4. System Validation Dipole (D5GHzV2,S/N:1020)

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

S Schweizerischer Kalibrierdienst
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Accreditation No.: **SCS 108**

Client **UL Japan (PTT)**

Certificate No: **D5GHzV2-1020_Jan13**

CALIBRATION CERTIFICATE

Object	D5GHzV2 - SN: 1020
Calibration procedure(s)	QA CAL-22.v2 Calibration procedure for dipole validation kits between 3-6 GHz
Calibration date:	January 11, 2013

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	01-Nov-12 (No. 217-01640)	Oct-13
Power sensor HP 8481A	US37292783	01-Nov-12 (No. 217-01640)	Oct-13
Reference 20 dB Attenuator	SN: 5058 (20k)	27-Mar-12 (No. 217-01530)	Apr-13
Type-N mismatch combination	SN: 5047.3 / 06327	27-Mar-12 (No. 217-01533)	Apr-13
Reference Probe EX3DV4	SN: 3503	28-Dec-12 (No. ES3-3503_Dec12)	Dec-13
DAE4	SN: 601	27-Jun-12 (No. DAE4-601_Jun12)	Jun-13

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP 8481A	MY41092317	18-Oct-02 (in house check Oct-11)	In house check: Oct-13
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-11)	In house check: Oct-13
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-12)	In house check: Oct-13

	Name	Function	Signature
Calibrated by:	Israe El-Naouq	Laboratory Technician	Israe El-Naouq
Approved by:	Katja Pokovic	Technical Manager	

Issued: January 11, 2013

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

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Accreditation No.: **SCS 108**

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) IEC 62209-2, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures"; Part 2: "Procedure to determine the Specific Absorption Rate (SAR) for including accessories and multiple transmitters", March 2010
b) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

Additional Documentation:

c) 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	V52.8.5
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz ± 1 MHz 5500 MHz ± 1 MHz 5800 MHz ± 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.6 ± 6 %	4.50 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.52 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**74.5 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.14 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**21.1 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.2 ± 6 %	4.79 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.08 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**80.0 W / kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.6 W/kg ± 19.5 % (k=2)**

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Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	33.8 ± 6 %	5.09 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.56 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**74.8 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.14 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**21.1 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.0 ± 6 %	5.42 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.50 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**74.4 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.10 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.8 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.5 ± 6 %	5.81 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.07 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**80.1 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.24 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**22.2 W/kg ± 19.5 % (k=2)**

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Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.0 ± 6 %	6.21 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.55 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**74.9 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.09 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.7 W/kg ± 19.5 % (k=2)**

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Appendix

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	49.6 Ω - 10.7 jΩ
Return Loss	- 19.5 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	50.2 Ω - 3.1 jΩ
Return Loss	- 30.2 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	56.8 Ω - 2.6 jΩ
Return Loss	- 23.3 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	49.3 Ω - 9.9 jΩ
Return Loss	- 20.0 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	50.5 Ω - 3.0 jΩ
Return Loss	- 30.4 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	57.4 Ω - 1.2 jΩ
Return Loss	- 23.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.199 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 05, 2004

DASY5 Validation Report for Head TSL

Date: 11.01.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1020

Communication System: CW; Frequency: 5200 MHz, Frequency: 5500 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 4.5 S/m; ε_r = 34.6; ρ = 1000 kg/m^3 , Medium parameters used: f = 5500 MHz; σ = 4.79 S/m; ε_r = 34.2; ρ = 1000 kg/m^3 , Medium parameters used: f = 5800 MHz; σ = 5.09 S/m; ε_r = 33.8; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.41, 5.41, 5.41); Calibrated: 28.12.2012, ConvF(4.91, 4.91, 4.91); Calibrated: 28.12.2012, ConvF(4.81, 4.81, 4.81); Calibrated: 28.12.2012;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.06.2012
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.5(1059); SEMCAD X 14.6.8(7028)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 63.407 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 28.8 W/kg
SAR(1 g) = 7.52 W/kg; SAR(10 g) = 2.14 W/kg
Maximum value of SAR (measured) = 18.0 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 63.837 V/m; Power Drift = 0.08 dB
Peak SAR (extrapolated) = 33.0 W/kg
SAR(1 g) = 8.08 W/kg; SAR(10 g) = 2.29 W/kg
Maximum value of SAR (measured) = 19.7 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 60.555 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 32.8 W/kg
SAR(1 g) = 7.56 W/kg; SAR(10 g) = 2.14 W/kg
Maximum value of SAR (measured) = 19.1 W/kg

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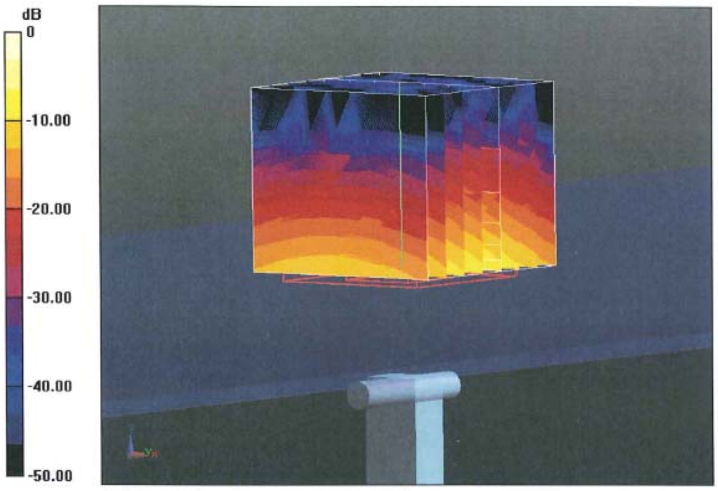
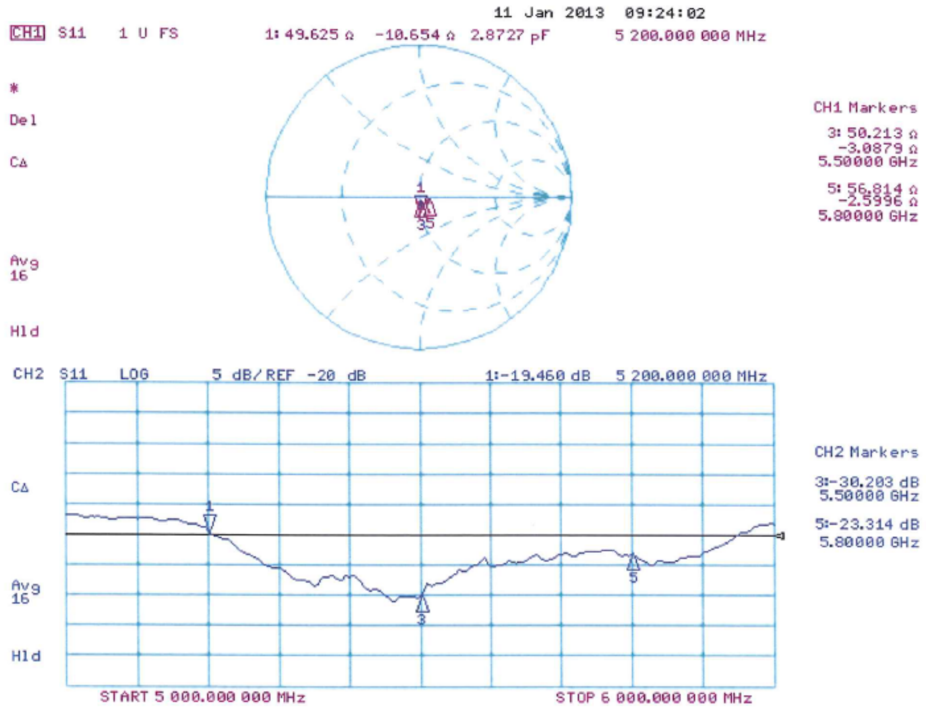


0 dB = 19.1 W/kg = 12.81 dBW/kg

Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL

Date: 10.01.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1020

Communication System: CW; Frequency: 5200 MHz, Frequency: 5500 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; $\sigma = 5.42$ S/m; $\varepsilon_r = 47$; $\rho = 1000$ kg/m^3 , Medium parameters used: f = 5500 MHz; $\sigma = 5.81$ S/m; $\varepsilon_r = 46.5$; $\rho = 1000$ kg/m^3 , Medium parameters used: f = 5800 MHz; $\sigma = 6.21$ S/m; $\varepsilon_r = 46$; $\rho = 1000$ kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(4.91, 4.91, 4.91); Calibrated: 28.12.2012, ConvF(4.43, 4.43, 4.43); Calibrated: 28.12.2012, ConvF(4.38, 4.38, 4.38); Calibrated: 28.12.2012;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.06.2012
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.5(1059); SEMCAD X 14.6.8(7028)

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 58.674 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 30.1 W/kg
SAR(1 g) = 7.5 W/kg; SAR(10 g) = 2.1 W/kg
Maximum value of SAR (measured) = 17.6 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 59.239 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 35.3 W/kg
SAR(1 g) = 8.07 W/kg; SAR(10 g) = 2.24 W/kg
Maximum value of SAR (measured) = 19.5 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 55.723 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 35.6 W/kg
SAR(1 g) = 7.55 W/kg; SAR(10 g) = 2.09 W/kg
Maximum value of SAR (measured) = 18.8 W/kg

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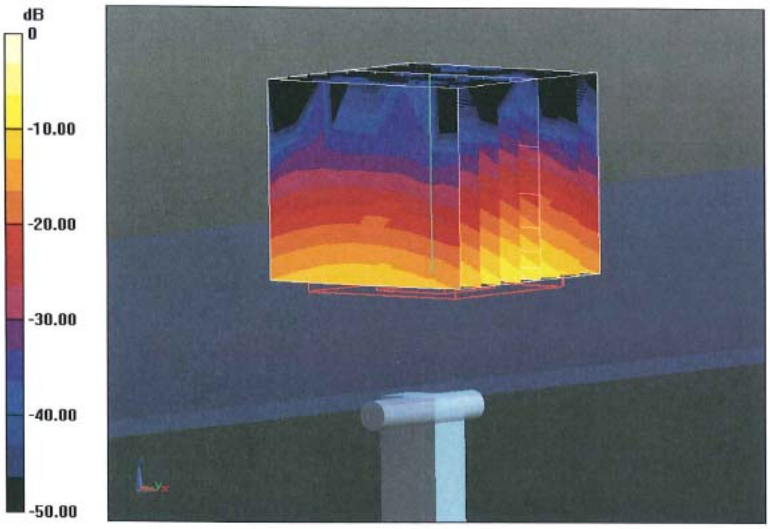

0 dB = 18.8 W/kg = 12.74 dBW/kg

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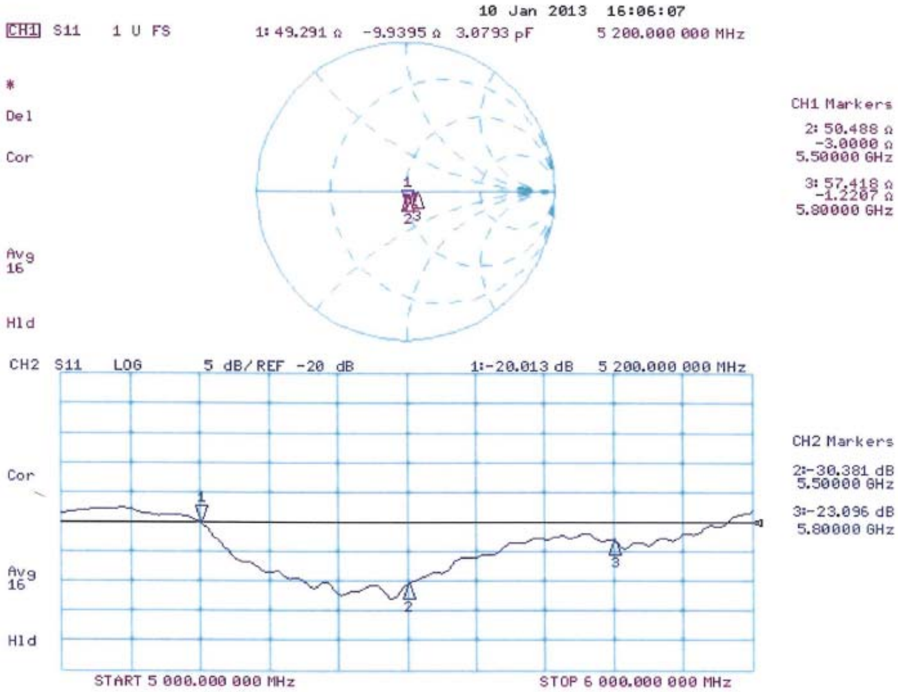
Impedance Measurement Plot for Body TSL



5. Validation uncertainty

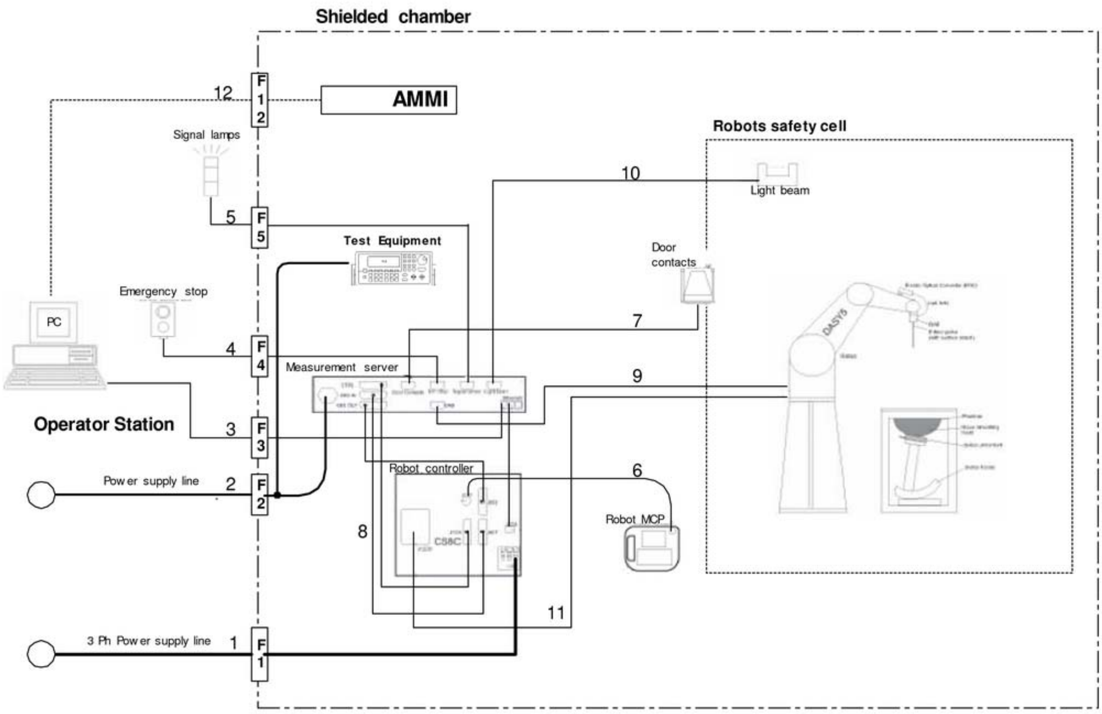
The uncertainty budget has been determined for the DASY5 measurement system according to the SPEAG documents[2] and is given in the following Table.

Error Description	Uncertai value ±		Probability distribution	divisor	(ci) 1g	Standard (1g)		vi or veff
Measurement System								
Probe calibration	±	6.55	Normal	1	1	±	6.55	∞
Axial isotropy of the probe	±	4.7	Rectangular	√3	1	±	2.7	∞
Spherical isotropy of the probe	±	9.6	Rectangular	√3	0	±	0.0	∞
Boundary effects	±	1.0	Rectangular	√3	1	±	0.6	∞
Probe linearity	±	4.7	Rectangular	√3	1	±	2.7	∞
Detection limit	±	1.0	Rectangular	√3	1	±	0.6	∞
Modulation response	±	0.0	Rectangular	√3	1	±	0.0	∞
Readout electronics	±	0.3	Normal	1	1	±	0.3	∞
Response time	±	0.0	Rectangular	√3	1	±	0.0	∞
Integration time	±	0.0	Rectangular	√3	1	±	0.0	∞
RF ambient Noise	±	1.0	Rectangular	√3	1	±	0.6	∞
RF ambient Reflections	±	1.0	Rectangular	√3	1	±	0.6	∞
Probe Positioner	±	0.8	Rectangular	√3	1	±	0.5	∞
Probe positioning	±	6.7	Rectangular	√3	1	±	3.9	∞
Max.SAR Eval.	±	2.0	Rectangular	√3	1	±	1.2	∞
Dipole Related								
Deviation of exp.dipole	±	5.5	Rectangular	√3	1	±	3.2	∞
Dipole Axis to Liquid Distance	±	2.0	Rectangular	√3	1	±	1.2	∞
Input power and SAR drift meas.	±	3.4	Rectangular	√3	1	±	2.0	∞
Phantom and Setup								
Phantom uncertainty	±	4.0	Rectangular	√3	1	±	2.3	∞
Liquid conductivity (target)	±	5.0	Rectangular	√3	0.78	±	2.3	∞
Liquid conductivity (meas.)	+	5.0	Normal	1	0.26	+	1.3	∞
Liquid permittivity (target)	±	5.0	Rectangular	√3	0.78	±	2.3	∞
Liquid permittivity (meas.)	-	5.0	Normal	1	0.23	-	1.2	∞
Liquid conductivity - temp.unc (below 2deg.C.)	±	1.7	Rectangular	√3	0.78	±	0.8	∞
Liquid permittivity - temp.unc (below 2deg.C.)	±	0.3	Rectangular	√3	0.23	±	0.0	∞
Combined Standard Uncertainty						±	**10.491**	
Expanded Uncertainty (k=2)						±	**21.0**	

Note: This uncertainty budget for validation is worst-case.

APPENDIX 3 : System specifications

1. Configuration and peripherals



The DASY5 system for performing compliance tests consist of the following items:

a) A standard high precision 6-axis robot (Stäubli RX family) with controller and software.
An arm extension for accommodating the data acquisition electronics (DAE).

b) An isotropic field probe optimized and calibrated for the targeted measurement.

c) A data acquisition electronic (DAE), which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.

d) The Electro-optical converter (EOC) performs the conversion between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection.
The EOC is connected to the measurement server.

e) The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.

f) The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.

g) A computer running WinXP and the DASY5 software.

h) Remote control with teaches pendant and additional circuitry for robot safety such as warning lamps, etc.

i) The phantom, the device holder and other accessories according to the targeted measurement.

2. Specifications

a)Robot TX60L

Number of Axes	:	6
Nominal Load	:	2 kg
Maximum Load	:	5kg
Reach	:	920mm
Repeatability	:	+/-0.03mm
Control Unit	:	CS8c
Programming Language	:	VAL3
Weight	:	52.2kg
Manufacture	:	Stäubli Robotics

b)E-Field Probe

EX3DV4 E-field Probe

Model	:	EX3DV4
Serial No.	:	3825
Construction	:	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., glycol ether)
Frequency	:	10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
Directivity	:	+/-0.3 dB in HSL (rotation around probe axis) +/-0.5 dB in tissue material (rotation normal probe axis)
Dynamic Range	:	10uW/g to > 100 mW/g;Linearity +/-0.2 dB(noise: typically < 1uW/g)
Dimensions	:	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 2.5mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm
Application	:	Highprecision dosimetric measurement in any exposure scenario (e.g., very strong gradient fields).Only probe which enables compliance testing for frequencies up to 6GHz with precision of better 30%.
Manufacture	:	Schimid & Partner Engineering AG

ET3DV6 E-field Probe

Model	:	ET3DV6
Serial No.	:	1685
Construction	:	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., glycol ether)
Frequency	:	10 MHz to 2.3 GHz Linearity: ± 0.2 dB (30 MHz to 2.3 GHz)
Directivity	:	+/-0.2 dB in HSL (rotation around probe axis) +/-0.4 dB in tissue material (rotation normal probe axis)
Dynamic Range	:	5 µW/g to > 100 mW/g; Linearity: ± 0.2 dB
Optical Surface Detection	:	± 0.2 mm repeatability in air and clear liquids over diffuse reflecting surfaces
Dimensions	:	Overall length: 337 mm (Tip: 16 mm) Tip diameter: 6.8 mm (Body: 12 mm) Distance from probe tip to dipole centers: 2.7 mm
Application	:	General dosimetric measurements up to 2.3 GHz Compliance tests of mobile phones Fast automatic scanning in arbitrary phantoms
Manufacture	:	Schimid & Partner Engineering AG

c)Data Acquisition Electronic (DAE4)

Features	:	Signal amplifier, multiplexer, A/D converter and control logic Serial optical link for communication with DASY5 embedded system (fully remote controlled) Two step probe touch detector for mechanical surface detection and emergency robot stop
Measurement Range	:	-100 to +300 mV (16 bit resolution and two range settings: 4mV, 400mV)
Input Offset voltage	:	< 5 μV (with auto zero)
Input Resistance	:	200 MΩ
Input Bias Current	:	< 50 fA
Battery Power	:	> 10 h of operation (with two 9.6 V NiMH accus)
Dimension	:	60 x 60 x 68 mm
Manufacture	:	Schimid & Partner Engineering AG

d)Electro-Optic Converter (EOC)

Version	:	EOC 61
Descrption	:	for TX60 robot arm, including proximity sensor
Manufacture	:	Schimid & Partner Engineering AG

e)DASY5 Measurement server

Features	:	Intel ULV Celeron 400MHz 128MB chip disk and 128MB RAM 16 Bit A/D converter for surface detection system Vacuum Fluorescent Display Robot Interface Serial link to DAE (with watchdog supervision) Door contact port (Possibility to connect a light curtain) Emergency stop port (to connect the remote control) Signal lamps port Light beam port Three Ethernet connection ports Two USB 2.0 Ports Two serial links Expansion port for future applications
Dimensions (L x W x H)	:	440 x 241 x 89 mm
Manufacture	:	Schimid & Partner Engineering AG

f) Light Beam Switches

Version	:	LB5
Dimensions (L x H)	:	110 x 80 mm
Thickness	:	12 mm
Beam-length	:	80 mm
Manufacture	:	Schimid & Partner Engineering AG

g)Software

Item	:	Dosimetric Assesment System DASY5
Type No.	:	SD 000 401A, SD 000 402A
Software version No.	:	DASY52, Version 52.6 (1)
Manufacture / Origin	:	Schimid & Partner Engineering AG

h)Robot Controll Unit

Weight	:	70 Kg
AC Input Voltage	:	selectable
Manufacturer	:	Stäubli Robotics

i)Phantom and Device Holder

Phantom

Type	:	SAM Twin Phantom V4.0
Description	:	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.
Material	:	Vinylester, glass fiber reinforced (VE-GF)
Shell Material	:	Fiberglass
Thickness	:	2.0 +/-0.2 mm
Dimensions	:	Length: 1000 mm Width: 500 mm Height: adjustable feet
Volume	:	Approx. 25 liters
Manufacture	:	Schimid & Partner Engineering AG

Type	:	2mm Flat phantom ERI4.0
Description	:	Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI4 is fully compatible with the latest draft of the standard IEC 62209 Part II and all known tissue simulating liquids. ELI4 has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is supported by software version DASY4.5 and higher and is compatible with all SPEAG dosimetric probes and dipoles.
Material	:	Vinylester, glass fiber reinforced (VE-GF)
Shell Thickness	:	2.0 ± 0.2 mm (sagging: <1%)
Filling Volume	:	approx. 30 liters
Dimensions	:	Major ellipse axis: 600 mm Minor axis: 400 mm
Manufacture	:	Schimid & Partner Engineering AG

Device Holder

In combination with the Twin SAM Phantom V4.0/V4.0c or ELI4, the Mounting Device enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to IEC, IEEE, FCC or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).

Material : POM

Laptio Extensions kit

Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices according to IEC 62209-2 (e.g., laptops, cameras, etc.). It is lightweight and fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin-SAM, ELI4 Phantoms.

Material : POM, Acrylic glass, Foam

Urethane

For this measurement, the urethane foam was used as device holder.

j)Simulated Tissues (Liquid)

The following tissue formulations are provided for reference only as some of the parameters have not been thoroughly verified. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for required for routine SAR evaluation.

Mixture (%)	Frequency (MHz)									
	450		900		1800		1950		2450	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body
Water	38.91	46.21	40.29	50.75	55.24	70.17	55.41	69.79	55.0	68.64
Sugar	56.93	51.17	57.90	48.21	-	-	-	-	-	-
Cellulose	0.25	0.18	0.24	0.00	-	-		-	-	-
Salt (NaCl)	3.79	2.34	1.38	0.94	0.31	0.39	0.08	0.2	-	-
Preventol	0.12	0.08	0.18	0.10	-				-	-
DGMBE	-	-	-	-	44.45	29.44	44.51	30.0	45.0	31.37
Dielectric Constant	43.42	58.0	42.54	56.1	42.0	56.8	39.9	54.0	39.8	52.5
Conductivity (S/m)	0.85	0.83	0.91	0.95	1.0	1.07	1.42	1.45	1.88	1.78

Note:DGMBE(Diethylenglycol-monobuthyl ether)

The simulated tissue (liguid) of 1800MHz was used for the test frequency of 1700MHz to 1800MHz.

Mixture (%)	Frequency(MHz)
	750
Tissue Type	Head and Body
Water	35-58%
Sugar	40-60%
Cellulose	<0.3%
Salt (NaCl)	0-6%
Preventol	0.1-0.7%
DGMBE	-

Mixture (%)	Frequency(MHz)	
	5800	
Tissue Type	Head	Body
Water	64.0	78.0
Mineral Oil	18.0	11.0
Emulsifiers	15.0	9.0
Additives and salt	3.0	2.0

Decision on Simulated Tissues of 750MHz

In the current standards (e.g., IEC62209-2, IEEE P1528, OET 65 Supplement C), the dielectric parameters suggested for head and body tissue simulating liquid are given at 450MHz and 835MHz. As an intermediate solution, dielectric parameters for the frequencies between 450 to 835MHz were obtained using linear interpolation. Therefore the dielectric parameter of 750MHz(The frequency for the validation) was decided as following.

f (MHz)	Head Tissue		Body Tissue		Reference
	ε r	σ [mho/m]	ε r	σ [mho/m]	
450	43.5	0.87	56.7	0.94	Standard
750	41.94	0.89	55.5	0.96	Interpolated
835	41.5	0.9	55.2	0.97	Standard

Standard and interpolated dielectric parameters for head and body tissue simulating liquid in the frequency range 450 to 835MHz.

Decision on Simulated Tissues of 1750MHz

In the current standards (e.g., IEC62209-2, IEEE P1528, OET 65 Supplement C), the dielectric parameters suggested for head and body tissue simulating liquid are given at 1610MHz and 1800MHz. As an intermediate solution, dielectric parameters for the frequencies between 1610 to 1800MHz were obtained using linear interpolation.
Therefore the dielectric parameter of 1750MHz(The frequency for the validation) was decided as following.

f (MHz)	Head Tissue		Body Tissue		Reference
	ε r	σ [mho/m]	E r	σ [mho/m]	
1450	40.5	0.87	54.0	1.30	Standard
1610	40.3	1.29	53.8	1.40	Standard
1750	40.08	1.37	53.43	1.49	Interpolated
1800	40.0	1.40	53.3	1.52	Standard

Standard and interpolated dielectric parameters for head and body tissue simulating liquid in the frequency range 1610 to 1800MHz.

Decision on Simulated Tissues of 5GHz band

In the current standards (e.g., IEC62209-2, IEEE P1528, OET 65 Supplement C), the dielectric parameters suggested for head and body tissue simulating liquid are given at 3000MHz and 5800MHz. As an intermediate solution, dielectric parameters for the frequencies between 5000to 5800 MHz were obtained using linear interpolation.
Therefore the dielectric parameters of 5200MHz,5300MHz,5600MHz and 5500MHz(The frequency for the validation) were decided as following.

f (MHz)	Head Tissue		Body Tissue		Reference
	ε r	σ [mho/m]	ε r	σ [mho/m]	
3000	38.5	2.40	52.0	2.73	Standard
5800	35.3	5.27	48.2	6.00	Standard
5000	36.2	4.45	49.3	5.07	Interpolated
5100	36.1	4.55	49.1	5.18	Interpolated
5200	36.0	4.66	49.0	5.30	Interpolated
5300	35.9	4.76	48.9	5.42	Interpolated
5400	35.8	4.86	48.7	5.53	Interpolated
5500	35.6	4.96	48.6	5.65	Interpolated
5600	35.5	5.07	48.5	5.77	Interpolated
5700	35.4	5.17	48.3	5.88	Interpolated

Standard and interpolated dielectric parameters for head and body tissue simulating liquid in the frequency range 3000 to 5800MHz.

3. Dosimetric E-Field Probe Calibration (EX3DV4, S/N: 3825)

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

S Schweizerischer Kalibrierdienst
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 108

Client UL Japan (PTT)

Certificate No: EX3-3825_Dec12

CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:3825

Calibration procedure(s): QA CAL-01.v8, QA CAL-14.v3, QA CAL-23.v4, QA CAL-25.v4
Calibration procedure for dosimetric E-field probes

Calibration date: December 10, 2012

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	29-Mar-12 (No. 217-01508)	Apr-13
Power sensor E4412A	MY41498087	29-Mar-12 (No. 217-01508)	Apr-13
Reference 3 dB Attenuator	SN: S5054 (3c)	27-Mar-12 (No. 217-01531)	Apr-13
Reference 20 dB Attenuator	SN: S5086 (20b)	27-Mar-12 (No. 217-01529)	Apr-13
Reference 30 dB Attenuator	SN: S5129 (30b)	27-Mar-12 (No. 217-01532)	Apr-13
Reference Probe ES3DV2	SN: 3013	29-Dec-11 (No. ES3-3013_Dec11)	Dec-12
DAE4	SN: 660	20-Jun-12 (No. DAE4-660_Jun12)	Jun-13
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-11)	In house check: Apr-13
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-12)	In house check: Oct-13

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: December 11, 2012

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

S Schweizerischer Kalibrierdienst
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 108**

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	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
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

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 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 E^2-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, VRx,y,z: A, B, C* 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.

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Probe EX3DV4

SN:3825

Manufactured: September 6, 2011
Calibrated: December 10, 2012

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

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3825

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm (µV/(V/m)^2)[A]	0.43	0.39	0.43	± 10.1 %
DCP (mV)[B]	96.9	102.5	99.7	

Modulation Calibration Parameters

UID	Communication System Name	PAR		A dB	B dB	C dB	VR mV	Unc[E] (k=2)
0	CW	0.00	X	0.0	0.0	1.0	147.0	±3.0 %
			Y	0.0	0.0	1.0	138.8	
			Z	0.0	0.0	1.0	149.6	

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 NormX,Y,Z do not affect the E^2-field uncertainty inside TSL (see Pages 5 and 6).
[B] Numerical 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.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3825

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
750	41.9	0.89	9.91	9.91	9.91	0.27	1.05	± 12.0 %
835	41.5	0.90	9.50	9.50	9.50	0.19	1.13	± 12.0 %
900	41.5	0.97	9.36	9.36	9.36	0.12	1.68	± 12.0 %
1750	40.1	1.37	8.18	8.18	8.18	0.27	0.94	± 12.0 %
1810	40.0	1.40	7.94	7.94	7.94	0.37	0.84	± 12.0 %
1900	40.0	1.40	7.93	7.93	7.93	0.71	0.63	± 12.0 %
2000	40.0	1.40	7.89	7.89	7.89	0.45	0.70	± 12.0 %
2450	39.2	1.80	7.21	7.21	7.21	0.37	0.76	± 12.0 %
2600	39.0	1.96	6.99	6.99	6.99	0.38	0.79	± 12.0 %
5200	36.0	4.66	5.39	5.39	5.39	0.30	1.80	± 13.1 %
5300	35.9	4.76	5.28	5.28	5.28	0.30	1.80	± 13.1 %
5500	35.6	4.96	5.03	5.03	5.03	0.30	1.80	± 13.1 %
5600	35.5	5.07	4.68	4.68	4.68	0.35	1.80	± 13.1 %
5800	35.3	5.27	4.84	4.84	4.84	0.30	1.80	± 13.1 %

[C] Frequency validity 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.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 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 ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3825

Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
750	55.5	0.96	9.69	9.69	9.69	0.44	0.79	± 12.0 %
835	55.2	0.97	9.55	9.55	9.55	0.67	0.65	± 12.0 %
900	55.0	1.05	9.38	9.38	9.38	0.73	0.60	± 12.0 %
1750	53.4	1.49	7.99	7.99	7.99	0.30	0.91	± 12.0 %
1810	53.3	1.52	7.77	7.77	7.77	0.24	1.08	± 12.0 %
1900	53.3	1.52	7.59	7.59	7.59	0.36	0.86	± 12.0 %
2000	53.3	1.52	7.73	7.73	7.73	0.47	0.72	± 12.0 %
2450	52.7	1.95	7.33	7.33	7.33	0.80	0.50	± 12.0 %
2600	52.5	2.16	7.01	7.01	7.01	0.80	0.50	± 12.0 %
5200	49.0	5.30	4.63	4.63	4.63	0.40	1.90	± 13.1 %
5300	48.9	5.42	4.34	4.34	4.34	0.45	1.90	± 13.1 %
5500	48.6	5.65	3.89	3.89	3.89	0.45	1.90	± 13.1 %
5600	48.5	5.77	3.85	3.85	3.85	0.40	1.90	± 13.1 %
5800	48.2	6.00	4.20	4.20	4.20	0.50	1.90	± 13.1 %

[C] Frequency validity 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.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 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 ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

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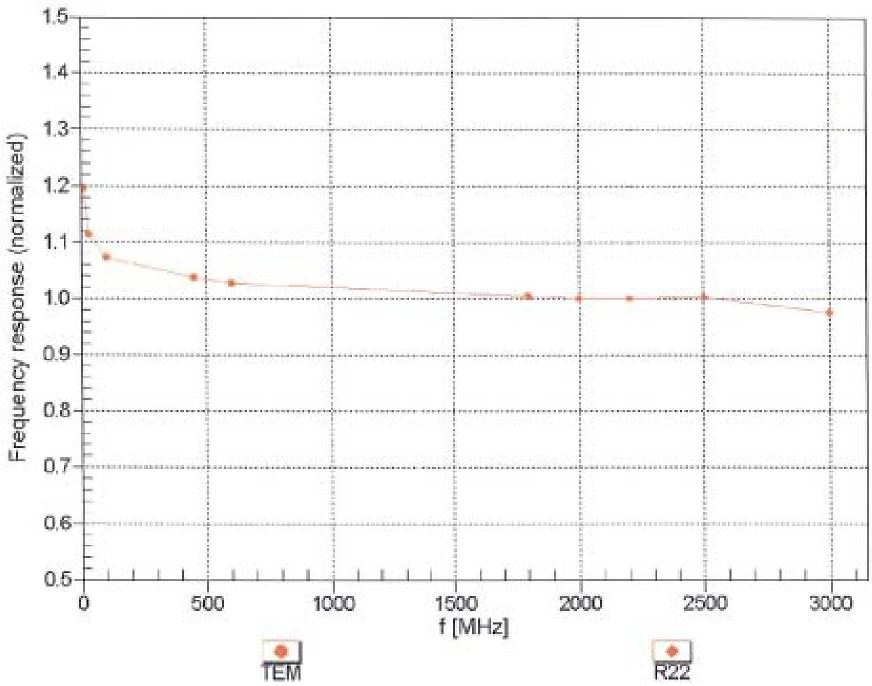
Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide: R22)



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

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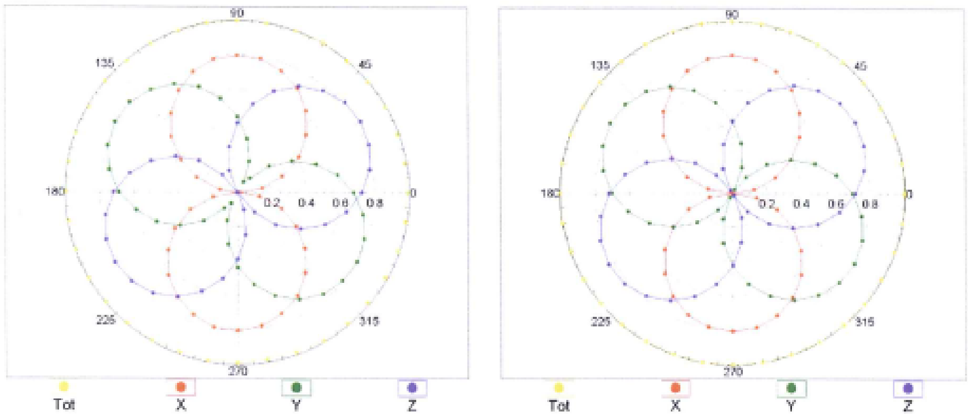
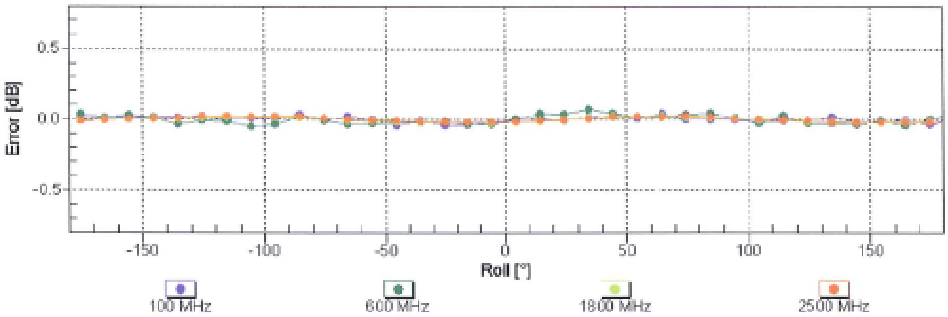
Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM f=1800 MHz,R22





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

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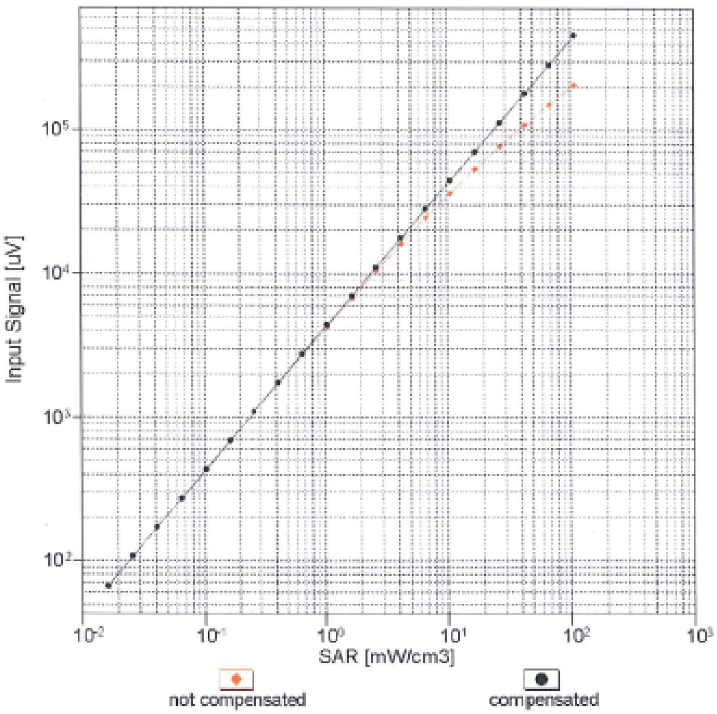
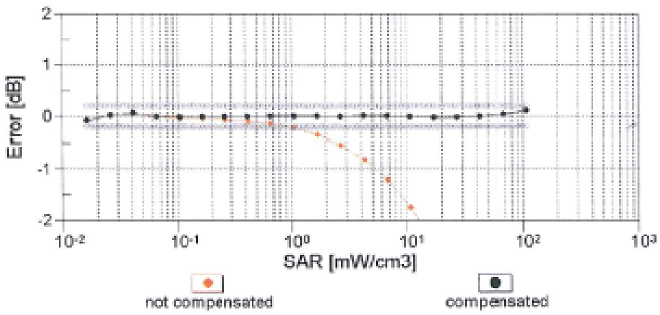
December 10, 2012

Dynamic Range f(SAR_{head})
(TEM cell , f = 900 MHz)





Uncertainty of Linearity Assessment: ± 0.6% (k=2)

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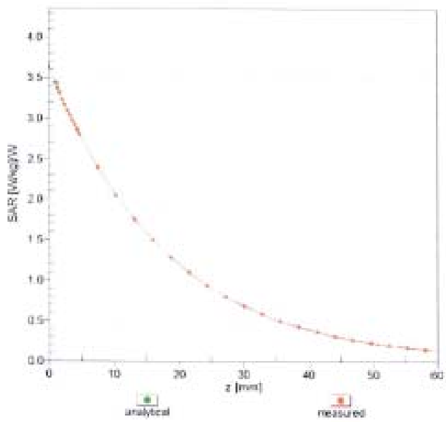
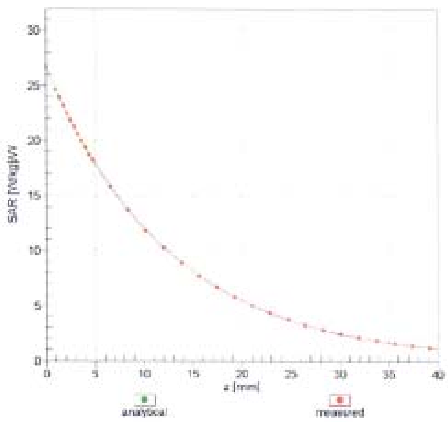
Conversion Factor Assessment

f = 900 MHz,WGLS R9 (H_convF)

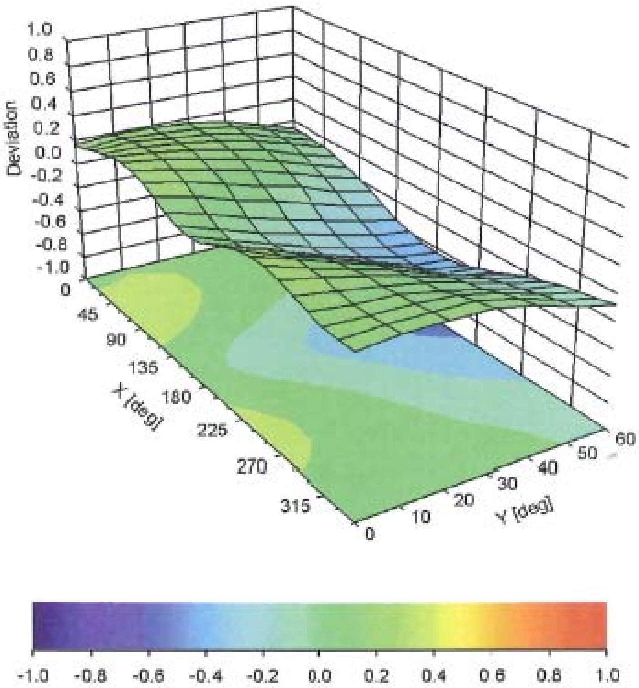


f = 1750 MHz,WGLS R22 (H_convF)



Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3825

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-25.5
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	2 mm

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