

Appendix C Dipole Calibration Certificates

Calibration Laboratory of
Schmid & Partner
Engineering AG
Pöggendorferstr. 45, 8004 Zurich, Switzerland



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Accreditation No.: SCS 0108

Client: **Motorola Solutions MY**

Certificate No: **CLA150-401E_Oct18**

CALIBRATION CERTIFICATE

Order: **CLA150 - SR: 401E**

Calibration procedure(s): **DA CAL-15-ME**
Calibration procedure for system validation assures below 700 MHz

Calibration date: **October 18, 2018**

The calibration certificate documents the traceability to national standards, which enable 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 ± 2°C and humidity: < 10%.

Calibration Equipment used (NISTE critical for calibration)

Primary Standards	U.S.	Cal Date (Certificate No.)	Scheduled Calibration
Power meter N99	SR 104716	28-Apr-18 (No. 217-0267206-18)	Apr-19
Power sensor N99-201	SR 102044	28-Apr-18 (No. 217-026720)	Apr-19
Power sensor N99-201	SR 102043	28-Apr-18 (No. 217-026720)	Apr-19
Reference 20-95 Attenuator	SR 0227 (200)	28-Apr-18 (No. 217-026720)	Apr-19
Type N1 impedance calibration	SR 0467 2 / 0467	24-Apr-18 (No. 217-026720)	Apr-19
Reference Probe 1500196	SR 0877	28-Dec-17 (No. 215-02677_28-17)	Dec-18
DAE-A	SR 004	28-Jul-18 (No. 0467-004_18-18)	Jul-19
Secondary Standards	U.S.	Check Date (in house)	Scheduled Check
Power meter 140100	SR 0261000014	12-Jun-18 (No. 217-0261000014)	In house check: Jun-20
Power sensor 144104	SR 0111400007	12-Jun-18 (No. 217-026100)	In house check: Jun-20
Power sensor 144104	SR 001140101	12-Jun-18 (No. 217-026100)	In house check: Jun-20
RF generator HP 8460C	SR 102842010700	04-Aug-18 (in house check: Jun-18)	In house check: Jun-20
Reference Antenna Right 100000	SR 1024100017	21-Mar-18 (in house check: Oct-18)	In house check: Oct-18

Calibrated by: **Michael Weber** (Name), **Calibrating Technician** (Function), *[Signature]* (Signature)

Approved by: **Klaus Pfister** (Name), **Technical Manager** (Function), *[Signature]* (Signature)

Issued: October 18, 2018

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Accreditation No.: SCS 0108

Glossary:

TSL tissue simulating liquid
ConvF sensitivity in TSL / NORM $k_{y,z}$
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) KDS 805664, "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 source is mounted in a touch configuration below the center marking of the flat phantom.
- **Return Loss:** This parameter is measured with the source positioned under the liquid filled phantom (as described in the measurement condition clause). The Return Loss ensures low reflected power. No uncertainty required.
- **SAR measured:** SAR measured at the stated antenna input power.
- **SAR normalized:** SAR as measured, normalized to an input power of 1 W at the antenna connector.
- **SAR for nominal TSL parameters:** The measured TSL parameters are used to calculate the nominal SAR result.

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

Measurement Conditions

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

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	ELI4 Flat Phantom	Shell thickness: 2 ± 0.2 mm
EUT Positioning	Touch Position	
Zoom Scan Resolution	$dx, dy = 4.0$ mm, $dz = 1.4$ mm	Graded Ratio = 1.4 (Z direction)
Frequency	150 MHz \pm 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	52.3	0.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	50.3 ± 6 %	0.76 mho/m \pm 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	1 W input power	3.67 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	3.64 W/kg \pm 18.4 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	1 W input power	2.45 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	2.43 W/kg \pm 18.0 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	61.9	0.80 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	63.3 ± 6 %	0.82 mho/m \pm 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	1 W input power	4.01 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	3.95 W/kg \pm 18.4 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	1 W input power	2.65 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	2.61 W/kg \pm 18.0 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	47.0 Ω - 4.4 jΩ
Return Loss	-25.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.9 Ω - 1.7 jΩ
Return Loss	-35.5 dB

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	August 28, 2014

DASY5 Validation Report for Head TSL

Date: 10.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: CLA150; **Type:** CLA150; **Serial:** CLA150 - SN: 4016

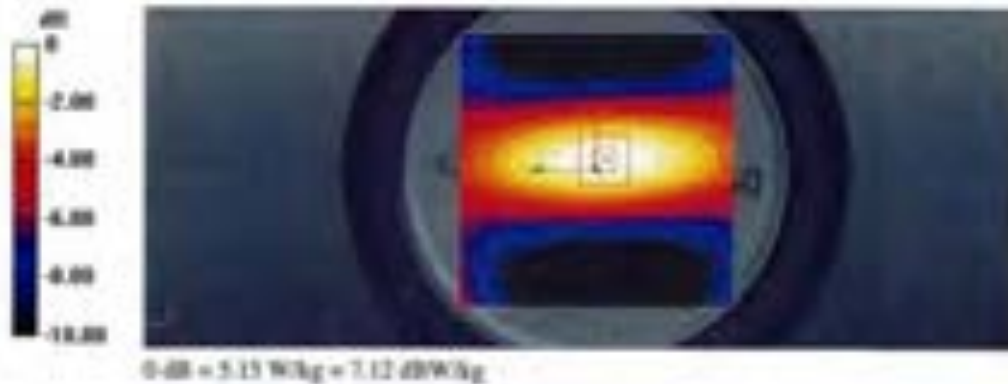
Communication System: UED 0 - CW; Frequency: 120 MHz
 Medium parameters used: $f = 120 \text{ MHz}$; $\epsilon = 0.38 \text{ S/m}$; $\mu = 50.3$; $\rho = 1000 \text{ kg/m}^3$
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

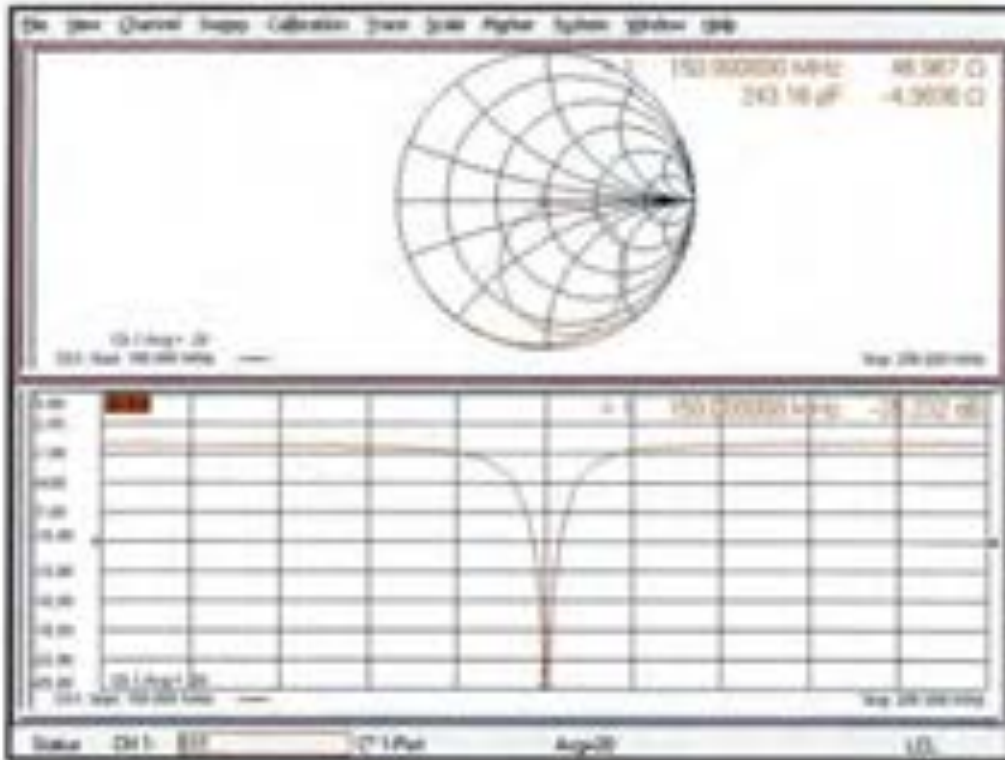
- Probe: EXNPV4 - SN3877; Coef: (12.12, 12.12, 12.12) @ 120 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Iso54; Calibrated: 05.07.2018
- Phantom: ELI v4.0; Type: QOOVA0610B; Serial: TP-1003
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(740)

CLA Calibration for HSL-LF Tissue/CLA150, touch configuration, Pin=1W/Area Scan (8x8x14): Interpolated grid: $dx=1.500 \text{ mm}$, $dy=1.500 \text{ mm}$
 Maximum value of SAR (interpolated) = 3.21 W/kg

CLA Calibration for HSL-LF Tissue/CLA150, touch configuration, Pin=1W/Zoom Scan, dist=1.4mm (8x10x7)/Cube 0: Measurement grid: $dx=8\text{mm}$, $dy=4\text{mm}$, $dz=1.4\text{mm}$
 Reference Value = 10.01 V/m; Power Drift = -0.09 dB
 Peak SAR (extrapolated) = 7.05 W/kg
 SAR(1 g) = 3.67 W/kg; SAR(10 g) = 2.45 W/kg
 Maximum value of SAR (measured) = 5.15 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 10.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: CLA150; Type: CLA150; Serial: CLA150 - SN: 4014

Communication System: UED 0 - CW; Frequency: 150 MHz

Medium parameters used: $f = 150$ MHz; $v = 0.02$ km/s; $n = 61.3$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY32 Configuration:

- Probe: EXDVA - SN3871; Coeff(11.57, 11.57, 11.57) @ 150 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAH Set54; Calibrated: 05.07.2018
- Phantom: ELI v4.0; Type: QDOVA00100; Serial: TP1003
- DASY32 52.10.2(1495); SEMCAD X 14.6.12(7450)

CLA Calibration for MSL-LF Tissue/CLA150, touch configuration, Pin=1W/Area Scan

(8x8x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 3.75 W/kg

CLA Calibration for MSL-LF Tissue/CLA150, touch configuration, Pin=1W/Zoom Scan

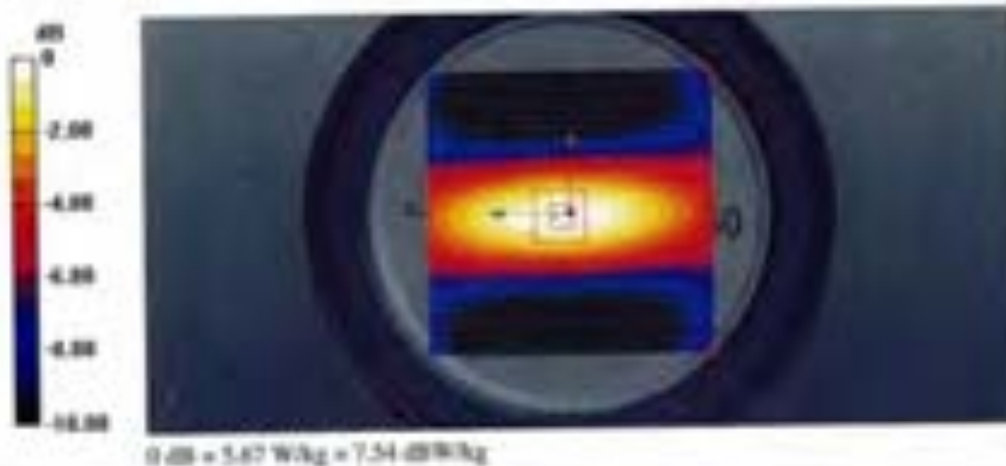
dist=1.4mm (8x10x7)/Cube @; Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 32.51 V/m; Power Diff = -0.04 dB

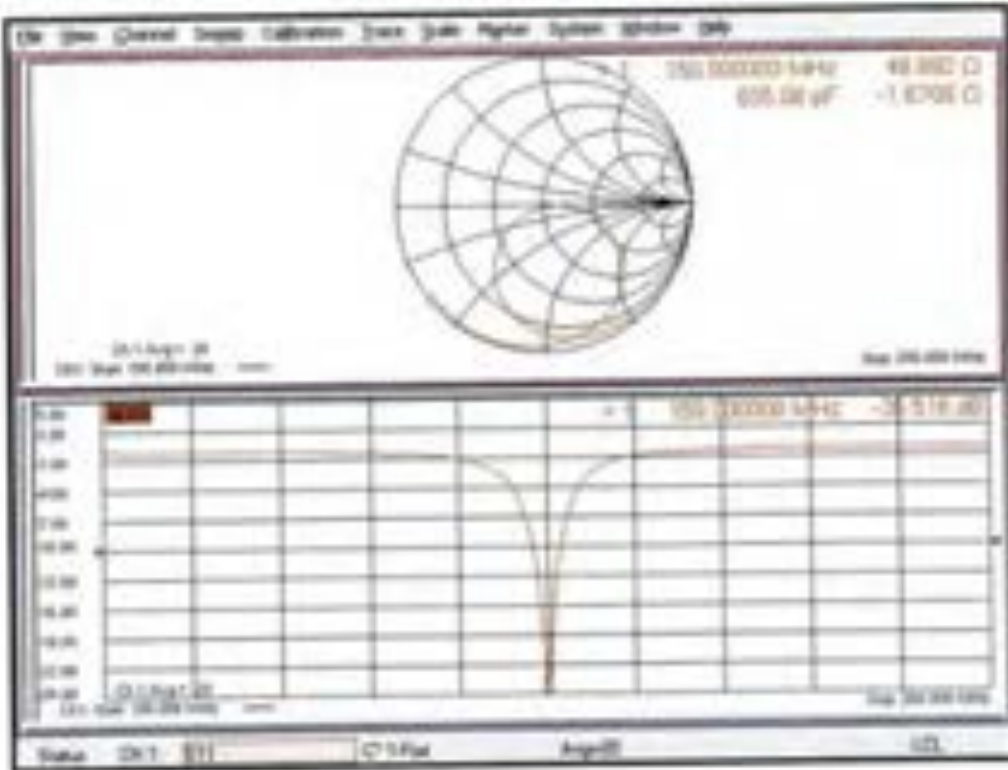
Peak SAR (extrapolated) = 7.87 W/kg

SAR(1 g) = 4.81 W/kg; SAR(10 g) = 2.65 W/kg

Maximum value of SAR (measured) = 5.67 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: SCS 0108

Client: **Motorola Solutions NY**

Certificate No.: **D480V3-1054_Mar18**

CALIBRATION CERTIFICATE

Client: **D480V3 - SN 1054**

Calibration procedure: **CA CAL 15-03
Calibration Procedure for SAR Validation Sources below 700 MHz**

Calibration date: **March 11, 2018**

This calibration certificate documents the traceability to national standards, which define 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 closest laboratory facility: environment temperature (20 ± 0.2°C) and humidity < 70%.

Calibration Equipment used (MPEU critical for calibration)

Primary Standard	SI	Cal Date / Certificate No.	Scheduled Calibration
Power meter 869	96 10476	04-Apr-18 (No. 017-028702018)	Apr-18
Power sensor 869-D0	96 10394	04-Apr-18 (No. 017-028702)	Apr-18
Power sensor 869-D0	96 10395	04-Apr-18 (No. 017-028702)	Apr-18
Reference (SI) 66 Microwave	96 0277 (20)	04-Apr-18 (No. 017-028692)	Apr-18
Type-N microwave combinator	96 0007 (2-1-0007)	04-Apr-18 (No. 017-028692)	Apr-18
Reference Probe EX25V4	96 0017	01-Dec-18 (No. 013-00171_1dec18)	Dec-18
2nd	96 004	05-Jul-18 (No. 0404-004_Jul18)	Jul-18
Secondary Standards	SI	Check Date (in house)	Scheduled Check
Power meter 124126	96 028102614	06-Apr-18 (in house check Jun-18)	in house check Jun-18
Power sensor 124126	96 027102607	06-Apr-18 (in house check Jun-18)	in house check Jun-18
Power sensor 124126	96 027102610	06-Apr-18 (in house check Jun-18)	in house check Jun-18
RF generator 147 80462	96 020640101106	06-Aug-08 (in house check Jun-18)	in house check Jun-18
Network Analyser Agilent 12852A	96 024102007	01-Mar-18 (in house check Oct-18)	in house check Oct-18

Calibrated by: **Christi Leuter** (Name) / **Laboratory Technician** (Function) 

Approved by: **Kaja Fritsch** (Name) / **Technical Manager** (Function) 

Issue: **March 11, 2018**

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Accreditation No.: SCS 0108

Glossary:

TSL	issue simulating liquid
CompF	sensitivity in TSL / NCRM 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 605654, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- a) 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 in position its feed point exactly below the center marking of the fat phantom section, with the arms oriented parallel to the body axis.
- **Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- **Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- **SAR measured:** SAR measured at the stated antenna input power.
- **SAR normalized:** SAR as measured, normalized to an input power of 1 W at the antenna connector.
- **SAR for nominal TSL parameters:** The measured TSL parameters are used to calculate the nominal SAR result.

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

Measurement Conditions

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

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	ELI4 Flat Phantom	Shell thickness: 2 ± 0.2 mm
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	43.5	0.87 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	44.1 ± 6 %	0.87 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	1.14 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	4.57 W/kg ± 18.1 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	0.763 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	3.06 W/kg ± 17.6 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	56.7	0.94 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.7 ± 6 %	0.93 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	1.13 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	4.54 W/kg ± 18.1 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	0.762 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	3.06 W/kg ± 17.6 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	60.2 Ω - 0.4 j Ω
Return Loss	- 20.7 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	57.7 Ω - 3.6 j Ω
Return Loss	- 22.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.346 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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

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

Additional EUT Data

Manufactured by	SPEAG
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DASY3 Validation Report for Head TSL

Date: 11.03.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 450 MHz; Type: D450P3; Serial: D450V3 - SN:1854

Communication System: UTD 0 - CW; Frequency: 450 MHz

Medium parameters used: $f = 450$ MHz; $v = 0.87$ V/m; $\epsilon_r = 44$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY3 (IEEE/IEC/ANSI C63.19-2011)

DASY32 Configuration:

- Probe: EK3DV4 - SN3077; CoreF(10.5, 10.5, 10.5) @ 450 MHz; Calibrated: 11.12.2018
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DA24 S4054; Calibrated: 05.07.2018
- Phantom: ELL v4.0; Type: QDOVA001BB; Serial: TP1000
- DASY32 52.10.21495; SEMCAD X 14.6.127490

Dipole Calibration for Head Tissue/d=15mm, P_{iso}=256caW/Zoom Scan (7x7x7)xCube @:

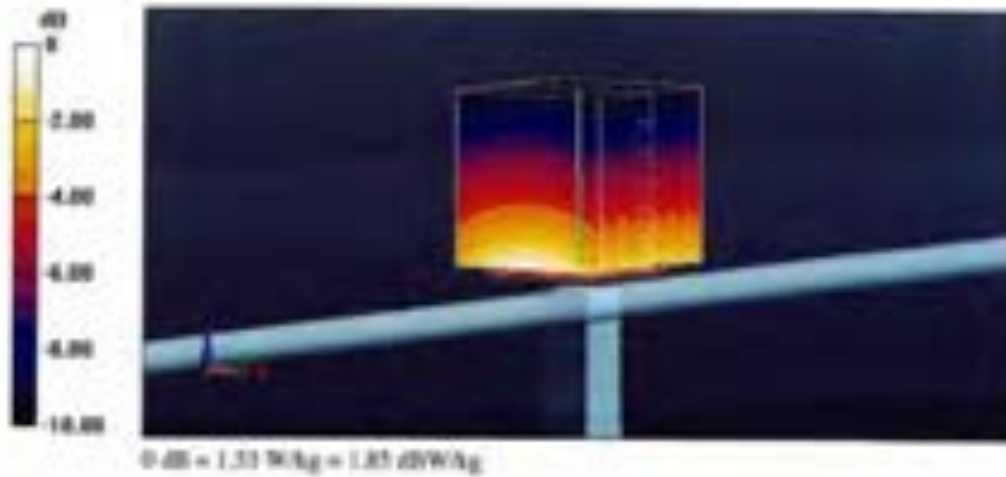
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 38.90 V/m; Power Dist = -0.01 dB

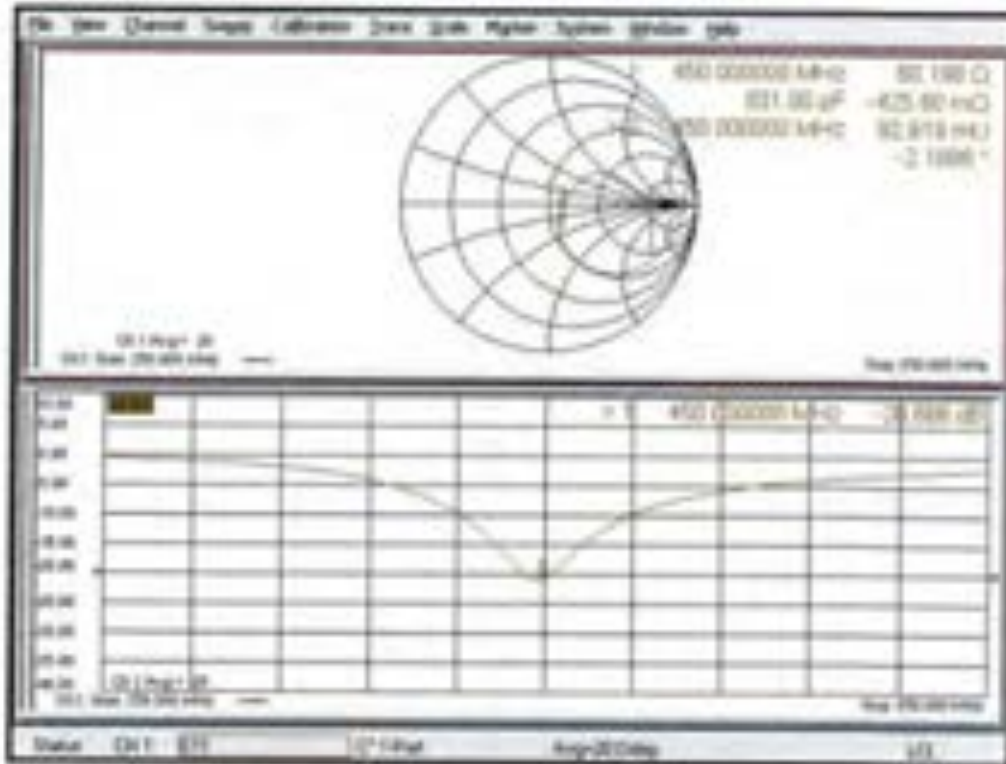
Peak SAR (extrapolated) = 1.73 W/kg

SAR(1 g) = 1.14 W/kg; SAR(10 g) = 0.763 W/kg

Maximum value of SAR (measured) = 1.53 W/kg



Impedance Measurement Plot for Head TSS



DASY5 Validation Report for Body TSL

Date: 11.03.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 450 MHz; Type: D450V3; Serial: D450V3 - SN:3054

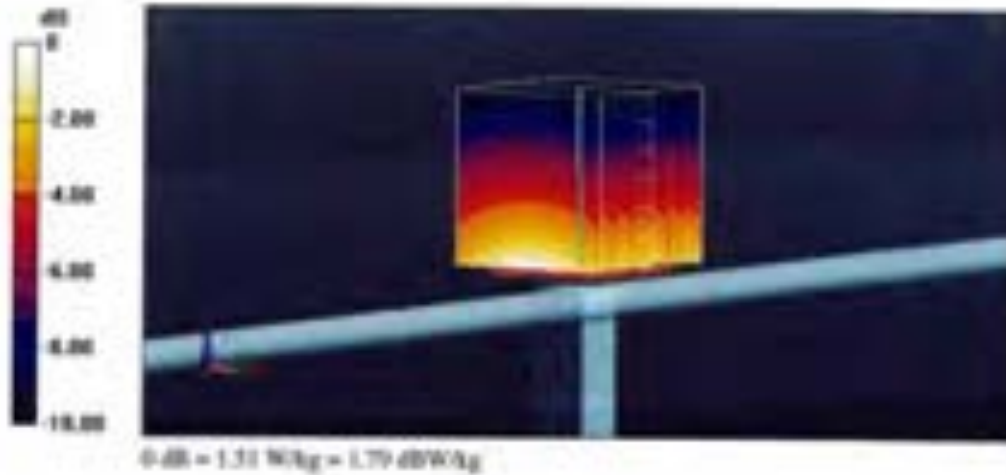
Communication System: UED-0 - CW; Frequency: 450 MHz
 Medium parameters used: $f = 450 \text{ MHz}$; $\sigma = 0.95 \text{ S/m}$; $\epsilon_r = 53.7$; $\rho = 1000 \text{ kg/m}^3$
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2017)

DASY5 Configuration:

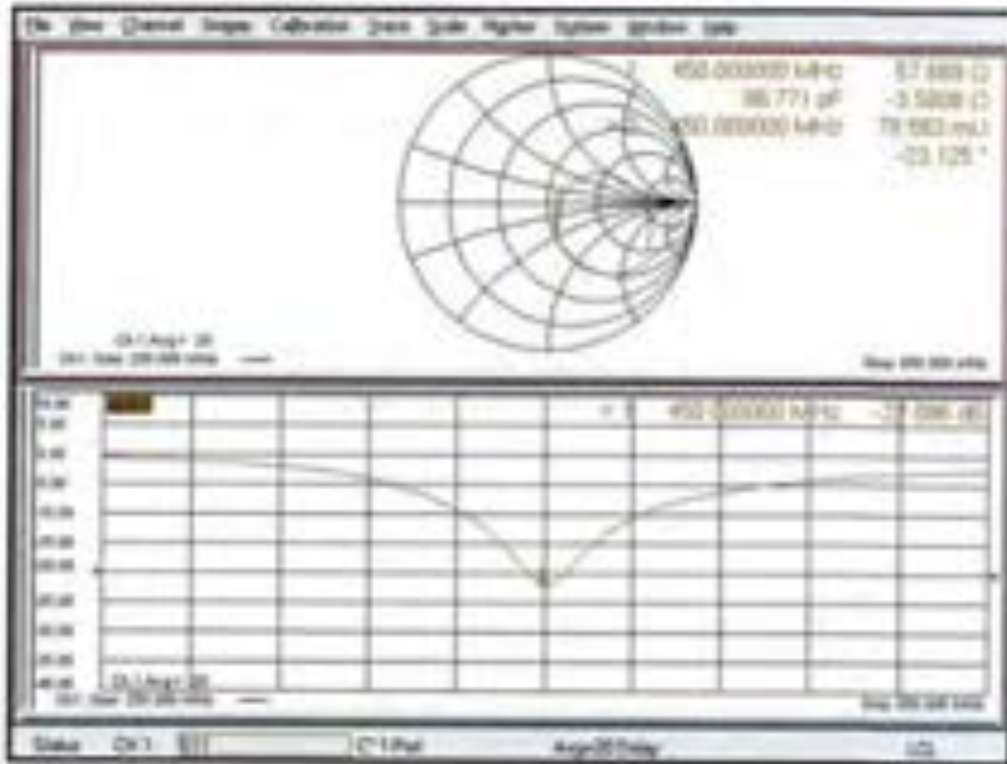
- Probe: EX3DV4 - SN3877; Coax:FC03.7, 10.7, 10.7 @ 450 MHz; Calibrated: 31.12.2018
- Sensor/Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DA14 S654; Calibrated: 05.07.2018
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP-1003
- DASY5: 52.10.2(1499); SEMCAD X 14.6.12(7450)

Dipole Calibration for Body Tissue(d=15mm, P_{in}=250mW/Zoom Scan (7x7x7)/Cube @:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
 Reference Value = 41.61 V/m; Power Diff = -0.03 dB
 Peak SAR (extrapolated) = 1.73 W/kg
 SAR(1 g) = 1.13 W/kg; SAR(10 g) = 0.762 W/kg
 Maximum value of SAR (measured) = 1.51 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client: **Motorola Solutions MY**

Certificate No.: **D450V3-1053 Oct18**

CALIBRATION CERTIFICATE

Object: **D450V3 - SN:1053**

Calibration procedure(s): **QA CAL-15.v8
Calibration procedure for dipole validation kits below 700 MHz**

Calibration date: **October 19, 2018**

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 ± 0.3°C) and humidity < 70%.

Calibration Equipment used (M&PE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104779	04-Apr-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-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: 52771206	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combinator	SN: 50472706327	04-Apr-18 (No. 217-02683)	Apr-19
Reference Probe EX20V4	SN: 9877	30-Dec-17 (No. EX3-3877_Dec17)	Dec-18
DAE4	SN: 654	05-Jul-18 (No. DAE4-654_Jul18)	Jul-19
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	12-Jun-18 (No. 217-02285/02284)	In house check: Jun-20
Power sensor E4412A	SN: MY41498067	12-Jun-18 (No. 217-02285)	In house check: Jun-20
Power sensor E4412A	SN: 000110210	12-Jun-18 (No. 217-02284)	In house check: Jun-20
RF generator HP 6648C	SN: US3642J01700	04-Aug-02 (in house check Jun-18)	In house check: Jun-20
Network Analyzer Agilent E8358A	SN: US41060477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19

Calibrated by: **Claudio Leleola** (Signature) Laboratory Technician

Approved by: **Kaja Polovic** (Signature) Technical Manager

Issued: October 19, 2018

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	ELI4 Flat Phantom	Shell thickness: 2 ± 0.2 mm
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	43,5	0.87 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	44,1 ± 6 %	0.87 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	1.14 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	4.57 W/kg ± 18.1 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	0.762 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	3.05 W/kg ± 17.6 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	56.7	0.94 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.5 ± 6 %	0.92 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	1.12 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	4.53 W/kg ± 18.1 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	0.753 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	3.05 W/kg ± 17.6 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	57.6 Ω - 4.4 jΩ
Return Loss	-21.7 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	55.1 Ω - 7.0 jΩ
Return Loss	-21.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.351 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	December 16, 2005

DASY5 Validation Report for Head TSL

Date: 19.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 450 MHz; Type: D450V3; Serial: D450V3 - SN:1053

Communication System: UID 0 - CW; Frequency: 450 MHz

Medium parameters used: $f = 450$ MHz; $\sigma = 0.87$ S/m; $\epsilon_r = 44.1$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3877; ConvF(10.5, 10.5, 10.5) @ 450 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn654; Calibrated: 05.07.2018
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1003
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

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

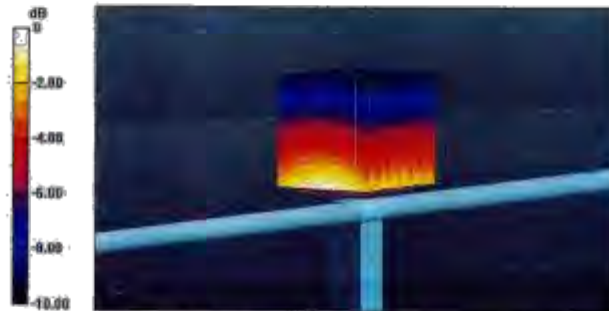
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 38.89 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 1.74 W/kg

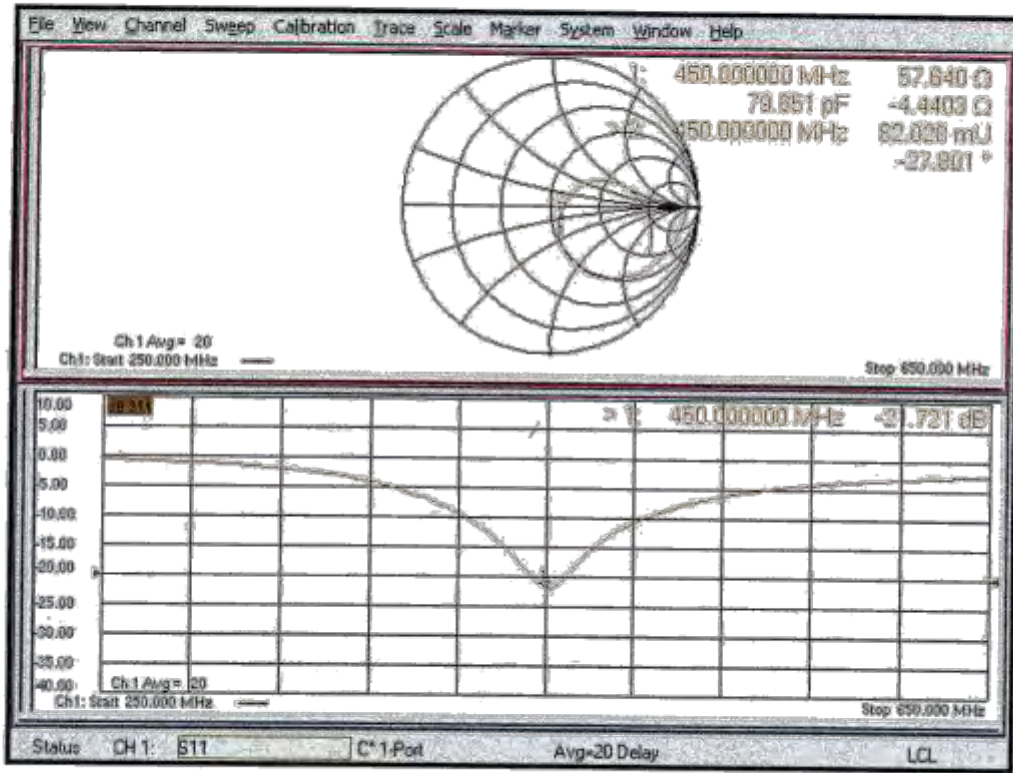
SAR(1 g) = 1.14 W/kg; SAR(10 g) = 0.762 W/kg

Maximum value of SAR (measured) = 1.52 W/kg



0 dB = 1.52 W/kg = 1.82 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 19.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 450 MHz; Type: D450V3; Serial: D450V3 - SN:1053

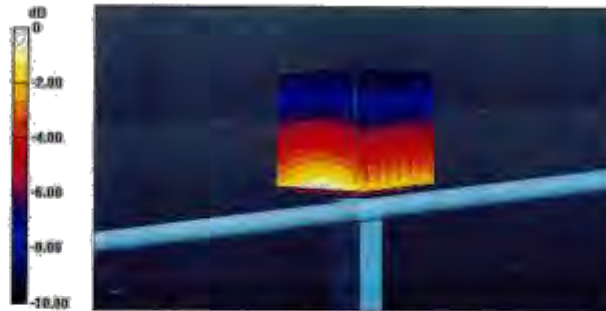
Communication System: UID 0 - CW; Frequency: 450 MHz
 Medium parameters used: $f = 450 \text{ MHz}$; $\sigma = 0.92 \text{ S/m}$; $\epsilon_r = 55.5$; $\rho = 1000 \text{ kg/m}^3$
 Phantom section; Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

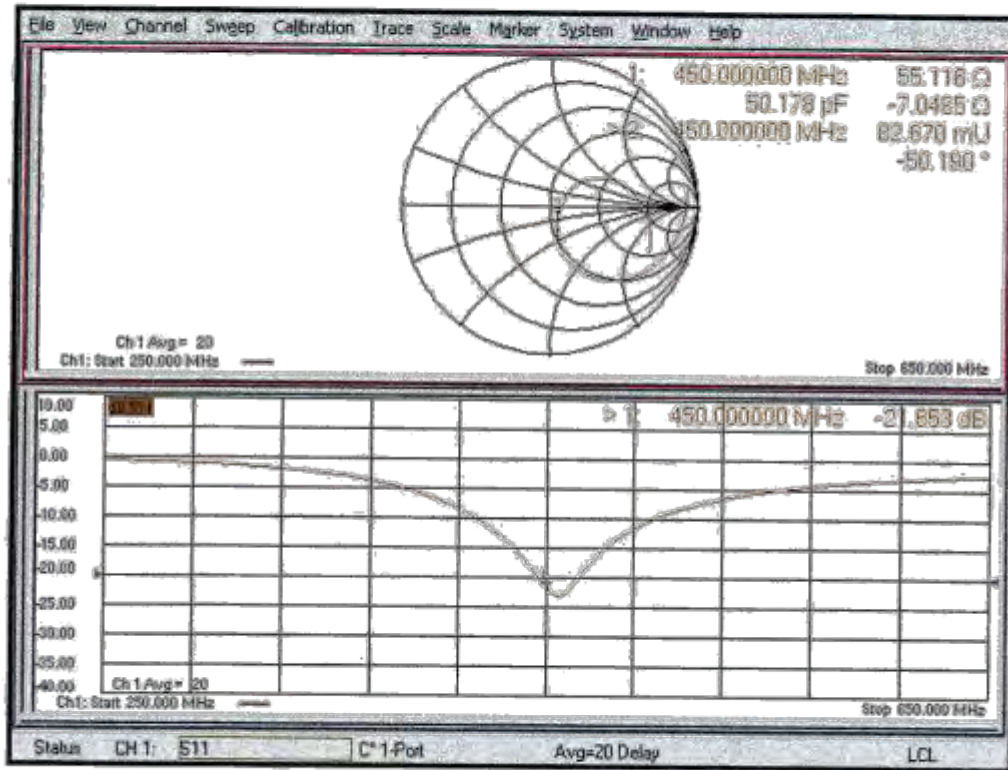
- Probe: EX3DV4 - SN3877; ConvF(10.8, 10.8, 10.8) @ 450 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn654; Calibrated: 05.07.2018
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1003
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

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

Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$
 Reference Value = 41.78 V/m; Power Drift = -0.04 dB
 Peak SAR (extrapolated) = 1.72 W/kg
SAR(1 g) = 1.12 W/kg; SAR(10 g) = 0.753 W/kg
 Maximum value of SAR (measured) = 1.50 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: SCS 0108

Client: **Motorola Solutions MT**

Certificate No.: **DT50V3-1142_Nov18**

CALIBRATION CERTIFICATE

Object: **DT50V3 - SN:1142**

Calibration procedure(s): **DA-CAL-05.v11
 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **November 20, 2018**

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 client's laboratory facility, ambient temperature 20 ± 0.2°C and humidity < 70%.

Calibration Equipment used (MPEF critical for calibration)

Primary Standards	U +	Cal Date (Certificate No.)	Scheduled Calibration
Power source NIST	50 144 118	05-Apr-18 No. 217 02867(2018)	Apr-20
Power source NIST-201	50 105814	05-Apr-18 No. 217 02862	Apr-20
Power source NIST-201	50 105814	05-Apr-18 No. 217 02862	Apr-20
Reference 20 dB Attenuator	50 5058 (20)	05-Apr-18 No. 217 02861	Apr-20
Type-B mismatch construction	50 10472 (2002)	05-Apr-18 No. 217 02862	Apr-20
Reference Probe L332414	50 1348	05-May-18 No. 212 (2018, May'18)	May-20
SARs	50 401	05-Apr-18 No. 2024-401_Apr18	Apr-20
Secondary Standards	U +	Check Date (in house)	Scheduled Check
Power meter 84418D	50 148001(2018)	05-Oct-18 in-house check Feb-19	in-house check Oct-20
Power meter HP 8471A	50 150729(2018)	05-Oct-18 in-house check Oct-18	in-house check Oct-20
Power meter HP 8471A	50 151108(2017)	07-Oct-18 in-house check Oct-18	in-house check Oct-20
HP generator N66 5017-06	50 102875	15-Jun-18 in-house check Oct-18	in-house check Oct-20
Network Analyzer Agilent 87220A	50 148108(2017)	01-May-18 in-house check Oct-18	in-house check Oct-20

Calibrated by: **Johel Salgado** (Name) **Laboratory Technician** (Function) *[Signature]* (Signature)

Approved by: **Klaus Pfister** (Name) **Technical Manager** (Function) *[Signature]* (Signature)

Issued: November 20, 2018

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

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Accreditation No.: **SCS 0108**

Glossary:

TSL: tissue simulating liquid
ConUF: 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) KDS 805664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- a) DASYS System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.10.3
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 %	0.88 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	—	—

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.11 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	8.52 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	5.56 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.2 ± 6 %	0.96 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	2.19 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	8.75 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.45 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	5.60 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.3 Ω - 5.0 jΩ
Return Loss	-26.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.3 Ω - 4.9 jΩ
Return Loss	-26.2 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.034 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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

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

Additional EUT Data

Manufactured by	SPEAG
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DASY5 Validation Report for Head TSL

Date: 20.11.2019

Test Laboratory: SPTEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: DT80Y3; Serial: DT80Y3 - SN:1142

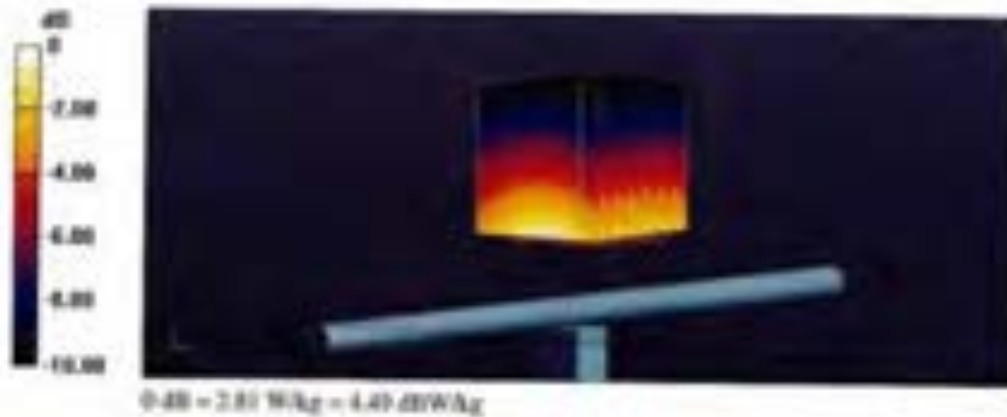
Communication System: UED 0 - CW; Frequency: 750 MHz
 Medium parameters used: $f = 750 \text{ MHz}$; $n = 0.98 \text{ Sin}$; $n_z = 42.3$; $\rho = 1000 \text{ kg/m}^3$
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C10.19-2011)

DASY52 Configuration:

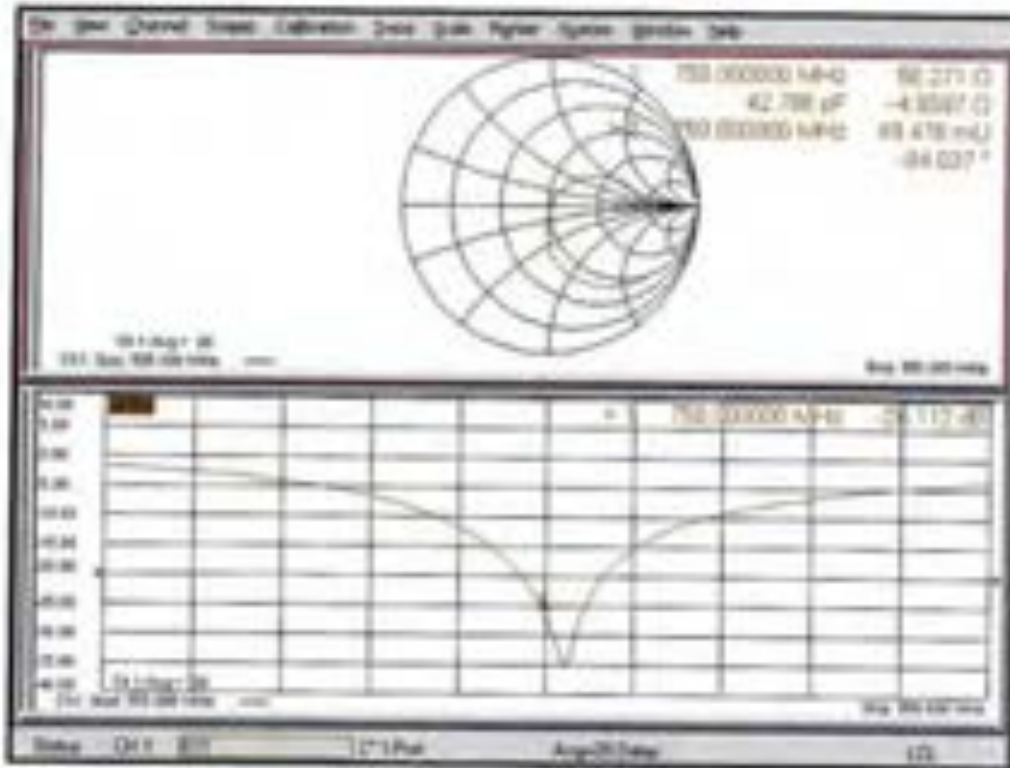
- Probe: EX3DV4 - SN7348; Coax: P130.0T, 30.0T, 30.0T) @ 750 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAH4 So6C; Calibrated: 30.04.2019
- Phantom: Flat Phantom 4.9 (fmc); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.3(1513); SEMCAD X 14.8.13(7474)

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

Measurement grid: $d_x=5\text{mm}$, $d_y=5\text{mm}$, $d_z=5\text{mm}$
 Reference Value = 29.70 V/m; Power Dens = -0.02 dB
 Peak SAR (interpolated) = 3.18 W/kg
 SAR(3 g) = 2.11 W/kg; SAR(10 g) = 1.36 W/kg
 Smallest distance from peaks to all points 3 dB below = 16.3 mm
 Ratio of SAR at M2 to SAR at M1 = 66.2%
 Maximum value of SAR (measured) = 2.81 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 20.11.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1142

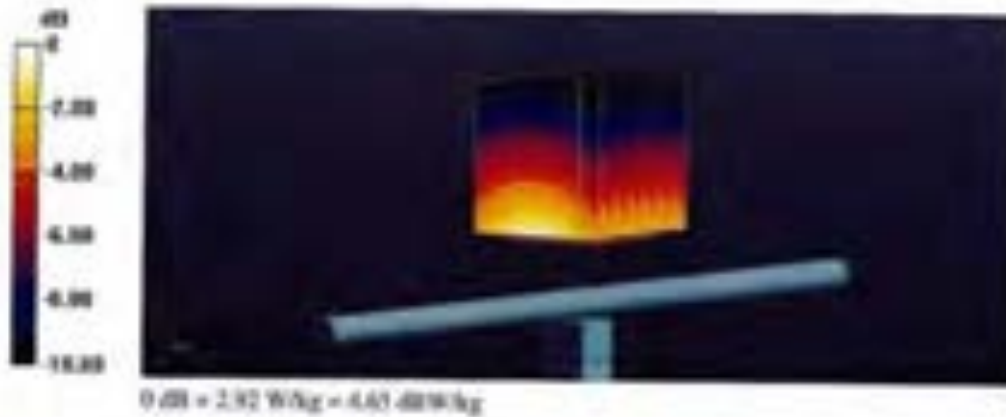
Communication System: UED 0 - CW; Frequency: 750 MHz
 Medium parameters used: $f = 750 \text{ MHz}$; $\epsilon = 0.96 \text{ S/m}$; $\epsilon_r = 35.2$; $\rho = 1000 \text{ kg/m}^3$
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EXDPV4 - SN7349; Cal=PI10.4, 10-4, 10-4 @ 750 MHz; Calibrated: 28.05.2019
- Sensor Surface: 1 Area (Mechanical Surface Detection)
- Electronics: DAH S601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 4.9 (Back); Type: QD 008 P49 AA; Serial: 1003
- DASY52 52.10.N(1311); SIMCAD X 14.6.13(7474)

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

Measurement grid: $d_x=5\text{mm}$, $d_y=5\text{mm}$, $d_z=5\text{mm}$
 Reference Value = 59.04 V/m; Power Drift = -0.00 dB
 Peak SAR (interpolated) = 3.30 W/kg
 SAR(1g) = 2.19 W/kg; SAR(10g) = 1.48 W/kg
 Smallest distance from peaks to all points 3 dB below = 13.5 mm
 Ratio of SAR at M2 to SAR at M1 = 66.5%
 Maximum value of SAR (measured) = 2.92 W/kg



Impedance Measurement Plot for Body TBA



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Accreditation No.: SCS 0108

Client **Motorola Solutions MY**

Certificate No. **D750V3-1098_Oct18**

CALIBRATION CERTIFICATE			
Client	D750V3 - SN 1098		
Calibration procedure(s)	GA CAL-05.v10 Calibration procedure for dipole validation kits above 700 MHz		
Calibration date	October 15, 2018		
<p>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.</p> <p>All calibrations have been conducted in the closest secondary facility, environment temperature 22 ± 0.1°C and humidity = 70%.</p> <p>Calibration Equipment used (M&P critical for calibration)</p>			
Primary Standards	SI	Exp Date (Certificate No.)	Scheduled Calibration
Power meter MFP	SI: 100118	04-Apr-18 (SI: 217-0007000070)	Apr-18
Power sensor MFP-201	SI: 100144	04-Apr-18 (SI: 217-000700)	Apr-18
Power sensor MFP-201	SI: 100142	04-Apr-18 (SI: 217-000700)	Apr-18
Reference 20 dB Attenuator	SI: 2000 (200)	04-Apr-18 (SI: 217-000600)	Apr-18
Type-N Hornmatch combination	SI: 5047 2 / 100007	04-Apr-18 (SI: 217-000600)	Apr-18
Reference Probe (R30704)	SI: 7148	05-Dec-17 (SI: 630-7040_0617)	Dec-18
SMU	SI: 601	04-Oct-18 (SI: 54014-001_0418)	Oct-18
Secondary Standards	SI	Check Date (SI trace)	Scheduled Check
Power meter EPM-662A	SI: 1281748104	07-Oct-18 (SI trace check Oct-18)	SI trace check Oct-18
Power sensor HP 8447A	SI: 1281748105	07-Oct-18 (SI trace check Oct-18)	SI trace check Oct-18
Power sensor HP 8447A	SI: 1281748107	07-Oct-18 (SI trace check Oct-18)	SI trace check Oct-18
RF generator Mod 3407-08	SI: 100070	12-Jun-18 (SI trace check Oct-18)	SI trace check Oct-18
Network Analyzer Agilent E8363B	SI: 1281748107	24-Mar-18 (SI trace check Oct-18)	SI trace check Oct-18
Calibrated by:	Name: Michael Weber	Function: Laboratory Technician	Signature:
Approved by:	Name: Kaja Fritsch	Technical Manager	Signature:
Issued: October 15, 2018			
This calibration certificate shall not be reproduced, copied or put without written approval of the calibrating			

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Accreditation No.: SCS 0108

Glossary:

TSL tissue simulating liquid
CompF sensitivity in TSL / NOMF 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 605664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- e) DASY4/S 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 fat phantom section, with the arms oriented parallel to the body axis.
- **Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- **Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- **SAR measured:** SAR measured at the stated antenna input power.
- **SAR normalized:** SAR as measured, normalized to an input power of 1 W at the antenna connector.
- **SAR for nominal TSL parameters:** The measured TSL parameters are used to calculate the nominal SAR result.

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

Measurement Conditions

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

DASY Version	DASY5	V52.10.2
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	40.8 ± 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	2.07 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	8.23 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	5.38 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.1 ± 6 %	0.96 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	2.16 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	8.63 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.42 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	5.67 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.1 Ω - 2.5 $j\Omega$
Return Loss	- 26.7 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.4 Ω - 3.6 $j\Omega$
Return Loss	- 29.0 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.034 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:	July 05, 2013

DASY5 Validation Report for Head TSL

Date: 15.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 0998

Communication System: UHF-D - CW; Frequency: 750 MHz

Medium parameters used: $f = 750$ MHz; $n = 1.09$ Skin; $\epsilon_r = 40.8$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SMT349; ConnF(10.22, 10.22, 10.22) @ 750 MHz; Calibrated: 30.12.2017
- Sensor Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DA64 S601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 4.9 (front); Type: QD D06 P49 AA; Serial: 1000
- DASY52.52.10.2(1495); SIMCAD X 14.6.12(749)

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

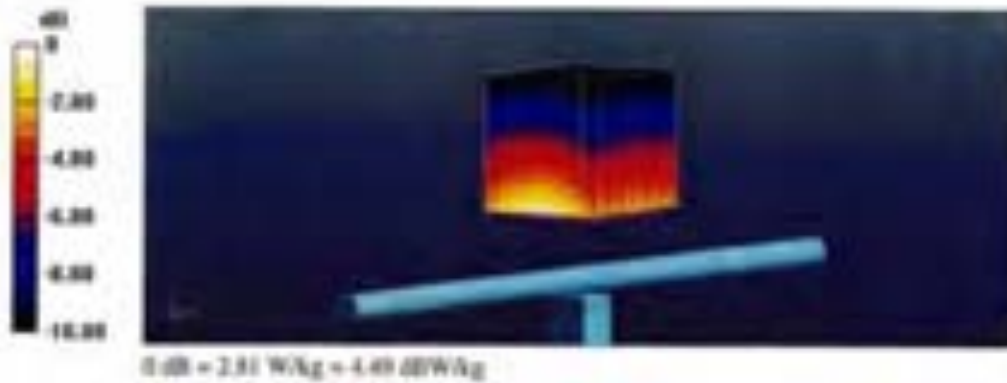
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 39.60 V/m; Power Drift = -0.04 dB

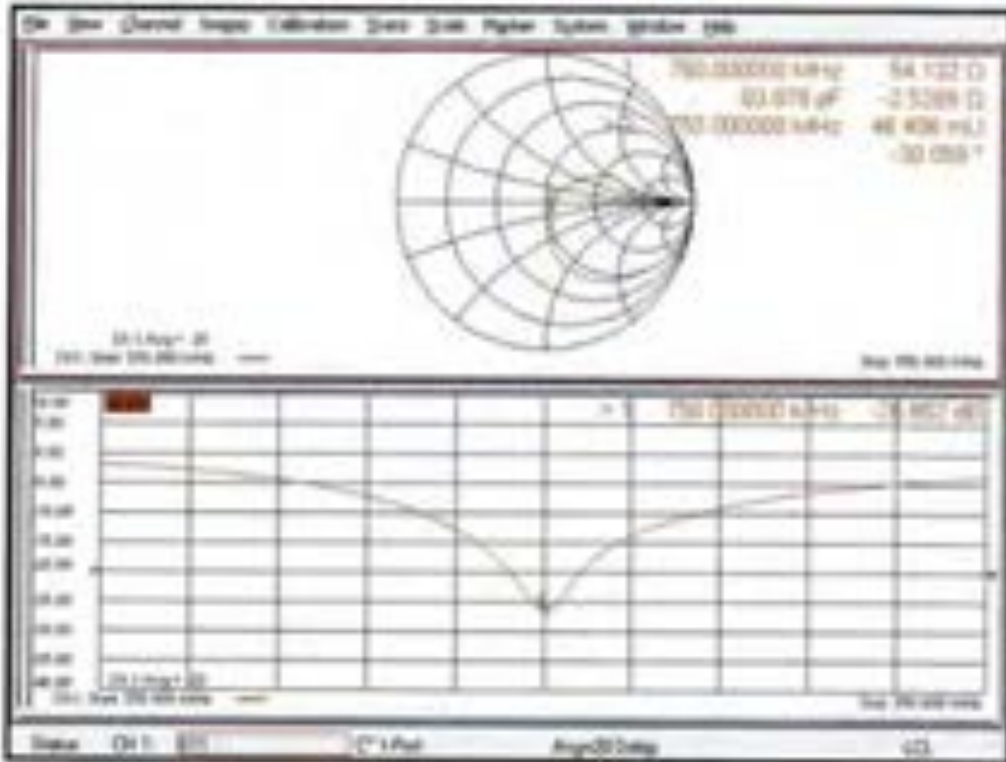
Peak SAR (extrapolated) = 3.19 W/kg

SAR(3 g) = 2.87 W/kg; SAR(10 g) = 1.35 W/kg

Maximum value of SAR (measured) = 2.81 W/kg



Impedance Measurement Plot for Head TBL



DASY5 Validation Report for Body TSL

Date: 12.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1098

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

Medium parameters used: $f = 750 \text{ MHz}$; $\epsilon = 0.96 \text{ S/m}$; $\sigma = 35.1$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EXDPV4 - SN7349; CoreF(10.18, 10.18, 10.18) @ 750 MHz; Calibrated: 30.12.2017
- Sensor Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAEM Soft1; Calibrated: 04.10.2018
- Phantom: Flat Phantom 4.0 (Back); Type: QD-008 P09 AA; Serial: 1000
- DASY52 32.10.201805; SEMCAD X 14.6.127450

Dipole Calibration for Body Tissue/Plane=250 mW, $d=15\text{mm}$ /Zoom Scan (9x9x7)/Cube 0:

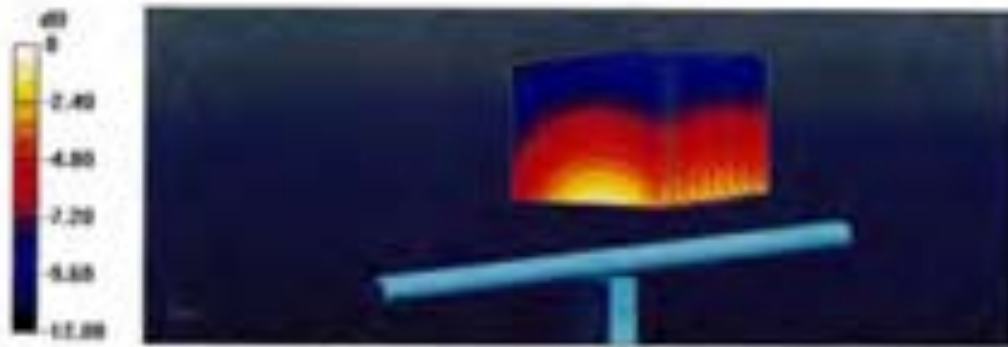
Measurement grid: $d_x=5\text{mm}$, $d_y=5\text{mm}$, $d_z=5\text{mm}$

Reference Value = 31.10 V/m; Power Dist = -0.02 dB

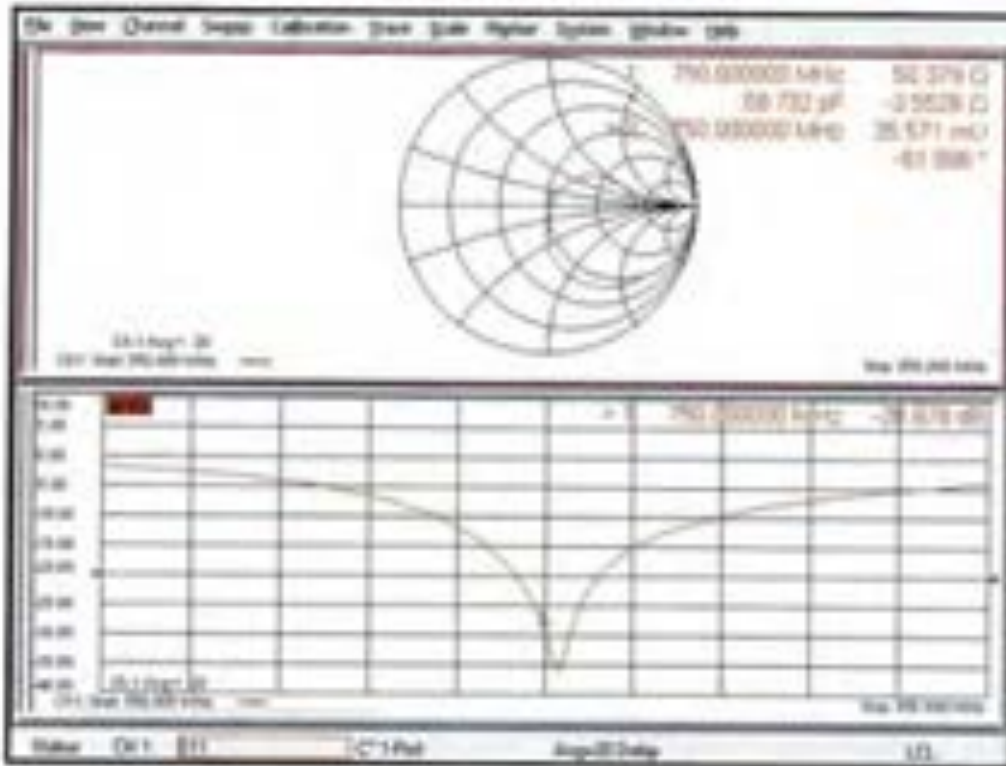
Peak SAR (extrapolated) = 3.25 W/kg

SAR(1 g) = 2.36 W/kg; SAR(10 g) = 1.42 W/kg

Maximum value of SAR (measured) = 2.86 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client: **Motorola Solutions MY**

Certificate No.: **D835V2-4d029_Feb20**

CALIBRATION CERTIFICATE

Object: **D835V2 - SN:4d029**

Calibration procedure(s): **QA CAL-05.v11
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **February 24, 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 (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probs 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-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41052317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-19)	In house check: Oct-20

Calibrated by: **Michael Weber** (Name), **Laboratory Technician** (Function), *[Signature]* (Signature)

Approved by: **Katja Pokovic** (Name), **Technical Manager** (Function), *[Signature]* (Signature)

Issued: February 24, 2020

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Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	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	42.8 ± 6 %	0.90 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.70 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.57 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.31 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	55.2 ± 6 %	0.99 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	2.44 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	9.61 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	6.32 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.0 Ω - 3.0 jΩ
Return Loss	- 30.0 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.9 Ω - 6.6 jΩ
Return Loss	- 23.0 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.398 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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

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

Additional EUT Data

Manufactured by	SPEAG
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DASY5 Validation Report for Head TSL

Date: 21.02.2020

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d029

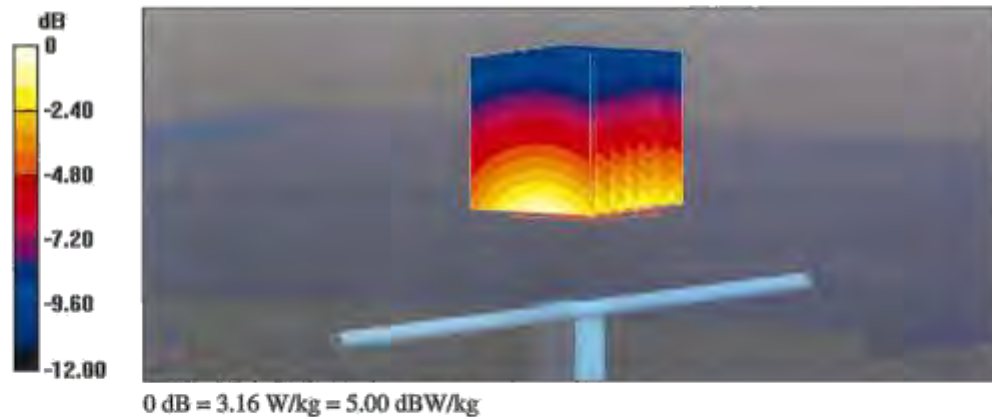
Communication System: UID 0 - CW; Frequency: 835 MHz
 Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.9 \text{ S/m}$; $\epsilon_r = 42.8$; $\rho = 1000 \text{ kg/m}^3$
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

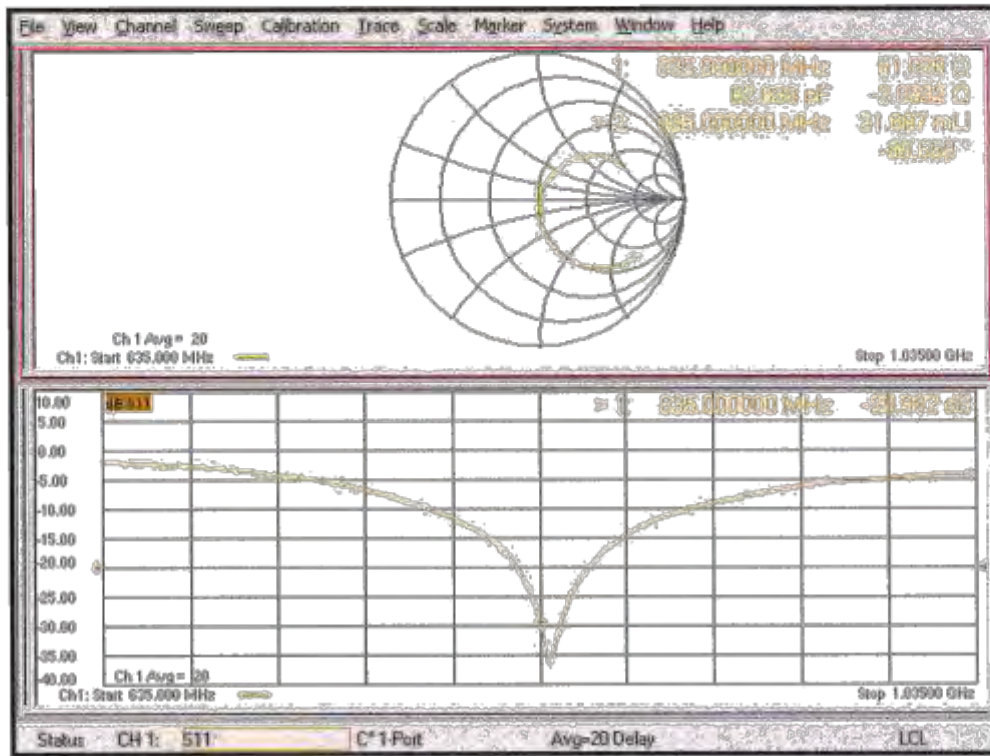
- Probe: EX3DV4 - SN7349; ConvF(9.89, 9.89, 9.89) @ 835 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

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

Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$
 Reference Value = 62.87 V/m; Power Drift = 0.00 dB
 Peak SAR (extrapolated) = 3.58 W/kg
SAR(1 g) = 2.41 W/kg; SAR(10 g) = 1.57 W/kg
 Smallest distance from peaks to all points 3 dB below = 16 mm
 Ratio of SAR at M2 to SAR at M1 = 67.2%
 Maximum value of SAR (measured) = 3.16 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 24.02.2020

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d029

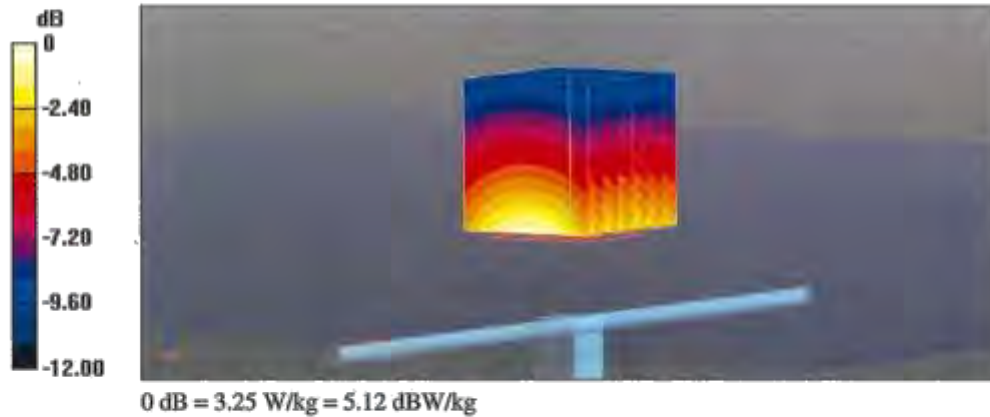
Communication System: UID 0 - CW; Frequency: 835 MHz
 Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.99 \text{ S/m}$; $\epsilon_r = 55.2$; $\rho = 1000 \text{ kg/m}^3$
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

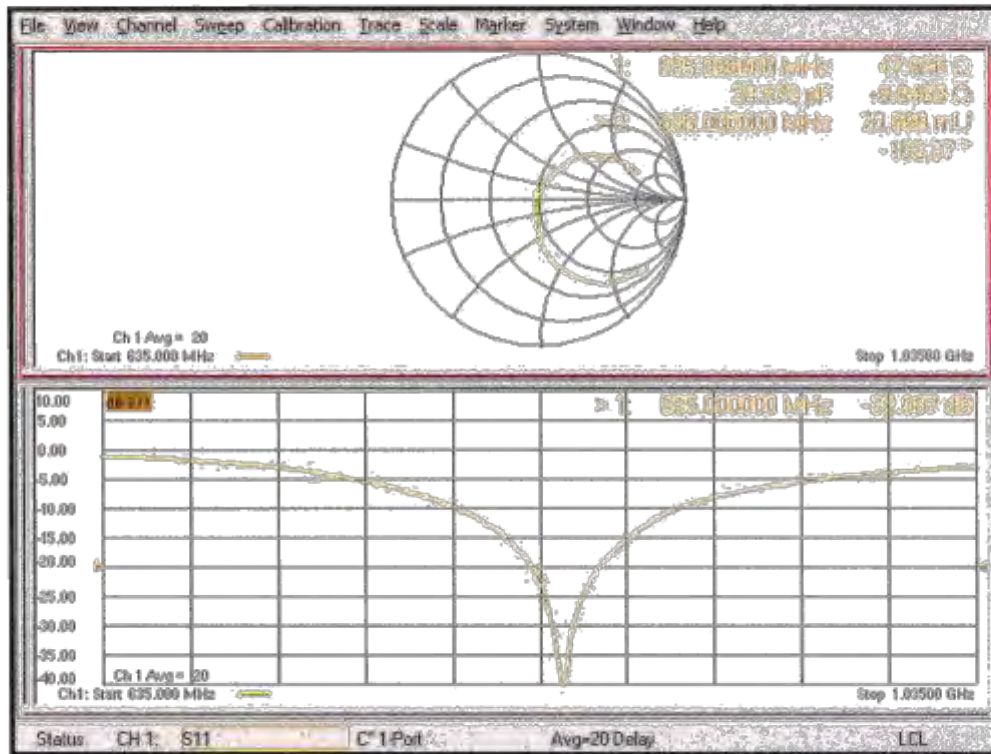
- Probe: EX3DV4 - SN7349; ConvF(10.16, 10.16, 10.16) @ 835 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

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

Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$
 Reference Value = 65.14 V/m; Power Drift = 0.01 dB
 Peak SAR (extrapolated) = 3.64 W/kg
SAR(1 g) = 2.44 W/kg; SAR(10 g) = 1.6 W/kg
 Smallest distance from peaks to all points 3 dB below = 15 mm
 Ratio of SAR at M2 to SAR at M1 = 67%
 Maximum value of SAR (measured) = 3.25 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: SCS 0108

Client: **Motorola Solutions MY**

Certificate No.: **D1800V2-278_Oct18**

CALIBRATION CERTIFICATE

Object: **D1800V2 - SN 278**

Calibration procedure: **QA CAL-05.v10**
Calibration procedure for dipole validation kits above 700 MHz

Calibration date: **October 15, 2018**

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

All calibrations have been conducted in the stated laboratory facility, environmental temperature (20 ± 0.1°C) and humidity ± 10%.

Calibration Equipment used (MUTU without for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Schedule Calibration
Power meter NRP	SN 100276	04-Apr-18 (No. 211-026718)	Apr-18
Power sensor NRP-201	SN 100266	04-Apr-18 (No. 211-026718)	Apr-18
Power sensor NRP-201	SN 100265	04-Apr-18 (No. 211-026718)	Apr-18
Reference 50 Ohm Attenuator	SN 1008 (200)	04-Apr-18 (No. 211-026620)	Apr-18
Type-B impedance combination	SN: 2047.2 / 10207	04-Apr-18 (No. 211-026620)	Apr-18
Reference Probe EX2019	SN: 7040	05-Dec-17 (No. 203-7040 (2017))	Dec-18
CRCA	SN: 801	04-Oct-18 (No. 204-801 (2018))	Oct-18
Secondary Standards	ID #	Check Date or Issue	Schedule Check
Power meter 1714-403	SN: 2007196704	07-Oct-18 (in house check Oct-18)	in house check Oct-20
Power sensor HP 8441A	SN: 208202763	07-Oct-18 (in house check Oct-18)	in house check Oct-20
Power sensor HP 8441A	SN: 2011020517	07-Oct-18 (in house check Oct-18)	in house check Oct-20
RF generator N61 207-08	SN: 100810	19-Jun-18 (in house check Oct-18)	in house check Oct-20
Network Analyzer Agilent 87220A	SN: 2047080417	07-Mar-18 (in house check Oct-18)	in house check Oct-20

Calibrated by: **Michael Mauer** (Name) / **Laboratory Technician** (Function) / *[Signature]* (Signature)

Approved by: **Kaja Finkler** (Name) / **Technical Manager** (Function) / *[Signature]* (Signature)

Issued October 15, 2018

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Accreditation No.: SAC 0108

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) KDS 805664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- a) DASY4S 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 fat phantom section, with the arms oriented parallel to the body axis.
- **Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- **Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- **SAR measured:** SAR measured at the stated antenna input power.
- **SAR normalized:** SAR as measured, normalized to an input power of 1 W at the antenna connector.
- **SAR for nominal TSL parameters:** The measured TSL parameters are used to calculate the nominal SAR result.

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

Measurement Conditions

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

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1800 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	38.8 ± 6 %	1.36 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	9.56 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	38.7 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.01 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	20.2 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.5 ± 6 %	1.49 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	9.77 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.6 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.15 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.8 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	48.9 Ω - 6.8 jΩ
Return Loss	- 23.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	44.9 Ω - 7.2 jΩ
Return Loss	- 20.6 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.198 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	November 25, 2000

DASY5 Validation Report for Head TSL

Date: 15.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1800 MHz; Type: D1800V2; Serial: D1800V2 - SN:278

Communication System: UED O - CW; Frequency: 1800 MHz

Medium parameters used: $f = 1800$ MHz; $\epsilon = 1.365$ (air); $\mu = 38.8$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX1DV4 - SNT349; Coef(8.3, 8.3, 8.3) @ 1800 MHz; Calibrated: 30.12.2017
- Sensor Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Soft; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (flat); Type: QD-000-P50-AA; Serial: 1001
- DASY52 52.10.2(1493); SEMCAD X 14.6.13(7450)

Dipole Calibration for Head Tissue($P_{in}=250$ mW, $d=10$ mm/Zoom Scan (7x7x7y)Cube @)

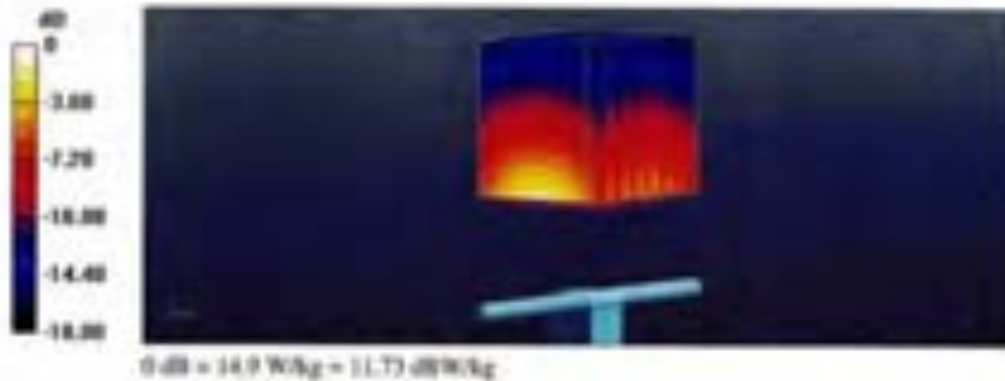
Measurement grid: $d_x=5$ mm, $d_y=5$ mm, $d_z=5$ mm

Reference Value = 110.2 V/m; Power Dens = -0.06 dB

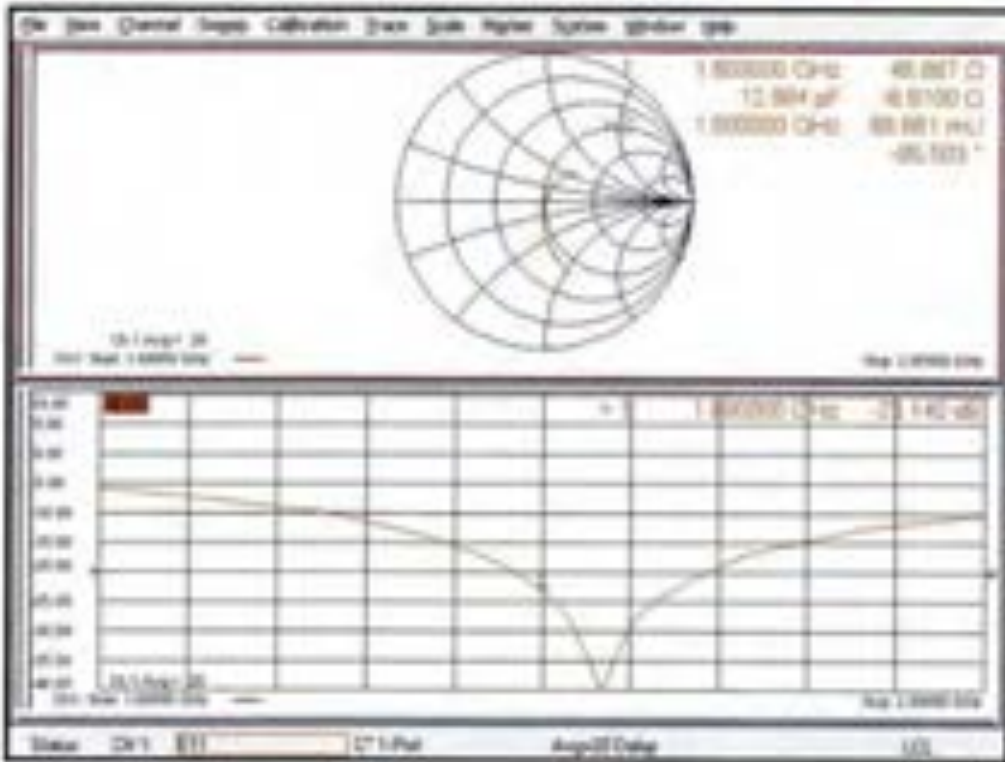
Peak SAR (extrapolated) = 17.9 W/kg

SAR(1 g) = 9.58 W/kg; SAR(10 g) = 5.01 W/kg

Maximum value of SAR (measured) = 14.9 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 12.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1800 MHz; Type: D1800V2; Serial: D1800V2 - SN:278

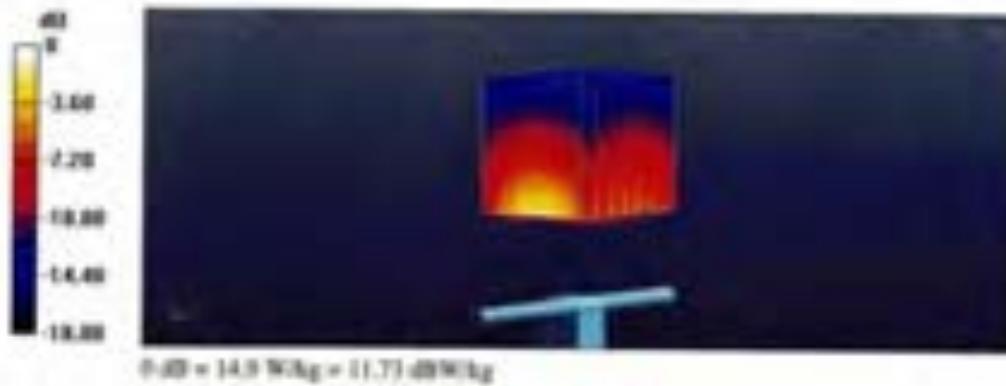
Communication System: UED-0 - CW; Frequency: 1800 MHz
 Medium parameters used: $f = 1800$ MHz; $n = 1.49$ S/m; $\epsilon = 53.5$; $\rho = 1000$ kg/m³
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY5 Configuration:

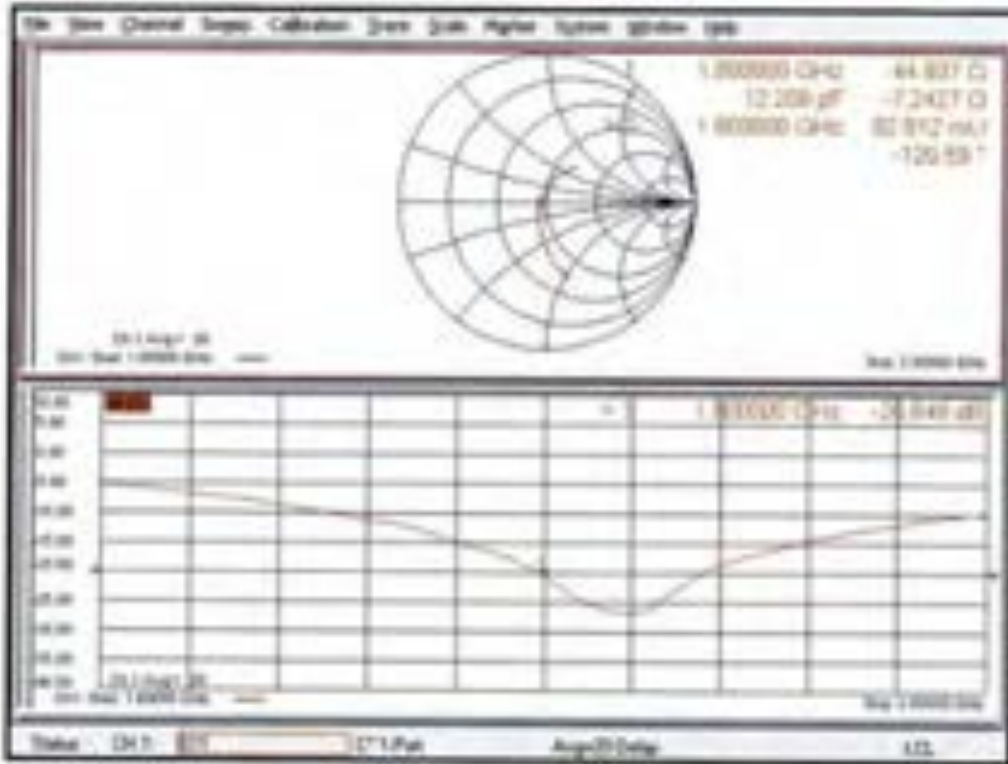
- Probe: EX3DV4 - SNT349; Coax(F8.25, 8.25, 8.25) @ 1800 MHz; Calibrated: 30.12.2007
- Sensor Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAH 5000; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY5: 5.1.10.2(1495); SEMCAD X 14.6.12(7430)

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

Measurement grid: $\Delta x=5$ mm, $\Delta y=5$ mm, $\Delta z=5$ mm
 Reference Value = 105.9 V/m; Power Drift = -0.06 dB
 Peak SAR (extrapolated) = 17.4 W/kg
 SAR(1 g) = 9.77 W/kg; SAR(10 g) = 5.15 W/kg
 Maximum value of SAR (measured) = 14.9 W/kg



Impedance Measurement Plot for Body TSL



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- S Service suisse d'Etat
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Accreditation No.: SCS 0108

Client: **Motorola Solutions MY**

Certificate No.: **D0450V2-703_Oct18**

CALIBRATION CERTIFICATE

Client: **D0450V2 - SW 703**

Calibration procedure: **QR_CAL-06.v10**
Calibration procedure for dipole validation kits above 700 MHz

Calibration date: **October 16, 2018**

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

All calibrations have been conducted in the closest laboratory facility: environment temperature (20 ± 0.1°C) and humidity < 10%.

Calibrated Equipment used (MUT) critical for validation:

Primary Standards	Q #	Exp. Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SW 100176	24-Apr-18 (No. 211-026180016)	Apr-18
Power sensor NRP-201	SW 100264	24-Apr-18 (No. 211-026172)	Apr-18
Power sensor NRP-201	SW 100265	24-Apr-18 (No. 211-026173)	Apr-18
Reference SW 40: 400MHz	SW 100266 (2018)	24-Apr-18 (No. 211-026182)	Apr-18
Type N measurement combination	SW 100473 / 100017	24-Apr-18 (No. 211-026183)	Apr-18
Reference Probe EX3010	SW 7143	25-Oct-17 (No. 530-1348, Ser 11)	Oct-18
Coax	SW 601	24-Oct-18 (No. 5404401, Ser 18)	Oct-18

Secondary Standards	Q #	Check Date (in house)	Scheduled Check
Power meter 07PA40A	SW 100176/0101	27-Oct-18 (in house check Oct-18)	in house check Oct-18
Power sensor HP 8481A	SW 100176/0102	27-Oct-18 (in house check Oct-18)	in house check Oct-18
Power sensor HP 8481A	SW 100176/0103	27-Oct-18 (in house check Oct-18)	in house check Oct-18
RF generator N60 60P 06	SW 100270	18-Jun-18 (in house check Oct-18)	in house check Oct-18
Network Analyzer Agilent 86900A	SW 100106/0101	21-Mar-18 (in house check Oct-18)	in house check Oct-18

Calibrated by: **Michael Weber** (Name), **Laboratory Technician** (Function), *[Signature]* (Signature)

Approved by: **Ruby Pflaum** (Name), **Technical Manager** (Function), *[Signature]* (Signature)

Issued: October 16, 2018

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**Calibration Laboratory of
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Englerstrasse 41, 8060 Zurich, Switzerland



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Accreditation No.: DCS 0108

Glossary:

TSL tissue simulating liquid
Conf sensitivity in TSL / NORM x,y,z
N/A not applicable or not measured

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.8 ± 6 %	1.85 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	13.5 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.9 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.24 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.6 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.2 ± 6 %	2.01 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	12.7 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	49.7 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.91 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.3 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.5 Ω + 2.9 j Ω
Return Loss	- 25.8 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.3 Ω + 6.1 j Ω
Return Loss	- 24.3 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1,146 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	March 22, 2001

DASY3 Validation Report for Head TSL

Date: 16.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:783

Communication System: UED 0 - CW, Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $n = 1.85$ (Skin); $\epsilon = 37.8$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY3 (IEEE/IEC/JANKE C63.19-2011)

DASY3 Configuration:

- Probe: EK1DV4 - SN:7349; Case: (7.88, 7.88, 7.88) @ 2450 MHz; Calibrated: 30.12.2017
- Sensor Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DA24 Sat01; Calibrated: 04.10.2018
- Phantom: Flat Phantom 3.0 (Brain); Type: QD 000 P50 AA; Serial: 1001
- DASY3: 52.10.201805; SEMCAD X 14.6.1207030

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

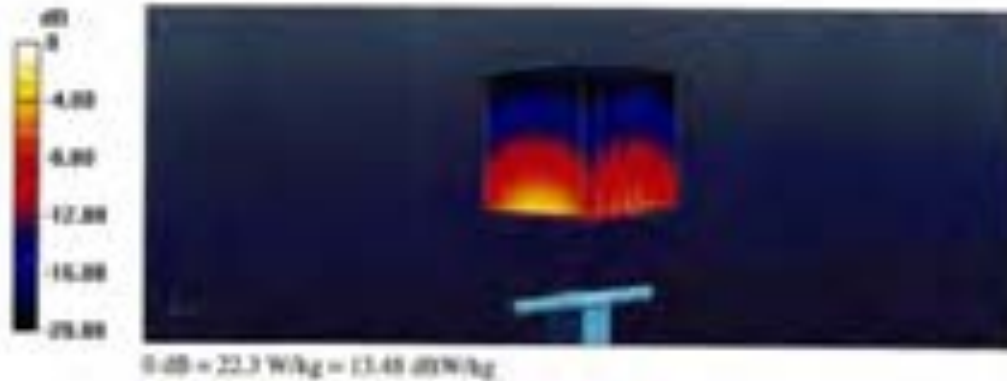
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 117.8 V/m; Power Diff = -0.04 dB

Peak SAR (extrapolated) = 27.1 W/kg

SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.24 W/kg

Maximum value of SAR (measured) = 22.3 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 16.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

EUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:703

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

Medium parameters used: $f = 2450$ MHz; $\epsilon = 2.01$ S/m; $\mu = 11.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY32 Configuration:

- Probe: EK3DV4 - SN7349; Coeff(8.01, 8.01, 8.01) @ 2450 MHz; Calibrated: 30.12.2017
- Sensor Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 So601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 3.0 (back); Type: QD 000 P30 AA; Serial: 1002
- DASY32 SI.10.213495; SEMCAD X 14.6.123490

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

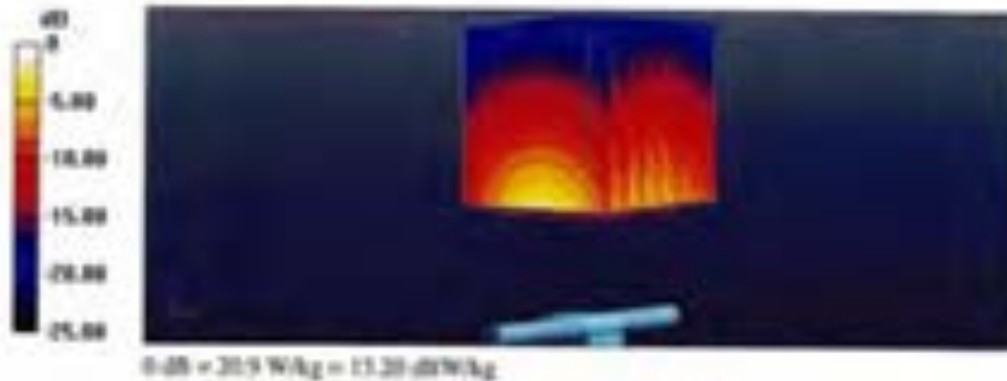
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 107.9 V/m; Power Diff = -0.07 dB

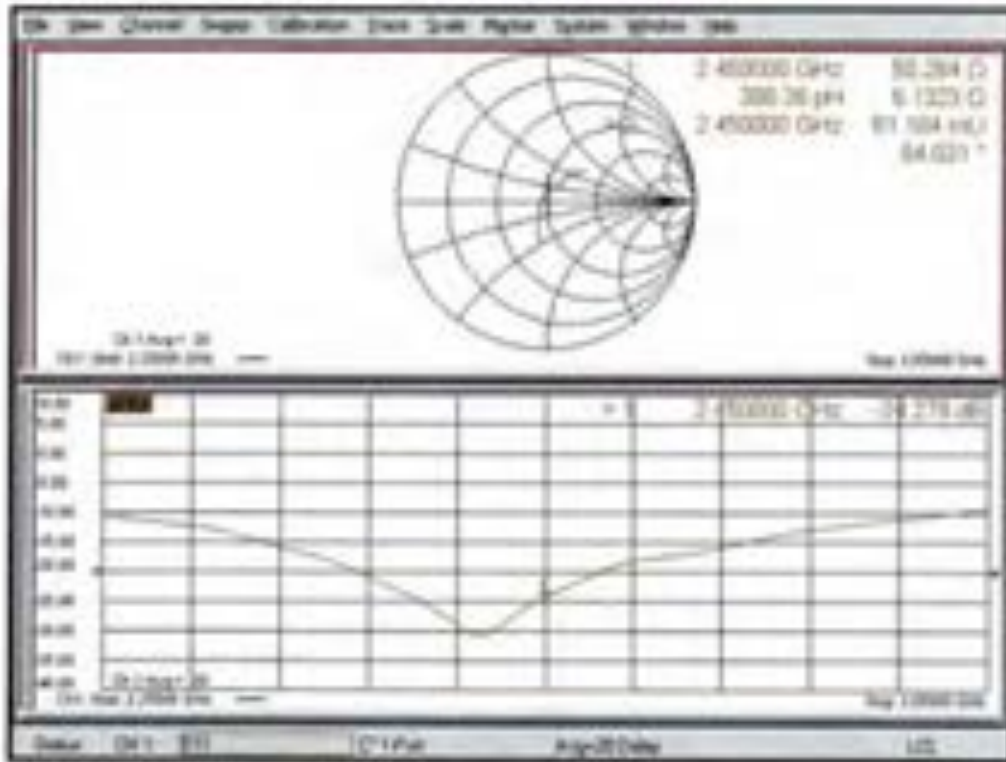
Peak SAR (extrapolated) = 25.7 W/kg

SAR(1 g) = 12.7 W/kg; SAR(10 g) = 5.91 W/kg

Maximum value of SAR (measured) = 20.9 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client **Motorola Solutions MY**

Certificate No: **D2450V2-782_Feb20**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN:782**

Calibration procedure(s) **QA CAL-05.v11
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **February 20, 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 (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probe EX3DV4	SN: 7349	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-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-19)	In house check: Oct-20

	Name	Function	Signature
Calibrated by:	Leif Klyzner	Laboratory Technician	<i>Leif Klyzner</i>
Approved by:	Katja Pokovic	Technical Manager	<i>Katja Pokovic</i>

Issued: February 20, 2020

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Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

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

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.4 ± 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 ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.9 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	54.4 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.3 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.4 ± 6 %	2.03 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	---	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.3 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	51.9 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.21 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.5 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.2 Ω + 3.8 j Ω
Return Loss	- 26.3 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.6 Ω + 5.9 j Ω
Return Loss	- 24.6 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.153 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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

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

Additional EUT Data

Manufactured by	SPEAG
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DASY5 Validation Report for Head TSL

Date: 20.02.2020

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:782

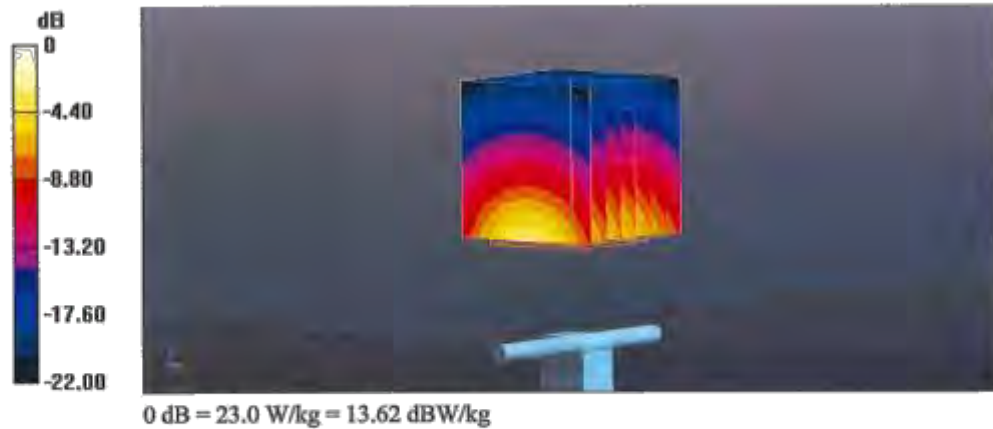
Communication System: UID 0 - CW; Frequency: 2450 MHz
 Medium parameters used: $f = 2450$ MHz; $\sigma = 1.86$ S/m; $\epsilon_r = 38.4$; $\rho = 1000$ kg/m³
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

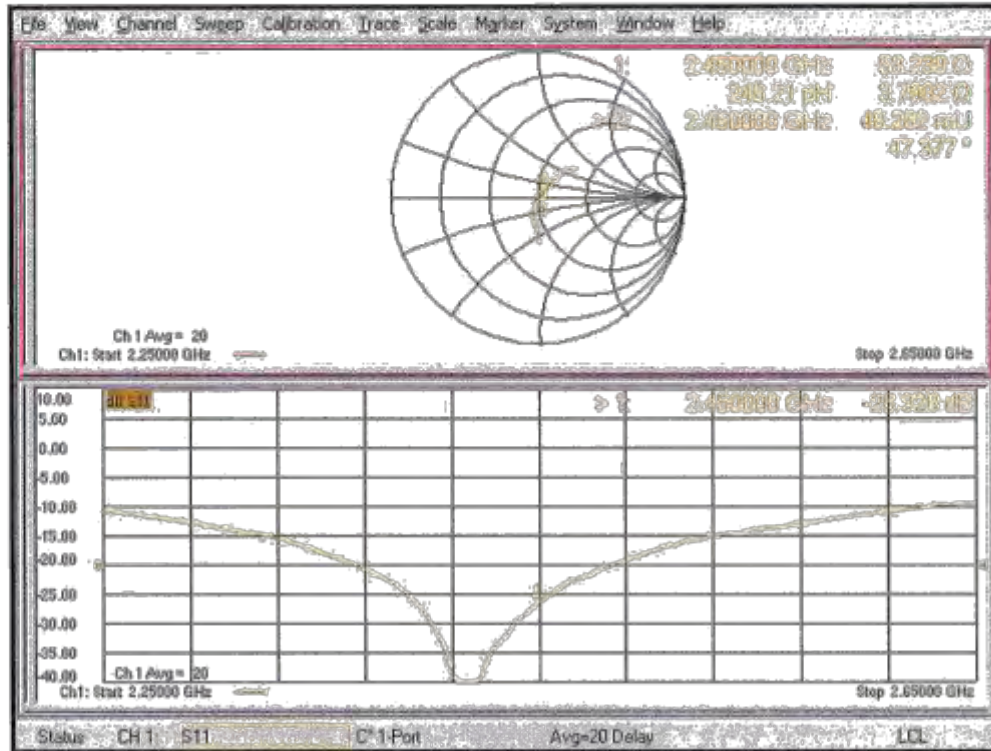
- Probe: EX3DV4 - SN7349; ConvF(7.98, 7.98, 7.98) @ 2450 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

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 = 120.1 V/m; Power Drift = -0.01 dB
 Peak SAR (extrapolated) = 27.7 W/kg
SAR(1 g) = 13.9 W/kg; SAR(10 g) = 6.41 W/kg
 Smallest distance from peaks to all points 3 dB below = 9 mm
 Ratio of SAR at M2 to SAR at M1 = 50%
 Maximum value of SAR (measured) = 23.0 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 20.02.2020

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:782

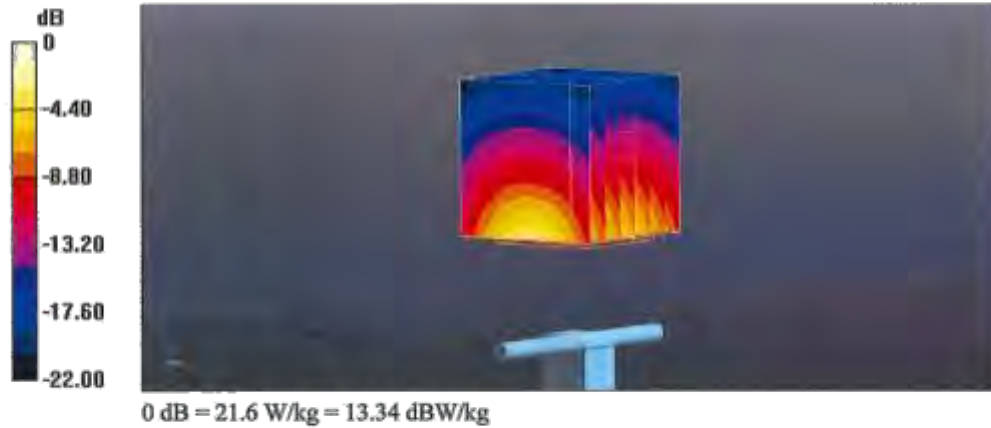
Communication System: UID 0 - CW; Frequency: 2450 MHz
 Medium parameters used: $f = 2450$ MHz; $\sigma = 2.03$ S/m; $\epsilon_r = 51.4$; $\rho = 1000$ kg/m³
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

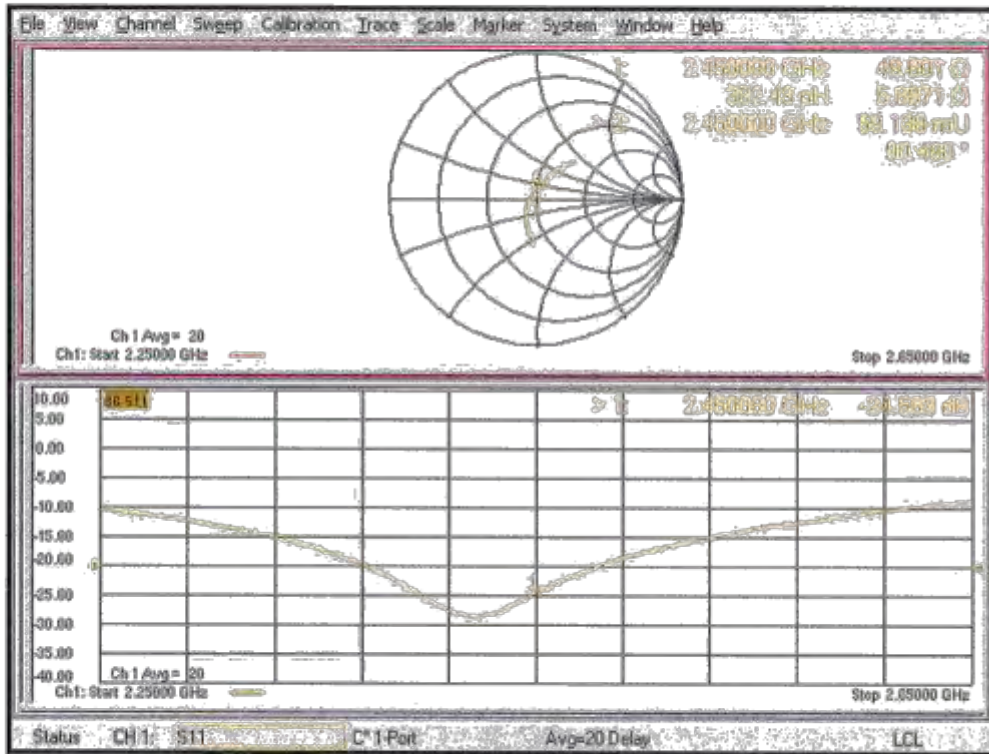
- Probe: EX3DV4 - SN7349; ConvF(8.02, 8.02, 8.02) @ 2450 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm
 Reference Value = 110.9 V/m; Power Drift = -0.06 dB
 Peak SAR (extrapolated) = 25.6 W/kg
SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.21 W/kg
 Smallest distance from peaks to all points 3 dB below = 8.9 mm
 Ratio of SAR at M2 to SAR at M1 = 52.9%
 Maximum value of SAR (measured) = 21.6 W/kg



Impedance Measurement Plot for Body TSL



Calibration Laboratory of
Schmid & Partner
Engineering AG
Enggendorferstrasse 14, 8001 Zurich, Switzerland



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SAC 0108

Client: **Motorola Solutions NY**

Certificate No: **D5GHV2-1026_Out18**

CALIBRATION CERTIFICATE

Order: **D5GHV2 - SN 1026**

Calibration procedure: **DA CAL 02 v3**
Calibration procedure for (pulse validation kits between 3-6 GHz)

Calibration date: **October 18, 2018**

This calibration certificate documents the conformity 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 client laboratory facility: environmental temperature (23 ± 0.2°C) and humidity < 75%.

Calibration Equipment used (MPE/C unless for calibration)

Primary Standards	U : a	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 1104718	24-Apr-18 (No. 217-00070)	Apr-18
Power sensor NRP-201	SN: 1102944	24-Apr-18 (No. 217-00070)	Apr-18
Power sensor NRP-201	SN: 1102945	24-Apr-18 (No. 217-00070)	Apr-18
Reference 3C 3C Attenuator	SN: 9188 (200)	24-Apr-18 (No. 217-00070)	Apr-18
Type H frequency counter	SN: 2047.2 / 10027	24-Apr-18 (No. 217-00070)	Apr-18
Reference Probe EX3014	SN: 8024	20-Nov-17 (No. 025-0002, Dec-17)	Dec-18
Probe	SN: 8017	24-Oct-18 (No. 044-001, Oct-18)	Oct-18
Secondary Standards	U : a	Check Date (in house)	Scheduled Check
Power meter EPA-40A	SN: 0201000104	07-Oct-18 (in house check Oct-18)	in house check Oct-18
Power sensor HP 4814	SN: 0001000102	07-Oct-18 (in house check Oct-18)	in house check Oct-18
Power sensor HP 4814	SN: 0014000101	07-Oct-18 (in house check Oct-18)	in house check Oct-18
RF generator N83 200T-04	SN: 110070	19-Jun-18 (in house check Oct-18)	in house check Oct-18
Network Analyzer Agilent 83604A	SN: 1041000017	01-Mar-18 (in house check Oct-18)	in house check Oct-18

Calibrated by: **Maria Sany** (Name), **Laboratory Technician** (Function), *[Signature]* (Signature)

Approved by: **Kaja Fahrens** (Name), **Technical Manager** (Function), *[Signature]* (Signature)

Issued: October 18, 2018

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

**Calibration Laboratory of
Schmid & Partner
Engineering AG**
Engelshausstrasse 42, 8004 Zurich, Switzerland



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Accreditation No.: SCS 0108

Glossary:

TSL tissue simulating liquid
Cov_{ref} 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 2019
- d) KCB 805664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.10.2
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	5000 MHz ± 1 MHz 5250 MHz ± 1 MHz 5500 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz 5800 MHz ± 1 MHz	

Head TSL parameters at 5000 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.2	4.45 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.0 ± 6 %	4.28 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	—	—

SAR result with Head TSL at 5000 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	73.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.14 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	21.3 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.7 ± 6 %	4.54 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	—	—

SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm 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	81.0 W / kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.2 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	35.3 ± 6 %	4.79 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	—	—

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	8.50 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	84.7 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.42 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.1 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.2 ± 6 %	4.90 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	---	---

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.62 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	85.9 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.47 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.5 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.0 ± 6 %	5.05 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	---	---

SAR result with Head TSL at 5750 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.23 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	82.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.4 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	34.9 ± 6 %	5.11 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	—	—

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.20 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.7 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.3 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5000 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	-49.3	5.07 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.6 ± 6 %	5.12 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	—	—

SAR result with Body TSL at 5000 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.10 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	70.5 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.01 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	19.9 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.36 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.2 ± 6 %	5.45 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	—	—

SAR result with Body TSL at 5250 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.50 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	74.5 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.09 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.7 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	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	46.7 ± 6 %	5.79 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	—	—

SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm ³ (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	77.5 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.17 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.5 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.5 ± 6 %	5.92 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	—	—

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.83 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	77.7 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.19 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.7 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.3	5.94 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.3 ± 6 %	6.13 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	—	—

SAR result with Body TSL at 5750 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.59 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	75.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.11 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.9 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	46.2 ± 6 %	6.20 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	—	—

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm 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	2.10 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.8 W/kg ± 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5000 MHz

Impedance, transformed to feed point	50.4 Ω + 10.8 jΩ
Return Loss	- 19.4 dB

Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	48.9 Ω - 3.5 jΩ
Return Loss	- 28.6 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	48.4 Ω - 2.4 jΩ
Return Loss	- 30.7 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	54.2 Ω + 1.7 jΩ
Return Loss	- 27.3 dB

Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	52.6 Ω + 3.0 jΩ
Return Loss	- 28.2 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	52.1 Ω + 1.2 jΩ
Return Loss	- 32.4 dB

Antenna Parameters with Body TSL at 5000 MHz

Impedance, transformed to feed point	49.4 Ω - 9.6 jΩ
Return Loss	- 20.3 dB

Antenna Parameters with Body TSL at 5250 MHz

Impedance, transformed to feed point	48.1 Ω - 0.8 jΩ
Return Loss	- 33.4 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	49.3 Ω - 0.5 jΩ
Return Loss	- 41.4 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	54.6 Ω + 3.2 jΩ
Return Loss	- 25.5 dB

Antenna Parameters with Body TSL at 5750 MHz

Impedance, transformed to feed point	53.1 Ω + 4.2 jΩ
Return Loss	- 25.9 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	53.1 Ω + 2.8 jΩ
Return Loss	- 27.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.204 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	February 05, 2004

DASY5 Validation Report for Head TSL

Date: 17.10.2018

Test Laboratory: The name of your organization

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1026

Communication System: UID 0 - CW; Frequency: 5000 MHz, Frequency: 5250 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5800 MHz
 Medium parameters used: $f = 5000$ MHz; $\sigma = 4.28$ S/m; $\epsilon_r = 36$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5250$ MHz; $\sigma = 4.54$ S/m; $\epsilon_r = 35.7$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5500$ MHz; $\sigma = 4.79$ S/m; $\epsilon_r = 35.3$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5600$ MHz; $\sigma = 4.9$ S/m; $\epsilon_r = 35.2$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5750$ MHz; $\sigma = 5.05$ S/m; $\epsilon_r = 35$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5800$ MHz; $\sigma = 5.11$ S/m; $\epsilon_r = 34.9$; $\rho = 1000$ kg/m³
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(6.5, 6.5, 6.5) @ 5000 MHz, ConvF(5.51, 5.51, 5.51) @ 5250 MHz, ConvF(5.2, 5.2, 5.2) @ 5500 MHz, ConvF(5.05, 5.05, 5.05) @ 5600 MHz, ConvF(4.98, 4.98, 4.98) @ 5750 MHz, ConvF(4.96, 4.96, 4.96) @ 5800 MHz; Calibrated: 30.12.2017
- 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=5000 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 71.36 V/m; Power Drift = 0.08 dB

Peak SAR (extrapolated) = 25.2 W/kg

SAR(1 g) = 7.34 W/kg; SAR(10 g) = 2.14 W/kg

Maximum value of SAR (measured) = 16.8 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 75.56 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 28.1 W/kg

SAR(1 g) = 8.12 W/kg; SAR(10 g) = 2.33 W/kg

Maximum value of SAR (measured) = 19.0 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 = 74.99 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 33.0 W/kg

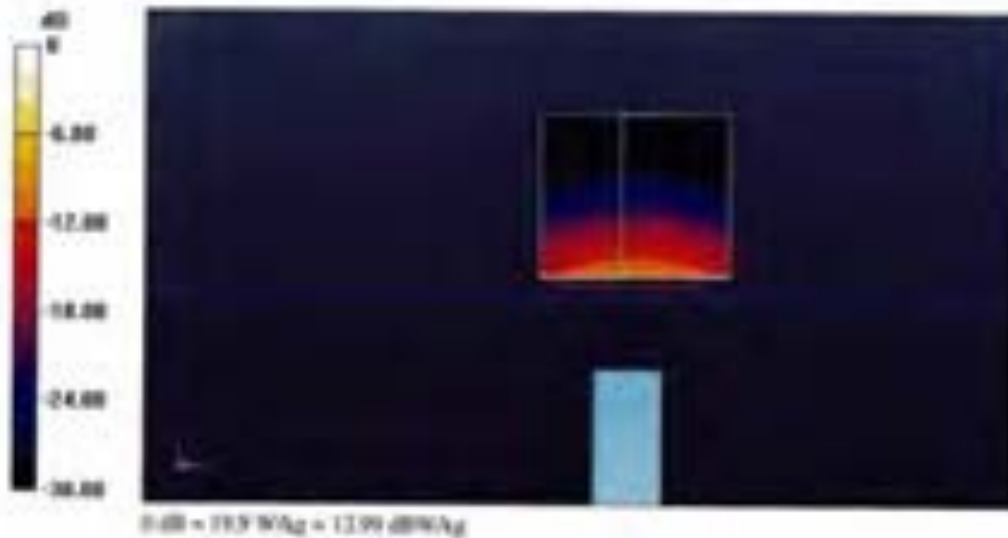
SAR(1 g) = 8.5 W/kg; SAR(10 g) = 2.42 W/kg

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

Dipole Calibration for Head Tissue/P_{iso}=100mW, dist=10mm, f=5600 MHz/Zoom Scan,
dist=1.4mm (8x8x7)/Cube B; Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 73.93 V/m; Power Delt = 0.07 dB
Peak SAR (interpolated) = 32.6 W/kg
SAR(1 g) = 8.62 W/kg; SAR(10 g) = 2.47 W/kg
Maximum value of SAR (measured) = 20.8 W/kg

Dipole Calibration for Head Tissue/P_{iso}=100mW, dist=10mm, f=5750 MHz/Zoom Scan,
dist=1.4mm (8x8x7)/Cube B; Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 73.91 V/m; Power Delt = 0.01 dB
Peak SAR (interpolated) = 31.8 W/kg
SAR(1 g) = 8.25 W/kg; SAR(10 g) = 2.36 W/kg
Maximum value of SAR (measured) = 19.9 W/kg

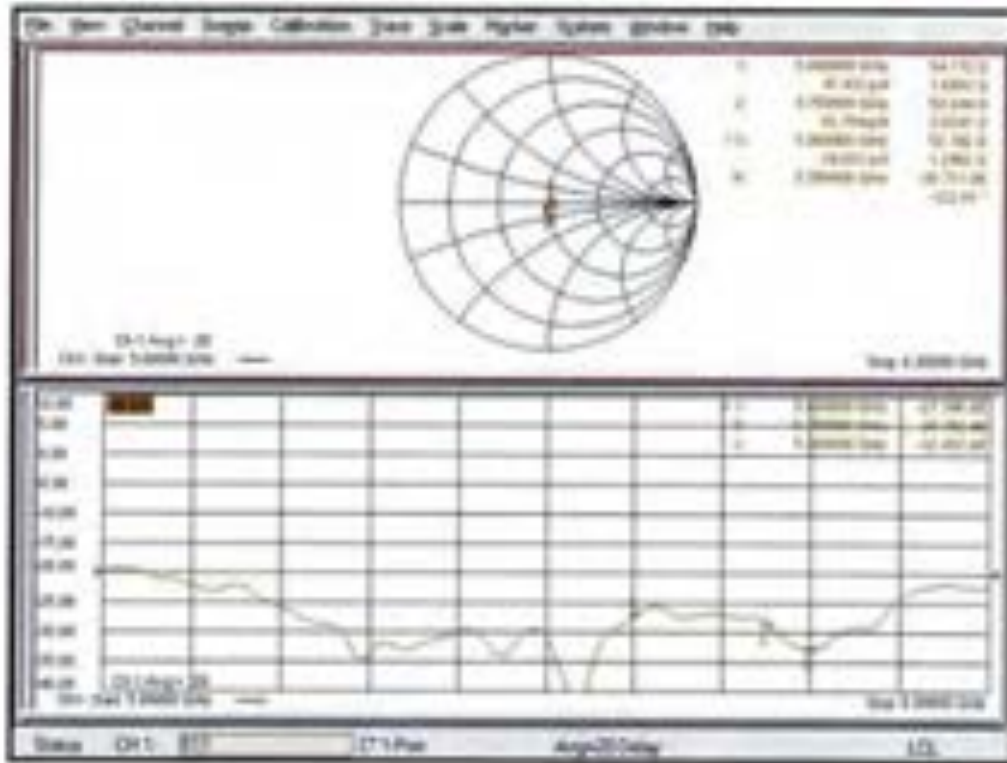
Dipole Calibration for Head Tissue/P_{iso}=100mW, dist=10mm, f=5800 MHz/Zoom Scan,
dist=1.4mm (8x8x7)/Cube B; Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 73.56 V/m; Power Delt = 0.00 dB
Peak SAR (interpolated) = 31.9 W/kg
SAR(1 g) = 8.2 W/kg; SAR(10 g) = 2.34 W/kg
Maximum value of SAR (measured) = 19.9 W/kg



Impedance Measurement Plot for Head TSL (5000, 5250, 5500GHz)



Impedance Measurement Plot for Head TSL (5600, 5750, 5900GHz)



DASY5 Validation Report for Body TSL

Date: 18.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1026

Communication System: UID 0 - CW; Frequency: 5000 MHz, Frequency: 5250 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5800 MHz
 Medium parameters used: $f = 5000$ MHz; $\sigma = 5.12$ S/m; $\epsilon_r = 47.6$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5250$ MHz; $\sigma = 5.45$ S/m; $\epsilon_r = 47.2$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5500$ MHz; $\sigma = 5.79$ S/m; $\epsilon_r = 46.7$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5600$ MHz; $\sigma = 5.92$ S/m; $\epsilon_r = 46.5$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5750$ MHz; $\sigma = 6.13$ S/m; $\epsilon_r = 46.3$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5800$ MHz; $\sigma = 6.2$ S/m; $\epsilon_r = 46.2$; $\rho = 1000$ kg/m³
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.7, 5.7, 5.7) @ 5000 MHz, ConvF(5.26, 5.26, 5.26) @ 5250 MHz, ConvF(4.7, 4.7, 4.7) @ 5500 MHz, ConvF(4.65, 4.65, 4.65) @ 5600 MHz, ConvF(4.57, 4.57, 4.57) @ 5750 MHz, ConvF(4.53, 4.53, 4.53) @ 5800 MHz; Calibrated: 30.12.2017
- 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=5000MHz/Zoom Scan,**dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 67.65 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 25.6 W/kg

SAR(1 g) = 7.1 W/kg; SAR(10 g) = 2.01 W/kg

Maximum value of SAR (measured) = 15.6 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan,**dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 68.08 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 28.9 W/kg

SAR(1 g) = 7.5 W/kg; SAR(10 g) = 2.09 W/kg

Maximum value of SAR (measured) = 17.2 W/kg

Dipole Calibration for Body 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 = 68.64 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 32.1 W/kg

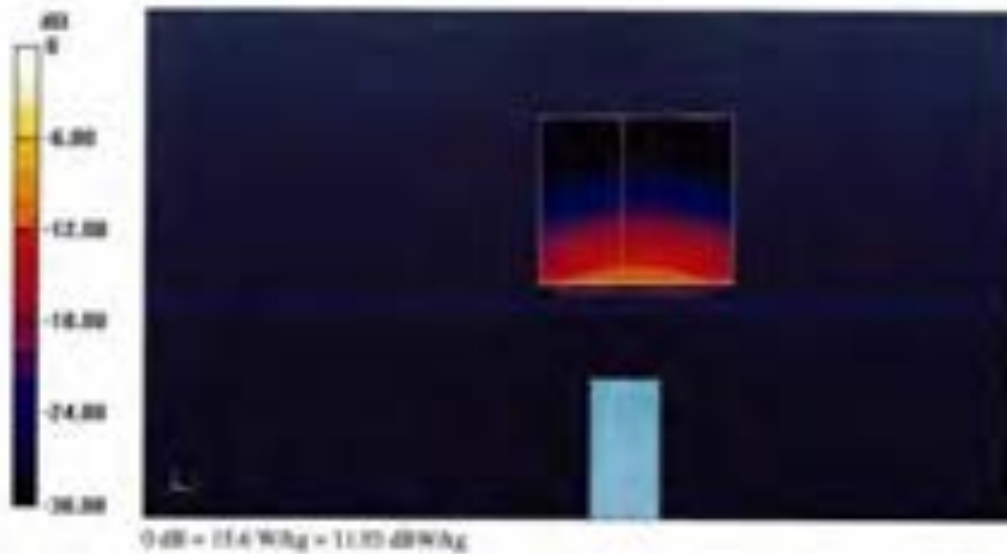
SAR(1 g) = 7.81 W/kg; SAR(10 g) = 2.17 W/kg

Maximum value of SAR (measured) = 18.3 W/kg

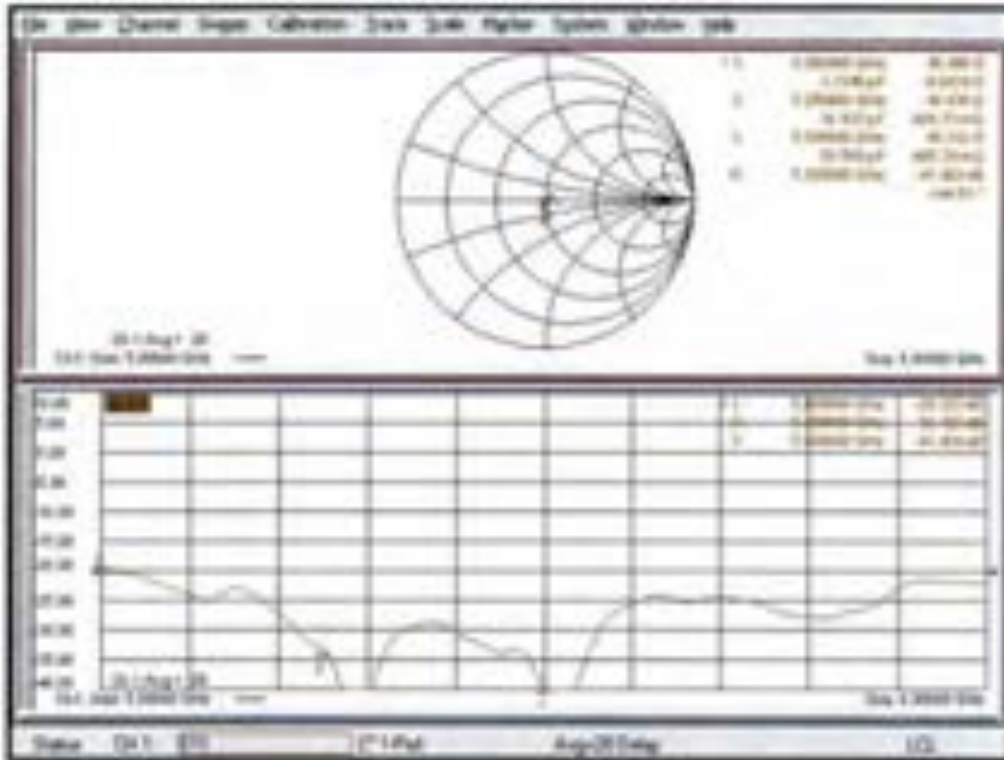
Dipole Calibration for Body Tissue/P_{in}=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube @; Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.12 V/m, Power Drift = -0.07 dB
Peak SAR (extrapolated) = 32.9 W/kg
SAR(1 g) = 7.83 W/kg; SAR(10 g) = 2.19 W/kg
Maximum value of SAR (measured) = 15.6 W/kg

Dipole Calibration for Body Tissue/P_{in}=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube @; Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.92 V/m, Power Drift = -0.07 dB
Peak SAR (extrapolated) = 32.3 W/kg
SAR(1 g) = 7.59 W/kg; SAR(10 g) = 2.11 W/kg
Maximum value of SAR (measured) = 15.2 W/kg

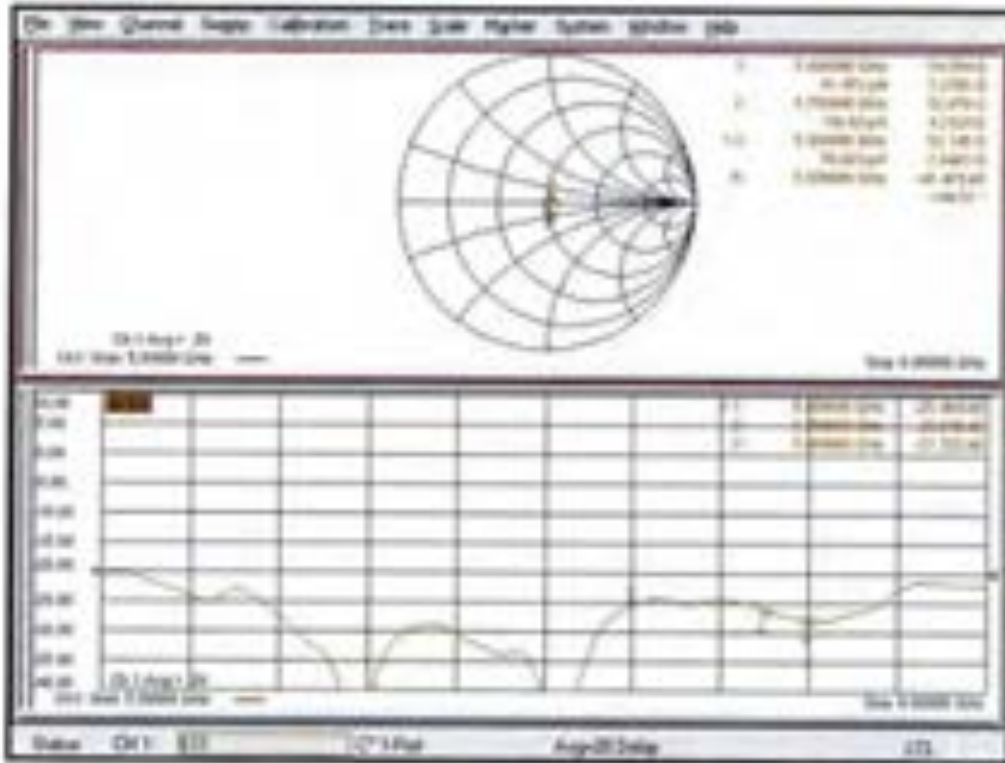
Dipole Calibration for Body Tissue/P_{in}=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube @; Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 66.55 V/m, Power Drift = -0.07 dB
Peak SAR (extrapolated) = 33.5 W/kg
SAR(1 g) = 7.57 W/kg; SAR(10 g) = 2.1 W/kg
Maximum value of SAR (measured) = 15.2 W/kg



Impedance Measurement Plot for Body TSL (5000, 5250, 5500GHz)



Impedance Measurement Plot for Body TSL (5600, 5750, 5900GHz)



**Calibration Laboratory of
Schmid & Partner
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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client: **Motorola Solutions MY**

Certificate No: **D5GHzV2-1027_Jan20**

CALIBRATION CERTIFICATE

Object: **D5GHzV2 - SN: 1027**

Calibration procedure(s): **QA CAL-22.v4
Calibration Procedure for SAR Validation Sources between 3-6 GHz**

Calibration date: **January 31, 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&PE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 9058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probe EX3DV4	SN: 3503	31-Dec-19 (No. EX3-3503_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: GB09512475	30-Oct-14 (in house check Feb-19)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41082317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-20

Calibrated by: **Name: Michael Weber, Function: Laboratory Technician, Signature: [Handwritten Signature]**

Approved by: **Name: Katja Pokovic, Function: Technical Manager, Signature: [Handwritten Signature]**

Issued: February 4, 2020

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

**Calibration Laboratory of
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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.10.3
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	5000 MHz ± 1 MHz 5250 MHz ± 1 MHz 5500 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz	

Head TSL parameters at 5000 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.2	4.45 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.6 ± 6%	4.29 mho/m ± 6%
Head TSL temperature change during test	< 0.5 °C	---	---

SAR result with Head TSL at 5000 MHz:

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.43 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	74.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.16 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	21.4 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5250 MHz

The following parameters and calculations were applied:

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.3 ± 6 %	4.54 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	---	---

SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.10 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.6 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.0 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	34.9 ± 6 %	4.79 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	---	---

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	8.37 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	83.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.3 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.6 ± 6 %	4.89 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	---	---

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	83.6 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.7 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.6 ± 6 %	5.05 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	---	---

SAR result with Head TSL at 5750 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.02 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	79.7 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.27 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.6 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5000 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.3	5.07 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.6 ± 6 %	5.16 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	---	---

SAR result with Body TSL at 5000 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.05 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	70.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	1.98 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	19.6 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.36 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.1 ± 6 %	5.49 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	---	---

SAR result with Body TSL at 5250 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.55 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	75.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.10 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.8 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	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	46.6 ± 6 %	5.83 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.96 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	79.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.19 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.7 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.5 ± 6 %	5.97 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.87 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	78.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.17 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.5 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.3	5.94 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.2 ± 6 %	6.17 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	---	---

SAR result with Body TSL at 5750 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.52 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	74.7 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.10 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.8 W/kg ± 19.5 % (k=2)

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

Antenna Parameters with Head TSL at 5000 MHz

Impedance, transformed to feed point	49.4 Ω - 9.9 j Ω
Return Loss	-20.0 dB

Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	49.6 Ω - 1.3 j Ω
Return Loss	-37.3 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	47.8 Ω + 1.3 j Ω
Return Loss	-31.7 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	53.7 Ω + 4.2 j Ω
Return Loss	-25.4 dB

Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	53.7 Ω + 6.8 j Ω
Return Loss	-22.5 dB

Antenna Parameters with Body TSL at 5000 MHz

Impedance, transformed to feed point	48.6 Ω - 9.0 j Ω
Return Loss	-20.7 dB

Antenna Parameters with Body TSL at 5250 MHz

Impedance, transformed to feed point	48.9 Ω + 0.9 j Ω
Return Loss	-36.9 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	47.4 Ω + 3.8 j Ω
Return Loss	-26.6 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	$53.8 \Omega + 6.3 j\Omega$
Return Loss	-23.1 dB

Antenna Parameters with Body TSL at 5750 MHz

Impedance, transformed to feed point	$55.6 \Omega + 7.9 j\Omega$
Return Loss	-20.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.191 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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

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

Additional EUT Data

Manufactured by	SPEAG
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DASY5 Validation Report for Head TSL

Date: 31.01.2020

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1027

Communication System: UID 0 - CW; Frequency: 5000 MHz, Frequency: 5250 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz

Medium parameters used: $f = 5000$ MHz; $\sigma = 4.29$ S/m; $\epsilon_r = 35.6$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5250$ MHz; $\sigma = 4.54$ S/m; $\epsilon_r = 35.3$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5500$ MHz; $\sigma = 4.79$ S/m; $\epsilon_r = 34.9$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5600$ MHz; $\sigma = 4.89$ S/m; $\epsilon_r = 34.8$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5750$ MHz; $\sigma = 5.05$ S/m; $\epsilon_r = 34.6$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- * Probe: EX3DV4 - SN3503; ConvF(6.23, 6.23, 6.23) @ 5000 MHz, ConvF(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.25, 5.25, 5.25) @ 5500 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.08, 5.08, 5.08) @ 5750 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 52.10.3(1513); SEMCAD X 14.6.13(7474)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5000 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 73.01 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 24.6 W/kg

SAR(1 g) = 7.43 W/kg; SAR(10 g) = 2.16 W/kg

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

Ratio of SAR at M2 to SAR at M1 = 72%

Maximum value of SAR (measured) = 16.4 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 75.14 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 28.0 W/kg

SAR(1 g) = 8.1 W/kg; SAR(10 g) = 2.31 W/kg

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

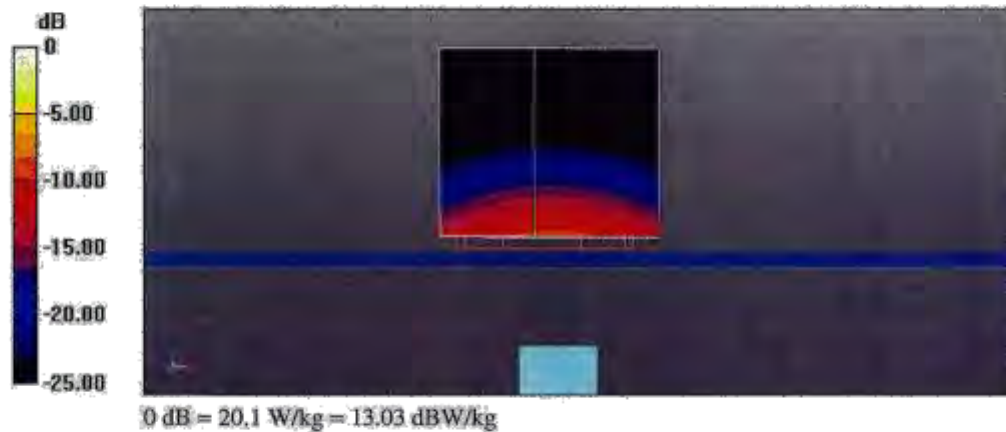
Ratio of SAR at M2 to SAR at M1 = 70.9%

Maximum value of SAR (measured) = 18.3 W/kg

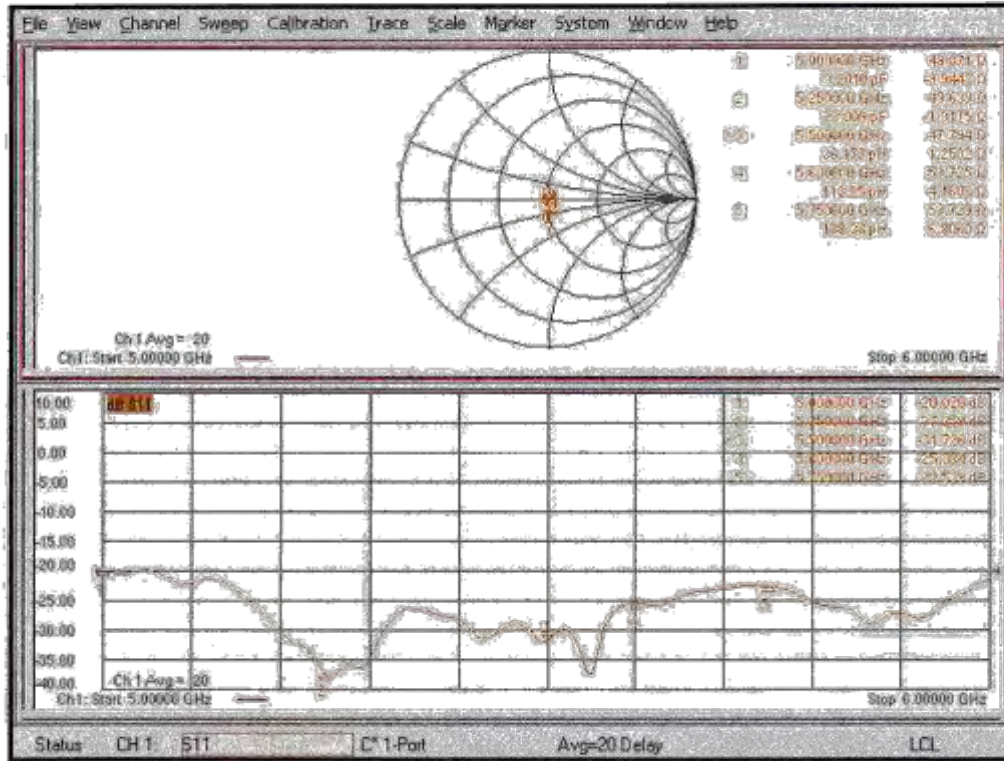
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
 Reference Value = 75.87 V/m; Power Drift = -0.02 dB
 Peak SAR (extrapolated) = 32.4 W/kg
SAR(1 g) = 8.37 W/kg; SAR(10 g) = 2.35 W/kg
 Smallest distance from peaks to all points 3 dB below = 7.2 mm
 Ratio of SAR at M2 to SAR at M1 = 67.2%
 Maximum value of SAR (measured) = 20.1 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 = 74.95 V/m; Power Drift = 0.02 dB
 Peak SAR (extrapolated) = 31.2 W/kg
SAR(1 g) = 8.41 W/kg; SAR(10 g) = 2.39 W/kg
 Smallest distance from peaks to all points 3 dB below = 7.5 mm
 Ratio of SAR at M2 to SAR at M1 = 68.2%
 Maximum value of SAR (measured) = 19.9 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
 Reference Value = 72.21 V/m; Power Drift = 0.01 dB
 Peak SAR (extrapolated) = 31.3 W/kg
SAR(1 g) = 8.02 W/kg; SAR(10 g) = 2.27 W/kg
 Smallest distance from peaks to all points 3 dB below = 7.5 mm
 Ratio of SAR at M2 to SAR at M1 = 66.7%
 Maximum value of SAR (measured) = 19.1 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 31.01.2020

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1027

Communication System: UID 0 - CW; Frequency: 5000 MHz, Frequency: 5250 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz

Medium parameters used: $f = 5000$ MHz; $\sigma = 5.16$ S/m; $\epsilon_r = 47.6$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5250$ MHz; $\sigma = 5.49$ S/m; $\epsilon_r = 47.1$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5500$ MHz; $\sigma = 5.83$ S/m; $\epsilon_r = 46.6$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5600$ MHz; $\sigma = 5.97$ S/m; $\epsilon_r = 46.5$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5750$ MHz; $\sigma = 6.17$ S/m; $\epsilon_r = 46.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.93, 5.93, 5.93) @ 5000 MHz, ConvF(5.26, 5.26, 5.26) @ 5250 MHz, ConvF(4.84, 4.84, 4.84) @ 5500 MHz, ConvF(4.79, 4.79, 4.79) @ 5600 MHz, ConvF(4.66, 4.66, 4.66) @ 5750 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4.Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5000 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 66.77 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 26.0 W/kg

SAR(1 g) = 7.05 W/kg; SAR(10 g) = 1.98 W/kg

Smallest distance from peaks to all points 3 dB below = 6.8 mm

Ratio of SAR at M2 to SAR at M1 = 68.5%

Maximum value of SAR (measured) = 15.9 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 68.19 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 29.4 W/kg

SAR(1 g) = 7.55 W/kg; SAR(10 g) = 2.1 W/kg

Smallest distance from peaks to all points 3 dB below = 6.8 mm

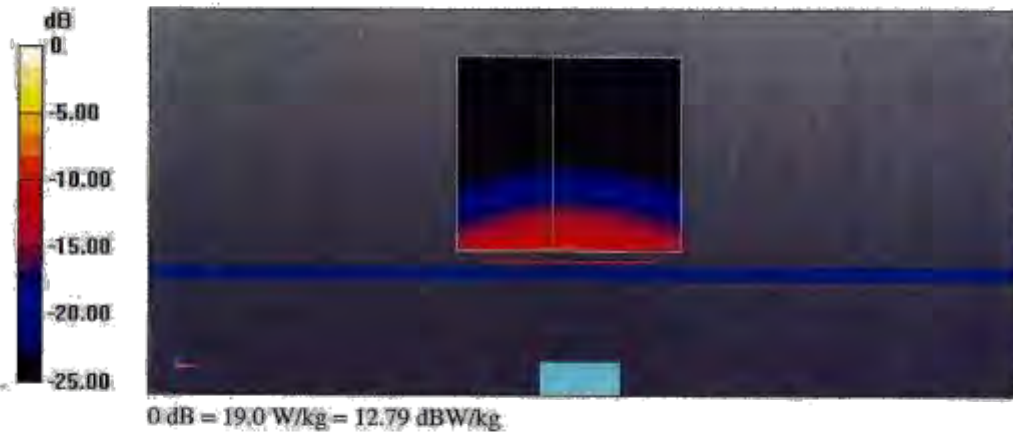
Ratio of SAR at M2 to SAR at M1 = 66.6%

Maximum value of SAR (measured) = 17.4 W/kg

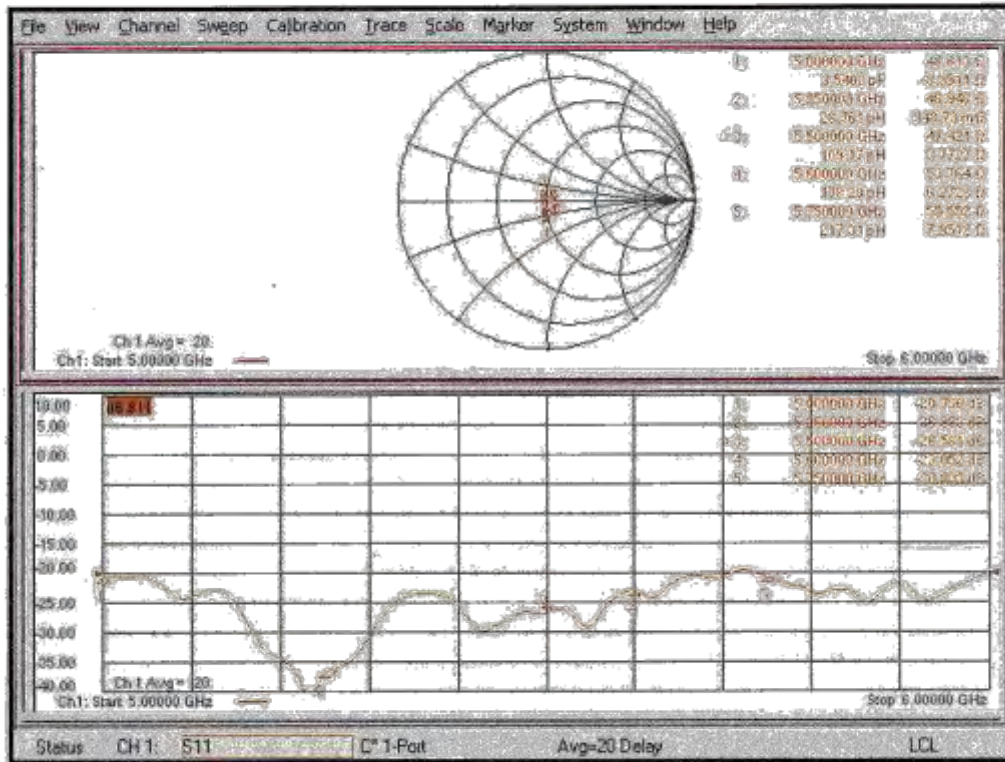
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
 Reference Value = 68.94 V/m; Power Drift = 0.00 dB
 Peak SAR (extrapolated) = 33.5 W/kg
SAR(1 g) = 7.96 W/kg; SAR(10 g) = 2.19 W/kg
 Smallest distance from peaks to all points 3 dB below = 7.2 mm
 Ratio of SAR at M2 to SAR at M1 = 64.3%
 Maximum value of SAR (measured) = 19.0 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
 Reference Value = 67.71 V/m; Power Drift = -0.01 dB
 Peak SAR (extrapolated) = 34.2 W/kg
SAR(1 g) = 7.87 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) = 19.0 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
 Reference Value = 66.38 V/m; Power Drift = -0.04 dB
 Peak SAR (extrapolated) = 33.8 W/kg
SAR(1 g) = 7.52 W/kg; SAR(10 g) = 2.10 W/kg
 Smallest distance from peaks to all points 3 dB below = 7.2 mm
 Ratio of SAR at M2 to SAR at M1 = 61.8%
 Maximum value of SAR (measured) = 18.2 W/kg



Impedance Measurement Plot for Body TSL



Dipole Data

The table below includes dipole impedance and return loss measurement data measured by Motorola Solutions' EME lab. The results meet the requirements stated in KDB 865664.

Dipole CLA150-4016	Head			Body		
	Impedance		Return Loss	Impedance		Return Loss
Date Measured	real Ω	imag $j\Omega$	dB	real Ω	imag $j\Omega$	dB
12/18/2018	44.51	6.18	-21.21	44.94	5.98	-21.59
11/09/2019	42.03	9.19	-21.64	45.01	6.36	-21.45

Dipole 450-1053	Head			Body		
	Impedance		Return Loss	Impedance		Return Loss
Date Measured	real Ω	imag $j\Omega$	dB	real Ω	imag $j\Omega$	dB
11/20/2018	53.78	-7.39	-21.97	49.27	-7.93	-21.94
11/10/2019	53.95	-6.72	-22.49	49.84	-7.37	-22.74

Dipole 450-1054	Head			Body		
	Impedance		Return Loss	Impedance		Return Loss
Date Measured	real Ω	imag $j\Omega$	dB	real Ω	imag $j\Omega$	dB
04/08/2019	59.46	-4.57	-20.36	56.02	-6.09	-21.87
04/13/2020	57.08	-6.58	-20.38	56.08	-3.56	-24.43

Dipole 750-1098	Head			Body		
	Impedance		Return Loss	Impedance		Return Loss
Date Measured	real Ω	imag $j\Omega$	dB	real Ω	imag $j\Omega$	dB
11/08/2018	46.65	-1.94	-27.95	50.51	-1.01	-38.98
11/10/2019	46.58	-1.25	-28.79	48.57	-1.14	-33.42

Dipole 1800-278	Head			Body		
	Impedance		Return Loss	Impedance		Return Loss
Date Measured	real Ω	imag $j\Omega$	dB	real Ω	imag $j\Omega$	dB
12/20/2018	56.79	-3.55	-22.89	53.55	-6.43	-23.00
04/13/2020	56.86	-0.70	-23.63	56.39	-9.23	-20.12

Dipole 2450-703	Head			Body		
	Impedance		Return Loss	Impedance		Return Loss
Date Measured	real Ω	imag $j\Omega$	dB	real Ω	imag $j\Omega$	dB
12/20/2018	49.44	3.73	-28.42	48.61	5.62	-24.65
11/11/2019	51.11	3.82	-28.38	48.94	3.93	-28.04

Dipole 5250-1026	Head			Body		
	Impedance		Return Loss	Impedance		Return Loss
Date Measured	real Ω	imag $j\Omega$	dB	real Ω	imag $j\Omega$	dB
12/20/2018	46.47	0.37	-28.69	49.07	2.41	-31.67
11/10/2019	50.87	3.02	-24.72	45.84	2.33	-30.96

Dipole 5600-1026	Head			Body		
	Impedance		Return Loss	Impedance		Return Loss
Date Measured	real Ω	imag $j\Omega$	dB	real Ω	imag $j\Omega$	dB
12/20/2018	56.25	4.23	-22.98	54.88	7.38	-21.50
11/10/2019	55.28	2.13	-26.74	51.68	3.39	-25.31

Dipole 5750-1026	Head			Body		
	Impedance		Return Loss	Impedance		Return Loss
Date Measured	real Ω	imag $j\Omega$	dB	real Ω	imag $j\Omega$	dB
12/20/2018	49.77	-1.59	-35.86	53.22	-2.52	-28.05
11/10/2019	49.02	-3.74	-31.56	54.25	-5.46	-25.09