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#### Calibration Laboratory of Schmid & Partner Engineering AG

Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



Schweizerischer 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 TüV Süd Zacta (Vitec)

Certificate No: D2450V2-925\_Dec15

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CALIBRATION C	CERTIFICATI		
Object	D2450V2 - SN: 9	025	
Calibration procedure(s)	QA CAL-05.v9 Calibration proce	edure for dipole validation kits at	pove 700 MHz
Calibration date:	December 10, 20	015	
This calibration certificate docum The measurements and the unce All calibrations have been conduc Calibration Equipment used (M&1	ents the traceability to nati rtainties with confidence p cted in the closed laborato "E critical for calibration)	ional standards, which realize the physical u robability are given on the following pages a ry facility: environment temperature ( $22 \pm 3$ )	units of measurements (SI). and are part of the certificate. °C and humidity < 70%.
Primary Standards	D#	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	US37292783	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	MY41092317	07-Oct-15 (No. 217-02223)	Oct-16
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
ype-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe EX3DV4	SN: 7349	30-Dec-14 (No. EX3-7349 Dec14)	Dec-15
DAE4	SN: 601	17-Aug-15 (No. DAE4-601_Aug15)	Aug-16
Dessender: Otenderde			0.1.1.1.0.1
E gonorator DIE CMT 06	100072	15 Jup 15 (in house)	Scheduled Check
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-15)	In house check: Oct-16
	Name	Function	Signature
Calibrated by:	Israe Elnaouq	Laboratory Technician	Aron Charley
Approved by:	Katja Pokovic	Technical Manager	felly
			Issued: December 10, 2015
his calibration certificate shall no	t be reproduced except in	full without written approval of the laborator	у.

Certificate No: D2450V2-925\_Dec15

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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%.

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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	
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	37.9 ± 6 %	1.88 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition			
SAR measured	250 mW input power	13.4 W/kg		
SAR for nominal Head TSL parameters	normalized to 1W	52.1 W/kg ± 17.0 % (k=2)		
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition			
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL SAR measured	condition 250 mW input power	6.15 W/kg		

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	52.2 ± 6 %	2.03 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

#### SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.4 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	52.5 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL SAR measured	condition 250 mW input power	6.22 W/kg

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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	55.3 Ω + 4.5 jΩ			
Return Loss	- 23.7 dB			

#### Antenna Parameters with Body TSL

Impedance, transformed to feed point	52.4 Ω + 6.2 jΩ	
Return Loss	- 23.8 dB	

#### **General Antenna Parameters and Design**

Electrical Delay (one direction)	1.158 ns
----------------------------------	----------

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

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

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

#### **Additional EUT Data**

Manufactured by	SPEAG
Manufactured on	September 26, 2013

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

Date: 10.12.2015

Test Laboratory: SPEAG, Zurich, Switzerland

## DUT: Dipole 2450 MHz ; Type: D2450V2; Serial: D2450V2 - SN: 925

Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz;  $\sigma$  = 1.88 S/m;  $\epsilon_r$  = 37.9;  $\rho$  = 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(7.67, 7.67, 7.67); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 112.6 V/m; Power Drift = 0.08 dB Peak SAR (extrapolated) = 27.8 W/kg SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.15 W/kg Maximum value of SAR (measured) = 22.0 W/kg



0 dB = 22.0 W/kg = 13.42 dBW/kg

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## Impedance Measurement Plot for Head TSL



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### **DASY5 Validation Report for Body TSL**

Date: 10.12.2015

Test Laboratory: SPEAG, Zurich, Switzerland

## DUT: Dipole 2450 MHz ; Type: D2450V2; Serial: D2450V2 - SN: 925

Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz;  $\sigma = 2.03$  S/m;  $\varepsilon_r = 52.2$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.53, 7.53, 7.53); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

### 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 = 108.2 V/m; Power Drift = 0.05 dB Peak SAR (extrapolated) = 26.6 W/kg SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.22 W/kg Maximum value of SAR (measured) = 21.8 W/kg



0 dB = 21.8 W/kg = 13.38 dBW/kg

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## Impedance Measurement Plot for Body TSL



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# 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 IEEE 1528-2013 and FCC KDB 865664 D01v01r04. 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.

CAD	Гиск		Droho	Droh	Proba CAL		COND.	C	W Validatio	n	МО	D. Validat	tion
SAR Svstem	Freq. [MHz]	Data	Probe Type	Probe	e CAL. Dint	(sr)	(m)	Sensi-	Probe	Probe	MOD.	Duty	PAR
- ,	[····-]					(01)	(0)	tivity	Linearity	Isotropy	Туре	Factor	1743
E	750	2016-09-05	3957	750	Head	42.01	0.933	PASS	PASS	PASS	QPSK	PASS	N/A
E	835	2016-09-09	3957	835	Head	41.98	0.917	PASS	PASS	PASS	GMSK	PASS	N/A
E	835	2016-09-12	3957	835	Head	41.59	0.907	PASS	PASS	PASS	GMSK	PASS	N/A
E	1900	2016-09-08	3957	1900	Head	39.73	1.392	PASS	PASS	PASS	GMSK	PASS	N/A
E	2450	2016-08-31	3957	2450	Head	37.96	1.852	PASS	PASS	PASS	OFDM	N/A	PASS
E	750	2016-09-05	3957	750	Body	55.01	0.990	PASS	PASS	PASS	QPSK	PASS	N/A
E	835	2016-09-06	3957	835	Body	54.62	1.005	PASS	PASS	PASS	GMSK	PASS	N/A
E	1900	2016-09-07	3957	1900	Body	52.59	1.528	PASS	PASS	PASS	GMSK	PASS	N/A
E	1900	2016-10-25	3957	1900	Body	52.92	1.506	PASS	PASS	PASS	GMSK	PASS	N/A
E	2450	2016-08-31	3957	2450	Body	51.14	1.951	PASS	PASS	PASS	OFDM	N/A	PASS

#### Table Attachment 3.1 SAR System Validation Summary