

Appendix C. Calibration Certificate for Probe and Dipole

The SPEAG calibration certificates are shown as follows.

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



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S Swiss Calibration Service

Accreditation No.: SCS 0108

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Client BV ADT CN (Auden)

Certificate No: D750V3-1067_Aug16

Cardina Contra da a	D750V3 - SN:106	57	
alibration procedure(s)	QA CAL-05.v9 Calibration proce	dure for dipole validation kits abo	ove 700 MHz
alibration date:	August 30, 2016		
his calibration certificate docu	ments the traceability to nat	ional standards, which realize the physical un	its of measurements (SI).
he measurements and the un	ertainties with confidence p	robability are given on the following pages an	d are part of the certificate.
Il calibrations have been cond	ucted in the closed laborato	ry facility: environment temperature $(22 \pm 3)^{\circ}$	C and humidity < 70%.
alibration Equipment used (M	&TE critical for calibration)		
rimary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
ower meter NRP	SN: 104778	06-Apr-16 (No. 217-02288/02289)	Apr-17
ower sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
ower sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
eference 20 dB Attenuator	SN: 5058 (20k)	05-Apr-16 (No. 217-02292)	Apr-17
pe-N mismatch combination	SN: 5047.2 / 06327	05-Apr-16 (No. 217-02295)	Apr-17
eference Probe EX3DV4	SN: 7349	15-Jun-16 (No. EX3-7349_Jun16)	Jun-17
AE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-16
	ID #	Check Date (in house)	Scheduled Check
Secondary Standards		onoon bate (in nodeo)	Scheduled Offeck
econdary Standards 'ower meter EPM-442A	SN: GB37480704	07-Oct-15 (No. 217-02222)	In house check: Oct-16
econdary Standards ower meter EPM-442A ower sensor HP 8481A	SN: GB37480704 SN: US37292783	07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222)	In house check: Oct-16 In house check: Oct-16
econdary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A	SN: GB37480704 SN: US37292783 SN: MY41092317	07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223)	In house check: Oct-16 In house check: Oct-16 In house check: Oct-16
econdary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972	07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15)	In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16
Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer HP 8753E	SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390585	07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15)	In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16
Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer HP 8753E	SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390585 Name	07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15) Function	In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 Signature
Secondary Standards Yower meter EPM-442A Yower sensor HP 8481A Yower sensor HP 8481A F generator R&S SMT-06 Ietwork Analyzer HP 8753E	SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390585 Name Michael Weber	07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15) Function Laboratory Technician	In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 Signature
Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer HP 8753E Calibrated by:	SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390585 Name Michael Weber	07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15) Function Laboratory Technician	In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 Signature

Calibration Laboratory of

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





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Accreditation No.: SCS 0108

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 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	750 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.9	0.89 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	42.4 ± 6 %	0.91 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.09 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	8.24 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm 3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.36 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	5.37 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	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.9 ± 6 %	0.99 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.25 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	8.77 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.47 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	5.76 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.8 Ω - 0.3 jΩ
Return Loss	- 26.8 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.0 Ω - 2.8 jΩ	
Return Loss	- 31.0 dB	

General Antenna Parameters and Design

Electrical Delay (one direction)	1.033 ns

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

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	May 10, 2012

DASY5 Validation Report for Head TSL

Date: 30.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1067

Communication System: UID 0 - CW; Frequency: 750 MHz Medium parameters used: f = 750 MHz; σ = 0.91 S/m; ϵ_r = 42.4; ρ = 1000 kg/m³ 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: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 57.93 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 3.12 W/kg SAR(1 g) = 2.09 W/kg; SAR(10 g) = 1.36 W/kg Maximum value of SAR (measured) = 2.77 W/kg



0 dB = 2.77 W/kg = 4.42 dBW/kg



DASY5 Validation Report for Body TSL

Date: 30.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1067

Communication System: UID 0 - CW; Frequency: 750 MHz Medium parameters used: f = 750 MHz; σ = 0.99 S/m; ϵ_r = 54.9; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(9.99, 9.99, 9.99); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 57.54 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 3.38 W/kg SAR(1 g) = 2.25 W/kg; SAR(10 g) = 1.47 W/kg Maximum value of SAR (measured) = 2.97 W/kg



0 dB = 2.97 W/kg = 4.73 dBW/kg



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BV ADT CN (Auden) Client

Certificate No: D835V2-4d139_Aug16

CALIBRATION CERTIFICATE

Object	D835V2 - SN: 4d	1139	
Calibration procedure(s)	QA CAL-05.v9		
	Calibration proce	dure for dipole validation kits abo	ove 700 MHz
Calibration date:	August 25, 2016		
This calibration certificate docume	ents the traceability to nat	ional standards, which realize the physical ur	its of measurements (SI)
The measurements and the uncer	tainties with confidence r	robability are given on the following pages ar	ad are part of the certificate
		······································	and part of the second second
Il calibrations have been conduc	ted in the closed laborato	ry facility: environment temperature $(22 \pm 3)^{\circ}$	C and humidity < 70%.
alibration Equipment used (M&T	E critical for calibration)		
rimary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
ower meter NRP	SN: 104778	06-Apr-16 (No. 217-02288/02289)	Apr-17
ower sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
ower sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
leference 20 dB Attenuator	SN: 5058 (20k)	05-Apr-16 (No. 217-02292)	Apr-17
ype-N mismatch combination	SN: 5047.2 / 06327	05-Apr-16 (No. 217-02295)	Apr-17
leference Probe EX3DV4	SN: 7349	15-Jun-16 (No. EX3-7349_Jun16)	Jun-17
AE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (No. 217-02223)	In house check: Oct-16
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Jun-15)	In house check: Oct-16
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16
	Name	Function	Signature
Calibrated by:	Michael Weber	Laboratory Technician	Milles
Approved by:	Katja Pokovic	Technical Manager	Ma

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

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Glossary:

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

Calibration is Performed According to the Following Standards:

- 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%.

Accreditation No.: SCS 0108

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	835 MHz ± 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	42.1 ± 6 %	0.93 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.40 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.40 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.55 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.09 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	54.7 ± 6 %	1.01 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.48 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	9.60 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	1.61 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	6.28 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.4 Ω - 3.2 jΩ
Return Loss	- 29.3 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.8 Ω - 5.4 jΩ
Return Loss	- 24.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.391 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	July 22, 2011

DASY5 Validation Report for Head TSL

Date: 25.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d139

Communication System: UID 0 - CW; Frequency: 835 MHz Medium parameters used: f = 835 MHz; $\sigma = 0.93$ S/m; $\epsilon_r = 42.1$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

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

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 62.09 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 3.65 W/kg SAR(1 g) = 2.4 W/kg; SAR(10 g) = 1.55 W/kg Maximum value of SAR (measured) = 3.24 W/kg



0 dB = 3.24 W/kg = 5.11 dBW/kg



DASY5 Validation Report for Body TSL

Date: 25.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d139

Communication System: UID 0 - CW; Frequency: 835 MHz Medium parameters used: f = 835 MHz; $\sigma = 1.01$ S/m; $\epsilon_r = 54.7$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

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

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 60.11 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 3.64 W/kg SAR(1 g) = 2.48 W/kg; SAR(10 g) = 1.61 W/kg Maximum value of SAR (measured) = 3.27 W/kg



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



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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

BV ADT CN (Auden) Client

Certificate No: D1750V2-1071_Aug16

Jolect	D1750V2 - SN:10	071	
Calibration procedure(s)	QA CAL-05.v9 Calibration proce	dure for dipole validation kits abo	ove 700 MHz
alibration date:	August 31, 2016		
his calibration certificate docume	ents the traceability to nati	ional standards, which realize the physical un	nits of measurements (SI).
he measurements and the unce	rtainties with confidence p	robability are given on the following pages ar	nd are part of the certificate.
Il calibrations have been conduc	ted in the closed laborato	ry facility: environment temperature (22 \pm 3)°	C and humidity < 70%.
Calibration Equipment used (M&T	E critical for calibration)		
	L.	and the second second	
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
ower meter NRP	SN: 104778	06-Apr-16 (No. 217-02288/02289)	Apr-17
ower sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
ower sensor NRP-Z91 ower sensor NRP-Z91	SN: 103244 SN: 103245	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289)	Apr-17 Apr-17
ower sensor NRP-Z91 ower sensor NRP-Z91 eference 20 dB Attenuator	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
Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination	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
ower sensor NRP-Z91 ower sensor NRP-Z91 eference 20 dB Attenuator ype-N mismatch combination eference Probe EX3DV4	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16)	Apr-17 Apr-17 Apr-17 Apr-17 Jun-17
Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 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) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15)	Apr-17 Apr-17 Apr-17 Apr-17 Jun-17 Dec-16
Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 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) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house)	Apr-17 Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check
Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 NAE4 Recondary Standards Tower meter EPM-442A	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 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) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222)	Apr-17 Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16
Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Recondary Standards Tower meter EPM-442A Tower sensor HP 8481A	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 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) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222)	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16 In house check: Oct-16
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: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223)	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16 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 Recondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A Regenerator R&S SMT-06 Retwork Analyzer HP 8753E	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: US37292783 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) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15)	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16
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	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: 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) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15) Function	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 Signature
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	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 Name Johannes Kurikka	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15) Function Laboratory Technician	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 Signature
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	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 Name Johannes Kurikka	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15) Function Laboratory Technician	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 Signature
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 Regenerator R&S SMT-06 Network Analyzer HP 8753E Calibrated by:	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: 100972 SN: US37390585 Name Johannes Kurikka Katja Pokovic	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15) Function Laboratory Technician Technical Manager	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 Signature
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 Retwork Analyzer HP 8753E Calibrated by:	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 Name Johannes Kurikka Katja Pokovic	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Jun-15) 18-Oct-01 (in house check Oct-15) Function Laboratory Technician	Apr-17 Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-10 In house check: Oct-10 In house check: Oct-10 In house check: Oct-10 Signature

Calibration Laboratory of

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



Schweizerischer Kalibrierdienst

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Swiss Calibration Service

Accreditation No.: SCS 0108

S

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, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)". February 2005
- c) IEC 62209-2. "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1750 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.1	1.37 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.3 ± 6 %	1.37 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.27 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	37.1 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	4.89 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	19.6 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	53.4	1.49 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.1 ± 6 %	1.49 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.32 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	37.2 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	4.99 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	19.9 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.5 Ω - 1.0 jΩ
Return Loss	- 39.3 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.3 Ω - 1.1 jΩ
Return Loss	- 30.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.220 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 19, 2011

DASY5 Validation Report for Head TSL

Date: 24.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1071

Communication System: UID 0 - CW; Frequency: 1750 MHz Medium parameters used: f = 1750 MHz; $\sigma = 1.37$ S/m; $\varepsilon_r = 40.3$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

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

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 105.8 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 17.3 W/kg SAR(1 g) = 9.27 W/kg; SAR(10 g) = 4.89 W/kg Maximum value of SAR (measured) = 14.4 W/kg



0 dB = 14.4 W/kg = 11.58 dBW/kg



DASY5 Validation Report for Body TSL

Date: 31.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1071

Communication System: UID 0 - CW; Frequency: 1750 MHz Medium parameters used: f = 1750 MHz; σ = 1.49 S/m; ϵ _r = 53.1; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

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

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 100.9 V/m; Power Drift = -0.00 dB Peak SAR (extrapolated) = 16.3 W/kg SAR(1 g) = 9.32 W/kg; SAR(10 g) = 4.99 W/kg Maximum value of SAR (measured) = 13.9 W/kg



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



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- S **Swiss Calibration Service**

Accreditation No.: SCS 0108

Certificate No: D1900V2-5d159_Aug16

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

BV ADT CN (Auden) Client

CALIBRATION CERTIFICATE D1900V2 - SN:5d159 Object QA CAL-05.v9 Calibration procedure(s) Calibration procedure for dipole validation kits above 700 MHz Calibration date: August 31, 2016 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) Scheduled Calibration Primary Standards ID # Cal Date (Certificate No.) SN: 104778 06-Apr-16 (No. 217-02288/02289) Apr-17 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 05-Apr-16 (No. 217-02292) Apr-17 SN: 5058 (20k) Reference 20 dB Attenuator Type-N mismatch combination SN: 5047.2 / 06327 05-Apr-16 (No. 217-02295) Apr-17 SN: 7349 15-Jun-16 (No. EX3-7349_Jun16) Jun-17 Reference Probe EX3DV4 DAE4 SN: 601 30-Dec-15 (No. DAE4-601_Dec15) Dec-16 Scheduled Check Secondary Standards 1D # Check Date (in house) SN: GB37480704 07-Oct-15 (No. 217-02222) In house check: Oct-16 Power meter EPM-442A In house check: Oct-16 Power sensor HP 8481A SN: US37292783 07-Oct-15 (No. 217-02222) SN: MY41092317 07-Oct-15 (No. 217-02223) In house check: Oct-16 Power sensor HP 8481A In house check: Oct-16 SN: 100972 15-Jun-15 (in house check Jun-15) RF generator R&S SMT-06 In house check: Oct-16 SN: US37390585 18-Oct-01 (in house check Oct-15) Network Analyzer HP 8753E Name Function Signature Mh Um Calibrated by: Johannes Kurikka Laboratory Technician Approved by: Katja Pokovic **Technical Manager** Issued: August 31, 2016 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

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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

Glossarv:

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

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	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	40.3 ± 6 %	1.40 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.96 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	39.9 W/kg ± 17.0 % (k=2)
	· · · ·	
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.25 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	21.0 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	52.9 ± 6 %	1.52 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.94 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.7 W/kg ± 17.0 % (k =2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.31 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.2 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.0 Ω + 7.3 jΩ
Return Loss	- 22.3 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.8 Ω + 8.7 jΩ
Return Loss	- 21.0 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 20, 2011

DASY5 Validation Report for Head TSL

Date: 31.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d159

Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; σ = 1.4 S/m; ϵ_r = 40.3; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

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

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 107.2 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 18.4 W/kg SAR(1 g) = 9.96 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



DASY5 Validation Report for Body TSL

Date: 31.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d159

Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; σ = 1.52 S/m; ϵ_r = 52.9; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.03, 8.03, 8.03); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 102.9 V/m; Power Drift = -0.06 dB Peak SAR (extrapolated) = 17.3 W/kg SAR(1 g) = 9.94 W/kg; SAR(10 g) = 5.31 W/kg Maximum value of SAR (measured) = 14.7 W/kg



0 dB = 14.7 W/kg = 11.67 dBW/kg



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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

Client BV ADT CN (Auden)

Certificate No: D2450V2-893_Aug16

Object	D2450V2 - SN:89	93	
Calibration procedure(s)	QA CAL-05.v9 Calibration proce	dure for dipole validation kits abo	ove 700 MHz
Calibration date:	August 26, 2016		
This calibration certificate docume	ents the traceability to nat	ional standards, which realize the physical ur	its of measurements (SI).
he measurements and the uncer	rtainties with confidence p	probability are given on the following pages ar	nd are part of the certificate.
Il calibrations have been conduc	ted in the closed laborato	ry facility: environment temperature $(22 \pm 3)^{\circ}$	C and humidity < 70%.
		, , , , , , , , , , , , , , , , , , ,	
Calibration Equipment used (M&T	E critical for calibration)		
Drive and Others devide	100 #	Col Data (Contificate No.)	Calendulad Calibration
Power motor NPP	CNI: 104779	Cal Date (Certificate No.)	Apr-17
ower meter NRP 701	SN: 104776	06 Apr 16 (No. 217-02266/02269)	Apr-17
ower sensor NRP-291	SN. 103244	06-Apr-16 (No. 217-02266)	Apr-17
oference 20 dB Attenuator	SN: 103245	06-Apt-16 (No. 217-02269)	Apr-17
ererence 20 dB Attenuator	SIN. 5056 (20K)	05-Apr-16 (No. 217-02292)	Apr-17
ype-IN mismatch combination	(SN: 5047.27 00327	05-Apr-16 (No. 217-02295)	Apr-17
AE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (No. 217-02222)	In house check: Oct-16
ower sensor HP 8481A	SN: MY41092317	07-Oct-15 (No. 217-02223)	In house check: Oct-16
F generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Jun-15)	In house check: Oct-16
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16
	Name	Function	Signature
Calibrated by:	Johannes Kurikka	Laboratory Technician	Julle Une
			1 2010
Approved by:	Katja Pokovic	Technical Manager	Alle
			10-6
		6	10-0-7

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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%.

Accreditation No.: SCS 0108

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	38.2 ± 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 ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.6 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	53.0 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.30 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.8 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	52.0 ± 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 ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.5 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	52.7 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.27 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.7 W/kg ± 16.5 % (k≃2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.6 Ω + 3.3 jΩ
Return Loss	- 26.6 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.4 Ω + 5.4 jΩ
Return Loss	- 24.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.160 ns
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	October 06, 2011

DASY5 Validation Report for Head TSL

Date: 26.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:893

Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz; σ = 1.88 S/m; ϵ_r = 38.2; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.72, 7.72, 7.72); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 112.9 V/m; Power Drift = 0.03 dB Peak SAR (extrapolated) = 27.3 W/kg SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.3 W/kg Maximum value of SAR (measured) = 22.3 W/kg



0 dB = 22.3 W/kg = 13.48 dBW/kg



DASY5 Validation Report for Body TSL

Date: 26.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:893

Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz; $\sigma = 2.04$ S/m; $\epsilon_r = 52$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

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

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 107.9 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 27.1 W/kg SAR(1 g) = 13.5 W/kg; SAR(10 g) = 6.27 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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BV ADT CN (Auden) Client

Certificate No: D2600V2-1110_Aug16

CALIBRATION CERTIFICATE

001601	D2600V2 - SN:11	10	
Calibration procedure(s)	QA CAL-05.v9 Calibration proce	dure for dipole validation kits abo	ove 700 MHz
Calibration date:	August 26, 2016		
This calibration certificate docume	ents the traceability to nati	onal standards, which realize the physical un	its of measurements (SI).
The measurements and the uncer	tainties with confidence p	robability are given of the following pages an	are part of the certificate.
All calibrations have been conduc	ted in the closed laborato	ry facility: environment temperature (22 \pm 3)°C	C and humidity < 70%.
Colibration Fourinment used /MAT	Continued for adjunction		
Calibration Equipment used (M& I	E chucai 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
ower sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91 Power sensor NRP-Z91	SN: 103244 SN: 103245	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289)	Apr-17 Apr-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) 05-Apr-16 (No. 217-02292)	Apr-17 Apr-17 Apr-17
Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Fype-N mismatch combination	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
Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Fype-N mismatch combination Reference Probe EX3DV4	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16)	Apr-17 Apr-17 Apr-17 Apr-17 Jun-17
Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 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) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15)	Apr-17 Apr-17 Apr-17 Apr-17 Jun-17 Dec-16
Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 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) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house)	Apr-17 Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check
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	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222)	Apr-17 Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16
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: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 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) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222)	Apr-17 Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16 In house check: Oct-16
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: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223)	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16 In house check: Oct-16 In house check: Oct-16
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	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15)	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16
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	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	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15)	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 Scheduled Check In house check: Oct-16 In house check: Oct-16
Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 <u>Secondary Standards</u> Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer HP 8753E	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: 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) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15) Function	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 <u>Scheduled Check</u> In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 Signature
Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 <u>Secondary Standards</u> Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer HP 8753E	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: 100972 SN: US37390585 Name Johannes Kurikka	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15) Function Laboratory Technician	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 <u>Scheduled Check</u> In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 Signature
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 Calibrated by:	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 Name Johannes Kurikka	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15) Function Laboratory Technician	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 <u>Scheduled Check</u> In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 Signature MMuu Muu
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Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 <u>Secondary Standards</u> Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer HP 8753E Calibrated by: Approved by:	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 Name Johannes Kurikka Katja Pokovic	06-Apr-16 (No. 217-02288) 06-Apr-16 (No. 217-02289) 05-Apr-16 (No. 217-02292) 05-Apr-16 (No. 217-02295) 15-Jun-16 (No. EX3-7349_Jun16) 30-Dec-15 (No. EX3-7349_Jun16) 30-Dec-15 (No. DAE4-601_Dec15) Check Date (in house) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02222) 07-Oct-15 (No. 217-02223) 15-Jun-15 (in house check Jun-15) 18-Oct-01 (in house check Oct-15) Function Laboratory Technician Technical Manager	Apr-17 Apr-17 Apr-17 Jun-17 Dec-16 <u>Scheduled Check</u> In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 In house check: Oct-16 Signature MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

Calibration Laboratory of

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



Schweizerischer Kalibrierdienst

S Service suisse d'étalonnage

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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 Accreditation No.: SCS 0108

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

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)". February 2005
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)". March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	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	37.6 ± 6 %	2.04 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	****	4W/80

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.5 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	56.5 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.3 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	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.6 ± 6 %	2.20 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	14.5 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	57.3 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.43 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	25.5 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	48.3 Ω - 8.5 jΩ		
Return Loss	- 21.2 dB		

Antenna Parameters with Body TSL

Impedance, transformed to feed point	44.9 Ω - 5.6 jΩ		
Return Loss	- 22.0 dB		

General Antenna Parameters and Design

Electrical Delay (one direction)	1.149 ns
----------------------------------	----------

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

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

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

Additional EUT Data

Manufactured by	SPEAG			
Manufactured on	February 18, 2015			

DASY5 Validation Report for Head TSL

Date: 26.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1110

Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz; $\sigma = 2.04$ S/m; $\epsilon_r = 37.6$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.56, 7.56, 7.56); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 115.4 V/m; Power Drift = 0.04 dB Peak SAR (extrapolated) = 30.8 W/kg SAR(1 g) = 14.5 W/kg; SAR(10 g) = 6.41 W/kg Maximum value of SAR (measured) = 24.8 W/kg



0 dB = 24.8 W/kg = 13.94 dBW/kg



DASY5 Validation Report for Body TSL

Date: 26.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1110

Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz; $\sigma = 2.2$ S/m; $\epsilon_r = 51.6$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.48, 7.48, 7.48); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 110.0 V/m; Power Drift = 0.03 dB Peak SAR (extrapolated) = 30.0 W/kg SAR(1 g) = 14.5 W/kg; SAR(10 g) = 6.43 W/kg Maximum value of SAR (measured) = 24.3 W/kg



0 dB = 24.3 W/kg = 13.86 dBW/kg



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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 BV ADT CN (Auden)

Certificate No: EX3-3873_Sep16

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3873
Calibration procedure(s)	QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6 Calibration procedure for dosimetric E-field probes
Calibration date:	September 1, 2016
Calibration date: This calibration certificate doc	September 1, 2016 uments the traceability to national standards, which realize the physical units of measurements (SI).

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)

ID	Cal Date (Certificate No.)	Scheduled Calibration
VRP SN: 104778 06-Apr-16 (No. 217-02288/02289)		Apr-17
SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
SN: S5277 (20x)	05-Apr-16 (No. 217-02293)	Apr-17
SN: 3013	31-Dec-15 (No. ES3-3013_Dec15)	Dec-16
SN: 660	23-Dec-15 (No. DAE4-660_Dec15)	Dec-16
1D	Check Date (in house)	Scheduled Check
SN: GB41293874	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
SN: MY41498087	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
SN: 000110210	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
SN: US3642U01700	04-Aug-99 (in house check Jun-16)	In house check: Jun-18
SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16
	ID SN: 104778 SN: 103244 SN: 103245 SN: S5277 (20x) SN: 3013 SN: 660 ID SN: GB41293874 SN: MY41498087 SN: 000110210 SN: US3642U01700 SN: US37390585	ID Cal Date (Certificate No.) SN: 104778 06-Apr-16 (No. 217-02288/02289) SN: 103244 06-Apr-16 (No. 217-02288) SN: 103245 06-Apr-16 (No. 217-02289) SN: S5277 (20x) 05-Apr-16 (No. 217-02293) SN: 3013 31-Dec-15 (No. ES3-3013_Dec15) SN: 660 23-Dec-15 (No. DAE4-660_Dec15) ID Check Date (in house) SN: GB41293874 06-Apr-16 (in house check Jun-16) SN: 000110210 06-Apr-16 (in house check Jun-16) SN: US3642U01700 04-Aug-99 (in house check Jun-16) SN: US37390585 18-Oct-01 (in house check Oct-15)

	Name	Function	Signature
Calibrated by:	Leif Klysner	Laboratory Technician	Seef Mly
Approved by:	Katja Pokovic	Technical Manager	flag.
			Issued: September 2, 2016
This calibration certificate	e shall not be reproduced except in ful	Il without written approval of the laborator	у.

Calibration Laboratory of

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



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- C Service suisse d'étalonnage
- S Servizio svizzero di taratura
- 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 Accreditation No.: SCS 0108

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization 9	9 rotation around an axis that is in the plane normal to probe axis (at measurement center),
	i.e., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

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"
- Methods Applied and Interpretation of Parameters:
 - NORMx, y, z: Assessed for E-field polarization 9 = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx, y, z are only intermediate values, i.e., the uncertainties of NORMx, y, z does not affect the E²-field uncertainty inside TSL (see below ConvF).
 - NORM(f)x,y,z = NORMx,y,z * frequency_response (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
 - DCPx,y,z: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
 - PAR: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
 - Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
 - ConvF and Boundary Effect Parameters: Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORMx,y,z * ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
 - Spherical isotropy (3D deviation from isotropy): in a field of low gradients realized using a flat phantom exposed by a patch antenna.
 - Sensor Offset: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
 - Connector Angle: The angle is assessed using the information gained by determining the NORMx (no uncertainty required).

Certificate No: EX3-3873_Sep16

Probe EX3DV4

SN:3873

Calibrated:

Manufactured: March 13, 2012 September 1, 2016

Calibrated for DASY/EASY Systems (Note: non-compatible with DASY2 system!)

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm (μV/(V/m)²) ^A	0.36	0.44	0.48	± 10.1 %
DCP (mV) ^B	97.0	96.4	97.5	

Modulation Calibration Parameters

UID	Communication System Name		Α	В	С	D	VR	Unc ^t
			dB	dB√μV		dB	mV	(k=2)
0	CW	Х	0.0	0.0	1.0	0.00	133.3	±2.5 %
		Y	0.0	0.0	1.0		148.6	
		Z	0.0	0.0	1.0		148.2	

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%.

^A The uncertainties of Norm X,Y,Z do not affect the E²-field uncertainty inside TSL (see Pages 5 and 6).

^BNumerical linearization parameter: uncertainty not required.

^E Uncertainty is determined using the max, deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

f (MHz) ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc (k=2)
750	41.9	0.89	10.26	10.26	10.26	0.38	0.80	± 12.0 %
835	41.5	0.90	9.78	9.78	9.78	0.30	1.01	± 12.0 %
900	41.5	0.97	9.66	9,66	9.66	0,45	0.80	± 12.0 %
1750	40.1	1.37	8.57	8.57	8.57	0.38	0.80	± 12.0 %
1900	40.0	1 40	8 30	8.30	8.30	0.32	0.80	+ 12 0 %
2300	39.5	1.67	7.91	7.91	7.91	0.31	0.88	+ 12 0 %
2450	39.2	1.80	7 42	7 42	7 42	0.32	0.80	+ 12.0 %
2600	39.0	1.96	7 29	7.29	7 29	0.28	0.80	+ 12.0 %
5250	35.9	4 71	5.09	5.09	5.09	0.35	1.80	+ 13.1 %
5600	35.5	5.07	4.67	4.67	4 67	0.40	1.80	+ 13 1 %
5800	35.3	5.27	4.76	4.76	4.76	0.40	1.80	± 13.1 %

Calibration Parameter Determined in Head Tissue Simulating Media

^c Frequency validity above 300 MHz of \pm 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to \pm 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is \pm 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to \pm 110 MHz.

validity can be extended to \pm 110 MHz. ^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to \pm 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to \pm 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

f (MHz) ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	СолуF Х	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc (k≃2)
750	55.5	0.96	9.73	9.73	9.73	0.42	0.87	± 12.0 %
835	55.2	0.97	9.90	9.90	9.90	0.40	0.90	± 12.0 %
900	55.0	1.05	9.55	9.55	9.55	0.49	0.80	± 12.0 %
1750	53.4	1.49	8.13	8.13	8.13	0.41	0.80	± 12.0 %
1900	53.3	1.52	7.85	7.85	7.85	0.40	0.80	± 12.0 %
2300	52.9	1.81	7.65	7.65	7.65	0.39	0.80	± 12.0 %
2450	52.7	1.95	7.46	7.46	7.46	0.32	0.80	± 12.0 %
2600	52.5	2.16	7.32	7.32	7.32	0.27	0.80	± 12.0 %
5250	48.9	5.36	4.39	4.39	4.39	0.45	1.90	± 13.1 %
5600	48.5	5.77	3.74	3.74	3.74	0.55	1.90	± 13.1 %
5800	48.2	6.00	3.97	3.97	3.97	0.55	1.90	± 13.1 %

Calibration Parameter Determined in Body Tissue Simulating Media

^c Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

⁶ At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to \pm 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to \pm 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.



Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)

Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)



Receiving Pattern (ϕ), $\vartheta = 0^{\circ}$

Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)



Dynamic Range f(SAR_{head}) (TEM cell , f_{eval}= 1900 MHz)



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Conversion Factor Assessment

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	25
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

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IMPORTANT NOTICE

USAGE OF THE DAE 4

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

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

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

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

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

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

Important Note:

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

Important Note:

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

Important Note:

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

Schmid & Partner Engineering

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



Schweizerischer Kalibrierdienst

S Service suisse d'étalonnage С

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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

BV ADT CN (Auden) Client

Certificate No: DAE4-1341_Aug16

Accreditation No.: SCS 0108

CALIBRATION CERTIFICATE

	DAE4 - SD 000 D0	04 BM - SN: 1341	
Calibration procedure(s)	QA CAL-06.v29 Calibration proced	lure for the data acquisition electro	onics (DAE)
Calibration date:	August 29, 2016		
This calibration certificate docume The measurements and the uncer All calibrations have been conduc Calibration Equipment used (M&1	ents the traceability to nation rtainties with confidence pro ited in the closed laboratory TE critical for calibration)	nal standards, which realize the physical units bability are given on the following pages and a facility: environment temperature (22 \pm 3)°C a	of measurements (SI). are part of the certificate. and humidity < 70%.
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
(eithley Multimeter Type 2001	SN: 0810278	09-Sep-15 (No:17153)	Sep-16
econdary Standards	1 ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit Calibrator Box V2.1	SE UWS 053 AA 1001 SE UMS 006 AA 1002	05-Jan-16 (in house check) 05-Jan-16 (in house check)	In house check: Jan-17 In house check: Jan-17
	Name	Function	Signature
Calibrated by:	Name Dominique Steffen	Function Technician	Signature
Calibrated by: Approved by:	Name Dominique Steffen Fin Bomholt	Function Technician Deputy Technical Manager	Signature Ala I.V. Burnur

Calibration Laboratory of

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





С

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Swiss Calibration Service

Accreditation No.: SCS 0108

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Glossary

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

Methods Applied and Interpretation of Parameters

coordinate system.

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

DC Voltage Measurement A/D - Converter Resolution nominal

High Range:	1LSB =	6.1μV,	full range =	-100+300 mV
Low Range:	1LSB =	61nV,	full range =	-1+3mV
DASY measurement p	arameters: Aut	o Zero Time: 3	sec; Measuring t	time: 3 sec

Calibration Factors	X	Y	Z
High Range	403.714 ± 0.02% (k=2)	403.944 ± 0.02% (k=2)	403.651 ± 0.02% (k=2)
Low Range	3.98549 ± 1.50% (k=2)	4.00465 ± 1.50% (k=2)	3.99812 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	170.5 ° ± 1 °
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Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (µV)	Difference (µV)	Error (%)
Channel X	+ Input	199995.85	0.08	0.00
Channel X	+ Input	20005.83	4.01	0.02
Channel X	- Input	-19998.95	1.59	-0.01
Channel Y	+ Input	199995.85	0.07	0.00
Channel Y	+ Input	20002.44	0.65	0.00
Channel Y	- Input	-20001.07	-0.54	0.00
Channel Z	+ Input	199996.01	0.46	0.00
Channel Z	+ Input	20000.52	-1.20	-0.01
Channel Z	- Input	-19999.96	0.74	-0.00

Low Range		Reading (µV)	Difference (µV)	Error (%)
Channel X	+ Input	2001.72	0.24	0.01
Channel X	+ Input	202.27	0.36	0.18
Channel X	- Input	-197.13	0.91	-0.46
Channel Y	+ Input	2001.81	0.44	0.02
Channel Y	+ Input	200.86	-0.89	-0.44
Channel Y	- Input	-199.26	-1.07	0.54
Channel Z	+ Input	2001.64	0.30	0.01
Channel Z	+ Input	200.73	-1.03	-0.51
Channel Z	- Input	-198.89	-0.56	0.28

2. Common mode sensitivity DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (μV)
Channel X	200	12.32	11.09
	- 200	-10.17	-11.00
Channel Y	200	-6.17	-6.53
	- 200	4.10	4.19
Channel Z	200	-21.37	-22.16
	- 200	21.13	20.83

3. Channel separation

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

	Input Voltage (mV)	Channel X (μV)	Channel Υ (μV)	Channel Z (μV)
Channel X	200	-	-4.18	-2.69
Channel Y	200	6.12	~	-1.73
Channel Z	200	10.16	2.60	_

4. AD-Converter Values with inputs shorted

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

	High Range (LSB)	Low Range (LSB)
Channel X	15983	17119
Channel Y	15927	16553
Channel Z	16264	16639

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec Input $10M\Omega$

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	1.33	0.39	2.35	0.42
Channel Y	-0.53	-1.56	0.59	0.41
Channel Z	-1.44	-2.48	-0.16	0.45

6. Input Offset Current

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

7. Input Resistance (Typical values for information)

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

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

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

9. Power Consumption (Typical values for information)

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



Appendix D. Photographs of EUT and Setup