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





S Schweizerischer Kalibrierdienst

C Service suisse d'étalonnage

Servizio svizzero di taraturaSwiss 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 62209-1, "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%.

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Accreditation No.: SCS 0108

## **Measurement Conditions**

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

DASY Version	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	102.10.0
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1900 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	40.7 ± 6 %	1.39 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	10.0 W/kg	
SAR for nominal Head TSL parameters	normalized to 1W	40.3 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	5.25 W/kg	

#### **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	55.2 ± 6 %	1.48 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	9.71 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.8 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	5.16 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	52.2 Ω + 6.0 ίΩ
Return Loss	- <b>-</b>
	- 24.0 dB

## Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.9 Ω + 7.5 ϳΩ
Return Loss	- 22.0 dB

## General Antenna Parameters and Design

Electrical Delay (one direction)	1.195 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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

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

## Additional EUT Data

Manufactured by	SPEAG	
Manufactured on	April 16, 2015	

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Date: 22.02.2018

## DASY5 Validation Report for Head TSL

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d226

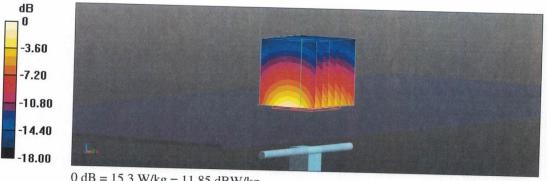
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz;  $\sigma$  = 1.39 S/m;  $\epsilon_r$  = 40.7;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.18, 8.18, 8.18); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection) .
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017 .
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

#### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 109.6 V/m; Power Drift = -0.09 dB Peak SAR (extrapolated) = 18.5 W/kgSAR(1 g) = 10 W/kg; SAR(10 g) = 5.25 W/kg

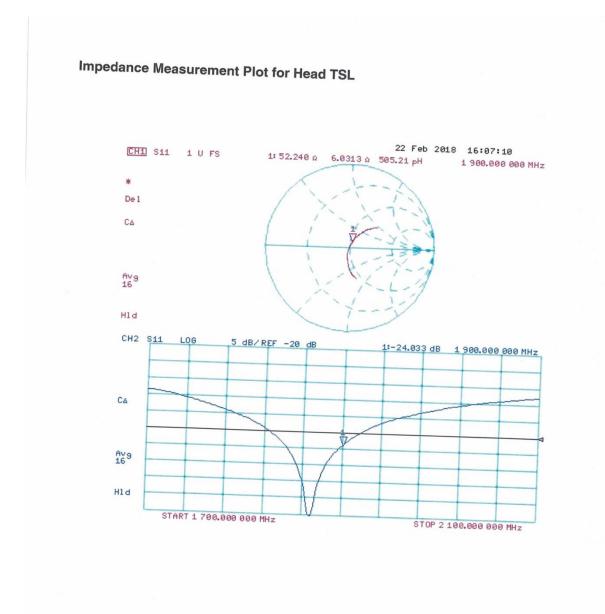
Maximum value of SAR (measured) = 15.3 W/kg



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

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Date: 22.02.2018

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

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d226

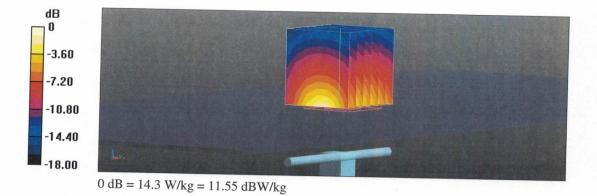
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz;  $\sigma$  = 1.48 S/m;  $\epsilon_r$  = 55.2;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.15, 8.15, 8.15); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

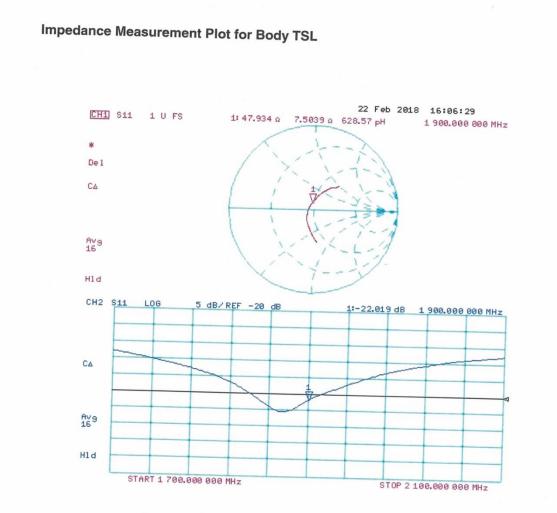
## **Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 102.8 V/m; Power Drift = -0.09 dB Peak SAR (extrapolated) = 17.2 W/kg SAR(1 g) = 9.71 W/kg; SAR(10 g) = 5.16 W/kg Maximum value of SAR (measured) = 14.3 W/kg



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# **Extended Dipole Calibrations**

Referring to KDB865664 D01, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

Head-1900						
Date of	Datum laga (dD)	$D_{olto}(0/)$	Real Impedance	Delta	Imaginary	Delta
measurement	Return-loss (dB)	Delta (%)	(ohm)	(ohm)	impedance (ohm)	(ohm)
2018/2/22	-24.0		52.2		6.0	
2019/2/20	-24.5	2.08%	52.6	0.4	6.5	0.5

Body-1900						
Date of	Poturn loop (dP)	Delta (%)	Real Impedance	Delta	Imaginary	Delta
measurement	Return-loss (dB)	Della (%)	(ohm)	(ohm)	impedance (ohm)	(ohm)
2018/2/22	-22.0		47.9		7.5	
2019/2/20	-22.3	1.36%	47.3	0.6	7.1	0.4

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 50hm of prior calibration. Therefore the verification result should support extended calibration.

## 1.5. D2450V2 Dipole Calibration Certificate

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Accredited by the Swiss Accre The Swiss Accreditation Ser Multilateral Agreement for th	Vice is one of the signet	ories to the EA ilon certificates	Accreditation No.: SCS 0108
Client CCIC-HTW (	Auden)	Certifica	ate No: D2450V2-1009_Feb18
CALIBRATION			
	D2450V2 - SN	:1009	
Calibration procedure(s)	QA CAL-05.v9 Calibration prod	cedure for dipole validation kits	above 700 MHz
Calibration date:	February 05, 20	018	
	ucted in the closed laborat	ational standards, which realize the physica probability are given on the following page ory facility: environment temperature (22 ±	es and are part of the certificate.
All calibrations have been cond Calibration Equipment used (M& Primary Standards	ucted in the closed laborat &TE critical for calibration)	tory facility: environment temperature (22 $\pm$	s and are part of the certificate. 3)°C and humidity < 70%.
All calibrations have been cond Calibration Equipment used (M& Primary Standards Power meter NRP	ucted in the closed laborat &TE critical for calibration) ID # SN: 104778	Cal Date (Certificate No.)	s and are part of the certificate. 3)°C and humidity < 70%. Scheduled Calibration
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All calibrations have been condi Calibration Equipment used (M& 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	ucted in the closed laborat &TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 5047.2 / 06327 SN: 5047.2 / 06327 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: WY41092317 SN: 100972 SN: US37390585 Name	Cal Date (Certificate No.)           04-Apr-17 (No. 217-02521/02522)           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)           30-Dec-17 (No. 217-02529)           30-Dec-17 (No. EX3-7349_Dec17)           26-Oct-17 (No. DAE4-601_Oct17)           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)	s and are part of the certificate. S)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18
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## 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

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:

ISL	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: D2450V2-1009\_Feb18

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## **Measurement Conditions**

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

DASY Version	DASY5	
Extrapolation	Advanced Extrapolation	V52.10.0
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Conserve
Zoom Scan Resolution	dx, dy, dz = 5 mm	with Spacer
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 %	1.87 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	13.2 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	51.5 W/kg ± 17.0 % (k=2)
SAR averaged over 10 and (40 ) and		
on 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	6.13 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	51.4 ± 6 %	2.04 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	12.7 W/kg	
SAR for nominal Body TSL parameters	normalized to 1W	49.4 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	5.92 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	
Return Loss	53.8 Ω + 2.2 jΩ
Heidin Loss	- 27.4 dB

## Antenna Parameters with Body TSL

Impedance, transformed to feed point	
Return Loss	49.9 Ω + 4.6 jΩ
	- 26.7 dB

## General Antenna Parameters and Design

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

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 No excessive force much here are in the area.

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	
Manufactured on	SPEAG
manufactured on	October 17, 2017

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Date: 05.02.2018

# DASY5 Validation Report for Head TSL

Test Laboratory: SPEAG, Zurich, Switzerland

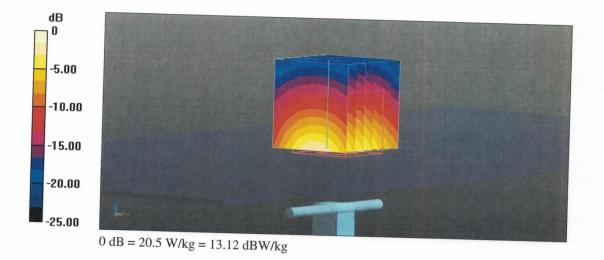
# DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:1009

Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz;  $\sigma$  = 1.87 S/m;  $\varepsilon$ <sub>r</sub> = 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(7.88, 7.88, 7.88); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

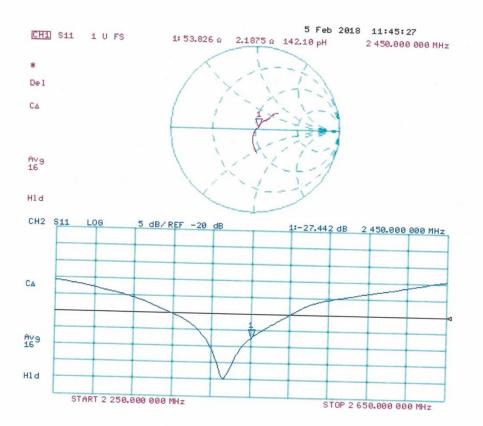
#### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 111.8 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 26.6 W/kg SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.13 W/kg Maximum value of SAR (measured) = 20.5 W/kg



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Date: 05.02.2018

## DASY5 Validation Report for Body TSL

Test Laboratory: SPEAG, Zurich, Switzerland

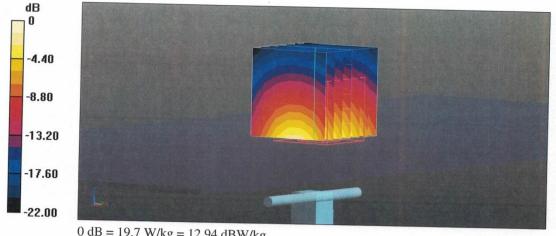
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:1009

Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz;  $\sigma$  = 2.04 S/m;  $\epsilon_r$  = 51.4;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.01, 8.01, 8.01); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection) .
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017 .
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002 .
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417) .

#### Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 104.2 V/m; Power Drift = -0.09 dB Peak SAR (extrapolated) = 25.5 W/kgSAR(1 g) = 12.7 W/kg; SAR(10 g) = 5.92 W/kg Maximum value of SAR (measured) = 19.7 W/kg

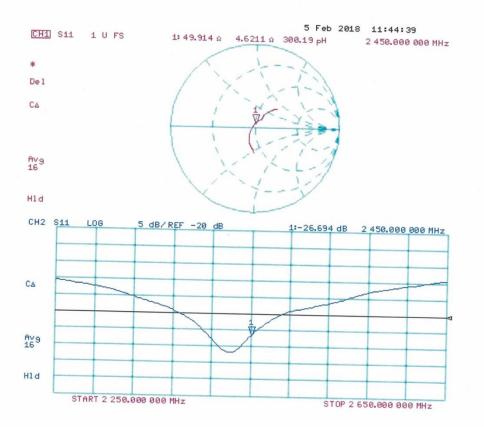


0 dB = 19.7 W/kg = 12.94 dBW/kg

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Certificate No: D2450V2-1009\_Feb18

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# **Extended Dipole Calibrations**

Referring to KDB865664 D01, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

Head-2450						
Date of	Poturn loop (dP)	Dolto (9/)	Real Impedance	Delta	Imaginary	Delta
measurement	Return-loss (dB)	Delta (%)	(ohm)	(ohm)	impedance (ohm)	(ohm)
2018-02-05	-27.4		53.8		2.2	
2019-02-03	-26.8	-2.19%	52.9	0.9	1.9	0.3

Body-2450						
Date of	Return-loss (dB)	Delta (%)	Real Impedance	Delta	Imaginary	Delta
measurement	Return-1055 (ub)	Della (%)	(ohm)	(ohm)	impedance (ohm)	(ohm)
2018-02-05	-26.7		49.9		4.6	
2019-02-03	-26.1	-2.25%	49.1	0.8	4.2	0.4

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 50hm of prior calibration. Therefore the verification result should support extended calibration.

## 1.6. D2600V2 Dipole Calibration Certificate

	ation Service (SAS) e is one of the signatories		ccreditation No.: SCS 0108
Itilateral Agreement for the		certificates	
ent CCIC-HTW (Au	ıden)	Certificate N	o: D2600V2-1150_Feb18
ALIBRATION (	CERTIFICATE		
pject	D2600V2 - SN:11	50	
alibration procedure(s)	QA CAL-05.v9 Calibration proce	dure for dipole validation kits ab	ove 700 MHz
alibration date:	February 05, 201	8	
alibration Equipment used (M	&TE critical for calibration)		°C and humidity < 70%.
rimary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
rimary Standards	ID # SN: 104778	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522)	Scheduled Calibration Apr-18
rimary Standards lower meter NRP lower sensor NRP-Z91	ID # SN: 104778 SN: 103244	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521)	Scheduled Calibration
rrimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91	ID # SN: 104778 SN: 103244 SN: 103245	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522)	Scheduled Calibration Apr-18 Apr-18
rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 teference 20 dB Attenuator	ID # SN: 104778 SN: 103244	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521)	Scheduled Calibration Apr-18 Apr-18 Apr-18
rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 teference 20 dB Attenuator ype-N mismatch combination	ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k)	Cal Date (Certificate No.) 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)	Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18
rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 teference 20 dB Attenuator ype-N mismatch combination teference Probe EX3DV4	ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327	Cal Date (Certificate No.) 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)	Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18
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rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 teference 20 dB Attenuator type-N mismatch combination teference Probe EX3DV4 0AE4 Secondary Standards	ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID #	Cal Date (Certificate No.) 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) 30-Dec-17 (No. EX3-7349_Dec17)	Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18
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rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 teference 20 dB Attenuator type-N mismatch combination teference Probe EX3DV4 0AE4 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	Cal Date (Certificate No.)           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)           30-Dec-17 (No. EX3-7349_Dec17)           26-Oct-17 (No. DAE4-601_Oct17)           Check Date (in house)           07-Oct-15 (in house check Oct-16)           07-Oct-15 (in house check Oct-16)           07-Oct-15 (in house check Oct-16)	Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
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## **Calibration Laboratory of** Schmid & Partner

Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland

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%.

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- Service suisse d'étalonnage С
- Servizio svizzero di taratura
- S Swiss Calibration Service

Accreditation No.: SCS 0108

## **Measurement Conditions**

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

DASY Version	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2600 MHz ± 1 MHz	

Head TSL parameters The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.3 ± 6 %	2.04 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	14.3 W/kg	
SAR for nominal Head TSL parameters	normalized to 1W	55.6 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	6.36 W/kg	

Body TSL parameters The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.0 ± 6 %	2.22 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	13.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	54.6 W/kg ± 17.0 % (k=2)
	condition	
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition 250 mW input power	6.16 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	49.4 Ω - 7.1 jΩ
Return Loss	- 22.9 dB

## Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.9 Ω - 4.4 jΩ
Return Loss	- 25.1 dB

## **General Antenna Parameters and Design**

1.141 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	August 29, 2017

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## DASY5 Validation Report for Head TSL

Date: 05.02.2018

Test Laboratory: SPEAG, Zurich, Switzerland

## DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1150

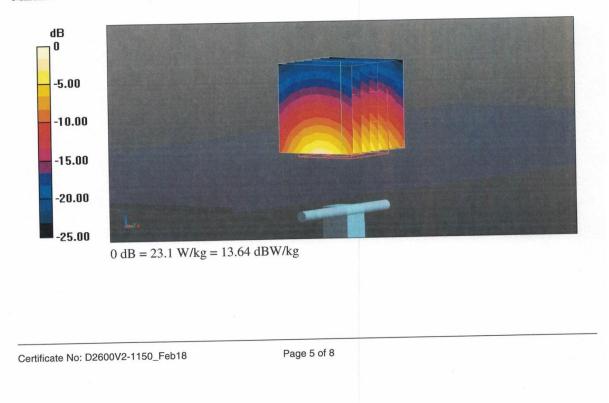
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz;  $\sigma$  = 2.04 S/m;  $\epsilon_r$  = 37.3;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

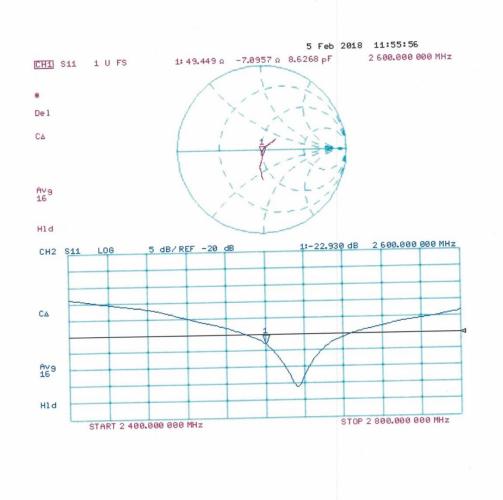
DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.7, 7.7, 7.7); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 116.4 V/m; Power Drift = -0.04 dB Peak SAR (extrapolated) = 28.9 W/kg SAR(1 g) = 14.3 W/kg; SAR(10 g) = 6.36 W/kg Maximum value of SAR (measured) = 23.1 W/kg





Impedance Measurement Plot for Head TSL

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## DASY5 Validation Report for Body TSL

Date: 05.02.2018

Test Laboratory: SPEAG, Zurich, Switzerland

## DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1150

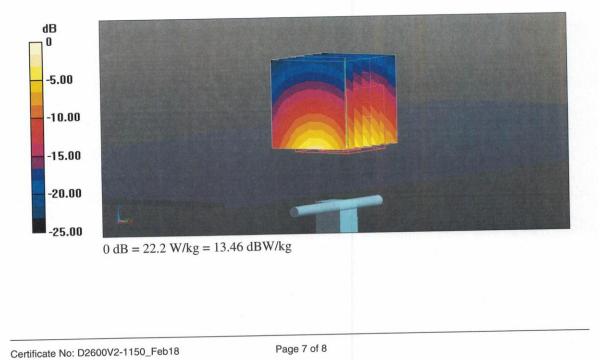
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz;  $\sigma$  = 2.22 S/m;  $\epsilon_r$  = 51;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

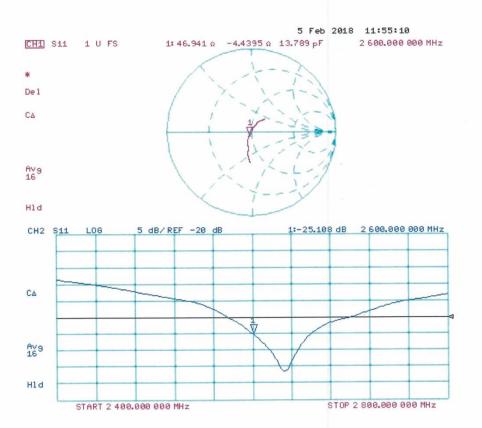
- Probe: EX3DV4 SN7349; ConvF(7.81, 7.81, 7.81); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 105.5 V/m; Power Drift = -0.07 dB Peak SAR (extrapolated) = 29.0 W/kg SAR(1 g) = 13.9 W/kg; SAR(10 g) = 6.16 W/kgMaximum value of SAR (measured) = 22.2 W/kg







Certificate No: D2600V2-1150\_Feb18

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# **Extended Dipole Calibrations**

Referring to KDB865664 D01, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

			Head-750			
Date of	Poturn loop (dP)	Dolto (9/)	Real Impedance	Delta	Imaginary	Delta
measurement	Return-loss (dB)	Delta (%)	(ohm)	(ohm)	impedance (ohm)	(ohm)
2018/2/5	-22.9		49.4		-7.1	
2019/2/3	-23.4	2.18%	48.8	0.6	-6.7	0.4

			Body-750			
Date of	Return-loss (dB)	Delta (%)	Real Impedance	Delta	Imaginary	Delta
measurement	Return-1055 (ub)	Della (%)	(ohm)	(ohm)	impedance (ohm)	(ohm)
2018/2/5	-25.1		46.9		-4.4	
2019/2/3	-25.7	2.39%	46.2	0.7	-3.9	0.5

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 50hm of prior calibration. Therefore the verification result should support extended calibration.

# 1.7. D5GHzV2 Dipole Calibration Certificate

coredited by the Swiss Accredit	ation Sonvice (SAS)	and a later and a later a late	S Swiss Calibration Service
accredited by the Swiss Accreditation Servic	e is one of the signatorie		Accreditation No.: SCS 0108
lultilateral Agreement for the r			No: D5GHzV2-1273 Feb18
			No: D3GH2V2-12/3_Feb10
Object	D5GHzV2 - SN:1	1273	
Calibration procedure(s)	QA CAL-22.v2 Calibration proce	edure for dipole validation kits b	between 3-6 GHz
Calibration date:	February 21, 201	18	
The measurements and the unce	ertainties with confidence p	ional standards, which realize the physical probability are given on the following pages ry facility: environment temperature ( $22 \pm 3$	and are part of the certificate.
The measurements and the unce NI calibrations have been conduc Calibration Equipment used (M&	ertainties with confidence p	probability are given on the following pages	and are part of the certificate.
The measurements and the unce	ertainties with confidence p cted in the closed laborato TE critical for calibration)	probability are given on the following pages ry facility: environment temperature (22 $\pm$ :	s and are part of the certificate. 3)°C and humidity < 70%.
The measurements and the unce NI calibrations have been conduc Calibration Equipment used (M& Primary Standards Power meter NRP	ertainties with confidence p cted in the closed laborato TE critical for calibration)	probability are given on the following pages ry facility: environment temperature (22 ± : Cal Date (Certificate No.)	s and are part of the certificate. 3)°C and humidity < 70%. Scheduled Calibration
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The measurements and the unce All calibrations have been conduc Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 PAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A	in the closed laborato           in the closed laborato           TE critical for calibration)           ID #           SN: 104778           SN: 103244           SN: 103245           SN: 5058 (20k)           SN: 5047.2 / 06327           SN: 3503           SN: 601           ID #           SN: GB37480704	Cal Date (Certificate No.)           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)           30-Dec-17 (No. 217-02529)           30-Dec-17 (No. 217-02529)           30-Dec-17 (No. EX3-3503_Dec17)           26-Oct-17 (No. DAE4-601_Oct17)           Check Date (in house)           07-Oct-15 (in house check Oct-16)	s and are part of the certificate. 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Dec-18 Oct-18 Scheduled Check In house check: Oct-18
The measurements and the unce All calibrations have been conduc Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 PAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A	in the closed laborato           in the closed laborato           TE critical for calibration)           ID #           SN: 104778           SN: 103244           SN: 103245           SN: 5058 (20k)           SN: 5047.2 / 06327           SN: 3503           SN: 601           ID #           SN: 0837480704           SN: US37292783	Cal Date (Certificate No.)           04-Apr-17 (No. 217-02521/02522)           04-Apr-17 (No. 217-02521)           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)           30-Dec-17 (No. EX3-3503_Dec17)           26-Oct-17 (No. DAE4-601_Oct17)           Check Date (in house)           07-Oct-15 (in house check Oct-16)           07-Oct-15 (in house check Oct-16)	s and are part of the certificate. 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18
The measurements and the unce All calibrations have been conduc Calibration Equipment used (M& Primary Standards Power meter NRP 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	in the closed laborato           in the closed laborato           TE critical for calibration)           ID #           SN: 104778           SN: 103244           SN: 103245           SN: 5058 (20k)           SN: 5047.2 / 06327           SN: 3503           SN: 601           ID #           SN: 037292783           SN: WY41092317	Cal Date (Certificate No.)           04-Apr-17 (No. 217-02521/02522)           04-Apr-17 (No. 217-02521)           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)           30-Dec-17 (No. 217-02529)           30-Dec-17 (No. EX3-3503_Dec17)           26-Oct-17 (No. DAE4-601_Oct17)           Check Date (in house)           07-Oct-15 (in house check Oct-16)           07-Oct-15 (in house check Oct-16)           07-Oct-15 (in house check Oct-16)	s and are part of the certificate. 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
The measurements and the unce All calibrations have been conduct Calibration Equipment used (M& Primary Standards Power meter NRP 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 Regenerator R&S SMT-06 letwork Analyzer HP 8753E	inthe closed laborato           in the closed laborato           TE critical for calibration)           ID #           SN: 104778           SN: 103244           SN: 103245           SN: 5058 (20k)           SN: 5047.2 / 06327           SN: 3503           SN: 601           ID #           SN: GB37480704           SN: US37292783           SN: 100972           SN: US37390585           Name	Cal Date (Certificate No.)           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)           30-Dec-17 (No. 217-02529)           30-Dec-17 (No. EX3-3503_Dec17)           26-Oct-17 (No. DAE4-601_Oct17)           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-17)	s and are part of the certificate. 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18
The measurements and the unce All calibrations have been conduct Calibration Equipment used (M& Primary Standards Power meter NRP 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 Regenerator R&S SMT-06 letwork Analyzer HP 8753E	ID #           SN: 104778           SN: 103244           SN: 103245           SN: 5058 (20k)           SN: 5047.2 / 06327           SN: 3503           SN: 601           ID #           SN: 037292783           SN: 100972           SN: 100972           SN: US37390585	Cal Date (Certificate No.)           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)           04-Apr-17 (No. 217-02528)           07-Apr-17 (No. 217-02529)           30-Dec-17 (No. 217-02529)           30-Dec-17 (No. EX3-3503_Dec17)           26-Oct-17 (No. DAE4-601_Oct17)           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-17)	s and are part of the certificate. 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18
The measurements and the unce All calibrations have been conduc Calibration Equipment used (M& Primary Standards 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 Power sensor HP 8481A Power sensor HP 8481A Power sensor HP 8481A	inthe closed laborato           in the closed laborato           TE critical for calibration)           ID #           SN: 104778           SN: 103244           SN: 103245           SN: 5058 (20k)           SN: 5047.2 / 06327           SN: 3503           SN: 601           ID #           SN: GB37480704           SN: US37292783           SN: 100972           SN: US37390585           Name	Cal Date (Certificate No.)           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)           30-Dec-17 (No. 217-02529)           30-Dec-17 (No. EX3-3503_Dec17)           26-Oct-17 (No. DAE4-601_Oct17)           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-17)	s and are part of the certificate. 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18