

## Head TSL parameters at 5400 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.8	4.86 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.9 ± 6 %	4.73 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL at 5400 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	83.3 W / kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.9 W/kg ± 19.5 % (k=2)

## Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.7 ± 6 %	4.94 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	8.52 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	85.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.43 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.3 W/kg ± 19.5 % (k=2)

## Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	35.4	5.22 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	35.4 ± 6 %	5.09 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 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	7.85 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	78.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.23 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.3 W/kg ± 19.5 % (k=2)

## Head TSL parameters at 5850 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	35.2	5.32 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	35.3 ± 6 %	5.20 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL at 5850 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.50 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	85.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.3 W/kg ± 19.5 % (k=2)

## Body TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	48.9	5.36 mho/m
<b>Measured Body TSL parameters</b>	(22.0 ± 0.2) °C	46.9 ± 6 %	5.51 mho/m ± 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL at 5250 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	100 mW input power	7.53 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>74.7 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	100 mW input power	2.11 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>20.9 W/kg ± 19.5 % (k=2)</b>

## Body TSL parameters at 5400 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	48.7	5.53 mho/m
<b>Measured Body TSL parameters</b>	(22.0 ± 0.2) °C	46.7 ± 6 %	5.71 mho/m ± 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL at 5400 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	100 mW input power	7.93 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>78.7 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	100 mW input power	2.22 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>22.0 W/kg ± 19.5 % (k=2)</b>

## Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	48.5	5.77 mho/m
<b>Measured Body TSL parameters</b>	(22.0 ± 0.2) °C	46.3 ± 6 %	5.99 mho/m ± 6 %
<b>Body TSL temperature change during test</b>	< 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	8.02 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	79.6 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.23 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
<b>Nominal Body TSL parameters</b>	22.0 °C	48.3	5.94 mho/m
<b>Measured Body TSL parameters</b>	(22.0 ± 0.2) °C	46.0 ± 6 %	6.19 mho/m ± 6 %
<b>Body TSL temperature change during test</b>	< 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	7.39 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.06 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.4 W/kg ± 19.5 % (k=2)

## Body TSL parameters at 5850 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	48.1	6.06 mho/m
<b>Measured Body TSL parameters</b>	(22.0 ± 0.2) °C	45.9 ± 6 %	6.33 mho/m ± 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL at 5850 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.85 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	78.1 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	2.18 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.7 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	55.3 $\Omega$ - 8.1 $j\Omega$
Return Loss	- 20.8 dB

**Antenna Parameters with Head TSL at 5400 MHz**

Impedance, transformed to feed point	49.5 $\Omega$ - 5.4 $j\Omega$
Return Loss	- 25.3 dB

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

Impedance, transformed to feed point	59.2 $\Omega$ - 6.3 $j\Omega$
Return Loss	- 19.8 dB

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

Impedance, transformed to feed point	57.3 $\Omega$ - 2.8 $j\Omega$
Return Loss	- 22.8 dB

**Antenna Parameters with Head TSL at 5850 MHz**

Impedance, transformed to feed point	55.4 $\Omega$ - 6.7 $j\Omega$
Return Loss	- 21.8 dB

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

Impedance, transformed to feed point	53.4 $\Omega$ - 5.5 $j\Omega$
Return Loss	- 24.1 dB

**Antenna Parameters with Body TSL at 5400 MHz**

Impedance, transformed to feed point	49.9 $\Omega$ - 3.3 $j\Omega$
Return Loss	- 29.6 dB

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

Impedance, transformed to feed point	60.6 $\Omega$ - 5.0 $j\Omega$
Return Loss	- 19.5 dB

### Antenna Parameters with Body TSL at 5750 MHz

Impedance, transformed to feed point	58.2 $\Omega$ - 1.6 $j\Omega$
Return Loss	- 22.3 dB

### Antenna Parameters with Body TSL at 5850 MHz

Impedance, transformed to feed point	56.3 $\Omega$ - 6.3 $j\Omega$
Return Loss	- 21.6 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.127 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	September 20, 2012

## DASY5 Validation Report for Head TSL

Date: 06.06.2018

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1155

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5400 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5850 MHz

Medium parameters used:  $f = 5250 \text{ MHz}$ ;  $\sigma = 4.57 \text{ S/m}$ ;  $\epsilon_r = 36.2$ ;  $\rho = 1000 \text{ kg/m}^3$

Medium parameters used:  $f = 5400 \text{ MHz}$ ;  $\sigma = 4.73 \text{ S/m}$ ;  $\epsilon_r = 35.9$ ;  $\rho = 1000 \text{ kg/m}^3$

Medium parameters used:  $f = 5600 \text{ MHz}$ ;  $\sigma = 4.94 \text{ S/m}$ ;  $\epsilon_r = 35.7$ ;  $\rho = 1000 \text{ kg/m}^3$

Medium parameters used:  $f = 5750 \text{ MHz}$ ;  $\sigma = 5.09 \text{ S/m}$ ;  $\epsilon_r = 35.4$ ;  $\rho = 1000 \text{ kg/m}^3$

Medium parameters used:  $f = 5850 \text{ MHz}$ ;  $\sigma = 5.2 \text{ S/m}$ ;  $\epsilon_r = 35.3$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.51, 5.51, 5.51) @ 5250 MHz, ConvF(5.5, 5.5, 5.5) @ 5400 MHz, ConvF(5.05, 5.05, 5.05) @ 5600 MHz, ConvF(4.98, 4.98, 4.98) @ 5750 MHz, ConvF(4.94, 4.94, 4.94) @ 5850 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601 (5GHz); Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

Measurement grid:  $dx=4\text{mm}$ ,  $dy=4\text{mm}$ ,  $dz=1.4\text{mm}$

Reference Value = 76.63 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 28.2 W/kg

**SAR(1 g) = 8.14 W/kg; SAR(10 g) = 2.35 W/kg**

Maximum value of SAR (measured) = 18.4 W/kg

### Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5400 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid:  $dx=4\text{mm}$ ,  $dy=4\text{mm}$ ,  $dz=1.4\text{mm}$

Reference Value = 75.16 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 31.4 W/kg

**SAR(1 g) = 8.33 W/kg; SAR(10 g) = 2.39 W/kg**

Maximum value of SAR (measured) = 19.4 W/kg

### Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid:  $dx=4\text{mm}$ ,  $dy=4\text{mm}$ ,  $dz=1.4\text{mm}$

Reference Value = 75.94 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 32.5 W/kg

**SAR(1 g) = 8.52 W/kg; SAR(10 g) = 2.43 W/kg**

Maximum value of SAR (measured) = 20.1 W/kg

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

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

Reference Value = 72.32 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 30.9 W/kg

**SAR(1 g) = 7.85 W/kg; SAR(10 g) = 2.23 W/kg**

Maximum value of SAR (measured) = 18.7 W/kg

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5850 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:**

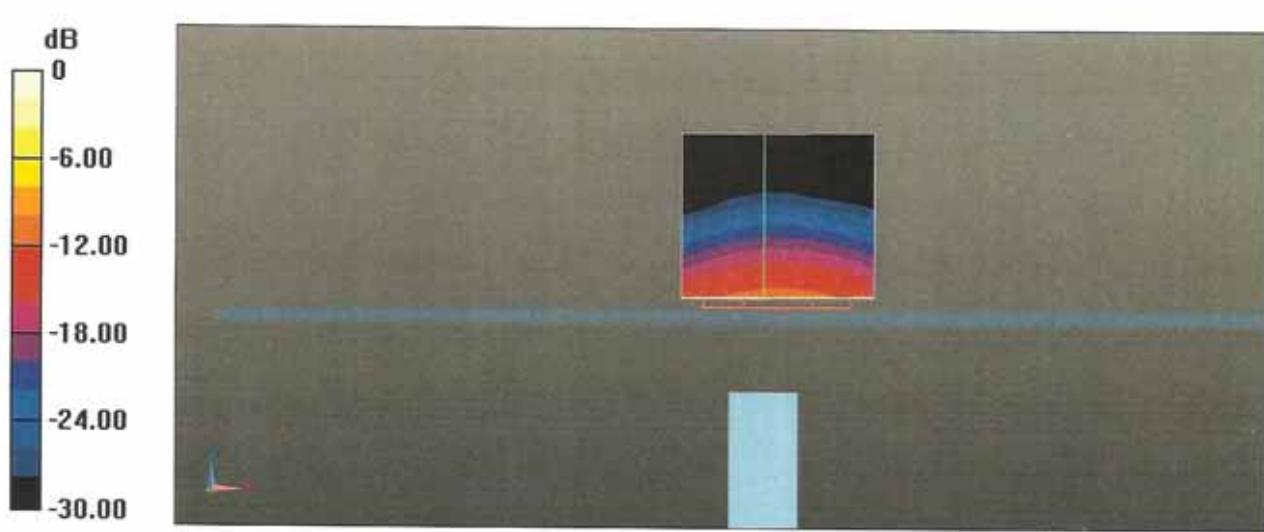
Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 73.54 V/m; Power Drift = -0.03 dB

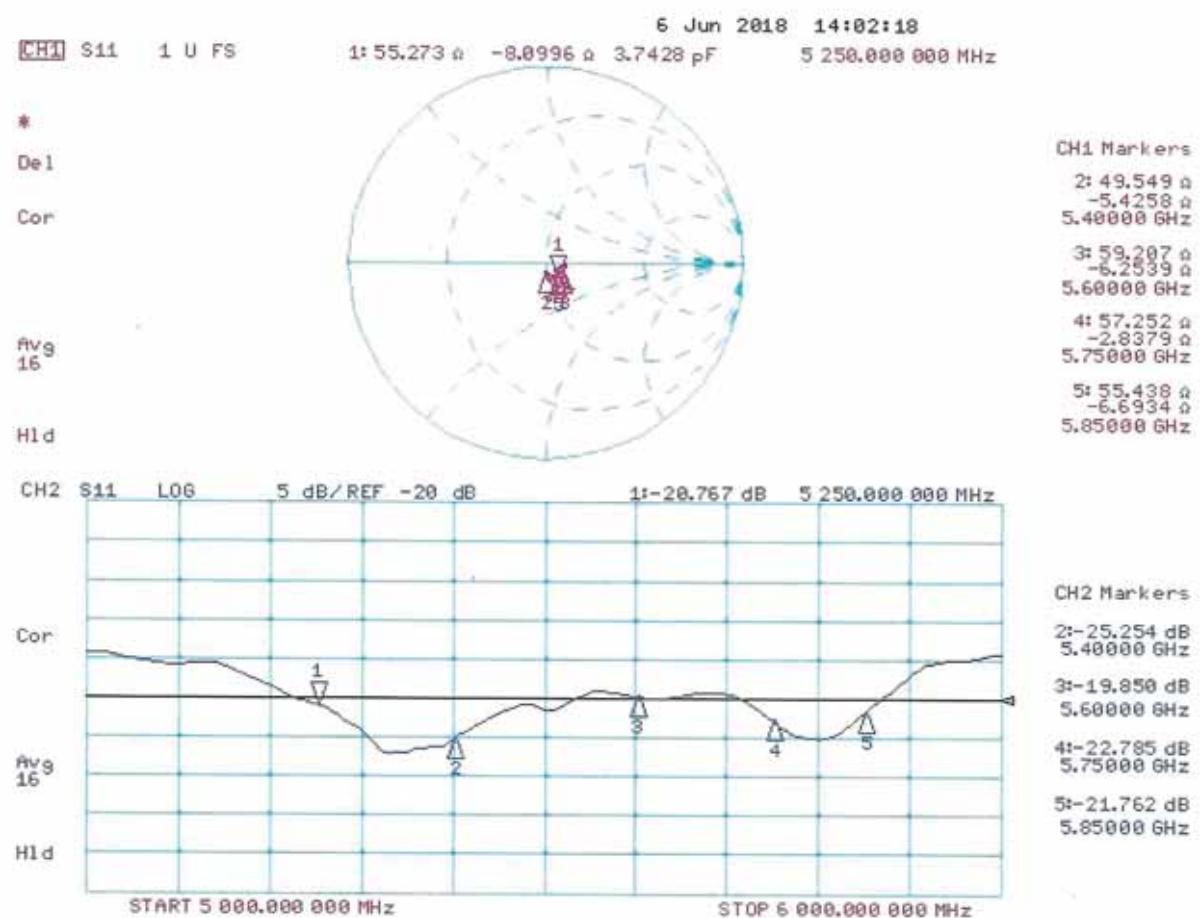
Peak SAR (extrapolated) = 36.0 W/kg

**SAR(1 g) = 8.5 W/kg; SAR(10 g) = 2.41 W/kg**

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



## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 08.06.2018

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1155

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5400 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5850 MHz

Medium parameters used:  $f = 5250 \text{ MHz}$ ;  $\sigma = 5.51 \text{ S/m}$ ;  $\epsilon_r = 46.9$ ;  $\rho = 1000 \text{ kg/m}^3$

Medium parameters used:  $f = 5400 \text{ MHz}$ ;  $\sigma = 5.71 \text{ S/m}$ ;  $\epsilon_r = 46.7$ ;  $\rho = 1000 \text{ kg/m}^3$

Medium parameters used:  $f = 5600 \text{ MHz}$ ;  $\sigma = 5.99 \text{ S/m}$ ;  $\epsilon_r = 46.3$ ;  $\rho = 1000 \text{ kg/m}^3$

Medium parameters used:  $f = 5750 \text{ MHz}$ ;  $\sigma = 6.19 \text{ S/m}$ ;  $\epsilon_r = 46$ ;  $\rho = 1000 \text{ kg/m}^3$

Medium parameters used:  $f = 5850 \text{ MHz}$ ;  $\sigma = 6.33 \text{ S/m}$ ;  $\epsilon_r = 45.9$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.26, 5.26, 5.26) @ 5250 MHz, ConvF(4.7, 4.7, 4.7) @ 5400 MHz, ConvF(4.65, 4.65, 4.65) @ 5600 MHz, ConvF(4.57, 4.57, 4.57) @ 5750 MHz, ConvF(4.47, 4.47, 4.47) @ 5850 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601 (5GHz); Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

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

Measurement grid:  $dx=4\text{mm}$ ,  $dy=4\text{mm}$ ,  $dz=1.4\text{mm}$

Reference Value = 67.19 V/m; Power Drift = -0.06dB

Peak SAR (extrapolated) = 28.5 W/kg

**SAR(1 g) = 7.53 W/kg; SAR(10 g) = 2.11 W/kg**

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

### Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5400 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid:  $dx=4\text{mm}$ ,  $dy=4\text{mm}$ ,  $dz=1.4\text{mm}$

Reference Value = 68.41 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 31.3 W/kg

**SAR(1 g) = 7.93 W/kg; SAR(10 g) = 2.22 W/kg**

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

### Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid:  $dx=4\text{mm}$ ,  $dy=4\text{mm}$ ,  $dz=1.4\text{mm}$

Reference Value = 67.66 V/m; Power Drift = -0.08 dB

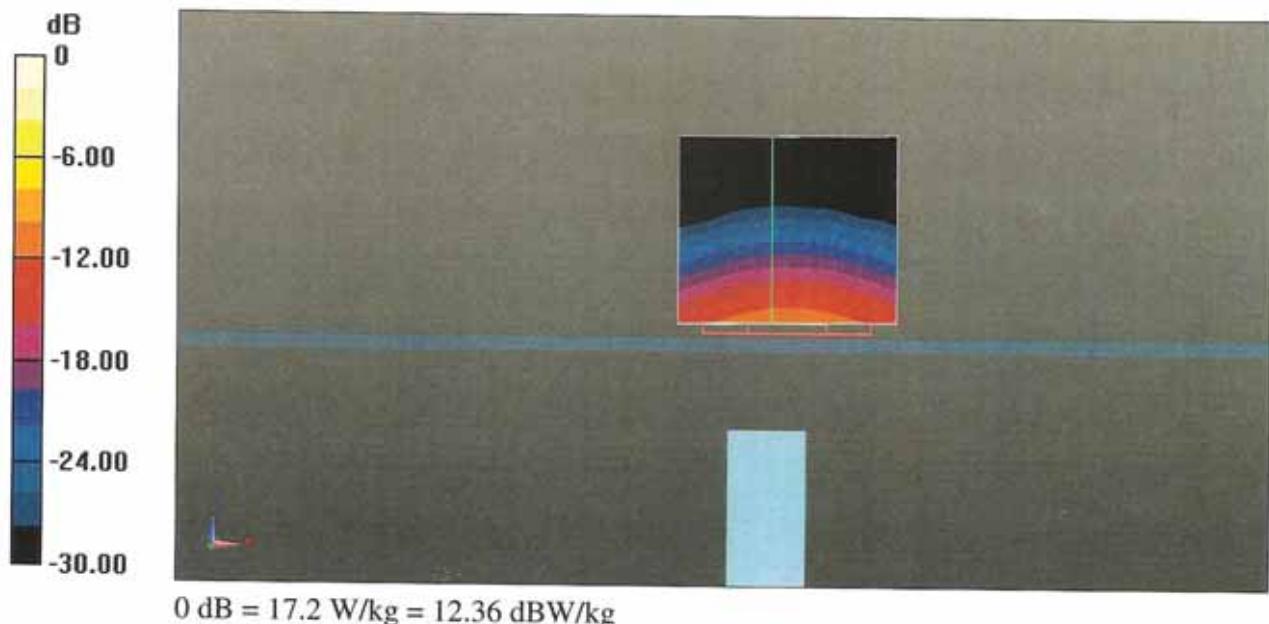
Peak SAR (extrapolated) = 33.5 W/kg

**SAR(1 g) = 8.02 W/kg; SAR(10 g) = 2.23 W/kg**

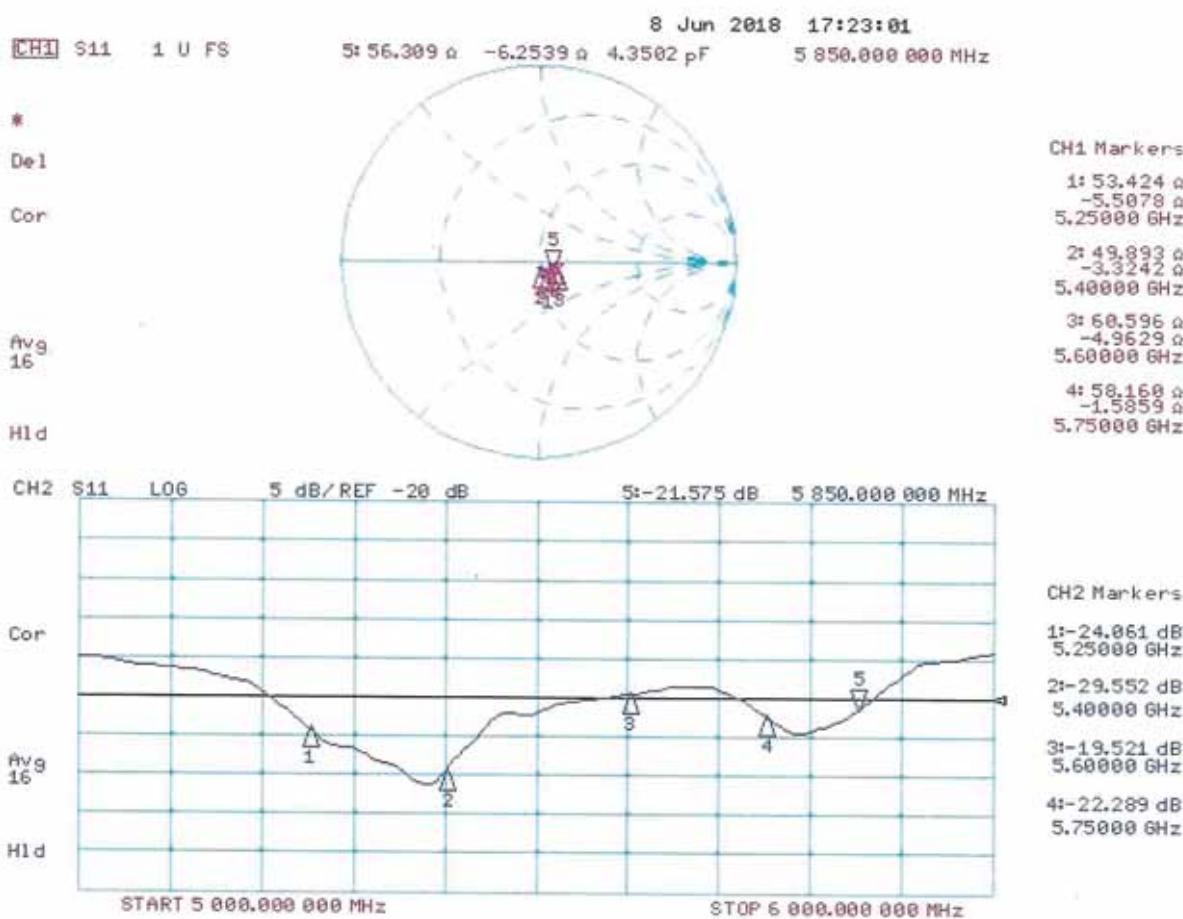
Maximum value of SAR (measured) = 19.2 W/kg

**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 = 64.78 V/m; Power Drift = -0.06 dB  
Peak SAR (extrapolated) = 31.5 W/kg  
**SAR(1 g) = 7.39 W/kg; SAR(10 g) = 2.06 W/kg**  
Maximum value of SAR (measured) = 17.8 W/kg

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5850 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
Reference Value = 65.90 V/m; Power Drift = -0.05 dB  
Peak SAR (extrapolated) = 34.8 W/kg  
**SAR(1 g) = 7.85 W/kg; SAR(10 g) = 2.18 W/kg**  
Maximum value of SAR (measured) = 19.1 W/kg



## Impedance Measurement Plot for Body TSL

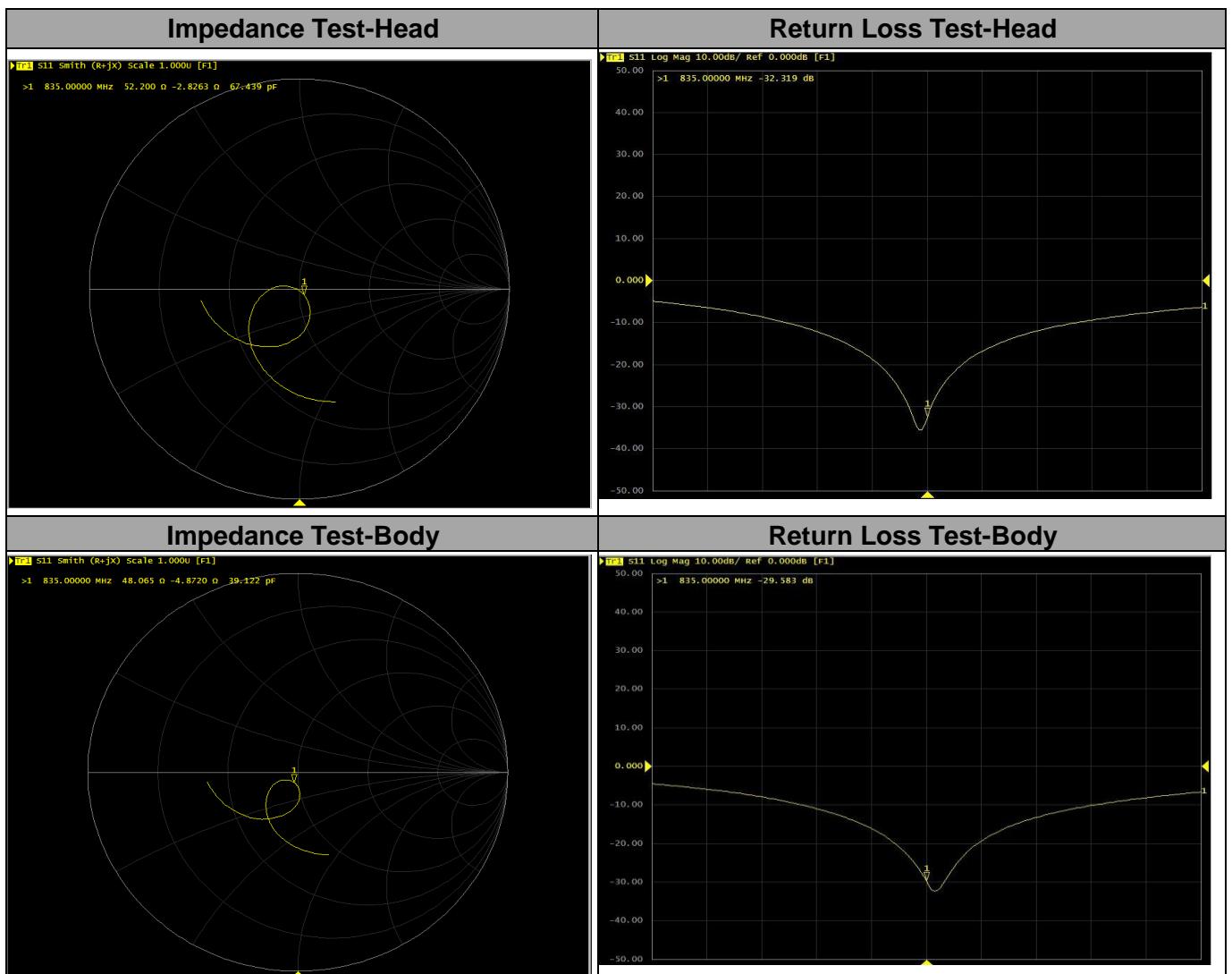


## Justification of the extended calibration of Dipole D835V2 SN:4d059

Per KDB 865664, we have measured the Impedance and Return Loss as below.

- 1) The most recent return-loss result, measured at least annually, deviates by no more than 20% from the previous measurement.
- 2) The most recent measurement of the real or imaginary parts of the impedance, measured at least annually is within 5 ohm from the previous measurement.

Dipole 835 Head TST	Target Value	Measured Value	Difference
Impedance transformed to feed point	52.0Ω-1.8j Ω	52.2Ω-2.83j Ω	R=0.2Ω,X=-1.03Ω
Return Loss	-31.4dB	-32.32 dB	-2.92%
Dipole 835 Body TST	Target Value	Measured Value	Difference
Impedance transformed to feed point	48.7Ω-4.2j Ω	48.07Ω-4.87j Ω	R=-0.63Ω,X=-0.67Ω
Return Loss	-27.1 dB	-29.58 dB	-9.15%
Measured Date	2016-04-20	2018-04-15	-----

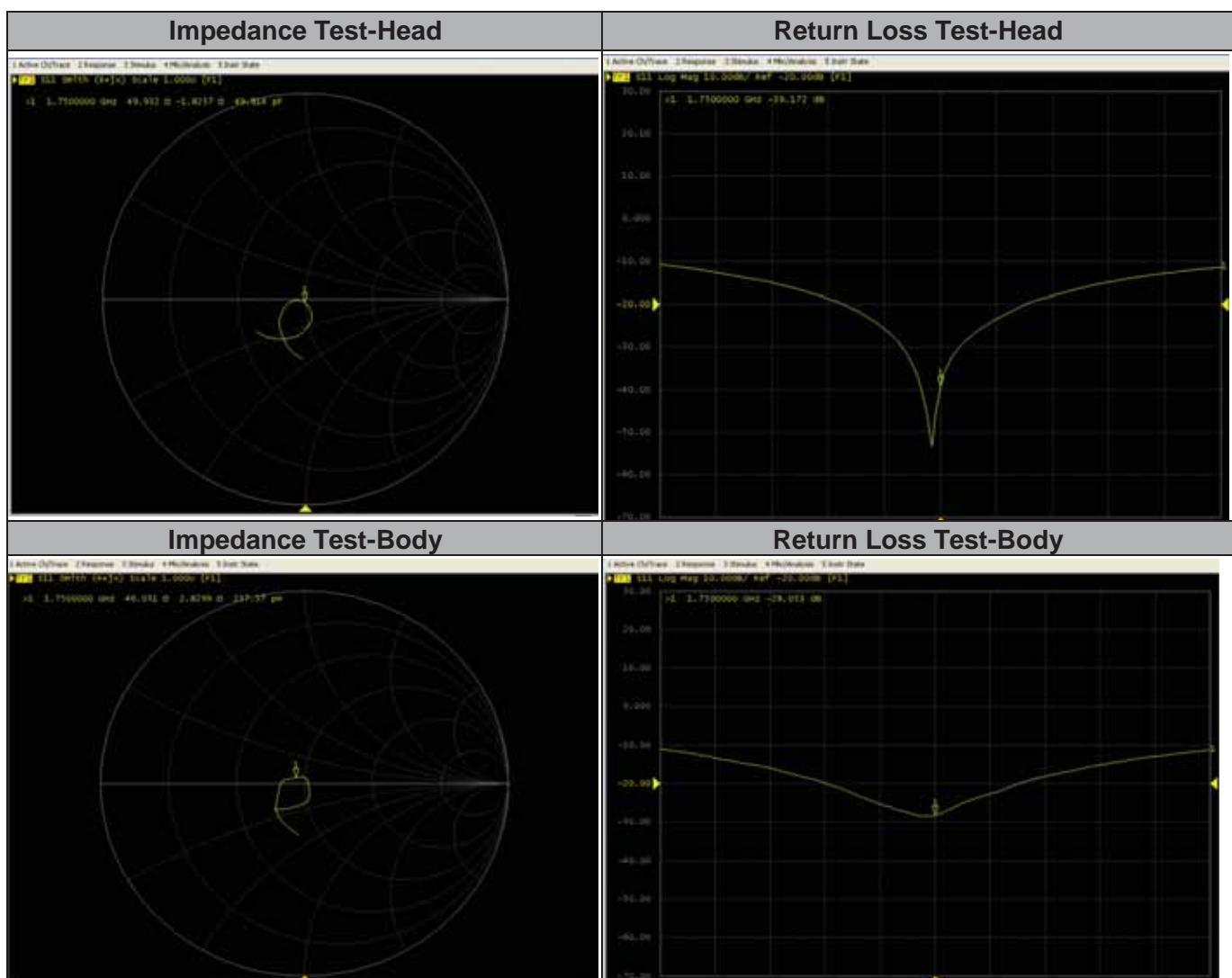


## Justification of the extended calibration of Dipole D1750V2 SN:1123

Per KDB 865664, we have measured the Impedance and Return Loss as below.

- 1) The most recent return-loss result, measured at least annually, deviates by no more than 20% from the previous measurement.
- 2) The most recent measurement of the real or imaginary parts of the impedance, measured at least annually is within 5 ohm from the previous measurement.

Dipole 835 Head TST	Target Value	Measured Value	Difference
Impedance transformed to feed point	$50.6\Omega-0.8j\Omega$	$49.93\Omega-1.83j\Omega$	$R=-0.67\Omega, X=-1.03j\Omega$
Return Loss	-40.2dB	-39.17 dB	-2.56%
Dipole 835 Body TST	Target Value	Measured Value	Difference
Impedance transformed to feed point	$46.9\Omega-1.0j\Omega$	$46.05\Omega+2.83j\Omega$	$R=-0.85\Omega, X=3.83j\Omega$
Return Loss	-29.5 dB	-28.05 dB	-4.92%
Measured Date	2017-07-27	2018-07-17	-----



## Justification of the extended calibration of Dipole D2450V2 SN:978

Per KDB 865664, we have Measured the Impedance and Return Loss as below, and the return loss is <-20dB, with 20% of prior calibration; the real or imaginary parts of the impedance is with 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

Dipole2450 Head TST	Target Value	Measured Value	Difference
Impedance transformed to feed point	$53\Omega+3.6j\Omega$	$50.89\Omega+0.18j\Omega$	$R=-2.11\Omega, X=-3.42\Omega$
Return Loss	-26.8dB	-29.84dB	-11.34%
Dipole2450 Body TST	Target Value	Measured Value	Difference
Impedance transformed to feed point	$49.8\Omega+5.8j\Omega$	$50.63\Omega+3.66j\Omega$	$R=0.83\Omega, X=-2.14\Omega$
Return Loss	-24.7dB	-28.74dB	-16.36%
Measured Date	2016-02-08	2018-01-26	-----
Impedance Test-Head	Return Loss Test-Head		
Impedance Test-Body	Return Loss Test-Body		

## **IMPORTANT NOTICE**

### **USAGE OF THE DAE 4**

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

**Battery Exchange:** The battery cover of the DAE4 unit is closed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

**Shipping of the DAE:** Before shipping the DAE to SPEAG for calibration, remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts during transportation. The package shall be marked to indicate that a fragile instrument is inside.

**E-Stop Failures:** Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, the customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

**Repair:** Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

**DASY Configuration Files:** Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 M $\Omega$  is given in the corresponding configuration file.

**Important Note:**

**Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.**

**Important Note:**

**Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.**

**Important Note:**

**To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.**



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Client **Huawei (Auden)**

Accreditation No.: **SCS 0108**

Certificate No: **DAE4-1492\_Nov18**

## CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BM - SN: 1492**

Calibration procedure(s) **QA CAL-06.v29**  
Calibration procedure for the data acquisition electronics (DAE)

Calibration date: **November 14, 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  $(22 \pm 3)^\circ\text{C}$  and humidity  $< 70\%$ .

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	03-Sep-18 (No:23488)	Sep-19
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	04-Jan-18 (in house check)	In house check: Jan-19
Calibrator Box V2.1	SE UMS 006 AA 1002	04-Jan-18 (in house check)	In house check: Jan-19

Calibrated by: Name **Adrian Gehring** Function **Laboratory Technician**

Signature

Approved by: Name **Sven Kühn** Function **Deputy Manager**

Signature

Issued: November 14, 2018

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## Glossary

DAE	data acquisition electronics
Connector angle	information used in DASY system to align probe sensor X to the robot coordinate system.

## Methods Applied and Interpretation of Parameters

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

## DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB =  $6.1\mu\text{V}$ , full range =  $-100\dots+300\text{ mV}$

Low Range: 1LSB =  $61\text{nV}$ , full range =  $-1\dots+3\text{mV}$

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

Calibration Factors	X	Y	Z
High Range	$403.956 \pm 0.02\% \text{ (k=2)}$	$403.858 \pm 0.02\% \text{ (k=2)}$	$404.094 \pm 0.02\% \text{ (k=2)}$
Low Range	$3.94639 \pm 1.50\% \text{ (k=2)}$	$3.96785 \pm 1.50\% \text{ (k=2)}$	$3.98626 \pm 1.50\% \text{ (k=2)}$

## Connector Angle

Connector Angle to be used in DASY system	$358.0^\circ \pm 1^\circ$
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## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

High Range		Reading ( $\mu$ V)	Difference ( $\mu$ V)	Error (%)
Channel X	+ Input	200037.21	-2.75	-0.00
Channel X	+ Input	20003.40	-2.08	-0.01
Channel X	- Input	-20003.99	1.92	-0.01
Channel Y	+ Input	200036.03	-1.70	-0.00
Channel Y	+ Input	20004.14	-1.25	-0.01
Channel Y	- Input	-20001.98	4.09	-0.02
Channel Z	+ Input	200036.83	-0.22	-0.00
Channel Z	+ Input	20002.21	-3.15	-0.02
Channel Z	- Input	-20006.69	-0.42	0.00

Low Range		Reading ( $\mu$ V)	Difference ( $\mu$ V)	Error (%)
Channel X	+ Input	2000.89	-0.19	-0.01
Channel X	+ Input	203.45	2.41	1.20
Channel X	- Input	-199.24	-0.24	0.12
Channel Y	+ Input	2002.17	1.14	0.06
Channel Y	+ Input	200.17	-0.74	-0.37
Channel Y	- Input	-199.93	-0.92	0.46
Channel Z	+ Input	2001.39	0.42	0.02
Channel Z	+ Input	199.25	-1.62	-0.81
Channel Z	- Input	-200.04	-0.96	0.48

### 2. Common mode sensitivity

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

	Common mode Input Voltage (mV)	High Range Average Reading ( $\mu$ V)	Low Range Average Reading ( $\mu$ V)
Channel X	200	25.15	23.13
	-200	-22.21	-23.74
Channel Y	200	0.74	0.62
	-200	-2.03	-2.23
Channel Z	200	6.05	5.36
	-200	-8.35	-8.14

### 3. Channel separation

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

	Input Voltage (mV)	Channel X ( $\mu$ V)	Channel Y ( $\mu$ V)	Channel Z ( $\mu$ V)
Channel X	200	-	-2.22	-2.97
Channel Y	200	5.99	-	-0.76
Channel Z	200	10.67	3.33	-

#### 4. AD-Converter Values with inputs shorted

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

	High Range (LSB)	Low Range (LSB)
Channel X	16353	16223
Channel Y	16523	15858
Channel Z	15888	15528

#### 5. Input Offset Measurement

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

Input  $10M\Omega$

	Average ( $\mu V$ )	min. Offset ( $\mu V$ )	max. Offset ( $\mu V$ )	Std. Deviation ( $\mu V$ )
Channel X	0.70	-0.60	2.12	0.51
Channel Y	0.39	-0.98	2.15	0.67
Channel Z	-0.32	-1.56	1.30	0.51

#### 6. Input Offset Current

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

#### 7. Input Resistance (Typical values for information)

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

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

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

#### 9. Power Consumption (Typical values for information)

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



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Client **Huawei-SZ (Auden)**

Certificate No: **D1900V2-5d143\_Sep17**

## CALIBRATION CERTIFICATE

Object **D1900V2 - SN:5d143**

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

Calibration date: **September 20, 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:	Name	Function	Signature
	Jeton Kastrati	Laboratory Technician	

Approved by:	Name	Function	Signature
	Katja Pokovic	Technical Manager	

Issued: September 21, 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.

<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>	1900 MHz ± 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	40.0	1.40 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	39.0 ± 6 %	1.38 mho/m ± 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	9.75 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>39.1 W/kg ± 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	5.11 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>20.5 W/kg ± 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	53.3	1.52 mho/m
<b>Measured Body TSL parameters</b>	(22.0 ± 0.2) °C	54.3 ± 6 %	1.47 mho/m ± 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	9.61 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>39.4 W/kg ± 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	5.13 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>20.8 W/kg ± 16.5 % (k=2)</b>