

4, LS-ro 182beon-gil, Gunpo-si, Gyeonggi-do, 15807 Tel. 031-428-5700 / Fax. 031-427-2371 http://www.sgsgroup.kr

Appendix B.2 Calibration certificate for DAE



Report File No: F690501/RF-SAR002774 Date of Issue: 2019-07-15 (All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and

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





Schweizerischer Kalibrierdienst Service suisse d'étalonnage C 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 Agraement for the recognition of calibration certificates

Glossary

DAE

data acquisition electronics

Connector angle

information used in DASY system to align probe sensor X to the robot

coordinate system.

Methods Applied and Interpretation of Parameters

- DC Voltage Measurement: Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range
- Connector angle: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
 - DC Voltage Measurement Linearity: Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
 - Common mode sensitivity: Influence of a positive or negative common mode voltage on the differential measurement.
 - Channel separation: Influence of a voltage on the neighbor channels not subject to an input voltage.
 - AD Converter Values with inputs shorted: Values on the internal AD converter corresponding to zero input voltage
 - Input Offset Measurement. Output voltage and statistical results over a large number of zero voltage measurements.
 - Input Offset Current: Typical value for information; Maximum channel input offset current, not considering the input resistance.
 - Input resistance: Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
 - Low Battery Alarm Voltage: Typical value for information. Below this voltage, a battery alarm signal is generated.
 - Power consumption: Typical value for information. Supply currents in various operating modes.

Certificate No. DAE4-1430_Mar19

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DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1μV, full range = -100...+300 mV
Low Range: 1LSB = 61πV, full range = -1.....+3mV

DASY measurement parameters: Auto Zero Time; 3 sec; Measuring time; 3 sec

Calibration Factors	X	Y	Z
High Range	403.976 ± 0.02% (k=2)	404.165 ± 0.02% (k=2)	404.001 ± 0.02% (k=2)
Low Range	3.99740 ± 1.50% (k=2)	3.98188 ± 1.50% (k=2)	3.99872 ± 1.50% (k=2)

Connector Angle

connector Angle to be used in DASY system	253.0°±1°
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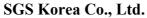
Certificate No: DAE4-1430_Mart9

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RTT5041-76(2015.10.01) (2)

A4 (210mm x 297mm)





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Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	199992.21	-0.91	-0.00
Channel X + Input	20004.43	3.01	0.02
Channel X - Input	-19998.34	3.32	-0.02
Channel Y + Input	199991.61	-1.67	-0.00
Channel Y + Input	20001.16	-0,19	-0.00
Channel Y - Input	-20002.49	-0.72	0.00
Channel Z + Input	199993.20	-0.08	-0.00
Channel Z + Input	20000.68	-0,59	-0.00
Channel Z - Input	-20002.47	-0.57	0.00

Low Range	Reading (µV)	Difference (μV)	Error (%)
Channel X + Input	2001.12	0.12	0.01
Channel X + Input	201.56	0.28	0.14
Channel X - Input	-197.97	0.64	-0.32
Channel Y + Input	2000.84	-0.15	-0.01
Channel Y + Input	200.16	-1.06	-0.53
Channel Y - Input	-199.70	-1.05	0.53
Channel Z + Input	2000.85	-0.07	-0,00
Channel Z + Input	200.52	-0.62	-0.31
Channel Z - Input	-199.59	-0.93	0.47

2. Common mode sensitivity

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (μV)
Channel X	200	3.24	1.55
	- 200	0.11	-1.79
Channel Y	200	-20.29	-21.12
	- 200	19.73	19.16
Channel Z	200	-17.98	-17.78
	- 200	16.98	16.46

3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec: Measuring time: 3 sec

	Input Voltage (mV)	Channel X (μV)	Channel Y (µV)	Channel Z (μV)
Channel X	200	13	1.32	-3.78
Channel Y	200	8.39	9.7	3.63
Channel Z	200	10.41	4.97	141

Certificate No: DAE4-1430_Mar19

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4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	High Range (LSB)	Low Range (LSB)
Channel X	16011	15250
Channel Y	16226	16109
Channel Z	15854	16203

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Input 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (µV)
Channel X	1,70	-0.10	3,15	0.54
Channel Y	-0.65	-2.11	0.65	0.47
Channel Z	-0.13	-1.74	1.49	0.59

6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

8. Low Battery Alarm Voltage (Typical values for information)

Typical values	Alarm Level (VDC)	
Supply (+ Vcc)	+7.9	
Supply (- Vcc)	-7.6	

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	-0.01	-8	-9

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Appendix B.3 Calibration certificate for Dipole



Report File No: F690501/RF-SAR002774 Date of Issue: 2019-07-15 (All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and

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Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstresse 43, 6004 Zurich, Switterfund





Schweizerischer Kalibrierdien Service suissa d'étalonnage Servizio svizzero di taratura Swiss Calibration Service

Accorditation No.: SCS 0108

Accredited by the 5www 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 Spalial-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
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%,

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Measurement Conditions

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

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	750 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41,9	0.89 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	42.1 ± 6 %	0.89 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.09 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	8.37 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.37 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	5.48 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.5 ± 6 %	0.98 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	(min)	-

SAR result with Body TSL

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2 16 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	8.47 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.42 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	5.59 W/kg ± 16.5 % (k=2)

Certificate No: D750V3-1085_Mar19

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	$54.6 \Omega + 0.4 j\Omega$	
Return Loss	- 27.1 dB	

Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.9 Ω - 2.9 jΩ
Return Loss	- 30.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.031 ns
----------------------------------	----------

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

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

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

Additional EUT Data

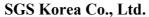
Manufactured by	SPEAG
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Certificate No: D750V3-1085 Mar19

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DASY5 Validation Report for Head TSL

Date: 21.03,2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1085

Communication System: UID 0 - CW; Frequency: 750 MHz

Medium parameters used: f = 750 MHz; $\sigma = 0.89 \text{ S/m}$; $\varepsilon_t = 42.1$; $\rho = 1000 \text{ kg/m}^2$

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

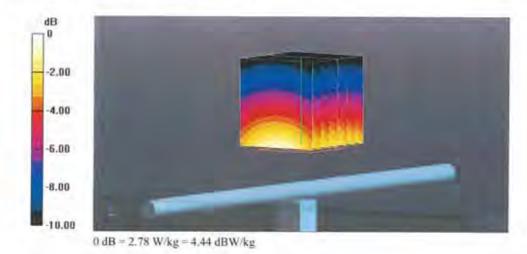
- Probe: EX3DV4 SN7349; ConvF(10.32, 10.32, 10.32) @ 750 MHz; Calibrated: 31.12.2018
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10,2018
- Phantom: Flat Phantom 4.9 (front): Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 59.33 V/m; Power Drift = 0.00 dB Peak SAR (extrapolated) = 3.11 W/kg

SAR(1 g) = 2.09 W/kg; SAR(10 g) = 1.37 W/kg

Maximum value of SAR (measured) = 2.78 W/kg



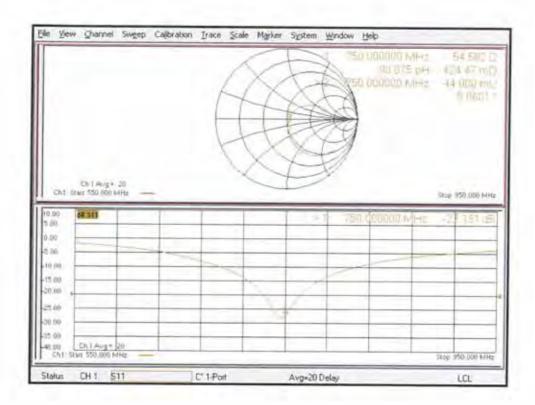
Certificate No: D750V3-1085 Mar19

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Impedance Measurement Plot for Head TSL



Certificate No: D750V3-1085_Mar19

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DASY5 Validation Report for Body TSL

Date: 21.03.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1085

Communication System: UID 0 - CW; Frequency: 750 MHz

Medium parameters used: f = 750 MHz; $\sigma = 0.98 \text{ S/m}$; $\epsilon_r = 54.5$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

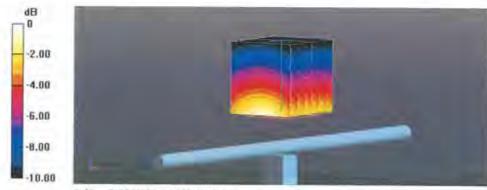
- Probe: EX3DV4 SN7349; ConvF(10.29, 10.29, 10.29) @ 750 MHz; Calibrated: 31.12.2018
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 57.29 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 3.16 W/kg

SAR(1 g) = 2.16 W/kg; SAR(10 g) = 1.42 W/kgMaximum value of SAR (measured) = 2.85 W/kg



0 dB = 2.85 W/kg = 4.55 dBW/kg

Certificate No: D750V3-1085 Mar19

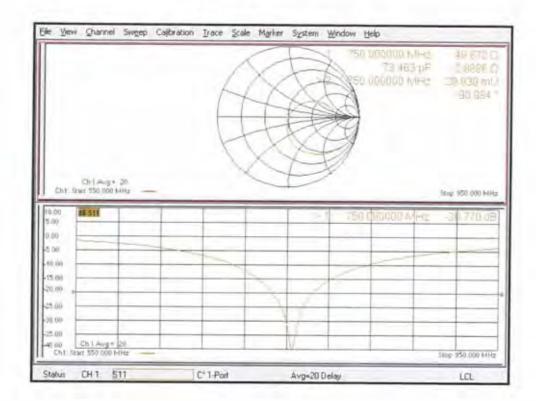
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Impedance Measurement Plot for Body TSL



Certificate No: D750V3-1085_Mar19

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Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 6004 Zurich, Switzerland





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

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS)

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SGS Korea (Dymstec)

Certificate No: D835V2-490_Jun18

Object	D835V2 - SN:490)	对自然包入
Calibration procedure(s)	QA CAL-05.v10 Calibration proce	dure for dipole validation kits abo	ove 700 MHz == 6 (C
Dalibration date:	June 01, 2018		
The measurements and the unce	rtainties with confidence p	ional standards, which realize the physical un erobability are given on the following pages an ry facility: environment temperature ($22 \pm 3)^{\circ}$)	d are part of the certificate.
Calibration Equipment used (M&	4	Car Date (Cartilland No.)	Scheduled Castivation
Primary Standards Power meter NRP	ID # SN: 104778	Oal Date (Certificate No.) 04-April II (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN 103244	04-Apr-18 (No. 217-02672)	Apr-19
		04-Apr-18 (No. 217-02673)	Apr-19
Power sensor NRP Z91	SN 103245	04-Apr-18 (No. 217-02682)	Apr-19
Reference 20 dB Attenuator	SN 5058 (20k)	04-Apr-18 (No. 217-02683)	Apr-19
	SN: 5047.2 / 06327 SN: 7349	30-Dec-17 (No. EX3-7349 Dec17)	Dec-18
AND THE RESERVE TO SERVE TO SE	SN 601	26-Oct-17 (No. DAE4-601, Oct17)	Oct-18
Reference Probe EX3DV4	DM 501		
Reference Probe EX3DV4 DAE4	15		Scheduled Check
Reference Probe EX3DV4 DAE4 Secondary Standards	10 #	Check Date (in bouse)	Scheduled Check In house check: Oct-18
Reference Probe EXSDV4 DAE4 Secondary Standards Power meter EPM-442A	ID# 5N GB37480704	Check Date (in house) 07-Oct-15 (in house check Oct-16)	
Reference Probe EXSDV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A	ID # SN GB37480704 SN US37292783	Check Date (in bouse)	In house check: Oct-18
Reference Probe EXSDV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A	ID# 5N GB37480704	Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	In house check: Oct-18 In house check: Oct-18
Reference Probe EXSDV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	ID # SN GB37480704 SN US37292763 SN: MY41082517	Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-15)	In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer HP 8753E	ID # SN GB37480704 SN US37292763 SN: MY41082317 SN 100972	Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16)	In house check: Oct-18 In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
Reference Probe EXSDV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	ID # SN GB37480704 SN US37292763 SN: MY41092317 SN 100972 SN: US37390585	Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-15) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-17)	In house check: Oct-18 In house check: Oct-18 In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
Reference Probe EXSDV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer HP 8753E	ID # SN GB37480704 SN US37292763 SN: MY41082317 SN 100972 SN: US37390585	Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-15) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-17) Function	In house check: Oct-18 In house check: Oct-18 In house check: Oct-18 In house check: Oct-18 In house check: Oct-18

Certificate No: D835V2-490: Jun18

Report File No: F690501/RF-SAR002774

Date of Issue: 2019-07-15 (All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and accessible at http://www.sgs.com/en/Terms-and-Conditions.aspx.)

RTT5041-76(2015.10.01) (2)

A4 (210mm x 297mm)



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Calibration Laboratory of

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





Schweizerlacher Kalibrierdienst Service sulsee d'étalonnage Servizio svizzero di taratura Swiss Calibration Service

Accreditation No.: SCS 0108

Accreated by the Swiss Accresistion Service (BAS)

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

Glossary:

tissue simulating liquid TSL

sensitivity in TSL / NORM x,y,z ConvF not applicable or not measured N/A

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
- EC 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
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Certificate No: D835V2-490 Jun 18

F690501/RF-SAR002774 Date of Issue: 2019-07-15 Report File No: (All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and accessible at http://www.sgs.com/en/Terms-and-Conditions.aspx.)



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Measurement Conditions

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

DASY Version	DASY5	V52,10.1
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy , $dz = 5 mm$	
Frequency	835 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.5	0.90 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.8 ± 6 %	0.92 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		[rest]

SAR result with Head TSL

SAR averaged over 1 cm3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.37 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.29 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.53 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.03 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.2	0.97 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) "C	54.6 ± 6.%	0.99 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.45 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	9.63 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.60 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	6.31 W/kg ± 16.5 % (k=2)

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.4 Ω - 2.5 jΩ	
Return Loss	- 29.4 dB	

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.7 Ω - 5.5 jΩ
Return Loss	- 24.3 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.384 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
Manufactured on	May 19, 2003

Certificate No. D835V2-490_Jun18

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DASY5 Validation Report for Head TSL

Date: 01.06.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:490

Communication System: UID 0 - CW; Frequency: 835 MHz.

Medium parameters used: $\Gamma = 835$ MHz; $\sigma = 0.92$ S/m; $\varepsilon_s = 40.8$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(9.9, 9.9, 9.9) @ 835 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10,2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 62.02 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 3.62 W/kg

SAR(1 g) = 2.37 W/kg; SAR(10 g) = 1.53 W/kgMaximum value of SAR (measured) = 3.18 W/kg



0 dB = 3.18 W/kg = 5.02 dBW/kg

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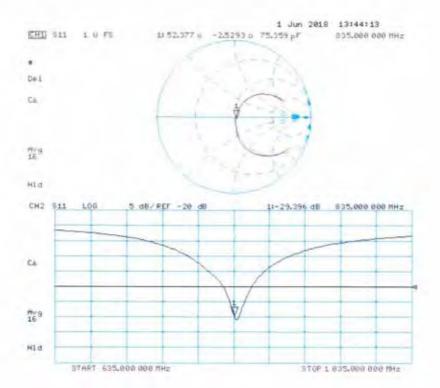
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Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL

Date: 01.06.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:490

Communication System: UID 0 - CW; Frequency: 835 MHz

Medium parameters used: f = 835 MHz; $\sigma = 0.99$ S/n; $\varepsilon_r = 54.6$; $\rho = 1000$ kg/m

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(10.05, 10.05, 10.05) @ 835 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10,2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 61.08 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 3.64 W/kg SAR(1 m) = 2.45 W/m; SAR(10 m) = 1.6 W/m

SAR(1 g) = 2.45 W/kg; SAR(10 g) = 1.6 W/kgMaximum value of SAR (measured) = 3.25 W/kg



0 dB = 3.25 W/kg = 5.12 dBW/kg

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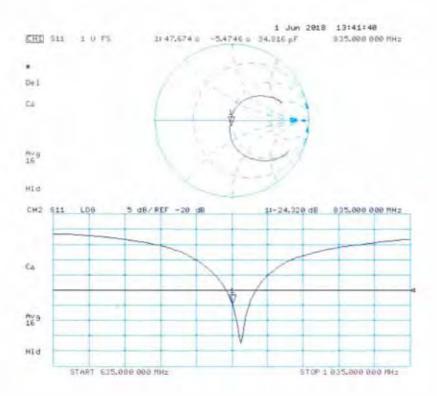
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Impedance Measurement Plot for Body TSL



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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

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS)

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SGS Korea (Dymstec)

No. D1750V2-1070 Jul18

CALIBRATION	ERTIFICAT	E	
Object	D1750V2 - SN:1	070	Pia = gl
Calibration procedure(s)	QA CAL-05.v10 Calibration proce	edure for dipole validation kits ab	ove 700 MHz
Calibration date:	July 20, 2018		
The measurements and the uncert	tainties with confidence p ed in the closed laborato	tional standards, which realize the physical ur probability are given on the following pages ar ary facility, environment temperature (22 ± 3)*	nd are part of the certificate.
Primary Standards	ID*	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN 104778	04-Apr-18 (No. 217-02672/02673)	Apr 19
Power sensor NRP-291	5N: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Reference 20 dB Attenuator			
Reference 20 dB Attenuation Type-N mismatch combination	The second secon	D4-Apr-18 (No. 217-02683)	
Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	SN: 5047.2 / 06327 SN: 7349	04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349, Dec17)	Apr+16
Type-N mismatch combination Reference Probe EX3DV4	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17)	
Type-N mismatch combination	SN: 5047.2 / 06327 SN: 7349	30-Dec-17 (No. EX3-7349_Dec17)	Apr-16 Dec-18
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A	SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704	30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17)	Apr-19 Dec-18 Oct-18
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A	SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783	30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house)	Apr-19 Dec-18 Oct-18 Scheduled Check
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A	SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317	30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16)	Apr-19 Dec-18 Det-18 Scheduled Check In house check: Oct-18
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 5047.2 / 06327 SN: 7349 SN: 801 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972	30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16)	Apr-19 Dec-18 Det-18 Scheduled Check In house check: Oct-18 In house check: Oct-18
Type-N mismatch combination Fielerunce Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317	30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	Apr-19 Dec-18 Det-18 Scheduled Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
Type-N mismatch combination Fielerunce Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agitent E8358A	SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US41080477 Name	30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 21-Mar-14 (in house check Oct-17) Function	Apr-19 Dec-18 Det-18 Scheduled Check In house check: Det-18 In house check: Det-18 In house check: Det-18 In house check: Oct-18 In house check: Oct-18
Type-N mismaich combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A	SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US41080477	30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16)	Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18
Type-N mamaich combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A Calibrated by:	SN: 5047.2 / 06327 SN: 7349 SN: 801 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US41080477 Name Manu Saitz	30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 31-Mar-14 (in house check Oct-17) Function Laboratory Technician	Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US41080477 Name	30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 21-Mar-14 (in house check Oct-17) Function	Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18

Certificate No: D1750V2-1070_Jul18

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F690501/RF-SAR002774 Report File No:

Date of Issue: 2019-07-15 (All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and

accessible at http://www.sgs.com/en/Terms-and-Conditions.aspx.) RTT5041-76(2015.10.01) (2)

A4 (210mm x 297mm)



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Calibration Laboratory of

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Accreditation No.: SCS 0108

According by the Swas According 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 Techniques¹, 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 leed 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
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Certificate No: D1750V2-1070 Juli8

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Report File No: F690501/RF-SAR002774 Date of Issue: 2019-07-15 (All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and accessible at http://www.sgs.com/en/Terms-and-Conditions.aspx.)



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Measurement Conditions

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

DASY5	V52.10.1
Advanced Extrapolation	
Modular Flat Phantom	
10 mm	with Spacer
dx, dy, dz = 5 mm	
1750 MHz ± 1 MHz	
	Advanced Extrapolation Modular Flat Phantom 10 mm dx, dy, dz = 5 mm

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22,0 °C	40.1	1.37 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	39.0 ± 6 %	1.34 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	****	

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	8.95 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	36.1 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	4.72 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	19.0 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	53.4	1.49 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.7 ± 6 %	1.46 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	8.91 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	36.1 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	4.77 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	19.3 W/kg ± 16.5 % (k=2)

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.9 Ω + 1.0 jΩ
Return Loss	- 33.8 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$47.5 \Omega + 0.6 \Omega$	
Return Loss	- 31.7 dB	

General Antenna Parameters and Design

Electrical Delay (one direction)	1.223 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.

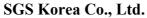
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG	
Manufactured on	June 15, 2010	

Certificate No: D1750V2-1070_Jul18

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DASY5 Validation Report for Head TSL

Date: 20.07.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1070

Communication System: UID 0 - CW; Frequency: 1750 MHz

Medium parameters used: f = 1750 MHz; $\sigma = 1.34 \text{ S/m}$; $\varepsilon_r = 39$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.5, 8.5, 8.5) @ 1750 MHz; Calibrated: 30.12.2017
- · Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics; DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

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 = 106.8 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 16.4 W/kg

SAR(1 g) = 8.95 W/kg; SAR(10 g) = 4.72 W/kgMaximum value of SAR (measured) = 13.8 W/kg



0 dB = 13.8 W/kg = 11.40 dBW/kg

Gertificate No: D1750V2-1070_Jul18

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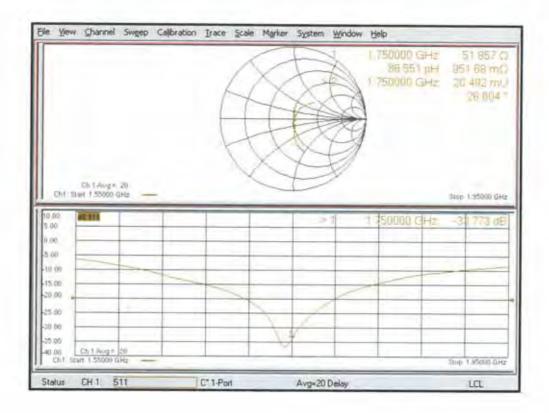
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Impedance Measurement Plot for Head TSL



Certificate No: D1750V2-1070_Jul18

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DASY5 Validation Report for Body TSL

Date: 20.07,2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1070

Communication System: UID 0 - CW; Frequency: 1750 MHz

Medium parameters used: f = 1750 MHz; $\sigma = 1.46$ S/m; $\varepsilon_r = 53.7$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

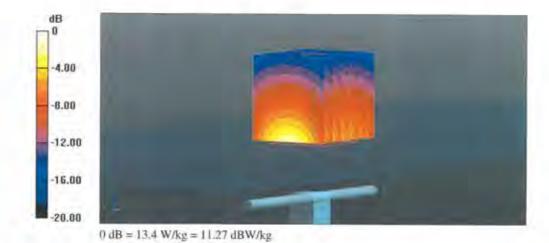
DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.35, 8.35, 8.35) @ 1750 MHz; Calibrated: 30.12.2017
- · Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
 - Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
 - DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 101.4 V/m; Power Drift = -0.04 dB Peak SAR (extrapolated) = 15.5 W/kg

SAR(1 g) = 8.91 W/kg; SAR(10 g) = 4.77 W/kgMaximum value of SAR (measured) = 13.4 W/kg



Certificate No: D1750V2-1070 Jul18

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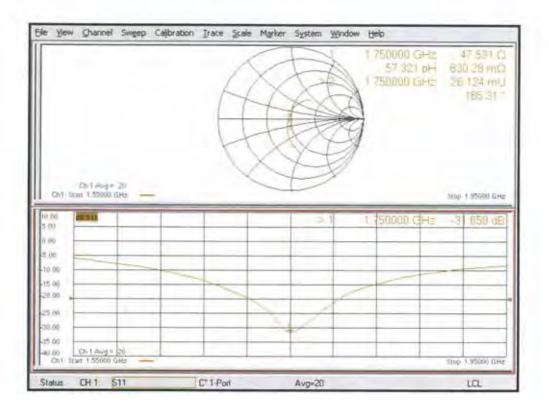
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Impedance Measurement Plot for Body TSL



Certificate No: D1750V2-1070_Jul18

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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

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS)

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

SGS Korea (Dymstec)

Certificate No: D1900V2-5d033 May18

Object	D1900V2 - SN:5	d033	2년 박감
Calibration procedurers)	QA CAL-05.v10 Calibration proce	edure for dipole validation kits abo	ove 700 MHz
Calibration date:	May 28, 2018		
The measurements and the unor	ortaintles with confidence p	sonal standards, which realize the physical un probability are given on the following pages ar any facility: environment temperature (22 ± 3) ¹	nd are part of the certificate.
Calbration Equipment used (M&		ny taoniny aniversiment temperature (cz ± 3)	C and numberly < 70%
Primary Standards	(D.4	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-18 (No. 217-02672/02673)	Apr-19
and the second second	SN 103244	04-Apr-18 (No. 217-02672)	Apr-19
ower sensor NRP-Z91			
Annual State of the State of th	SN: 103245	04-Apr-18 (No. 217-02673)	
ower sensor NRP-Z91	200	04-Apr-18 (No. 217-02673)	Apr-19
Power sensor NRP-Z91 Reference 20 dB Attenuator	SN: 103245		
Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination	SN: 103245 SN: 5058 (20k)	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683)	Apr-19 Apr-19 Apr-19
Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismittch combination Reference Probe EX3DV4	SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682)	Apr-19 Apr-19
Pawer sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismilitch combination Reference Probe EX3DV4 DAE4	SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-801_Oct17)	Apr-19 Apr-19 Apr-19 Dec-18 Oct-18
Power sensor NRP-291 Reference 20 dB Attenuator Type-N mismilitch combination Reference Probe EX3DV4 DAE4 Secondary Standards	SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7340 SN: 601	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-801_Oct17) Chock Date (In house)	Apr-19 Apr-19 Apr-19 Dec-18 Oct-18 Scheduled Check
Power sensor NRP-291 Reference 20 dB Attenuator Type-N mismitich combination Reference Probe EX3DV4 DAE4 Secondary Standards	SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-801_Oct17) Check Date (In house) 07-Oct-15 (in house check Oct-16)	Apr-19 Apr-19 Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18
Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A	SN: 103245 SN: 5058 (20k) SN: 5047 2 / 06327 SN: 7340 SN: 601	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-801_Oct17) Check Date (In house) 07-Oct-15 (In house check Oct-16) 07-Oct-15 (In house check Oct-16)	Apr-19 Apr-19 Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18
Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power mater EPM-442A Power sensor HP 8481A	SN: 103245 SN: 5058 (20k) SN: 5047 2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-801_Oct17) Check Date (In house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	Apr-19 Apr-19 Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A RF generator R&S SMT-06	SN: 103245 SN: 5058 (20k) SN: 5047 2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-801_Oct17) Check Date (In house) 07-Oct-15 (In house check Oct-16) 07-Oct-15 (In house check Oct-16)	Apr-19 Apr-19 Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18
Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A RF generator R&S SMT-06	SN: 103245 SN: 5058 (20k) SN: 5047 2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-801_Oct17) Check Date (In house) 07-Oct-15 (In house check Oct-16) 07-Oct-15 (In house check Oct-16) 17-Oct-15 (In house check Oct-16) 15-Jun-15 (In house check Oct-16) 18-Oct-01 (In house check Oct-17)	Apr-19 Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18
Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer HP 8753E	SN: 103245 SN: 5058 (20k) SN: 5047 2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: WY41092317 SN: 100972 SN: US37390586	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-17) Function	Apr-19 Apr-19 Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18
Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A RF generator R8.5 SMT-06 Network Analyzer HP 8753E	SN: 103245 SN: 5058 (20k) SN: 5047 2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390586	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-801_Oct17) Check Date (In house) 07-Oct-15 (In house check Oct-16) 07-Oct-15 (In house check Oct-16) 17-Oct-15 (In house check Oct-16) 15-Jun-15 (In house check Oct-16) 18-Oct-01 (In house check Oct-17)	Apr-19 Apr-19 Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18
Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismilich combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator HP 8753E Calibrated by	SN: 103245 SN: 5058 (20k) SN: 5047 2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390586 Name Manu Seitz	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Chock Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 17-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-17) Function Laboratory Technicien	Apr-19 Apr-19 Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18
Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismilitich combinition Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A RF generator H8 S SMT-06 Network Analyzer HP 8753E Calibrated by	SN: 103245 SN: 5058 (20k) SN: 5047 2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: WY41092317 SN: 100972 SN: US37390586	04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-17) Function	Apr-19 Apr-19 Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18

Certificate No: D1900V2-5d033_May18

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Report File No: F690501/RF-SAR002774



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Calibration Laboratory of

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





Schweizerlscher Kallbrierdienst Service suisse d'étalonnage Servizio avizzero di taratura Swiss Calibration Service

Accreditation No: SCS 0108

Accredited by the Swiss Accreditation Service (SAS).

The Swiss Accreditation Service is one of the signaturies 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 priented parallel to the body axis.
- Feed Point Impedance and Return Loss: These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay: One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Certificate No: D1900V2-5d033_May I 8

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Report File No: F690501/RF-SAR002774 Date of Issue: 2019-07-15 (All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and

accessible at http://www.sgs.com/en/Terms-and-Conditions.aspx.)



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Measurement Conditions

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

DASY Version	DASY5	V52.10.1
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	41.2 ± 6 %	1.35 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	int.	-

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.69 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	39.9 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.14 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	55.3 ± 6 %	1.46 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		****

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.81 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	40.5 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5,26 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.5 W/kg ± 16.5 % (k=2)

Certificate No: D1900V2-5d033_May18

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	$52.8 \Omega + 4.2 J\Omega$	
Return Loss	- 26.2 dB	

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.6 Ω + 3.3 jΩ
Return Loss	- 26.3 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.204 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
Manufactured on	March 17, 2003

Certificate No: D1900V2-5d033_May18

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DASY5 Validation Report for Head TSL

Date: 25.05.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d033

Communication System: UID 0 - CW; Frequency: 1900 MHz

Medium parameters used: f = 1900 MHz; $\sigma = 1.46 \text{ S/m}$; $\epsilon_f = 55.3$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63,19-2011)

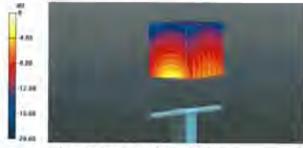
DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.15, 8.15, 8.15) @ 1900 MHz; Calibrated: 30.12.2017
- · Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 104.8 V/m; Power Drift = -0.05 dB Peak SAR (extrapolated) = 17.1 W/kg

SAR(1 g) = 9.81 W/kg; SAR(10 g) = 5.26 W/kgMaximum value of SAR (measured) = 14.7 W/kg



0 dB = 14.7 W/kg = 11.67 dBW/kg

Certificate No. D1900V2-5d033_May18

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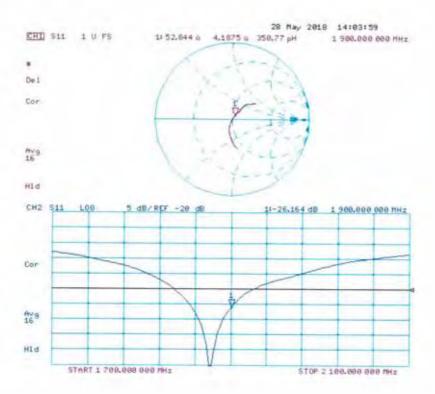
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Impedance Measurement Plot for Head TSL



Certificate No: D1900V2-5d033_May18

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Date: 25.05,2018

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Test Laboratory: SPEAG, Zurich, Switzerland

DASY5 Validation Report for Body TSL

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d033

Communication System: UID 0 - CW; Frequency: 1900 MHz.

Medium parameters used: f = 1900 MHz; $\sigma = 1.46$ S/m; $\epsilon_r = 55.3$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

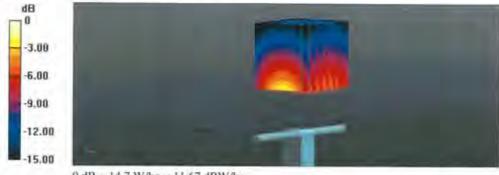
DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.15, 8.15, 8.15) @ 1900 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601: Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439).

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 104.8 V/m; Power Drift = -0.05 dB Peak SAR (extrapolated) = 17.1 W/kg

SAR(1 g) = 9.81 W/kg; SAR(10 g) = 5.26 W/kgMaximum value of SAR (measured) = 14.7 W/kg



0 dB = 14.7 W/kg = 11.67 dBW/kg

Certificate No: D1900V2-5d033_May18

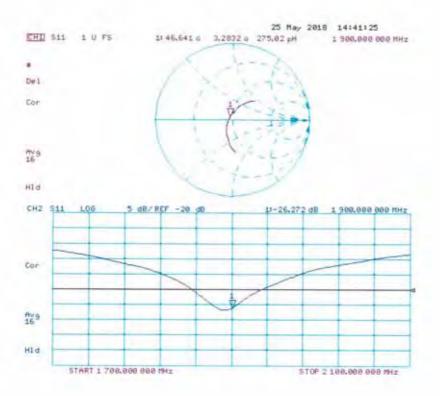
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Impedance Measurement Plot for Body TSL



Certificate No: D1900V2-5d033_May18

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Calibration Laboratory of

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





Schweizerischer Kalibrierdienst 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

Client SGS Korea (Dymstec)

Certificate No: D2450V2-734_May18

Disjoict	D2450V2 - SN:7	34	7(설 박당기
Gillibridion procedury(s)	QA CAL-05.v10 Calibration proce	dure for dipole validation kits abo	ove 700 MHz Just 6 /1
Gelibration date	May 30, 2018		
The measurements and the unce All calibrations have been conduc	stainties with confidence p	ional standards, which realize the physical un irobability are given on the following pages an ry facility: environment temperature (22 \pm 3)°C	d are part of the certificate
Calibration Equipment used (M&)	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Primary Standards Power meter NRP	SN 104778	D4-Apr-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	5N: 103944	D4-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr+19
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
	SN: 5047.2 / 06327	D4-Apr-18 (No. 217-02683)	Apr-19
	SN: 7349	30-Duc-17 (No. EX3-7349 Duc17)	Duc-18
Type-N mismatch combination		The part of the contract of th	
Type-N mismatch combination Reference Probe EX3DV4	SN: 801	26-Oct-17 (No. DAE4-601, Oct17)	Oct-18
Type-N mismatch combination Reference Probe EX3DV4 DAE4	811	26-Oct-17 (No DAE4-601 Oct17) Chock Date (in house)	Scheduled Check
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	SN: 601	And the second s	
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power mater EPM-442A	SN: 801	Check Date (in bouse)	Scheduled Check
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power mater EPM-442A Power sensor HP 8481A	SN: 801 ID # SN: GB37480704	Check Date (in house) 07-Oct-15 (ii) house check Oct-16)	Schedulind Check In house check: Oct-19
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A	SN: 801 ID # SN: GB:37480704 SN: US37292783	Chock Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-16 (in house-check Oct-16)	Scheduled Check In house check: Oct-18 In house check: Oct-18
Type-N mismatch combination Reference Probe EX3EV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 801 ID # SN: GB97480704 SN: US97290783 SN: MY41092317	Chock Date (in bouse) 07-Oct-15 (in house check Oct-16) 07-Oct-16 (in house-check Oct-16) 07-Oct-15 (in house check Oct-16)	Scheduled Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
Type-N mismatch combination Reference Probe EX3EV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 801 SN: GB37480704 SN: US37293783 SN: MY41092317 SN: 100972	Chock Date (in bouse) 07-Oct-15 (in house check Oct-16) 07-Oct-16 (in house-check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16)	Scheduled Check. In house check. Oct-18 In house check. Oct-18 In house check. Oct-18 In house check. Oct-18
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Prover sensor HP 8481A RF generator HP 8753E Calibrated by	SN: 801 ID # SN: GB37480704 SN: US37293783 SN: MY41092317 SN: 100972 SN: US37390585	Chock Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-17)	Scheduled Check. In house check. Oct-18
Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator H&S SMT-06 Network Analyzer HP 8753E	SN: 801 SN: GB:07480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390585	Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-17) Function	Scheduled Check. In house check. Oct-18

Certificate No: D2450V2-734_May18

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Report File No: F690501/RF-SAR002774 2019-07-15 Date of Issue: (All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and

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http://www.sgsgroup.kr

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Engineering AG
Zeughausstrasse 42, 8004 Zurich, Switzenmil





S Schweizerischer Kallbrierdier Service aulaue d'atalonnage Servizio svizzen di landura S Swiss Calibration Service

Accreditation No.: SCS 0108

Accredited by the Swee Accreditation Service (SAS)

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

Glossary

TSL

tissue simulating liquid

ConvF N/A sensitivity in TSL / NORM x.y.z not applicable or not measured

Calibration is Performed According to the Following Standards:

 IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013

 b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016

c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010

d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- Measurement Conditions: Further details are available from the Validation Report at the end
 of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL. The dipole is mounted with the spacer to position its feed
 point exactly below the center marking of the flat phantom section, with the arms oriented
 parallel to the body axis.
- Feed Point Impedance and Return Loss: These parameters are measured with the dipole
 positioned under the liquid filled phantom. The impedance stated is transformed from the
 measurement at the SMA connector to the feed point. The Return Loss ensures low
 reflected power. No uncertainty required.
- Electrical Delay: One-way delay between the SMA connector and the antenna feed point.
 No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Certificate No: D2450V2-73= May18

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Report File No: F690501/RF-SAR002774 Date of Issue: 2019-07-15 (All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and accessible at http://www.sgs.com/en/Terms-and-Conditions.aspx.)



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Measurement Conditions

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

DASY Version	DASY5	V52.10.1
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22,0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38,2 ± 6 %	1.85 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	jee-)111-

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13,1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	51.4 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.08 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.0 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 mha/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	52.3 ± 6 %	1,99 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	in.	j. +++j

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.5 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	49.4 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.86 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.3 W/kg ± 16.5 % (k=2)

Certificate No: D2450V2-734_May18

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	$54.8 \Omega + 9.2 j\Omega$
Return Loss	- 20.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.1 \(\Omega\) + 8.6 \(\omega\) i 2	
Return Loss	- 21.3 dB	

General Antenna Parameters and Design

Electrical Delay (one direction)	1.152 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 teedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	May 07, 2003

Certificate No: D2450V2-734_May18

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Report File No: F690501/RF-SAR002774 Date of Issue: 2019-07-15 (All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and accessible at http://www.sgs.com/en/Terms-and-Conditions.aspx.)

RTT5041-76(2015.10.01) (2)

A4 (210mm x 297mm)

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DASY5 Validation Report for Head TSL

Date: 30,05,2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:734

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: f = 2450 MHz; $\sigma = 1.85 \text{ S/m}$; $r_e = 38.2$; $p = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

Measurement Standard; DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.88, 7.88, 7.88) @ 2450 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

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 = 115.5 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 25.8 W/kg

SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.08 W/kg

Maximum value of SAR (measured) = 21.4 W/kg



Certificate No: D2450V2-734_May18

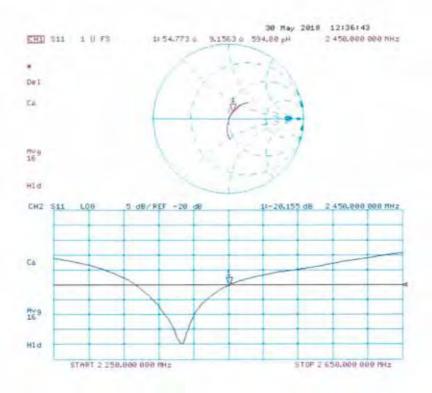
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Impedance Measurement Plot for Head TSL



Certificate No: D2450V2-734_May18

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DASY5 Validation Report for Body TSL

Date: 29.05,2018

Page: 142/166

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:734

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: f = 2450 MHz: $\sigma = 1.99 \text{ S/m}$; $\epsilon_r = 52.3$; $\rho = 1000 \text{ kg/m}^2$

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

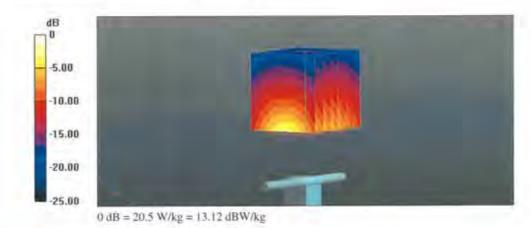
- Probe: EX3DV4 SN7349; ConvF(8,01, 8.01, 8.01) @ 2450 MHz; Calibrated: 30.12,2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 107.3 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 24.6 W/kg

SAR(1 g) = 12.5 W/kg; SAR(10 g) = 5.86 W/kg

Maximum value of SAR (measured) = 20.5 W/kg



Certificate No: D2450V2-734_May18

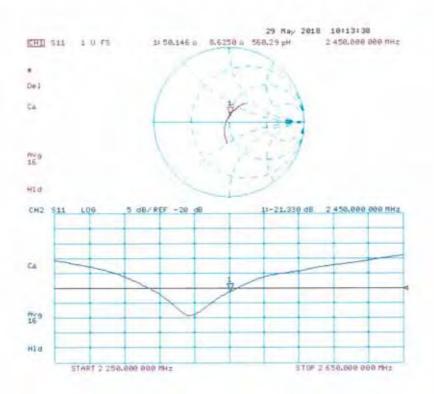
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Impedance Measurement Plot for Body TSL



Certificate No: D2450V2-734_May18

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Accreditation No.: SCS 0108

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SGS Korea (Dymstec)

Certificate No: D2600V2-1124_Jul18



Certificate No: D2600V2-1124_Jul18

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Report File No: F690501/RF-SAR002774

Date of Issue: 2019-07-15 (All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and accessible at http://www.sgs.com/en/Terms-and-Conditions.aspx.)



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Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland





S Schweizerlscher Källbrierdienet
C Service aulsse d'étalonnage
Servizio svizzero di saratura
S Swiss Calibration Service

Accreditation No.: SCS 0108

According by the Swiss According to 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 N/A sensitivity in TSL / NORM x,y,z 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
- iEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- Measurement Conditions: Further details are available from the Validation Report at the end
 of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The dipole is mounted with the spacer to position its feed
 point exactly below the center marking of the flat phantom section, with the arms oriented
 parallel to the body axis.
- Feed Point Impedance and Return Loss: These parameters are measured with the dipole
 positioned under the liquid filled phantom. The impedance stated is transformed from the
 measurement at the SMA connector to the feed point. The Return Loss ensures low
 reflected power. No uncertainty required.
- Electrical Delay: One-way delay between the SMA connector and the antenna feed point.
 No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Certificate No: D2600V2-1124_Jul18

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Measurement Conditions

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

DASY Version	DASY5	V52.10.1
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	37.2 ± 6 %	2.02 mha/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	int.	Times .

SAR result with Head TSL

SAR averaged over 1 cm3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.2 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	55.4 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm3 (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

	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	51.5 ± 6 %	2.20 mha/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		-

SAR result with Body TSL

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.8 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	54.5 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.16 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.5 W/kg ± 16.5 % (k=2)

Certificate No: D2600V2-1124_Jul18

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.1 Ω - 7.1 μΩ
Return Loss	- 22,9 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.1 Ω - 5.2 jΩ	
Return Loss	- 23.5 dB	

General Antenna Parameters and Design

52 ns
15

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 on	October 22, 2015	

Certificate No: D2600V2-1124_Jul18

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DASY5 Validation Report for Head TSL

Date: 26.07.2018

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Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1124

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used: f = 2600 MHz; $\sigma = 2.02 \text{ S/m}$; $\varepsilon_r = 37.2$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63:19-2011)

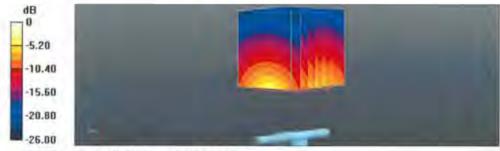
DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.7, 7.7, 7.7) @ 2600 MHz; Calibrated; 30.12.2017
- · Sensor-Surface: L4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439).

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 = 118.4 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 28.3 W/kg

SAR(1 g) = 14.2 W/kg; SAR(10 g) = 6.34 W/kgMaximum value of SAR (measured) = 23.5 W/kg



0 dB = 23.5 W/kg = 13.71 dBW/kg

Certificate No: D2600V2-1124_Jul18

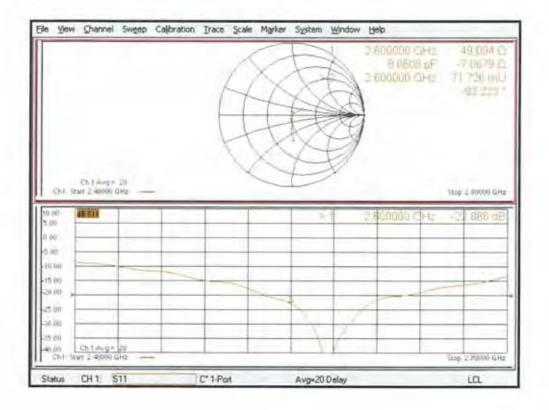
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Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL

Date: 26.07.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1124

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used: f = 2600 MHz; $\sigma = 2.2 \text{ S/m}$; $\varepsilon_r = 51.5$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

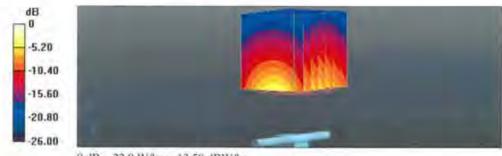
DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.81, 7.81, 7.81) @ 2600 MHz; Calibrated: 30.12.2017
- Sensor-Surface: L4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 108.2 V/m; Power Drift = -0.08 dB Peak SAR (extrapolated) = 27.8 W/kg

SAR(1 g) = 13.8 W/kg; SAR(10 g) = 6.16 W/kgMaximum value of SAR (measured) = 22.8 W/kg



0 dB = 22.8 W/kg = 13.58 dBW/kg

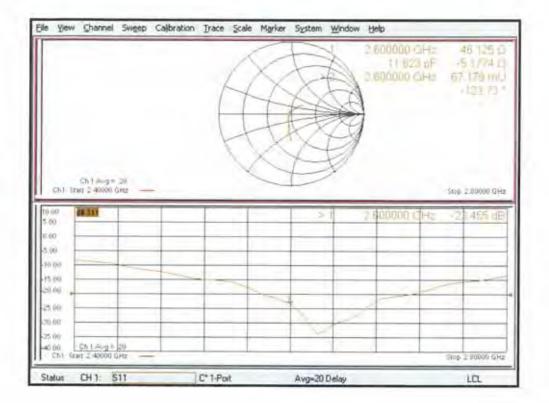
Certificate No: D2600V2-1124_Jul18

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Impedance Measurement Plot for Body TSL



Certificate No: D2600V2-1124_Jul18

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Report File No: F690501/RF-SAR002774 Date of Issue: 2019-07-15 (All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and accessible at http://www.sgs.com/en/Terms-and-Conditions.aspx.)

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





Schweizerischer Kalibrierdienst Service suisse d'étalonnage C 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

SGS Korea (Dymstec)

Certificate No: D5GHzV2-1106_Feb19/2

ALIDITATION	ENTIFICATI	E (Replacement of No: D5G	mzvz-1100_ren19)
Object	D5GHzV2 - SN:1106		
Calibration procedum(s)	QA CAL-22.v4		100
	Gallbration Proce	edure for SAR Validation Source	es between 3-6 GHz = 7 3 5
Calibration date	February 04, 201	19	
This calibration certificate docume	ints the tracesbilly to nat	ional standards, which realize the physical c	units of measurements (SI)
he measurements and the uncer	tainties with confidence p	probability are given on the following pages :	and are perf of the certificate.
W. in Durations from book and and	led in the place of late of the	as facilities and comment to make the same	Of and boundary - 700
ill calibrations have been canduct	led in the closell laborato	ry facility: environment temperature (22 ± 3)	C and humidity < 70%
Calibration Equipment used (M&T)	E critical for calibration)		
rimary Standards	in a	Cal Date (Certificate No.)	Scheduled Calibration
ower mater NRP	SN: 104778	04-Apr-18 (No. 217-02672/02673)	Apr-19
ower sensor NRP-Z9T	5N: 103244	04-Apr-T8 (No. 217-02672)	Apr-19
ower sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Agr-19
ype-N mismatch combination	5N: 5047.2 / 08327	04-Apr-18 (No. 217-02683)	Apr-19
Reference Probe EX3DV4	SN: 3503	31-Dec-18 (No. EX3-3503, Dec18)	Dec-19
DAE4	SN: 601	04-Oct-18 (No. DAE4-601_Oct18)	Oct-19
Secondary Standards	ib «	Check Date (in house)	Scheduled Check
Power meter E4419B	SN GB41293874	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
ower sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
ower sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	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
letwork Analyzer Agilient EB35EA	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19
	Name	Function	Signature
alibrated by	Manu Seitz	Laboratory Technician	-
			great .
			0
approved by	Katja Pokovic	Technical Manager	ASSET.

Certificate No: D5GHzV2-1106_Feb19/2

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Calibration Laboratory of

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





Schweizerleicher Kallbrierdienst Service suisse d'étalonnage Servizio svizzero di tareture Swiss Calibration Service

Accreditation No.: SCS 0108

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Glossary:

TSL tissue simulating liquid

ConvF sensitivity in TSL / NORM x,y,z N/A not applicable or not measured

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013

b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016

 EC 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.
- Anlenna 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 leed 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
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

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Measurement Conditions

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

DASY Version	DASY5	V52,10,2
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 5300 MHz ± 1 MHz 5500 MHz ± 1 MHz 5600 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	36.8 ± 6 %	4.49 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	Sec.	

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.12 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81,5 W/kg ± 19,9 % (k=2)

SAR averaged over 10 cm3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.32 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.3 W/kg ± 19.5 % (k=2)

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Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.6 ± 6 %	4.59 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	****	

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.24 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	82.6 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm3 (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	23.7 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.4 ± 6 %	4.80 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	i ne c	4-5-

SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.60 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	86.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.43 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.4 W/kg ± 19.5 % (k=2)

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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	36.2 ± 6 %	4.90 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		nee'

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8,48 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	85.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.2 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5800 MHz

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	35.9 ± 6 %	5.11 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	8008	

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm ¹ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.12 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.0 W/kg ± 19.5 % (k=2)

Certificate No: D5GHzV2-1106_Feb19/2

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Body TSL parameters at 5200 MHz

	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	47.3 ± 6 %	5.36 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	Time.	

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.44 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.9 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.09 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.7 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5300 MHz

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.1 ± 6 %	5.49 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL at 5300 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.57 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	75.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (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	21.0 W/kg ± 19.5 % (k=2)

Certificate No: D5GHzV2-1106_Feb19/2

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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	46.6 ± 6 %	5.90 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	(neer	

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.09 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	80.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.26 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	22.4 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	46.3 ± 6 %	6.18 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		ini

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.63 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	75.8 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm3 (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	21.0 W/kg ± 19.5 % (k=2)

Certificate No: D5GHzV2-1106_Feb19/2

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	$46.5 \Omega + 8.5 j\Omega$
Return Loss	- 20.4 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	49,1 Ω + 2.8]Ω	
Return Loss	- 30.4 dB	

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	52.9 Ω + 5.8 jΩ
Return Loss	- 24.1 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	$45.3 \Omega + 3.7 j\Omega$
Return Loss	- 24.1 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	$47.5 \Omega - 1.1 J\Omega$	
Return Loss	- 31.1 dB	

Certificate No: D5GHzV2-1106_Feb19/2

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Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	50.9 Ω - 10.1 jΩ	
Return Loss	- 20.0 dB	

Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	51.1 Ω - 1.6 jΩ	
Return Loss	- 34.2 dB	

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	57.6 Ω - 4.3 Ω	
Return Loss	- 21.8 dB	

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	54.3 Ω - 0.3 jΩ	
Return Loss	- 27.6 dB	

General Antenna Parameters and Design

Electrical Delay (one direction)	1.198 ns

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

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

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

Additional EUT Data

		-
Manufactured by	SPEAG	

Certificate No: D5GHzV2-1106_Feb19/2

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DASY5 Validation Report for Head TSL

Date: 04.02.2019

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Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1106

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500

MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: f = 5200 MHz; $\sigma = 4.49 \text{ S/m}$; $\varepsilon_f = 36.8$; $\rho = 1000 \text{ kg/m}^3$.

Medium parameters used: f = 5300 MHz; $\sigma = 4.59 \text{ S/m}$; $\varepsilon_r = 36.6$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: f = 5500 MHz; $\sigma = 4.8$ S/m; $\epsilon_r = 36.4$; $\rho = 1000$ kg/m³,

Medium parameters used: f = 5600 MHz; $\sigma = 4.9 \text{ S/m}$; $\epsilon_r = 36.2$; $\rho = 1000 \text{ kg/m}^3$.

Medium parameters used: f = 5800 MHz; $\sigma = 5.11$ S/m; $\varepsilon_r = 35.9$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.69, 5.69, 5.69) @ 5200 MHz, ConvF(5.45, 5.45, 5.45) @ 5300 MHz, ConvF(5.15, 5.15, 5.15) @ 5500 MHz, ConvF(5, 5, 5) @ 5600 MHz, ConvF(4.96, 4.96, 4.96) @ 5800 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=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 = 78.64 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 29.2 W/kg

SAR(1 g) = 8.12 W/kg; SAR(10 g) = 2.32 W/kg

Maximum value of SAR (measured) = 18.9 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 75.73 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 29.4 W/kg

SAR(1 g) = 8.24 W/kg; SAR(10 g) = 2.36 W/kg

Maximum value of SAR (measured) = 19.3 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 75.46 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 33.8 W/kg

SAR(1 g) = 8.6 W/kg; SAR(10 g) = 2.43 W/kg

Certificate No: D5GHzV2-1106_Feb19/2

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RTT5041-76(2015.10.01) (2)

A4 (210mm x 297mm)



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Maximum value of SAR (measured) = 20.7 W/kg

Maximum value of SAR (measured) = 20.4 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 = 75.80 V/m; Power Drift = 0.03 dB

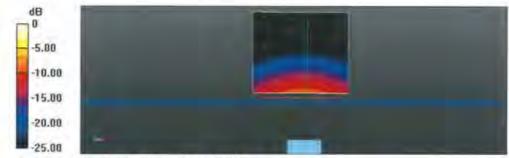
Peak SAR (extrapolated) = 32.1 W/kg

SAR(1 g) = 8.48 W/kg; SAR(10 g) = 2.41 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 = 73.16 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 32.8 W/kg SAR(1 g) = 8.12 W/kg; SAR(10 g) = 2.29 W/kg

Maximum value of SAR (measured) = 20.0 W/kg



0 dB = 20.0 W/kg = 13.01 dBW/kg

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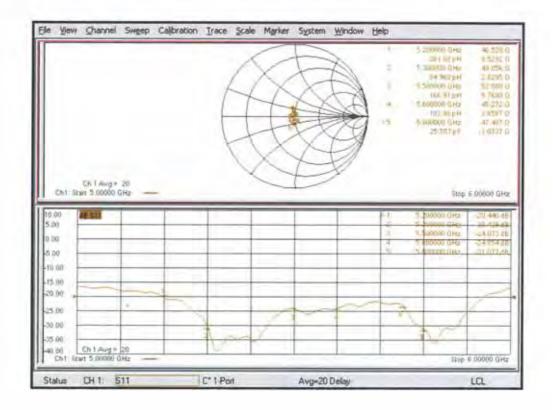
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Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL

Date: 31.01,2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1106

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5600

MHz, Frequency: 5800 MHz

Medium parameters used: f = 5200 MHz; $\sigma = 5.36 \text{ S/m}$; $\varepsilon_r = 47.3$; $\rho = 1000 \text{ kg/m}^3$.

Medium parameters used: f = 5300 MHz; $\sigma = 5.49$ S/m; $\varepsilon_r = 47.1$; $\rho = 1000$ kg/m³,

Medium parameters used: f = 5600 MHz; $\sigma = 5.9$ S/m; $\varepsilon_r = 46.6$; $\rho = 1000$ kg/m³.

Medium parameters used: f = 5800 MHz; $\sigma = 6.18 \text{ S/m}$; $\varepsilon_r = 46.3$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.24, 5.24, 5.24) @ 5200 MHz, ConvF(5.2, 5.2, 5.2) @ 5300 MHz, ConvF(4.7, 4.7, 4.7) @ 5600 MHz, ConvF(4.58, 4.58, 4.58) @ 5800 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=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 = 67.86 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 28.1 W/kg

SAR(1 g) = 7.44 W/kg; SAR(10 g) = 2.09 W/kg

Maximum value of SAR (measured) = 17.3 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 67.93 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 29.8 W/kg

SAR(1 g) = 7.57 W/kg; SAR(10 g) = 2.12 W/kg

Maximum value of SAR (measured) = 17.9 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 = 68.18 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 34.6 W/kg

SAR(1 g) = 8.09 W/kg; SAR(10 g) = 2.26 W/kg

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

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RTT5041-76(2015.10.01) (2)

A4 (210mm x 297mm)

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Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan,

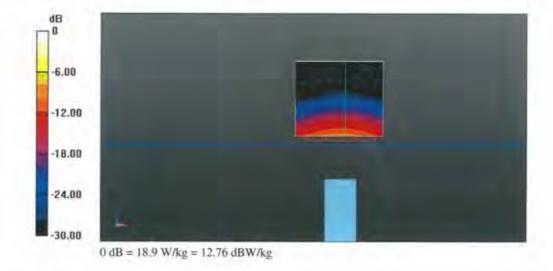
dist=1.4mm (8x8x7)/Cube 0; Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 66.14 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 33.9 W/kg

SAR(1 g) = 7.63 W/kg; SAR(10 g) = 2.12 W/kg

Maximum value of SAR (measured) = 18.9 W/kg



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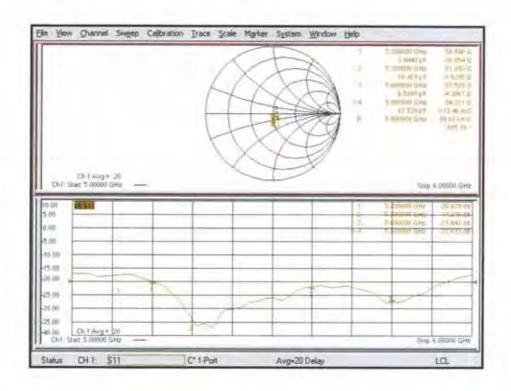
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Impedance Measurement Plot for Body TSL



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-THE END-

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