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# **Appendix C**

# **Phantom Description**

Schmid & Partner Engineering AG

a

Zeughausstrasse 43, 8004 Zurich, Switzerland Phone +41 44 245 9700, Fax +41 44 245 9779 info@speag.com, http://www.speag.com

#### Certificate of Conformity / First Article Inspection

Item	Oval Flat Phantom ELI 5.0			
Type No	QD OVA 002 A			
Series No	1108 and higher			
Manufacturer Untersee Composites Knebelstrasse 8, CH-8268 Mannenbach, Switzerland				

Complete tests were made on the prototype units QD OVA 001 A, pre-series units QD OVA 001 B as well as on some series units QD OVA 001 B. Some tests are made on all series units QD OVA 002 A.

Test	Requirement	Details	Units tested
Shape	Internal dimensions, depth and sagging are compatible with standards	Bottom elliptical 600 x 400 mm, Depth 190 mm, dimension compliant with [1] for f > 375 MHz	Prototypes
Material thickness Bottom:		dimension compliant with [3] for f > 800 MHz	all
Material rel. permittivity 2 − 5, loss tangent ≤ 0.05, at f ≤ 6 GHz		rel. permittivity 3.5 +/- 0.5 loss tangent ≤ 0.05	Material samples
Material Compatibility with tissue simulating liquids .		Compatible with SPEAG liquids. **	Phantoms, Material sample
Sagging	Sagging of the flat section in tolerance when filled with tissue simulating liquid.	within tolerance for filling height up to 155 mm	Prototypes, samples

Note: Compatibility restrictions apply certain liquid components mentioned in the standard, containing e.g. DGBE, DGMHE or Triton X-100. Observe technical note on material compatibility.

- [1] OET Bulletin 65, Supplement C, "Evaluating Compliance with FCC Guidelines for Human Exposure
- to Radiofrequency Electromagnetic Fields\*, Edition 01-01
  IEEE 1528-2003, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques, December 2003
- [3] IEC 62209-1 ed1.0, "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices Human models, instrumentation, and procedures Part 1:
- Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)\*, 2005-02-18 IEC 62209–2 ed1.0, "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices Human models, instrumentation, and procedures Part 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)<sup>a</sup>, 2010-03-30

Based on the sample tests above, we certify that this item is in compliance with the uncertainty requirements of body-worn SAR measurements and system performance checks as specified in [1 – 4] and further standards

25.7.2011

Signature / Stamp

Doc No 881 - QD OVA 002 A - A

Unless otherwise stated the results shown in this test report refer only to the sample(s) tested and such sample(s) are retained for 90 days only.

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# **System Validation from Original Equipment Supplier**

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





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

SGS-TW (Auden)

Certificate No: D2450V2-727\_Apr20

Calibration procedure(s)  QA CAL-05.v11 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz  Calibration date:  April 22, 2020  Chis calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate. All calibrations have been conducted in the closed faboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.  Calibration Equipment used (M&TE critical for calibration)  Primary Standards  ID # Cal Date (Certificate No.) Scheduled Calibration  Primary Standards  ID # Cal Date (Certificate No.) Scheduled Calibration  Primary Standards  ID # Cal Date (Certificate No.) Apr-21  Scheduled Calibration  Scheduled Calibration  Apr-21  SN: 103244 01-Apr-20 (No. 217-03100) Apr-21  SN: 103245 01-Apr-20 (No. 217-03100) Apr-21  Reference 20 dB Attenuator SN: BH9394 (20k) 31-Mar-20 (No. 217-03100) Apr-21  Reference Probe EX3DV4 SN: 310982 / 06327 31-Mar-20 (No. 217-03104) Apr-21  SN: 601 27-Dec-19 (No. DAE4-601_Dec19) Dec-20  Secondary Standards  ID # Check Date (in house) Scheduled Check  Power sensor HP 8481A SN: US37292783 07-Oct-14 (in house check Feb-19) In house check: Oct-18  SN: 100972 15-Jun-15 (in house check Oct-18) In house check: Oct-18  Reference Probe EX3SNAT-06 SN: 100972 15-Jun-15 (in house check Oct-18) In house check: Oct-18  Name Function Signature  Jeffrey Katzman Laboratory Technician		ERTIFICATE		
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz  Calibration date: April 22, 2020  This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate. All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.  Calibration Equipment used (M&TE critical for calibration)  Primary Standards    D #	Object	D2450V2 - SN:72	27	
This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.  All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.  Calibration Equipment used (M&TE critical for calibration)  Primary Standards  ID # Cal Date (Certificate No.) Scheduled Calibration  Power meter NRP  SN: 104778	Calibration procedure(s)		dure for SAR Validation Sources	between 0.7-3 GHz
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.  All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.  Calibration Equipment used (M&TE critical for calibration)  Primary Standards  ID # Cal Date (Certificate No.) Scheduled Calibration  Power meter NRP  SN: 104778 01-Apr-20 (No. 217-03100/03101) Apr-21  Power sensor NRP-Z91 SN: 103244 01-Apr-20 (No. 217-03100) Apr-21  Power sensor NRP-Z91 SN: 103245 01-Apr-20 (No. 217-03101) Apr-21  Reference 20 dB Attenuator SN: BH9394 (20k) 31-Mar-20 (No. 217-03106) Apr-21  Type-N mismatch combination SN: 310982 / 06327 31-Mar-20 (No. 217-03104) Apr-21  Reference Probe EX3DV4 SN: 7349 31-Dec-19 (No. EX3-7349_Dec19) Dec-20  DAE4 SN: 601 27-Dec-19 (No. DAE4-601_Dec19) Dec-20  Secondary Standards  ID # Check Date (in house) Scheduled Check  Power meter E4419B SN: GB39512475 30-Oct-14 (in house check Feb-19) In house check: Oct-1  Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-1  RF generator R&S SMT-06 SN: 100972 15-Jun-15 (in house check Oct-18) In house check: Oct-1  Reference Probe EX358A SN: US41080477 31-Mar-14 (in house check Oct-19) In house check: Oct-1  Name Function Signature  Calibrated by: Jeffrey Katzman Laboratory Technician	Calibration date:	April 22, 2020		
Primary Standards	The measurements and the uncertainty	ainties with confidence p	robability are given on the following pages an	nd are part of the certificate.
Power meter NRP	Calibration Equipment used (M&TE	Ecritical for calibration)		
Power sensor NRP-Z91	Primary Standards	ID#	Cal Date (Certificate No.)	Scheduled Calibration
SN: 103245   O1-Apr-20 (No. 217-03101)   Apr-21	Power meter NRP	SN: 104778	01-Apr-20 (No. 217-03100/03101)	Apr-21
SN: BH9394 (20k)   31-Mar-20 (No. 217-03106)   Apr-21	Power sensor NRP-Z91	SN: 103244	01-Apr-20 (No. 217-03100)	Apr-21
SN: 310982 / 06327   31-Mar-20 (No. 217-03104)   Apr-21	ONDD 704	SN: 103245	01-Apr-20 (No. 217-03101)	Apr-21
Secondary Standards	Power sensor NRP-Z91	SN: BH9394 (20k)	31-Mar-20 (No. 217-03106)	Apr-21
SN: 601   27-Dec-19 (No. DAE4-601_Dec19)   Dec-20	Carles and applications and a	See Brigger (Easily		
Secondary Standards  ID # Check Date (in house)  Scheduled Check  Power meter E4419B  SN: GB39512475  SN: US37292783  O7-Oct-14 (in house check Feb-19)  In house check: Oct-19  Power sensor HP 8481A  SN: W337292783  O7-Oct-15 (in house check Oct-18)  In house check: Oct-19  In house check: Oct	Reference 20 dB Attenuator		31-Mar-20 (No. 217-03104)	Apr-21
Power meter E4419B SN: GB39512475 30-Oct-14 (in house check Feb-19) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: MY41092317 07-Oct-15 (in house check Oct-18) In house check: Oct-18 Power sensor HP 8481A SN: MY41092317 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-19 Power sensor HP 8481A SN: US372927978	Reference 20 dB Attenuator Type-N mismatch combination	SN: 310982 / 06327		1.6.00
Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct- Power sensor HP 8481A SN: MY41092317 07-Oct-15 (in house check Oct-18) In house check: Oct- RF generator R&S SMT-06 SN: 100972 15-Jun-15 (in house check Oct-18) In house check: Oct- Network Analyzer Agilent E8358A SN: US41080477 31-Mar-14 (in house check Oct-19) In house check: Oct- Name Function Signature Calibrated by: Jeffrey Katzman Laboratory Technician	Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	SN: 310982 / 06327 SN: 7349	31-Dec-19 (No. EX3-7349_Dec19)	Dec-20
Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A  Name SM: W441092317 Name SM: M941092317 Name Function Laboratory Technician  Name Signature  Signature	Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4	SN: 310982 / 06327 SN: 7349 SN: 601	31-Dec-19 (No. EX3-7349_Dec19) 27-Dec-19 (No. DAE4-601_Dec19)	Dec-20 Dec-20
RF generator R&S SMT-06 SN: 100972 15-Jun-15 (in house check Oct-18) In house check: Oct-18 SN: US41080477 31-Mar-14 (in house check Oct-19) In house check: Oct-19 In house check: Oct	Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	SN: 310982 / 06327 SN: 7349 SN: 601	31-Dec-19 (No. EX3-7349_Dec19) 27-Dec-19 (No. DAE4-601_Dec19) Check Date (in house)	Dec-20 Dec-20
Network Analyzer Agilent E8358A SN: US41080477 31-Mar-14 (In house check Oct-19) In house check: Oct-  Name Function Signature  Calibrated by: Laboratory Technician	Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter E4419B	SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475	31-Dec-19 (No. EX3-7349_Dec19) 27-Dec-19 (No. DAE4-601_Dec19) Check Date (in house) 30-Oct-14 (in house check Feb-19)	Dec-20 Dec-20 Scheduled Check
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Issued: April 24, 2020	Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4  Secondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A  Calibrated by:	SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317 SN: 100972 SN: US41080477 Name	31-Dec-19 (No. EX3-7349_Dec19) 27-Dec-19 (No. DAE4-601_Dec19)  Check Date (in house)  30-Oct-14 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 07-Oct-15 (in house check Oct-18) 15-Jun-15 (in house check Oct-18) 31-Mar-14 (in house check Oct-19)  Function Laboratory Technician	Dec-20 Dec-20 Scheduled Check In house check: Oct-20

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





S 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

#### 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
- 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 Version	DASY5	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

## Head TSL parameters

	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	38.6 ± 6 %	1.86 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.4 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.6 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6,23 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.7 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	$56.0 \Omega + 2.6 j\Omega$	
Return Loss	- 24.1 dB	

#### General Antenna Parameters and Design

1.149 ns

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

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

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

#### **Additional EUT Data**

Manufactured by	SPEAG

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

Date: 22.04.2020

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:727

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

Medium parameters used: f = 2450 MHz;  $\sigma = 1.86$  S/m;  $\epsilon_r = 38.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

#### DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.98, 7.98, 7.98) @ 2450 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

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

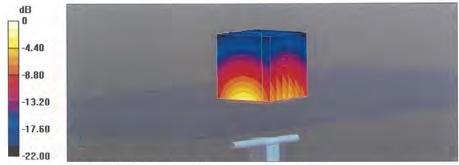
Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 116.9 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 26.1 W/kg

SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.23 W/kg

Smallest distance from peaks to all points 3 dB below = 9 mm

Ratio of SAR at M2 to SAR at M1 = 51.2%

Maximum value of SAR (measured) = 21.9 W/kg



0 dB = 21.9 W/kg = 13.40 dBW/kg

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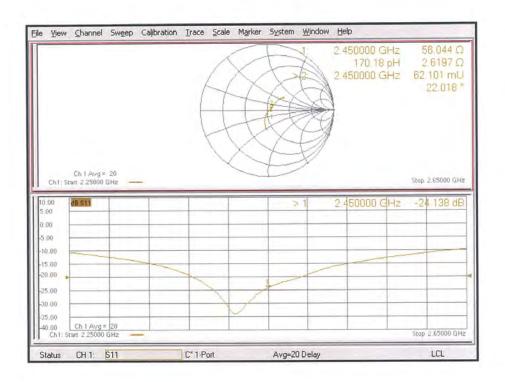
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#### Impedance Measurement Plot for Head TSL



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# **CALIBRATION CERTIFICATE**

Object D5GHzV2 - SN: 1040

Calibration Procedure(s) FF-Z11-003-01

Calibration Procedures for dipole validation kits

Calibration date: June 23, 2020

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)°C and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID#	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	106277	04-Sep-19 (CTTL, No.J19X07825)	Sep-20
Power sensor NRP8S	104291	04-Sep-19 (CTTL, No.J19X07825)	Sep-20
ReferenceProbe EX3DV4	SN 7514	27-Sep-19(CTTL-SPEAG,No.Z19-60306)	Sep-20
DAE4	SN 1555	22-Aug-19(CTTL-SPEAG,No.Z19-60295)	Aug-20
Secondary Standards	ID#	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Signal Generator E4438C	MY49071430	25-Feb-20 (CTTL, No.J20X00516)	Feb-21
NetworkAnalyzerE5071C	MY46107873	10-Feb-20 (CTTL, No.J20X00515)	Feb-21
		10 100 20 (0112, 110.020/100010)	F ED-21

	Name	Function	Signature
Calibrated by:	Zhao Jing	SAR Test Engineer	(2)
Reviewed by:	Lin Hao	SAR Test Engineer	THE TO
Approved by:	Qi Dianyuan	SAR Project Leader	200

Issued: June 26, 2020

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

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Glossary:

tissue simulating liquid TSL ConvF sensitivity in TSL / NORMx,y,z 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 assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to
- 6GHz)", July 2016 c) IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
- d) KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

#### Additional Documentation:

e) DASY4/5 System Handbook

# Methods Applied and Interpretation of Parameters:

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

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

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#### **Measurement Conditions**

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Triple Flat Phantom 5.1C	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4 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	36.0 ± 6 %	4.65 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C		****

# SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.59 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	75.9 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.17 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	21.7 W/kg ± 24.2 % (k=2)

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# Head TSL parameters at 5300 MHz

ne 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	35.8 ± 6 %	4.75 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C		

#### SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.84 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	78.4 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.24 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.4 W/kg ± 24.2 % (k=2)

#### Head TSL parameters at 5500 MHz

he 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	35.5 ± 6 %	4.98 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C		

# SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.23 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	82.2 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.3 W/kg ± 24.2 % (k=2)

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# Head TSL parameters at 5600 MHz

	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	35.3 ± 6 %	5.09 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	-	****

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

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.07 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.6 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.30 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.0 W/kg ± 24.2 % (k=2)

# Head TSL parameters at 5800 MHz

	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	35.0 ± 6 %	5.29 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C		****

# SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.94 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	79.3 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.8 W/kg ± 24.2 % (k=2)

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# Body TSL parameters at 5200 MHz

he following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.2 ± 6 %	5.20 mho/m ± 6 %
Body TSL temperature change during test	<1.0 °C		

#### 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	7.04 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	70.4 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	Condition	
SAR measured	100 mW input power	2.00 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.0 W/kg ± 24.2 % (k=2)

# Body TSL parameters at 5300 MHz

e following parameters and calculations were applied.

	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	49.0 ± 6 %	5.33 mho/m ± 6 %
Body TSL temperature change during test	<1.0 °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	7.37 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.7 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	Condition	
SAR measured	100 mW input power	2.10 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.0 W/kg ± 24.2 % (k=2)

Certificate No: Z20-60232

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#### Body TSL parameters at 5500 MHz

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.5 ± 6 %	5.59 mho/m ± 6 %
Body TSL temperature change during test	<1.0 °C	***	

SAR result with Body TSI at EEO MU-

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.81 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	78.0 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	Condition	
SAR measured	100 mW input power	2.20 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	22.0 W/kg ± 24.2 % (k=2)

#### Body TSL parameters at 5600 MHz

The following parameters and calculations were applied

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.4 ± 6 %	5.73 mho/m ± 6 %
Body TSL temperature change during test	<1.0 °C		

## SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.68 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	76.8 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	Condition	
SAR measured	100 mW input power	2.17 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.7 W/kg ± 24.2 % (k=2)

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# Body TSL parameters at 5800 MHz The following parameters and calculations with the following parameters and calculations with the following parameters and calculations with the following parameters at 5800 MHz

	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	48.0 ± 6 %	6.07 mho/m ± 6 %
Body TSL temperature change during test	<1.0 °C		

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

SAR averaged over 1 $cm^3$ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.36 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.6 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	Condition	
SAR measured	100 mW input power	2.06 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.6 W/kg ± 24.2 % (k=2)

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# Appendix (Additional assessments outside the scope of CNAS L0570)

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

Impedance, transformed to feed point	49.9Ω - 6.48jΩ	
Return Loss	- 23.8dB	

### Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	46.1Ω - 2.44jΩ	
Return Loss	- 26.5dB	

#### Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	50.6Ω - 6.11jΩ	
Return Loss	- 24.3dB	

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

Impedance, transformed to feed point	56.7Ω - 1.61jΩ	
Return Loss	- 23.8dB	

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

Impedance, transformed to feed point	52.0Ω - 2.47jΩ	
Return Loss	- 30.1dB	

### Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	49.5Ω - 4.59jΩ	
Return Loss	- 26.7dB	

# Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	45.9Ω - 0.66jΩ	
Return Loss	- 27.4dB	

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# Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	51.5Ω - 4.98jΩ	
Return Loss	- 25.8dB	

### Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	58.0Ω + 0.39jΩ	
Return Loss	- 22.6dB	

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

Impedance, transformed to feed point	53.3Ω - 1.63jΩ	
Return Loss	- 28.9dB	

#### General Antenna Parameters and Design

Electrical Delay (one direction)	1.065 ns

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

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard. No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

## Additional EUT Data

Manufactured by	SPEAG

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DASY5 Validation Report for Head TSL

Date: 06 22 2020

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1040

Communication System: CW; Frequency: 5200 MHz, Frequency: 5300 MHz,

Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz,

Medium parameters used; f = 5200 MHz;  $\sigma = 4.65$  S/m;  $\varepsilon_r = 36.02$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5300 MHz;  $\sigma$  = 4.751 S/m;  $\epsilon_r$  = 35.82;  $\rho$  = 1000 kg/m³, Medium parameters used: f = 5500 MHz;  $\sigma$  = 4.975 S/m;  $\epsilon_r$  = 35.46;  $\rho$  = 1000 kg/m<sup>3</sup>,Medium parameters used: f = 5600 MHz;  $\sigma$  = 5.092 S/m;  $\epsilon_r$  = 35.31;  $\rho$ = 1000 kg/m<sup>3</sup>, Medium parameters used: f = 5800 MHz;  $\sigma$  = 5.29 S/m;  $\epsilon_r$  = 35.04;  $\rho$  $= 1000 \text{ kg/m}^3$ 

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 SN7514; ConvF(5.24, 5.24, 5.24) @ 5200 MHz; ConvF(5.24, 5.24, 5.24) @ 5300 MHz; ConvF(4.57, 4.57, 4.57) @ 5500 MHz; ConvF(4.57, 4.57, 4.57) @ 5600 MHz; ConvF(4.56, 4.56, 4.56) @ 5800 MHz; Calibrated: 2019-09-27
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1555; Calibrated: 2019-08-22
- Phantom: MFP\_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx; Serial:
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7483)

Dipole Calibration /Pin=100mW, d=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 64.49 V/m; Power Drift = -0.06 dB Peak SAR (extrapolated) = 30.8 W/kg SAR(1 g) = 7.59 W/kg; SAR(10 g) = 2.17 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 65.1% Maximum value of SAR (measured) = 18.1 W/kg

Dipole Calibration /Pin=100mW, d=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 65.06 V/m; Power Drift = -0.04 dB Peak SAR (extrapolated) = 32.3 W/kg SAR(1 g) = 7.84 W/kg; SAR(10 g) = 2.24 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 64.4% Maximum value of SAR (measured) = 18.6 W/kg

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Dipole Calibration /Pin=100mW, d=10mm, f=5500 MHz/Zoom Scan,

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

Reference Value = 67.53 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 35.7 W/kg

SAR(1 g) = 8.23 W/kg; SAR(10 g) = 2.33 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 62.9% Maximum value of SAR (measured) = 20.2 W/kg

Dipole Calibration /Pin=100mW, d=10mm, f=5600 MHz/Zoom Scan,

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

Reference Value = 65.19 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 35.5 W/kg

SAR(1 g) = 8.07 W/kg; SAR(10 g) = 2.3 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 62.4%

Maximum value of SAR (measured) = 19.8 W/kg

Dipole Calibration /Pin=100mW, d=10mm, f=5800 MHz/Zoom Scan,

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

Reference Value = 68.05 V/m; Power Drift = -0.04 dB

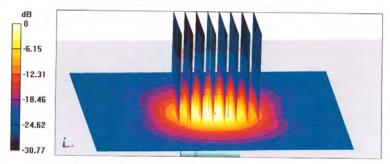
Peak SAR (extrapolated) = 33.4 W/kg

SAR(1 g) = 7.94 W/kg; SAR(10 g) = 2.28 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 63.1%

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



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

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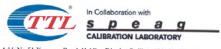
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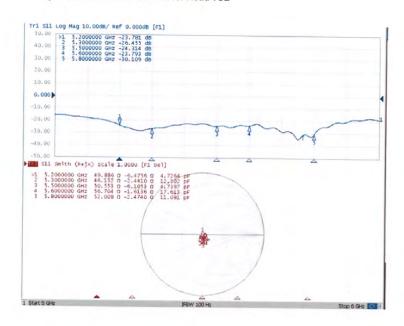
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#### Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL Test Laboratory: CTTL, Beijing, China

Date: 06.23.2020

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1040

Communication System: CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz,

Medium parameters used: f = 5200 MHz;  $\sigma = 5.2$  S/m;  $\varepsilon_r = 49.17$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5300 MHz;  $\sigma$  = 5.327 S/m;  $\epsilon_r$  = 49.01;  $\rho$  = 1000 kg/m³, Medium parameters used: f = 5500 MHz;  $\sigma$  = 5.59 S/m;  $\epsilon_r$  = 48.46;  $\rho$  = 1000 kg/m³, Medium parameters used; f = 5600 MHz;  $\sigma$  = 5.732 S/m;  $\epsilon_{\rm r}$  = 48.42;  $\rho$  = 1000 kg/m³, Medium parameters used: f = 5800 MHz;  $\sigma$  = 6.072 S/m;  $\epsilon_r$  = 47.98;  $\rho$ 

 $= 1000 \text{ kg/m}^3$ 

Phantom section: Right Section

#### DASY5 Configuration:

- Probe: EX3DV4 SN7514; ConvF(4.63, 4.63, 4.63) @ 5200 MHz; ConvF(4.63, 4.63, 4.63) @ 5300 MHz; ConvF(4.09, 4.09, 4.09) @ 5500 MHz; ConvF(4.09, 4.09, 4.09) @ 5600 MHz; ConvF(4.16, 4.16, 4.16) @ 5800 MHz; Calibrated: 2019-09-27.
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1555; Calibrated: 2019-08-22
- Phantom: MFP\_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14

Dipole Calibration /Pin=100mW, d=10mm, f=5200 MHz/Zoom Scan,

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

Reference Value = 57.25 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 27.2 W/kg

SAR(1 g) = 7.04 W/kg; SAR(10 g) = 2 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 66.6%

Maximum value of SAR (measured) = 16.6 W/kg

Dipole Calibration /Pin=100mW, d=10mm, f=5300 MHz/Zoom Scan,

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

Reference Value = 58.45 V/m; Power Drift = 0.09 dB

Peak SAR (extrapolated) = 29.0 W/kg

SAR(1 g) = 7.37 W/kg; SAR(10 g) = 2.1 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 65.7%

Maximum value of SAR (measured) = 17.5 W/kg

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Dipole Calibration /Pin=100mW, d=10mm, f=5500 MHz/Zoom Scan,

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

Reference Value = 59.48 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 32.4 W/kg

SAR(1 g) = 7.81 W/kg; SAR(10 g) = 2.2 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 64.2% Maximum value of SAR (measured) = 19.0 W/kg

Dipole Calibration /Pin=100mW, d=10mm, f=5600 MHz/Zoom Scan,

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

Reference Value = 60.58 V/m; Power Drift = 0.08 dB

Peak SAR (extrapolated) = 33.1 W/kg

SAR(1 g) = 7.68 W/kg; SAR(10 g) = 2.17 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 63.2% Maximum value of SAR (measured) = 18.8 W/kg

Dipole Calibration /Pin=100mW, d=10mm, f=5800 MHz/Zoom Scan.

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

Reference Value = 56.73 V/m; Power Drift = 0.01 dB

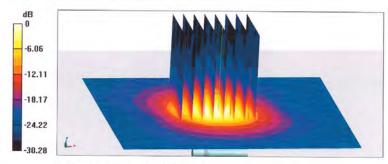
Peak SAR (extrapolated) = 31.9 W/kg

SAR(1 g) = 7.36 W/kg; SAR(10 g) = 2.06 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 62.7%

Maximum value of SAR (measured) = 18.6 W/kg



0 dB = 18.6 W/kg = 12.70 dBW/kg

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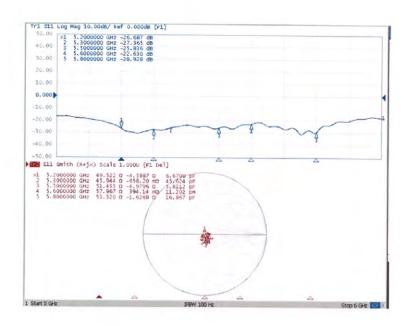
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#### Impedance Measurement Plot for Body TSL



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# - End of report -

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