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Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D5GHzV2-1191\_Sep16**

## CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN:1191**

Calibration procedure(s) **QA CAL-22.v2**  
**Calibration procedure for dipole validation kits between 3-6 GHz**

Calibration date: **September 21, 2016**

*BNV*  
*09-28-2016*  
*Extended*  
*09/2017*  
*SC*

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 ( $22 \pm 3$ )°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	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: 5058 (20k)	05-Apr-16 (No. 217-02292)	Apr-17
Type-N mismatch combination	SN: 5047.2 / 06327	05-Apr-16 (No. 217-02295)	Apr-17
Reference Probe EX3DV4	SN: 3503	30-Jun-16 (No. EX3-3503_Jun16)	Jun-17
DAE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (No. 217-02223)	In house check: Oct-16
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Jun-15)	In house check: Oct-16
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

Calibrated by: **Leif Klysner** Laboratory Technician *Leif Klysner*

Approved by: **Katja Pokovic** Technical Manager *Katja Pokovic*

Issued: September 22, 2016

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



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**Glossary:**

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

**Calibration is Performed According to the Following Standards:**

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

**Additional Documentation:**

- 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.

<b>DASY Version</b>	DASY5	V52.8.8
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom V5.0	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
<b>Frequency</b>	5250 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz	

## Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	35.9	4.71 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	34.5 ± 6 %	4.59 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL at 5250 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	7.96 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>78.9 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	100 mW input power	2.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>22.6 W/kg ± 19.5 % (k=2)</b>

### 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	34.0 ± 6 %	4.93 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.45 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>83.6 W / kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.8 W/kg ± 19.5 % (k=2)</b>

### Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	33.8 ± 6 %	5.08 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5750 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.99 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>79.1 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (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	<b>22.4 W/kg ± 19.5 % (k=2)</b>

### 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	47.4 ± 6 %	5.52 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5250 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.74 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	77.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.17 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.6 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	46.8 ± 6 %	6.00 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.96 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	79.2 W/kg ± 19.9 % (k=2)

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

## Body TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.3	5.94 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.5 ± 6 %	6.21 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Body TSL at 5750 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.65 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	76.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.14 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.2 W/kg ± 19.5 % (k=2)

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

### Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	55.7 $\Omega$ - 4.3 j $\Omega$
Return Loss	- 23.4 dB

### Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	58.3 $\Omega$ - 3.2 j $\Omega$
Return Loss	- 21.8 dB

### Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	58.1 $\Omega$ + 4.8 j $\Omega$
Return Loss	- 21.2 dB

### Antenna Parameters with Body TSL at 5250 MHz

Impedance, transformed to feed point	56.1 $\Omega$ - 3.7 j $\Omega$
Return Loss	- 23.4 dB

### Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	58.9 $\Omega$ - 1.7 j $\Omega$
Return Loss	- 21.7 dB

### Antenna Parameters with Body TSL at 5750 MHz

Impedance, transformed to feed point	59.5 $\Omega$ + 6.9 j $\Omega$
Return Loss	- 19.4 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	August 28, 2003

## DASY5 Validation Report for Head TSL

Date: 21.09.2016

Test Laboratory: SPEAG, Zurich, Switzerland

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

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz  
Medium parameters used:  $f = 5250$  MHz;  $\sigma = 4.59$  S/m;  $\epsilon_r = 34.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5600$  MHz;  $\sigma = 4.93$  S/m;  $\epsilon_r = 34$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5750$  MHz;  $\sigma = 5.08$  S/m;  $\epsilon_r = 33.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.42, 5.42, 5.42); Calibrated: 30.06.2016, ConvF(4.89, 4.89, 4.89); Calibrated: 30.06.2016, ConvF(4.85, 4.85, 4.85); Calibrated: 30.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**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 = 68.49 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 28.6 W/kg

**SAR(1 g) = 7.96 W/kg; SAR(10 g) = 2.29 W/kg**

Maximum value of SAR (measured) = 18.2 W/kg

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 69.34 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 32.9 W/kg

**SAR(1 g) = 8.45 W/kg; SAR(10 g) = 2.41 W/kg**

Maximum value of SAR (measured) = 20.0 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

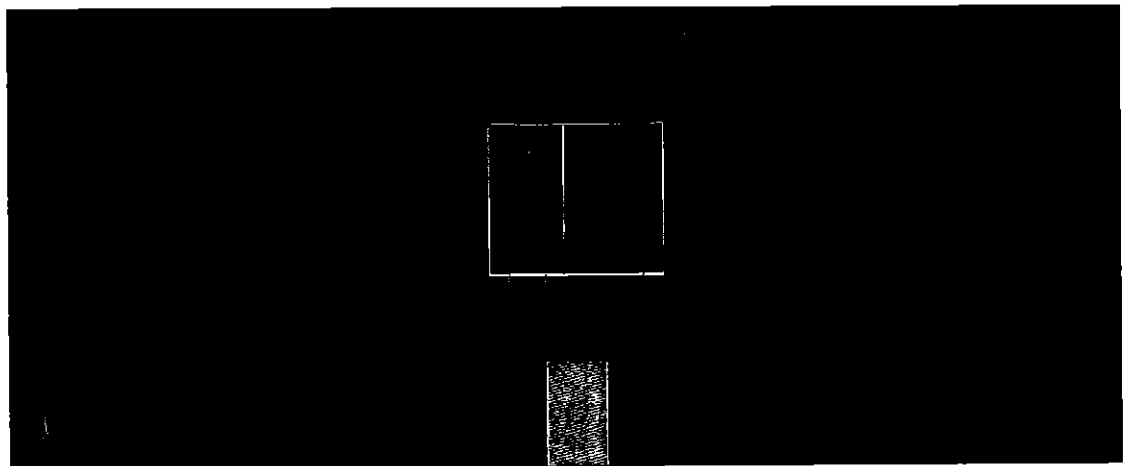
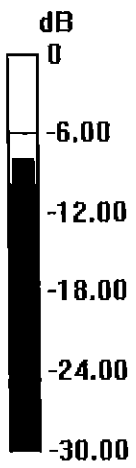
Reference Value = 67.15 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 32.3 W/kg

**SAR(1 g) = 7.99 W/kg; SAR(10 g) = 2.27 W/kg**

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





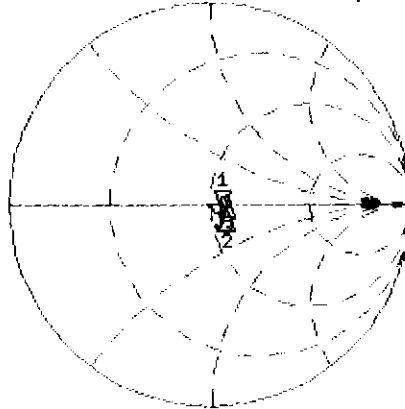
0 dB = 18.2 W/kg = 12.60 dBW/kg

# Impedance Measurement Plot for Head TSL

20 Sep 2016 13:20:17

CH1 S11 1 U FS 1: 55.695  $\Omega$  -4.2793  $\Omega$  7.0842 pF 5 250.000 000 MHz

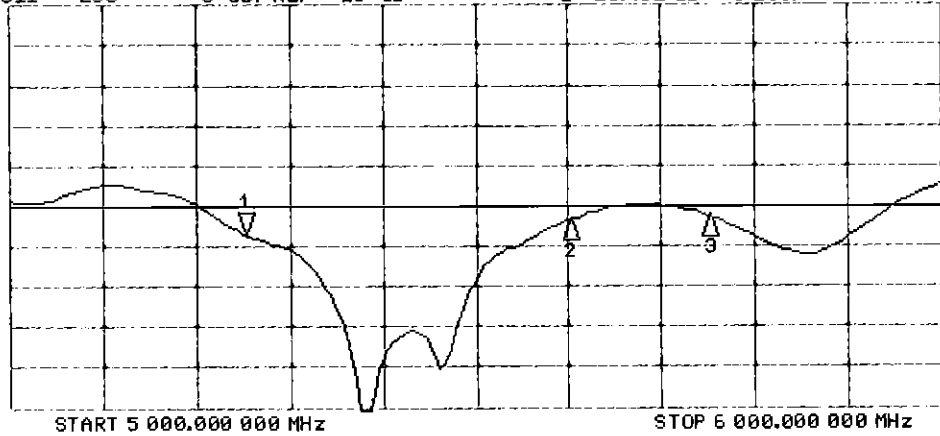
\*  
Del  
Cor  
Avg  
16  
H1d



CH1 Markers  
2: 58.262  $\Omega$   
-3.1738  $\Omega$   
5.60000 GHz  
3: 58.078  $\Omega$   
4.7969  $\Omega$   
5.75000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1: -23.432 dB 5 250.000 000 MHz

Cor  
Avg  
16  
H1d



CH2 Markers  
2: -21.752 dB  
5.60000 GHz  
3: -21.228 dB  
5.75000 GHz

## DASY5 Validation Report for Body TSL

Date: 20.09.2016

Test Laboratory: SPEAG, Zurich, Switzerland

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

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz  
Medium parameters used:  $f = 5250$  MHz;  $\sigma = 5.52$  S/m;  $\epsilon_r = 47.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5600$  MHz;  $\sigma = 6$  S/m;  $\epsilon_r = 46.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5750$  MHz;  $\sigma = 6.21$  S/m;  $\epsilon_r = 46.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(4.85, 4.85, 4.85); Calibrated: 30.06.2016, ConvF(4.35, 4.35, 4.35); Calibrated: 30.06.2016, ConvF(4.3, 4.3, 4.3); Calibrated: 30.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

### **Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5250MHz/Zoom Scan,**

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

Reference Value = 66.49 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 29.1 W/kg

**SAR(1 g) = 7.74 W/kg; SAR(10 g) = 2.17 W/kg**

Maximum value of SAR (measured) = 17.7 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 = 65.85 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 32.5 W/kg

**SAR(1 g) = 7.96 W/kg; SAR(10 g) = 2.24 W/kg**

Maximum value of SAR (measured) = 18.8 W/kg

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

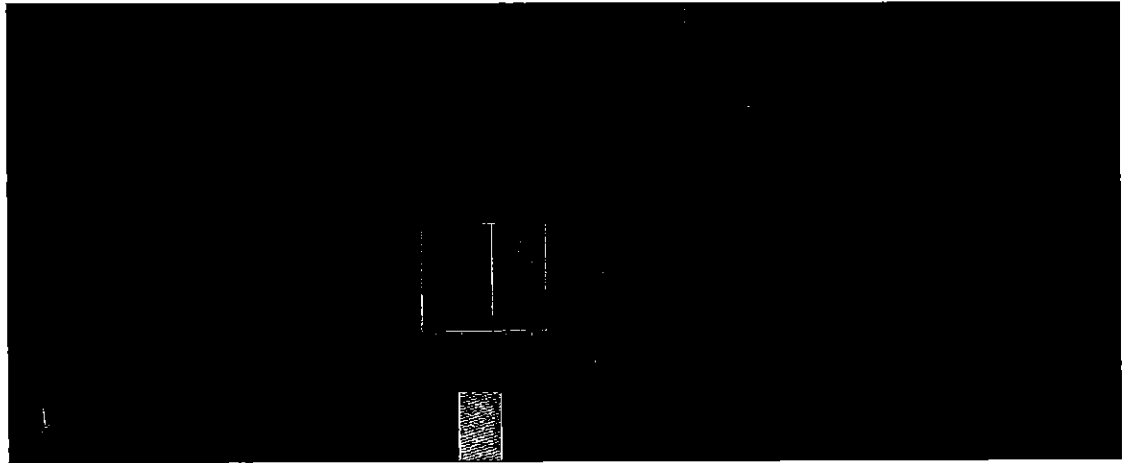
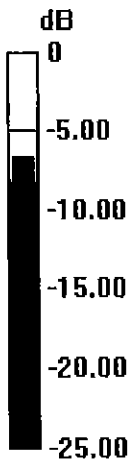
**dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 64.21 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 32.7 W/kg

**SAR(1 g) = 7.65 W/kg; SAR(10 g) = 2.14 W/kg**

Maximum value of SAR (measured) = 18.5 W/kg



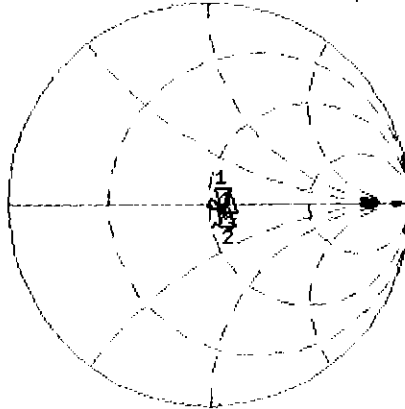
0 dB = 17.7 W/kg = 12.48 dBW/kg

# Impedance Measurement Plot for Body TSL

20 Sep 2016 13:19:13

CH1 S11 1 U FS 1: 56.143  $\Omega$  -3.6992  $\Omega$  8.1950 pF 5 250.000 000 MHz

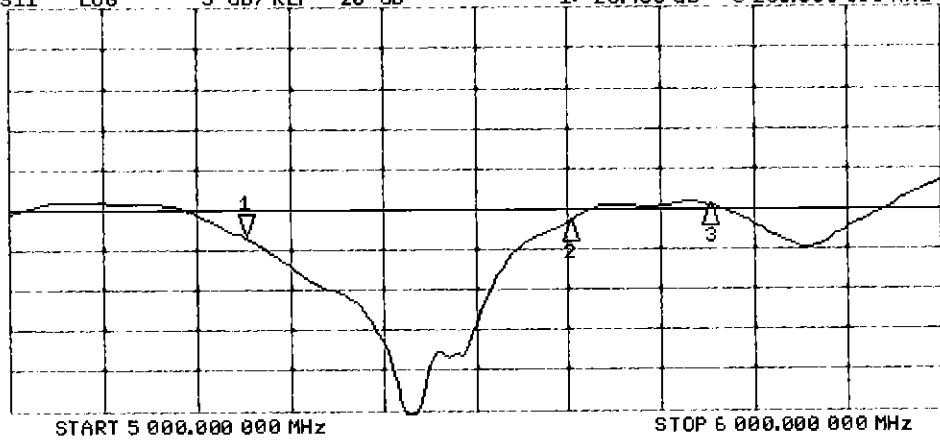
\*  
De1  
Cor  
Avg  
16  
H1d



CH1 Markers  
2: 58.887  $\Omega$   
-1.6504  $\Omega$   
5.60000 GHz  
3: 59.510  $\Omega$   
6.9121  $\Omega$   
5.75000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1: -23.406 dB 5 250.000 000 MHz

Cor  
Avg  
16  
H1d



CH2 Markers  
2: -21.616 dB  
5.60000 GHz  
3: -19.400 dB  
5.75000 GHz

# Certification of Calibration

Object: D5GHzV2 – SN: 1191

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

Extension Calibration date: 9/19/2017

Description: SAR Validation Dipole at 5250, 5600, and 5750 MHz.

## Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	3/31/2017	Biennial	3/31/2019	170232394
Control Company	4352	Ultra Long Stem Thermometer	5/2/2017	Biennial	5/2/2019	170330156
Amplifier Research	1551G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/1/2017	Annual	6/1/2018	MY53401181
Agilent	8753ES	S-Parameter Network Analyzer	10/26/2016	Annual	10/26/2017	US39170118
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/10/2017	Annual	5/10/2018	1070
SPEAG	EX3DV4	SAR Probe	1/13/2017	Annual	1/13/2018	3589
SPEAG	EX3DV4	SAR Probe	2/13/2017	Annual	2/13/2018	3914
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/16/2017	Annual	1/16/2018	1466
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/9/2017	Annual	2/9/2018	665
Anritsu	MA2411B	Pulse Power Sensor	2/10/2017	Annual	2/10/2018	1207364
Anritsu	MA2411B	Pulse Power Sensor	2/10/2017	Annual	2/10/2018	1339018
Anritsu	ML2495A	Power Meter	10/16/2015	Biennial	10/16/2017	941001
Agilent	N5182A	MXG Vector Signal Generator	2/28/2017	Annual	2/28/2018	MY47420800
Seekonk	NC-100	Torque Wrench	11/6/2015	Biennial	11/6/2017	N/A
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Narda	4014C-6	4 - 8 GHz SMA 6 dB Directional Coupler	CBT	N/A	CBT	N/A

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

	Name	Function	Signature
Calibrated By:	Brodie Halfoster	Test Engineer	<i>BRODIE HALBFOSTER</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

# DIPOLE CALIBRATION EXTENSION

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

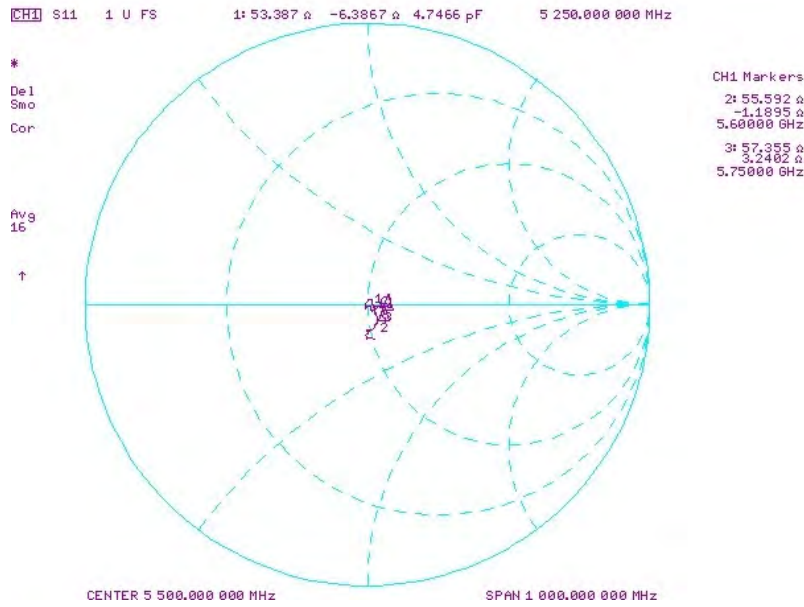
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does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

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

Frequency (MHz)	Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g W/kg @ 17.0 dBm)	Measured Head SAR (1g) W/kg @ 17.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g W/kg @ 17.0 dBm)	Measured Head SAR (10g) W/kg @ 17.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
5250	9/21/2016	9/19/2017	1.204	3.95	3.70	-6.21%	1.13	1.05	-7.08%	55.7	53.4	2.3	-4.3	-6.4	2.1	-23.4	-26.9	-15.00%	PASS
5600	9/21/2016	9/19/2017	1.204	4.18	4.03	-3.59%	1.19	1.13	-5.04%	58.3	55.8	2.7	-3.2	-1.2	2.0	-21.8	-26.1	-19.80%	PASS
5750	9/21/2016	9/19/2017	1.204	3.96	3.84	-3.08%	1.12	1.10	-1.79%	58.1	57.4	0.7	4.8	3.2	1.6	-21.2	-21.0	0.90%	PASS

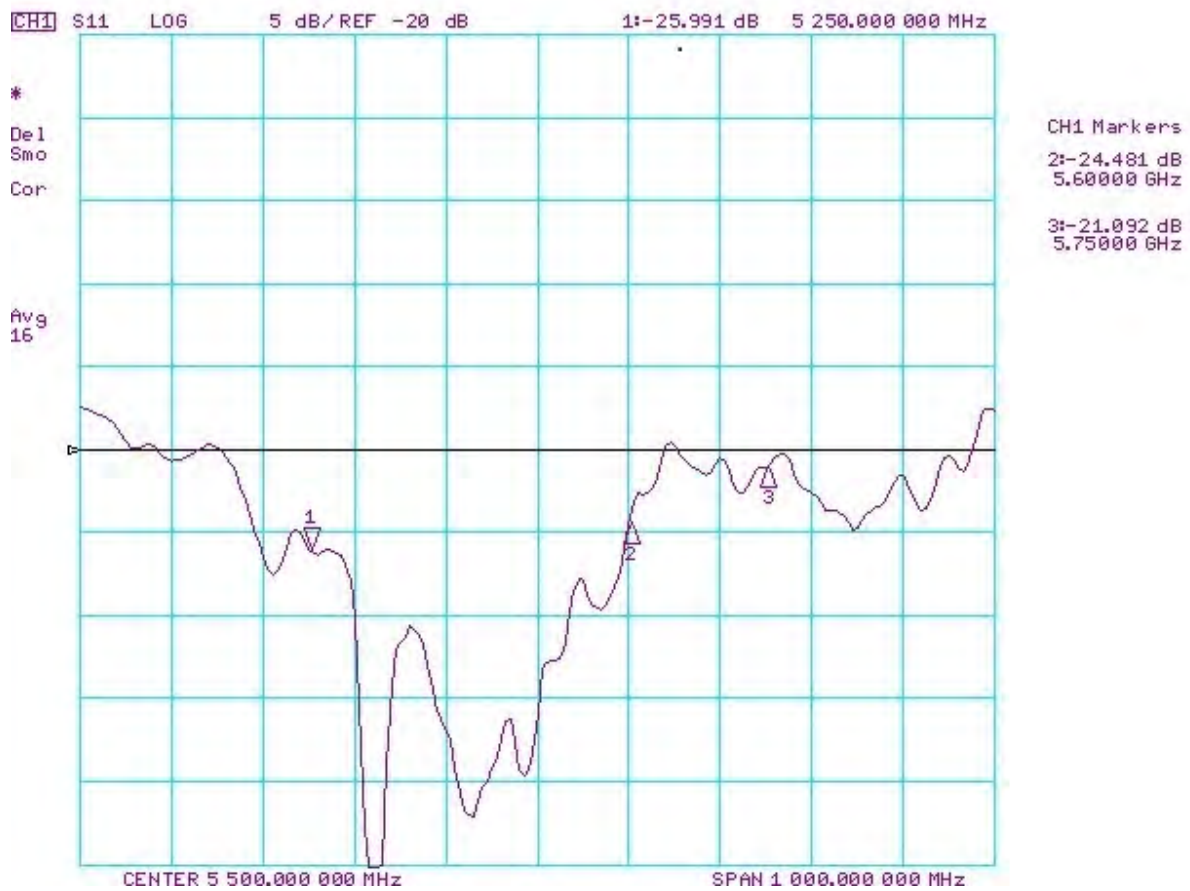
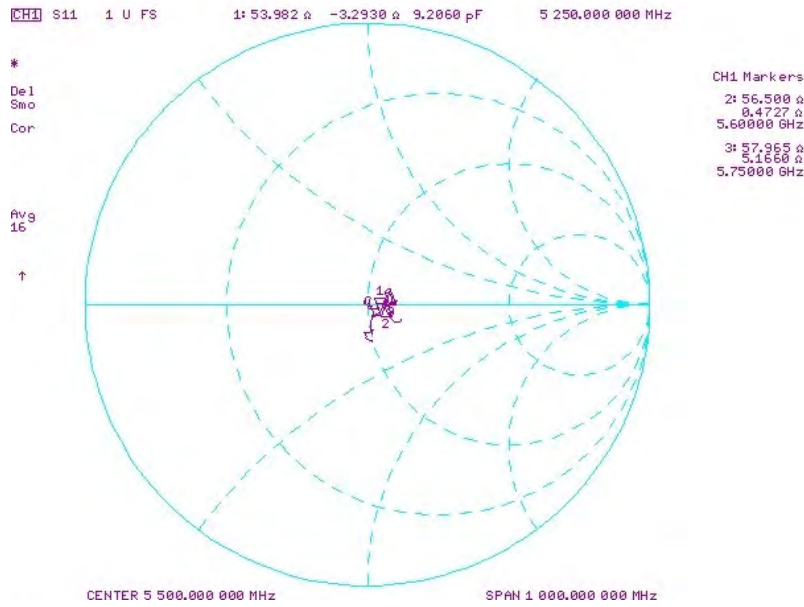
Frequency (MHz)	Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g W/kg @ 17.0 dBm)	Measured Body SAR (1g) W/kg @ 17.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g W/kg @ 17.0 dBm)	Measured Body SAR (10g) W/kg @ 17.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
5250	9/21/2016	9/19/2017	1.204	3.85	3.80	-1.30%	1.08	1.06	-1.85%	56.1	54.0	2.1	-3.7	-3.3	0.4	-23.4	-26.0	-11.10%	PASS
5600	9/21/2016	9/19/2017	1.204	3.96	4.06	2.53%	1.11	1.13	1.80%	58.9	56.5	2.4	-1.7	0.5	2.2	-21.7	-24.5	-12.80%	PASS
5750	9/21/2016	9/19/2017	1.204	3.81	3.66	-3.81%	1.06	1.02	-3.77%	59.5	58.0	1.5	6.9	5.2	1.7	-19.4	-21.1	-8.70%	PASS

# Impedance & Return-Loss Measurement Plot for Head TSL





# Impedance & Return-Loss Measurement Plot for Body TSL





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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D750V3-1054\_Mar17**

**CALIBRATION CERTIFICATE**

Object **D750V3 - SN:1054**

Calibration procedure(s) **QA CAL-05.v9  
Calibration procedure for dipole validation kits above 700 MHz**

*BNV*  
*03-27-2017*  
*BNV*  
*04-04-2018*

Calibration date: **March 07, 2017**

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	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: 5058 (20K)	05-Apr-16 (No. 217-02292)	Apr-17
Type-N mismatch combination	SN: 5047.2 / 06327	05-Apr-16 (No. 217-02295)	Apr-17
Reference Probe EX3DV4	SN: 7349	31-Dec-16 (No. EX3-7349_Dec16)	Dec-17
DAE4	SN: 601	04-Jan-17 (No. DAE4-601_Jan17)	Jan-18

Secondary Standards	ID #	Check Date (In house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (In house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (In house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (In house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (In house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (In house check Oct-18)	In house check: Oct-17

Calibrated by: **Johannes Kurikka**      Name: Johannes Kurikka      Function: Laboratory Technician

Signature: *Johannes Kurikka*

Approved by: **Katja Pokovic**      Name: Katja Pokovic      Technical Manager

Signature: *Katja Pokovic*

Issued: March 14, 2017

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



Accredited by the Swiss Accreditation Service (SAS)  
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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, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- 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	V52.8.8
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	40.9 ± 6 %	0.91 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.14 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>8.37 W/kg ± 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.40 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>5.60 W/kg ± 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.6 ± 6 %	0.99 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.21 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>8.61 W/kg ± 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (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	<b>5.68 W/kg ± 16.5 % (k=2)</b>

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.7 $\Omega$ - 0.7 j $\Omega$
Return Loss	- 26.8 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.7 $\Omega$ - 3.6 j $\Omega$
Return Loss	- 28.7 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.033 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	November 08, 2011

# DASY5 Validation Report for Head TSL

Date: 07.03.2017

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1054**

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

Medium parameters used:  $f = 750 \text{ MHz}$ ;  $\sigma = 0.91 \text{ S/m}$ ;  $\epsilon_r = 40.9$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.17, 10.17, 10.17); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.01.2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

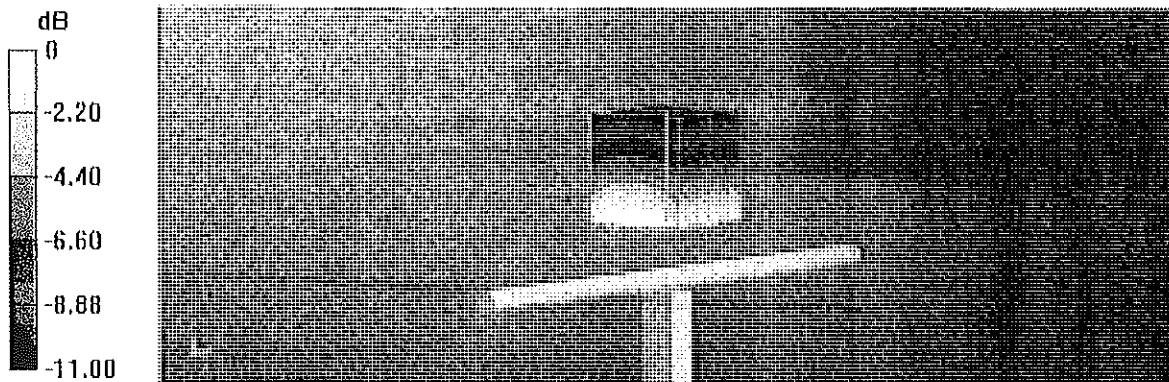
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 59.71 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 3.21 W/kg

**SAR(1 g) = 2.14 W/kg; SAR(10 g) = 1.4 W/kg**

Maximum value of SAR (measured) = 2.85 W/kg

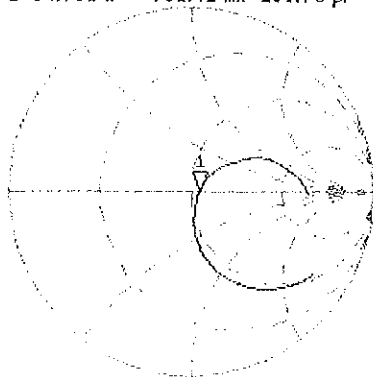


0 dB = 2.85 W/kg = 4.55 dBW/kg

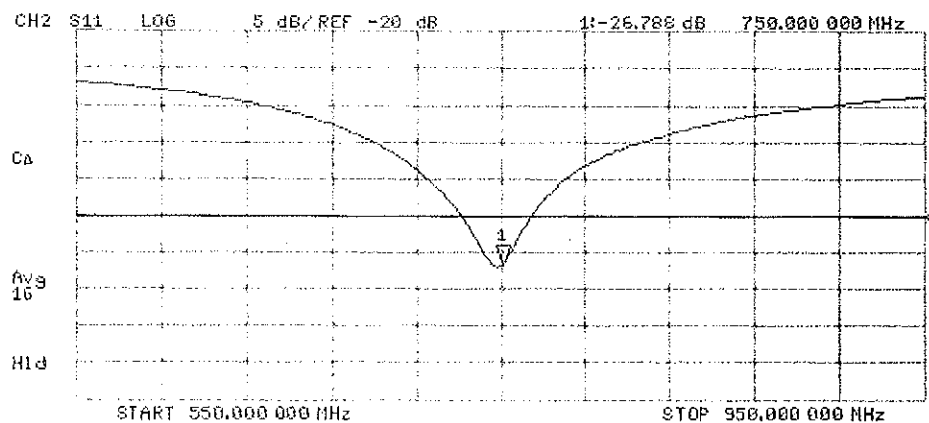
# Impedance Measurement Plot for Head TSL

7 Mar 2017 12:25:14  
 CH1 S11 1 U FS 1: 54.732  $\Omega$  -732.42  $m\Omega$  289.73 pF 750.000 000 MHz

\*  
 Del  
 CA



Avg  
 16  
 H1d



## DASY5 Validation Report for Body TSL

Date: 07.03.2017

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT:** Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1054

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

Medium parameters used:  $f = 750$  MHz;  $\sigma = 0.99$  S/m;  $\epsilon_r = 54.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.99, 9.99, 9.99); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.01.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

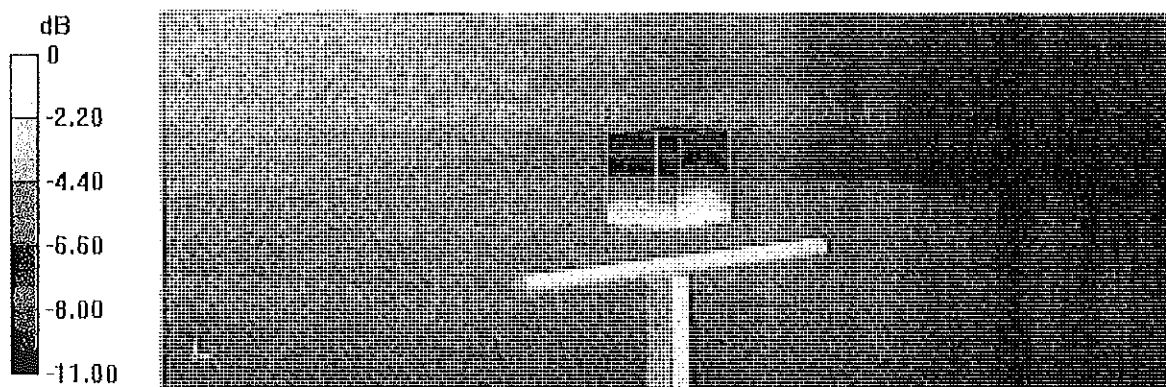
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 57.88 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 3.31 W/kg

**SAR(1 g) = 2.21 W/kg; SAR(10 g) = 1.45 W/kg**

Maximum value of SAR (measured) = 2.94 W/kg



0 dB = 2.94 W/kg = 4.68 dBW/kg



# Impedance Measurement Plot for Body TSL

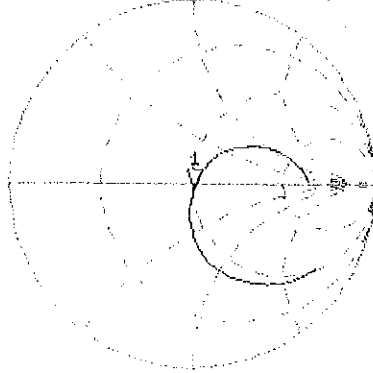
7 Mar 2017 11:51:37  
S11 1 U FS 1150.666  $\Omega$  -3.6309  $\Omega$  58.445 pF 750.000 000 MHz

\*  
De1

Ca

Avg  
16

H1d

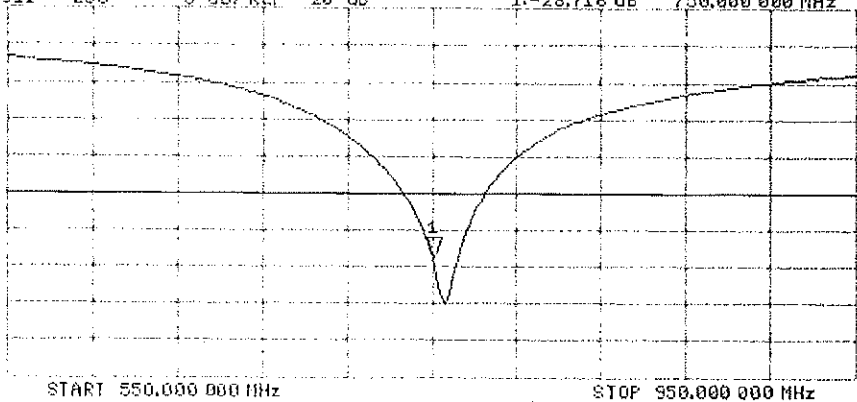


CH2 S11 LOG 5 dB/REF -20 dB 1:-28.716 dB 750.000 000 MHz

Ca

Avg  
16

H1d



## Certification of Calibration

Object: D750V3 – SN:1054  
 Calibration procedure(s): Procedure for Calibration Extension for SAR Dipoles.  
 Extended Calibration date: March 07, 2018  
 Description: SAR Validation Dipole at 750 MHz.

**Calibration Equipment used:**

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	8/3/2017	Annual	8/3/2018	MY40000670
Agilent	N5182A	MXG Vector Signal Generator	1/24/2018	Annual	1/24/2019	MY47420651
Amplifier Research	1551G6	Amplifier	CBT	N/A	CBT	433971
Anritsu	MA2411B	Pulse Power Sensor	3/2/2018	Annual	3/2/2019	1207364
Anritsu	MA2411B	Pulse Power Sensor	10/16/2017	Annual	10/16/2018	1126066
Anritsu	ML2495A	Power Meter	10/22/2017	Annual	10/22/2018	1328004
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/1/2017	Annual	6/1/2018	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Seekonk	NC-100	Torque Wrench 5/16", 8" lbs	1/22/2018	Annual	1/22/2019	N/A
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/13/2017	Annual	7/13/2018	1322
SPEAG	DAE4	Dasy Data Acquisition Electronics	6/21/2017	Annual	6/21/2018	1333
SPEAG	EX3DV4	SAR Probe	7/17/2017	Annual	7/17/2018	7410
SPEAG	ES3DV3	SAR Probe	9/18/2017	Annual	9/18/2018	3287

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

	Name	Function	Signature
Calibrated By:	Brodie Halfoster	Test Engineer	<i>BRODIE HALFOSTER</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

## DIPOLE CALIBRATION EXTENSION

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

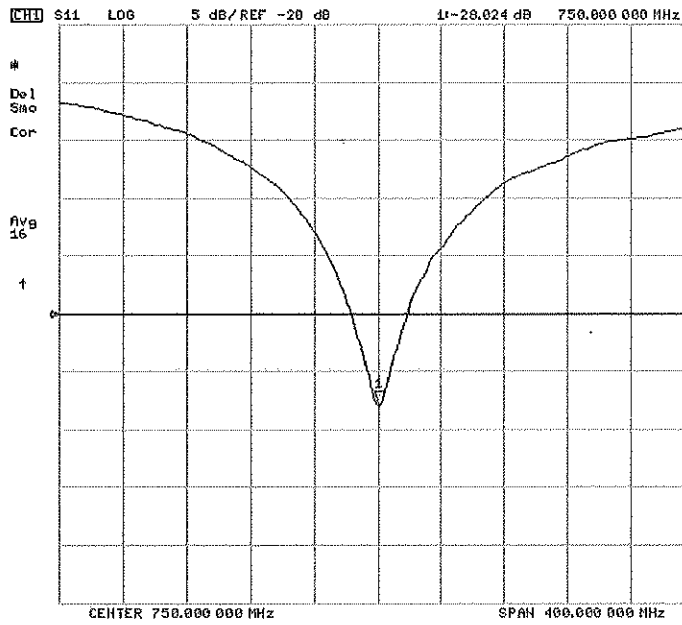
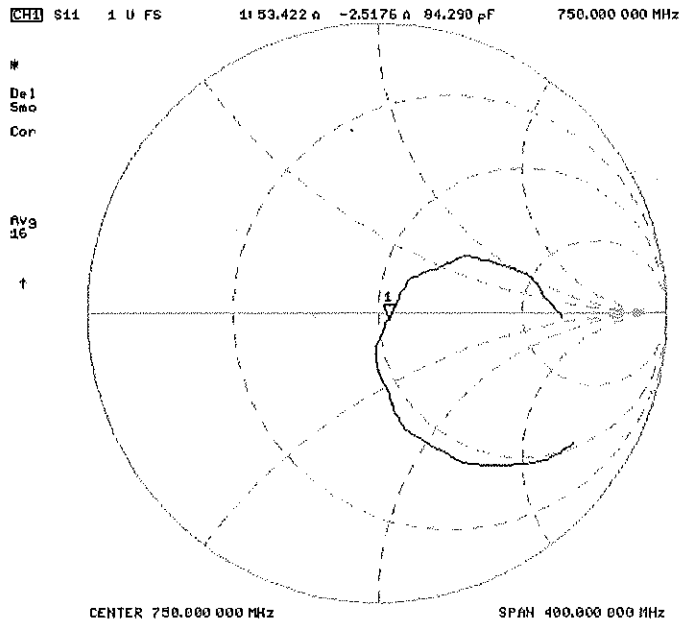
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does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

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

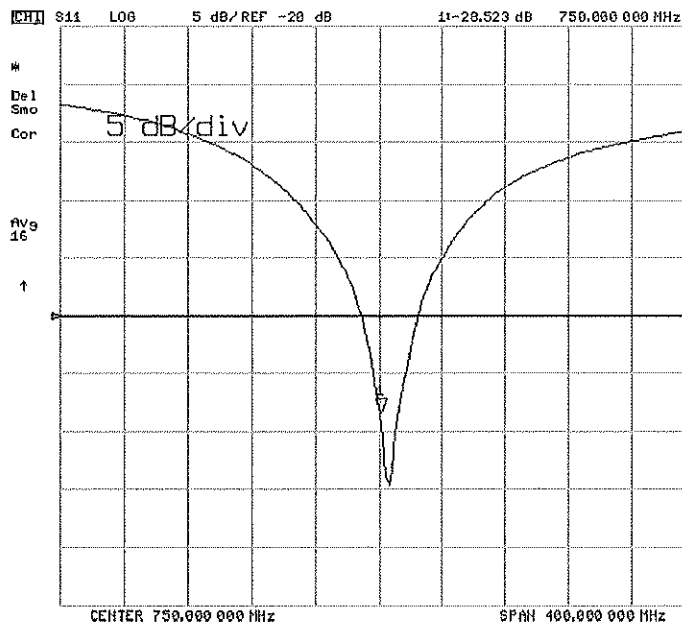
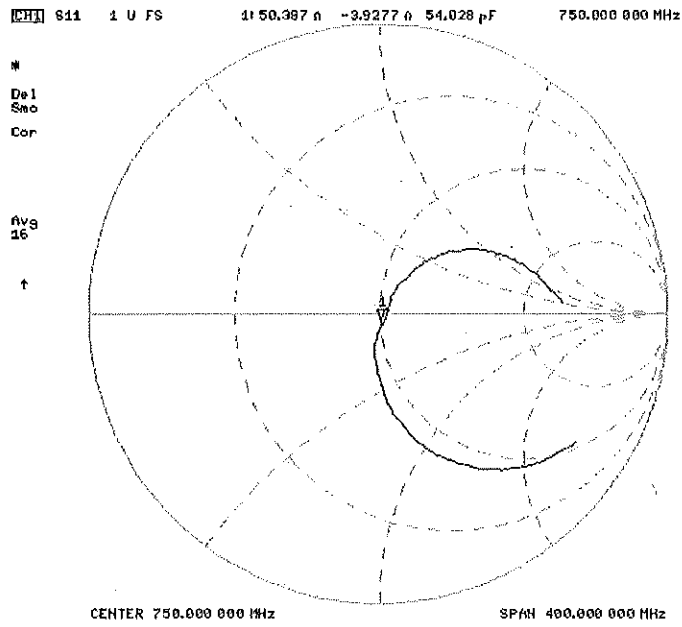
Calibration Date	Expiration Date	Certificate Elect Cal Delay (ns)	Certificate SAR Target Head (150 W/m <sup>2</sup> @ 210 dBm)	Measured Head SAR (150 W/m <sup>2</sup> @ 210 dBm)	Deviation (%)	Certificate SAR Target Body (150 W/m <sup>2</sup> @ 210 dBm)	Measured Body SAR (150 W/m <sup>2</sup> @ 210 dBm)	Deviation (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
3/7/2017	3/7/2018	1.033	1.67	1.70	1.80%	1.10	1.11	0.01%	50.7	50.4	-0.3	-0.7	-2.0	1.8	-20.6	-20.0	-4.00%	PASS

Calibration Date	Expiration Date	Certificate Elect Cal Delay (ns)	Certificate SAR Target Body (150 W/m <sup>2</sup> @ 210 dBm)	Measured Body SAR (150 W/m <sup>2</sup> @ 210 dBm)	Deviation (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL			
3/7/2017	3/7/2018	1.033	1.72	1.70	-1.20%	1.14	1.12	-1.41%	50.7	50.4	-0.3	-3.6	-3.0	0.3	-28.7	-28.5	0.69%	PASS

# Impedance & Return-Loss Measurement Plot for Head TSL



# Impedance & Return-Loss Measurement Plot for Body TSL





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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D750V3-1003\_Jan18**

## CALIBRATION CERTIFICATE

Object **D750V3 - SN:1003**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **January 15, 2018**

*BN*  
*01-25-2018*

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 ( $22 \pm 3$ )°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	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	30-Dec-17 (No. EX3-7349_Dec17)	Dec-18
DAE4	SN: 601	26-Oct-17 (No. DAE4-601_Oct17)	Oct-18
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

Calibrated by: **Leif Klysner**      Function: **Laboratory Technician**

Signature  
*Leif Klysner*

Approved by: **Katja Pokovic**      Technical Manager

*Katja Pokovic*

Issued: January 15, 2018

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



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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:

- 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
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- 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.

<b>DASY Version</b>	DASY5	V52.10.0
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	15 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5.0 mm	
<b>Frequency</b>	750 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	41.9	0.89 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	40.9 $\pm$ 6 %	0.90 mho/m $\pm$ 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	2.10 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>8.28 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	1.37 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>5.42 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	55.5	0.96 mho/m
<b>Measured Body TSL parameters</b>	(22.0 $\pm$ 0.2) °C	55.0 $\pm$ 6 %	0.96 mho/m $\pm$ 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	2.15 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>8.58 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	250 mW input power	1.43 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>5.71 W/kg <math>\pm</math> 16.5 % (k=2)</b>



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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.8 $\Omega$ - 2.1 j $\Omega$
Return Loss	- 27.6 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.2 $\Omega$ - 6.2 j $\Omega$
Return Loss	- 24.0 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.043 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	January 21, 2009

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

### Measurement Conditions

DASY system configuration, as far as not given on page 1 and 3.

Phantom	SAM Head Phantom	For usage with cSAR3DV2-R/L
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### SAR result with SAM Head (Top)

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	1.98 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	7.94 W/kg ± 17.5 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	5.32 W/kg ± 16.9 % (k=2)

### SAR result with SAM Head (Mouth)

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.05 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	8.22 W/kg ± 17.5 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	5.52 W/kg ± 16.9 % (k=2)

### SAR result with SAM Head (Neck)

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.01 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	8.06 W/kg ± 17.5 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	5.52 W/kg ± 16.9 % (k=2)

### SAR result with SAM Head (Ear)

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	1.67 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.70 W/kg ± 17.5 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.15 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	4.60 W/kg ± 16.9 % (k=2)

# DASY5 Validation Report for Head TSL

Date: 12.01.2018

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1003**

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

Medium parameters used:  $f = 750$  MHz;  $\sigma = 0.9$  S/m;  $\epsilon_r = 40.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.22, 10.22, 10.22); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

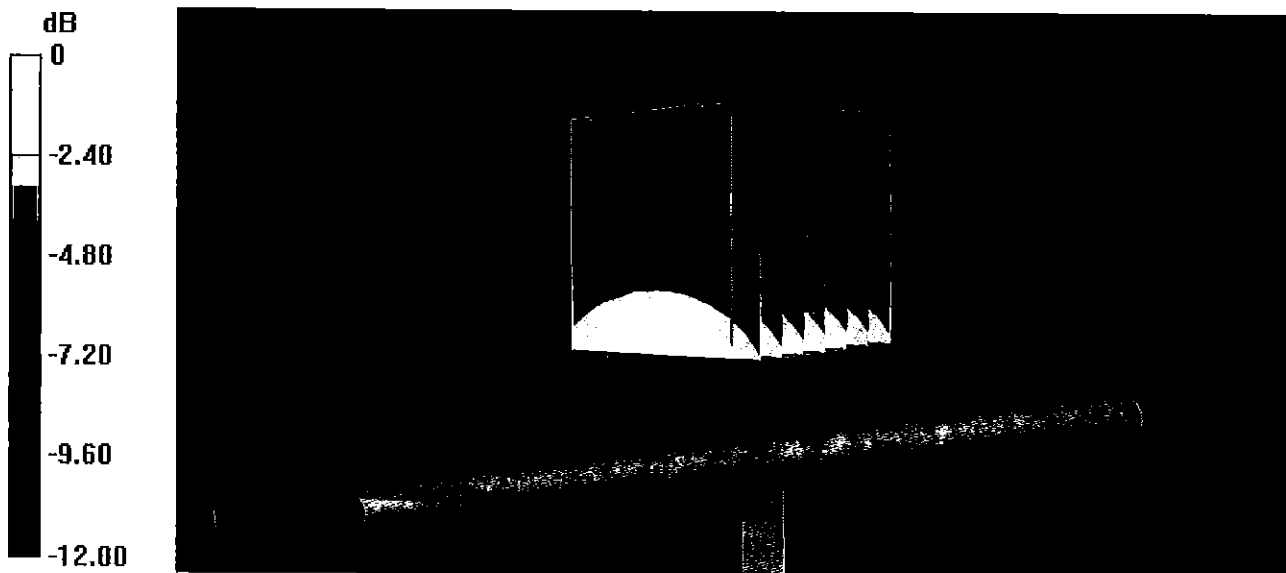
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 59.11 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 3.15 W/kg

**SAR(1 g) = 2.1 W/kg; SAR(10 g) = 1.37 W/kg**

Maximum value of SAR (measured) = 2.80 W/kg

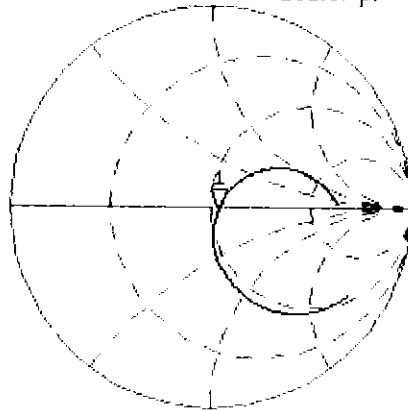


0 dB = 2.80 W/kg = 4.47 dBW/kg

# Impedance Measurement Plot for Head TSL

12 Jan 2018 13:14:07  
CH1 S11 1 U FS 1: 53.754  $\Omega$  -2.0996  $\Omega$  101.07 pF 750.000 000 MHz

\*  
Del  
CA



Avg  
16

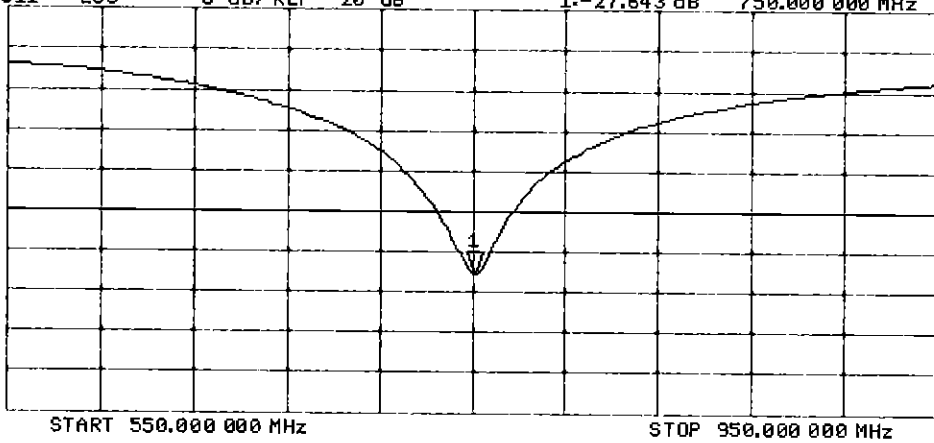
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1:-27.643 dB 750.000 000 MHz

CA

Avg  
16

H1d



# DASY5 Validation Report for Body TSL

Date: 12.01.2018

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1003**

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

Medium parameters used:  $f = 750$  MHz;  $\sigma = 0.96$  S/m;  $\epsilon_r = 55$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.19, 10.19, 10.19); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

## Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x8x7)/Cube 0:

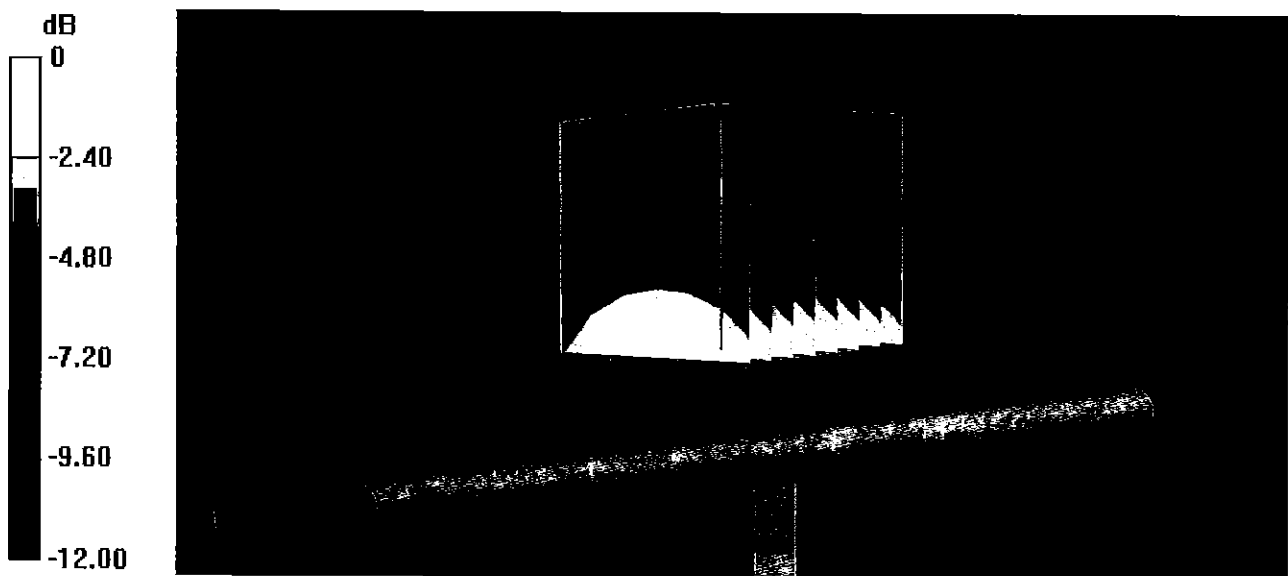
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 57.31 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 3.17 W/kg

**SAR(1 g) = 2.15 W/kg; SAR(10 g) = 1.43 W/kg**

Maximum value of SAR (measured) = 2.83 W/kg



0 dB = 2.83 W/kg = 4.52 dBW/kg

# Impedance Measurement Plot for Body TSL

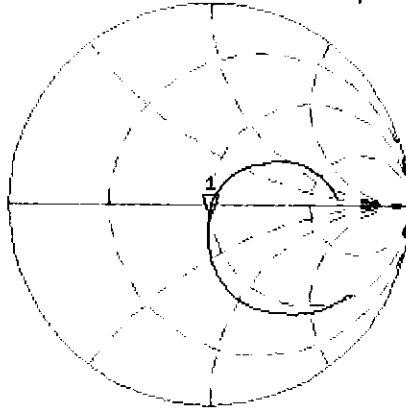
12 Jan 2018 13:13:21  
CH1 S11 1 U FS 1: 49.234  $\Omega$  -6.1934  $\Omega$  34.264 pF 750.000 000 MHz

\*  
De1

CA

Avg  
16

H1d

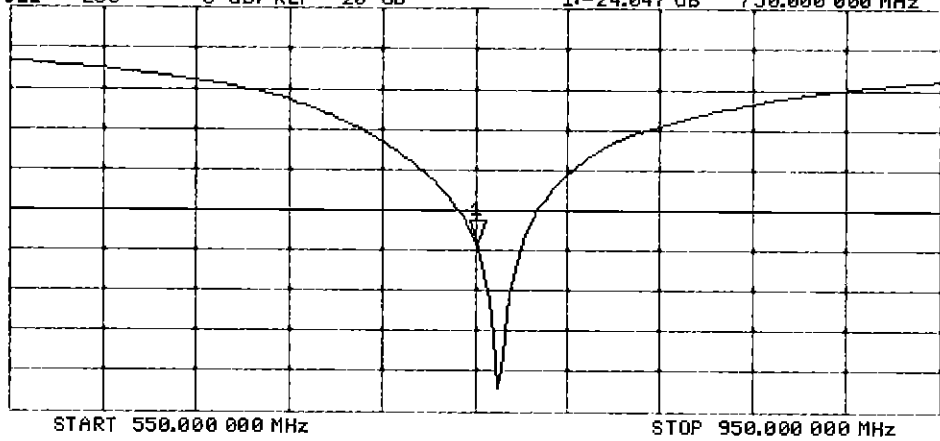


CH2 S11 LOG 5 dB/REF -20 dB 1:-24.047 dB 750.000 000 MHz

CA

Avg  
16

H1d



## DASY5 Validation Report for SAM Head

Date: 15.01.2018

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1003**

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

Medium parameters used:  $f = 750$  MHz;  $\sigma = 0.9$  S/m;  $\epsilon_r = 44.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.22, 10.22, 10.22); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: SAM Head
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

**SAM Head/Top/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 56.79 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 2.89 W/kg

**SAR(1 g) = 1.98 W/kg; SAR(10 g) = 1.33 W/kg**

Maximum value of SAR (measured) = 2.58 W/kg

**SAM Head/Mouth/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 56.85 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 2.94 W/kg

**SAR(1 g) = 2.05 W/kg; SAR(10 g) = 1.38 W/kg**

Maximum value of SAR (measured) = 2.62 W/kg

**SAM Head/Neck/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 56.29 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 2.78 W/kg

**SAR(1 g) = 2.01 W/kg; SAR(10 g) = 1.38 W/kg**

Maximum value of SAR (measured) = 2.56 W/kg

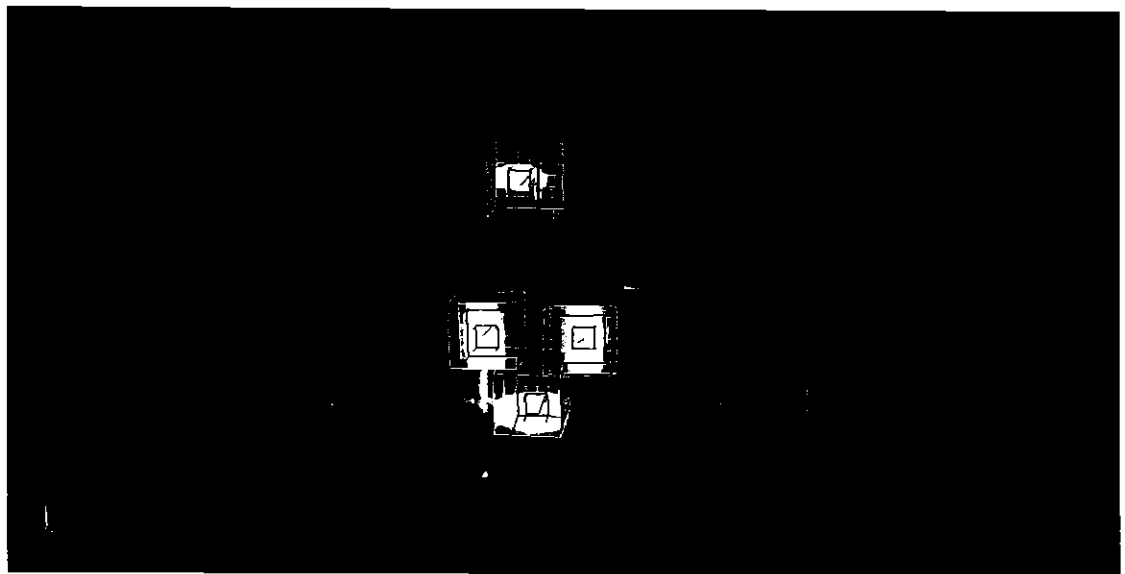
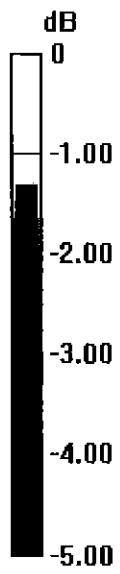
**SAM Head/Ear/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 51.01 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 2.31 W/kg

**SAR(1 g) = 1.67 W/kg; SAR(10 g) = 1.15 W/kg**

Maximum value of SAR (measured) = 2.11 W/kg



0 dB = 2.58 W/kg = 4.12 dBW/kg





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

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D835V2-4d047\_Jul16**

## CALIBRATION CERTIFICATE

Object **D835V2 - SN:4d047**

Calibration procedure(s) **QA CAL-05.v9  
Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **July 13, 2016**

*BNV  
7/16/2016  
Extended  
7/2017  
SCV*

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	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: 5058 (20k)	05-Apr-16 (No. 217-02292)	Apr-17
Type-N mismatch combination	SN: 5047.2 / 06327	05-Apr-16 (No. 217-02295)	Apr-17
Reference Probe EX3DV4	SN: 7349	15-Jun-16 (No. EX3-7349_Jun16)	Jun-17
DAE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (No. 217-02223)	In house check: Oct-16
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Jun-15)	In house check: Oct-16
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

Calibrated by: **Jeton Kastrati** (Name) / **Laboratory Technician** (Function) / *[Signature]* (Signature)

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

Issued: July 13, 2016

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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:

- 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
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- 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	V52.8.8
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 $\pm$ 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 $\pm$ 0.2) °C	40.6 $\pm$ 6 %	0.94 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.37 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.13 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.53 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	5.95 W/kg $\pm$ 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 $\pm$ 0.2) °C	54.9 $\pm$ 6 %	1.01 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.47 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	9.57 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (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	6.24 W/kg $\pm$ 16.5 % (k=2)

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.8 $\Omega$ - 5.9 j $\Omega$
Return Loss	- 24.5 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	45.8 $\Omega$ - 8.2 j $\Omega$
Return Loss	- 20.3 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	None 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	August 16, 2006

## DASY5 Validation Report for Head TSL

Date: 13.07.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz D835V2; Type: D835V2; Serial: D835V2 - SN:4d047**

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

Medium parameters used:  $f = 835$  MHz;  $\sigma = 0.94$  S/m;  $\epsilon_r = 40.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.72, 9.72, 9.72); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

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

Reference Value = 60.98 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 3.56 W/kg

**SAR(1 g) = 2.37 W/kg; SAR(10 g) = 1.53 W/kg**

Maximum value of SAR (measured) = 3.17 W/kg



0 dB = 3.17 W/kg = 5.01 dBW/kg

# Impedance Measurement Plot for Head TSL

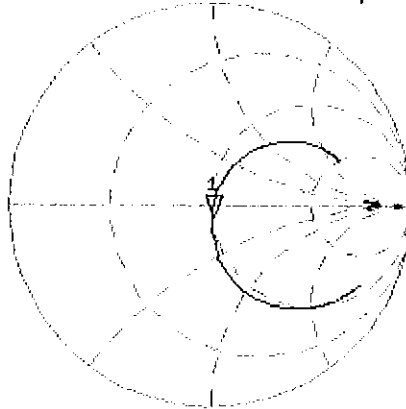
13 Jul 2016 12:00:27

CH1 S11 1 U FS

1: 49.820  $\Omega$  -5.9316  $\Omega$  32.134 pF

835.000 000 MHz

\*  
De1  
CA



Avg  
16

H1d

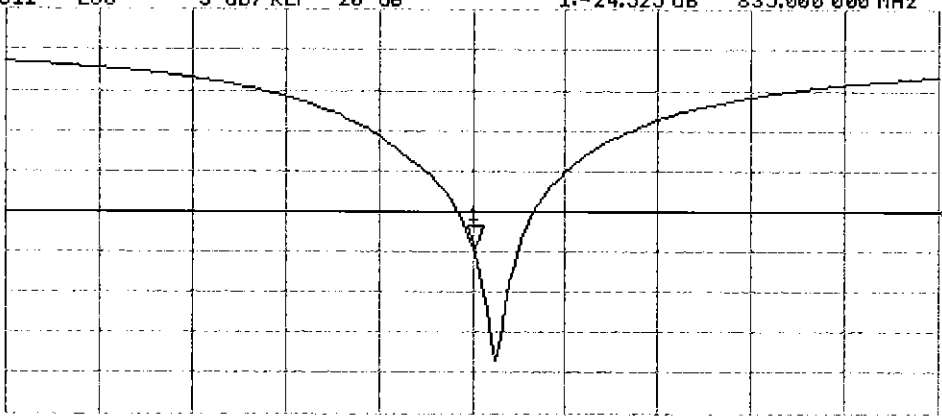
CH2 S11 LOG

5 dB/REF -20 dB

1:-24.525 dB

835.000 000 MHz

CA



Avg  
16

H1d

START 635.000 000 MHz

STOP 1 035.000 000 MHz

## DASY5 Validation Report for Body TSL

Date: 13.07.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz D835V2; Type: D835V2; Serial: D835V2 - SN:4d047**

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

Medium parameters used:  $f = 835$  MHz;  $\sigma = 1.01$  S/m;  $\epsilon_r = 54.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.73, 9.73, 9.73); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

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

Reference Value = 59.88 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 3.67 W/kg

**SAR(1 g) = 2.47 W/kg; SAR(10 g) = 1.6 W/kg**

Maximum value of SAR (measured) = 3.27 W/kg



0 dB = 3.27 W/kg = 5.15 dBW/kg

# Impedance Measurement Plot for Body TSL

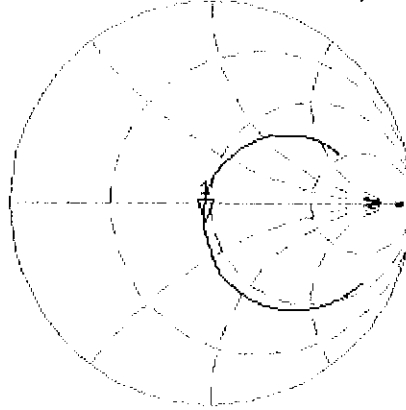
13 Jul 2016 13:35:41  
CH1 S11 1 U FS 1: 45.793  $\Omega$  -8.1777  $\Omega$  23.308 pF 835.000 000 MHz

\*  
Del

CA

Avg  
16

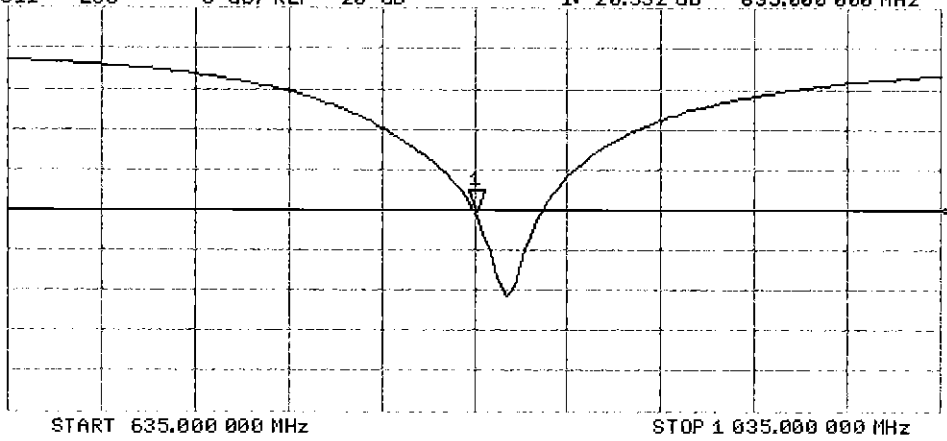
H1 d



CH2 S11 LOG 5 dB/ REF -20 dB 1: -20.332 dB 835.000 000 MHz

CA

H1 d





## Certification of Calibration

Object D835V2 – SN: 4d047

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

Calibration date: July 13, 2017

Description: SAR Validation Dipole at 835 MHz.

**Calibration Equipment used:**

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	3/31/2017	Biennial	3/31/2019	170232394
Control Company	4352	Ultra Long Stem Thermometer	5/2/2017	Biennial	5/2/2019	170330156
Amplifier Research	1551G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/1/2017	Annual	6/1/2018	MY53401181
Agilent	8753ES	S-Parameter Network Analyzer	10/26/2016	Annual	10/26/2017	US39170118
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/8/2017	Annual	3/8/2018	1368
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/13/2017	Annual	3/13/2018	1415
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/10/2017	Annual	5/10/2018	1070
SPEAG	ES3DV3	SAR Probe	3/14/2017	Annual	3/14/2018	3209
SPEAG	ES3DV3	SAR Probe	3/14/2017	Annual	3/14/2018	3319
Anritsu	MA2411B	Pulse Power Sensor	2/10/2017	Annual	2/10/2018	1207364
Anritsu	MA2411B	Pulse Power Sensor	2/10/2017	Annual	2/10/2018	1339018
Anritsu	ML2495A	Power Meter	10/16/2015	Biennial	10/16/2017	941001
Agilent	N5182A	MXG Vector Signal Generator	2/28/2017	Annual	2/28/2018	MY47420800
Seekonk	NC-100	Torque Wrench	11/6/2015	Biennial	11/6/2017	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A

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

	Name	Function	Signature
Calibrated By:	Brodie Halfoster	Test Engineer	<i>BRODIE HALBFOSTER</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

# DIPOLE CALIBRATION EXTENSION

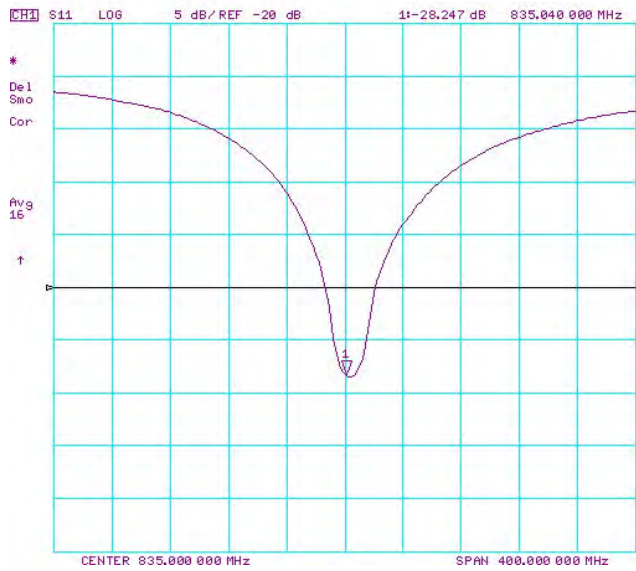
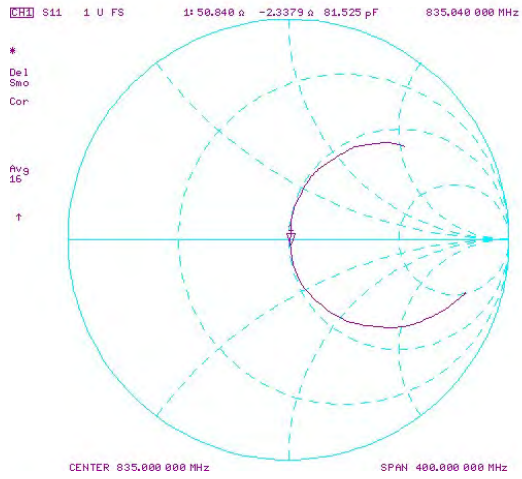
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

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

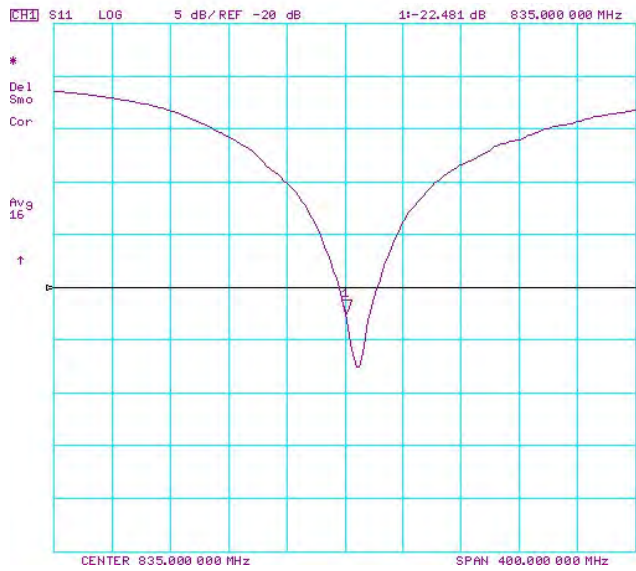
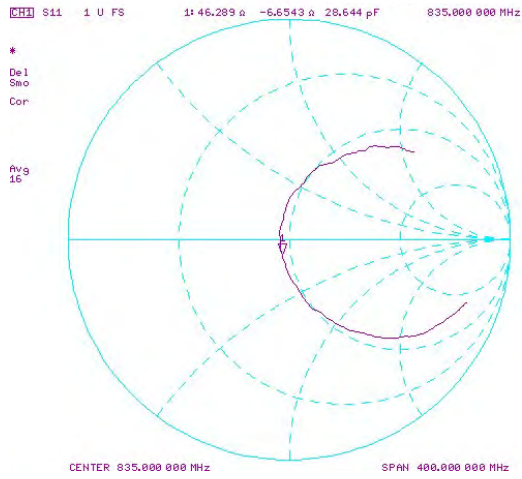
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 23.0 dBm	Measured Head SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 23.0 dBm	Measured Head SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
7/13/2016	7/13/2017	0	1.83	1.95	6.79%	1.19	1.28	7.56%	49.8	50.8	1	-5.0	-2.3	3.6	-24.5	-25.2	-15.10%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 23.0 dBm	Measured Body SAR (1g) W/kg @ 23.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 23.0 dBm	Measured Body SAR (10g) W/kg @ 23.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
7/13/2016	7/13/2017	0	1.91	1.99	3.97%	1.25	1.31	4.97%	45.8	46.3	0.5	-8.2	-6.7	1.5	-20.3	-22.5	-10.80%	PASS

# Impedance & Return-Loss Measurement Plot for Head TSL



# Impedance & Return-Loss Measurement Plot for Body TSL





Accredited by the Swiss Accreditation Service (SAS)  
The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D1750V2-1150\_Jul16**

## CALIBRATION CERTIFICATE

Object **D1750V2 - SN:1150**

Calibration procedure(s) **QA CAL-05.v9  
Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **July 14, 2016**

✓ PM  
8/9/16  
Extended  
9/2017  
SC ✓

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	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: 5058 (20k)	05-Apr-16 (No. 217-02292)	Apr-17
Type-N mismatch combination	SN: 5047.2 / 06327	05-Apr-16 (No. 217-02295)	Apr-17
Reference Probe EX3DV4	SN: 7349	15-Jun-16 (No. EX3-7349_Jun16)	Jun-17
DAE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (No. 217-02223)	In house check: Oct-16
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Jun-15)	In house check: Oct-16
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

Calibrated by: **Name** Jeton Kastrati **Function** Laboratory Technician

**Signature**

Approved by: **Name** Katja Pokovic **Function** Technical Manager

**Signature**

Issued: July 14, 2016

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



Accredited by the Swiss Accreditation Service (SAS)  
The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

**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, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- 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	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1750 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.1	1.37 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	38.8 $\pm$ 6 %	1.36 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.06 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	36.1 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	4.80 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	19.2 W/kg $\pm$ 16.5 % (k=2)

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.4	1.49 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	53.4 $\pm$ 6 %	1.48 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.09 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	36.5 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	4.85 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	19.5 W/kg $\pm$ 16.5 % (k=2)

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.9 $\Omega$ + 0.4 j $\Omega$
Return Loss	- 40.2 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.4 $\Omega$ - 0.5 j $\Omega$
Return Loss	- 28.5 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.218 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	April 10, 2015



## DASY5 Validation Report for Head TSL

Date: 14.07.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1750 MHz D1750V2; Type: D1750V2; Serial: D1750V2 - SN:1150**

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

Medium parameters used:  $f = 1750$  MHz;  $\sigma = 1.36$  S/m;  $\epsilon_r = 38.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.46, 8.46, 8.46); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

### 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 = 104.4 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 16.6 W/kg

**SAR(1 g) = 9.06 W/kg; SAR(10 g) = 4.8 W/kg**

Maximum value of SAR (measured) = 13.9 W/kg



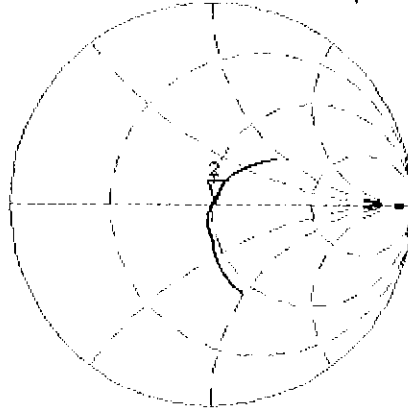
0 dB = 13.9 W/kg = 11.43 dBW/kg

# Impedance Measurement Plot for Head TSL

14 Jul 2016 13:09:21

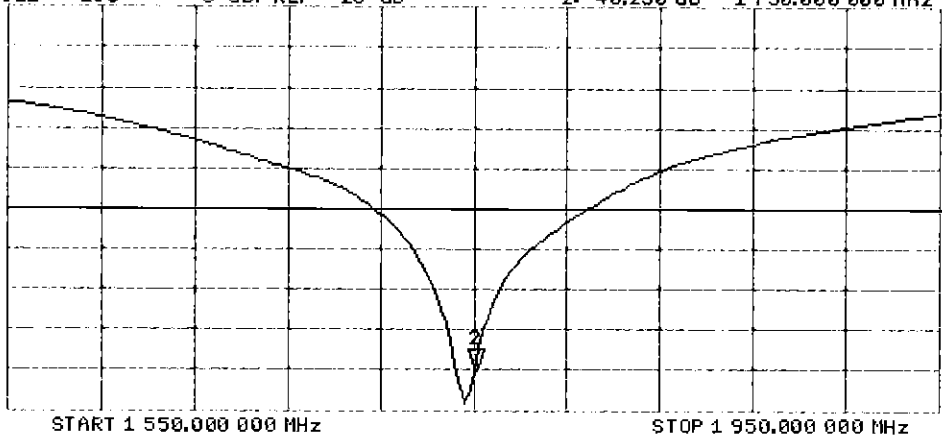
CH1 S11 1 U FS 2: 50.889  $\Omega$  0.4121  $\Omega$  37.479 pF 1 750.000 000 MHz

\*  
De1  
CA  
Avg  
16  
H1d



CH2 S11 LOG 5 dB/REF -20 dB 2:-40.230 dB 1 750.000 000 MHz

CA  
Avg  
16  
H1d



## DASY5 Validation Report for Body TSL

Date: 14.07.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1750 MHz D1750V2; Type: D1750V2; Serial: D1750V2 - SN:1150**

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

Medium parameters used:  $f = 1750$  MHz;  $\sigma = 1.48$  S/m;  $\epsilon_r = 53.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.25, 8.25, 8.25); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

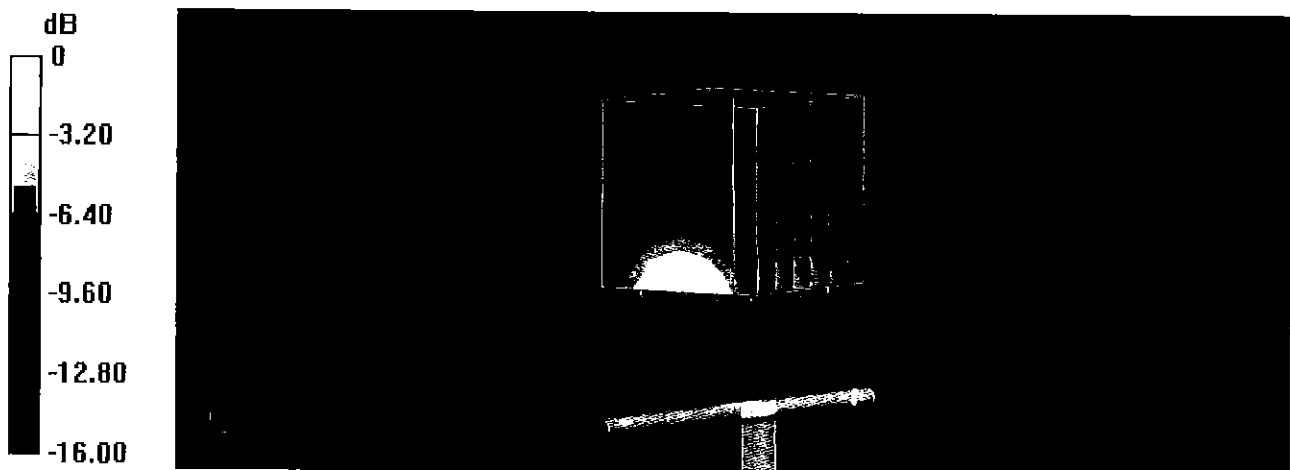
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 100.4 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 16.0 W/kg

**SAR(1 g) = 9.09 W/kg; SAR(10 g) = 4.85 W/kg**

Maximum value of SAR (measured) = 13.7 W/kg



0 dB = 13.7 W/kg = 11.37 dBW/kg

# Impedance Measurement Plot for Body TSL

14 Jul 2016 13:08:43

CH1 S11 1 U FS

2: 46.404  $\Omega$  -456.80 m $\Omega$  194.83 pF

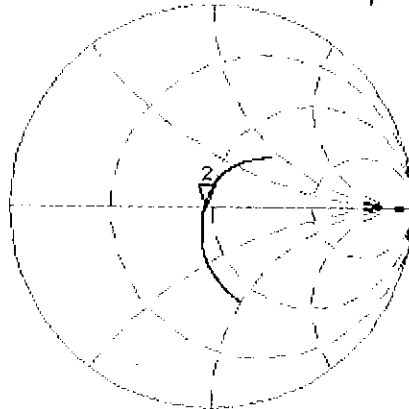
1 750.000 000 MHz

\*  
De 1

CA

Avg  
16

H1 d



CH2 S11 LOG

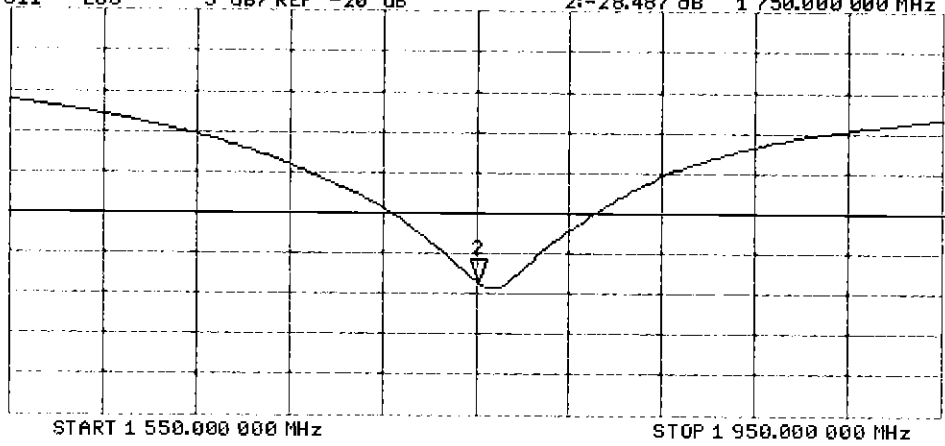
5 dB/REF -20 dB

2: -28.487 dB 1 750.000 000 MHz

CA

Avg  
16

H1 d



## Certification of Calibration

Object D1750V2 – SN: 1150

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

Calibration date: July 07, 2017

Description: SAR Validation Dipole at 1750 MHz.

**Calibration Equipment used:**

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	3/31/2017	Biennial	3/31/2019	170232394
Control Company	4352	Ultra Long Stem Thermometer	5/2/2017	Biennial	5/2/2019	170330156
Amplifier Research	1551G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/1/2017	Annual	6/1/2018	MY53401181
Agilent	8753ES	S-Parameter Network Analyzer	10/26/2016	Annual	10/26/2017	US39170118
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/8/2017	Annual	3/8/2018	1368
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/13/2017	Annual	3/13/2018	1415
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/10/2017	Annual	5/10/2018	1070
SPEAG	ES3DV3	SAR Probe	3/14/2017	Annual	3/14/2018	3209
SPEAG	ES3DV3	SAR Probe	3/14/2017	Annual	3/14/2018	3319
Anritsu	MA2411B	Pulse Power Sensor	2/10/2017	Annual	2/10/2018	1207364
Anritsu	MA2411B	Pulse Power Sensor	2/10/2017	Annual	2/10/2018	1339018
Anritsu	ML2495A	Power Meter	10/16/2015	Biennial	10/16/2017	941001
Agilent	N5182A	MXG Vector Signal Generator	2/28/2017	Annual	2/28/2018	MY47420800
Seekonk	NC-100	Torque Wrench	11/6/2015	Biennial	11/6/2017	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A

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

	Name	Function	Signature
Calibrated By:	Brodie Halfoster	Test Engineer	<i>BRODIE HALBFOSTER</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

# DIPOLE CALIBRATION EXTENSION

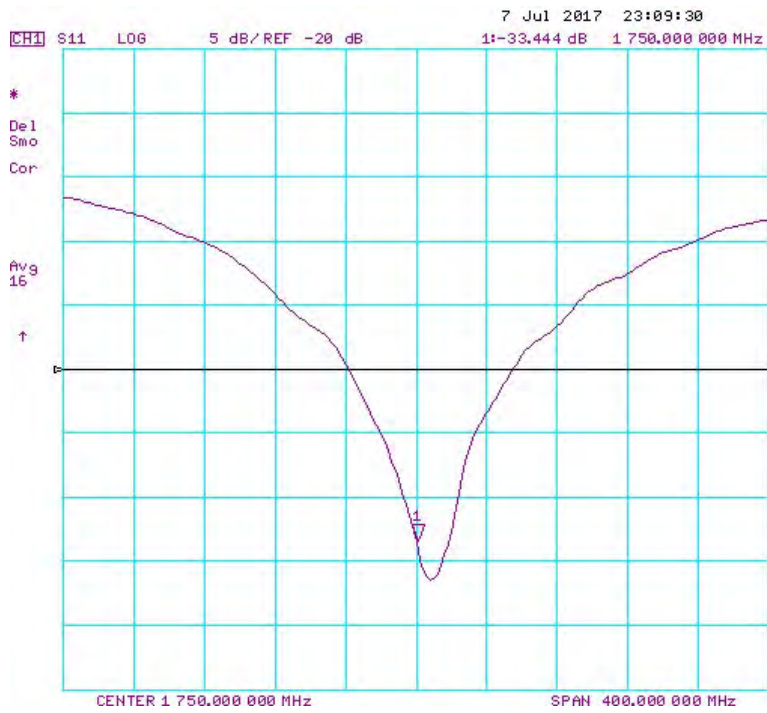
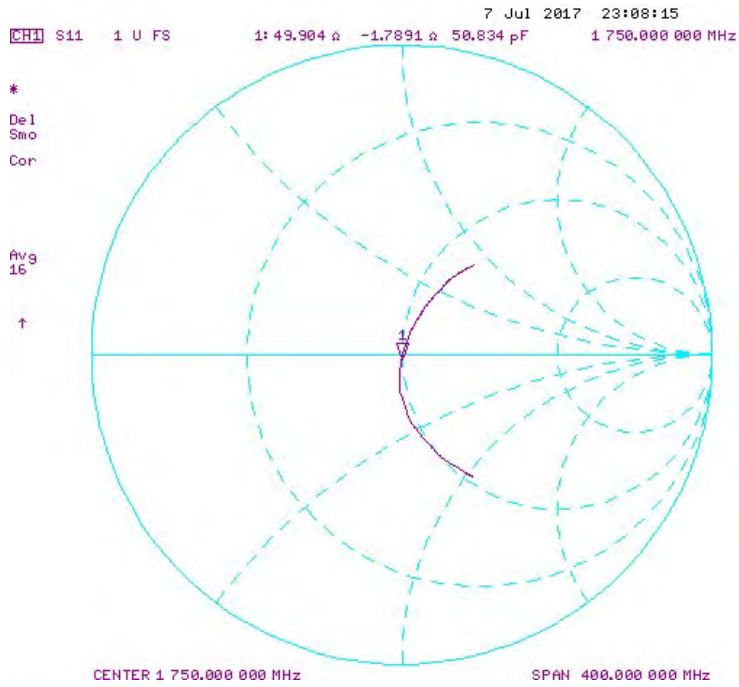
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

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

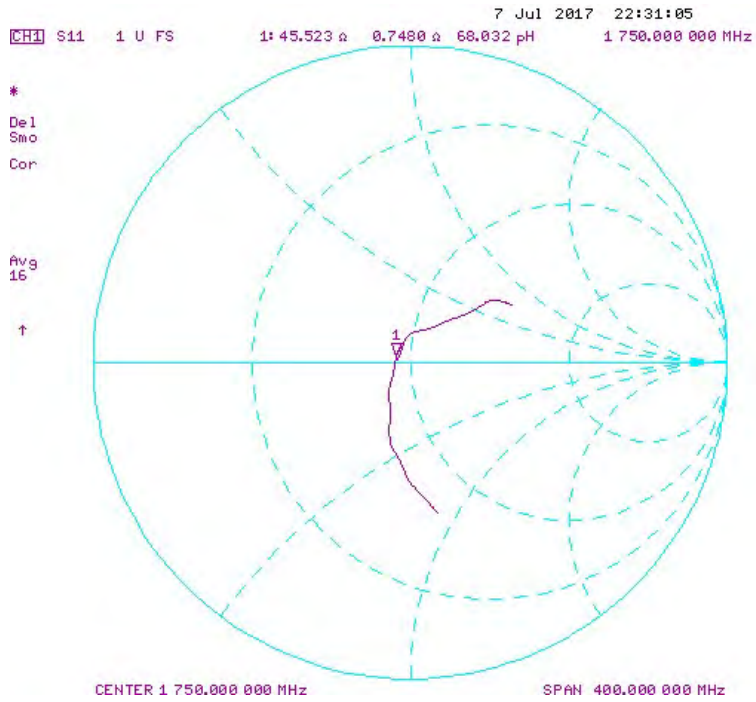
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
7/14/2016	7/7/2017	1.218	3.67	3.57	-1.11%	1.92	1.88	-2.08%	50.9	49.9	1	0.4	-1.8	2.1	-40.2	-33.4	16.90%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
7/14/2016	7/7/2017	1.218	3.65	3.68	0.82%	1.95	1.97	1.03%	46.4	45.5	0.9	-0.5	0.7	1.2	-28.5	-23.6	17.20%	PASS

# Impedance & Return-Loss Measurement Plot for Head TSL



# Impedance & Return-Loss Measurement Plot for Body TSL







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

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D2300V2-1073\_Jul16**

## CALIBRATION CERTIFICATE

Object: **D2300V2 - SN:1073**

Calibration procedure(s): **QA CAL-05.v9  
Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **July 25, 2016**

*VPIT*  
*8/9/16*  
*Extended*  
*7/20/17*  
*SCV*

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	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: 5058 (20k)	05-Apr-16 (No. 217-02292)	Apr-17
Type-N mismatch combination	SN: 5047.2 / 06327	05-Apr-16 (No. 217-02295)	Apr-17
Reference Probe EX3DV4	SN: 7349	15-Jun-16 (No. EX3-7349_Jun16)	Jun-17
DAE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (No. 217-02223)	In house check: Oct-16
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Jun-15)	In house check: Oct-16
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

Calibrated by: **Michael Weber** (Name), **Laboratory Technician** (Function), *M. Weber* (Signature)

Approved by: **Katja Pokovic** (Name), **Technical Manager** (Function), *K. Pokovic* (Signature)

Issued: July 26, 2016

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



Accredited by the Swiss Accreditation Service (SAS)  
The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

**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, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- 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	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2300 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.5	1.67 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	38.6 $\pm$ 6 %	1.69 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	12.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>48.6 W/kg <math>\pm</math> 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.90 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.4 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.9	1.81 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	52.2 $\pm$ 6 %	1.85 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.2 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>48.1 W/kg <math>\pm</math> 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.85 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>23.2 W/kg <math>\pm</math> 16.5 % (k=2)</b>

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	48.9 $\Omega$ - 4.9 j $\Omega$
Return Loss	- 25.8 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	45.5 $\Omega$ - 4.1 j $\Omega$
Return Loss	- 23.9 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.171 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	November 16, 2015

## DASY5 Validation Report for Head TSL

Date: 13.07.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN:1073**

Communication System: UID 0 - CW; Frequency: 2300 MHz

Medium parameters used:  $f = 2300$  MHz;  $\sigma = 1.69$  S/m;  $\epsilon_r = 38.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.99, 7.99, 7.99); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

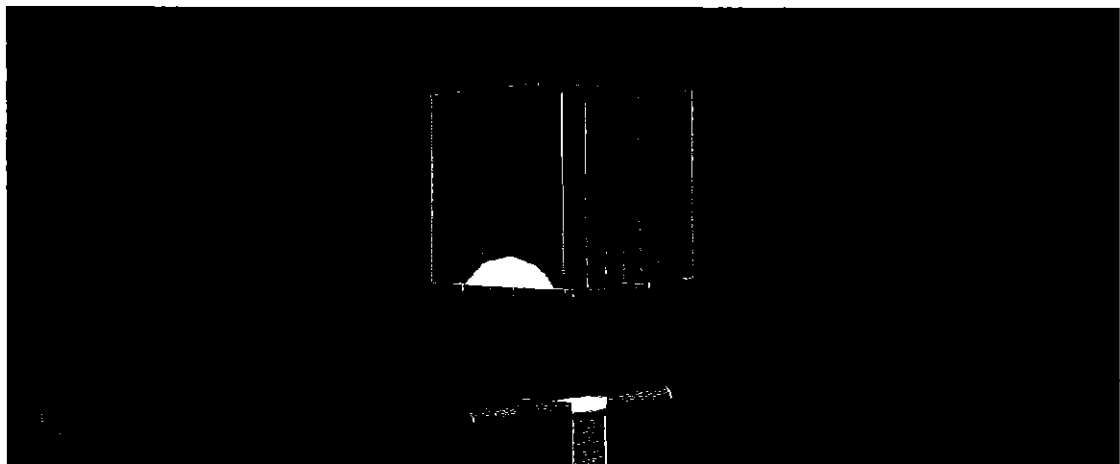
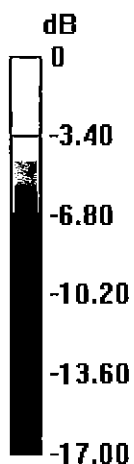
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 113.1 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 24.1 W/kg

**SAR(1 g) = 12.3 W/kg; SAR(10 g) = 5.9 W/kg**

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



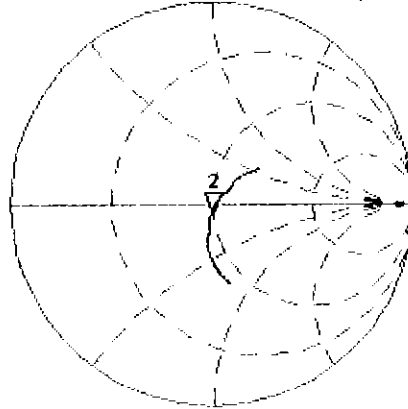
0 dB = 19.8 W/kg = 12.97 dBW/kg

# Impedance Measurement Plot for Head TSL

13 Jul 2016 12:44:09

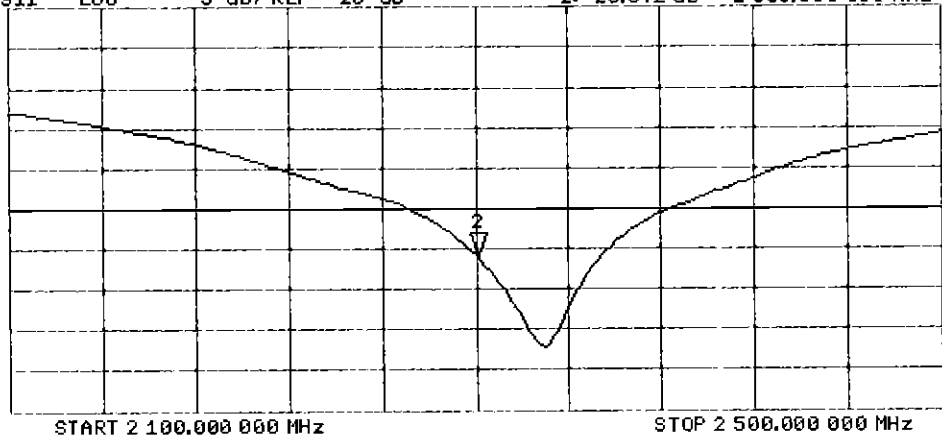
CH1 S11 1 U FS 2: 48.926  $\Omega$  -4.9414  $\Omega$  14.004 pF 2 300.000 000 MHz

\*  
De1  
CA  
Avg  
16  
H1d



CH2 S11 LOG 5 dB/REF -20 dB 2:-25.842 dB 2 300.000 000 MHz

CA  
Avg  
16  
H1d



# DASY5 Validation Report for Body TSL

Date: 25.07.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN:1073**

Communication System: UID 0 - CW; Frequency: 2300 MHz

Medium parameters used:  $f = 2300$  MHz;  $\sigma = 1.85$  S/m;  $\epsilon_r = 52.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

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

Reference Value = 104.8 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 23.8 W/kg

**SAR(1 g) = 12.2 W/kg; SAR(10 g) = 5.85 W/kg**

Maximum value of SAR (measured) = 19.0 W/kg



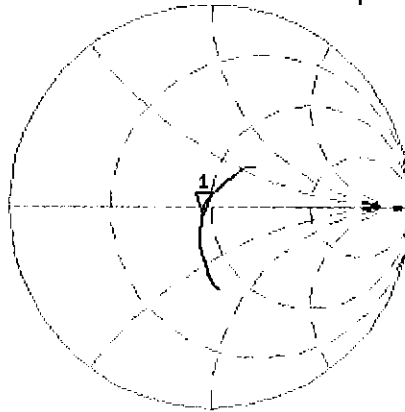
0 dB = 19.0 W/kg = 12.79 dBW/kg

# Impedance Measurement Plot for Body TSL

25 Jul 2016 14:32:48

CH1 S11 1 U FS 1: 45.496  $\Omega$  -4.1348  $\Omega$  16.736 pF 2 300.000 000 MHz

\*  
Del  
CA

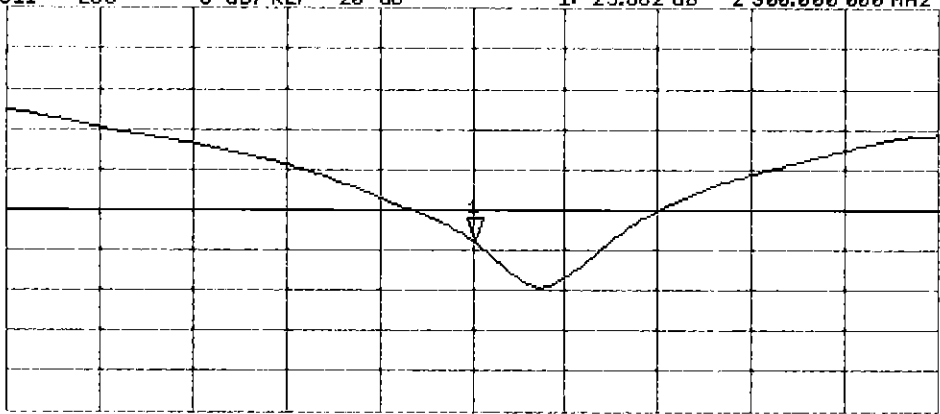


Avg  
16

H1d

CH2 S11 LOG 5 dB/REF -20 dB 1: -23.882 dB 2 300.000 000 MHz

CA



START 2 100.000 000 MHz

STOP 2 500.000 000 MHz



## Certification of Calibration

Object D2300V2 – SN: 1073

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

Calibration date: July 24, 2017

Description: SAR Validation Dipole at 2300 MHz.

**Calibration Equipment used:**

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	3/31/2017	Biennial	3/31/2019	170232394
Control Company	4352	Ultra Long Stem Thermometer	5/2/2017	Biennial	5/2/2019	170330156
Amplifier Research	1551G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/1/2017	Annual	6/1/2018	MY53401181
Agilent	8753ES	S-Parameter Network Analyzer	10/26/2016	Annual	10/26/2017	US39170118
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAE4	Dasy Data Acquisition Electronics	9/14/2016	Annual	9/14/2017	1408
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/9/2017	Annual	2/9/2018	1272
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/10/2017	Annual	5/10/2018	1070
SPEAG	ES3DV3	SAR Probe	9/19/2016	Annual	9/19/2017	3287
SPEAG	ES3DV3	SAR Probe	2/10/2017	Annual	2/10/2018	3213
Anritsu	MA2411B	Pulse Power Sensor	2/10/2017	Annual	2/10/2018	1207364
Anritsu	MA2411B	Pulse Power Sensor	2/10/2017	Annual	2/10/2018	1339018
Anritsu	ML2495A	Power Meter	10/16/2015	Biennial	10/16/2017	941001
Agilent	N5182A	MXG Vector Signal Generator	2/28/2017	Annual	2/28/2018	MY47420800
Seekonk	NC-100	Torque Wrench	11/6/2015	Biennial	11/6/2017	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A

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

	Name	Function	Signature
Calibrated By:	Brodie Halfoster	Test Engineer	<i>BRODIE HALBFOSTER</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

# DIPOLE CALIBRATION EXTENSION

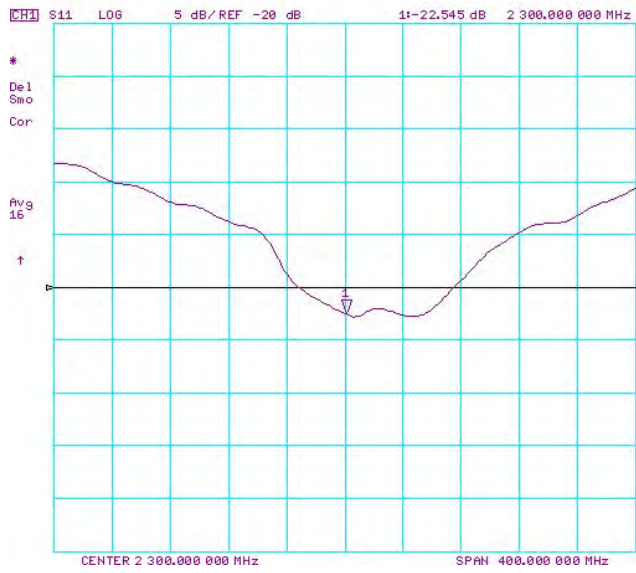
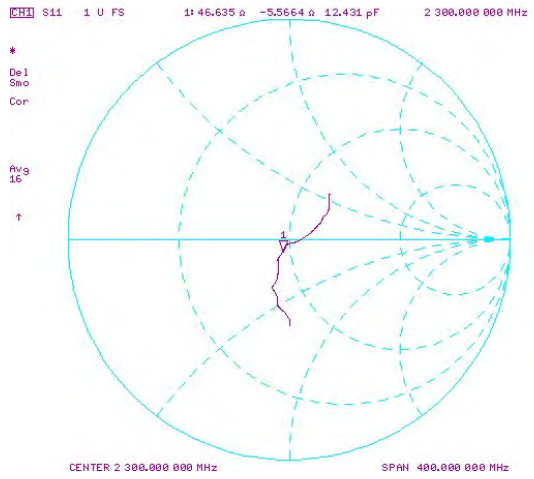
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

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

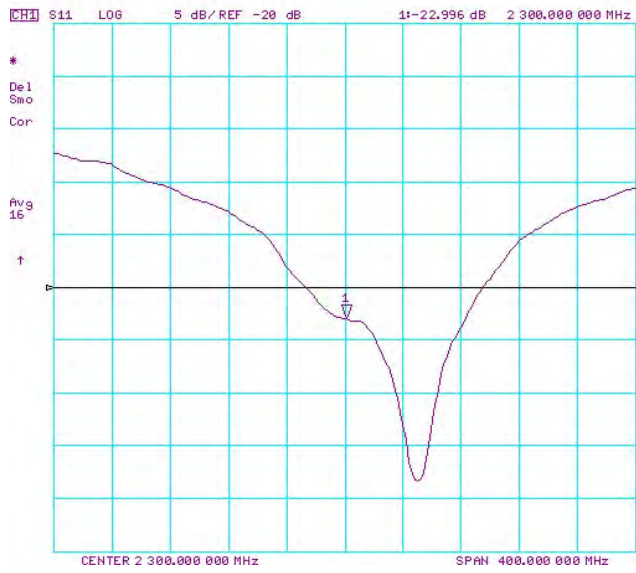
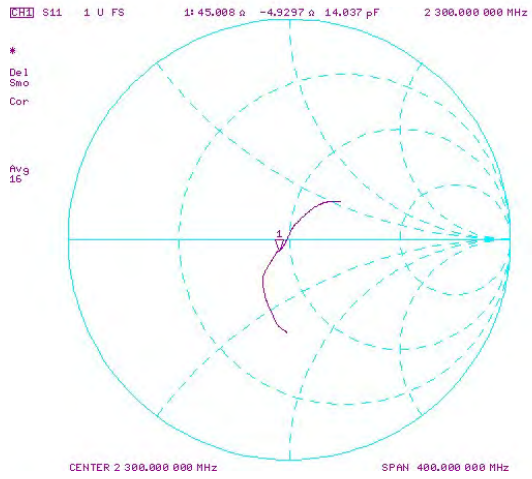
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
7/25/2016	7/24/2017	1.171	4.88	5.08	4.12%	2.34	2.40	2.58%	48.9	46.6	2.3	-4.9	-5.6	0.7	-25.8	-22.5	12.80%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
7/25/2016	7/24/2017	1.171	4.81	4.63	-3.74%	2.32	2.18	-6.03%	45.5	45.0	0.5	-4.1	-4.9	0.8	-23.9	-23.0	3.80%	PASS

# Impedance & Return-Loss Measurement Plot for Head TSL



# Impedance & Return-Loss Measurement Plot for Body TSL





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

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D2450V2-797\_Sep17**

**CALIBRATION CERTIFICATE**

Object **D2450V2 - SN:797**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

*SCS ✓  
10/03/2017*

Calibration date: **September 11, 2017**

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	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	31-May-17 (No. EX3-7349_May17)	May-18
DAE4	SN: 601	28-Mar-17 (No. DAE4-601_Mar17)	Mar-18
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

Calibrated by: **Michael Weber**      Name: Michael Weber      Function: Laboratory Technician

Approved by: **Katja Pokovic**      Name: Katja Pokovic      Function: Technical Manager

Signature  
*M. Weber*  
*K. Pokovic*

Issued: September 11, 2017

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

### Calibration is Performed According to the Following Standards:

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

### Additional Documentation:

- 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.

<b>DASY Version</b>	DASY5	V52.10.0
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	2450 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	39.2	1.80 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	37.8 $\pm$ 6 %	1.86 mho/m $\pm$ 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	---	---

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	13.5 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>52.7 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	6.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>24.8 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	52.7	1.95 mho/m
<b>Measured Body TSL parameters</b>	(22.0 $\pm$ 0.2) °C	51.9 $\pm$ 6 %	2.04 mho/m $\pm$ 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	---	---

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	13.1 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>51.1 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	250 mW input power	6.14 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>24.2 W/kg <math>\pm</math> 16.5 % (k=2)</b>

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.8 $\Omega$ + 7.4 j $\Omega$
Return Loss	- 21.9 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.7 $\Omega$ + 9.1 j $\Omega$
Return Loss	- 20.9 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.152 ns
----------------------------------	----------

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

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

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

### Additional EUT Data

Manufactured by	SPEAG
Manufactured on	January 24, 2006



## DASY5 Validation Report for Head TSL

Date: 11.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 797**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.86$  S/m;  $\epsilon_r = 37.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.12, 8.12, 8.12); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

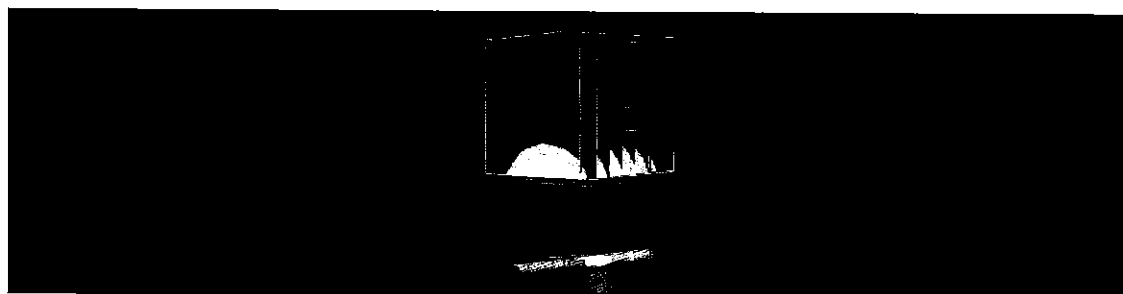
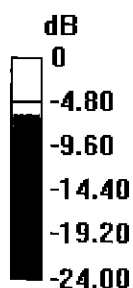
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 113.5 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 26.9 W/kg

**SAR(1 g) = 13.5 W/kg; SAR(10 g) = 6.28 W/kg**

Maximum value of SAR (measured) = 21.6 W/kg



0 dB = 21.6 W/kg = 13.34 dBW/kg

# Impedance Measurement Plot for Head TSL

11 Sep 2017 11:52:57

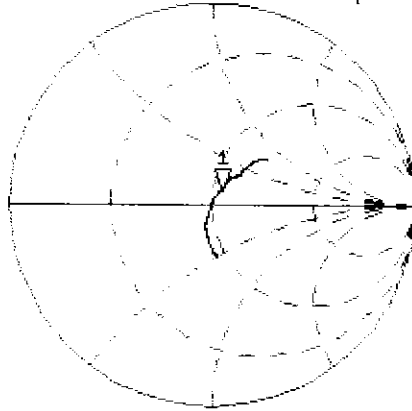
CH1 S11 1 U FS 1: 53.777  $\Omega$  7.4395  $\Omega$  483.28  $\mu\text{H}$  2 450.000 000 MHz

\*  
De1

CA

Avg  
16

H1d

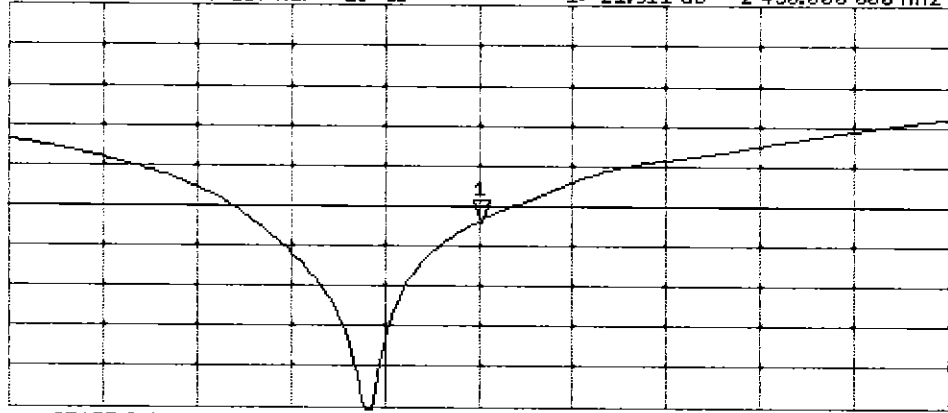


CH2 S11 LOG 5 dB/REF -20 dB 1: -21.911 dB 2 450.000 000 MHz

CA

Avg  
16

H1d



START 2 250.000 000 MHz

STOP 2 650.000 000 MHz

# DASY5 Validation Report for Body TSL

Date: 11.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 797**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.04$  S/m;  $\epsilon_r = 51.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.1, 8.1, 8.1); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

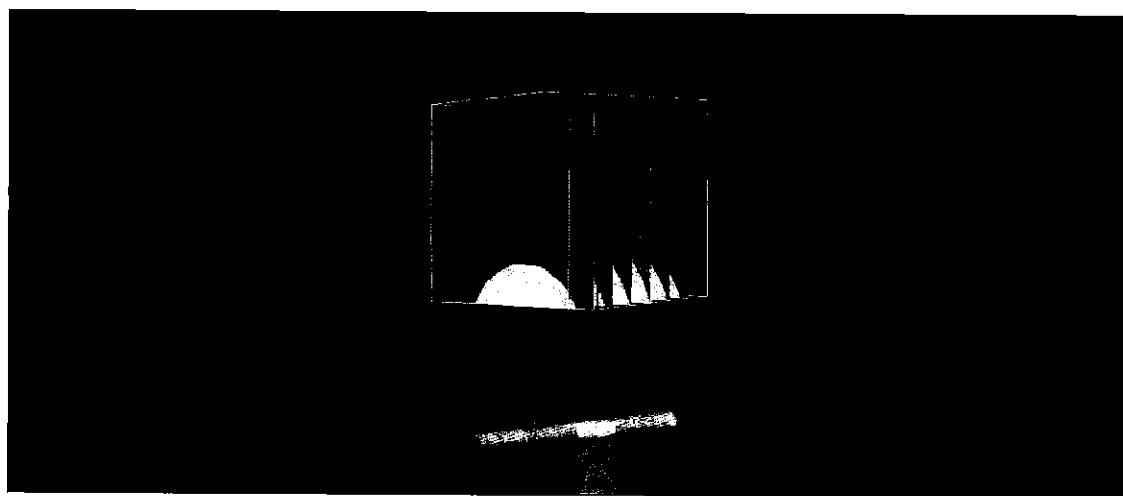
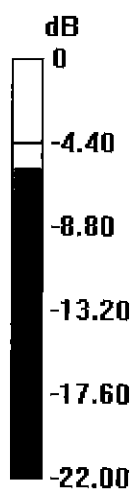
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 105.4 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 25.6 W/kg

**SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.14 W/kg**

Maximum value of SAR (measured) = 20.3 W/kg



0 dB = 20.3 W/kg = 13.07 dBW/kg

# Impedance Measurement Plot for Body TSL

11 Sep 2017 11:52:10

CH1 S11 1 U FS

1: 49.725  $\Omega$  9.0703  $\Omega$  589.22 pF

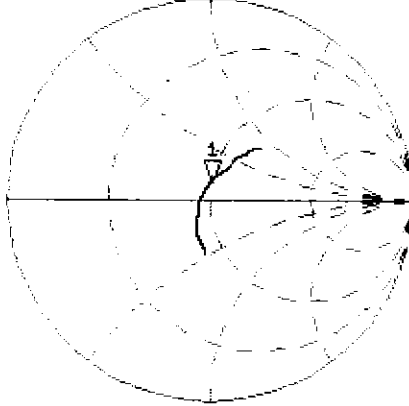
2 450.000 000 MHz

\*  
Del

CA

Avg  
16

H1d



CH2 S11 LOG

5 dB/REF -20 dB

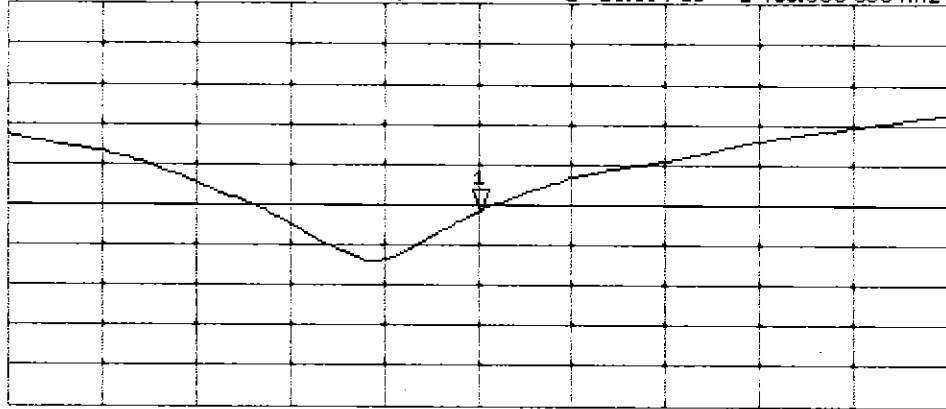
1: -20.854 dB

2 450.000 000 MHz

CA

Avg  
16

H1d



START 2 250.000 000 MHz

STOP 2 650.000 000 MHz



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D2450V2-719\_Aug17**

**CALIBRATION CERTIFICATE**

Object **D2450V2 - SN:719**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **August 17, 2017**

PM ✓  
8/27/17

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	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	31-May-17 (No. EX3-7349_May17)	May-18
DAE4	SN: 601	28-Mar-17 (No. DAE4-601_Mar17)	Mar-18
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

Calibrated by: **Michael Weber** Laboratory Technician

Signature  
*M. Weber*

Approved by: **Katja Pokovic** Technical Manager

*Katja Pokovic*

Issued: August 17, 2017

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



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The Swiss Accreditation Service is one of the signatories to the EA  
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:

- 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
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- 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.

<b>DASY Version</b>	DASY5	V52.10.0
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	2450 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	39.2	1.80 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	37.8 $\pm$ 6 %	1.86 mho/m $\pm$ 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	13.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>51.9 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	6.15 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>24.3 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	52.7	1.95 mho/m
<b>Measured Body TSL parameters</b>	(22.0 $\pm$ 0.2) °C	51.9 $\pm$ 6 %	2.03 mho/m $\pm$ 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	12.8 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>50.1 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	250 mW input power	6.00 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>23.7 W/kg <math>\pm</math> 16.5 % (k=2)</b>

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	55.7 $\Omega$ + 7.0 j $\Omega$
Return Loss	- 21.4 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	51.4 $\Omega$ + 8.1 j $\Omega$
Return Loss	- 21.8 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.150 ns
----------------------------------	----------

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

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

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

### Additional EUT Data

Manufactured by	SPEAG
Manufactured on	September 10, 2002



## DASY5 Validation Report for Head TSL

Date: 17.08.2017

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 719**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.86$  S/m;  $\epsilon_r = 37.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.12, 8.12, 8.12); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

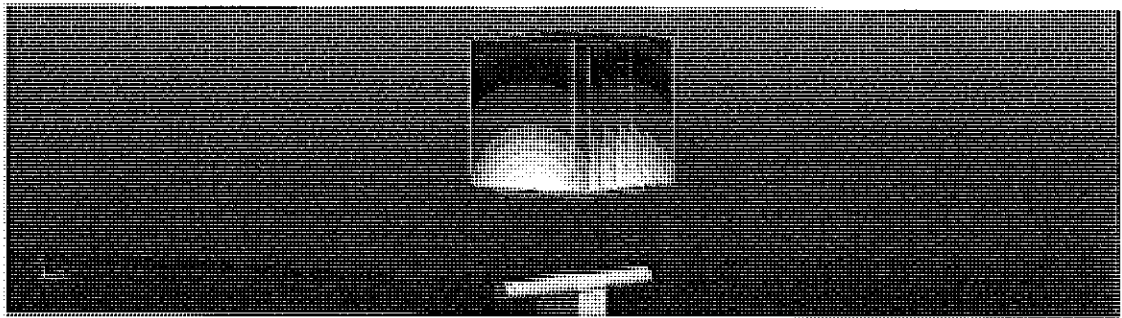
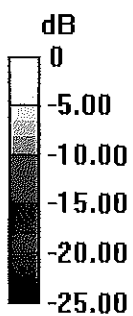
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 112.8 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 26.9 W/kg

**SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.15 W/kg**

Maximum value of SAR (measured) = 21.6 W/kg

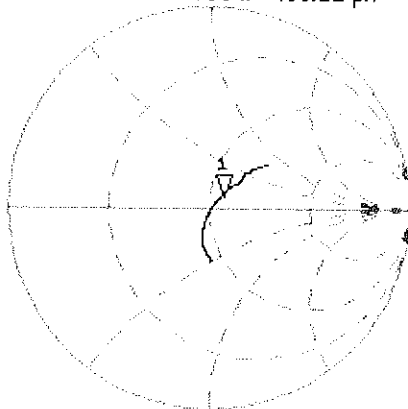


0 dB = 21.6 W/kg = 13.34 dBW/kg

# Impedance Measurement Plot for Head TSL

17 Aug 2017 12:38:03  
 CH1 S11 1 U FS 1: 55.682  $\Omega$  6.9766  $\Omega$  453.21  $\mu\text{H}$  2 450.000 000 MHz

\*  
 De1  
 CA



Avg  
 16

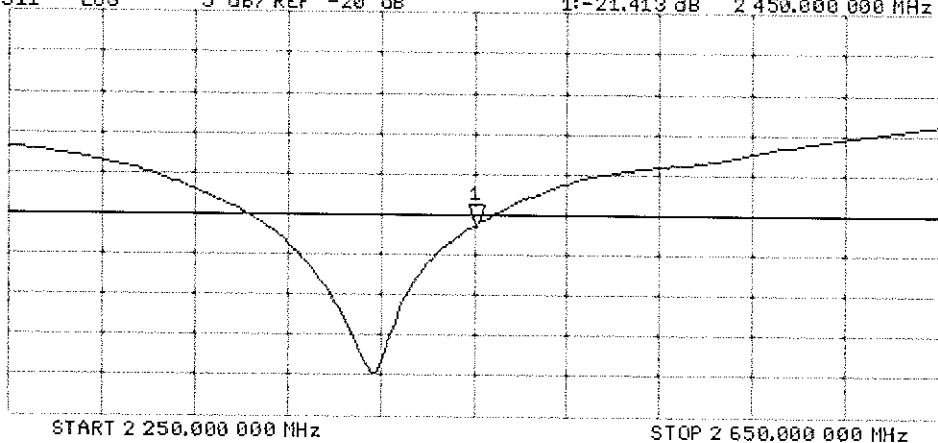
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1: -21.413 dB 2 450.000 000 MHz

CA

Avg  
 16

H1d



## DASY5 Validation Report for Body TSL

Date: 17.08.2017

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 719**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.03$  S/m;  $\epsilon_r = 51.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.1, 8.1, 8.1); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

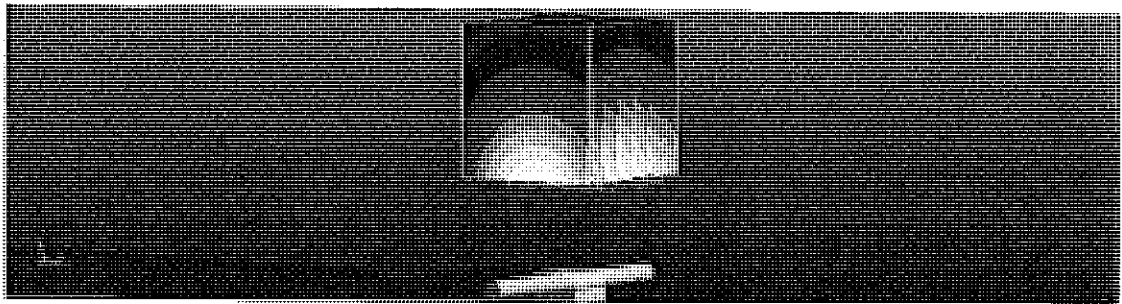
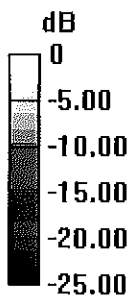
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 103.0 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 25.2 W/kg

**SAR(1 g) = 12.8 W/kg; SAR(10 g) = 6 W/kg**

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

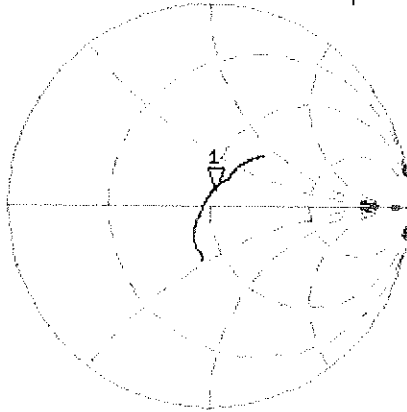


0 dB = 19.8 W/kg = 12.97 dBW/kg

# Impedance Measurement Plot for Body TSL

17 Aug 2017 12:37:27  
[CH1] S11 1 U FS 1: 51.379  $\Omega$  8.1367  $\Omega$  528.57 pF 2 450.000 000 MHz

\*  
De1  
C4



Avg  
16

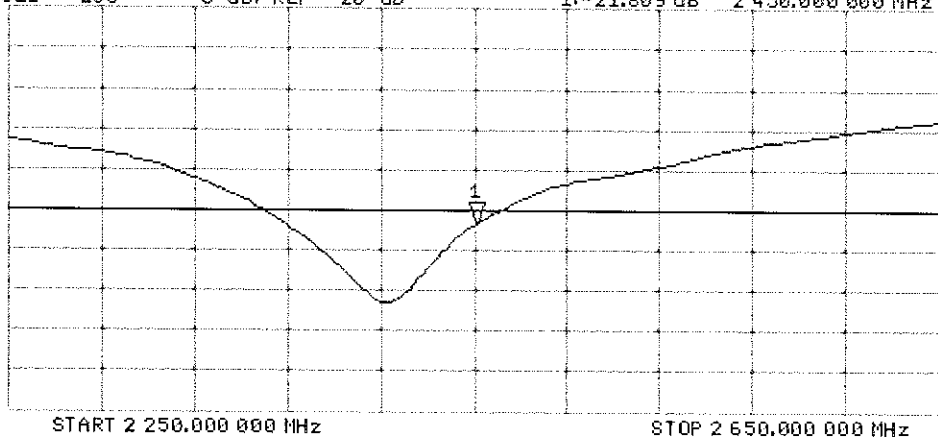
H1 d

CH2 S11 LOG 5 dB/REF -20 dB 1: -21.809 dB 2 450.000 000 MHz

C4

Avg  
16

H1 d





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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D2600V2-1126\_Jul17**

## CALIBRATION CERTIFICATE

Object **D2600V2 - SN:1126**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

*BNV*  
*8/3/2017*

Calibration date: **July 10, 2017**

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 ( $22 \pm 3$ )°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	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	31-May-17 (No. EX3-7349_May17)	May-18
DAE4	SN: 601	28-Mar-17 (No. DAE4-601_Mar17)	Mar-18
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

Calibrated by: **Jeton Kastrall**      **Function**  
**Laboratory Technician**

Signature

Approved by: **Katja Pokovic**      **Technical Manager**

Issued: July 11, 2017

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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:

- 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
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- 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	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2600 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	37.2 $\pm$ 6 %	2.04 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.5 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	56.4 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.40 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.2 W/kg $\pm$ 16.5 % (k=2)

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	51.6 $\pm$ 6 %	2.22 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.8 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	54.3 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.16 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.4 W/kg $\pm$ 16.5 % (k=2)

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	47.8 $\Omega$ - 7.7 j $\Omega$
Return Loss	- 21.8 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	44.8 $\Omega$ - 5.8 j $\Omega$
Return Loss	- 21.7 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.154 ns
----------------------------------	----------

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

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

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

### Additional EUT Data

Manufactured by	SPEAG
Manufactured on	October 22, 2015



## DASY5 Validation Report for Head TSL

Date: 10.07.2017

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1126**

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

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.04$  S/m;  $\epsilon_r = 37.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.96, 7.96, 7.96); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

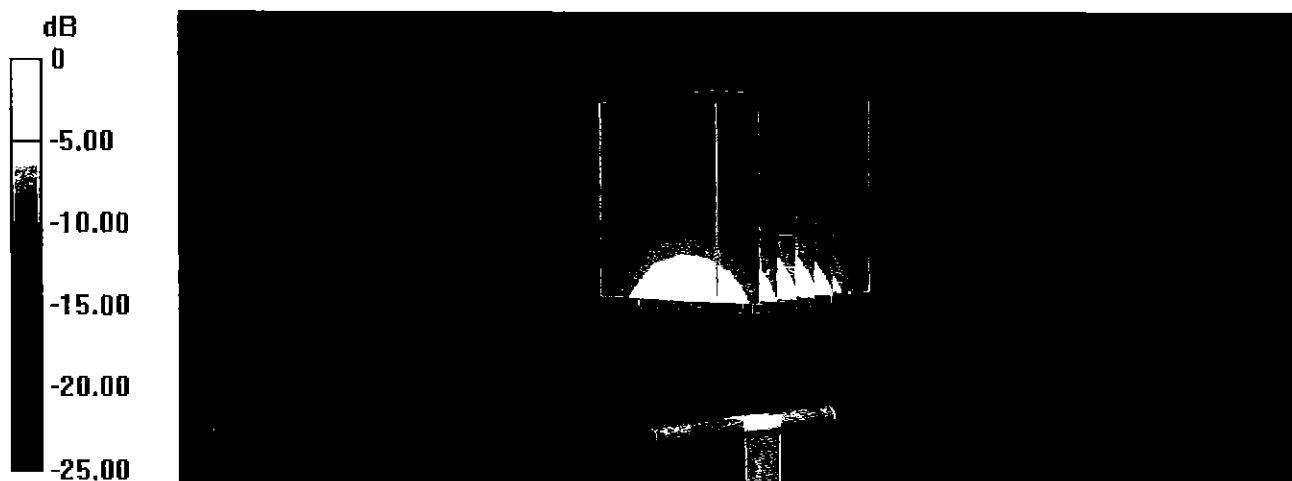
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 113.2 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 31.3 W/kg

**SAR(1 g) = 14.5 W/kg; SAR(10 g) = 6.4 W/kg**

Maximum value of SAR (measured) = 24.0 W/kg



0 dB = 24.0 W/kg = 13.80 dBW/kg

# Impedance Measurement Plot for Head TSL

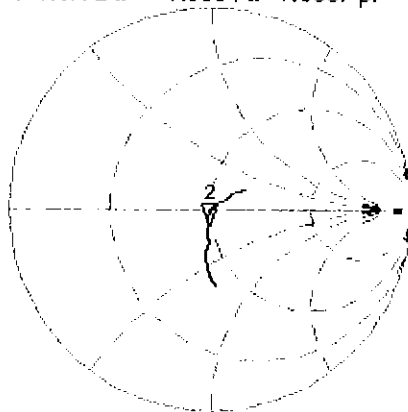
10 Jul 2017 14:28:06

CH1 S11 1 U FS

2: 47.771  $\Omega$  -7.6934  $\Omega$  7.9567 pF

2 600.000 000 MHz

\*  
De1  
CA



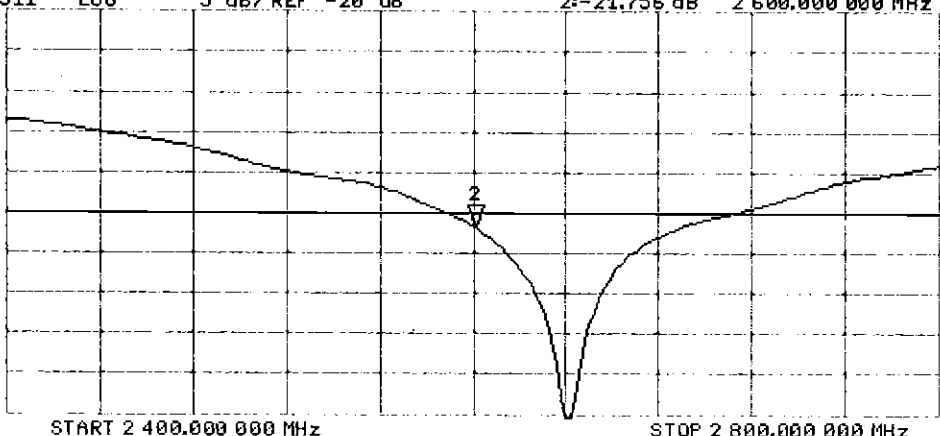
Avg  
16  
H1d

CH2 S11 LOG

5 dB/REF -20 dB

2:-21.756 dB 2 600.000 000 MHz

CA  
Avg  
16  
H1d



## DASY5 Validation Report for Body TSL

Date: 10.07.2017

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1126**

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

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.22$  S/m;  $\epsilon_r = 51.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.94, 7.94, 7.94); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

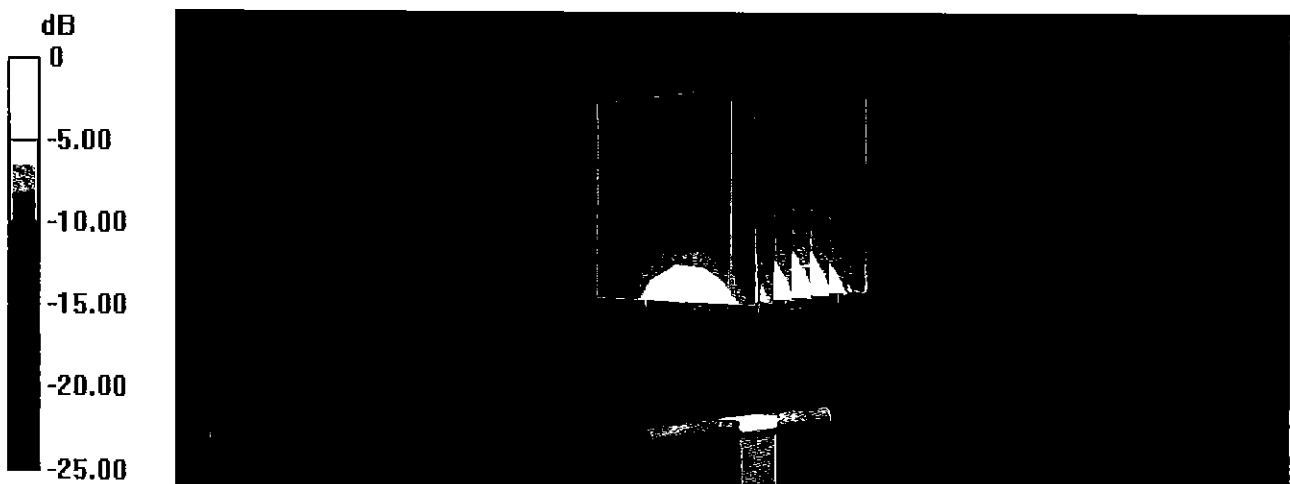
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 103.8 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 28.9 W/kg

**SAR(1 g) = 13.8 W/kg; SAR(10 g) = 6.16 W/kg**

Maximum value of SAR (measured) = 22.2 W/kg

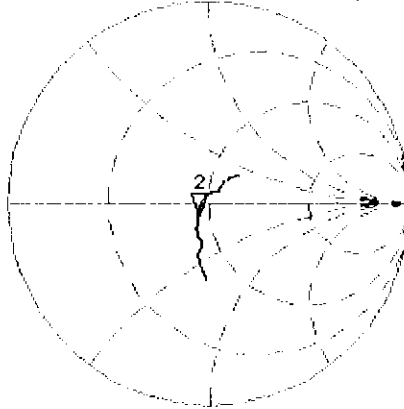


# Impedance Measurement Plot for Body TSL

10 Jul 2017 14:27:30

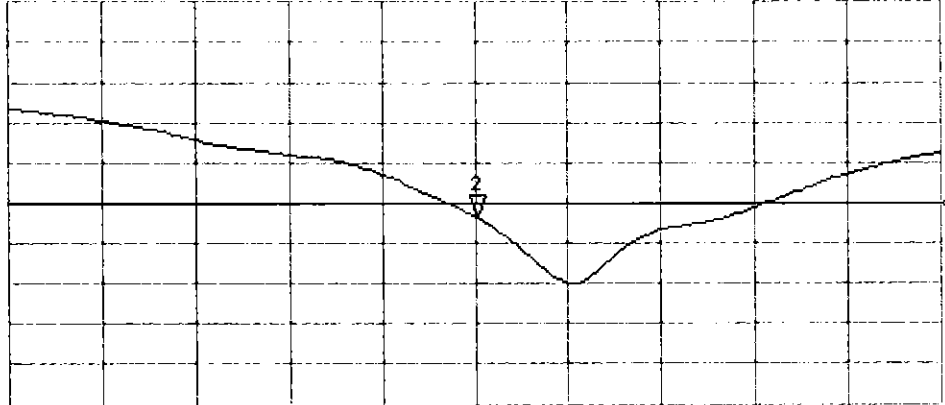
CH1 S11 1 U FS 2: 44.785  $\Omega$  -5.8145  $\Omega$  10.528 pF 2 600.000 000 MHz

\*  
De1  
CA  
Avg  
16  
H1d



CH2 S11 LOG 5 dB/REF -20 dB 2:-21.696 dB 2 600.000 000 MHz

CA  
Avg  
16  
H1d



START 2 400.000 000 MHz

STOP 2 800.000 000 MHz



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Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D5GHzV2-1237\_Aug17**

## CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN:1237**

Calibration procedure(s) **QA CAL-22.v2  
Calibration procedure for dipole validation kits between 3-6 GHz**

Calibration date: **August 15, 2017**

*PMV*  
*8/27/17*

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	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 3503	31-Dec-16 (No. EX3-3503_Dec16)	Dec-17
DAE4	SN: 601	28-Mar-17 (No. DAE4-601_Mar17)	Mar-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

Calibrated by:	Name <b>Johannes Kurikka</b>	Function <b>Laboratory Technician</b>	Signature 
Approved by:	Name <b>Katja Pokovic</b>	Function <b>Technical Manager</b>	Signature 

Issued: August 16, 2017

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**Glossary:**

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

**Calibration is Performed According to the Following Standards:**

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

**Additional Documentation:**

- e) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

DASY Version	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5250 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz	

## Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.7 ± 6 %	4.49 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.14 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>80.7 W/kg ± 19.9 % (k=2)</b>

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

### Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.2 ± 6 %	4.84 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>82.5 W / kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.5 W/kg ± 19.5 % (k=2)</b>

### Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.0 ± 6 %	4.99 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5750 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.10 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>80.2 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (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	<b>22.8 W/kg ± 19.5 % (k=2)</b>



### 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	47.0 ± 6 %	5.46 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5250 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.75 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	76.9 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.17 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	46.4 ± 6 %	5.93 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.91 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	78.5 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.23 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	22.1 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 %	6.13 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 <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.77 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	77.1 W/kg ± 19.9 % (k=2)

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

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

### Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	49.9 $\Omega$ - 5.3 j $\Omega$
Return Loss	- 25.5 dB

### Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	51.9 $\Omega$ + 2.3 j $\Omega$
Return Loss	- 30.7 dB

### Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	55.6 $\Omega$ - 0.5 j $\Omega$
Return Loss	- 25.5 dB

### Antenna Parameters with Body TSL at 5250 MHz

Impedance, transformed to feed point	46.9 $\Omega$ - 4.2 j $\Omega$
Return Loss	- 25.4 dB

### Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	50.2 $\Omega$ + 3.0 j $\Omega$
Return Loss	- 30.4 dB

### Antenna Parameters with Body TSL at 5750 MHz

Impedance, transformed to feed point	53.4 $\Omega$ + 0.2 j $\Omega$
Return Loss	- 29.7 dB

## General Antenna Parameters and Design

Electrical Delay (one direction)	1.194 ns
----------------------------------	----------

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

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

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

## Additional EUT Data

Manufactured by	SPEAG
Manufactured on	May 04, 2015

## DASY5 Validation Report for Head TSL

Date: 15.08.2017

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1237**

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz  
Medium parameters used:  $f = 5250$  MHz;  $\sigma = 4.49$  S/m;  $\epsilon_r = 34.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>,  
Medium parameters used:  $f = 5600$  MHz;  $\sigma = 4.84$  S/m;  $\epsilon_r = 34.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>,  
Medium parameters used:  $f = 5750$  MHz;  $\sigma = 4.99$  S/m;  $\epsilon_r = 34$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.58, 5.58, 5.58); Calibrated: 31.12.2016, ConvF(5.09, 5.09, 5.09); Calibrated: 31.12.2016, ConvF(5.02, 5.02, 5.02); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

**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 = 70.08 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 30.6 W/kg

**SAR(1 g) = 8.14 W/kg; SAR(10 g) = 2.33 W/kg**

Maximum value of SAR (measured) = 19.2 W/kg

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 70.04 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 32.7 W/kg

**SAR(1 g) = 8.33 W/kg; SAR(10 g) = 2.38 W/kg**

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

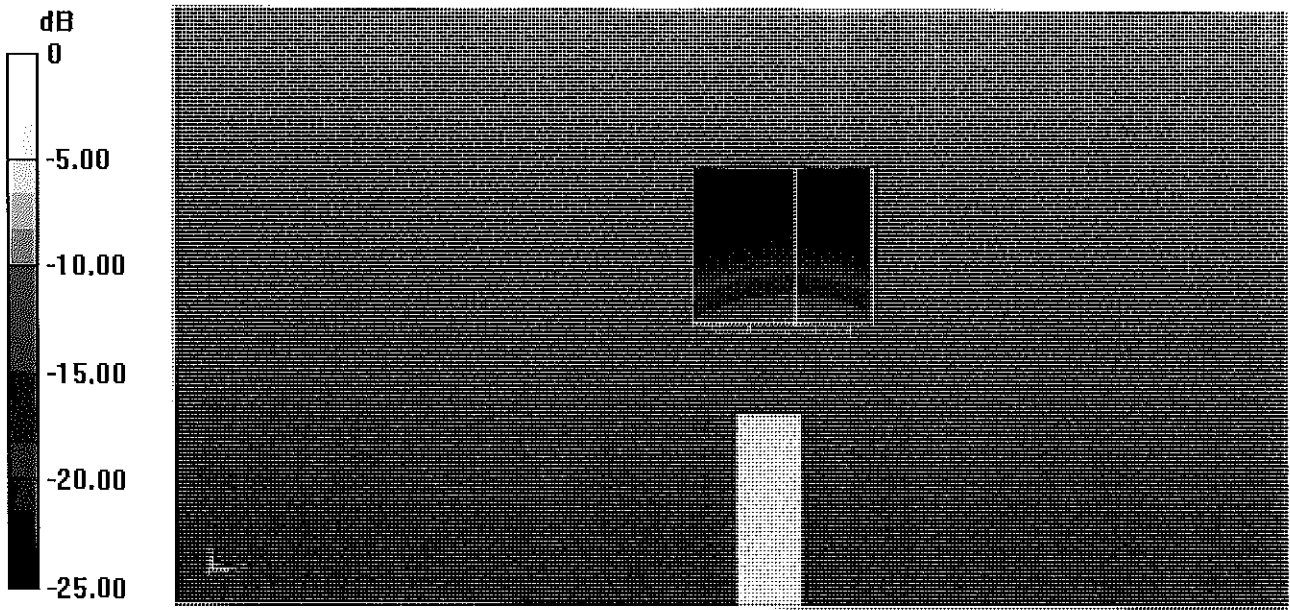
**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 69.11 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 32.4 W/kg

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

Maximum value of SAR (measured) = 19.6 W/kg



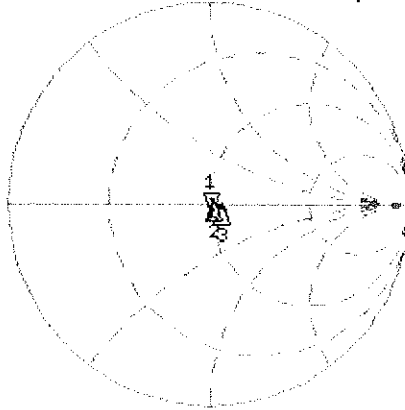
0 dB = 19.2 W/kg = 12.83 dBW/kg

# Impedance Measurement Plot for Head TSL

9 Aug 2017 12:04:29

CH1 S11 1 U FS 1: 49.920  $\Omega$  -5.3223  $\Omega$  5.6959  $\mu$ F 5 250.000 000 MHz

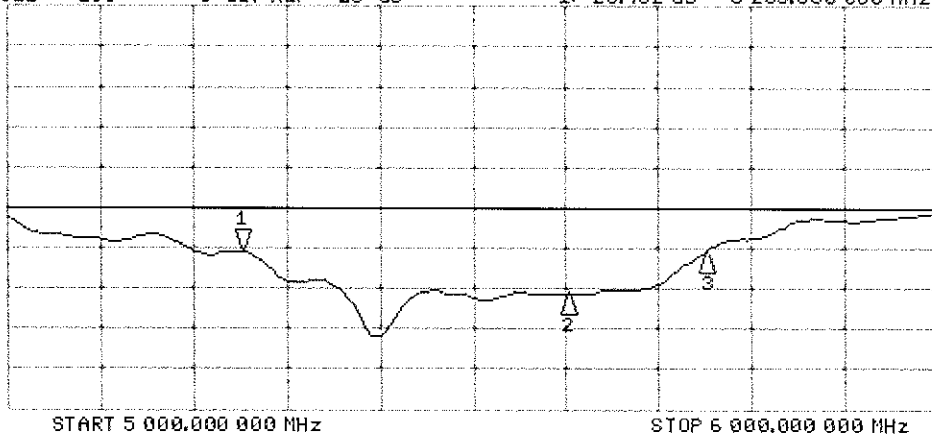
\*  
De1  
Cor  
Avg  
16  
H1d



CH1 Markers  
2: 51.904  $\Omega$   
2.3008  $\Omega$   
5.60000 GHz  
3: 55.609  $\Omega$   
-492.19  $m\Omega$   
5.75000 GHz

CH2 S11 LOG 5 dB/ REF -20 dB 1: -25.482 dB 5 250.000 000 MHz

Cor  
Avg  
16  
H1d



CH2 Markers  
2: -30.654 dB  
5.60000 GHz  
3: -25.460 dB  
5.75000 GHz

START 5 000.000 000 MHz

STOP 6 000.000 000 MHz

## DASY5 Validation Report for Body TSL

Date: 08.08.2017

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1237**

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz  
Medium parameters used:  $f = 5250$  MHz;  $\sigma = 5.46$  S/m;  $\epsilon_r = 47$ ;  $\rho = 1000$  kg/m<sup>3</sup>,  
Medium parameters used:  $f = 5600$  MHz;  $\sigma = 5.93$  S/m;  $\epsilon_r = 46.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>,  
Medium parameters used:  $f = 5750$  MHz;  $\sigma = 6.13$  S/m;  $\epsilon_r = 46.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.14, 5.14, 5.14); Calibrated: 31.12.2016, ConvF(4.57, 4.57, 4.57); Calibrated: 31.12.2016, ConvF(4.51, 4.51, 4.51); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

Reference Value = 65.87 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 29.9 W/kg

**SAR(1 g) = 7.75 W/kg; SAR(10 g) = 2.17 W/kg**

Maximum value of SAR (measured) = 18.4 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 = 65.11 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 33.0 W/kg

**SAR(1 g) = 7.91 W/kg; SAR(10 g) = 2.23 W/kg**

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

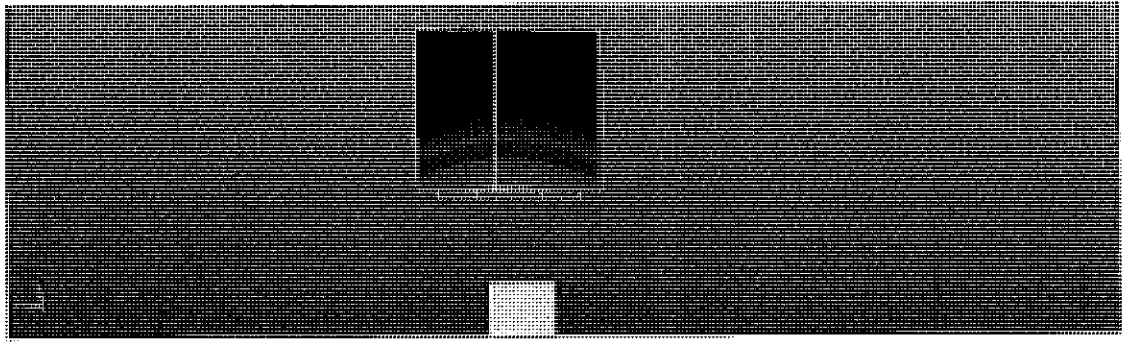
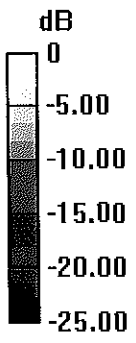
**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 63.64 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 33.8 W/kg

**SAR(1 g) = 7.77 W/kg; SAR(10 g) = 2.16 W/kg**

Maximum value of SAR (measured) = 19.1 W/kg



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

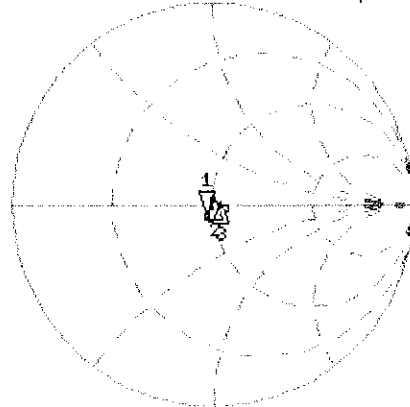


# Impedance Measurement Plot for Body TSL

8 Aug 2017 15:23:50

CH1 S11 1 U FS 1: 46.885  $\Omega$  -4.1973  $\Omega$  7.2226 pF 5 250.000 000 MHz

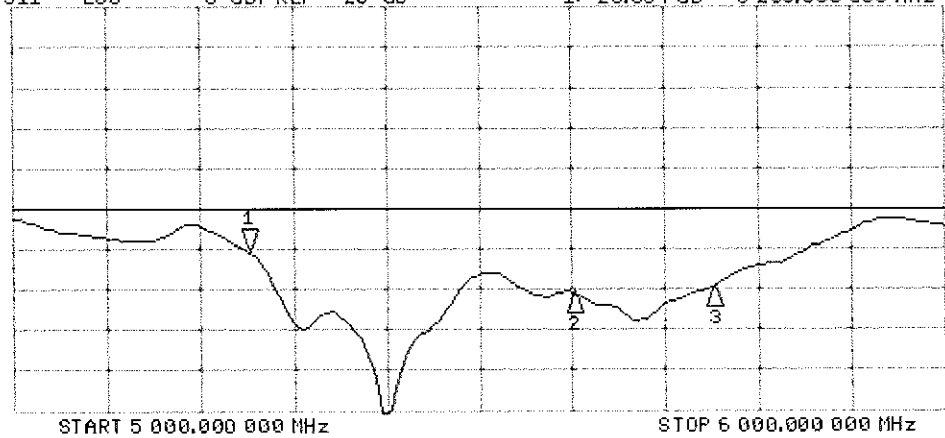
\*  
De1  
Cor  
Avg  
16  
H1d



CH1 Markers  
2: 50.184  $\Omega$   
3: 0.215  $\Omega$   
5.60000 GHz  
3: 53.363  $\Omega$   
0.1719  $\Omega$   
5.75000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1: -25.364 dB 5 250.000 000 MHz

Cor  
Avg  
16  
H1d



CH2 Markers  
2: -30.389 dB  
5.60000 GHz  
3: -29.742 dB  
5.75000 GHz



Accredited by the Swiss Accreditation Service (SAS)  
The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D1750V2-1051\_Apr18**

## CALIBRATION CERTIFICATE

Object **D1750V2 - SN: 1051**

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

Calibration date: **April 19, 2018**

*BN ✓  
05-01-2018*

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 ± 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	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: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
Reference Probe EX3DV4	SN: 7349	30-Dec-17 (No. EX3-7349_Dec17)	Dec-18
DAE4	SN: 601	26-Oct-17 (No. DAE4-601_Oct17)	Oct-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

Calibrated by: **Name** Michael Weber **Function** Laboratory Technician **Signature** *M. Weber*

Approved by: **Name** Katja Pokovic **Function** Technical Manager **Signature** *K. Pokovic*

Issued: April 19, 2018

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



Accredited by the Swiss Accreditation Service (SAS)

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

### Glossary:

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

### Calibration is Performed According to the Following Standards:

- 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
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- 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.

<b>DASY Version</b>	DASY5	V52.10.0
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	1750 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	40.1	1.37 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	39.2 $\pm$ 6 %	1.35 mho/m $\pm$ 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	9.10 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>36.5 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	4.82 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>19.3 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	53.4	1.49 mho/m
<b>Measured Body TSL parameters</b>	(22.0 $\pm$ 0.2) °C	52.4 $\pm$ 6 %	1.46 mho/m $\pm$ 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	9.21 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>37.2 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	250 mW input power	4.94 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>19.9 W/kg <math>\pm</math> 16.5 % (k=2)</b>

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.7 $\Omega$ + 2.5 j $\Omega$
Return Loss	- 30.4 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.6 $\Omega$ + 1.3 j $\Omega$
Return Loss	- 31.1 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.222 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	February 19, 2010

# DASY5 Validation Report for Head TSL

Date: 19.04.2018

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1051**

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

Medium parameters used:  $f = 1750$  MHz;  $\sigma = 1.35$  S/m;  $\epsilon_r = 39.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.5, 8.5, 8.5); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

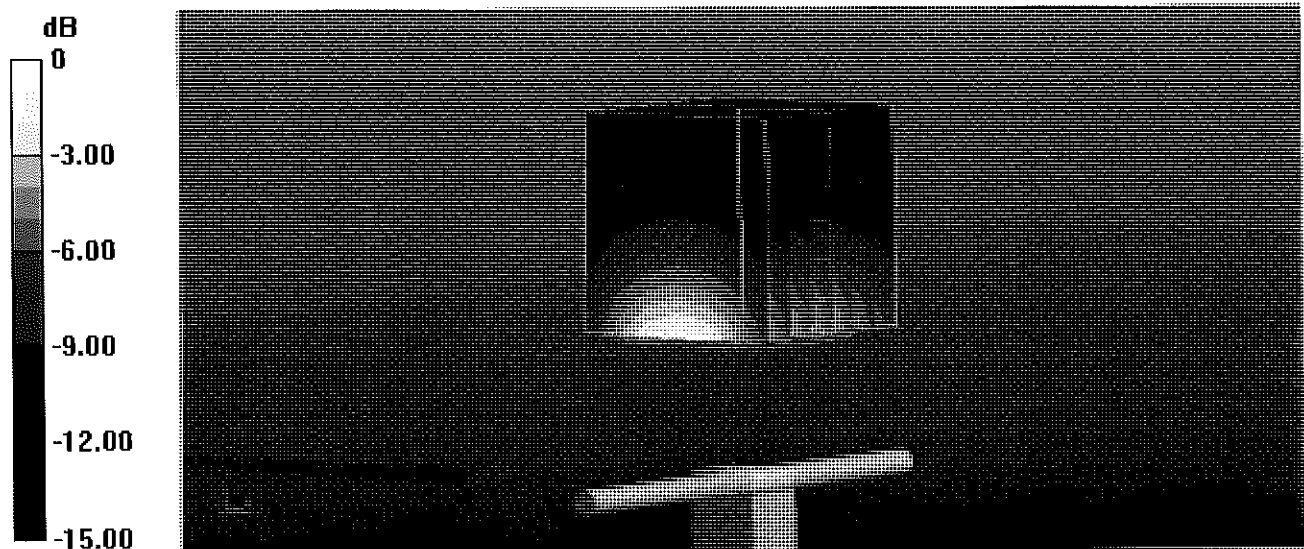
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 107.3 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 16.7 W/kg

**SAR(1 g) = 9.1 W/kg; SAR(10 g) = 4.82 W/kg**

Maximum value of SAR (measured) = 14.0 W/kg



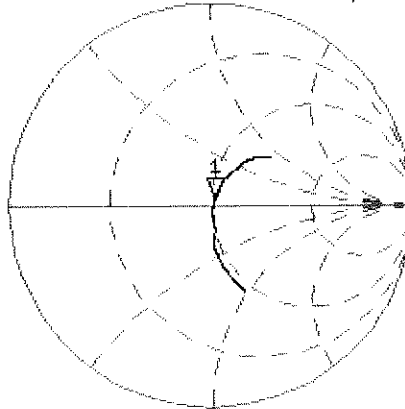
0 dB = 14.0 W/kg = 11.46 dBW/kg

# Impedance Measurement Plot for Head TSL

19 Apr 2018 16:34:28

CH1 S11 1 U FS 1: 51.703  $\Omega$  2.5391  $\Omega$  230.92 pF 1 750.000 000 MHz

\*  
De1  
CA



Avg  
16

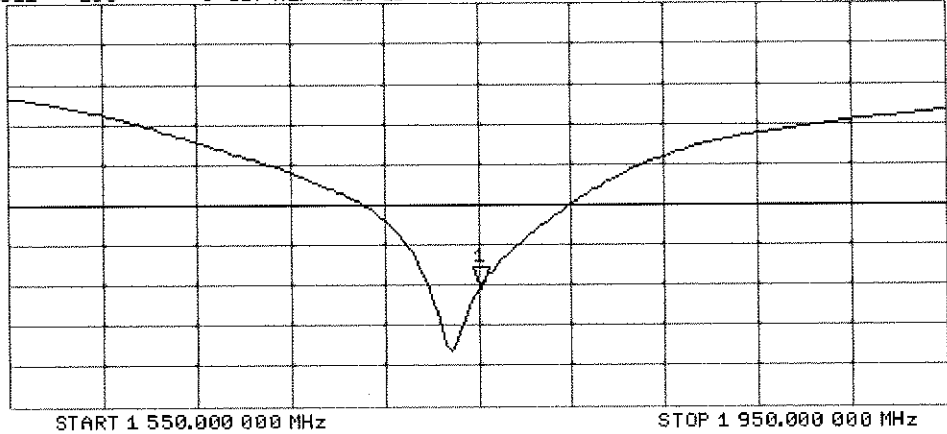
H1 d

CH2 S11 LOG 5 dB/REF -20 dB 1:-30.440 dB 1 750.000 000 MHz

CA

Avg  
16

H1 d



# DASY5 Validation Report for Body TSL

Date: 19.04.2018

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1051**

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

Medium parameters used:  $f = 1750$  MHz;  $\sigma = 1.46$  S/m;  $\epsilon_r = 52.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.35, 8.35, 8.35); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

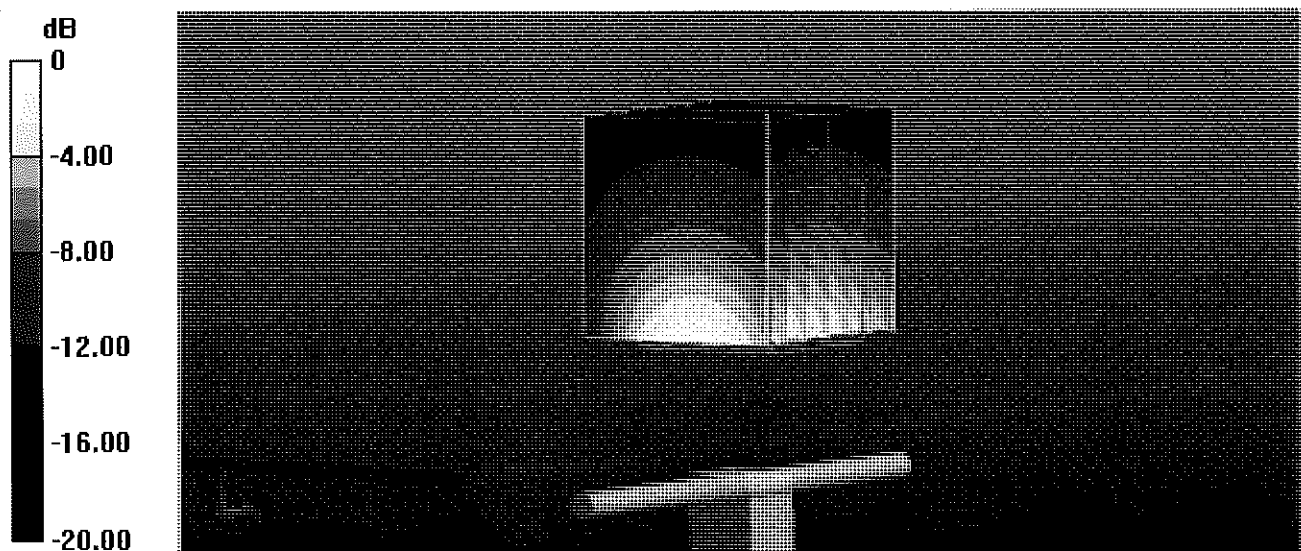
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 99.30 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 16.2 W/kg

**SAR(1 g) = 9.21 W/kg; SAR(10 g) = 4.94 W/kg**

Maximum value of SAR (measured) = 13.3 W/kg



0 dB = 13.3 W/kg = 11.24 dBW/kg

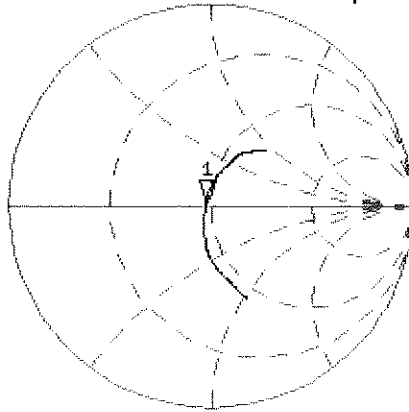


# Impedance Measurement Plot for Body TSL

19 Apr 2018 17:21:05

CH1 S11 1 U FS 1: 47.590  $\Omega$  1.2520  $\Omega$  113.86  $\mu$ H 1 750.000 000 MHz

\*  
Del  
CA



Avg  
16

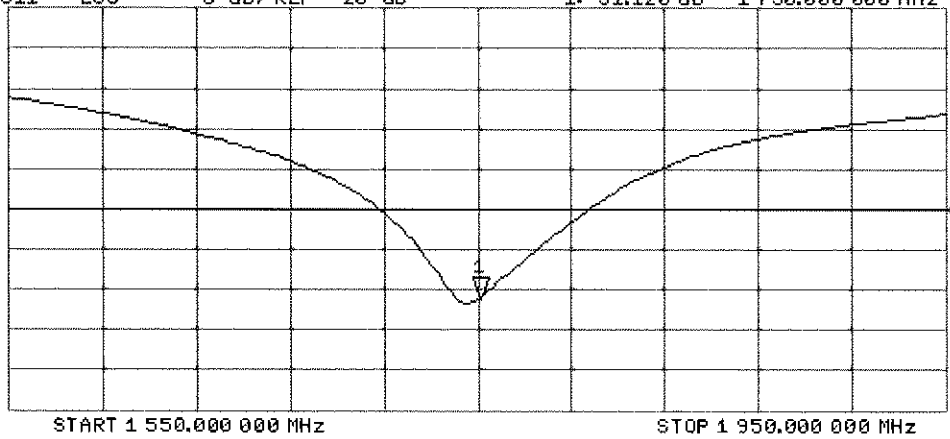
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1:-31.120 dB 1 750.000 000 MHz

CA

Avg  
16

H1d



## APPENDIX D: SAR TISSUE SPECIFICATIONS

Measurement Procedure for Tissue verification:

- 1) The network analyzer and probe system was configured and calibrated.
- 2) The probe was immersed in the tissue. The tissue was placed in a nonmetallic container. Trapped air bubbles beneath the flange were minimized by placing the probe at a slight angle.
- 3) The complex admittance with respect to the probe aperture was measured
- 4) The complex relative permittivity  $\epsilon'$  can be calculated from the below equation (Pournaropoulos and Misra):

$$Y = \frac{j2\omega\epsilon_r\epsilon_0}{[\ln(b/a)]^2} \int_a^b \int_a^b \int_0^\pi \cos\phi' \frac{\exp[-j\omega r(\mu_0\epsilon_r'\epsilon_0)^{1/2}]}{r} d\phi' d\rho' d\rho$$

where Y is the admittance of the probe in contact with the sample, the primed and unprimed coordinates refer to source and observation points, respectively,  $r^2 = \rho^2 + \rho'^2 - 2\rho\rho' \cos\phi'$ ,  $\omega$  is the angular frequency, and  $j = \sqrt{-1}$ .

**Table D-I  
Composition of the Tissue Equivalent Matter**

Frequency (MHz)	750	750	835	835	1750	1750	1900	1900	2450	2450	5200-5800	5200-5800
Tissue	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body
Ingredients (% by weight)												
Bactericide	See page 2-3	See page 2	0.1	0.1					See page 4		See page 5	
DGBE					47	31	44.92	29.44		26.7		
HEC			1	1								
NaCl			1.45	0.94	0.4	0.2	0.18	0.39		0.1		
Sucrose			57	44.9								
Polysorbate (Tween) 80												20
Water					40.45	53.06	52.6	68.8		54.9		70.17

<b>FCC ID:</b> A3LSMN960U	 <small>PROFESSIONAL COMMUNICATIONS TEST EQUIPMENT, INC.</small>	<b>SAR EVALUATION REPORT</b>		<b>Approved by:</b> Quality Manager
<b>Test Dates:</b> 05/07/18 - 06/11/18	<b>DUT Type:</b> Portable Handset			APPENDIX D: Page 1 of 5

## 2 Composition / Information on ingredients

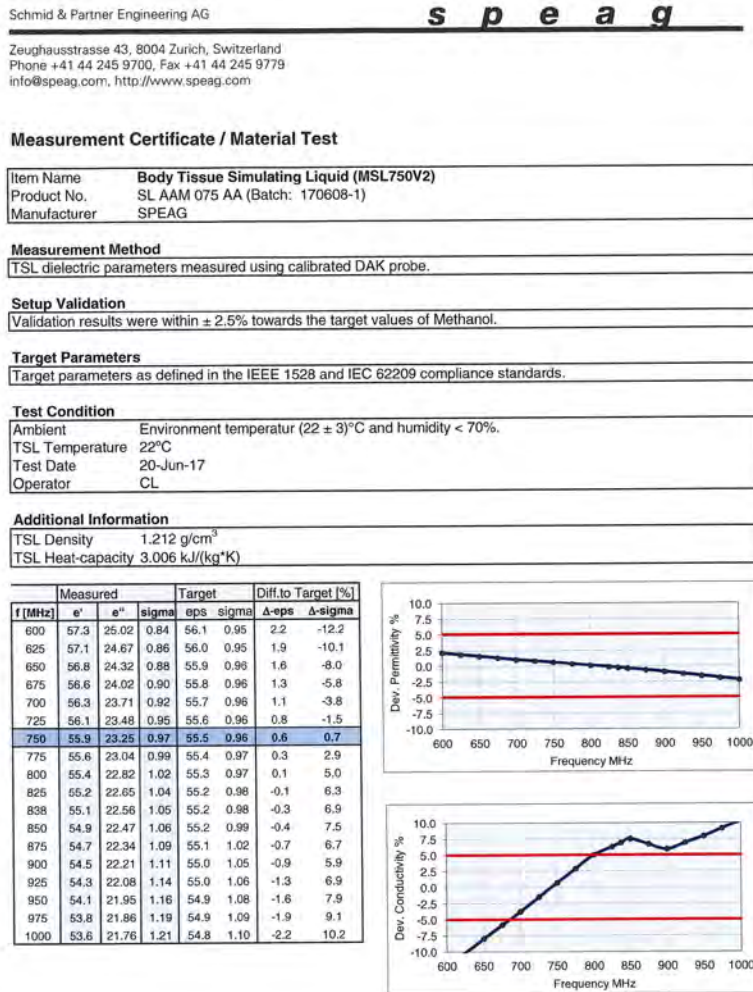
The Item is composed of the following ingredients:

H <sub>2</sub> O	Water, 35 – 58%
Sucrose	Sugar, white, refined, 40 – 60%
NaCl	Sodium Chloride, 0 – 6%
Hydroxyethyl-cellulose	Medium Viscosity (CAS# 9004-62-0), <0.3%
Preventol-D7	Preservative: aqueous preparation, (CAS# 55965-84-9), containing 5-chloro-2-methyl-3(2H)-isothiazolone and 2-methyl-3(2H)-isothiazolone, 0.1 – 0.7%

Relevant for safety; Refer to the respective Safety Data Sheet\*.

**Figure D-1**  
**Composition of 750 MHz Head and Body Tissue Equivalent Matter**

**Note:** 750MHz liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.



**Figure D-2**  
**750MHz Body Tissue Equivalent Matter**

<b>FCC ID:</b> A3LSMN960U		<b>SAR EVALUATION REPORT</b>		<b>Approved by:</b> Quality Manager
<b>Test Dates:</b> 05/07/18 - 06/11/18	<b>DUT Type:</b> Portable Handset			<b>APPENDIX D:</b> Page 2 of 5

**Measurement Certificate / Material Test**

Item Name	Head Tissue Simulating Liquid (HSL750V2)
Product No.	SL AAH 075 AA (Batch: 170612-4)
Manufacturer	SPEAG

**Measurement Method**  
 TSL dielectric parameters measured using calibrated DAK probe.

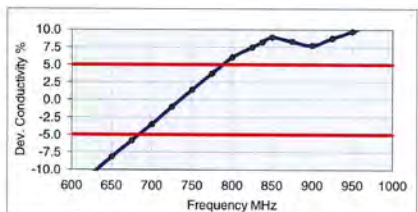
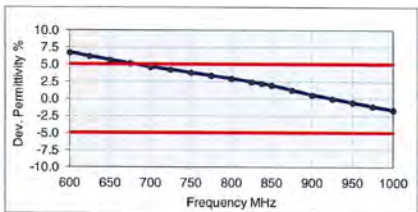
**Setup Validation**  
 Validation results were within  $\pm 2.5\%$  towards the target values of Methanol.

**Target Parameters**  
 Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

**Test Condition**  
 Ambient Environment temperatur ( $22 \pm 3$ )°C and humidity < 70%.  
 TSL Temperature 22°C  
 Test Date 20-Jun-17  
 Operator CL

**Additional Information**  
 TSL Density 1.284 g/cm<sup>3</sup>  
 TSL Heat-capacity 2.701 kJ/(kg\*K)

f [MHz]	Measured			Target		Diff.to Target [%]	
	e'	e''	sigma	eps	sigma	$\Delta$ -eps	$\Delta$ -sigma
600	45.6	22.97	0.77	42.7	0.88	6.7	-13.1
625	45.2	22.73	0.79	42.6	0.88	6.2	-10.6
650	44.9	22.49	0.81	42.5	0.89	5.6	-8.2
675	44.5	22.27	0.84	42.3	0.89	5.1	-5.8
700	44.2	22.05	0.86	42.2	0.89	4.6	-3.5
725	43.8	21.88	0.88	42.1	0.89	4.2	-1.0
750	43.5	21.72	0.91	41.9	0.89	3.8	1.4
775	43.2	21.55	0.93	41.8	0.90	3.4	3.7
800	42.9	21.38	0.95	41.7	0.90	2.9	6.0
825	42.6	21.24	0.97	41.6	0.91	2.4	7.5
838	42.5	21.17	0.99	41.5	0.91	2.2	8.2
850	42.3	21.09	1.00	41.5	0.92	2.0	8.9
875	42.0	20.98	1.02	41.5	0.94	1.2	8.3
900	41.7	20.87	1.05	41.5	0.97	0.5	7.7
925	41.5	20.76	1.07	41.5	0.98	0.0	8.7
950	41.2	20.64	1.09	41.4	0.99	-0.6	9.7
975	40.9	20.55	1.11	41.4	1.00	-1.1	10.9
1000	40.6	20.46	1.14	41.3	1.01	-1.7	12.1



**Figure D-3**  
**750MHz Head Tissue Equivalent Matter**

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### 3 Composition / Information on ingredients

The Item is composed of the following ingredients:

Water	50 – 73 %	
Non-ionic detergents	25 – 50 %	polyoxyethylenesorbitan monolaurate
NaCl	0 – 2 %	
Preservative	0.05 – 0.1%	Preventol-D7

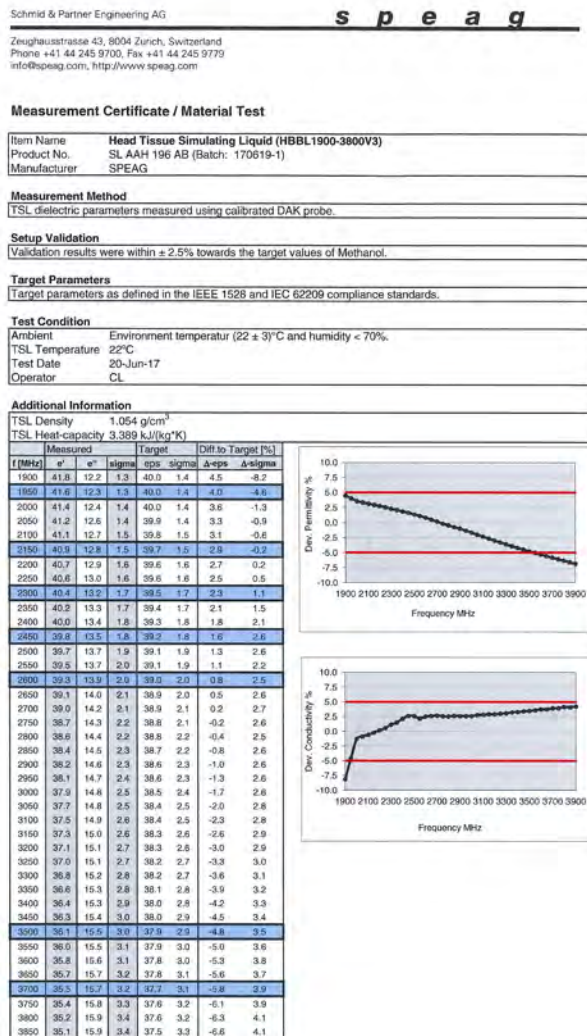
Safety relevant ingredients:

CAS-No. 55965-84-9	< 0.1 %	aqueous preparation, containing 5-chloro-2-methyl-3(2H)-isothiazolone and 2-methyl-3(2H)-isothiazolone
CAS-No. 9005-64-5	<50 %	polyoxyethylenesorbitan monolaurate

According to international guidelines, the product is not a dangerous mixture and therefore not required to be marked by symbols.

**Figure D-4**  
**Composition of 2.4 GHz Head Tissue Equivalent Matter**

**Note:** 2.4 GHz head liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.



**Figure D-5**  
**2.4 GHz Head Tissue Equivalent Matter**

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## 2 Composition / Information on ingredients

The Item is composed of the following ingredients:

Water	50 – 65%
Mineral oil	10 – 30%
Emulsifiers	8 – 25%
Sodium salt	0 – 1.5%

Figure D-6

### Composition of 5 GHz Head Tissue Equivalent Matter

**Note:** 5GHz head liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.

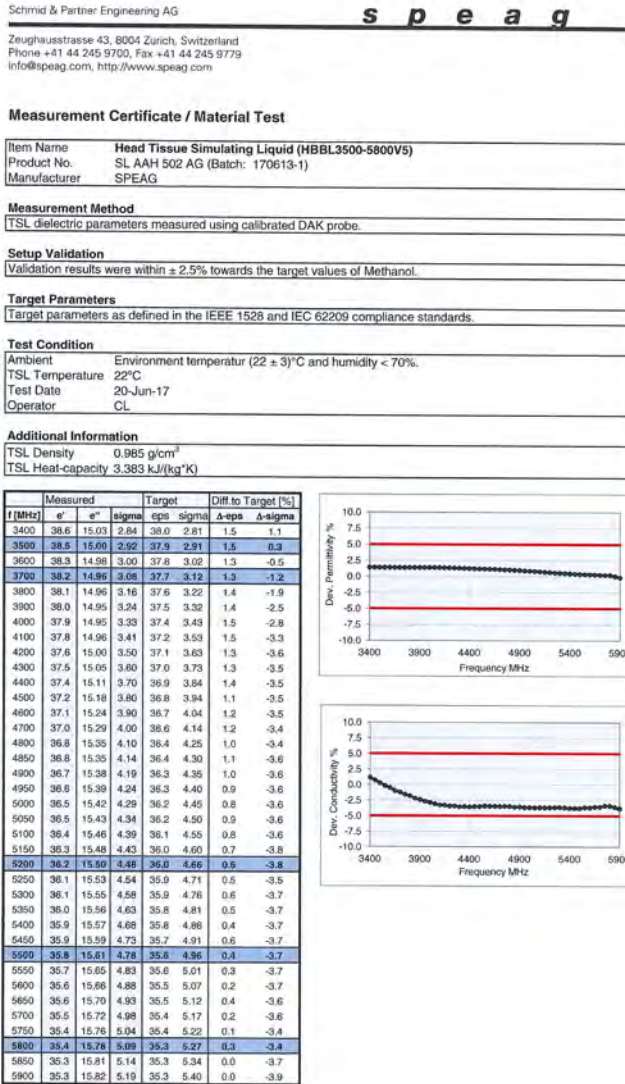


Figure D-7  
5GHz Head Tissue Equivalent Matter

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## APPENDIX E: SAR SYSTEM VALIDATION

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

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



**Table E-1**  
**SAR System Validation Summary – 1g**

SAR SYSTEM #	FREQ. [MHz]	DATE	PROBE SN	PROBE TYPE	PROBE CAL. POINT		COND.	PERM.	CW VALIDATION			MOD. VALIDATION		
							(σ)	(εr)	SENSITIVITY	PROBE LINEARITY	PROBE ISOTROPY	MOD. TYPE	DUTY FACTOR	PAR
E	750	3/11/2018	3213	ES3DV3	750	Head	0.890	40.788	PASS	PASS	PASS	N/A	N/A	N/A
E	835	3/5/2018	3213	ES3DV3	835	Head	0.925	43.335	PASS	PASS	PASS	GMSK	PASS	N/A
E	1750	3/2/2018	3213	ES3DV3	1750	Head	1.397	38.415	PASS	PASS	PASS	N/A	N/A	N/A
G	1900	8/31/2017	3332	ES3DV3	1900	Head	1.457	40.398	PASS	PASS	PASS	GMSK	PASS	N/A
G	2300	10/16/2017	3332	ES3DV3	2300	Head	1.715	39.101	PASS	PASS	PASS	N/A	N/A	N/A
G	2450	10/16/2017	3332	ES3DV3	2450	Head	1.880	38.615	PASS	PASS	PASS	OFDM/TDD	PASS	PASS
G	2600	10/16/2017	3332	ES3DV3	2600	Head	2.051	38.039	PASS	PASS	PASS	TDD	PASS	N/A
H	5250	1/31/2018	3589	EX3DV4	5250	Head	4.516	36.066	PASS	PASS	PASS	OFDM	N/A	PASS
H	5600	1/31/2018	3589	EX3DV4	5600	Head	4.869	35.597	PASS	PASS	PASS	OFDM	N/A	PASS
H	5750	1/31/2018	3589	EX3DV4	5750	Head	5.112	35.351	PASS	PASS	PASS	OFDM	N/A	PASS
H	750	8/30/2017	7410	EX3DV4	750	Body	0.956	56.276	PASS	PASS	PASS	N/A	N/A	N/A
I	835	4/24/2018	3287	ES3DV3	835	Body	0.998	53.355	PASS	PASS	PASS	GMSK	PASS	N/A
J	1750	5/14/2018	3347	ES3DV3	1750	Body	1.516	52.662	PASS	PASS	PASS	N/A	N/A	N/A
J	1900	4/30/2018	3347	ES3DV3	1900	Body	1.529	53.419	PASS	PASS	PASS	GMSK	PASS	N/A
K	2300	4/3/2018	3319	ES3DV3	2300	Body	1.871	51.575	PASS	PASS	PASS	N/A	N/A	N/A
K	2450	4/3/2018	3319	ES3DV3	2450	Body	2.043	51.130	PASS	PASS	PASS	OFDM/TDD	PASS	PASS
D	2450	12/18/2017	3318	ES3DV3	2450	Body	2.029	51.304	PASS	PASS	PASS	OFDM/TDD	PASS	PASS
K	2600	4/3/2018	3319	ES3DV3	2600	Body	2.225	50.665	PASS	PASS	PASS	TDD	PASS	N/A
D	5250	10/24/2017	7308	EX3DV4	5250	Body	5.405	48.529	PASS	PASS	PASS	OFDM	N/A	PASS
D	5600	10/24/2017	7308	EX3DV4	5600	Body	5.910	47.818	PASS	PASS	PASS	OFDM	N/A	PASS
D	5750	10/24/2017	7308	EX3DV4	5750	Body	6.135	47.546	PASS	PASS	PASS	OFDM	N/A	PASS

**Table E-2**  
**SAR System Validation Summary – 10g**

SAR SYSTEM #	FREQ. [MHz]	DATE	PROBE SN	PROBE TYPE	PROBE CAL. POINT		COND.	PERM.	CW VALIDATION			MOD. VALIDATION		
							(σ)	(εr)	SENSITIVITY	PROBE LINEARITY	PROBE ISOTROPY	MOD. TYPE	DUTY FACTOR	PAR
I	1750	3/12/2018	3287	ES3DV3	1750	Body	1.462	52.350	PASS	PASS	PASS	N/A	N/A	N/A
J	1900	4/30/2018	3347	ES3DV3	1900	Body	1.529	53.419	PASS	PASS	PASS	GMSK	PASS	N/A
K	2300	4/3/2018	3319	ES3DV3	2300	Body	1.871	51.575	PASS	PASS	PASS	N/A	N/A	N/A
K	2450	4/3/2018	3319	ES3DV3	2450	Body	2.043	51.130	PASS	PASS	PASS	OFDM/TDD	PASS	PASS
K	2600	4/3/2018	3319	ES3DV3	2600	Body	2.225	50.665	PASS	PASS	PASS	TDD	PASS	N/A
D	5250	10/24/2017	7308	EX3DV4	5250	Body	5.405	48.529	PASS	PASS	PASS	OFDM	N/A	PASS
D	5600	10/24/2017	7308	EX3DV4	5600	Body	5.910	47.818	PASS	PASS	PASS	OFDM	N/A	PASS
D	5750	10/24/2017	7308	EX3DV4	5750	Body	6.135	47.546	PASS	PASS	PASS	OFDM	N/A	PASS

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

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# APPENDIX G: POWER REDUCTION VERIFICATION

Per the May 2017 TCBC Workshop Notes, demonstration of proper functioning of the power reduction mechanisms is required to support the corresponding SAR configurations. The verification process was divided into two parts: (1) evaluation of output power levels for individual or multiple triggering mechanisms and (2) evaluation of the triggering distances for proximity-based sensors.

## 1.1 Power Verification Procedure



The power verification was performed according to the following procedure:

1. A base station simulator was used to establish a conducted RF connection and the output power was monitored. The power measurements were confirmed to be within expected tolerances for all states before and after a power reduction mechanism was triggered.
2. Step 1 was repeated for all relevant modes and frequency bands for the mechanism being investigated.
3. Steps 1 and 2 were repeated for all individual power reduction mechanisms and combinations thereof. For the combination cases, one mechanism was switched to a 'triggered' state at a time; powers were confirmed to be within tolerances after each additional mechanism was activated.

## 1.2 Distance Verification Procedure

The distance verification procedure was performed according to the following procedure:

1. A base station simulator was used to establish an RF connection and to monitor the power levels. The device being tested was placed below the relevant section of the phantom with the relevant side or edge of the device facing toward the phantom.
2. The device was moved toward and away from the phantom to determine the distance at which the mechanism triggers and the output power is reduced, per KDB Publication 616217 D04v01r02 and FCC Guidance. Each applicable test position was evaluated. The distances were confirmed to be the same or larger (more conservative) than the minimum distances provided by the manufacturer.
3. Steps 1 and 2 were repeated for all relevant frequency bands.
4. Steps 1 through 3 were repeated for all distance-based power reduction mechanisms.

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### 1.3 Main Antenna Verification Summary

Table G-1

Power Measurement Verification for Main Antenna

Mechanism(s)	Mode/Band	Conducted Power (dBm)		
		Un-triggered (Max)	Mechanism #1 (Reduced)	Mechanism #2 (Reduced)
Hotspot On	GSM 1900	30.35	26.32	
Hotspot On	UMTS B4	24.92	19.76	
Hotspot On	UMTS B2	24.76	19.58	
Hotspot On	CDMA BC1	24.82	19.65	
Hotspot On	LTE B4	24.46	20.04	
Hotspot On	LTE B66	25.08	20.2	
Hotspot On	LTE B2	24.3	19.11	
Hotspot On	LTE B25	24.26	19.3	
Hotspot On	LTE B30 Ant A	23.27	20.24	
Hotspot On	LTE B30 Ant B	22.73	19.78	
Hotspot On	LTE B7 Ant A	23.58	19.57	
Hotspot On	LTE B7 Ant B	23.62	19.53	
Hotspot On	LTE B38	23.02	20.98	
Hotspot On	LTE B41 PC3	23.68	21.08	
Hotspot On	LTE B41 PC2	27.06	21.41	
Grip	GSM 1900	30.3	26.34	
Grip	UMTS B4	24.96	21.27	
Grip	UMTS B2	24.7	19.51	
Grip	CDMA BC1	24.85	19.85	
Grip	LTE B4	24.64	21.04	
Grip	LTE B66	25.06	21.22	
Grip	LTE B2	24.31	19.55	
Grip	LTE B25	24.25	19.76	
Grip	LTE B30 Ant A	23.24	21.75	
Grip	LTE B30 Ant B	22.77	21.26	
Grip	LTE B7 Ant A	23.57	20.11	
Grip	LTE B7 Ant B	23.63	20.19	
Grip	LTE B41 PC3	23.64	22.65	
Grip	LTE B41 PC2	27.11	22.9	
Hotspot On, then Grip	GSM 1900	30.31	26.38	26.39
Hotspot On, then Grip	UMTS B4	24.95	19.7	19.73
Hotspot On, then Grip	UMTS B2	24.8	19.6	19.61
Hotspot On, then Grip	CDMA BC1	24.78	19.74	19.76
Hotspot On, then Grip	LTE B4	24.63	20.1	20.08
Hotspot On, then Grip	LTE B66	25.07	20.19	20.21
Hotspot On, then Grip	LTE B2	24.17	19.27	19.28
Hotspot On, then Grip	LTE B25	24.27	19.3	19.31
Hotspot On, then Grip	LTE B30 Ant A	23.23	20.27	20.25
Hotspot On, then Grip	LTE B30 Ant B	22.75	19.78	19.77
Hotspot On, then Grip	LTE B7 Ant A	23.59	19.56	19.53
Hotspot On, then Grip	LTE B7 Ant B	23.6	19.55	19.56
Hotspot On, then Grip	LTE B41 PC3	23.66	21.06	21.11
Hotspot On, then Grip	LTE B41 PC2	27.1	21.42	21.4
Grip, then Hotspot On	GSM 1900	30.28	26.31	26.32
Grip, then Hotspot On	UMTS B4	24.94	21.25	19.78
Grip, then Hotspot On	UMTS B2	24.68	19.55	19.48
Grip, then Hotspot On	CDMA BC1	24.79	19.88	19.76
Grip, then Hotspot On	LTE B4	24.68	21.03	20.03
Grip, then Hotspot On	LTE B66	25.09	21.26	20.24
Grip, then Hotspot On	LTE B2	24.22	19.16	19.14
Grip, then Hotspot On	LTE B25	24.3	19.79	19.31
Grip, then Hotspot On	LTE B30 Ant A	23.21	21.74	20.23
Grip, then Hotspot On	LTE B30 Ant B	22.77	21.23	19.72
Grip, then Hotspot On	LTE B7 Ant A	23.59	20.11	19.55
Grip, then Hotspot On	LTE B7 Ant B	23.62	20.8	19.57
Grip, then Hotspot On	LTE B41 PC3	23.64	22.55	21.16
Grip, then Hotspot On	LTE B41 PC2	27.09	22.9	21.4

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**Table G-2**

**Distance Measurement Verification for Main Antenna**

Mechanism(s)	Test Condition	Band	Distance Measurements (mm)		Distance per Manufacturer
			Moving Toward	Moving Away	
Grip	Phablet - Back Side	Mid	11	15	8
Grip	Phablet - Back Side	High	11	14	8
Grip	Phablet - Front Side	Mid	9	10	6
Grip	Phablet - Front Side	High	9	10	6
Grip	Phablet - Bottom Edge	Mid	12	15	11
Grip	Phablet - Bottom Edge	High	12	14	11

**Note: Mid band refers to: CDMA BC1, GSM1900, UMTS B2/4, LTE B2/4/25/66;  
High band refers to: LTE B7/30 Ant A & Ant B/LTE B41 PC2 & PC3.**

## 1.4 WIFI Verification Summary

**Table G-3**



**Power Measurement Verification WIFI**

Mechanism(s)	Mode/Band	Conducted Power (dBm)	
		Un-triggered (Max)	Mechanism #1 (Reduced)
Held-to-Ear	802.11b	19.04	15.02
Held-to-Ear	802.11g	16.58	15.1
Held-to-Ear	802.11n (2.4GHz)	16.71	15.45
Held-to-Ear	802.11a	16.97	11.6
Held-to-Ear	802.11n (5GHz, 20MHz BW)	17.04	11.58
Held-to-Ear	802.11ac (20MHz BW)	17.01	11.76
Held-to-Ear	802.11n (5GHz, 40MHz BW)	15.8	11.5
Held-to-Ear	802.11ac (40MHz BW)	15.01	11.67
Held-to-Ear	802.11ac (80MHz BW)	15.07	11.6

**Table G-4**

**Distance Measurement Verification for WIFI**

Mechanism(s)	Test Condition	Band	Distance Measurements (mm)		Minimum Distance per Manufacturer (mm)
			Moving Toward	Moving Away	
Held-to-Ear	Head - Right Cheek	2.4GHz	55	71	50
Held-to-Ear	Head - Right Cheek	5GHz	59	74	50
Held-to-Ear	Head - Left Cheek	2.4GHz	52	65	50
Held-to-Ear	Head - Left Cheek	5GHz	52	71	50

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# APPENDIX H: DOWNLINK LTE CA RF CONDUCTED POWERS

## 1.1 LTE Downlink Only Carrier Aggregation Test Reduction Methodology

SAR test exclusion for LTE downlink Carrier Aggregation is determined by power measurements according to the number of component carriers (CCs) supported by the product implementation. Per April 2018 TCBC Workshop Notes, the following test reduction methodology was applied to determine the combinations required for conducted power measurements.

### LTE DLCA Test Reduction Methodology:

- The supported combinations were arranged by the number of component carriers in columns.
- Any limitations on the PCC or SCC for each combination were identified alongside the combination (e.g. CA\_2A-2A-4A-12A, but B12 can only be configured as a SCC).
- Power measurements were performed for "supersets" (LTE CA combinations with multiple components carriers) and any "subsets" (LTE CA combinations with fewer component carriers) that were not completely covered by the supersets.
- Only subsets that have the exact same components as a superset were excluded for measurement.
- When there were certain restrictions on component carriers that existed in the superset that were not applied for the subset, the subset configuration was additionally evaluated.
- Both inter-band and intra-band downlink carrier aggregation scenarios were considered.
- Downlink CA combinations for SISO and 4x4 Downlink MIMO operations were measured independently, per May 2017 TCBC Workshop notes.

Table 1 – Example of Exclusion Table for SISO Configurations

Index	SCC	Supported Channel Bandwidth (MHz)				Restriction	Completely Covered by Measurement Superset
		CC1	CC2	CC3	CC4		
SCC#1	CA_2A	5, 10, 15, 20	5, 10, 15, 20			SCC#1	No
SCC#2	CA_2A-2A	5, 10, 15, 20	5, 10, 15, 20			SCC#2	No
SCC#3	CA_2A-2A-2A	5, 10, 15, 20	5, 10, 15, 20			SCC#3	No
SCC#4	CA_2A-2A-4A	5, 10, 15, 20	5, 10, 15, 20			SCC#4	No
SCC#5	CA_2A-2A-4A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#5	No
SCC#6	CA_2A-2A-4A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#6	No
SCC#7	CA_2A-2A-4A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#7	No
SCC#8	CA_2A-2A-4A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#8	No
SCC#9	CA_2A-2A-4A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#9	No
SCC#10	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#10	No
SCC#11	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#11	No
SCC#12	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#12	No
SCC#13	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#13	No
SCC#14	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#14	No
SCC#15	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#15	No
SCC#16	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#16	No
SCC#17	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#17	No
SCC#18	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#18	No
SCC#19	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#19	No
SCC#20	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20			SCC#20	No

Table 2 – Example of Exclusion Table for 4x4 Downlink MIMO Configurations

Index	SCC	Supported Channel Bandwidth (MHz)			Restriction	Completely Covered by Measurement Superset
		CC1	CC2	CC3		
SCC#M1	CA_2A	5, 10, 15, 20	5, 10, 15, 20		SCC#M1	No
SCC#M2	CA_2A-2A	5, 10, 15, 20	5, 10, 15, 20		SCC#M2	No
SCC#M3	CA_2A-2A-2A	5, 10, 15, 20	5, 10, 15, 20		SCC#M3	No
SCC#M4	CA_2A-2A-4A	5, 10, 15, 20	5, 10, 15, 20		SCC#M4	No
SCC#M5	CA_2A-2A-4A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M5	No
SCC#M6	CA_2A-2A-4A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M6	No
SCC#M7	CA_2A-2A-4A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M7	No
SCC#M8	CA_2A-2A-4A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M8	No
SCC#M9	CA_2A-2A-4A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M9	No
SCC#M10	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M10	No
SCC#M11	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M11	No
SCC#M12	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M12	No
SCC#M13	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M13	No
SCC#M14	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M14	No
SCC#M15	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M15	No
SCC#M16	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M16	No
SCC#M17	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M17	No
SCC#M18	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M18	No
SCC#M19	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M19	No
SCC#M20	CA_2A-2A-4A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A-12A	5, 10, 15, 20	5, 10, 15, 20		SCC#M20	No

Note: [CC] indicates component carrier with 4x4 DL MIMO antenna configuration

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## 1.2 LTE Downlink Only Carrier Aggregation Test Selection and Setup

SAR test exclusion for LTE downlink Carrier Aggregation is determined by power measurements according to the number component carriers (CCs) supported by the product implementation. For those configurations required by April 2018 TCBC Workshop Notes, conducted power measurements with LTE Carrier Aggregation (CA) (downlink only) active are made in accordance to KDB Publication 941225 D05Av01r02. The RRC connection is only handled by one cell, the primary component carrier (PCC) for downlink and uplink communications. After making a data connection to the PCC, the UE device adds secondary component carrier(s) (SCC) on the downlink only. All uplink communications and acknowledgements remain identical to specifications when downlink carrier aggregation is inactive on the PCC. Additional conducted output powers are measured with the downlink carrier aggregation active for the configuration with highest measured maximum conducted power with downlink carrier aggregation inactive measured among the channel bandwidth, modulation, and RB combinations in each frequency band.

Per FCC KDB Publication 941225 D05Av01r02, no SAR measurements are required for carrier aggregation configurations when the average output power with downlink only carrier aggregation active is not more than 0.25 dB higher than the average output power with downlink only carrier aggregation inactive.

General PCC and SCC configuration selection procedure

- PCC uplink channel, channel bandwidth, modulation and RB configurations were selected based on section C)3)b)ii) of KDB 941225 D05 V01r02. The downlink PCC channel was paired with the selected PCC uplink channel according to normal configurations without carrier aggregation.
- To maximize aggregated bandwidth, highest channel bandwidth available for that CA combination was selected for SCC. For inter-band CA, the SCC downlink channels were selected near the middle of their transmission bands. For contiguous intra-band CA, the downlink channel spacing between the component carriers was set to multiple of 300 kHz less than the nominal channel spacing defined in section 5.4.1A of 3GPP TS 36.521. For non-contiguous intra-band CA, the downlink channel spacing between the component carriers was set to be larger than the nominal channel spacing and provided maximum separation between the component carriers.
- All selected PCC and SCC(s) remained fully within the uplink/downlink transmission band of the respective component carrier.
- When a device supports LTE capabilities with overlapping transmission frequency ranges, the standalone powers from the band with a larger transmission frequency range can be used to select measurement configurations for the band with the fully covered transmission frequency range.

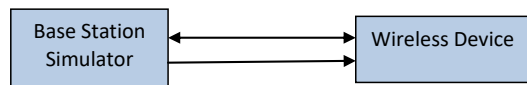


Figure 1  
SISO CA Power Measurement Setup

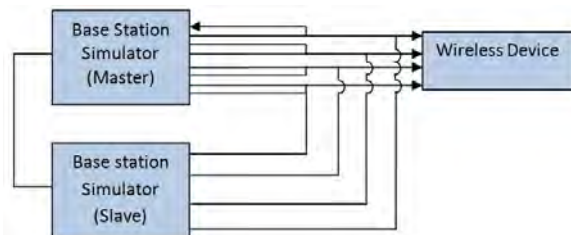




Figure 2  
4x4 DL MIMO CA Power Measurement Setup

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# 1.3 SISO Downlink Carrier Aggregation RF Conducted Powers

## 1.3.1 LTE Band 12 as PCC

Table 1  
Maximum Output Powers

Combination	PCC Band	PCC BW [MHz]	PCC						SCC 1				SCC 2				Power		
			PCC (UL) Ch.	PCC (UL) Freq. [MHz]	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) Channel	PCC (DL) Freq. [MHz]	SCC Band	SCC BW [MHz]	SCC (DL) Channel	SCC (DL) Freq. [MHz]	SCC Band	SCC BW [MHz]	SCC (DL) Channel	SCC (DL) Freq. [MHz]	LTE Tx.Power with DL CA Enabled (dBm)	LTE Single Carrier Tx Power (dBm)
CA_2A-12A (1)	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	LTE B2	20	900	1960	-	-	-	-	24.71	24.64
CA_4A-12A (2)	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	LTE B4	20	2175	2132.5	-	-	-	-	24.57	24.64
CA_12A-25A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	LTE B25	20	8365	1962.5	-	-	-	-	24.66	24.64
CA_12A-66A (1)	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	LTE B66	20	66786	2145	-	-	-	-	24.68	24.64
CA_2A-2A-12A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	LTE B2	20	900	1960	LTE B2	20	700	1940	24.78	24.64
CA_2A-4A-12A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	LTE B2	20	900	1960	LTE B4	20	2175	2132.5	24.79	24.64
CA_2A-7A-12A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	LTE B2	20	900	1960	LTE B7	20	3100	2655	24.62	24.64
CA_2A-12B	LTE B12	5	23035	701.5	QPSK	1	24	5035	731.5	LTE B12	10	5107	738.7	LTE B2	20	900	1960	24.66	24.55
CA_2A-12A-30A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	LTE B2	20	900	1960	LTE B30	10	9820	2355	24.40	24.64
CA_2A-12A-66A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	LTE B2	20	900	1960	LTE B66	20	66786	2145	24.76	24.64
CA_4A-4A-12A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	LTE B4	20	2175	2132.5	LTE B4	10	2350	2150	24.80	24.64
CA_4A-12B	LTE B12	5	23035	701.5	QPSK	1	24	5035	731.5	LTE B12	10	5107	738.7	LTE B4	20	2175	2132.5	24.64	24.55
CA_12A-66C	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	LTE B66	20	66786	2145	LTE B66	20	66984	2164.8	24.79	24.64
CA_12A-66A-66A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	LTE B66	20	66786	2145	LTE B66	20	67236	2190	24.81	24.64

## 1.3.2 LTE Band 17 as PCC

Table 2  
Maximum Output Powers

Combination	PCC Band	PCC BW [MHz]	PCC						SCC 1				Power						
			PCC (UL) Ch.	PCC (UL) Freq. [MHz]	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) Channel	PCC (DL) Freq. [MHz]	SCC Band	SCC BW [MHz]	SCC (DL) Channel	SCC (DL) Freq. [MHz]	LTE Tx.Power with DL CA Enabled (dBm)	LTE Single Carrier Tx Power (dBm)				
CA_2A-17A	LTE B17	10	23790	710	QPSK	1	0	5790	740	LTE B2	10	900	1960	-	-	-	-	24.65	24.64

## 1.3.3 LTE Band 13 as PCC



Table 3  
Maximum Output Powers

Combination	PCC Band	PCC BW [MHz]	PCC						SCC 1				SCC 2				SCC 3				Power				
			PCC (UL) Ch.	PCC (UL) Freq. [MHz]	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) Channel	PCC (DL) Freq. [MHz]	SCC Band	SCC BW [MHz]	SCC (DL) Channel	SCC (DL) Freq. [MHz]	SCC Band	SCC BW [MHz]	SCC (DL) Channel	SCC (DL) Freq. [MHz]	SCC Band	SCC BW [MHz]	SCC (DL) Channel	SCC (DL) Freq. [MHz]	LTE Tx.Power with DL CA Enabled (dBm)	LTE Single Carrier Tx Power (dBm)		
CA_2A-4A-13A	LTE B13	10	22230	782	QPSK	1	25	5230	751	LTE B2	20	900	1960	LTE B4	20	2175	2132.5	-	-	-	-	-	-	25.16	25.11
CA_4A-4A-13A	LTE B13	10	22230	782	QPSK	1	25	5230	751	LTE B4	20	2175	2132.5	LTE B4	10	2350	2150	-	-	-	-	-	-	25.14	25.11
CA_2A-2A-13A-66A	LTE B13	10	22230	782	QPSK	1	25	5230	751	LTE B2	20	900	1960	LTE B2	20	700	1940	LTE B66	20	66786	2145	-	-	25.10	25.11
CA_2A-13A-66B	LTE B13	10	22230	782	QPSK	1	25	5230	751	LTE B2	20	900	1960	LTE B66	15	66786	2145	LTE B66	5	66879	2154.3	-	-	25.11	25.11
CA_2A-13A-66C	LTE B13	10	22230	782	QPSK	1	25	5230	751	LTE B2	20	900	1960	LTE B66	20	66786	2145	LTE B66	20	66984	2164.8	-	-	25.09	25.11
CA_2A-13A-66A-66A	LTE B13	10	22230	782	QPSK	1	25	5230	751	LTE B2	20	900	1960	LTE B66	20	66786	2145	LTE B66	20	67236	2190	-	-	25.12	25.11

## 1.3.4 LTE Band 71 as PCC

Table 4  
Maximum Output Powers

Combination	PCC Band	PCC BW [MHz]	PCC						SCC 1				SCC 2				Power								
			PCC (UL) Ch.	PCC (UL) Freq. [MHz]	Mod.	PCC UL# RB	PCC UL RB Offset	PCC (DL) Channel	PCC (DL) Freq. [MHz]	SCC Band	SCC BW [MHz]	SCC (DL) Channel	SCC (DL) Freq. [MHz]	SCC Band	SCC BW [MHz]	SCC (DL) Channel	SCC (DL) Freq. [MHz]	LTE Tx.Power with DL CA Enabled (dBm)	LTE Single Carrier Tx Power (dBm)						
CA_2A-2A-71A	LTE B71	15	133297	680.5	QPSK	1	36	68761	634.5	LTE B2	20	900	1960	LTE B2	20	700	1940	-	-	-	-	-	-	25.10	25.06
CA_2A-4A-71A	LTE B71	15	133297	680.5	QPSK	1	36	68761	634.5	LTE B2	20	900	1960	LTE B4	20	2175	2132.5	-	-	-	-	-	-	25.09	25.06
CA_2A-66A-71A	LTE B71	15	133297	680.5	QPSK	1	36	68761	634.5	LTE B2	20	900	1960	LTE B66	20	66786	2145	-	-	-	-	-	-	25.09	25.06
CA_4A-4A-71A	LTE B71	15	133297	680.5	QPSK	1	36	68761	634.5	LTE B4	20	2175	2132.5	LTE B4	10	2350	2150	-	-	-	-	-	-	25.11	25.06
CA_66C-71A	LTE B71	15	133297	680.5	QPSK	1	36	68761	634.5	LTE B66	20	66786	2145	LTE B66	20	66984	2164.8	-	-	-	-	-	-	25.08	25.06
CA_66A-66A-71A	LTE B71	15	133297	680.5	QPSK	1	36	68761	634.5	LTE B66	20	66786	2145	LTE B66	20	67236	2190	-	-	-	-	-	-	25.10	25.06

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1.3.15

LTE Band 41 PC2 as PCC

Table 29
Maximum Output Powers

Table with 23 columns: Combination, PCC Band, PCC BW, PCC (UL) Ch, PCC (UL) Freq, Mod, PCC UL RB, PCC UL RB Offset, PCC (DL) Channel, PCC (DL) Freq, SCC Band, SCC BW, SCC (DL) Channel, SCC (DL) Freq, SCC Band, SCC BW, SCC (DL) Channel, SCC (DL) Freq, SCC Band, SCC BW, SCC (DL) Channel, SCC (DL) Freq, LTE Tx Power with DL CA Enabled (dBm), LTE Single Carrier Tx Power (dBm)

Table 30
Reduced Output Powers – Hotspot Mode Active

Table with 23 columns: Combination, PCC Band, PCC BW, PCC (UL) Ch, PCC (UL) Freq, Mod, PCC UL RB, PCC UL RB Offset, PCC (DL) Channel, PCC (DL) Freq, SCC Band, SCC BW, SCC (DL) Channel, SCC (DL) Freq, SCC Band, SCC BW, SCC (DL) Channel, SCC (DL) Freq, SCC Band, SCC BW, SCC (DL) Channel, SCC (DL) Freq, LTE Tx Power with DL CA Enabled (dBm), LTE Single Carrier Tx Power (dBm)

Table 31
Reduced Output Powers – Grip Sensor Active

Table with 23 columns: Combination, PCC Band, PCC BW, PCC (UL) Ch, PCC (UL) Freq, Mod, PCC UL RB, PCC UL RB Offset, PCC (DL) Channel, PCC (DL) Freq, SCC Band, SCC BW, SCC (DL) Channel, SCC (DL) Freq, SCC Band, SCC BW, SCC (DL) Channel, SCC (DL) Freq, SCC Band, SCC BW, SCC (DL) Channel, SCC (DL) Freq, LTE Tx Power with DL CA Enabled (dBm), LTE Single Carrier Tx Power (dBm)

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## 1.4 4x4 Downlink MIMO RF Conduction Powers

This device supports downlink 4x4 MIMO operations for some LTE bands. Uplink transmission is limited to a single output stream. When carrier aggregation was applicable, the general test selection and setup procedures described in Section 1.2 were applied.

Per May 2017 TCB Workshop Notes, SAR for 4x4 DL MIMO was not needed since the maximum average output power in 4x4 DL MIMO mode was not more than 0.25 dB higher than the maximum output power with 4x4 DL MIMO inactive. Additionally, SAR for 4x4 MIMO Downlink Carrier Aggregation was not needed since the maximum average output power in 4x4 MIMO Downlink Carrier Aggregation mode was not more than 0.25 dB higher than the maximum output power with 4x4 MIMO Downlink and downlink carrier aggregation inactive.



### 1.4.1 LTE 4x4 DL MIMO Standalone Powers

Table 32  
Maximum Output Powers

LTE Band	Bandwidth [MHz]	Channel	Frequency [MHz]	Modulation	RB Size	RB Offset	4x4 DL MIMO Tx. Power [dBm]	Single Antenna Tx. Power [dBm]	Target Power [dBm]
4	20	20050	1720	QPSK	1	0	24.36	24.24	24.5
66	20	132072	1720	QPSK	1	0	24.33	24.24	24.5
2	10	19150	1905	QPSK	1	0	24.70	24.56	24.2
25	10	26640	1910	QPSK	1	0	24.69	24.56	24.2
7	20	21350	2560	QPSK	1	0	23.59	23.62	23.0
30	5	27710	2310	QPSK	1	24	23.81	23.91	23.5
41	15	40620	2593	QPSK	1	0	24.20	24.15	24.0
41 PC2	20	39750	2506	QPSK	1	0	27.51	27.54	27.2

Table 33  
Reduced Output Powers – Hotspot Mode Active

LTE Band	Bandwidth [MHz]	Channel	Frequency [MHz]	Modulation	RB Size	RB Offset	4x4 DL MIMO Tx. Power [dBm]	Single Antenna Tx. Power [dBm]	Target Power [dBm]
4	20	20050	1720	16QAM	1	0	20.99	21.00	20.0
66	20	132072	1720	16QAM	1	0	20.97	21.00	20.0
2	20	18700	1860	QPSK	1	0	20.48	20.50	19.5
25	20	26140	1860	QPSK	1	0	20.44	20.50	19.5
7	15	21100	2535	16QAM	1	0	20.41	20.38	19.5
30	10	27710	2310	16QAM	1	0	20.68	20.78	20.0
41	20	40620	2593	16QAM	1	0	22.48	22.49	21.5
41 PC2	20	41055	2636.5	16QAM	1	0	22.48	22.50	21.5

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**Table 34  
Reduced Output Powers – Grip Sensor Active**

LTE Band	Bandwidth [MHz]	Channel	Frequency [MHz]	Modulation	RB Size	RB Offset	4x4 DL MIMO Tx. Power [dBm]	Single Antenna Tx. Power [dBm]	Target Power [dBm]
4	15	20300	1745	16QAM	1	0	21.96	21.93	21.0
66	15	132322	1745	16QAM	1	0	21.95	21.93	21.0
2	20	18700	1860	16QAM	1	0	20.48	20.50	19.5
25	20	26140	1860	16QAM	1	0	20.44	20.50	19.5
7	15	20825	2507.5	16QAM	1	0	20.64	20.61	20.0
30	10	27710	2310	64QAM	1	0	22.12	22.03	21.5
41	20	41490	2680	16QAM	1	0	23.29	23.30	23.0
41 PC2	20	41490	2680	16QAM	1	0	23.62	23.49	23.0

1.4.2

LTE Band 12 as PCC

**Table 35  
Maximum Output Powers**

Combination	PCC Band	PCC BW [MHz]	PCC						SCC 1						SCC 2						Power		
			PCC (UL) Ch.	PCC (UL) Freq. [MHz]	Mod.	PCC UL RB	PCC UL RB Offset	PCC (DL) Ch.	PCC (DL) Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC (DL) Ch.	SCC (DL) Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC (DL) Ch.	SCC (DL) Freq. [MHz]	DL Ant. Config.	LTE Tx. Power with DL CA Enabled (dBm)	LTE Single Carrier Tx Power (dBm)	
CA [2A]-12A(1)	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	-	-	-	-	-	-	24.69	24.64
CA [4A]-12A(2)	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B4	20	2175	2132.5	4x4 MIMO	-	-	-	-	-	-	24.68	24.64
CA [3A]-66A(1)	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B66	20	66786	2145	4x4 MIMO	-	-	-	-	-	-	24.73	24.64
CA [2A]-2A-12A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B4	20	2175	2132.5	2x2 MIMO	24.67	24.64	
CA [2A]-4A-12A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B4	20	2175	2132.5	2x2 MIMO	24.68	24.64	
CA [2A]-7A-12A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B7	20	3100	2655	2x2 MIMO	24.30	24.64	
CA [2A]-7A-12A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B7	20	3100	2655	4x4 MIMO	24.31	24.64	
CA [2A]-12A-30A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B30	10	9820	2355	2x2 MIMO	24.10	24.64	
CA [2A]-12A-180A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B2	20	900	1960	2x2 MIMO	LTE B30	10	9820	2355	4x4 MIMO	24.09	24.64	
CA [2A]-12A-66A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B66	20	66786	2145	2x2 MIMO	24.66	24.64	
CA [2A]-12A-66A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B2	20	900	1960	2x2 MIMO	LTE B66	20	66786	2145	4x4 MIMO	24.65	24.64	
CA [4A]-4A-12A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B4	20	2175	2132.5	4x4 MIMO	LTE B4	10	2350	2150	2x2 MIMO	24.67	24.64	
CA [3A]-66A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B66	20	66786	2145	4x4 MIMO	LTE B66	20	66984	2164.8	4x4 MIMO	24.69	24.64	
CA [3A]-66A	LTE B12	10	23095	707.5	QPSK	1	0	5095	737.5	2x2 MIMO	LTE B66	20	66786	2145	4x4 MIMO	LTE B66	20	67246	2190	2x2 MIMO	24.64	24.64	

1.4.3

LTE Band 17 as PCC

**Table 36  
Maximum Output Powers**

Combination	PCC Band	PCC BW [MHz]	PCC						SCC 1						Power							
			PCC (UL) Ch.	PCC (UL) Freq. [MHz]	Mod.	PCC UL RB	PCC UL RB Offset	PCC (DL) Ch.	PCC (DL) Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC (DL) Ch.	SCC (DL) Freq. [MHz]	DL Ant. Config.	LTE Tx. Power with DL CA Enabled (dBm)	LTE Single Carrier Tx Power (dBm)					
CA [2A]-17A	LTE B17	10	23790	710	QPSK	1	0	5790	740	2x2 MIMO	LTE B2	10	900	1960	4x4 MIMO	-	-	-	-	-	24.63	24.64

1.4.4

LTE Band 13 as PCC

**Table 37  
Maximum Output Powers**

Combination	PCC Band	PCC BW [MHz]	PCC						SCC 1						SCC 2						Power						
			PCC (UL) Ch.	PCC (UL) Freq. [MHz]	Mod.	PCC UL RB	PCC UL RB Offset	PCC (DL) Ch.	PCC (DL) Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC (DL) Ch.	SCC (DL) Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC (DL) Ch.	SCC (DL) Freq. [MHz]	DL Ant. Config.	LTE Tx. Power with DL CA Enabled (dBm)	LTE Single Carrier Tx Power (dBm)					
CA [3A]-2A-13A	LTE B13	10	2230	782	QPSK	1	25	5230	751	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B2	20	900	1960	2x2 MIMO	-	-	21.08	21.11			
CA [3A]-4A-13A	LTE B13	10	2230	782	QPSK	1	25	5230	751	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B4	20	2175	2132.5	2x2 MIMO	-	-	21.08	21.11			
CA [3A]-4A-13A	LTE B13	10	2230	782	QPSK	1	25	5230	751	2x2 MIMO	LTE B2	20	900	1960	2x2 MIMO	LTE B4	20	2175	2132.5	4x4 MIMO	-	-	21.11	21.11			
CA [3A]-13A-66A	LTE B13	10	2230	782	QPSK	1	25	5230	751	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B66	20	66786	2145	2x2 MIMO	-	-	21.11	21.11			
CA [3A]-13A-66A	LTE B13	10	2230	782	QPSK	1	25	5230	751	2x2 MIMO	LTE B2	20	900	1960	2x2 MIMO	LTE B66	20	66786	2145	4x4 MIMO	-	-	21.11	21.11			
CA [3A]-13A-66A	LTE B13	10	2230	782	QPSK	1	25	5230	751	2x2 MIMO	LTE B66	20	66786	2145	4x4 MIMO	LTE B66	20	67236	2190	2x2 MIMO	-	-	21.11	21.11			
CA [2A]-13A-66B	LTE B13	10	2230	782	QPSK	1	25	5230	751	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B66	15	66786	2145	2x2 MIMO	LTE B66	5	66879	2144.3	2x2 MIMO	24.95	21.11
CA [2A]-13A-66B	LTE B13	10	2230	782	QPSK	1	25	5230	751	2x2 MIMO	LTE B2	20	900	1960	2x2 MIMO	LTE B66	15	66786	2145	4x4 MIMO	LTE B66	5	66879	2144.3	4x4 MIMO	24.95	21.11
CA [2A]-13A-66C	LTE B13	10	2230	782	QPSK	1	25	5230	751	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B66	20	66786	2145	2x2 MIMO	LTE B66	20	66984	2164.8	2x2 MIMO	24.95	21.11
CA [2A]-13A-66C	LTE B13	10	2230	782	QPSK	1	25	5230	751	2x2 MIMO	LTE B2	20	900	1960	2x2 MIMO	LTE B66	20	66786	2145	4x4 MIMO	LTE B66	20	66984	2164.8	4x4 MIMO	24.95	21.11

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1.4.5

LTE Band 71 as PCC

Table 38
Maximum Output Powers

Table with 19 columns: Combination, PCC Band, PCC BW, PCC (UL) Ch, PCC (UL) Freq, Mod, PCC UL RB, PCC UL RB Offset, PCC (DL) Ch, PCC (DL) Freq, DL Ant. Config, SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config, SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config, LTE Tx Power with DL CA Enabled (dBm), LTE Single Carrier Tx Power (dBm)

1.4.6

LTE Band 5 as PCC

Table 39
Maximum Output Powers

Table with 19 columns: Combination, PCC Band, PCC BW, PCC (UL) Ch, PCC (UL) Freq, Mod, PCC UL RB, PCC UL RB Offset, PCC (DL) Ch, PCC (DL) Freq, DL Ant. Config, SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config, SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config, LTE Tx Power with DL CA Enabled (dBm), LTE Single Carrier Tx Power (dBm)

1.4.7

LTE Band 26 as PCC

Table 40
Maximum Output Powers

Table with 19 columns: Combination, PCC Band, PCC BW, PCC (UL) Ch, PCC (UL) Freq, Mod, PCC UL RB, PCC UL RB Offset, PCC (DL) Ch, PCC (DL) Freq, DL Ant. Config, SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config, SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config, LTE Tx Power with DL CA Enabled (dBm), LTE Single Carrier Tx Power (dBm)

1.4.8

LTE Band 4 as PCC

Table 41
Maximum Output Powers

Table with 19 columns: Combination, PCC Band, PCC BW, PCC (UL) Ch, PCC (UL) Freq, Mod, PCC UL RB, PCC UL RB Offset, PCC (DL) Ch, PCC (DL) Freq, DL Ant. Config, SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config, SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config, LTE Tx Power with DL CA Enabled (dBm), LTE Single Carrier Tx Power (dBm)

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1.4.9

LTE Band 66 as PCC

Table 44 Maximum Output Powers

Table 44: Maximum Output Powers. A detailed table with columns for Combination, PCC Band, PCC BW, PCC (DL) Ch, PCC (UL) Freq, Mod., PCC Upl RB, PCC UL RB, PCC (DL) Ch, PCC (UL) Freq, DL Ant. Config., SCC Band, SCC (DL) Ch, SCC (UL) Freq, DL Ant. Config., SCC Band, SCC (DL) Ch, SCC (UL) Freq, DL Ant. Config., SCC Band, SCC (DL) Ch, SCC (UL) Freq, DL Ant. Config., LTE Tx Power, LTE Single Carrier Tx Power (dBm).

Table 45 Reduced Output Powers – Hotspot Mode Active

Table 45: Reduced Output Powers – Hotspot Mode Active. A detailed table with columns for Combination, PCC Band, PCC BW, PCC (DL) Ch, PCC (UL) Freq, Mod., PCC Upl RB, PCC UL RB, PCC (DL) Ch, PCC (UL) Freq, DL Ant. Config., SCC Band, SCC (DL) Ch, SCC (UL) Freq, DL Ant. Config., SCC Band, SCC (DL) Ch, SCC (UL) Freq, DL Ant. Config., SCC Band, SCC (DL) Ch, SCC (UL) Freq, DL Ant. Config., LTE Tx Power, LTE Single Carrier Tx Power (dBm).

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Table 53  
Reduced Output Powers – Grip Sensor Active

Combination	PCC Band	PCC BW [MHz]	PCC [UL] Ch.	PCC [UL] Freq. [MHz]	Mod.	PCC UL RB	PCC UL RB Offset	PCC [DL] Ch.	PCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	Power		
																										LTE Tx Power with DL CA Enabled [dBm]	LTE Ant. A Tx Power [dBm]	
CA [2A]-[30A]	LTE B30 ANA	10	27710	2310	64QAM	1	0	9820	2355	4x4 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B2	20	700	1940	2x2 MIMO	22.30	22.44					22.47	22.44
CA [2A]-2A-30A	LTE B30 ANA	10	27710	2310	64QAM	1	0	9820	2355	4x4 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B2	20	700	1940	2x2 MIMO	22.44	22.44					22.44	22.44
CA [2A]-4A-[30A]	LTE B30 ANA	10	27710	2310	64QAM	1	0	9820	2355	4x4 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B2	20	700	1940	2x2 MIMO	22.44	22.44					22.44	22.44

1.4.1

LTE Band 7 Antenna A as PCC

Table 54  
Maximum Output Powers

Combination	PCC Band	PCC BW [MHz]	PCC [UL] Ch.	PCC [UL] Freq. [MHz]	Mod.	PCC UL RB	PCC UL RB Offset	PCC [DL] Ch.	PCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	Power		
																										LTE Tx Power with DL CA Enabled [dBm]	LTE Ant. A Tx Power [dBm]	
CA [2A]-4A-7A	LTE B7 ANA	10	20800	2505	QPSK	1	0	2800	2525	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B4	20	2175	2132.5	2x2 MIMO	-	-	-	-	-	-	23.54	23.48
CA [2A]-4A-7A (1)	LTE B7 ANA	10	20800	2505	QPSK	1	0	2800	2525	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B4	20	2175	2132.5	2x2 MIMO	-	-	-	-	-	-	23.48	23.48

Table 55  
Reduced Output Powers – Hotspot Mode Active

Combination	PCC Band	PCC BW [MHz]	PCC [UL] Ch.	PCC [UL] Freq. [MHz]	Mod.	PCC UL RB	PCC UL RB Offset	PCC [DL] Ch.	PCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	Power		
																										LTE Tx Power with DL CA Enabled [dBm]	LTE Ant. A Tx Power [dBm]	
CA [2A]-4A-7A	LTE B7 ANA	15	21100	2535	16QAM	1	0	3100	2555	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B4	20	2175	2132.5	2x2 MIMO	-	-	-	-	-	-	20.05	20.18
CA [2A]-4A-7A (1)	LTE B7 ANA	15	21100	2535	16QAM	1	0	3100	2555	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B4	20	2175	2132.5	2x2 MIMO	-	-	-	-	-	-	20.05	20.18

Table 56  
Reduced Output Powers – Grip Sensor Active

Combination	PCC Band	PCC BW [MHz]	PCC [UL] Ch.	PCC [UL] Freq. [MHz]	Mod.	PCC UL RB	PCC UL RB Offset	PCC [DL] Ch.	PCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	Power		
																										LTE Tx Power with DL CA Enabled [dBm]	LTE Ant. A Tx Power [dBm]	
CA [2A]-4A-7A	LTE B7 ANA	10	21100	2535	16QAM	1	0	3100	2555	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B4	20	2175	2132.5	2x2 MIMO	-	-	-	-	-	-	20.05	20.18
CA [2A]-4A-7A (1)	LTE B7 ANA	10	21100	2535	16QAM	1	0	3100	2555	2x2 MIMO	LTE B2	20	900	1960	4x4 MIMO	LTE B4	20	2175	2132.5	2x2 MIMO	-	-	-	-	-	-	20.05	20.18

1.4.2

LTE Band 7 Antenna B as PCC

Table 57  
Maximum Output Powers

Combination	PCC Band	PCC BW [MHz]	PCC [UL] Ch.	PCC [UL] Freq. [MHz]	Mod.	PCC UL RB	PCC UL RB Offset	PCC [DL] Ch.	PCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	Power	
																										LTE Tx Power with DL CA Enabled [dBm]	LTE Single Carrier Tx Power [dBm]
CA [7A]-[7A]	LTE B7	20	21350	2560	QPSK	1	0	3350	2680	4x4 MIMO	LTE B7	20	3152	2660.2	4x4 MIMO	-	-	-	-	-	-	-	-	-	-	23.59	23.62
CA [7A]-[7A] (1)	LTE B7	20	21350	2560	QPSK	1	0	3350	2680	4x4 MIMO	LTE B7	20	2850	2630	2x2 MIMO	-	-	-	-	-	-	-	-	-	-	23.61	23.62
CA [7A]-[7A] (1)	LTE B7	20	21350	2560	QPSK	1	0	3350	2680	2x2 MIMO	LTE B7	20	2850	2630	4x4 MIMO	-	-	-	-	-	-	-	-	-	-	23.60	23.62

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**Table 64**  
**Reduced Output Powers – Hotspot Mode Active**

Combination	PCC Band	PCC BW [MHz]	PCC								SCC 1				SCC 2				SCC 3				Power					
			PCC [UL] Ch.	PCC [UL] Freq. [MHz]	Mod.	PCC UL RB	PCC UL RB Offset	PCC [DL] Ch.	PCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	LTE Tx Power with DL CA Enabled (dBm)	LTE Single Carrier Tx Power (dBm)	
CA_141A141A1	LTE B41 PC2	20	41055	2636.5	100QAM	1	0	41055	2636.5	4x4 MIMO	LTE B41 PC2	20	39750	2506	2x2 MIMO	-	-	-	-	-	-	-	-	-	-	-	21.00	21.50

**Table 65**  
**Reduced Output Powers – Grip Sensor Active**

Combination	PCC Band	PCC BW [MHz]	PCC								SCC 1				SCC 2				SCC 3				Power					
			PCC [UL] Ch.	PCC [UL] Freq. [MHz]	Mod.	PCC UL RB	PCC UL RB Offset	PCC [DL] Ch.	PCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	LTE Tx Power with DL CA Enabled (dBm)	LTE Single Carrier Tx Power (dBm)	
CA_141A141A1	LTE B41 PC2	20	41490	2680	100QAM	1	0	41490	2680	4x4 MIMO	LTE B41 PC2	20	39750	2506	2x2 MIMO	-	-	-	-	-	-	-	-	-	-	-	21.40	21.40

## 1.5 LAA Downlink Carrier Aggregation

This device supports LAA with downlink carrier aggregation only. It uses carrier aggregation in the downlink to combine LTE in the unlicensed spectrum (i.e. LTE Band 46) with LTE in the licensed band (served as PCC). All uplink communications and acknowledgements on the PCC remain identical to specifications when downlink carrier aggregation is inactive. Due to the wide downlink bandwidth, each Band 46 sub-band, represented by subscripts A, B, C, and D, was evaluated independently. The general test selection and setup procedures described in Section 1.2 were applied.

Per FCC KDB Publication 941225 D05Av01r02, no SAR measurements are required for carrier aggregation configurations when the average output power with downlink only carrier aggregation active is not more than 0.25 dB higher than the average output power with downlink only carrier aggregation inactive.

### 1.5.1 SISO LAA Downlink Carrier Aggregation RF Conducted Powers

#### 1.5.1.1 LTE Band 13 as PCC

**Table 66**  
**Maximum Output Powers**

Combination	PCC Band	PCC BW [MHz]	PCC								SCC 1				SCC 2				SCC 3				Power				
			PCC [UL] Ch.	PCC [UL] Freq. [MHz]	Mod.	PCC UL RB	PCC UL RB Offset	PCC [DL] Ch.	PCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	SCC Band	SCC BW [MHz]	SCC [DL] Ch.	SCC [DL] Freq. [MHz]	DL Ant. Config.	LTE Tx Power with DL CA Enabled (dBm)	LTE Single Carrier Tx Power (dBm)
CA_13A-46_A	LTE B13	10	23230	782	QPSK	1	25	5230	751	LTE B46c	20	47290	5200	-	-	-	-	-	-	-	-	-	-	-	-	25.05	25.11

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1.5.2

4x4 DL MIMO LAA Downlink Carrier Aggregation RF Conducted Powers

1.5.2.1

LTE Band 4 as PCC

Table 78 Maximum Output Powers

Table with 15 columns: Combination, PCC Band, PCC BW, PCC UL Ch, PCC UL Freq, Mod., PCC UL RB, PCC UL RB Offset, PCC DL Ch, PCC DL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, LTE Tx Power with DL CA Enabled (dBm), LTE Single Carrier Tx Power (dBm).

Table 79 Reduced Output Powers – Hotspot Mode Active

Table with 15 columns: Combination, PCC Band, PCC BW, PCC UL Ch, PCC UL Freq, Mod., PCC UL RB, PCC UL RB Offset, PCC DL Ch, PCC DL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, LTE Tx Power with DL CA Enabled (dBm), LTE Single Carrier Tx Power (dBm).

Table 80 Reduced Output Powers – Grip Sensor Active

Table with 15 columns: Combination, PCC Band, PCC BW, PCC UL Ch, PCC UL Freq, Mod., PCC UL RB, PCC UL RB Offset, PCC DL Ch, PCC DL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, LTE Tx Power with DL CA Enabled (dBm), LTE Single Carrier Tx Power (dBm).

1.5.2.2

LTE Band 66 as PCC

Table 81 Maximum Output Powers

Table with 15 columns: Combination, PCC Band, PCC BW, PCC UL Ch, PCC UL Freq, Mod., PCC UL RB, PCC UL RB Offset, PCC DL Ch, PCC DL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, LTE Tx Power with DL CA Enabled (dBm), LTE Single Carrier Tx Power (dBm).

Table 82 Reduced Output Powers – Hotspot Mode Active

Table with 15 columns: Combination, PCC Band, PCC BW, PCC UL Ch, PCC UL Freq, Mod., PCC UL RB, PCC UL RB Offset, PCC DL Ch, PCC DL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, SCC Band, SCC BW, SCC UL Ch, SCC UL Freq, DL Ant. Config, LTE Tx Power with DL CA Enabled (dBm), LTE Single Carrier Tx Power (dBm).

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1.5.2.4

LTE Band 7 Antenna B as PCC

Table 86

Maximum Output Powers

Table with columns for Combination, PCC Band, PCC BW, PCC (UL) Ch, PCC (UL) Freq, Mod., PCC UL RB, PCC UL RB Offset, SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config., SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config., SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config., LTE Tx Power with DL CA Enabled (dBm), and LTE Single Carrier Tx Power (dBm).

Table 87

Reduced Output Powers – Hotspot Mode Active

Table with columns for Combination, PCC Band, PCC BW, PCC (UL) Ch, PCC (UL) Freq, Mod., PCC UL RB, PCC UL RB Offset, SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config., SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config., SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config., LTE Tx Power with DL CA Enabled (dBm), and LTE Single Carrier Tx Power (dBm).

Table 88

Reduced Output Powers – Grip Sensor Active

Table with columns for Combination, PCC Band, PCC BW, PCC (UL) Ch, PCC (UL) Freq, Mod., PCC UL RB, PCC UL RB Offset, SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config., SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config., SCC Band, SCC BW, SCC (DL) Ch, SCC (DL) Freq, DL Ant. Config., LTE Tx Power with DL CA Enabled (dBm), and LTE Single Carrier Tx Power (dBm).

1.6 Downlink Carrier Aggregation with CA\_41C Uplink Carrier Aggregation enabled

This device supports uplink carrier aggregation (ULCA) for CA\_41C with additional Carrier Aggregation configurations active in the downlink. Power measurements were performed with ULCA CA\_41C active and additional CA configurations active in the downlink for the configuration required for ULCA CA\_41C per Fall 2017 TCB Workshop Notes.

Per FCC Guidance, additional SAR measurements for these configurations were not required since their maximum output power was not more than 0.25 dB higher than the maximum output power for ULCA with only CA\_41C active.

1.6.1

SISO Carrier Aggregation RF Conducted Powers

Table 89
Maximum Output Powers

Table with columns for Combination, PCC Band, PCC BW, PCC (UL/DL) Channel, PCC (UL/DL) Freq, Modulation, PCC UL RB, PCC UL RB Offset, SCC Band, SCC Bandwidth, SCC (UL/DL) Channel, SCC (UL/DL) Freq, Modulation, SCC UL RB, SCC UL RB Offset, SCC2 Band, SCC2 Bandwidth, SCC2 (UL) Channel, SCC2 (UL) Freq, SCC2 UL RB, SCC2 UL RB Offset, SCC3 Band, SCC3 Bandwidth, SCC3 (UL) Channel, SCC3 (UL) Freq, SCC3 UL RB, SCC3 UL RB Offset, SCC4 Band, SCC4 Bandwidth, SCC4 (UL) Channel, SCC4 (UL) Freq, SCC4 UL RB, SCC4 UL RB Offset, CA\_41C ULCA Tx Power with add'l CA configuration active in DL (dBm), CA\_41C ULCA Tx Power (dBm).

Table with four columns: FCC ID: A3LSMN960U, PCTEST SAR EVALUATION REPORT, Samsung logo, and Reviewed by: Quality Manager. Below it, Test Dates: 05/07/18 - 06/11/18, DUT Type: Portable Handset, and APPENDIX H: Page 27 of 28.

