# Attachment 2. – Dipole Calibration Data

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





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

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS)

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

Multilateral Agreement for the recognition of calibration certificates

**CALIBRATION CERTIFICATE** 

Client DT&C (Dymstec)

Certificate No: D835V2-464\_Sep17

Object	D835V2 - SN:464		
Calibration procedure(s)	QA CAL-05.v9		
	Calibration proce	edure for dipole validation kits ab	ove 700 MHz
Calibration date:	September 21, 2	2017	
The measurements and the unce	ertainties with confidence p	tional standards, which realize the physical ur probability are given on the following pages are pry facility: environment temperature $(22 \pm 3)^\circ$	nd are part of the certificate.
Calibration Equipment used (M&	4.5		
Primary Standards	ID#	Cal Date (Certificate No.)	Scheduled Calibration
Primary Standards Power meter NRP	ID# SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
Primary Standards Power meter NRP Power sensor NRP-Z91	ID # SN: 104778 SN: 103244	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521)	Apr-18 Apr-18
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91	ID # SN: 104778 SN: 103244 SN: 103245	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522)	Apr-18 Apr-18 Apr-18
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator	ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k)	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528)	Apr-18 Apr-18 Apr-18 Apr-18
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination	ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k)	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528)	Apr-18 Apr-18 Apr-18 Apr-18
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4	ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 31-May-17 (No. EX3-7349_May17)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	ID #  SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17) Check Date (in house)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 Mar-18
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A	ID #  SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02528) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17) Check Date (in house)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 May-18 Mar-18 Scheduled Check In house check: Oct-18
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A	ID #  SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601  ID #  SN: GB37480704	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17) Check Date (in house)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 Mar-18 Scheduled Check In house check: Oct-18 In house check: Oct-18
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A	ID #  SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601  ID #  SN: GB37480704 SN: US37292783	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02528) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 Mar-18 Scheduled Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4  Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer HP 8753E	ID #  SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601  ID #  SN: GB37480704 SN: US37292783 SN: MY41092317	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02528) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 Mar-18 Scheduled Check In house check: Oct-18 In house check: Oct-18
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4  Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	ID #  SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601  ID #  SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02528) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17)  Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 Mar-18 Scheduled Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18 In house check: Oct-18

Issued: September 21, 2017

Certificate No: D835V2-464\_Sep17

Michael Weber

Katja Pokovic

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Calibrated by:

Approved by:

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Laboratory Technician

Technical Manager

## Calibration Laboratory of

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





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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%.

Certificate No: D835V2-464\_Sep17

#### **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	15 mm	with Spacer
Zoom Scan Resolution	dx, $dy$ , $dz = 5 mm$	
Frequency	835 MHz ± 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.5	0.90 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.9 ± 6 %	0.93 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		1940

#### SAR result with Head TSL

SAR averaged over 1 cm3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.38 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.54 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.03 W/kg ± 16.5 % (k=2)

## **Body TSL parameters**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.2	0.97 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.3 ± 6 %	0.98 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	(AAAA)	5

## 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	2.38 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	9.45 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL.	condition	
SAR measured	250 mW input power	1.55 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	6.16 W/kg ± 16.5 % (k=2)

Certificate No: D835V2-464\_Sep17



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

## Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.6 Ω - 1.4 jΩ	
Return Loss	- 36.5 dB	

## Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.4 Ω - 3.9 jΩ
Return Loss	- 26.3 dB

## General Antenna Parameters and Design

Electrical Delay (one direction)	1.380 ns

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

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

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

#### Additional EUT Data

Manufactured by	SPEAG
Manufactured on	March 27, 2002

Certificate No: D835V2-464\_Sep17

## DASY5 Validation Report for Head TSL

Date: 21.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:464

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

Medium parameters used: f = 835 MHz;  $\sigma = 0.93$  S/m;  $\epsilon_r = 40.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

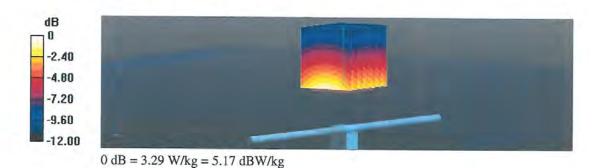
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

## DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(10.07, 10.07, 10.07); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

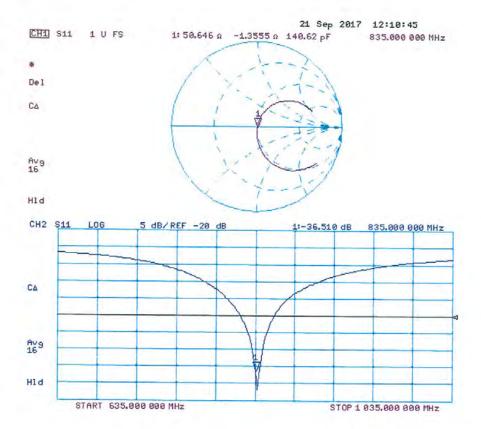
## Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 62.00 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 3.75 W/kg SAR(1 g) = 2.41 W/kg; SAR(10 g) = 1.54 W/kg Maximum value of SAR (measured) = 3.29 W/kg





## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 21.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:464

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

Medium parameters used: f = 835 MHz;  $\sigma$  = 0.98 S/m;  $\epsilon_r$  = 55.3;  $\rho$  = 1000 kg/m³

Phantom section: Flat Section

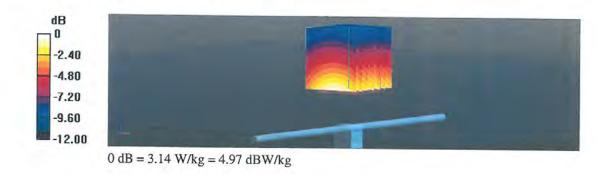
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

## DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(10.2, 10.2, 10.2); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

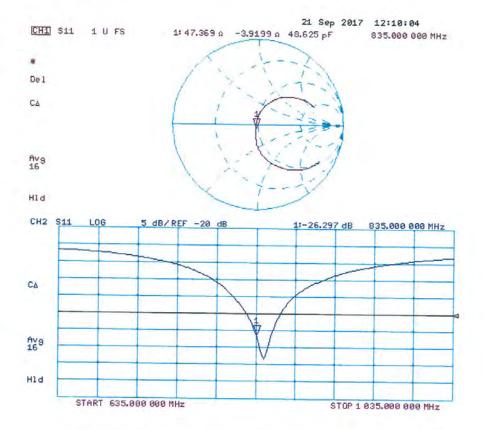
# Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 59.50 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 3.58 W/kg SAR(1 g) = 2.38 W/kg; SAR(10 g) = 1.55 W/kg Maximum value of SAR (measured) = 3.14 W/kg





# Impedance Measurement Plot for Body TSL





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





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

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Client DT&C (Dymstec)

Certificate No: D1800V2-2d047\_May17

## **CALIBRATION CERTIFICATE**

Object D1800V2 - SN:2d047

Calibration procedure(s) QA CAL-05.v9

Calibration procedure for dipole validation kits above 700 MHz

Calibration date: May 23, 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)

100 11

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: 7460	19-May-17 (No. EX3-7460_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
	Name	Function	Signature
Calibrated by:	Johannes Kurikka	Laboratory Technician	pere un
Approved by:	Katja Pokovic	Technical Manager	18M

Issued: May 30, 2017

Certificate No: D1800V2-2d047\_May17

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





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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, "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%.

Certificate No: D1800V2-2d047\_May17

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#### 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	1800 MHz ± 1 MHz	

Head TSL parameters
The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.9 ± 6 %	1.39 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL

SAR averaged over 1 cm3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.99 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	39.9 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.18 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	20.7 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.6 ± 6 %	1.50 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	жжен	440

## SAR result with Body TSL

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.72 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.2 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.11 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.6 W/kg ± 16.5 % (k=2)

Certificate No: D1800V2-2d047\_May17

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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	47.5 Ω - 5.8 jΩ	
Return Loss	- 23.8 dB	

## Antenna Parameters with Body TSL

Impedance, transformed to feed point	43.2 Ω - 5.4 jΩ	
Return Loss	- 20,6 dB	

#### General Antenna Parameters and Design

	1
Electrical Delay (one direction)	1.210 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 16, 2002

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

Date: 23.05.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1800 MHz; Type: D1800V2; Serial: D1800V2 - SN:2d047

Communication System: UID 0 - CW; Frequency: 1800 MHz

Medium parameters used: f = 1800 MHz;  $\sigma = 1.39 \text{ S/m}$ ;  $\varepsilon_r = 38.9$ ;  $\rho = 1000 \text{ kg/m}^3$ 

Phantom section: Flat Section

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

#### DASY52 Configuration:

Probe: EX3DV4 - SN7460; ConvF(8.15, 8.15, 8.15); Calibrated: 19.05.2017;

Sensor-Surface: 1.4mm (Mechanical Surface Detection)

Electronics: DAE4 Sn601; Calibrated: 28.03.2017

Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; 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 = 108.2 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 19.2 W/kg

SAR(1 g) = 9.99 W/kg; SAR(10 g) = 5.18 W/kg

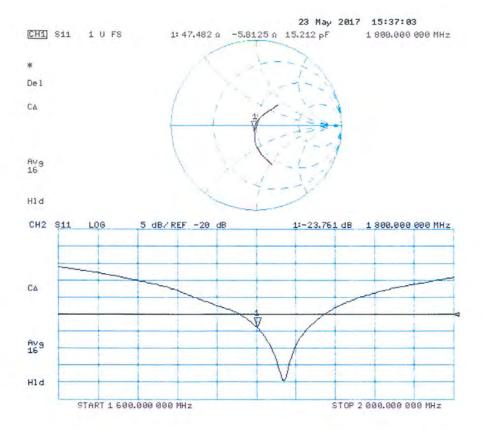
Maximum value of SAR (measured) = 15.3 W/kg



0 dB = 15.3 W/kg = 11.85 dBW/kg



## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 23.05.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1800 MHz; Type: D1800V2; Serial: D1800V2 - SN:2d047

Communication System: UID 0 - CW; Frequency: 1800 MHz

Medium parameters used: f = 1800 MHz;  $\sigma = 1.5 \text{ S/m}$ ;  $\varepsilon_r = 53.6$ ;  $\rho = 1000 \text{ kg/m}^3$ 

Phantom section: Flat Section

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

## DASY52 Configuration:

Probe: EX3DV4 - SN7460; ConvF(7.98, 7.98, 7.98); Calibrated: 19.05.2017;

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:

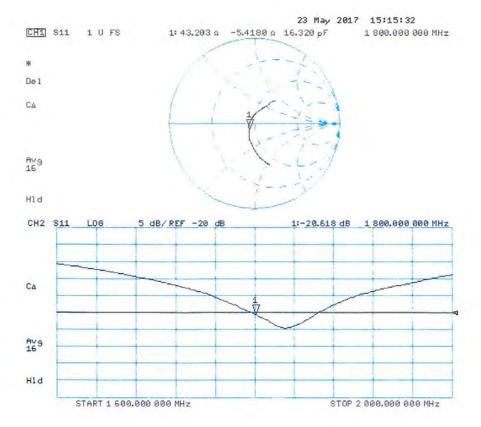
Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 101.8 V/m; Power Drift = -0.09 dB Peak SAR (extrapolated) = 17.4 W/kg SAR(1 g) = 9.72 W/kg; SAR(10 g) = 5.11 W/kg Maximum value of SAR (measured) = 14.0 W/kg



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



## Impedance Measurement Plot for Body TSL





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





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

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS)

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

Client DT&C (Dymstec)

Certificate No: D1900V2-5d029\_Sep17

# CALIBRATION CERTIFICATE

Object D1900V2 - SN:5d029

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	JD#	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
	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	te le
Approved by:	Katja Pokovic	Technical Manager	PORC

Issued: September 21, 2017

Certificate No: D1900V2-5d029\_Sep17 Page 1 of 8

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

# Calibration Laboratory of Schmid & Partner

Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





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

Accreditation No.: SCS 0108

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

#### Glossary:

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%.

Certificate No: D1900V2-5d029\_Sep17

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#### Measurement Conditions

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

with Spacer

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	39.0 ± 6 %	1.38 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	S	1-91-1

## SAR result with Head TSL

SAR averaged over 1 cm3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.78 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	39.2 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.13 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	20.6 W/kg ± 16.5 % (k=2)

## **Body TSL parameters**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1,52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.3 ± 6 %	1.47 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	2000	

## SAR result with Body TSL

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.66 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.6 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.15 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.9 W/kg ± 16.5 % (k=2)

Certificate No: D1900V2-5d029\_Sep17



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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.7 $\Omega$ + 3.4 $J\Omega$
Return Loss	- 27.3 dB

#### Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.9 Ω + 5.8 jΩ	
Return Loss	- 24.5 dB	

## General Antenna Parameters and Design

Electrical Delay (one direction)	1.201 ns

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

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

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

#### Additional EUT Data

Manufactured by	SPEAG
Manufactured on	December 17, 2002

Certificate No: D1900V2-5d029\_Sep17

# DASY5 Validation Report for Head TSL

Date: 20.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d029

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

Medium parameters used: f = 1900 MHz;  $\sigma$  = 1.38 S/m;  $\epsilon_r$  = 39;  $\rho$  = 1000 kg/m³

Phantom section: Flat Section

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

#### DASY52 Configuration:

Probe: EX3DV4 - SN7349; ConvF(8.43, 8.43, 8.43); Calibrated: 31.05.2017;

Sensor-Surface: 1.4mm (Mechanical Surface Detection)

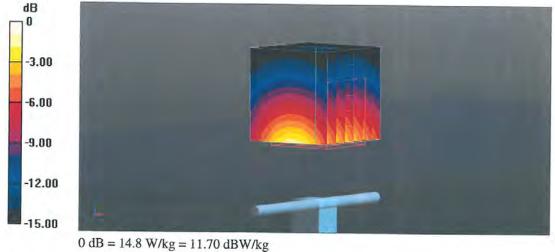
Electronics: DAE4 Sn601; Calibrated: 28.03.2017

Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001

DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

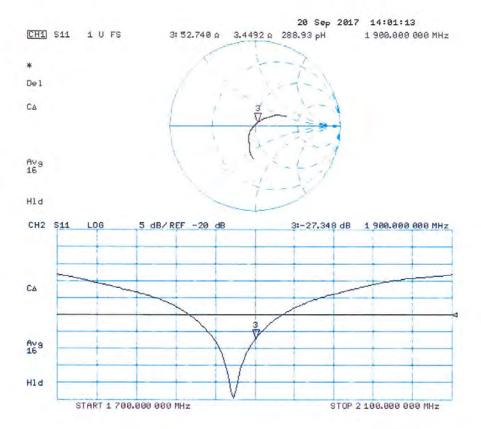
# Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 106.6 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 18.3 W/kg SAR(1 g) = 9.78 W/kg; SAR(10 g) = 5.13 W/kgMaximum value of SAR (measured) = 14.8 W/kg





## Impedance Measurement Plot for Head TSL





## DASY5 Validation Report for Body TSL

Date: 20.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d029

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

Medium parameters used: f = 1900 MHz;  $\sigma = 1.47$  S/m;  $\epsilon_r = 54.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

## DASY52 Configuration:

Probe: EX3DV4 - SN7349; ConvF(8.2, 8.2, 8.2); Calibrated: 31.05.2017;

Sensor-Surface: 1.4mm (Mechanical Surface Detection)

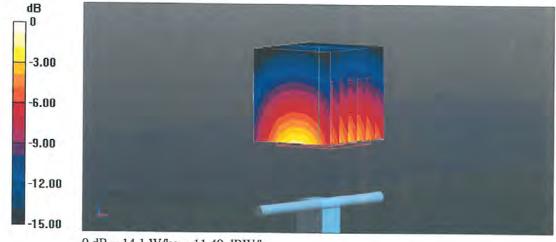
Electronics: DAE4 Sn601; Calibrated: 28.03.2017

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:

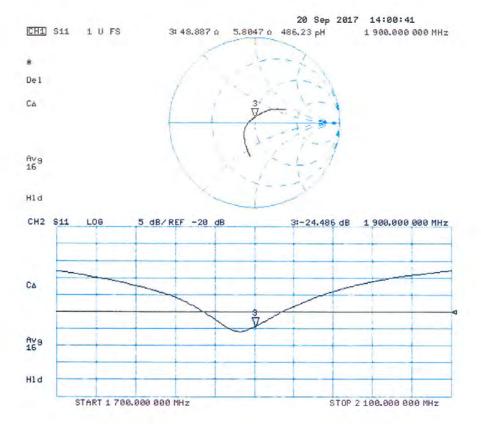
Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 101.8 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 17.0 W/kg SAR(1 g) = 9.66 W/kg; SAR(10 g) = 5.15 W/kg Maximum value of SAR (measured) = 14.1 W/kg



0 dB = 14.1 W/kg = 11.49 dBW/kg



## Impedance Measurement Plot for Body TSL





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





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Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS)

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Client DT&C (Dymstec)

Certificate No: D2450V2-726\_Sep17

Object	D2450V2 - SN:7	26	
Calibration procedure(s)	QA CAL-05.v9 Calibration proce	edure for dipole validation kits abo	ove 700 MHz
Calibration date:	September 19, 2	017	
		ional standards, which realize the physical un probability are given on the following pages an	And the second s
		ry facility: environment temperature (22 ± 3)°(	
Calibration Equipment used (M&		ly radility. Briving interit temperature (22 ± 5) (	Sand numbers 2 70%.
Calibration Equipment used (Ma	TE chilical for calibration)		
Primary Standards	lin #	Cal Data (Cartificate No.)	Pahadulad Calibratian
	ID#	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power meter NRP Power sensor NRP-Z91	SN: 104778 SN: 103244	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521)	Apr-18 Apr-18
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91	SN: 104778 SN: 103244 SN: 103245	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522)	Apr-18 Apr-18 Apr-18
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator	SN: 104778 SN: 103244	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528)	Apr-18 Apr-18 Apr-18 Apr-18
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k)	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522)	Apr-18 Apr-18 Apr-18
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 31-May-17 (No. EX3-7349_May17)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 Mar-18
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02528) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17) Check Date (in house)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 Mar-18
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17)  Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 Mar-18 Scheduled Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4  Secondary Standards Power meter EPM-442A Power sensor HP 8481A RF generator R&S SMT-06	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17)  Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 Mar-18 Scheduled Check In house check: Oct-18
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17)  Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 Mar-18 Scheduled Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4  Secondary Standards Power meter EPM-442A Power sensor HP 8481A RF generator R&S SMT-06	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17)  Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 Mar-18 Scheduled Check In house check: Oct-18
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4  Secondary Standards Power meter EPM-442A Power sensor HP 8481A RF generator R&S SMT-06	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601  ID #  SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390585	04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 31-May-17 (No. EX3-7349_May17) 28-Mar-17 (No. DAE4-601_Mar17)  Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-16)	Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 May-18 Mar-18  Scheduled Check In house check: Oct-18 In house check: Oct-17

Certificate No: D2450V2-726\_Sep17

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





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Accreditation No.: SCS 0108

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

Glossary:

TSL tissue simulating liquid

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

Multilateral Agreement for the recognition of calibration certificates

## 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%.

Certificate No: D2450V2-726\_Sep17

#### **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	2450 MHz ± 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

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

#### SAR result with Head TSL

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

SAR averaged over 10 cm3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.22 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.5 W/kg ± 16.5 % (k=2)

## **Body TSL parameters**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.9 ± 6 %	2.04 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	2	3440

## SAR result with Body TSL

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	50.3 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.05 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.9 W/kg ± 16.5 % (k=2)

Certificate No: D2450V2-726\_Sep17



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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	$52.6 \Omega + 4.0 j\Omega$
Return Loss	- 26.6 dB

## Antenna Parameters with Body TSL

Impedance, transformed to feed point	$49.4 \Omega + 6.5 j\Omega$
Return Loss	- 23.7 dB

## General Antenna Parameters and Design

Electrical Delay (one direction)	1.160 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 09, 2003

Certificate No: D2450V2-726\_Sep17

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

Date: 19.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:726

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

Medium parameters used: f = 2450 MHz;  $\sigma = 1.86 \text{ S/m}$ ;  $\varepsilon_r = 37.8$ ;  $\rho = 1000 \text{ kg/m}^3$ 

Phantom section: Flat Section

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

#### DASY52 Configuration:

Probe: EX3DV4 - SN7349; ConvF(8.12, 8.12, 8.12); Calibrated: 31.05.2017;

Sensor-Surface: 1.4mm (Mechanical Surface Detection)

Electronics: DAE4 Sn601; Calibrated: 28.03.2017

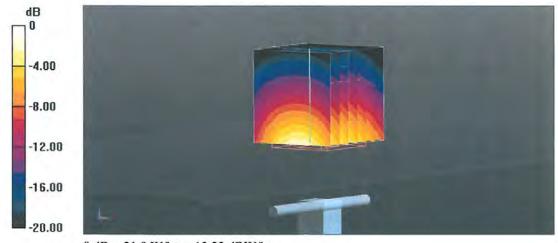
Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001

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 = 110.8 V/m; Power Drift = -0.06 dB Peak SAR (extrapolated) = 26.9 W/kg SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.22 W/kg

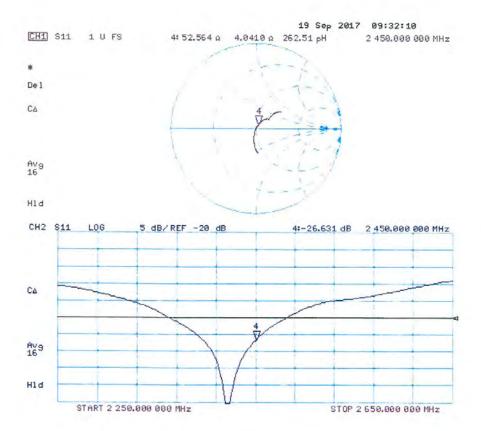
Maximum value of SAR (measured) = 21.0 W/kg



0 dB = 21.0 W/kg = 13.22 dBW/kg



## Impedance Measurement Plot for Head TSL





## DASY5 Validation Report for Body TSL

Date: 19.09.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:726

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

Medium parameters used: f = 2450 MHz;  $\sigma = 2.04 \text{ S/m}$ ;  $\varepsilon_r = 51.9$ ;  $\rho = 1000 \text{ kg/m}^3$ 

Phantom section: Flat Section

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

#### DASY52 Configuration:

Probe: EX3DV4 - SN7349; ConvF(8.1, 8.1, 8.1); Calibrated: 31,05.2017;

Sensor-Surface: 1.4mm (Mechanical Surface Detection)

Electronics: DAE4 Sn601; Calibrated: 28.03.2017

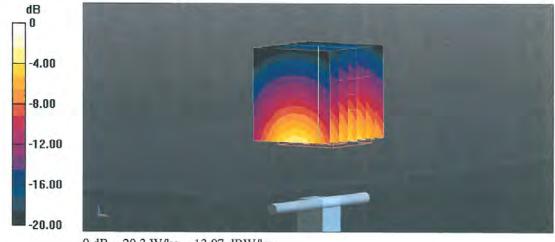
Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002

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 = 104.9 V/m; Power Drift = -0.08 dB Peak SAR (extrapolated) = 25.4 W/kg SAR(1 g) = 12.9 W/kg; SAR(10 g) = 6.05 W/kg

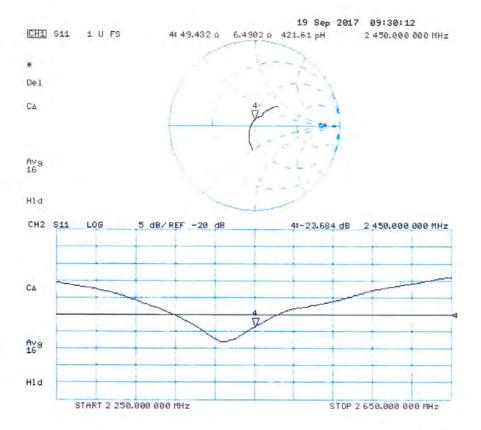
Maximum value of SAR (measured) = 20.3 W/kg



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



## Impedance Measurement Plot for Body TSL



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





S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
Servizlo svizzero di taratura
Swiss Calibration Service

Accreditation No.: SCS 0108

Issued: March 17, 2017

Accredited by the Swiss Accreditation Service (SAS)

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

Client DT&C (Dymstec)

Certificate No: D5GHzV2-1103\_Mar17

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  Power sensor NRP-Z91 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 31-Dec-16 (No. EX3-3503_Dec-16) Dec-17  DAE4 SN: 601 04-Jan-17 (No. DAE4-601_Jan17) Jan-18  Secondary Standards  ID # Check Date (in house) Scheduled Check  Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-16) In house check: Oct-  Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-16) In house check: Oct-  Reference R&S SMT-06 SN: 109972 15-Jun-15 (in house check Oct-16) In house check: Oct-  In house check: Oct	Object	D5GHzV2 - SN:	1103	
Calibration date:  March 17, 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  Prower meter NRP  Power meter NRP  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: 5047.2 / 06327 05-Apr-16 (No. 217-02292) Apr-17  Reference 20 dB Attenuator SN: 5047.2 / 06327 05-Apr-16 (No. 217-02295) Apr-17  Reference Probe EX3DV4 SN: 3503 31-Dec-16 (No. EX3-3503_Dec16) Dec-17  Reference Probe EX3DV4 SN: 601 04-Jan-17 (No. DAE4-601_Jan17) Jan-18  Secondary Standards  Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-16) In house check: Oct-16 (No. 201-0218) SN: 100972 15-Jun-15 (in house check Oct-16) In house check: Oct-16 (No. 201-0218) SN: 100972 15-Jun-15 (in house check Oct-16) In house check: Oct-16 (No. 201-0218) SIGNATUre  Power sensor HP 8481A SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-16 (No. 201-0218) SIGNATUre  Power sensor HP 8753E SN: 100972 15-Jun-15 (in house check Oct-16) In house check: Oct-16 (No. 201-0218) SIGNATUre  Power sensor HP 8753E SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-16 (No. 201-0218) SIGNATUre	Calibration procedure(s)			
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  Power meter NRP  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. 217-02292) Apr-17  Reference Probe EX3DV4 SN: 3503 31-Dec-16 (No. 217-02295) Apr-17  Apr-17  Secondary Standards  ID # Check Date (in house) Scheduled Check  Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-16) In house check: Oct-  Tolver sensor HP 8481A SN: MY41092317 07-Oct-15 (in house check Oct-16) In house check: Oct-  Tolver sensor HP 8481A SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-  Tolver Sensor HP 8481A SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-  Tolver Sensor HP 8753E SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-  Tolver Sensor HP 8753E SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-  Tolver Sensor HP 8753E SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-  Tolver Sensor HP 8753E SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-  Tolver Sensor HP 8753E SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-  Tolver Sensor HP 8753E SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-  Tolver Sensor HP 8753E SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-  Tolver Sensor HP 8753		Calibration proc	edure for dipole validation kits be	etween 3-6 GHz
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  SN: 103244 06-Apr-16 (No. 217-02289) 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. 217-02289) Apr-17  Type-N mismatch combination SN: 5047-2 / 06327 05-Apr-16 (No. 217-02292) Apr-17  Reference Probe EX3DV4 SN: 3503 31-Dec-16 (No. EX3-3503_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 sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-16) In house check: Oct-  Ower sensor HP 8481A SN: MY41092317 07-Oct-15 (in house check Oct-16) In house check: Oct-  Ower sensor HP 8481A SN: MY41092317 07-Oct-15 (in house check Oct-16) In house check: Oct-  Reference RAS SMT-06 SN: 100972 15-Jun-15 (in house check Oct-16) In house check: Oct-  In house ch	Calibration date:	March 17, 2017		
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  Prower 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. 217-02288) Apr-17  Reference 20 dB Attenuator SN: 5058 (20k) 05-Apr-16 (No. 217-02292) Apr-17  Fype-N mismatch combination SN: 5058 (20k) 05-Apr-16 (No. 217-02295) Apr-17  Reference Probe EX3DV4 SN: 3503 31-Dec-16 (No. EX3-3503_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-  Vower sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-16) In house check: Oct-  Vower sensor HP 8481A SN: MY410982317 07-Oct-15 (in house check Oct-16) In house check: Oct-  Vower sensor HP 8455E SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-  Volume Standards In house check Oct-16 (In house check: Oct-  Volume Suitable Check Oc	This calibration certificate documents	nante the trace-but is		
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: 3503 31-Dec-16 (No. EX3-3503_Dec16) Dec-17  DAE4 SN: 601 04-Jan-17 (No. DAE4-601_Jan17) Jan-18  Recondary Standards  Fower meter EPM-442A SN: GB37480704 07-Oct-15 (in house check Oct-16) In house check: Oct-16 (No. 217-0228) SN: 100972 15-Jun-15 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: 100972 15-Jun-15 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: 100972 15-Jun-15 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: 100972 15-Jun-15 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: 100972 15-Jun-15 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-16 (No. 217-0229) SN: US37390585 18-Oct-01 (in house check Oct-16) In house check:	The measurements and the unce	ertainties with confidence	tional standards, which realize the physical u probability are given on the following pages a	nits of measurements (SI). and are part of the certificate.
Calibration Equipment used (M&TE critical for calibration)   Cal Date (Certificate No.)   Scheduled Calibration				
Solution   Scheduled Calibration   Scheduled Calibra				
SN: 104778   O6-Apr-16 (No. 217-02288/02289)   Apr-17	Primary Standards	ID#	Cal Date (Certificate No.)	Schodulad Calibration
SN: 103244   O6-Apr-16 (No. 217-02288)   Apr-17		Ott to the li		
SN: 103245   O6-Apr-16 (No. 217-02289)   Apr-17		SN: 104778	06-Apr-16 (No. 217-02288/02289)	
SN: 5058 (20k)   05-Apr-16 (No. 217-02292)   Apr-17	Power sensor NRP-Z91			Apr-17
SN: 5047.2 / 06327   O5-Apr-16 (No. 217-02295)   Apr-17	Power sensor NRP-Z91 Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17 Apr-17
SN: 3503   31-Dec-16 (No. EX3-3503_Dec16)   Dec-17	Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator	SN: 103244 SN: 103245 SN: 5058 (20k)	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289)	Apr-17 Apr-17 Apr-17
SN: 601   O4-Jan-17 (No. DAE4-601_Jan17)   Jan-18	Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination	SN: 103244 SN: 103245 SN: 5058 (20k)	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292)	Apr-17 Apr-17 Apr-17 Apr-17
Solution   Content   Con	Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295)	Apr-17 Apr-17 Apr-17 Apr-17 Apr-17
SN: GB37480704   O7-Oct-15 (in house check Oct-16)   In house check: Oct-16   Oxwer sensor HP 8481A   SN: US37292783   O7-Oct-15 (in house check Oct-16)   In house check: Oct-17   Oxwer sensor HP 8481A   SN: WS37292783   O7-Oct-15 (in house check Oct-16)   In house check: Oct-17   Oxwer sensor HP 8481A   SN: MY41092317   O7-Oct-15 (in house check Oct-16)   In house check: Oct-17   Oxwer sensor HP 8481A   SN: MY41092317   O7-Oct-15 (in house check Oct-16)   In house check: Oct-18   Oxwer sensor HP 8481A   SN: WS37390585   I8-Oct-01 (in house check Oct-16)   In house check: Oct-18   Oxwer sensor HP 8481A   SN: US37390585   I8-Oct-01 (in house check Oct-16)   In house check: Oct-18   Oxwer sensor HP 8481A   SN: WS37390585   I8-Oct-01 (in house check Oct-16)   In house check: Oct-18   Oxwer sensor HP 8481A   SN: WS37390585   I8-Oct-01 (in house check Oct-16)   In house check: Oct-18   Oxwer sensor HP 8481A   SN: WS37390585   I8-Oct-01 (in house check Oct-16)   In house check: Oct-18   Oxwer sensor HP 8481A   Oxwer sensor HP	Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 3503	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 31-Dec-16 (No. EX3-3503_Dec16)	Apr-17 Apr-17 Apr-17 Apr-17 Apr-17 Dec-17
SN: US37292783   O7-Oct-15 (in house check Oct-16)   In house check: Oct-16   Over sensor HP 8481A   SN: US37292783   O7-Oct-15 (in house check Oct-16)   In house check: Oct-17   O7-Oct-15 (in house check Oct-16)   In house check: Oct-17   O7-Oct-15 (in house check Oct-16)   In house check: Oct-17   O7-Oct-15 (in house check Oct-16)   In house check: Oct-17   O7-Oct-15 (in house check Oct-16)   In house check: Oct-18   O7-Oct-15 (in house check Oct-16)   O	Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Gecondary Standards	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 3503 SN: 601	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 31-Dec-16 (No. EX3-3503_Dec16) 04-Jan-17 (No. DAE4-601_Jan17)	Apr-17 Apr-17 Apr-17 Apr-17 Apr-17 Dec-17 Jan-18
SN: MY41092317   07-Oct-15 (in house check Oct-16)   In house check: Oct-16   In house check: Oct-17   In house check: Oct-17   In house check: Oct-18   In house check: Oct-18   In house check: Oct-19   In house check:	Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Recondary Standards Power meter EPM-442A	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 3503 SN: 601	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 31-Dec-16 (No. EX3-3503_Dec16) 04-Jan-17 (No. DAE4-601_Jan17) Check Date (in house)	Apr-17 Apr-17 Apr-17 Apr-17 Apr-17 Dec-17 Jan-18 Scheduled Check
SN: 100972 15-Jun-15 (in house check Oct-16) In house check: Oct-16 In house check: Oct-16 In house check: Oct-17 In house check: Oct-18 In house check: Oct-18 In house check: Oct-19	Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Recondary Standards Power meter EPM-442A Reversensor HP 8481A	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 3503 SN: 601	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 31-Dec-16 (No. EX3-3503_Dec16) 04-Jan-17 (No. DAE4-601_Jan17) Check Date (in house) 07-Oct-15 (in house check Oct-16)	Apr-17 Apr-17 Apr-17 Apr-17 Apr-17 Dec-17 Jan-18 Scheduled Check In house check: Oct-1
letwork Analyzer HP 8753E   SN: US37390585 18-Oct-01 (in house check Oct-16) In house check: Oct-1  Name Function Signature	Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Recondary Standards Power meter EPM-442A Rower sensor HP 8481A	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 3503 SN: 601 ID # SN: GB37480704 SN: US37292783	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 31-Dec-16 (No. EX3-3503_Dec16) 04-Jan-17 (No. DAE4-601_Jan17)  Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	Apr-17 Apr-17 Apr-17 Apr-17 Apr-17 Dec-17 Jan-18 Scheduled Check In house check: Oct-16 In house check: Oct-16
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	Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A RF generator R&S SMT-06	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 3503 SN: 601  ID #  SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390585	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 31-Dec-16 (No. EX3-3503_Dec16) 04-Jan-17 (No. DAE4-601_Jan17)  Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-16)	Apr-17 Apr-17 Apr-17 Apr-17 Apr-17 Dec-17 Jan-18  Scheduled Check In house check: Oct-1
	ower sensor NRP-Z91 ower sensor NRP-Z91 eference 20 dB Attenuator ype-N mismatch combination eference Probe EX3DV4 AE4 econdary Standards ower meter EPM-442A ower sensor HP 8481A F generator R&S SMT-06 etwork Analyzer HP 8753E	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 3503 SN: 601  ID #  SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390585  Name	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 31-Dec-16 (No. EX3-3503_Dec16) 04-Jan-17 (No. DAE4-601_Jan17)  Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-16)	Apr-17 Apr-17 Apr-17 Apr-17 Apr-17 Dec-17 Jan-18 Scheduled Check In house check: Oct-1

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Katja Pokovic

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Approved by:

Technical Manager

## Calibration Laboratory of

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





Schweizerischer Kalibrierdienst

C Service suisse d'étalonnage Servizio svizzero di taratura

Accreditation No.: SCS 0108

S Swiss Calibration Service

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:

- 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 62209-2, "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
- c) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### Additional Documentation:

d) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

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

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

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## **Measurement Conditions**

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0  mm, dz = 1.4  mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz ± 1 MHz 5300 MHz ± 1 MHz 5500 MHz ± 1 MHz 5600 MHz ± 1 MHz 5800 MHz ± 1 MHz	

## Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.0 ± 6 %	4.52 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	The same of	

## SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.00 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	79.5 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	2.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.7 W/kg ± 19.5 % (k=2)



# Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.8 ± 6 %	4.62 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		Lucy

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

SAR averaged over 1 cm3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.47 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	84.1 W / kg ± 19.9 % (k=2)

SAR averaged over 10 cm3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.42 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.0 W/kg ± 19.5 % (k=2)

# Head TSL parameters at 5500 MHz

The following parameters and calculations were applied

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.5 ± 6 %	4.81 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		2000

#### SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	83.2 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	2.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.6 W/kg ± 19.5 % (k=2)

# Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.4 ± 6 %	4.92 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

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

SAR averaged over 1 cm3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.52 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	84.5 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.43 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.1 W/kg ± 19.5 % (k=2)

# Head TSL parameters at 5800 MHz The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.1 ± 6 %	5.13 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.18 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.1 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	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.1 W/kg ± 19.5 % (k=2)



### Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.2 ± 6 %	5.45 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

# SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.43 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	74.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.09 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.8 W/kg ± 19.5 % (k=2)

# Body TSL parameters at 5300 MHz The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.0 ± 6 %	5.58 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	7-16	

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

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.69 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	76.7 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 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.7 ± 6 %	5.85 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

# SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.12 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	81.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.25 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	22.4 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	47.5 ± 6 %	5.99 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

# SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.03 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	80.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.25 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	22.4 W/kg ± 19.5 % (k=2)

#### Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.2 ± 6 %	6.28 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	COL	277

# SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.77 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	77.5 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm3 (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	21.5 W/kg ± 19.5 % (k=2)

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

### Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	52.4 Ω - 5.8 jΩ
Return Loss	- 24.3 dB

## Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	48.8 Ω - 0.2 ]Ω	
Return Loss	- 38.0 dB	

### Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	50,2 Ω - 2.8 įΩ
Return Loss	- 30.9 dB

## Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	55.1 Ω + 0.9 jΩ	
Return Loss	- 26.2 dB	

### Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	$52.2 \Omega + 0.9 j\Omega$	
Return Loss	- 32.5 dB	

### Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	51.7 Ω - 4.9 ]Ω
Return Loss	- 25.9 dB

#### Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	$49.8 \Omega + 0.6 j\Omega$
Return Loss	- 43.6 dB

# Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	49.8 Ω - 1.6 jΩ
Return Loss	- 35.6 dB

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# Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	57.5 Ω + 1.5 jΩ
Return Loss	- 22.9 dB

### Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	52.5 Ω + 1.5 jΩ
Return Loss	- 30.9 dB

#### General Antenna Parameters and Design

The Art of	
Electrical Delay (one direction)	Carrier and an artist and a second a second and a second
Control Dolay (one direction)	1.209 ns
/0	1,200 110

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 24, 2010

Certificate No: D5GHzV2-1103\_Mar17



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

Date: 17.03.2017

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1103

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz Medium parameters used: f = 5200 MHz;  $\sigma = 4.52$  S/m;  $\epsilon_r = 35$ ;  $\rho = 1000$  kg/m³, Medium parameters used: f = 5300 MHz;  $\sigma = 4.62$  S/m;  $\epsilon_r = 34.8$ ;  $\rho = 1000$  kg/m³, Medium parameters used: f = 5500 MHz;  $\sigma = 4.81$  S/m;  $\epsilon_r = 34.5$ ;  $\rho = 1000$  kg/m³. Medium parameters used: f = 5600 MHz;  $\sigma = 4.92$  S/m;  $\epsilon_r = 34.4$ ;  $\rho = 1000$  kg/m³, Medium parameters used: f = 5800 MHz;  $\sigma = 5.13$  S/m;  $\epsilon_r = 34.1$ ;  $\rho = 1000$  kg/m³ Phantom section: Flat Section

#### DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.76, 5.76, 5.76); Calibrated: 31.12.2016, ConvF(5.35, 5.35, 5.35);
   Calibrated: 31.12.2016, ConvF(5.2, 5.2, 5.2); Calibrated: 31.12.2016, ConvF(5.09, 5.09, 5.09);
   Calibrated: 31.12.2016, ConvF(5.01, 5.01, 5.01); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.01.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

# Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan,

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

Reference Value = 70.95 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 29.3 W/kg

SAR(1 g) = 8 W/kg; SAR(10 g) = 2.29 W/kg

Maximum value of SAR (measured) = 17.9 W/kg

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

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

Reference Value = 72.36 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 30.5 W/kg

SAR(1 g) = 8.47 W/kg; SAR(10 g) = 2.42 W/kg

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

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

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

Reference Value = 70.89 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 32.7 W/kg

SAR(1 g) = 8.38 W/kg; SAR(10 g) = 2.38 W/kg

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

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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 = 71.46 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 33.2 W/kg
SAR(1 g) = 8.52 W/kg; SAR(10 g) = 2.43 W/kg
Maximum value of SAR (measured) = 19.6 W/kg

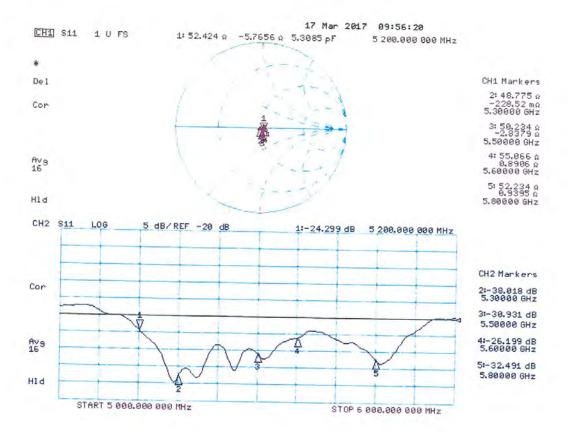
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 69.17 V/m; Power Drift = -0.08 dB Peak SAR (extrapolated) = 33.1 W/kg SAR(1 g) = 8.18 W/kg; SAR(10 g) = 2.33 W/kg



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



# Impedance Measurement Plot for Head TSL





#### DASY5 Validation Report for Body TSL

Date: 16.03.2017

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1103

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz Medium parameters used: f = 5200 MHz;  $\sigma = 5.45$  S/m;  $\epsilon_r = 48.2$ ;  $\rho = 1000$  kg/m³, Medium parameters used: f = 5300 MHz;  $\sigma = 5.58$  S/m;  $\epsilon_r = 48$ ;  $\rho = 1000$  kg/m³, Medium parameters used: f = 5500 MHz;  $\sigma = 5.85$  S/m;  $\epsilon_r = 47.7$ ;  $\rho = 1000$  kg/m³, Medium parameters used: f = 5600 MHz;  $\sigma = 5.99$  S/m;  $\epsilon_r = 47.5$ ;  $\rho = 1000$  kg/m³, Medium parameters used: f = 5800 MHz;  $\sigma = 6.28$  S/m;  $\epsilon_r = 47.2$ ;  $\rho = 1000$  kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

#### DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.29, 5.29, 5.29); Calibrated: 31.12.2016, ConvF(5.04, 5.04, 5.04);
   Calibrated: 31.12.2016, ConvF(4.62, 4.62, 4.62); Calibrated: 31.12.2016, ConvF(4.57, 4.57, 4.57);
   Calibrated: 31.12.2016, ConvF(4.48, 4.48, 4.48); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.01.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

# Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 64.58 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 28.4 W/kg

SAR(1 g) = 7.43 W/kg; SAR(10 g) = 2.09 W/kg

Maximum value of SAR (measured) = 17.8 W/kg

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

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

Reference Value = 65.42 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 30.0 W/kg

SAR(1 g) = 7.69 W/kg; SAR(10 g) = 2.17 W/kg

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

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

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

Reference Value = 66.66 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 33.6 W/kg

SAR(1 g) = 8.12 W/kg; SAR(10 g) = 2.25 W/kg

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

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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 = 65.60 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 33.9 W/kg

SAR(1 g) = 8.03 W/kg; SAR(10 g) = 2.25 W/kg

SAR(1 g) = 8.03 W/kg; SAR(10 g) = 2.25 W/kgMaximum value of SAR (measured) = 19.6 W/kg

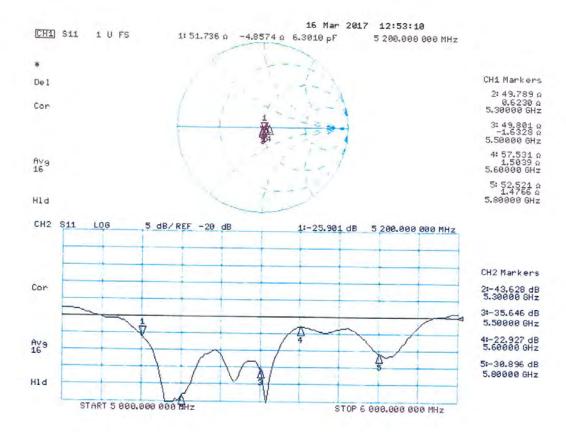
Maximum value of SAR (measured) = 19.8 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 63.69 V/m; Power Drift = -0.04 dB Peak SAR (extrapolated) = 34.6 W/kg SAR(1 g) = 7.77 W/kg; SAR(10 g) = 2.16 W/kg





# Impedance Measurement Plot for Body TSL



## Attachment 3. - SAR SYSTEM VALIDATION

#### **SAR System Validation**

Per FCC KDB 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 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.

PERM. COND. **CW Validation** MOD. Validation SAR Probe Frea. Probe Date Probe CAL. Point Probe MOD. Sensi-Probe Dutv [MHz] System SN Type (er) (**o**) tivity Linearity Isortopy Type Factor 40.645 0.869 PASS PASS Α 835 10/03/2017 3327 ES3DV3 835 Head PASS **PASS GMSK** N/A Α 1800 10/04/2017 3327 ES3DV3 1800 Head 39.446 1.388 **PASS PASS PASS** N/A N/A N/A Α 1900 10/05/2017 3327 ES3DV3 1900 39.551 1.442 PASS PASS PASS **GMSK PASS** N/A Head 10/06/2017 PASS Α 2450 3327 FS3DV3 2450 38 885 1 811 PASS PASS OFDM N/A PASS Head Α 5200 08/10/2017 3930 EX3DV4 5300 Head 35.051 4.719 **PASS PASS PASS OFDM** N/A **PASS** Α 5300 08/11/2017 3930 EX3DV4 5300 Head 34.515 4.887 **PASS** PASS **PASS** OFDM N/A **PASS** Α 5500 08/15/2017 3930 EX3DV4 5600 Head 34 337 5 113 PASS PASS PASS OFDM N/A PASS Α 5600 08/15/2017 3930 EX3DV4 5600 34.228 5.236 PASS PASS PASS OFDM N/A PASS Head PASS Α 5800 08/16/2017 3930 EX3DV4 5600 Head 34.001 5.378 **PASS** PASS OFDM N/A **PASS** Α 835 10/03/2017 3327 ES3DV3 835 54.223 0.954 **PASS PASS** PASS **GMSK PASS** N/A Body Α 1800 10/04/2017 3327 ES3DV3 1800 52.887 1.533 PASS PASS PASS N/A N/A N/A Body Α 1900 10/05/2017 3327 ES3DV3 1900 Body 52.774 1.546 PASS PASS PASS **GMSK PASS** N/A

51.665

48.051

47 797

47.587

47.445

47.016

1.949

5.448

5 567

5.779

5.911

6 214

**PASS** 

**PASS** 

PASS

**PASS** 

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PASS

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PASS

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**PASS** 

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PASS

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PASS

OFDM

OFDM

OFDM

**OFDM** 

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OFDM

N/A

N/A

N/A

N/A

N/A

N/A

**PASS** 

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PASS

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PASS

**Table Attachment 3.1 SAR System Validation Summary** 

NOTE: While the probes have been calibrated for both a 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 KDB 865664.

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Α

Α

Α

2450

5200

5300

5500

5600

5800

10/06/2017

08/10/2017

08/11/2017

08/15/2017

08/15/2017

08/16/2017

3327

3930

3930

3930

3930

3930

ES3DV3

EX3DV4

FX3DV4

EX3DV4

EX3DV4

EX3DV4

2450

5300

5300

5600

5600

5600

Body

Body

Body

Body

Body

Body