -15.00 -20.00	B					> <sup>·</sup>		1.900000 GH	z -27	'.556 dB
5.00 0.00 -5.00 -10.00 -15.00	B							1.900000 GH	z -27	<u>2.556 dB</u>
5.00 0.00 -5.00 -10.00 -15.00 -20.00 -25.00 -30.00 -35.00	B					>			z -27	'.556 dB
5.00 0.00 -5.00 -15.00 -20.00 -25.00 -30.00 -35.00 -40.00	Image: Start         Image: Start<	20 GHz				> '				2.10000 GHz

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

Date: 19.06.2019

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d030

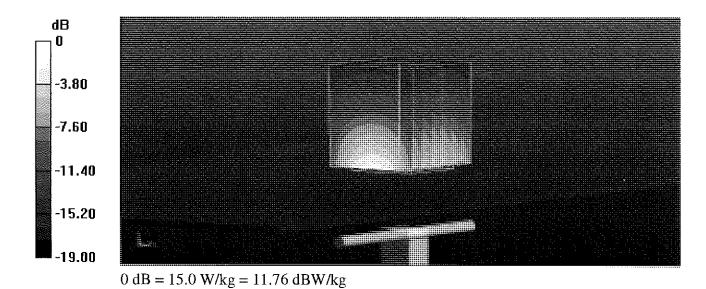
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz;  $\sigma$  = 1.5 S/m;  $\epsilon_r$  = 54.2;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.42, 8.42, 8.42) @ 1900 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 104.1 V/m; Power Drift = -0.06 dB Peak SAR (extrapolated) = 17.6 W/kg SAR(1 g) = 9.86 W/kg; SAR(10 g) = 5.24 W/kg Maximum value of SAR (measured) = 15.0 W/kg



## Impedance Measurement Plot for Body TSL

Eile 1	<u>View C</u> hannel	Sw <u>e</u> ep C	alibration <u>T</u> ra	ce <u>S</u> cale M	arker S <u>y</u> stem	<u>W</u> indow	<u>H</u> elp		
					THE REAL PROPERTY IN THE REAL PROPERTY INTO THE REA	À	.900000 GH 448.94 p .900000 GH	iH 5. Hz 83.1	7.009 Ω 3594 Ω 169 mU 116.00 °
Ŭ	Ch 1 Avg ≃ Ch 1: Start 1.70000	20 GHz		~				Stop 2	10000 GHz
T in the second s									
19.00 5.00					>		.900000 GH	lz -2\$	.990 dB
5.00 0.00					>		.900000 GH	lz -23	.990 dB
5.00					>		.900000 GH	lz -23	.990 dB
5.00 0.00 -5.00 -10.0 -15.0					>		.900000 GH	lz -23	.990 dB
5.00 0.00 -5.00 -10.0 -15.0 -15.0							.900000 GH	lz -23	.990 dB
5.00 0.00 -5.00 -10.0 -15.0					>		.900000 GH	lz -23	.990 dB
5.00 0.00 -5.00 -10.0 -15.0 -25.0 -25.0 -30.0 -35.0								lz -23	.990 dB
5.00 0.00 -5.00 -10.0 -15.0 -20.0 -25.0 -25.0 -30.0 -35.0 -40.0		20 GHz							10000 GHz





# **Certification of Calibration**

Object

D1900V2 - SN: 5d030

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

June 19, 2020

Extended Calibration date:

Description:

SAR Validation Dipole at 1900 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	1/16/2020	Annual	1/16/2021	US39170118
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	MA2411B	Pulse Power Sensor	1/21/2020	Annual	1/21/2021	1207470
Anritsu	MA2411B	Pulse Power Sensor	1/21/2020	Annual	1/21/2021	1339007
Anritsu	ML2495A	Power Meter	1/15/2020	Annual	1/15/2021	1328004
Control Company	62344-734	Therm./ Clock/ Humidity Monitor	3/18/2019	Biennial	3/18/2021	192038436
Control Company	4352	Ultra Long Stem Thermometer	8/2/2018	Biennial	8/2/2020	181292000
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Seekonk	NC-100	Torque Wrench	7/18/2019	Annual	7/18/2020	N/A
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/14/2020	Annual	1/14/2021	793
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2020	Annual	5/12/2021	1070
SPEAG	EX3DV4	SAR Probe	1/20/2020	Annual	1/20/2021	3837

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Managing Director	ROK

# **DIPOLE CALIBRATION EXTENSION**

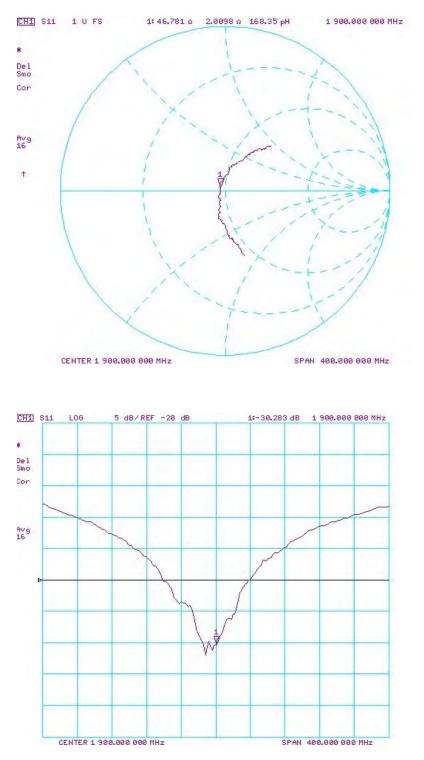
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than  $5\Omega$  from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

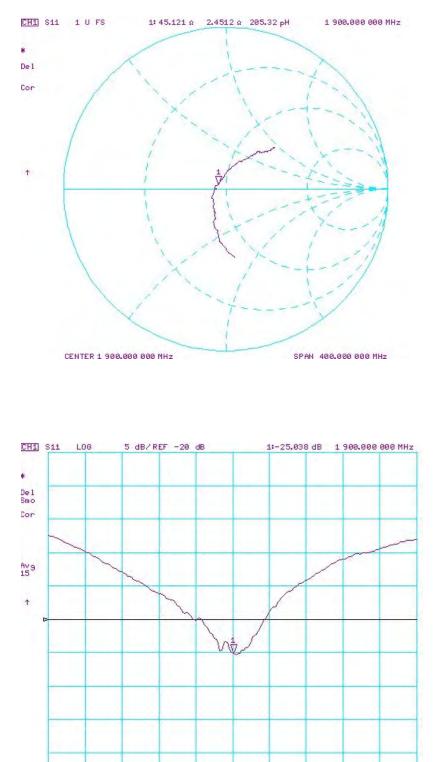
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	(%)	W/kg @ 20.0 dBm	(10g) W/kg @ 20.0 dBm		Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Head (dB)	Deviation (%)	
6/19/2019	6/19/2020	1.191	3.99	4.3	7.77%	2.09	2.2	5.26%	50	46.8	3.2	4.2	2	2.2	-27.6	-30.3	-9.80%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Body SAR (1g) W/kg @ 20.0 dBm	(0/)		(40-) Million (2)	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
6/19/2019	6/19/2020	1.191	3.99	4.29	7.52%	2.11	2.2	4.27%	47	45.1	1.9	5.4	2.5	2.9	-24	-25	-4.20%	PASS

Object:	Date Issued:	Page 2 of 4
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#### Impedance & Return-Loss Measurement Plot for Head TSL

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CENTER 1 900.000 000 MHz

#### Impedance & Return-Loss Measurement Plot for Body TSL

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D1900V2 – SN: 5d030	6/19/2020	Page 4 of 4

SPAN 400.000 000 MHz





# **Certification of Calibration**

Object

D1900V2 - SN: 5d030

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

June 19, 2021

Extended Calibration date:

Description:

SAR Validation Dipole at 1900 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	4/14/2021	Annual	4/14/2022	US39170118
Agilent	N5182A	MXG Vector Signal Generator	12/1/2020	Annual	12/1/2021	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	MA2411B	Pulse Power Sensor	3/9/2021	Annual	3/9/2022	1207470
Anritsu	MA2411B	Pulse Power Sensor	3/8/2021	Annual	3/8/2022	1339007
Anritsu	ML2495A	Power Meter	3/4/2021	Annual	3/4/2022	1328004
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670635
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291463
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	9/1/2020	Annual	9/1/2021	MY53401181
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Seekonk	NC-100	Torque Wrench	7/30/2020	Biennial	7/30/2022	22217
SPEAG	DAE4	Dasy Data Acquisition Electronics	10/12/2020	Annual	10/12/2021	1213
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/13/2021	Annual	1/13/2022	793
SPEAG	EX3DV4	SAR Probe	10/21/2020	Annual	10/21/2021	7420
SPEAG	EX3DV4	SAR Probe	1/18/2021	Annual	1/18/2022	3837
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2021	Annual	5/12/2022	1070

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Managing Director	ROK

Object:	Date Issued:	Page 1 of 4
D1900V2 – SN: 5d030	6/19/2021	raye i 014

# **DIPOLE CALIBRATION EXTENSION**

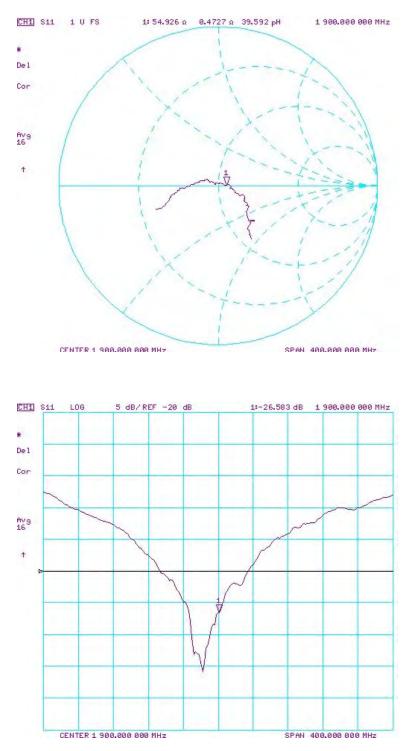
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than  $5\Omega$  from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

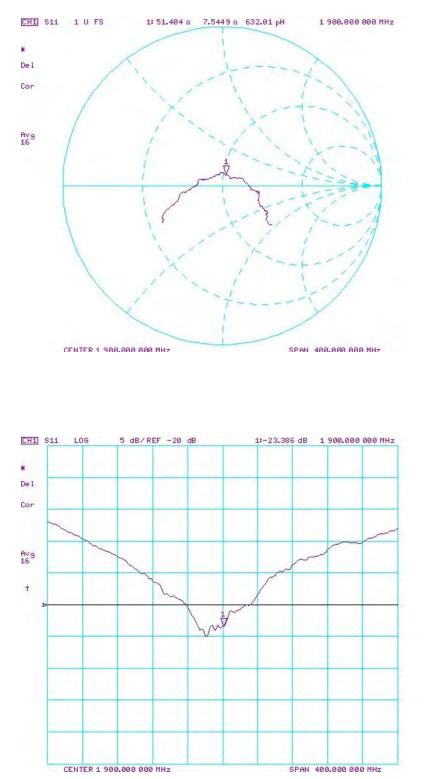
Date	Extension Date	Certificate Electrical Delay (ns)	Head (19) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	(%)	Head (10g) W/kg @ 20.0 dBm	(10g) W/kg @ 20.0 dBm		Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Head (dB)	Deviation (%)	
6/19/2019	6/19/2021	1.191	3.99	4.09	2.51%	2.09	2.08	-0.48%	50	54.9	4.9	4.2	0.5	3.7	-27.6	-26.6	3.70%	PASS
Date	Extension Date	Certificate Electrical Delay (ns)	W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	(%)	W/kg @ 20.0 dBm	20.0 dBm		Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Body (dB)	Deviation (%)	
6/19/2019	6/19/2021	1.191	3.99	4.11	3.01%	2.11	2.11	0.00%	47	51.4	4.4	5.4	7.5	2.1	-24	-23.4	2.60%	PASS

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D1900V2 – SN: 5d030	6/19/2021	raye 2 014



Impedance & Return-Loss Measurement Plot for Head TSL

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#### Impedance & Return-Loss Measurement Plot for Body TSL

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D1900V2 – SN: 5d030	6/19/2021	Page 4 of 4	

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





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S Schweizerischer Kalibrierdienst

C 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

Certificate No: D1900V2-5d148\_Feb19

Client	PCTest
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Object     ID1900V2 - SN:561448       Calibration procedure(s)     QA CAL-05 v11 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz (5-6/14)       Calibration date:     February 21, 2019       This calibration certificate documents the traceability to national standards, which resize the physical units of measurements (S).     D2-26       The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.     BW Q2-25       All calibration certificate documents the traceability to national standards, which resize the physical units of measurements (S).     D2-26       The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.     BW Q2-25       All calibration Equipment used (M&TE critical for calibration)     BW Q2-25       Primary Standards     ID #     Cal Date (Certificate No.)     Scheduled Calibration       Prower meler NFIP-P     SN: 103245     04-Apr+18 (No. 217-02727(2677)     Apr-19       Power ensory NFP-291     SN: 103245     04-Apr+18 (No. 217-02727)     Apr-19       Power ensory NFP-291     SN: 103245     04-Apr+18 (No. 217-0272)     Apr-19       Power ensory NFP-291     SN: 103245     04-Apr+18 (No. 217-0272)     Apr-19       Power ensory NFP-291     SN: 103245     04-Apr+18 (No. 217-0272)     Apr-19       Power sensory NFP-291     SN: 10372     04-Apr+18 (No. 217-0273)	CALIBE AND ONEC	ERIFICAT			
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz         Calibration date:       February 21, 2019         This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (S).       BNV         This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (S).       BNV         All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)*C and humidity < 70%.       BNV         Calibration Equipment used (M&TE critical for calibration)       Primary Standards       ID #       Cal Date (Certificate No.)       Scheduled Calibration         Power sensor NRP-291       SN: 103244       04-Apr-18 (No. 217-02672)       Apr-19         Power sensor NRP-291       SN: 103244       04-Apr-18 (No. 217-02672)       Apr-19         Power sensor NRP-291       SN: 103244       04-Apr-18 (No. 217-02672)       Apr-19         Power sensor NRP-291       SN: 103245       04-Apr-18 (No. 217-02672)       Apr-19         Power sensor NRP-291       SN: 5037.2 / 0827       04-Apr-19 (No. 217-02672)       Apr-19         Reference Probe EX3DV4       SN: 5037.2 / 0827       04-Apr-19 (No. 217-02672)       Apr-19         SN: 601       04-Oct-18 (No. D27-02673)       Apr-19       Dec-19       Dec-19         Data       Dit	Object	D1900V2 - SN:5	d148		
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Type-N mismatch combination       SN: 5047.2 / 06327       04-Apr-18 (No. 217-02683)       Apr-19         Reference Probe EX3DV4       SN: 7349       31-Dec-18 (No. EX3-7349_Dec18)       Dec-19         DAE4       SN: 601       04-Oct-18 (No. DAE4-601_Oct18)       Dec-19         Secondary Standards       ID #       Check Date (in house)       Scheduled Check         Power meter E4419B       SN: GB39512475       07-Oct-15 (in house check Feb-19)       In house check: Oct-20         Power sensor HP 8481A       SN: US37292783       07-Oct-15 (in house check Oct-18)       In house check: Oct-20         Power sensor HP 8481A       SN: 100372       15-Jun-15 (in house check Oct-18)       In house check: Oct-20         SN: 100972       15-Jun-15 (in house check Oct-18)       In house check: Oct-20       SN: W741092317         SN: 100972       15-Jun-15 (in house check Oct-18)       In house check: Oct-20         SN: 100972       15-Jun-15 (in house check Oct-18)       In house check: Oct-19         SN: Warne       Function       Signature         Calibrated by:       Mame       Function       Signature         Approved by:       Kalja Pokovic       Technical Manager       Mature         Issued: February 21, 2019       Issued: February 21, 2019       Issued: February 21, 2019	Reference 20 dB Attenuator	SN: 5058 (20k)	,		
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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

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
IOL	<b>U</b>
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%.

Accreditation No.: SCS 0108

#### **Measurement Conditions**

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

DASY Version	DASY5	V52.10.2
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 %	1.38 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	9.65 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	39.1 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	5.05 W/kg

#### **Body TSL parameters**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.6 ± 6 %	1.47 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	9.56 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.1 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.05 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.5 W/kg ± 16.5 % (k=2)

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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.8 Ω + 6.8 jΩ
Return Loss	- 23.2 dB

#### Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.4 Ω + 7.8 jΩ
Return Loss	- 21.9 dB

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

Electrical Delay (one direction)	
	1.170 ns
	1370115

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
	JEAG

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

Date: 21.02.2019

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d148

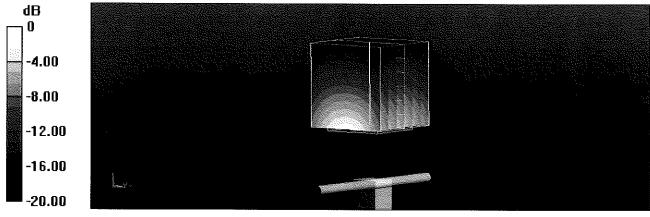
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz;  $\sigma = 1.38$  S/m;  $\varepsilon_r = 40.9$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

#### DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.26, 8.26, 8.26) @ 1900 MHz; Calibrated: 31.12.2018
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 109.4 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 17.8 W/kg **SAR(1 g) = 9.65 W/kg; SAR(10 g) = 5.05 W/kg** Maximum value of SAR (measured) = 15.0 W/kg



0 dB = 15.0 W/kg = 11.76 dBW/kg

# Impedance Measurement Plot for Head TSL

<u>File Viev</u>	v <u>C</u> hannel Sw <u>e</u> e	ep Calibration <u>T</u> r	ace <u>S</u> cale M <u>a</u> r	'ker S <u>y</u> stem <u>Wi</u> ni	dow Help	
Ch1::	Ch 1 Awg = 20 Start 1.70000 GHz				1.900000 GHz 573.82 pH 1.900000 GHz	51.822 Ω 6.8503 Ω 69.458 mU 71.260 °
10.00 5.00 -5.00 -10.00 -15.00 -20.00 -25.00 -30.00 -35.00 -40.00 Ch1: 5	Ch 1 Avg = 20 3tart 1.70000 GHz				1.900000 GHz	-23.166 dB
Status	CH 1: <u>811</u>	C*-	1-Port	Avg=20 Delay		Stop 2.10000 GHz

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

Date: 21.02.2019

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d148

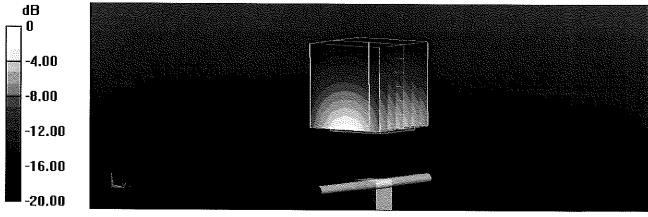
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz;  $\sigma = 1.47$  S/m;  $\epsilon_r = 53.6$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.23, 8.23, 8.23) @ 1900 MHz; Calibrated: 31.12.2018
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 103.7 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 17.0 W/kg SAR(1 g) = 9.56 W/kg; SAR(10 g) = 5.05 W/kg Maximum value of SAR (measured) = 14.4 W/kg



0 dB = 14.4 W/kg = 11.58 dBW/kg

## Impedance Measurement Plot for Body TSL

File	View	<u>C</u> hannel	Sweep	Calibration	<u>Trace</u> <u>S</u> c.	ale M <u>a</u> rker	System	Window	Help			
		Ch1Avg=				XXX			1.900000 G 652.32 1.900000 G	pН	48.446 Ω 7.7874 Ω 80.412 mU 96.762 °	
		rt 1.70000 (					-4			S	top 2,10000 GHz	
10.0	no 16	THE REAL PROPERTY OF THE PROPERTY OF THE REAL PROPE	7			Contraction of the second s		The second se	The second s			
5.0 0.0 -5.0 -10. -15. -20. -25. -30. -35. -40. (		Ch 1 Awg = rt 1.70000 c	20 3Hz								-21.894 dB	





# **Certification of Calibration**

Object

D1900V2 - SN: 5d148

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

2/21/2020

Extension Calibration date:

Description:

SAR Validation Dipole at 1900 MHz.

#### Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291470
Control Company	4352	Ultra Long Stem Thermometer	8/2/2018	Biennial	8/2/2020	181334684
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/11/2019	Annual	10/11/2020	101307
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAKS-3.5	Portable DAK	9/10/2019	Annual	9/10/2020	1045
Anritsu	MA2411B	Pulse Power Sensor	8/14/2019	Annual	8/14/2020	1315051
Anritsu	MA2411B	Pulse Power Sensor	8/8/2019	Annual	8/8/2020	1339008
Anritsu	ML2495A	Power Meter	12/17/2019	Annual	12/17/2020	941001
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837
Seekonk	NC-100	Torque Wrench	5/9/2018	Biennial	5/9/2020	22217
MiniCircuits	ZHDC-16-63-S+	Bidirectional Coupler	CBT	N/A	CBT	N/A
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
SPEAG	EX3DV4	SAR Probe	9/19/2019	Annual	9/19/2020	7551
SPEAG	EX3DV4	SAR Probe	7/16/2019	Annual	7/16/2020	7410
SPEAG	DAE4	Dasy Data Acquisition Electronics	9/17/2019	Annual	9/17/2020	1333
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/11/2019	Annual	7/11/2020	1322

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Test Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	XOK

Object:	Date Issued:	Page 1 of 4
D1900V2 – SN: 5d148	02/21/2020	Fage 1014

# **DIPOLE CALIBRATION EXTENSION**

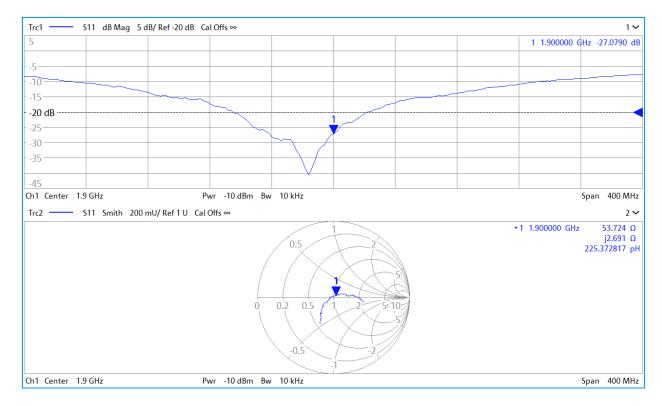
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than  $5\Omega$  from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	(0/)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	(40-) 10/0	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
2/21/2019	2/21/2020	1.17	3.91	4.15	6.14%	2.04	2.13	4.41%	51.8	53.7	1.9	6.8	2.7	4.1	-23.2	-27.1	-16.70%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	(0/)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	(40-) 10/0	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
2/21/2019	2/21/2020	1.17	3.91	4.06	3.84%	2.05	2.08	1.46%	48.4	50.9	2.5	7.8	5.4	2.4	-21.9	-25.3	-15.60%	PASS

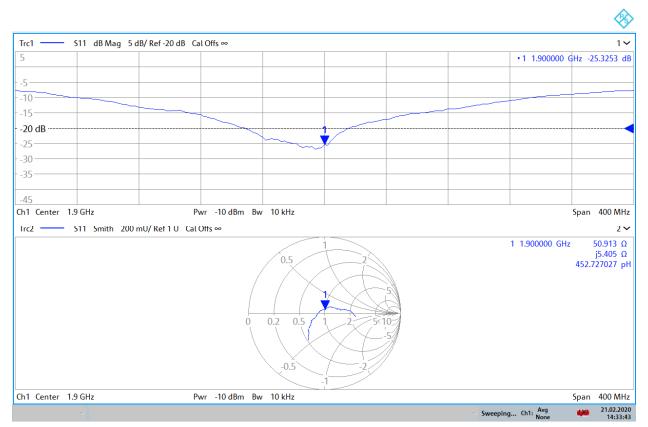
Object:	Date Issued:	Page 2 of 4
D1900V2 – SN: 5d148	02/21/2020	raye 2 01 4



#### Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Daga 2 of 4
D1900V2 – SN: 5d148	02/21/2020	Page 3 of 4

#### Impedance & Return-Loss Measurement Plot for Body TSL



14:33:44 21.02.2020

Object:	Date Issued:	Page 4 of 4
D1900V2 – SN: 5d148	02/21/2020	Fage 4 01 4





# **Certification of Calibration**

Object

D1900V2 - SN: 5d148

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

2/21/2021

Extension Calibration date:

Description:

SAR Validation Dipole at 1900 MHz.

#### Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291470
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670623
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Agilent	85033E	3.5mm Standard Calibration Kit	6/6/2020	Annual	6/6/2021	MY53402352
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	9/29/2020	Annual	9/29/2021	101307
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2020	Annual	5/12/2021	1070
Anritsu	MA2411B	Pulse Power Sensor	8/12/2020	Annual	8/12/2021	1207364
Anritsu	MA2411B	Pulse Power Sensor	9/22/2020	Annual	9/22/2021	1315051
Anritsu	ML2495A	Power Meter	11/3/2020	Annual	11/3/2021	1039008
Anritsu	ML2495A	Power Meter	1/18/2021	Annual	1/18/2022	941001
Agilent	N5182A	MXG Vector Signal Generator	5/13/2020	Annual	5/13/2021	MY47420603
Pasternack	NC-100	Torque Wrench	8/4/2020	Biennial	8/4/2022	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
MiniCircuits	ZHDC-16-63-S+	Bidirectional Coupler	CBT	N/A	CBT	N/A
SPEAG	EX3DV4	SAR Probe	7/31/2020	Annual	7/31/2021	7308
SPEAG	EX3DV4	SAR Probe	12/15/2020	Annual	12/15/2021	7570
SPEAG	DAE4	Dasy Data Acquisition Electronics	12/7/2020	Annual	12/7/2021	859
SPEAG	DAE4	Dasy Data Acquisition Electronics	8/11/2020	Annual	8/11/2021	1450

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Test Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	ROK

Object:	Date Issued:	Dogo 1 of 4
D1900V2 – SN: 5d148	2/21/2021	Page 1 of 4

# **DIPOLE CALIBRATION EXTENSION**

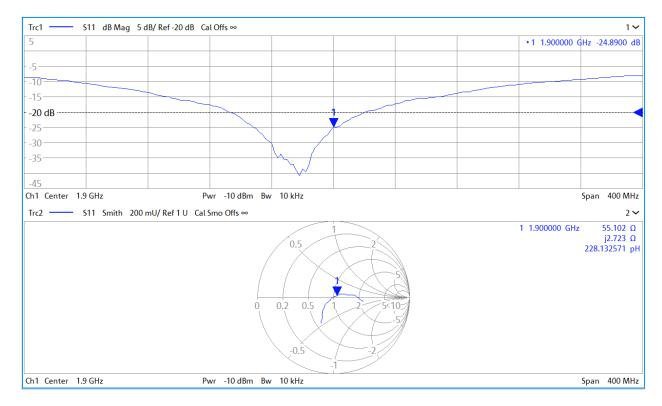
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than  $5\Omega$  from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

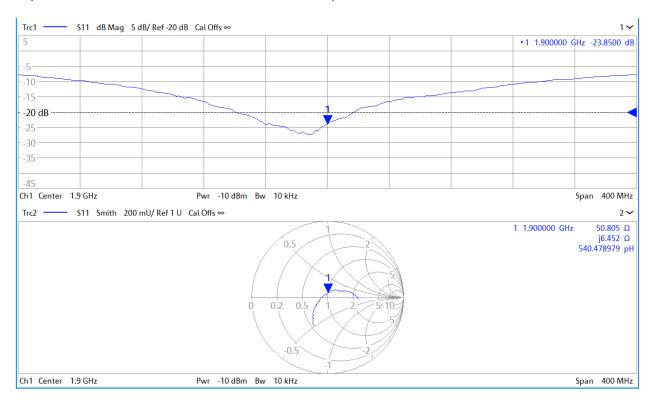
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Head SAR (1g) W/kg @ 20.0 dBm		Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	(10a) W/ka @	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
2/21/2019	2/21/2021	1.17	3.91	3.85	-1.53%	2.04	1.96	-3.92%	51.8	55.1	3.2	6.8	2.7	4.1	-23.2	-24.9	-7.30%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
2/21/2019	2/21/2021	1.17	3.91	4.07	4.09%	2.05	2.1	2.44%	48.4	50.8	2.4	7.8	6.5	1.3	-21.9	-23.9	-8.90%	PASS

Object:	Date Issued:	Page 2 of 4
D1900V2 – SN: 5d148	2/21/2021	Fage 2 01 4



#### Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Page 3 of 4
D1900V2 – SN: 5d148	2/21/2021	Fage 5 01 4



#### Impedance & Return-Loss Measurement Plot for Body TSL

Object:	Date Issued:	Page 4 of 4
D1900V2 – SN: 5d148	2/21/2021	Fage 4 01 4

### **Calibration Laboratory of**

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

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

#### Service suisse d'étalonnage С Servizio svizzero di taratura S

Schweizerischer Kalibrierdienst

Swiss Calibration Service

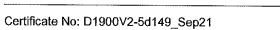
S

### Accreditation No.: SCS 0108

Certificate No: D1900V2-5d149\_Sep21

Client PC Test
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CALIBRATION C	ERTIFICATE		
Object	D1900V2 - SN:50	1149	
Calibration procedure(s)			
	Cendigran Frau	al e di 245 vensior 30005	i Litierstan II. ( 63 saitie
Calibration date:	September 21, 20	021	
		onal standards, which realize the physical un	
The measurements and the uncerta	ainties with confidence pr	obability are given on the following pages ar	nd are part of the certificate.
All calibrations have been conducte	ed in the closed laborator	y 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-Z91	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. 217-0 <b>3</b> 344)	Арг-22
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:	Leif Klysner	Laboratory Technician	Sel Man
Approved by:	Katja Pokovic	Technical Manager	all
This calibration certificate shall not	be reproduced except in	full without written approval of the laboratory	Issued: September 21, 2021



### **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

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%.

#### **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	10.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	40.5 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	5.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	21.2 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	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.9 ± 6 %	1.50 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	44 Jan 100, 600	

#### 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	10.0 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	40.4 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.25 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.1 W/kg ± 16.5 % (k=2)

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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.6 Ω + 6.6 jΩ
Return Loss	- 23.3 dB

#### Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.2 Ω + 6.9 jΩ
Return Loss	- 22.8 dB

#### General Antenna Parameters and Design

Electrical Delay (one direction) 1.197 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	

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

Date: 21.09.2021

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d149

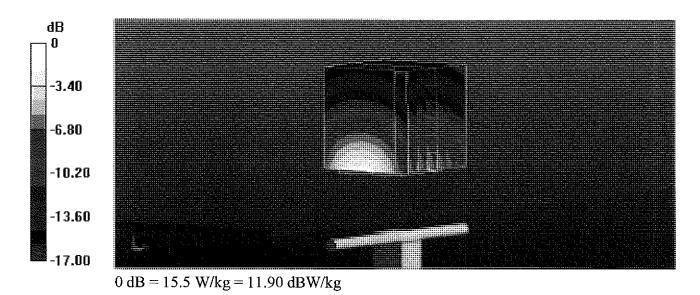
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz;  $\sigma = 1.4$  S/m;  $\epsilon_r = 40.4$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

#### DASY52 Configuration:

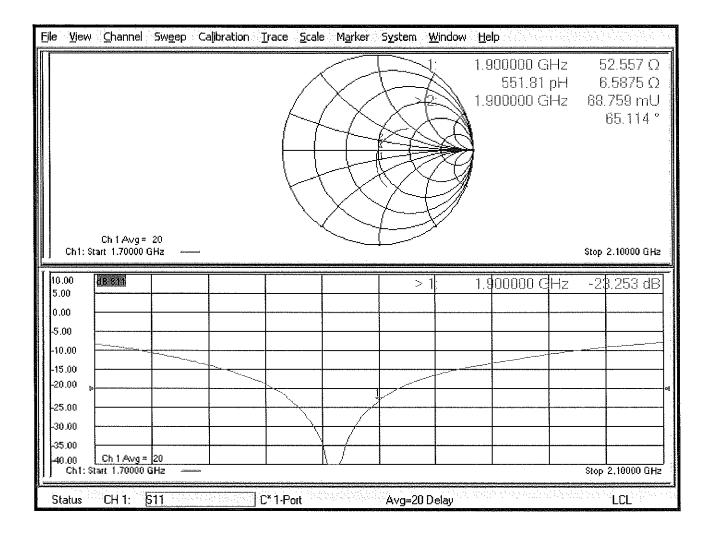
- Probe: EX3DV4 SN7349; ConvF(8.43, 8.43, 8.43) @ 1900 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 110.8 V/m; Power Drift = 0.02 dB Peak SAR (extrapolated) = 18.7 W/kg SAR(1 g) = 10.1 W/kg; SAR(10 g) = 5.29 W/kg Smallest distance from peaks to all points 3 dB below = 10 mm Ratio of SAR at M2 to SAR at M1 = 55.1% Maximum value of SAR (measured) = 15.5 W/kg



### Impedance Measurement Plot for Head TSL



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

Date: 21.09.2021

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d149

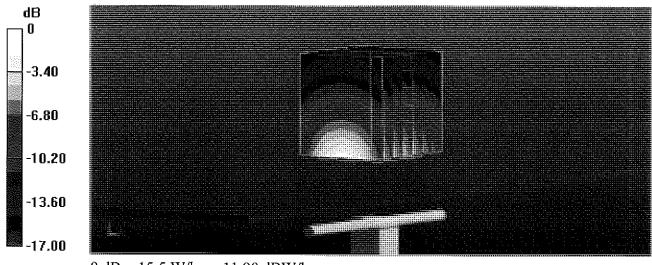
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz;  $\sigma = 1.5$  S/m;  $\epsilon_r = 53.9$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

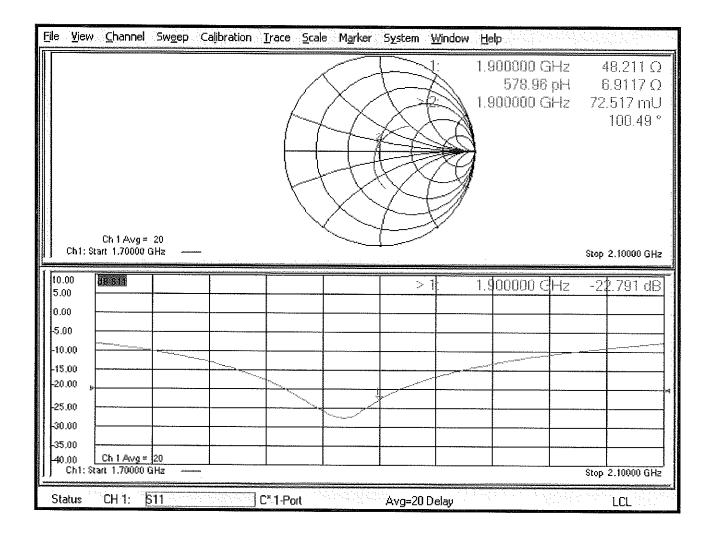
- Probe: EX3DV4 SN7349; ConvF(8.42, 8.42, 8.42) @ 1900 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 105.7 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 18.5 W/kg **SAR(1 g) = 10 W/kg; SAR(10 g) = 5.25 W/kg** Smallest distance from peaks to all points 3 dB below = 9 mm Ratio of SAR at M2 to SAR at M1 = 55.1% Maximum value of SAR (measured) = 15.5 W/kg



### Impedance Measurement Plot for Body TSL



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



S Schweizerischer Kallbrierdienst Service eulese d'étalonnage Servizio svizzero di taratura S swiss Calibration Service

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Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates Accreditation No.: SCS 0108

Cartificate No: D2450V2-750 Jun19 Client PC Test CALIBRATION CERTIFICATE D2450V2 - SN:750 Object 6128119 @A CAL-05.v11 Calibration procedure(s) Calibration Procedure for SAR Validation Sources between 0.7-3 G Calibration date: June 14, 2019 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, 7/10/2021 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 1D # Cal Date (Certificate No.) Scheduled Calibration SN: 104778 Power meter NRP 03-Apr-19 (No. 217-02892/02893) Apr-20 Power sensor NRP-Z91 SN: 103244 03-Apr-19 (No. 217-02892) Apr-20 Power sensor NRP-Z91 SN: 103245 03-Apr-19 (No. 217-02893) Apr-20 Reference 20 dB Attenuator SN: 5058 (20k) 04-Apr-19 (No. 217-02894) Apr-20 Type-N mismatch combination SN: 5047,2 / 06327 04-Apr-19 (No. 217-02895) Apr-20 May-20 **Reference Probe EX3DV4** SN: 7349 29-May-19 (No. EX3-7349\_May19) SN: 601 DAE4 30-Apr-19 (No. DAE4-801\_Apr19) Apr-20 Secondary Standards ID # Check Date (in house) Scheduled Check Power meter E4419B SN: GB39512475 30-Oct-14 (in house check Feb-19) In house check: Oct-20 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-20 Power sensor HP 8481A SN: MY41092317 07-Oct-15 (In house check Oct-18) In house check; Oct-20 RF generator R&S SMT-06 SN: 100972 15-Jun-15 (In house check Oct-18) In house check: Oct-20 SN: US41080477 Network Analyzer Aglient E8358A 31-Mar-14 (In house check Ocl-18) In house check: Oct-19 Name Function Signature Calibrated by: Michael Weber Laboratory Technician Approved by: Kalla Pokovic Technical Manager issued; June 20, 2019

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

### **Calibration Laboratory of**

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





Schweizerischer Kalibrierdienst

S Service suisse d'étalonnage

С Servizio svizzero di taratura

S 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

### **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.
- 6 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%.

Accreditation No.: SCS 0108

### **Measurement Conditions**

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

DASY Version	DASY5	V52.10.2
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	37.9 ± 6 %	1.86 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	13.6 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	53.1 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	6.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.0 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	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.0 ± 6 %	2.03 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	13.1 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	51.0 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.12 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.1 W/kg ± 16.5 % (k=2)

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.7 Ω + 3.9 jΩ
Return Loss	- 25.7 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.3 Ω + 6.2 jΩ
Return Loss	- 24.2 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
-	

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

Date: 14.06.2019

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:750

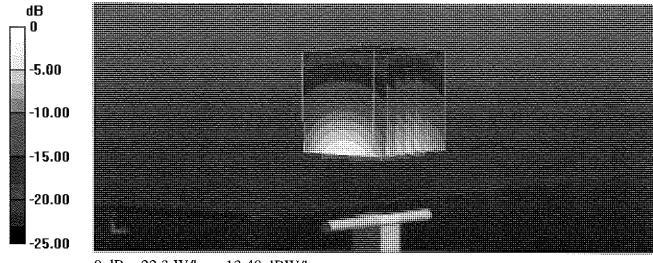
Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz;  $\sigma = 1.86$  S/m;  $\varepsilon_r = 37.9$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

### DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.9, 7.9, 7.9) @ 2450 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 117.9 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 26.7 W/kg SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.34 W/kg Maximum value of SAR (measured) = 22.3 W/kg



File	View	Channel	Sw <u>e</u> ep	Calibration	<u>Trace S</u> cal	e M <u>a</u> rker	S <u>v</u> stem <u>V</u>	<u>V</u> indow	<u>H</u> elp		
					A	XXX			2.450000 GHz 256.19 pH 2.450000 GHz	ł 3 2 52.	3.699 Ω .9438 Ω 107 mU 44.653 °
	Ch1:St	Ch 1 Avg = art 2.25000 (					~			Stop	2,65000 GHz
10.) 5.0 -5.0 -10 -15 -20 -25 -30 -35 -35 -40	0 00 .00 .00 .00 .00	Ch 1 Avg = art 2.25000	20 3Hz				> 1		2.450000 GHz		2.65000 GHz
Sta	atus	CH 1:	311		C* 1-Port		Avg=20 D	elay			LCL

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

Date: 14.06.2019

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:750

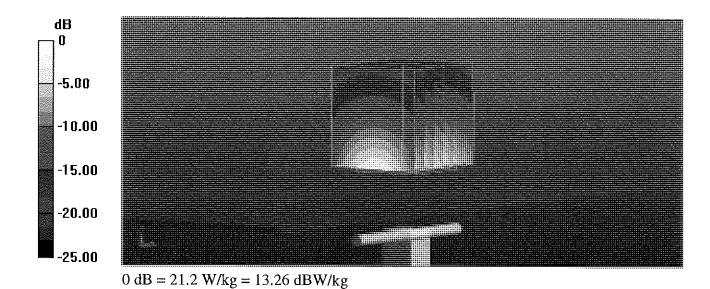
Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz;  $\sigma = 2.03$  S/m;  $\epsilon_r = 51$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

### DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.94, 7.94, 7.94) @ 2450 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 108.6 V/m; Power Drift = -0.06 dB Peak SAR (extrapolated) = 25.9 W/kg SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.12 W/kg Maximum value of SAR (measured) = 21.2 W/kg



<u>File V</u> ie	w <u>C</u> hannel S	5w <u>e</u> ep Ca <u>l</u> ibra	tion <u>T</u> race <u>S</u> cal	e M <u>a</u> rker S <u>v</u> ste	m <u>W</u> indow	<u>H</u> elp	
				A A A A A A A A A A A A A A A A A A A		.450000 GHz 402.78 pH .450000 GHz	50.310 Ω 6.2005 Ω 61.772 mU 83.597 °
Ch1:	Ch 1 Avg = -2 Start 2.25000 GH			<u>~</u>			Stop 2,65000 GHz
10.00 5.00 -5.00 -10.00 -15.00 -20.00 -25.00 -30.00 -35.00 -40.00	BSII      Ch 1 Avg = 2	0			> 1: 2	450000 GHz	-24.184 dB
[] Ch1:	: Start 2.25000 GH	Z ,					Stop 2.65000 GHz





# **Certification of Calibration**

Object

D2450V2 – SN: 750

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

June 14, 2020

Extended Calibration date:

Description:

SAR Validation Dipole at 2450 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	1/16/2020	Annual	1/16/2021	US39170118
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	MA2411B	Pulse Power Sensor	1/21/2020	Annual	1/21/2021	1207470
Anritsu	MA2411B	Pulse Power Sensor	1/21/2020	Annual	1/21/2021	1339007
Anritsu	ML2495A	Power Meter	1/15/2020	Annual	1/15/2021	1328004
Control Company	62344-734	Therm./ Clock/ Humidity Monitor	3/18/2019	Biennial	3/18/2021	192038436
Control Company	4352	Ultra Long Stem Thermometer	8/2/2018	Biennial	8/2/2020	181292000
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Seekonk	NC-100	Torque Wrench	7/18/2019	Annual	7/18/2020	N/A
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/14/2020	Annual	1/14/2021	793
SPEAG	DAE4	Dasy Data Acquisition Electronics	8/12/2019	Annual	8/12/2020	1408
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2020	Annual	5/12/2021	1070
SPEAG	EX3DV4	SAR Probe	1/20/2020	Annual	1/20/2021	3837
SPEAG	EX3DV4	SAR Probe	8/29/2019	Annual	8/29/2020	3949

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Managing Director	ROK

Object:	Date Issued:	Dogo 1 of 4
D2450V2 – SN: 750	6/14/2020	Page 1 of 4

## **DIPOLE CALIBRATION EXTENSION**

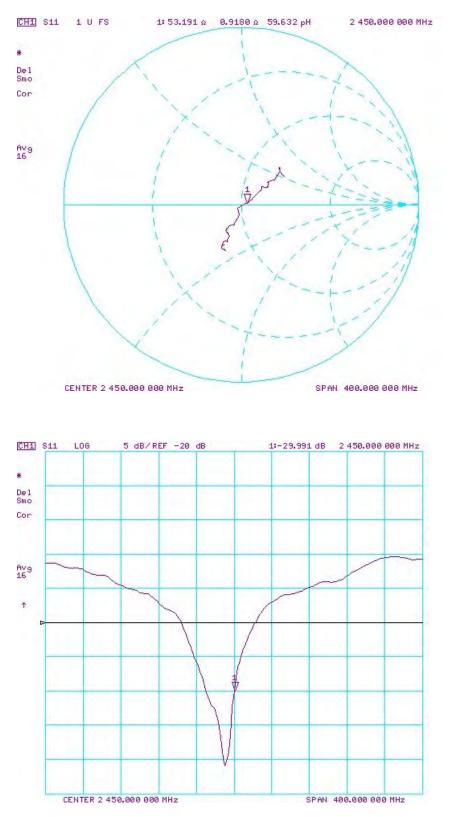
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than  $5\Omega$  from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

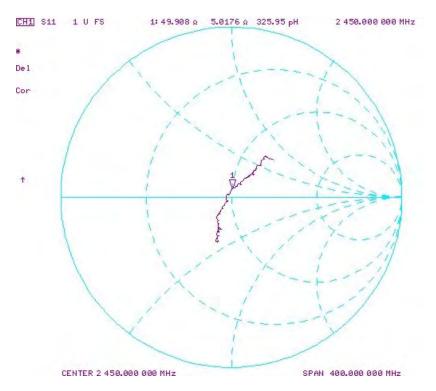
Date	Extension Date		Head (19) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	(%)	w/kg @ 20.0 dBm	(10g) W/kg @ 20.0 dBm		Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Head (dB)	Deviation (%)	
6/14/2019	6/14/2020	1.154	5.31	5.54	4.33%	2.5	2.56	2.40%	53.7	53.2	0.5	3.9	0.9	3	-25.7	-30	-16.70%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Body SAR (1g) W/kg @ 20.0 dBm	(0/)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	(40-) Million (2)	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
6/14/2019	6/14/2020	1.154	5.1	5.33	4.51%	2.41	2.47	2.49%	50.3	49.9	0.4	6.2	5	1.2	-24.2	-25.8	-6.60%	PASS

Object:	Date Issued:	Page 2 of 4
D2450V2 – SN: 750	6/14/2020	raye 2 01 4

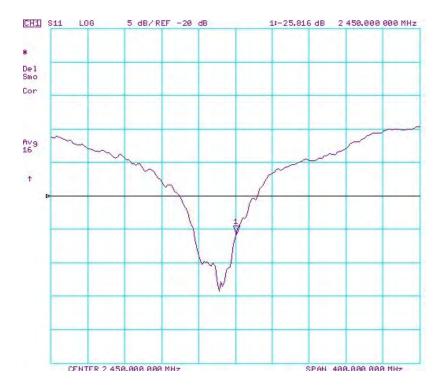


### Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Daga 2 of 4
D2450V2 – SN: 750	6/14/2020	Page 3 of 4



### Impedance & Return-Loss Measurement Plot for Body TSL



Object:	Date Issued:	Dogo 4 of 4
D2450V2 – SN: 750	6/14/2020	Page 4 of 4





# **Certification of Calibration**

Object

D2450V2 – SN: 750

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

June 14, 2021

Extended Calibration date:

Description:

SAR Validation Dipole at 2450 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	4/14/2021	Annual	4/14/2022	US39170118
Agilent	N5182A	MXG Vector Signal Generator	12/1/2020	Annual	12/1/2021	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	MA2411B	Pulse Power Sensor	3/9/2021	Annual	3/9/2022	1207470
Anritsu	MA2411B	Pulse Power Sensor	3/8/2021	Annual	3/8/2022	1339007
Anritsu	ML2495A	Power Meter	3/4/2021	Annual	3/4/2022	1328004
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670635
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291463
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	9/1/2020	Annual	9/1/2021	MY53401181
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Seekonk	NC-100	Torque Wrench	7/30/2020	Biennial	7/30/2022	22217
SPEAG	DAE4	Dasy Data Acquisition Electronics	9/13/2020	Annual	9/13/2021	1408
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/11/2021	Annual	1/11/2022	1645
SPEAG	EX3DV4	SAR Probe	8/19/2020	Annual	8/19/2021	3949
SPEAG	EX3DV4	SAR Probe	3/3/2021	Annual	3/3/2022	7640
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2021	Annual	5/12/2022	1070

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Managing Director	ROK

Object:	Date Issued:	Page 1 of 4
D2450V2 – SN: 750	6/14/2021	Page 1 of 4

## **DIPOLE CALIBRATION EXTENSION**

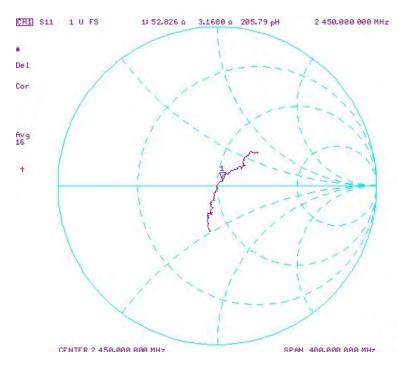
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than  $5\Omega$  from the previous measurement.

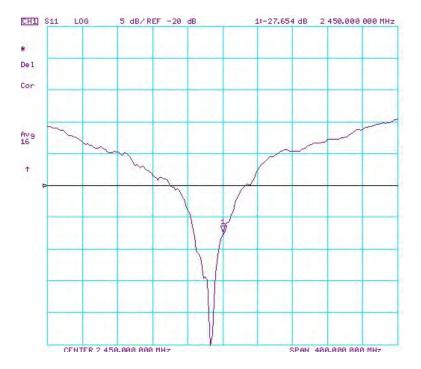
The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

Date	Extension Date	Certificate Electrical Delay (ns)	Head (19) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	(%)	Head (10g) W/kg @ 20.0 dBm	(40-) M(0 (2)		Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Head (dB)	Deviation (%)	
6/14/2019	6/14/2021	1.154	5.31	5.29	-0.38%	2.50	2.4	-4.00%	53.7	52.8	0.9	3.9	3.2	0.7	-25.7	-27.7	-7.60%	PASS
Date	Extension Date	Certificate Electrical Delay (ns)	W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	(%)	W/kg @ 20.0 dBm	(10g) W/kg @ 20.0 dBm		Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Body (dB)	Deviation (%)	
6/14/2019	6/14/2021	1.154	5.10	4.87	-4.51%	2.41	2.24	-7.05%	50.3	48.5	1.8	6.2	2.9	3.3	-24.2	-28.5	-17.70%	PASS

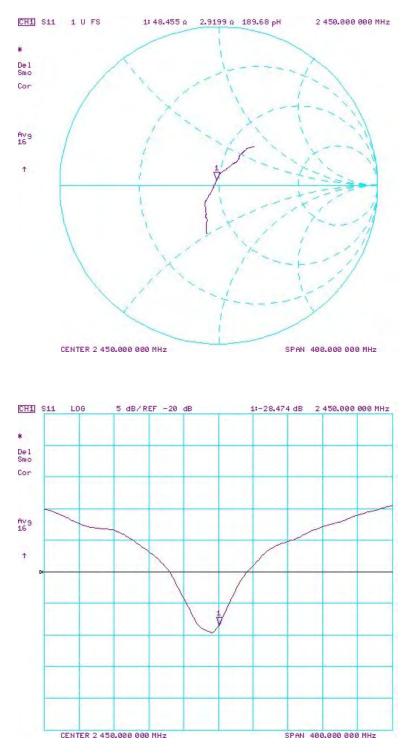
Object:	Date Issued:	Page 2 of 4
D2450V2 – SN: 750	6/14/2021	raye 2 014



Impedance & Return-Loss Measurement Plot for Head TSL



Object:	Date Issued:	Page 3 of 4
D2450V2 – SN: 750	6/14/2021	1 age 5 01 4



### Impedance & Return-Loss Measurement Plot for Body TSL

Object:	Date Issued:	Page 4 of 4
D2450V2 – SN: 750	6/14/2021	Fage 4 01 4

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



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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

Client PC Test Certificate No: D2600V2-1042 Jun19

s,

Accreditation No.: SCS 0108

# **CALIBRATION CERTIFICATE**

Object	D2600V2 - SN:1	042	ATH LINDIA				
Calibration procedure(s)	QA CAL-05,v11		6 -5/11				
		edure for SAR Validation Source	as between 0,7-3,6Hz				
			VATH				
Calibration date:	June 14, 2019		7/6/2020				
This sollyration portificate desures							
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 ere given on the following pages and are part of the certificate.							
The measurements and the uncent	ainties with confidence p	robability ere given on the following pages a	and are part of the certificate,				
All calibrations have been conducte	ed in the closed laborato	ry facility: environment temperature (22 $\pm$ 3)	)°C and humidity < 70%.				
			V ATM				
Calibration Equipment used (M&TE	critical for calibration)		, , ,				
	1		7/10/2021				
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration				
Power meter NRP	SN: 104778	03-Apr-19 (No. 217-02892/02893)	Apr-20				
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20				
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20				
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20				
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20				
Reference Probe EX3DV4	SN: 7349	29-May-19 (No. EX3-7349_May19)	May-20				
DAE4	SN: 601	30-Apr-19 (No. DAE4-601_Apr19)	Apr-20				
	1						
Secondary Standards	ID #	Check Date (In house)	Scheduled Check				
Power meter E4419B	SN: GB39512475	30-Oct-14 (In house check Feb-19)	In house check: Oct-20				
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20				
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (In house check Oct-18)	In house check: Oct-20				
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	in house check: Oct-20				
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (In house check Oct-18)	In house check: Oct-19				
	Name	Function	Signature				
Calibrated by:	Michael Weber	Laboratory Technician	/////				
			M.KRSR				
Approved by:	Kalja Pokovic	Technical Manager	et lle				
			10-9				

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

### **Calibration Laboratory of**

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





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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

### **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 6 point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- 0 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. 6 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 ക 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%.

Accreditation No.: SCS 0108

### **Measurement Conditions**

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

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	· · · · · · · · · · · · · · · · · · ·
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2600 MHz ± 1 MHz	······

### **Head TSL parameters**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.3 ± 6 %	2.03 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	14.8 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	57.7 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	6.57 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.9 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	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	50.5 ± 6 %	2.22 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	14.1 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	55.2 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.30 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.9 W/kg ± 16.5 % (k=2)

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.6 Ω - 8.4 jΩ
Return Loss	- 21.5 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	45.8 Ω - 6.2 jΩ
Return Loss	- 22.2 dB

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

Electrical Delay (one direction)	1.150 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	

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

Date: 14.06.2019

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1042

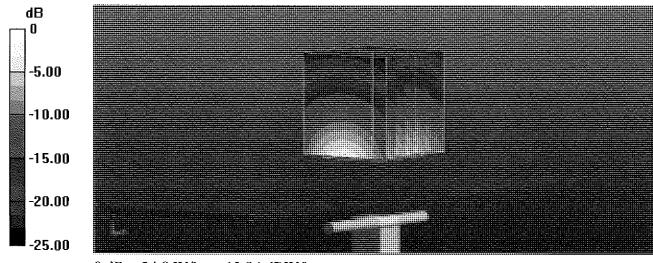
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz;  $\sigma$  = 2.03 S/m;  $\epsilon_r$  = 37.3;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

### DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.69, 7.69, 7.69) @ 2600 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 120.0 V/m; Power Drift = 0.04 dB Peak SAR (extrapolated) = 29.9 W/kg SAR(1 g) = 14.8 W/kg; SAR(10 g) = 6.57 W/kg Maximum value of SAR (measured) = 24.8 W/kg



0 dB = 24.8 W/kg = 13.94 dBW/kg

## Impedance Measurement Plot for Head TSL

File	View	Channel	Sw <u>e</u> ep	Calibration	<u>T</u> race <u>S</u> cal	e M <u>a</u> rker	S <u>v</u> stem <u>V</u>	<u>M</u> indow <u>H</u>	elp			
					A				600000 G 7.2565 600000 G	iрF	-8. 84.	9.607 Ω 4357 Ω 480 mU 37.829 °
	Ch1:St	Ch 1 Avg = art 2.40000 (	20 3Hz	112			<b></b>				Stop 2	:.80000 GHz
10.1 5.0 -5.0 -10 -15 -20 -25 -30 -35 -40	0 00 .00 .00 .00 .00 .00	18 S11					> 1	2.	₿00000 C	Hz		.485 dB
Sta	alus	CH 1:	511		C* 1-Port		Avg=20 D	elay				lcl.

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

Date: 14.06.2019

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1042

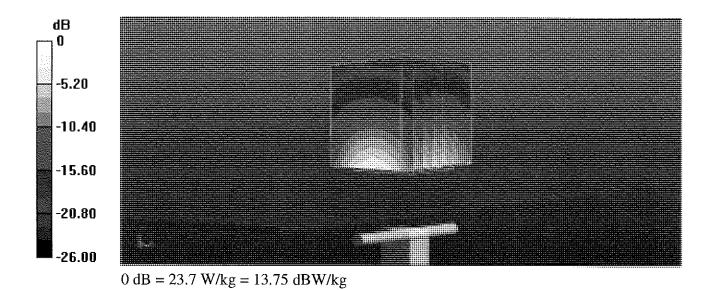
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz;  $\sigma$  = 2.22 S/m;  $\epsilon_r$  = 50.5;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.8, 7.8, 7.8) @ 2600 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 110.3 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 28.9 W/kg SAR(1 g) = 14.1 W/kg; SAR(10 g) = 6.3 W/kg Maximum value of SAR (measured) = 23.7 W/kg



## Impedance Measurement Plot for Body TSL

<u>File V</u> iew	/ <u>C</u> hannel S	5w <u>e</u> ep Calibration	<u>I</u> race <u>S</u> cale	: M <u>a</u> rker S <u>v</u>	stem <u>W</u> indov	v <u>H</u> elp	
Ch1:S	Ch 1 Avg = 2 Start 2.40000 GH	)				2.800000 GH: 9.9180 pl 2.800000 GH	6.1732 Ω
10.00	BB/S11	I	1	1	> 11	n dagaaa duu	
5.00 0.00 -5.00					~ 1,	2.600000 GH	z -22.160 dB
-10.00		······································					
-15.00 -20.00	k			·····			
-25.00 -30.00							
-35.00 -40.00 Ch1: 9	Ch 1 Awg = 2 Start 2.40000 GF	0 1z					Stop 2.30000 GHz
Status	CH 1: 51		C" 1-Port	A,	vg=20 Delay		LCL





# **Certification of Calibration**

Object

D2600V2 - SN: 1042

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

June 14, 2020

Extended Calibration date:

Description:

SAR Validation Dipole at 2600 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	1/16/2020	Annual	1/16/2021	US39170118
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	MA2411B	Pulse Power Sensor	1/21/2020	Annual	1/21/2021	1207470
Anritsu	MA2411B	Pulse Power Sensor	1/21/2020	Annual	1/21/2021	1339007
Anritsu	ML2495A	Power Meter	1/15/2020	Annual	1/15/2021	1328004
Control Company	62344-734	Therm./ Clock/ Humidity Monitor	3/18/2019	Biennial	3/18/2021	192038436
Control Company	4352	Ultra Long Stem Thermometer	8/2/2018	Biennial	8/2/2020	181292000
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Seekonk	NC-100	Torque Wrench	7/18/2019	Annual	7/18/2020	N/A
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/14/2020	Annual	1/14/2021	793
SPEAG	DAE4	Dasy Data Acquisition Electronics	8/12/2019	Annual	8/12/2020	1408
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2020	Annual	5/12/2021	1070
SPEAG	EX3DV4	SAR Probe	1/20/2020	Annual	1/20/2021	3837
SPEAG	EX3DV4	SAR Probe	8/29/2019	Annual	8/29/2020	3949

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Managing Director	ROK

Object:	Date Issued:	Dogo 1 of 4
D2600V2 – SN: 1042	6/14/2020	Page 1 of 4

## **DIPOLE CALIBRATION EXTENSION**

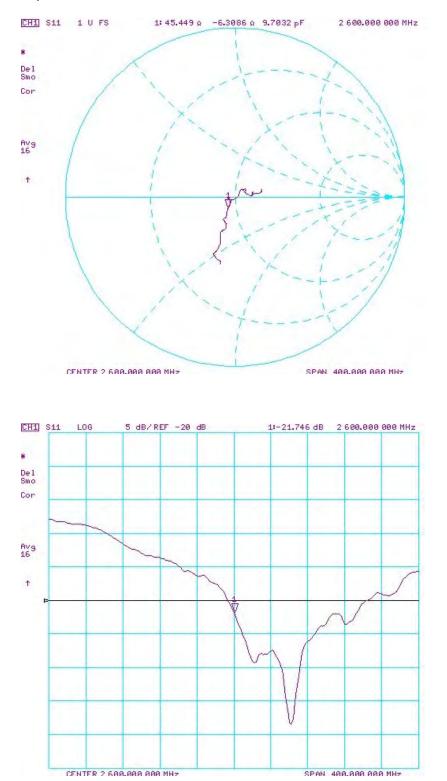
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than  $5\Omega$  from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

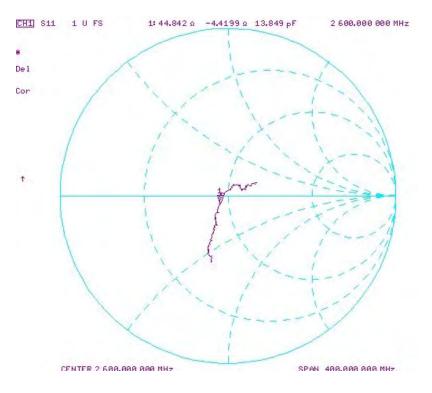
Date	Extension Date	Certificate Electrical Delay (ns)	Head (19) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	(%)	vv/кg @ 20.0 dBm	(10g) W/kg @ 20.0 dBm		Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Head (dB)	Deviation (%)	
6/14/2019	6/14/2020	1.15	5.77	6.11	5.89%	2.59	2.75	6.18%	49.6	45.4	4.2	-8.4	-6.3	2.1	-21.5	-21.7	-0.90%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Body SAR (1g) W/kg @ 20.0 dBm	(0/)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	(40-) Million (2)	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
6/14/2019	6/14/2020	1.15	5.52	5.85	5.98%	2.49	2.58	3.61%	45.8	44.8	1	-6.2	-4.4	1.8	-22.2	-22.7	-2.30%	PASS

Object:	Date Issued:	Dogo 2 of 4
D2600V2 – SN: 1042	6/14/2020	Page 2 of 4



### Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Dogo 2 of 4
D2600V2 – SN: 1042	6/14/2020	Page 3 of 4



### Impedance & Return-Loss Measurement Plot for Body TSL



Object:	Date Issued:	Dogo 4 of 4
D2600V2 – SN: 1042	6/14/2020	Page 4 of 4





# **Certification of Calibration**

Object

D2600V2 - SN: 1042

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

June 14, 2021

Extended Calibration date:

Description:

SAR Validation Dipole at 2600 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	4/14/2021	Annual	4/14/2022	US39170118
Agilent	N5182A	MXG Vector Signal Generator	12/1/2020	Annual	12/1/2021	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	MA2411B	Pulse Power Sensor	3/9/2021	Annual	3/9/2022	1207470
Anritsu	MA2411B	Pulse Power Sensor	3/8/2021	Annual	3/8/2022	1339007
Anritsu	ML2495A	Power Meter	3/4/2021	Annual	3/4/2022	1328004
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670635
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291463
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	9/1/2020	Annual	9/1/2021	MY53401181
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Seekonk	NC-100	Torque Wrench	7/30/2020	Biennial	7/30/2022	22217
SPEAG	DAE4	Dasy Data Acquisition Electronics	10/12/2020	Annual	10/12/2021	1213
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/11/2021	Annual	1/11/2022	1645
SPEAG	EX3DV4	SAR Probe 10		Annual	10/21/2021	7420
SPEAG	EX3DV4	SAR Probe	3/3/2021	Annual	3/3/2022	7640
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2021	Annual	5/12/2022	1070

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Parker Jones	Team Lead Engineer	Parker Jones
Approved By:	Kaitlin O'Keefe	Managing Director	ROK

Object:	Date Issued:	Page 1 of 4
D2600V2 – SN: 1042	6/14/2021	Page 1 of 4

## **DIPOLE CALIBRATION EXTENSION**

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

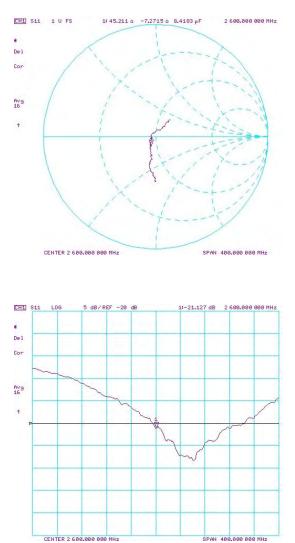
- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than  $5\Omega$  from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

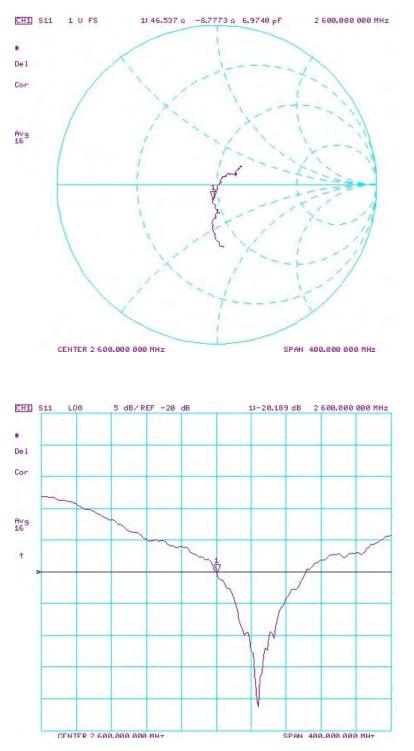
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Head SAR (1g) W/kg @ 20.0 dBm	(9()	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	(10a) W/ka @	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
6/14/2019	6/14/2021	1.15	5.77	5.65	-2.08%	2.59	2.44	-5.79%	49.6	45.2	4.4	-8.4	-7.3	1.1	-21.5	-21.1	1.70%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Body SAR (1g) W/kg @ 20.0 dBm	(0/)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	(40-) 10/0 (2)	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
6/14/2019	6/14/2021	1.15	5.52	5.31	-3.80%	2.49	2.35	-5.62%	45.8	46.5	0.7	-6.2	-8.8	2.6	-22.2	-20.2	9,10%	PASS

Object:	Date Issued:	Page 2 of 4
D2600V2 – SN: 1042	6/14/2021	Page 2 01 4

### Impedance & Return-Loss Measurement Plot for Head TSL



Object:	Date Issued:	Page 3 of 4
D2600V2 – SN: 1042	6/14/2021	rage 5 01 4



### Impedance & Return-Loss Measurement Plot for Body TSL

Object:	Date Issued:	Page 4 of 4
D2600V2 – SN: 1042	6/14/2021	Faye 4 01 4

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

PC Test

Client



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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

Certificate No: D5GHzV2-1123 Mar21

## **CALIBRATION CERTIFICATE**

Object		<b>j23</b>	ATM	
Calibration procedure(s)	QA CAL-22.v6 Calibration Proce	edure for SAR Validation Sourc	F177 es between 3-10 GHz 3/3//	$\mathcal{N}$
Calibration date:	March 10, 2021			
The measurements and the uncert	ainties with confidence p	onal standards, which realize the physical robability are given on the following pages	and are part of the certificate.	
All calibrations have been conducted		y facility: environment temperature (22 $\pm$ 3	)°C and humidity < 70%.	
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration	
Power meter NRP	SN: 104778	01-Apr-20 (No. 217-03100/03101)	Apr-21	
Power sensor NRP-Z91	SN: 103244	01-Apr-20 (No. 217-03100)	Apr-21	
Power sensor NRP-Z91	SN: 103245	01-Apr-20 (No. 217-03101)	Apr-21	
Reference 20 dB Attenuator	SN: BH9394 (20k)	31-Mar-20 (No. 217-03106)	Apr-21	
Type-N mismatch combination	SN: 310982 / 06327	31-Mar-20 (No. 217-03104)	Apr-21	
Reference Probe EX3DV4	SN: 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	
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:	Michael Weber	Laboratory Technician	Millets	
Approved by:	Katja Pokovic	Technical Manager	ACH-	
This calibration certificate shall not	be reproduced except in	full without written approval of the laborato	Issued: March 10, 2021 ry.	

#### Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





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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
	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%.

#### **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	5250 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz	

Head TSL parameters at 5250 MHz The following parameters and calculations were applied.

·	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.7 ± 6 %	4.51 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

### SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	82.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.37 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.4 W/kg ± 19.5 % (k=2)

#### Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.2 ± 6 %	4.86 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.53 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	84.5 W/kg ± 19.9 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	

normalized to 1W

23.9 W/kg ± 19.5 % (k=2)

#### Head TSL parameters at 5750 MHz

SAR for nominal Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.0 ± 6 %	5.01 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5750 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.21 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.0 W/kg ± 19.5 % (k=2)

#### Body TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.36 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.5 ± 6 %	5.49 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

#### SAR result with Body TSL at 5250 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	······································
SAR measured	100 mW input power	7.36 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.5 W/kg ± 19.9 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.03 W/kg

normalized to 1W

20.3 W/kg ± 19.5 % (k=2)

#### Body TSL parameters at 5600 MHz

SAR for nominal Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.9 ± 6 %	5.97 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

#### SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	······································
SAR measured	100 mW input power	7.75 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	77.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2,12 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.2 W/kg ± 19.5 % (k=2)

#### Body TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.3	5.94 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.6 ± 6 %	6.19 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

### SAR result with Body TSL at 5750 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.32 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.1 W/kg ± 19.9 % (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 100 mW input power	2.01 W/kg

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

#### Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	53.5 Ω - 5.7 jΩ
Return Loss	- 23.8 dB

#### Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	58.4 Ω - 0.3 jΩ
Return Loss	- 22.2 dB

#### Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	58.0 Ω + 0.5 jΩ
Return Loss	- 22.6 dB

#### Antenna Parameters with Body TSL at 5250 MHz

Impedance, transformed to feed point	52.8 Ω - 4.3 jΩ
Return Loss	- 26.0 dB

#### Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	56.7 Ω + 0.4 jΩ
Return Loss	- 24.0 dB

#### Antenna Parameters with Body TSL at 5750 MHz

Impedance, transformed to feed point	58.5 Ω - 0.3 jΩ
Return Loss	- 22.1 dB

#### General Antenna Parameters and Design

Electrical Delay (one direction)	
	1.206 ns
	1200110

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
manufactured by	SPEAG

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

Date: 08.03.2021

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1123

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz Medium parameters used: f = 5250 MHz;  $\sigma$  = 4.51 S/m;  $\epsilon_r$  = 34.7;  $\rho$  = 1000 kg/m<sup>3</sup>, Medium parameters used: f = 5600 MHz;  $\sigma$  = 4.86 S/m;  $\epsilon_r$  = 34.2;  $\rho$  = 1000 kg/m<sup>3</sup>, Medium parameters used: f = 5750 MHz;  $\sigma$  = 5.01 S/m;  $\epsilon_r$  = 34;  $\rho$  = 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(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.08, 5.08, 5.08) @ 5750 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=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 78.30 V/m; Power Drift = 0.09 dB Peak SAR (extrapolated) = 28.5 W/kg SAR(1 g) = 8.28 W/kg; SAR(10 g) = 2.37 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 70.5% Maximum value of SAR (measured) = 18.5 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 78.38 V/m; Power Drift = 0.04 dB Peak SAR (extrapolated) = 31.5 W/kg SAR(1 g) = 8.53 W/kg; SAR(10 g) = 2.42 W/kg Smallest distance from peaks to all points 3 dB below = 7.4 mm Ratio of SAR at M2 to SAR at M1 = 68% Maximum value of SAR (measured) = 19.8 W/kg

# Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 75.65 V/m; Power Drift = 0.04 dB

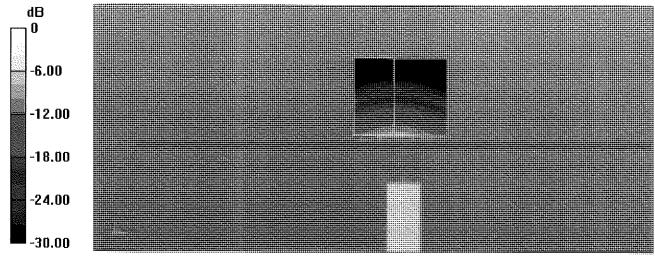
Peak SAR (extrapolated) = 32.3 W/kg

SAR(1 g) = 8.21 W/kg; SAR(10 g) = 2.33 W/kg

Smallest distance from peaks to all points 3 dB below = 7.4 mm

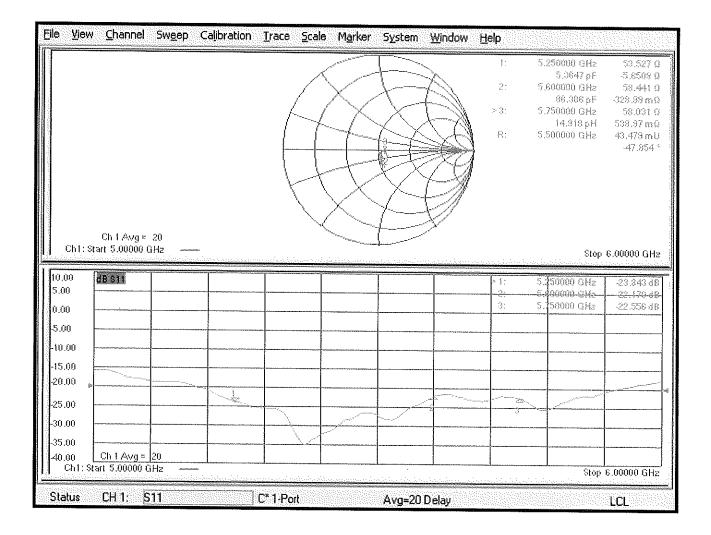
Ratio of SAR at M2 to SAR at M1 = 66.1%

Maximum value of SAR (measured) = 19.5 W/kg



0 dB = 19.8 W/kg = 12.96 dBW/kg

### Impedance Measurement Plot for Head TSL



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

Date: 10.03.2021

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1123

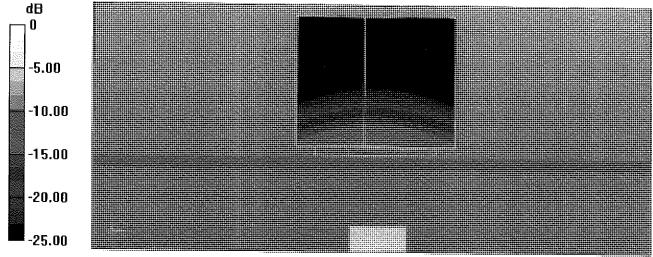
Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz Medium parameters used: f = 5250 MHz;  $\sigma = 5.49$  S/m;  $\varepsilon_r = 48.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5600 MHz;  $\sigma = 5.97$  S/m;  $\varepsilon_r = 47.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5750 MHz;  $\sigma = 6.19$  S/m;  $\varepsilon_r = 47.6$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.26, 5.26, 5.26) @ 5250 MHz, ConvF(4.79, 4.79, 4.79) @ 5600 MHz, ConvF(4.66, 4.66, 4.66) @ 5750 MHz; Calibrated: 30.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- 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=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 67.76 V/m; Power Drift = -0.09 dB Peak SAR (extrapolated) = 29.0 W/kg SAR(1 g) = 7.36 W/kg; SAR(10 g) = 2.03 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 66.6% Maximum value of SAR (measured) = 17.2 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 68.03 V/m; Power Drift = -0.08 dB Peak SAR (extrapolated) = 33.9 W/kg SAR(1 g) = 7.75 W/kg; SAR(10 g) = 2.12 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 63.4%Maximum value of SAR (measured) = 18.6 W/kg Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 65.05 V/m; Power Drift = -0.07 dB Peak SAR (extrapolated) = 33.6 W/kg SAR(1 g) = 7.32 W/kg; SAR(10 g) = 2.01 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 61.9% Maximum value of SAR (measured) = 18.0 W/kg



0 dB = 18.0 W/kg = 12.55 dBW/kg

## Impedance Measurement Plot for Body TSL

File 1	View	Channel	Sw <u>e</u> ep	Calibration	n <u>T</u> race	<u>S</u> cale	M <u>a</u> rker	System	Window	Help				
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						ł			Ì	R:	47 kr 13 t.	104,39 pF 200000 GHz	-265.16 m 39.74† m -26.111	ιU
C1	al: Star	Ch 1 A∨g ≈ 8 5.00000	6Hz									Stop	6.00000 61	Ha
		•• 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1	1											
5.00 0.00		B <u>\$11</u>								> 1: 3:	- 5.4	50009 GHz 09000 GHz 50000 GHz	-26.007 c -24.031 c -22.147 c	48-
5.00 0.00 -5.00 -10.00	  }	<b>B</b> <u>SU 1</u>									- 5.4	00000-Ghla-	4-24.023	48-
5.00 0.00 -5.00											- 5.4	00000-Ghla-	4-24.023	48-
5.00 0.00 5.00 -10.00 -15.00 -20.00 25.00 30.00 -35.00 -40.00			20									00000-Ghla-	4-24.023	48-
5.00 0.00 5.00 10.00 20.00 20.00 30.00 35.00 40.00			20 5H2									09000 GH2 50000 GH2	4-24.023	

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



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- S 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 Accreditation No.: SCS 0108

Certificate No: D5GHzV2-1163\_Jun21

**PC** Test Client

#### **IBRATION CERTIFICATE** AI

Object	D5GHzV2 - SN:1	163	ATM
Calibration procedure(s)	QA CAL-22.v6 Calibration Proce	dure for SAR Validation Sour	6//6/2/ ces between 3-10 GHz
Calibration date:	June 09, 2021		
The measurements and the uncertain	ainties with confidence p	onal standards, which realize the physica robability are given on the following page	s and are part of the certificate.
All calibrations have been conducte	ed in the closed laborator	y facility: environment temperature (22 ±	: 3)°C and humidity < 70%.
Calibration Equipment used (M&TE	E critical for calibration)		
Primary Standards	1D #	Cal Date (Certificate No.)	Scheduled Calibration
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: 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
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:	Jeton Kastrati	Laboratory Technician	Othe
Approved by:	Katja Pokovic	Technical Manager	I III

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

Issued: June 10, 2021

### **Calibration Laboratory of**

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





Schweizerischer Kalibrierdienst

S Service suisse d'étalonnage

С 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

#### Glossarv:

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 0 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 ø 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. 0 No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power. 6
- 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%.

#### **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 = 10.0 mm, dz = 10.0 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5250 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz	

Head TSL parameters at 5250 MHz The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.6 ± 6 %	4.59 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.09 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.1 W/kg ± 19.5 % (k=2)

## Head TSL parameters at 5600 MHz The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.1 ± 6 %	4.95 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition		
SAR measured	100 mW input power	8.41 W/kg	
SAR for nominal Head TSL parameters	normalized to 1W	83.3 W/kg ± 19.9 % (k=2)	
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition		

	oonanon	
SAR measured	100 mW input power	2.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.8 W/kg ± 19.5 % (k=2)

#### Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	33.9 ± 6 %	5.10 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5750 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.18 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.0 W/kg ± 19.5 % (k=2)

#### Body TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.36 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.4 ± 6 %	5.52 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

#### SAR result with Body TSL at 5250 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.64 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	76.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.11 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.1 W/kg ± 19.5 % (k=2)

#### Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.7 ± 6 %	6.01 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

#### SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.97 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	79.6 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.18 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.7 W/kg ± 19.5 % (k=2)

# Body TSL parameters at 5750 MHz The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.3	5.94 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.5 ± 6 %	6.22 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

#### SAR result with Body TSL at 5750 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.64 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	76.3 W/kg ± 19.9 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.10 W/kg

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

#### Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	50.3 Ω - 5.2 jΩ
Return Loss	- 25.7 dB

#### Antenna Parameters with Head TSL at 5600 MHz

Imp	pedance, transformed to feed point	51.7 Ω - 0.6 jΩ
Ret	urn Loss	- 35.1 dB

#### Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	55.0 Ω + 2.0 jΩ	
Return Loss	- 25.8 dB	

#### Antenna Parameters with Body TSL at 5250 MHz

Impedance, transformed to feed point	50.5 Ω - 1.8 jΩ	
Return Loss	- 34.5 dB	

#### Antenna Parameters with Body TSL at 5600 MHz

[	Impedance, transformed to feed point	53.6 Ω + 3.2 jΩ
	Return Loss	- 26.7 dB

#### Antenna Parameters with Body TSL at 5750 MHz

Impedance, transformed to feed point	55.6 Ω + 3.9 jΩ
Return Loss	- 23.8 dB

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

Electrical Delay (one direction)	1.189 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

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

Date: 08.06.2021

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1163

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz Medium parameters used: f = 5250 MHz;  $\sigma = 4.59$  S/m;  $\varepsilon_r = 34.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5600 MHz;  $\sigma = 4.95$  S/m;  $\varepsilon_r = 34.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5750 MHz;  $\sigma = 5.1$  S/m;  $\varepsilon_r = 33.9$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

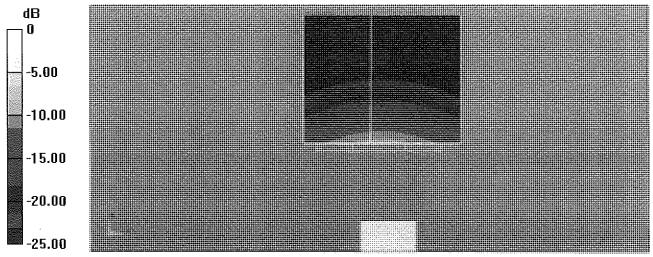
#### DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.08, 5.08, 5.08) @ 5750 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=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 77.21 V/m; Power Drift = 0.02 dB Peak SAR (extrapolated) = 27.9 W/kg SAR(1 g) = 8.09 W/kg; SAR(10 g) = 2.33 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 69.9% Maximum value of SAR (measured) = 18.4 W/kg

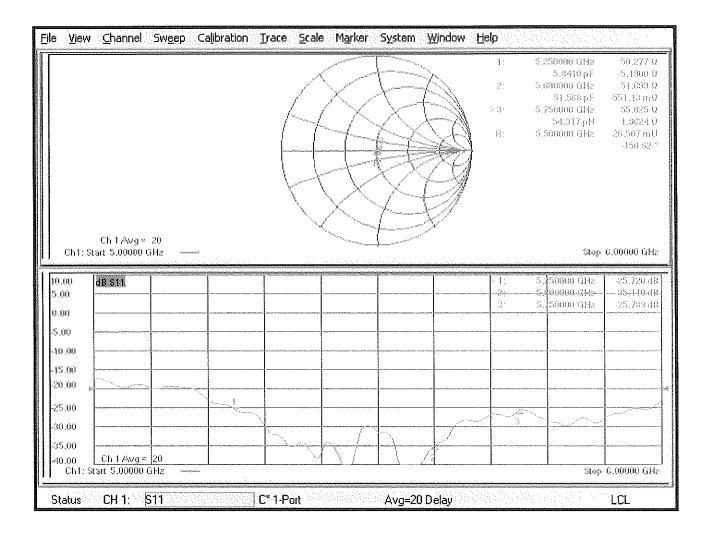
#### Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 77.48 V/m; Power Drift = 0.03 dB Peak SAR (extrapolated) = 31.2 W/kg SAR(1 g) = 8.41 W/kg; SAR(10 g) = 2.41 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 67.2% Maximum value of SAR (measured) = 19.8 W/kg

#### Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 75.33 V/m; Power Drift = 0.02 dB Peak SAR (extrapolated) = 32.1 W/kg SAR(1 g) = 8.18 W/kg; SAR(10 g) = 2.33 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 65.2% Maximum value of SAR (measured) = 19.8 W/kg



0 dB = 18.4 W/kg = 12.65 dBW/kg

#### Impedance Measurement Plot for Head TSL



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

Date: 09.06.2021

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1163

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz Medium parameters used: f = 5250 MHz;  $\sigma = 5.52$  S/m;  $\varepsilon_r = 48.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5600 MHz;  $\sigma = 6.01$  S/m;  $\varepsilon_r = 47.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5750 MHz;  $\sigma = 6.22$  S/m;  $\varepsilon_r = 47.5$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

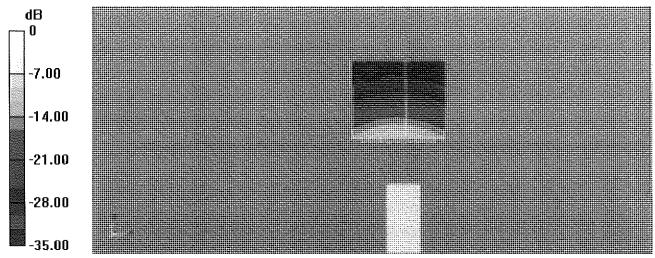
#### DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.26, 5.26, 5.26) @ 5250 MHz, ConvF(4.79, 4.79, 4.79) @ 5600 MHz, ConvF(4.66, 4.66) @ 5750 MHz; Calibrated: 30.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- 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=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 68.98 V/m; Power Drift = -0.07 dB Peak SAR (extrapolated) = 30.3 W/kg SAR(1 g) = 7.64 W/kg; SAR(10 g) = 2.11 W/kg Smallest distance from peaks to all points 3 dB below = 6.9 mm Ratio of SAR at M2 to SAR at M1 = 65.6% Maximum value of SAR (measured) = 18.0 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 68.60 V/m; Power Drift = -0.07 dB Peak SAR (extrapolated) = 35.1 W/kg SAR(1 g) = 7.97 W/kg; SAR(10 g) = 2.18 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 62.1% Maximum value of SAR (measured) = 19.5 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 66.58 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 35.5 W/kg SAR(1 g) = 7.64 W/kg; SAR(10 g) = 2.1 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 60.4% Maximum value of SAR (measured) = 19.1 W/kg



0 dB = 18.0 W/kg = 12.55 dBW/kg

### Impedance Measurement Plot for Body TSL

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#### Schmid & Partner Engineering AG

#### Zeughausstrasse 43, 8004 Zurich, Switzerland Phone +41 44 245 9700, Fax +41 44 245 9779 www.speag.swiss, info@speag.swiss

### <u>speag</u>

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### **DIPOLE REPAIR REPORT – SPEAG Production Center**

PRODUCT:	D5GHzV2 Dipole	IN DATE:	31-May-2021
SERIAL Nr.:	1163	PRODUCT Nr.:	SA AAD 510 BB
CUSTOMER:	PC Test		
MATERIAL	WORK DESCRIPTION		WORKING TIME (h)
Dipole Arm:	fixed <b>O</b> exchanged <b>X</b>		0 2.00 hours
Dipole Connector:	fixed O exchanged X	······	0 0.50 hours
Gold Plating:	fixed O exchanged O	••••••••••	0 hours
Housing:	fixed O exchanged O		0 hours
Disassemble / Clean:	fixed O exchanged O		0 hours
	fixed O exchanged O		0 hours
	fixed O exchanged O	·····	0 hours
	fixed O exchanged O		0 hours
	fixed O exchanged O		0 hours
Analysis:			0.50 hours
Final Assembly:			0.50 hours
Total hours			3.50 hours
COMMENTS:	The dipole was returned for re were bent. Also feed lines wer both feed lines near by dipole repair was not possible. In ord arm unit and the SMA-connect show below. The dipole will be	e completely demolised, they tab. The occurred damage wa er to re-establish full function tor were replaced. The cost fo	had cracks on as such that a ality, the dipole or this repair is
CONDUCTED BY:		APPROVED BY:	7 primes
DATE:	3-Jun-2021	DATE:	3-Jun-2021
REPAIR COST: MATERIAL REPAIR:	COST: <u>1190.00</u> X <u>472.50</u> X	]	Euro O O
TOTAL COST:	1662.50	QUOTATION Nr.:	16441
APPROVED BY: DATE:	<u>3-Jun-2021</u>		1

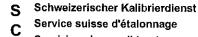
860-SAAAD510\_1163\_2106031-B.xlsx

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

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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: D5GHzV2-1191\_Sep21

Accreditation No.: SCS 0108

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Object	D5GHzV2 - SN:1	191	
Calibration procedure(s)	OA CAL-22.98 Calibration Proce	dute for SAR Validation Sources	Defineen 3-10 GHz 10 -07-202
Calibration date:	September 15, 2	021	10-07-202
This calibration certificate docume The measurements and the uncert	nts the traceability to natio ainties with confidence pr	onal standards, which realize the physical unit robability are given on the following pages and	s of measurements (SI). I are part of the certificate,
		y facility: environment temperature (22 $\pm$ 3)°C	and humidity < 70%.
Calibration Equipment used (M&T	E 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-Z91	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
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:	Jeffrey Katzman	Laboratory Technician	Alto
Approved by:	Katja Pokovic	Technical Manager	alles
			Issued: Sentember 20, 2021

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

#### Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





Schweizerischer Kalibrierdienst

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- 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%.

#### **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 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	5200 MHz ± 1 MHz 5250 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz 5800 MHz ± 1 MHz	

Head TSL parameters at 5200 MHz The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.8 ± 6 %	4.47 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

### SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.89 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	78.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.24 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.2 W/kg ± 19.5 % (k=2)

#### Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.7 ± 6 %	4.52 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5250 MHz

Condition	
100 mW input power	8.03 W/kg
normalized to 1W	79.6 W/kg ± 19.9 % (k=2)
condition	
	100 mW input power

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.30 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.7 W/kg ± 19.5 % (k=2)

#### Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.0 <b>7</b> mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.2 ± 6 %	4.86 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	82.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.36 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.3 W/kg ± 19.5 % (k=2)

### Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.0 ± 6 %	5.01 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5750 MHz

SAR averaged over 1 $cm^3$ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.90 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	78.2 W/kg ± 19.9 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	· · · · · · · · · · · · · · · · · · ·
SAR measured	100 mW input power	2.24 W/kg

normalized to 1W

22.2 W/kg ± 19.5 % (k=2)

2.24 W/kg

22.2 W/kg ± 19.5 % (k=2)

#### Head TSL parameters at 5800 MHz

SAR for nominal Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.0 ± 6 %	5.06 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5800 MHz

SAR for nominal Head TSL parameters

	Condition	
SAR measured	100 mW input power	7.99 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	79.2 W/kg ± 19.9 % (k=2)

100 mW input power

normalized to 1W

SAR measured

#### Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.9 ± 6 %	5.44 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

#### SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.38 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.8 W/kg ± 19.9 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.05 W/kg

#### Body TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.36 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.8 ± 6 %	5.50 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

#### SAR result with Body TSL at 5250 MHz

SAR for nominal Body TSL parameters

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.41 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	74.1 W/kg ± 19.9 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.07 W/kg

normalized to 1W

20.8 W/kg ± 19.5 % (k=2)

#### Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body ⊺SL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.2 ± 6 %	5.99 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

### SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.69 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	76.9 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.13 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.3 W/kg ± 19.5 % (k=2)

### Body TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.3	5.94 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.0 ± 6 %	6.20 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

### SAR result with Body TSL at 5750 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	<u> </u>
SAR measured	100 mW input power	7.43 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	74.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.07 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.7 W/kg ± 19.5 % (k=2)

# Body TSL parameters at 5800 MHz The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.9 ± 6 %	6.28 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

#### SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition		
SAR measured	100 mW input power	7.34 W/kg	
SAR for nominal Body TSL parameters	normalized to 1W	73.5 W/kg ± 19.9 % (k=2)	
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition		
SAR measured	100 mW input power	2.02 W/kg	

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

#### Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	50.3 Ω - 9.9 jΩ
Return Loss	- 20.2 dB

#### Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	52.0 Ω - 6.7 jΩ
Return Loss	- 23.3 dB

#### Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	53.2 Ω - 4.7 jΩ
Return Loss	- 25.3 dB

#### Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	55.3 Ω + 3.7 jΩ
Return Loss	- 24.3 dB

#### Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	52.5 Ω + 3.9 jΩ
Return Loss	- 26.9 dB

#### Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	51.6 Ω - 9.8 jΩ
Return Loss	- 20.2 dB

#### Antenna Parameters with Body TSL at 5250 MHz

Impedance, transformed to feed point	52.5 Ω - 5.3 jΩ
Return Loss	- 24.8 dB

#### Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	55.5 Ω - 5.6 jΩ
Return Loss	- 22.6 dB

#### Antenna Parameters with Body TSL at 5750 MHz

Impedance, transformed to feed point	56.3 Ω - 0.7 jΩ
Return Loss	- 24.6 dB

#### Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	53.1 Ω - 1.5 jΩ
Return Loss	- 29.4 dB

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

Electo	deal Datas (and discution)		1	i
	rical Delay (one direction)		1.202 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

Date: 15.09.2021

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1191

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5800 MHz Medium parameters used: f = 5200 MHz;  $\sigma = 4.47$  S/m;  $\varepsilon_r = 34.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5250 MHz;  $\sigma = 4.52$  S/m;  $\varepsilon_r = 34.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5600 MHz;  $\sigma = 4.86$  S/m;  $\varepsilon_r = 34.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5750 MHz;  $\sigma = 5.01$  S/m;  $\varepsilon_r = 34$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5750 MHz;  $\sigma = 5.06$  S/m;  $\varepsilon_r = 34$ ;  $\rho = 1000$  kg/m<sup>3</sup> Medium parameters used: f = 5800 MHz;  $\sigma = 5.06$  S/m;  $\varepsilon_r = 34$ ;  $\rho = 1000$  kg/m<sup>3</sup> Medium parameters used: f = 5800 MHz;  $\sigma = 5.06$  S/m;  $\varepsilon_r = 34$ ;  $\rho = 1000$  kg/m<sup>3</sup>

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.8, 5.8, 5.8) @ 5200 MHz, ConvF(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.08, 5.08, 5.08) @ 5750 MHz, ConvF(5.01, 5.01, 5.01) @ 5800 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(1535); SEMCAD X 14.6.14(7501)

### Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 76.97 V/m; Power Drift = 0.02 dBPeak SAR (extrapolated) = 27.7 W/kg SAR(1 g) = 7.89 W/kg; SAR(10 g) = 2.24 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 70.2% Maximum value of SAR (measured) = 17.8 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 77.82 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 27.4 W/kg SAR(1 g) = 8.03 W/kg; SAR(10 g) = 2.30 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 71.1% Maximum value of SAR (measured) = 18.2 W/kg

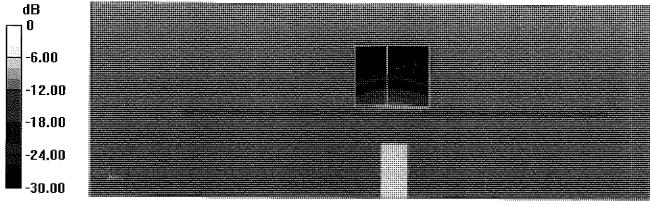
### Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 77.69 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 30.4 W/kg SAR(1 g) = 8.29 W/kg; SAR(10 g) = 2.36 W/kg Smallest distance from peaks to all points 3 dB below = 7.4 mm Ratio of SAR at M2 to SAR at M1 = 68.6% Maximum value of SAR (measured) = 19.3 W/kg

### Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 75.09 V/m; Power Drift = -0.01 dBPeak SAR (extrapolated) = 30.6 W/kg SAR(1 g) = 7.90 W/kg; SAR(10 g) = 2.24 W/kg Smallest distance from peaks to all points 3 dB below = 7.5 mm Ratio of SAR at M2 to SAR at M1 = 66.4% Maximum value of SAR (measured) = 18.9 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 75.66 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 31.5 W/kg SAR(1 g) = 7.99 W/kg; SAR(10 g) = 2.24 W/kg Smallest distance from peaks to all points 3 dB below = 7.5 mm Ratio of SAR at M2 to SAR at M1 = 66.3% Maximum value of SAR (measured) = 19.1 W/kg



0 dB = 19.3 W/kg = 12.86 dBW/kg

### Impedance Measurement Plot for Head TSL

File	<u>V</u> iew	<u>C</u> hannel	Sw <u>e</u> ep	Calibration	<u>Trace S</u> ca	ale M <u>a</u> rker	S <u>y</u> stem	Window	Help		
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					/			$\Sigma$	2:	3.0989 pF 5.250000 GHz	-9.8767 Ω 52.038 Ω
:						×/	<u>∖</u>	11-1		4.5359 pF	-6.6834 Q
					· /~	$\downarrow$ $\land$	X.	<i>[[</i> ]	> 3:	5.600000 GHz 6.1035 pF	53.158 Ω -4.6564 Ω
					[ ]	(	-		4:	5.750000 GHz	55.25S Q
									5:	101.34pH 5.800000 GHz	3,6613 Ω 52,520 Ω
						l-t-	F-X	A		106,26 pH	3.8724 Ω
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5.0 0.0	0 - 0	18-811								5.:00000 GH2 5.:50000 GH2 5.00000 GH2 5.:50000 GH2 5.:50000 GH2	-20.172 dB -23.398 dB -25.275 d8 -24.320 dB
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5.0 0.0 -5.0 -10.	0 - 0 - 00 - 00 -									5.:00000 GH2 5.:50000 GH2 5.00000 GH2 5.:50000 GH2 5.:50000 GH2	-20.172 dB -23.398 dB -25.275 d8 -24.320 dB
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5.0 0.0 -5.0 -10, -15, -20,		1 <b>b.3</b> /11								5.:00000 GH2 5.:50000 GH2 5.00000 GH2 5.:50000 GH2 5.:50000 GH2	-20.172 dB -23.398 dB -25.275 d8 -24.320 dB
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5.0 0.0 -10, -15, -20, -25, -30, -35, -40,									2:	5.300000 GH2 5.50000 GH2 5.80000 GH2 5.50000 GH2 5.50000 GH2 5.300000 GH2	-20.172 dB 23.300 dB -25.275 dB -24.320 dB -26.323 dB
5.0 0.0 -10. -15. -20, -25, -30, -35, -40,									2:	5.300000 GH2 5.50000 GH2 5.80000 GH2 5.50000 GH2 5.50000 GH2 5.300000 GH2	-20.172 dB -23.398 dB -25.275 d8 -24.320 dB

Date: 14.09.2021

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1191

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5800 MHz Medium parameters used: f = 5200 MHz;  $\sigma = 5.44$  S/m;  $\varepsilon_r = 48.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5250 MHz;  $\sigma = 5.5$  S/m;  $\varepsilon_r = 48.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5600 MHz;  $\sigma = 5.99$  S/m;  $\varepsilon_r = 48.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5750 MHz;  $\sigma = 6.2$  S/m;  $\varepsilon_r = 48$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5750 MHz;  $\sigma = 6.2$  S/m;  $\varepsilon_r = 47.9$ ;  $\rho = 1000$  kg/m<sup>3</sup> Medium parameters used: f = 5800 MHz;  $\sigma = 6.28$  S/m;  $\varepsilon_r = 47.9$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.29, 5.29, 5.29) @ 5200 MHz, ConvF(5.26, 5.26, 5.26) @ 5250 MHz, ConvF(4.79, 4.79, 4.79) @ 5600 MHz, ConvF(4.66, 4.66, 4.66) @ 5750 MHz, ConvF(4.62, 4.62, 4.62) @ 5800 MHz; Calibrated: 30.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

### Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 68.16 V/m; Power Drift = -0.05 dB Peak SAR (extrapolated) = 27.0 W/kg SAR(1 g) = 7.38 W/kg; SAR(10 g) = 2.05 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 68.7%Maximum value of SAR (measured) = 17.2 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 67.78 V/m; Power Drift = -0.08 dB Peak SAR (extrapolated) = 27.8 W/kg SAR(1 g) = 7.41 W/kg; SAR(10 g) = 2.07 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 67.6% Maximum value of SAR (measured) = 17.5 W/kg

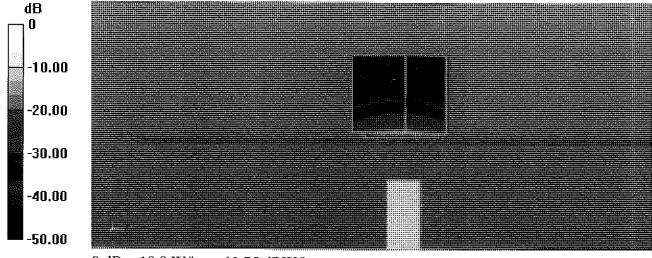
### Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 67.02 V/m; Power Drift = -0.07 dB Peak SAR (extrapolated) = 32.4 W/kg SAR(1 g) = 7.69 W/kg; SAR(10 g) = 2.13 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 64%Maximum value of SAR (measured) = 18.8 W/kg

#### Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 65.12 V/m; Power Drift = -0.09 dB Peak SAR (extrapolated) = 32.5 W/kg SAR(1 g) = 7.43 W/kg; SAR(10 g) = 2.07 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 62.7% Maximum value of SAR (measured) = 18.4 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 65.69 V/m; Power Drift = -0.09 dB Peak SAR (extrapolated) = 31.2 W/kg SAR(1 g) = 7.34 W/kg; SAR(10 g) = 2.02 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 63.8% Maximum value of SAR (measured) = 18.2 W/kg



0 dB = 18.8 W/kg = 12.75 dBW/kg

### Impedance Measurement Plot for Body TSL

	<u>View</u> <u>C</u> hannel	Sw <u>e</u> ep	Calibration	<u>Trace S</u> cal	e M <u>a</u> rker	System	Window	Help		
						$\left\{ \begin{array}{c} \\ \end{array} \right\}$	A	t: 2:	5.200000 GHz 3.1144 pF 5.250000 GHz	51.635 Ω -9.8275 Ω 52.520 Ω
					X	1_	124		5.6913 pF	-5.3359 $\Omega$
				[	$\langle \ \land \ \rangle$	X.	\$	>3:	5.600000 GHz 5.1031 pF	55.542 Ω -5.5693 Ω
					~	A	₩.	4:	5.750000 GHz	56.253 Q
						转表		5:	42.070 pF 5.800000 GHz	-657.93 mΩ 53.118 Ω
						X-X	$\square$		17.784pF	-1.5421 Q
				Ţ	$\setminus X$		//			
					$\sim$	7	$\mathbf{Y}$			
	Ch 1 Avg =	20		· ·	Contraction and the second		and the second se			
C	Ch1: Start 5.00000	GHz							Stop	6.00000 GHz
10.0							· · · · · · · · · · · · · · · · · · ·	1:	5. <b>1</b> 00000 GHz	-20.214.68
5.00	Ĵ								5.100000 GHz 5.150000 GHz	-20.214.85 -24.810.68
5.00 0.00	) )							- <u>2:</u> 3: 4:	5.200000 GHz 5.30000 GHz 5.80000 GHz 5.30000 GHz 5.30000 GHz	-20.214.38 -24,810.38 -22.576.38 -24,557.38
5.00 0.00 -5.00	0 							<u>2;</u> 3:	5.200000 GHz 5.350000 GHz 5.400000 GHz	-20.214 dB -24.810 dB -22.576 dB
5.00 0.00 -5.00 -10.0	0 0 00							- <u>2:</u> 3: 4:	5.200000 GHz 5.30000 GHz 5.80000 GHz 5.30000 GHz 5.30000 GHz	-20.214.38 -24,810.38 -22.576.38 -24,557.38
5.00 0.00 -5.00 -10.0	0							- <u>2:</u> 3: 4:	5.200000 GHz 5.30000 GHz 5.80000 GHz 5.30000 GHz 5.30000 GHz	-20.214.38 -24,810.38 -22.576.38 -24,557.38
5.00 0.00 -5.00 -10.0 -15.0 -20.0								- <u>2:</u> 3: 4:	5.200000 GHz 5.30000 GHz 5.80000 GHz 5.30000 GHz 5.30000 GHz	-20.214.38 -24,810.38 -22.576.38 -24,557.38
5.00 0.00 -5.00 -10.0 -15.0 -20.0 -25.0								- <u>2:</u> 3: 4:	5.200000 GHz 5.30000 GHz 5.80000 GHz 5.30000 GHz 5.30000 GHz	-20.214.38 -24,810.38 -22.576.38 -24,557.38
5.00 0.00 -5.00 -10.0 -15.0 -20.0 -25.0 -30.0								3: 4: 25: 	5.200000 GH2 5.250000 GH2 5.800000 GH2 5.550000 GH2 5.550000 GH2 5.400000 GH2	-20.214.38 -24,810.38 -22.576.38 -24,557.38
5.00 0.00 -5.00 -10.0 -15.0 -20.0 -25.0 -30.0 -35.0		20	1					3: 4: 25: 	5.200000 GH2 5.250000 GH2 5.800000 GH2 5.550000 GH2 5.550000 GH2 5.400000 GH2	-20.214.38 -24,810.38 -22.576.38 -24,557.38
5.00 0.00 -5.00 -10.0 -20.0 -25.0 -35.0 -35.0 -35.0			1 2					3: 4: 25: 	5.200000 GH2 5.350000 GH2 5.350000 GH2 5.350000 GH2 5.35000 GH2 5.30000 GH2 5.400000 GH2	-20.214.38 -24,810.38 -22.576.38 -24,557.38

### Appendix: Transfer Calibration at Four Validation Locations on SAM Head<sup>1</sup>

#### Evaluation Conditions (f=5200 MHz)

Phantom	SAM Head Phantom	Ear usage with an A DODVO D/
	Univi Lieau Fliancull	For usage with cSAR3DV2-R/L

#### SAR result with SAM Head (Top)

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR for nominal Head TSL parameters	normalized to 1W	82.9 W/kg ± 20.3 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	

#### SAR result with SAM Head (Mouth)

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR for nominal Head TSL parameters	normalized to 1W	86.7 W/kg ± 20.3 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	

#### SAR result with SAM Head (Neck)

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR for nominal Head TSL parameters	normalized to 1W	82.8 W/kg ± 20.3 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	· · · · · · · · · · · · · · · · · · ·

#### SAR result with SAM Head (Ear)

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR for nominal Head TSL parameters	normalized to 1W	52.7 W/kg ± 20.3 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR for nominal Head TSL parameters	normalized to 1W	17.8 W/kg ± 19.9 % (k=2)

<sup>&</sup>lt;sup>1</sup> Additional assessments outside the current scope of SCS 0108

## Appendix: Transfer Calibration at Four Validation Locations on SAM Head<sup>2</sup>

### Evaluation Conditions (f=5800 MHz)

i			
	Phantom	SAM Head Phantom	East upone with -OADODNO D#
I		OFINI HEAU / HAHLUIT	For usage with cSAR3DV2-R/L
			_

### SAR result with SAM Head (Top)

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR for nominal Head TSL parameters	normalized to 1W	82.3 W/kg ± 20.3 % (k=2)
		······································
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	

### SAR result with SAM Head (Mouth)

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR for nominal Head TSL parameters	normalized to 1W	89.0 W/kg ± 20.3 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	

### SAR result with SAM Head (Neck)

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR for nominal Head TSL parameters	normalized to 1W	79.4 W/kg ± 20.3 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	

### SAR result with SAM Head (Ear)

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR for nominal Head TSL parameters	normalized to 1W	56.6 W/kg ± 20.3 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR for nominal Head TSL parameters	normalized to 1W	18.7 W/kg ± 19.9 % (k=2)

<sup>&</sup>lt;sup>2</sup> Additional assessments outside the current scope of SCS 0108