APPENDIX 3: Test instruments

Appendix 3-1: Equipment used

Control No.	Instrument	Manufacturer	Model No	Serial No	Test Item	Calibration Date * Interval(month)
COTS-KSAR-01	DASY4	Schmid&Partner Engineering AG	DASY4 V4.7 B80	–	SAR	–
COTS-KSEP-01	Dielectric measurement	Agilent	85070	1	SAR	–
KSAR-01	SAR measurement system	Schmid&Partner Engineering AG	DASY4	1088	SAR	Pre Check
SSRBT-01	SAR robot	Schmid&Partner Engineering AG	RX60B L	F04/5Z71A1/A/01	SAR	2012/02/06 * 12
KDAE-01	Data Acquisition Electronics	Schmid&Partner Engineering AG	DAE4	626	SAR	2012/02/15 * 12
KPB-01	Dosimetric E-Field Probe	Schmid&Partner Engineering AG	EX3DV4	3679	SAR	2012/06/21 * 12
KSDA-01	Dipole Antenna	Schmid&Partner Engineering AG	D2450V2	822	SAR	2012/01/10 * 12
KPFL-01	Flat Phantom	Schmid&Partner Engineering AG	Oval flat phantom ELI 4.0	1059	SAR	2011/10/26 * 12
SSNA-01	Network Analyzer	Agilent	8753ES	US39171777	SAR	2011/12/15 * 12
KEPP-01	Dielectric probe	Agilent	85070E/8710-2036	2540	SAR	2012/02/20 * 12
KSG-08	Signal Generator	Rohde & Schwarz	SMT06	100763	SAR	2012/06/26 * 12
KPA-12	RF Power Amplifier	MILMEGA	AS2560-50	1018582	SAR	Pre Check
KCPL-07	Directional Coupler	Pulsar Microwave Corp.	CCS30-B26	0621	SAR	Pre Check
KPM-06	Power Meter	Rohde & Schwarz	NRVD	101599	SAR(Pf)	2011/09/13 * 12
KIU-08	Power sensor	Rohde & Schwarz	NRV-Z4	100372	SAR(Pf)	2011/09/13 * 12
KIU-09	Power sensor	Rohde & Schwarz	NRV-Z4	100371	SAR(dipl)	2011/09/13 * 12
KPM-05	Power meter	Agilent	E4417A	GB41290718	SAR(dipl)	2012/03/22 * 12
KPSS-01	Power sensor	Agilent	E9327A	US40440544	SAR(dipl)	2012/03/22 * 12
KAT10-CS1	Attenuator	HUBER+SUHNER	6810.17.A	768898-1	SAR	2012/01/10 * 12
KAT10-CS2	Attenuator	HUBER+SUHNER	6810.17.A	768898-2	SAR	2012/01/10 * 12
KRU-02	Ruler(150mm,L)	Shinwa	12103	–	SAR	2012/03/08 * 12
KRU-04	Ruler(300mm)	Shinwa	13134	–	SAR	2012/05/29 * 12
KRU-05	Ruler(100x50mm,L)	Shinwa	12101	–	SAR	2012/05/29 * 12
KOS-13	Digtal thermometer	HANNA	Checktemp-2	KOS-13	SAR	2012/01/06 * 12
KOS-14	Thermo-Hygrometer data logger	SATO KEIRYOKI	SK-L200THII α / SK-LTHII α -2	015246/08169	SAR	2012/01/06 * 12
SOS-11	Humidity Indicator	A&D	AD-5681	4063424	SAR	2012/02/06 * 12
KPM-08	Power meter	Anritsu	ML2495A	6K00003356	Ant.pwr	2011/09/12 * 12
KPSS-04	Power sensor	Anritsu	MA2411B	012088	Ant.pwr	2011/09/12 * 12
KAT10-S3	Attenuator	Agilent	8490D 010	50924	Ant.pwr	2012/02/15 * 12
KCC-D23	Microwave cable	Hirose Electric	U.FL-2LP-066J1-A-(200)	–		Pre Check
SSA-04	Spectrum Analyzer	Advantest	R3272	101100994	SAR(moni.)	2011/12/28 * 12
KSLM245-01	Tissue simulation liqud (2450MHz,body)	Schmid&Partner Engineering AG	SL AAM 245	–	SAR	Daily check) Target value ±5%
No.7 Shielded room	SAR shielded room (2.76m(W)x3.76m(D)x2.4m(H))	TDK	-	-	SAR	(Daily check) Ambient noise: < 12mW/kg

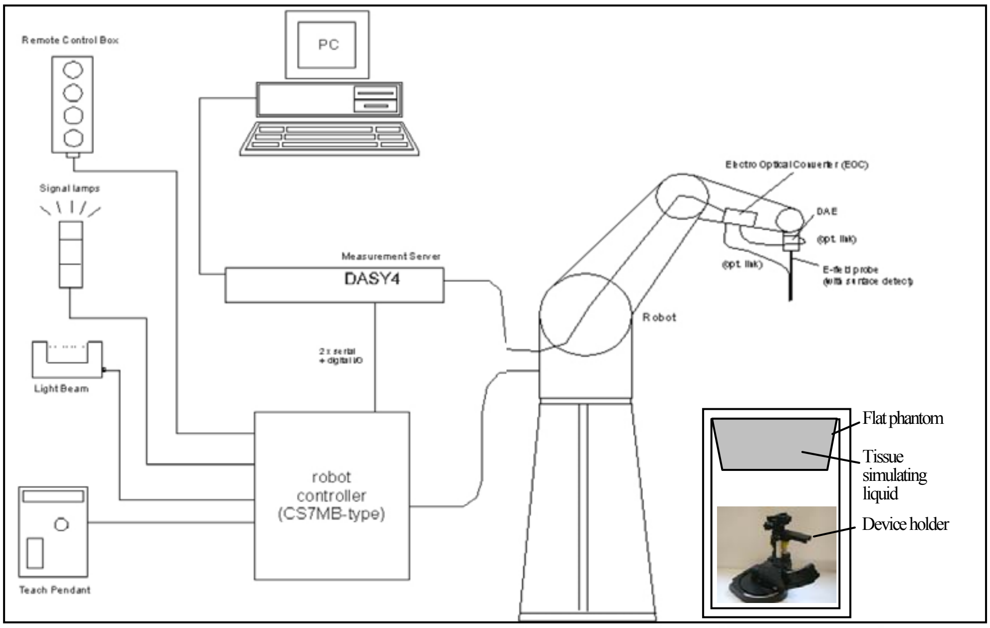
The expiration date of calibration is the end of the expired month.
As for some calibrations performed after the tested dates, those test equipment have been controlled by means of an unbroken chains of calibrations.
All equipment is calibrated with valid calibrations. Each measurement data is traceable to the national or international standards.

[Test Item] SAR: Specific Absorption Rate, Ant.pwr: Antenna terminal conducted power

Appendix 3-2: Dosimetry assessment setup

These measurements were performed with the automated near-field scanning system DASY4 from Schmid & Partner Engineering AG (SPEAG). The system is based on a high precision robot (working range greater than 0.9 m), which positions the probes with a positional repeatability of better than ±0.02 mm. Special E- and H-field probes have been developed for measurements close to material discontinuity, the sensors of which are directly loaded with a Schottky diode and connected via highly resistive lines to the data acquisition unit. The SAR measurements were conducted with the dosimetry probes EX3DV4 (manufactured by SPEAG), designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe has been calibrated according to the procedure described in [2] with accuracy of better than ±10%. The spherical isotropy was evaluated with the procedure described in [3] and found to be better than ±0.25 dB.

Appendix 3-3: Configuration and peripherals



The DASY4 system for performing compliance tests consist of the following items:

1	A standard high precision 6-axis robot (Stäubli RX family) with controller and software. An arm extension for accommodating the data acquisition electronics (DAE).
2	A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
3	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.
4	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.
5	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.
6	A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
7	A computer operating Windows XP.
8	DASY4 software.
9	Remote control with teaches pendant and additional circuitry for robot safety such as warning lamps, etc.
10	The phantom.
11	The device holder for EUT. (low-loss dielectric palette) (*. when it was used.)
12	Tissue simulating liquid mixed according to the given recipes.
13	Validation dipole kits allowing to validate the proper functioning of the system.

Appendix 3-4: System components

1) EX3DV4 Probe Specification

EX3DV4 E-field Probe

Construction:
- Symmetrical design with triangular core.
- Built-in shielding against static charges.
- PEEK enclosure material (resistant to organic solvents, e.g., DGBE).

Calibration (S/N 3679):
Basic broad band calibration in air.
Conversion Factors(Head and Body): 2450, 5200, 5300, 5500, 5600, 5800MHz

Frequency:
10 MHz to > 6GHz, Linearity: ±0.2 dB (30MHz to 6GHz)

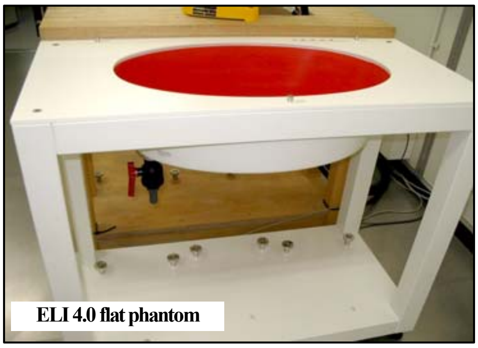
Directivity:
±0.3 dB in HSL (rotation around probe axis)
±0.5 dB in tissue material (rotation normal to probe axis)

Dynamic Range:
10μW/g to > 100 mW/g; Linearity: ±0.2 dB (noise: typically < 1μW/g)

Dimensions:
Overall length: 330mm (Tip: 20mm)
Tip diameter: 2.5mm (Body: 12mm)
Typical distance from probe tip to dipole centers: 1mm

Application:
High precision 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%.

2) Phantom (Flat type)



ELI 4.0 flat phantom

Construction:
A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom position and measurement grids by manually teaching three points with the robot.

Shell Thickness:
Bottom plate: 2 ±0.2mm

Dimensions:
Bottom elliptical: 600×400mm, Depth: 190mm

Filling Volume:
Approx. 30 liters

3) Device Holder

Device holder

For this measurement, the urethane foam was used as 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. Transmitter devices can be easily and accurately positioned.
The low-loss dielectric urethane foam was used for the mounting section of device holder.

Appendix 3-5: Test system specification

RX60L Robot

- Number of Axes : 6
- Payload : 1.6 kg
- Reach : 800mm
- Repeatability : ±0.025mm
- Control Unit : CS7M
- Programming Language : V+
- Manufacture : Stäubli Unimation Corp. Robot Model: RX60

DASY4 Measurement server

- Features : 166MHz low power Pentium MMX.
  32MB chipdisk and 64MB RAM Serial link to DAE (with watchdog supervision) 16 Bit A/D converter for surface detection system. Two serial links to robot (one for real-time communication which is supervised by watchdog) Ethernet link to PC (with watchdog supervision).
  Emergency stop relay for robot safety chain. Two expansion slots for future applications.
- Manufacture : Schmid & Partner Engineering AG

Data Acquisition Electronic (DAE)

- Features : Signal amplifier, multiplexer, A/D converter and control logic.
  Serial optical link for communication with DASY4 embedded system (fully remote controlled).
  2 step probe touch detector for mechanical surface detection and emergency robot stop (not in -R version)
- Measurement Range : 1μV to > 200mV (16bit resolution and two range settings: 4mV, 400mV)
- Input Offset voltage : < 1μV (with auto zero)
- Input Resistance : 200MΩ
- Battery Power : > 10hr of operation (with two 9V battery)
- Dimension : 60×60×68mm
- Manufacture : Schmid & Partner Engineering AG

Software

- Item : Dosimetric Assessment System DASY4
- Software version No. : DASY4, V4.7 B80
- Manufacture / Origin : Schmid & Partner Engineering AG

E-Field Probe

- Model : EX3DV4 (sn: 3679)
- Construction : Symmetrical design with triangular core
- Frequency : 10MHz to 6GHz
- Linearity : ±0.2dB (30MHz to 3GHz)
- Manufacture : Schmid & Partner Engineering AG

Phantom

- Type : ELI 4.0 oval flat phantom
- Shell Material : Fiberglass
- Shell Thickness : Bottom plate: 2 ±0.2mm
- Dimensions : Bottom elliptical: 600×400mm, Depth: 190mm
- Manufacture : Schmid & Partner Engineering AG

Appendix 3-6: Simulated tissue composition

Liquid type	☐ / Head, HSL 2450	☒ / Body, MSL 2450
M/N / Control No.	SL AAH 245 / KSLH245-01	SL AAM 245 / KSLM245-01
Ingredient	**Mixture (%)**	**Mixture (%)**
Water	52-75 %	52-75 %
$C_8H_{18}O_3$ (DGBE) (Diethylene glycol monobutyl ether)	25-48%	25-48%
NaCl	<1.0%	<1.0%
Manufacture	Schmid&Partner Engineering AG	Schmid&Partner Engineering AG

1-22-3 Megumigaoka, Hiratsuka-shi, Kanagawa-ken, 259-1220 JAPAN
Telephone: +81 463 50 6400 / Facsimile: +81 463 50 6401

Appendix 3-7: Simulated tissue parameter confirmation

The dielectric parameters were checked prior to assessment using the 85070E dielectric probe kit.
The dielectric parameters measurement is reported in each correspondent section.

Dielectric parameter measurement results

Date	Freq. [MHz]	Ambient		Liq.T.[deg.C.]		Liquid Depth [mm]	Parameters	Target value		Measured	Deviation for #1 (Std.)[%]	Limit [%]	Deviation for #2 (Cal.)[%]	Limit [%]
		Temp [deg.C.]	Humidity [%RH]	Before	After			#1:Std. (*1)	#2:Cal. (*2)					
July 25, 2012	2450	24.0	55	22.8	22.8	153	Relative permittivity: εr [-]	52.7	50.6	51.32	-2.6	±5	+1.4	±5
							Conductivity: σ [S/m]	1.95	2.01	1.982	+1.6	±5	-1.4	±5

*1. The target value is a parameter defined in OET65, Supplement C.
*2. The target value is a parameter defined in the calibration data sheet of D2450V2 (sn:822) dipole calibrated by Schmid & Partner Engineering AG (Certification No. D2450V2-822_Jan12, the data sheet was filed in this report.).

***. Decision on Simulated Tissues of 2450MHz**

In the current standards (e.g., IEEE 1528, OET 65 Supplement C), the dielectric parameters suggested for head and body tissue simulating liquid are given at 2000MHz, 2450 and 3000MHz. As an intermediate solution, dielectric parameters for the frequencies between 2000 to 2450 MHz and 2450-3000MHz were obtained using linear interpolation. Therefore the dielectric parameters of Wi-Fi frequency of 2.4GHz band which were SAR tested were decided as following.

Standard					*Interpolated*				
f (MHz)	Head Tissue		Body Tissue		f (MHz)	Head Tissue		Body Tissue	
	εr	σ [S/m]	εr	σ [S/m]		εr	σ [S/m]	εr	σ [S/m]
(1800-)2000	40.0	1.40	53.3	1.52	*2412*	*39.26*	*1.771*	*52.75*	*1.914*
2450	39.2	1.80	52.7	1.95	*2437*	*39.21*	*1.793*	*52.72*	*1.938*
3000	38.5	2.40	52.0	2.73	*2462*	*39.18*	*1.819*	*52.68*	*1.967*

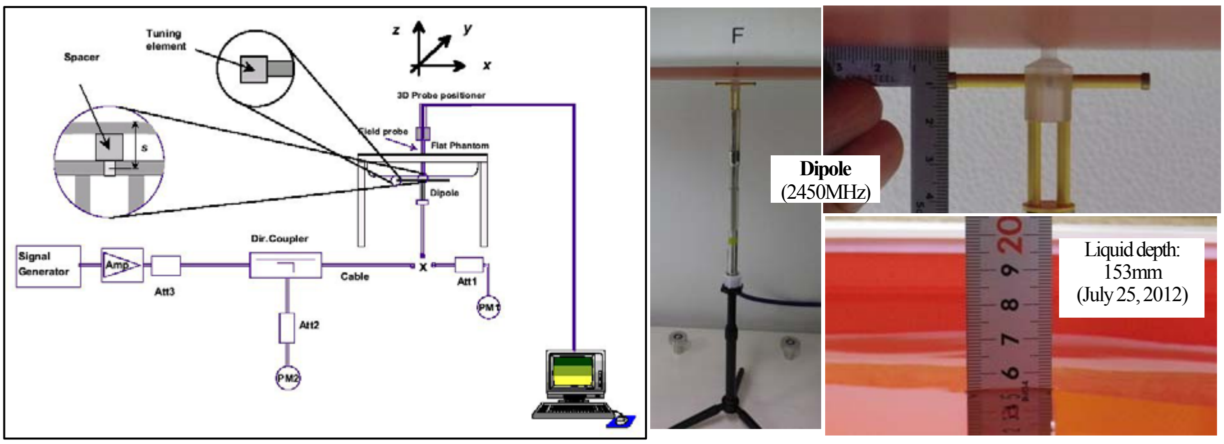
Appendix 3-8: System check data

Prior to the SAR assessment of EUT, the system validation kit was used to test whether the system was operating within its specifications of ±10%. The system check results are in the table below.

System check results

Date	Freq. [MHz]	Liquid Type	Ambient		Liquid Temp. [deg.C.]			Liquid Depth [mm]	Permittivity measured εr [-]	Conductivity measured σ [S/m]]	Power drift [dB]	System check target & measured SAR 1g [W/kg] (at 250mW)		Deviation [%]	Limit [%]
			Temp [deg.C.]	Humidity [%RH]	Check	Before	After					Target value	Measured		
July 25, 2012	2450	Body	24.0	55	22.8	22.4	22.4	153	51.32	1.982	-0.058	13.2 (*3)	12.9	-2.3	±10

Note: Refer to Appendix 3-9 System Check measurement data for the above result representation in plot data.
*3. The target value is a parameter defined in the calibration data sheet of D2450V2 (sn:822) dipole calibrated by Schmid & Partner Engineering AG (Certification No. D2450V2-822_Jan12, the data sheet was filed in this report.).
*. We performed the system check based on FCC requirement, "The 1g or 10g SAR values measured using the required tissue dielectric parameters should be within 10% of manufacturer calibrated dipole SAR values. However these manufacturer calibrated dipole target SAR values should be substantially similar to those defined in IEEE Standard 1528." and FCC permits "SAR system verification with the actual liquid used for EUT's SAR measurement, should be the default operating procedures." We confirmed the this dipole manufacture's validation data for head is within 5% against IEEE Standard 1528 (manufacture's cal.: 52.1W/kg (-0.6%, vs. standard=52.4W/kg). so we can only use Body liquid validation data for our system check procedure



Test setup for the system performance check

Appendix 3-9: System check measurement data

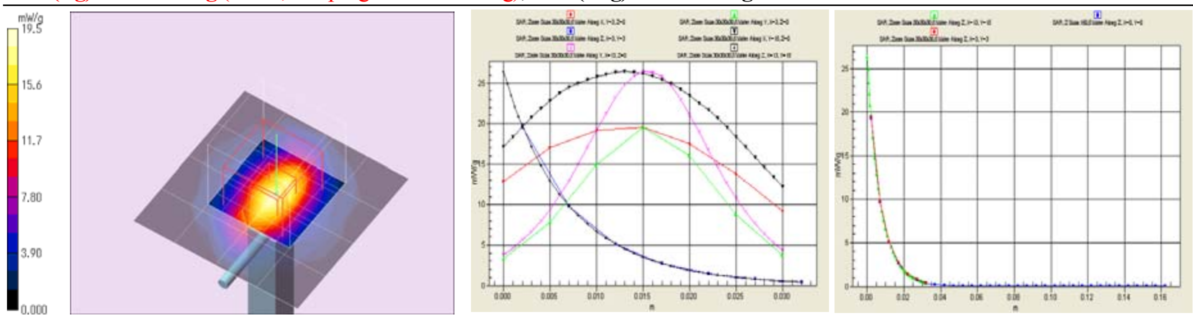
2450MHz system check (Body) / Forward conducted power: 250mW

EUT: Dipole 2450 MHz; Type: D2450V2; Serial: 822
Communication System: CW; Frequency: 2450 MHz; Crest Factor: 1.0
Medium: M2450; Medium parameters used: f = 2450 MHz; σ = 1.98 S/m; ε_r = 51.3; ρ = 1000 kg/m^3

DASY4 Configuration: - Probe: EX3DV4 - SN3679; ConvF(6.77, 6.77, 6.77); Calibrated: 2012/06/21
- Sensor-Surface: 2mm (Mechanical Surface Detection) - Electronics: DAE4 Sn626; Calibrated: 2012/02/15
- Phantom: ELI 4.0; Type: QDOVA001BA; Serial: 1059; Phantom section: Flat Section
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 184

Area Scan:60x60,15 (5x5x1): Measurement grid: dx=15mm, dy=15mm, Maximum value of SAR (measured) = 19.5 mW/g
Area Scan:60x60,15 (41x41x1): Measurement grid: dx=15mm, dy=15mm, Maximum value of SAR (interpolated) = 19.7 mW/g
Z Scan:160,5 (1x1x33): Measurement grid: dx=20mm, dy=20mm, dz=5mm, Maximum value of SAR (measured) = 19.3 mW/g

Zoom Scan:30x30x30,5 (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 101.1 V/m; Power Drift = -0.058 dB, Maximum value of SAR (measured) = 19.3 mW/g
Peak SAR (extrapolated) = 26.4 W/kg (-2.6%, vs. speag cal.=27.1 W/kg)
SAR(1 g) = 12.9 mW/g (-2.3%, vs. speag cal.=13.2 mW/g); **SAR(10 g) = 6.03 mW/g**



Remarks:*. Date tested: Date/Time: 2012/07/25 9:10:32; Tested by: Tomochika Sato; Tested place:No.7 shielded room,
*.liquid depth: 153mm; Position: distance of EUT to phantom: 8mm (10mm to liquid); ambient: 24.0 deg.C. / 55 %RH,
*.liquid temperature: 22.4(start)/22.4(end)/22.8(in check) deg.C.; *.White cubic: zoom scan area, Red cubic: big=SAR(10g)/small=SAR(1g)

Appendix 3-10: System check uncertainty

Uncertainty of system validation (v04)	Under 3GHz (v04)	
	1g SAR	10g SAR
Combined measurement uncertainty of the measurement system (k=1)	± 9.5%	± 9.2%
Expanded uncertainty (k=2)	± 19.0%	± 18.4%

	Error Description (Under 3GHz) (v04)	Uncertainty Value	Probability distribution	Divisor	ci (1g)	ci (10g)	ui (1g) (std. uncertainty)	ui (10g) (std. uncertainty)	Vi, veff
A	Measurement System								
1	Probe Calibration Error(2.45GHz±100MHz)	±6.0 %	Normal	1	1	1	±6.0 %	±6.0 %	∞
2	Axial isotropy	±4.7 %	Rectangular	√3	0.7	0.7	±1.9 %	±1.9 %	∞
3	Hemispherical isotropy (*flat phantom, <5°)	±9.6 %	Rectangular	√3	0.7	0.7	±3.9 %	±3.9 %	∞
4	Boundary effects	±1.4 %	Rectangular	√3	1	1	±0.8 %	±0.8 %	∞
5	Probe linearity	±4.7 %	Rectangular	√3	1	1	±2.7 %	±2.7 %	∞
6	System detection limit	±1.0 %	Rectangular	√3	1	1	±0.6 %	±0.6 %	∞
7	Response Time Error (<5ms/100ms wait)	±0.0 %	Rectangular	√3	1	1	±0.0 %	±0.0 %	∞
8	Integration Time Error(100% duty cycle)	±0.0 %	Rectangular	√3	1	1	±0.0 %	±0.0 %	∞
9	System readout electronics (DAE)	±0.3 %	Normal	1	1	1	±0.3 %	±0.3 %	∞
10	RF ambient conditions-noise (<0.12mW/g)	±3.0 %	Rectangular	√3	1	1	±1.7 %	±1.7 %	∞
11	RF ambient conditions-reflections (<0.12mW/g)	±3.0 %	Rectangular	√3	1	1	±1.7 %	±1.7 %	∞
12	Probe positioner mechanical tolerance	±1.1 %	Rectangular	√3	1	1	±0.6 %	±0.6 %	∞
13	Probe positioning with respect to phantom shell	±2.9 %	Rectangular	√3	1	1	±1.7 %	±1.7 %	∞
14	Max.SAR evaluation	±1.0 %	Rectangular	√3	1	1	±0.6 %	±0.6 %	∞
B	Dipole								
15	Dipole to liquid distance(10mm±0.2mm,<2deg.)	±2.0 %	Rectangular	√3	1	1	±1.2 %	±1.2 %	∞
16	Drift of output power (measured, <0.2dB)	±2.5 %	Rectangular	√3	1	1	±1.4 %	±1.4 %	∞
C	Phantom and Setup								
17	Phantom uncertainty	±2.0 %	Rectangular	√3	1	1	±1.2 %	±1.2 %	∞
18	Liquid conductivity (target) (≤5%)	±5.0 %	Rectangular	√3	0.64	0.43	±1.8 %	±1.2 %	∞
19	Liquid conductivity (meas.)	±2.9 %	Normal	1	0.64	0.43	±1.9 %	±1.2 %	3
20	Liquid permittivity (target) (≤5%)	±5.0 %	Rectangular	√3	0.6	0.49	±1.7 %	±1.4 %	∞
21	Liquid permittivity (meas.)	±2.9 %	Normal	1	0.6	0.49	±1.7 %	±1.4 %	3
	Combined Standard Uncertainty						±9.5 %	±9.2 %	7711
	Expanded Uncertainty (k=2)						±19.0 %	±18.4 %	

*. This measurement uncertainty budget is suggested by IEEE 1528 and determined by Schmid & Partner Engineering AG.[6]

Appendix 3-11: Calibration certificate: Dipole (D2450V2) (sn:822)

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: D2450V2-822_Jan12

CALIBRATION CERTIFICATE

Object	D2450V2 - SN: 822
Calibration procedure(s)	QA CAL-05.v8 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	January 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 EPM-442A	GB37480704	05-Oct-11 (No. 217-01451)	Oct-12
Power sensor HP 8481A	US37292783	05-Oct-11 (No. 217-01451)	Oct-12
Reference 20 dB Attenuator	SN: 5086 (20g)	29-Mar-11 (No. 217-01368)	Apr-12
Type-N mismatch combination	SN: 5047.2 / 06327	29-Mar-11 (No. 217-01371)	Apr-12
Reference Probe ES3DV3	SN: 3205	30-Dec-11 (No. ES3-3205_Dec11)	Dec-12
DAE4	SN: 601	04-Jul-11 (No. DAE4-601_Jul11)	Jul-12

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-11)	In house check: Oct-12

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

Issued: January 10, 2012

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

Appendix 3-11: Calibration certificate: Dipole (D2450V2) (sn:822) (cont'd)

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
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 1528-2003, "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
c) 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:

d) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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Appendix 3-11: Calibration certificate: Dipole (D2450V2) (sn:822) (cont'd)

Measurement Conditions

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

DASY Version	DASY5	V52.8.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	39.2 ± 6 %	1.85 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	13.2 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	**52.1 mW /g ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.12 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	**24.3 mW /g ± 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	50.6 ± 6 %	2.01 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	13.2 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**51.6 mW / g ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.10 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**24.1 mW / g ± 16.5 % (k=2)**

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Appendix 3-11: Calibration certificate: Dipole (D2450V2) (sn:822) (cont'd)

Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.9 Ω + 4.1 jΩ
Return Loss	- 25.3 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	51.1 Ω + 5.3 jΩ
Return Loss	- 25.4 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.159 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 11, 2008

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Appendix 3-11: Calibration certificate: Dipole (D2450V2) (sn:822) (cont'd)

DASY5 Validation Report for Head TSL

Date: 10.01.2012

Test Laboratory: SPEAG, Zurich, Switzerland

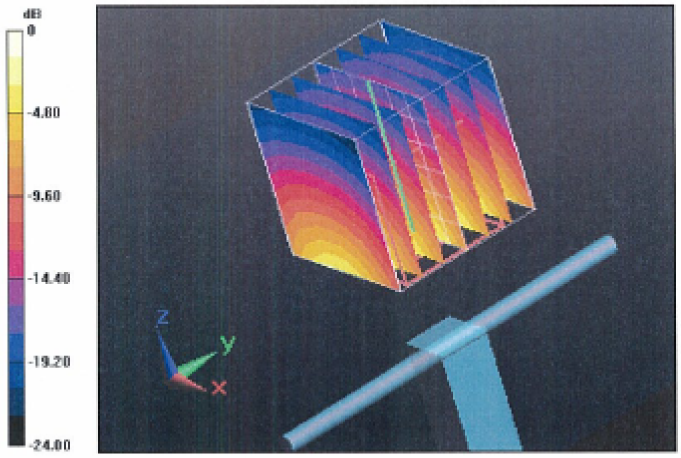
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 822

Communication System: CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.85 mho/m; ε_r = 39.2; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.45, 4.45, 4.45); Calibrated: 30.12.2011
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.07.2011
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.0(692); SEMCAD X 14.6.4(4989)

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 = 99.405 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 27.1020
SAR(1 g) = 13.2 mW/g; SAR(10 g) = 6.12 mW/g
Maximum value of SAR (measured) = 16.876 mW/g



0 dB = 16.880mW/g = 24.55 dB mW/g

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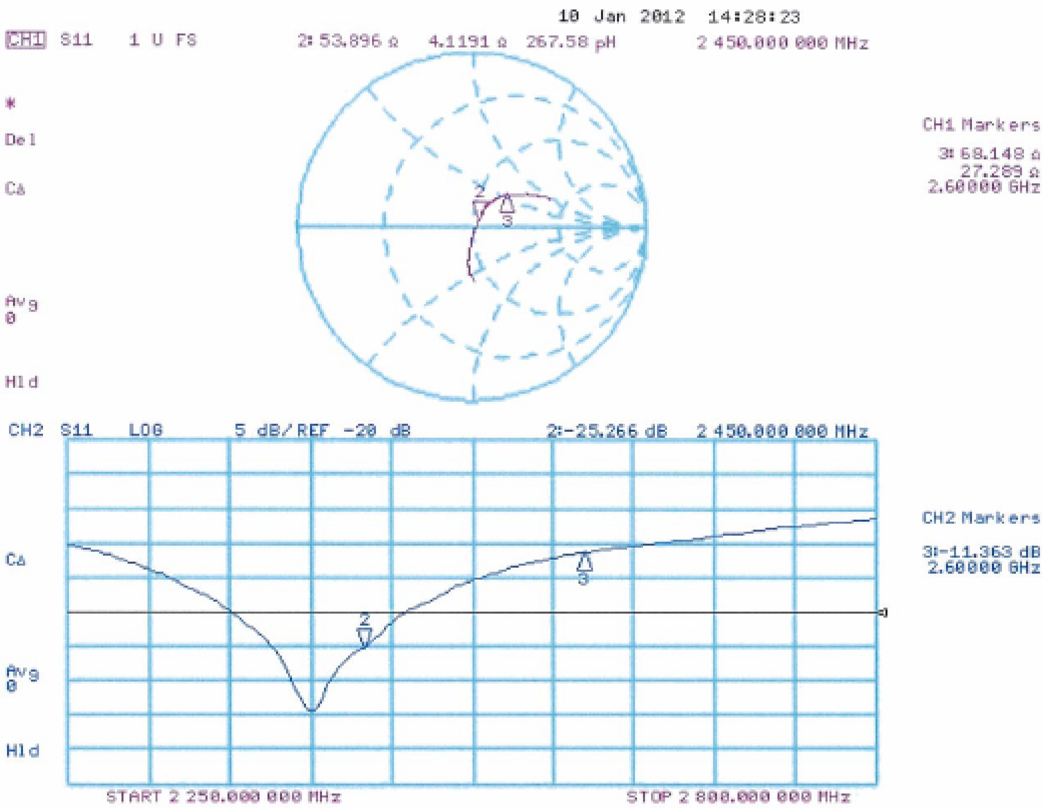
Appendix 3-11: Calibration certificate: Dipole (D2450V2) (sn:822) (cont'd)

Impedance Measurement Plot for Head TSL



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Appendix 3-11: Calibration certificate: Dipole (D2450V2) (sn:822) (cont'd)

DASY5 Validation Report for Body TSL

Date: 06.01.2012

Test Laboratory: SPEAG, Zurich, Switzerland

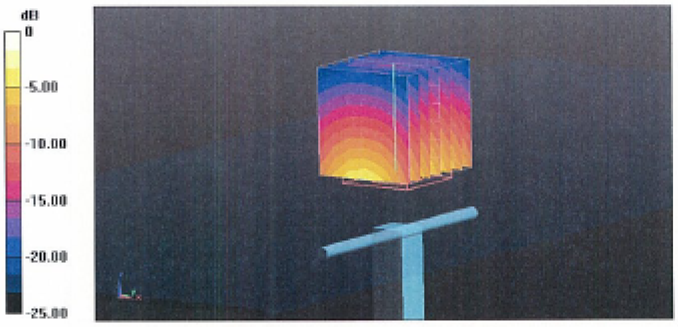
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 822

Communication System: CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.01 mho/m; ε_r = 50.6; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.26, 4.26, 4.26); Calibrated: 30.12.2011
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.07.2011
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.0(692); SEMCAD X 14.6.4(4989)

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 = 96.185 V/m; Power Drift = -0.0031 dB
Peak SAR (extrapolated) = 27.0610
SAR(1 g) = 13.2 mW/g; SAR(10 g) = 6.1 mW/g
Maximum value of SAR (measured) = 17.340 mW/g



0 dB = 17.340mW/g = 24.78 dB mW/g

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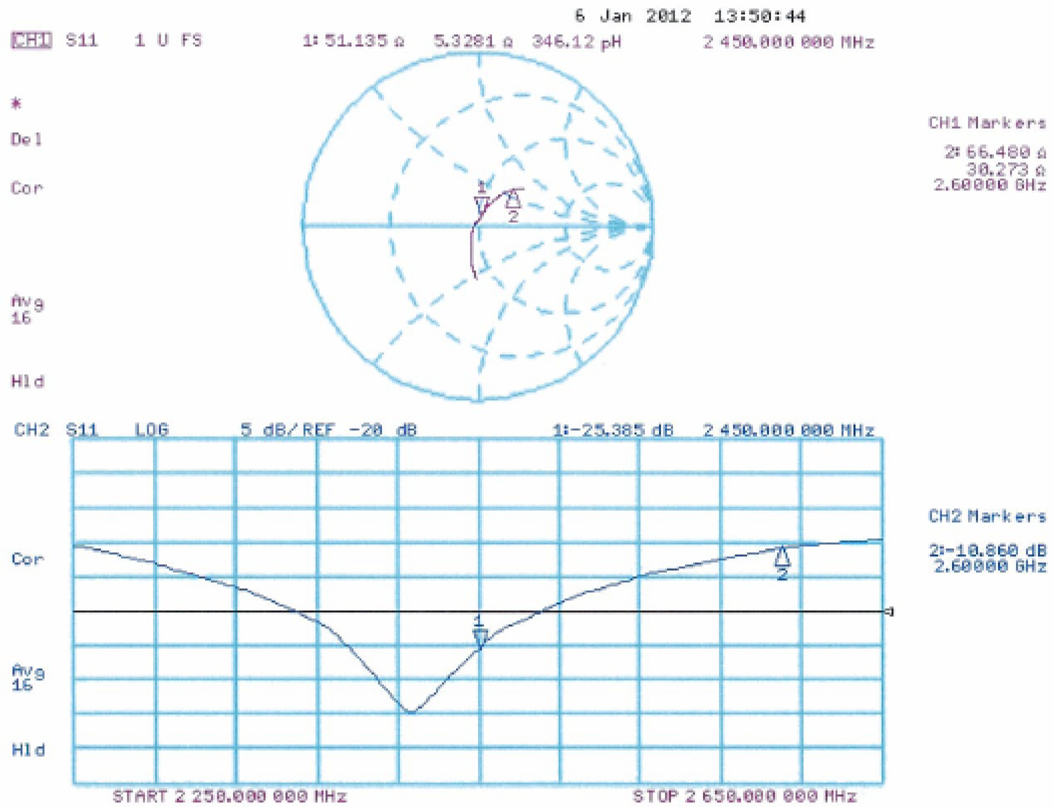
Appendix 3-11: Calibration certificate: Dipole (D2450V2) (sn:822) (cont'd)

Impedance Measurement Plot for Body TSL



Appendix 3-12: Calibration certificate: E-Field Probe (EX3DV4) (sn:3679)

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
Servizio svizzero di taratura
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 108**

Client: UL Japan Shonan (PTT)

Certificate No: **EX3-3679_Jun12**

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3679
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:	June 21, 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	10-Jan-12 (No. DAE4-660_Jan12)	Jan-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-11)	In house check: Oct-12

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

Issued: June 22, 2012

Appendix 3-12: Calibration certificate: E-Field Probe (EX3DV4) (sn:3679) (cont'd)

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:3679

Manufactured: September 9, 2008
Calibrated: June 21, 2012

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

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Appendix 3-12: Calibration certificate: E-Field Probe (EX3DV4) (sn:3679) (cont'd)

EX3DV4– SN:3679

June 21, 2012

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3679

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.58	0.54	0.53	± 10.1 %
DCP (mV)[B]	96.7	99.1	101.0	

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	0.00	0.00	1.00	168.7	±3.3 %
			Y	0.00	0.00	1.00	172.8	
			Z	0.00	0.00	1.00	158.0	

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.

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Appendix 3-12: Calibration certificate: E-Field Probe (EX3DV4) (sn:3679) (cont'd)

EX3DV4– SN:3679 June 21, 2012

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3679

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)
2450	39.2	1.80	6.72	6.72	6.72	0.31	1.00	± 12.0 %
5200	36.0	4.66	4.66	4.66	4.66	0.40	1.80	± 13.1 %
5300	35.9	4.76	4.63	4.63	4.63	0.40	1.80	± 13.1 %
5500	35.6	4.96	4.30	4.30	4.30	0.45	1.80	± 13.1 %
5600	35.5	5.07	4.04	4.04	4.04	0.45	1.80	± 13.1 %
5800	35.3	5.27	4.19	4.19	4.19	0.50	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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Appendix 3-12: Calibration certificate: E-Field Probe (EX3DV4) (sn:3679) (cont'd)

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3679

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)
2450	52.7	1.95	6.77	6.77	6.77	0.80	0.60	± 12.0 %
5200	49.0	5.30	4.13	4.13	4.13	0.50	1.80	± 13.1 %
5300	48.9	5.42	3.98	3.98	3.98	0.50	1.80	± 13.1 %
5500	48.6	5.65	3.70	3.70	3.70	0.55	1.80	± 13.1 %
5600	48.5	5.77	3.61	3.61	3.61	0.55	1.80	± 13.1 %
5800	48.2	6.00	3.87	3.87	3.87	0.60	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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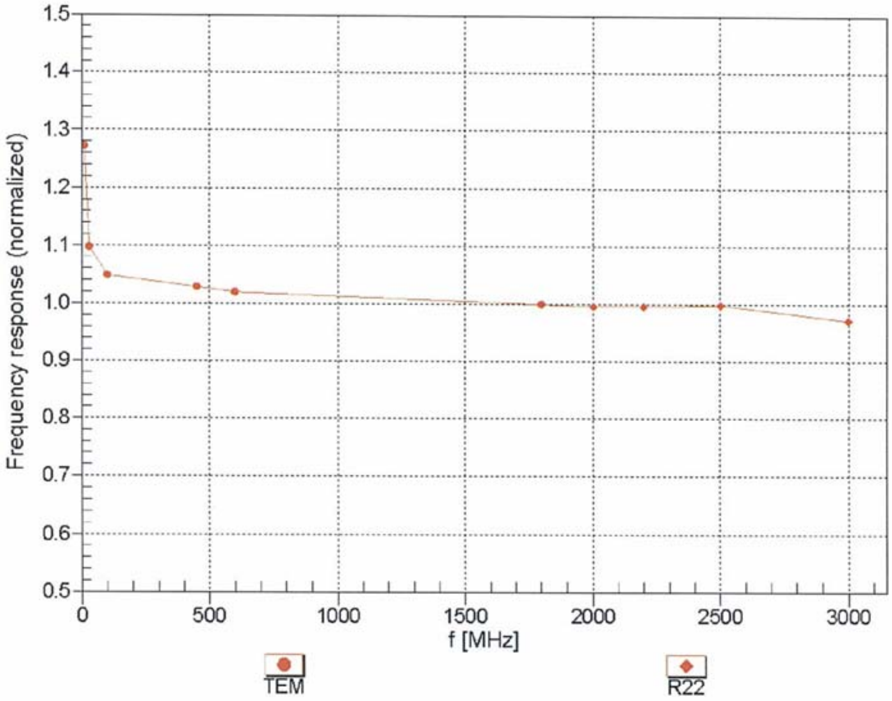
Appendix 3-12: Calibration certificate: E-Field Probe (EX3DV4) (sn:3679) (cont'd)

EX3DV4– SN:3679 June 21, 2012

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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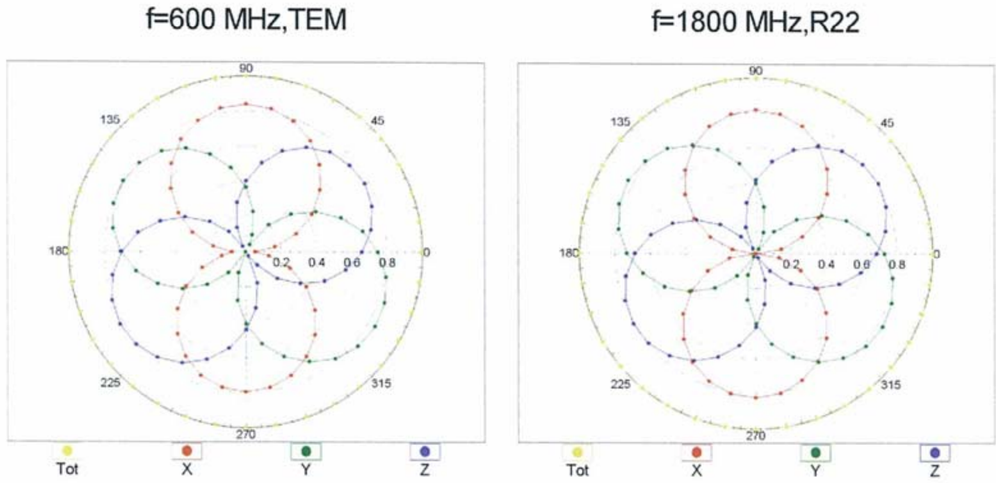
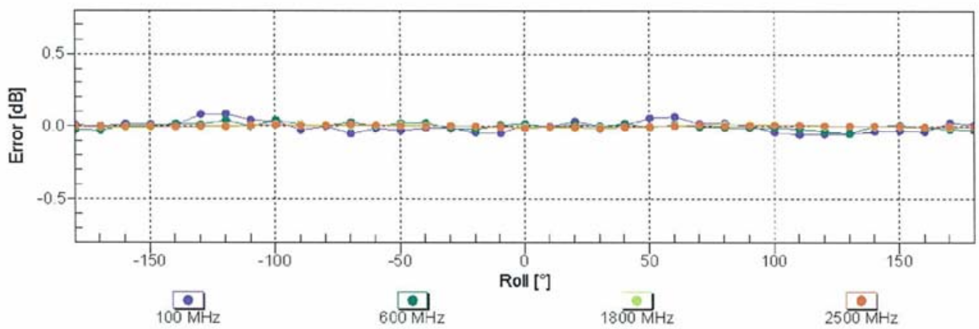
Appendix 3-12: Calibration certificate: E-Field Probe (EX3DV4) (sn:3679) (cont'd)

EX3DV4– SN:3679 June 21, 2012

Receiving Pattern (φ), ϑ = 0°





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

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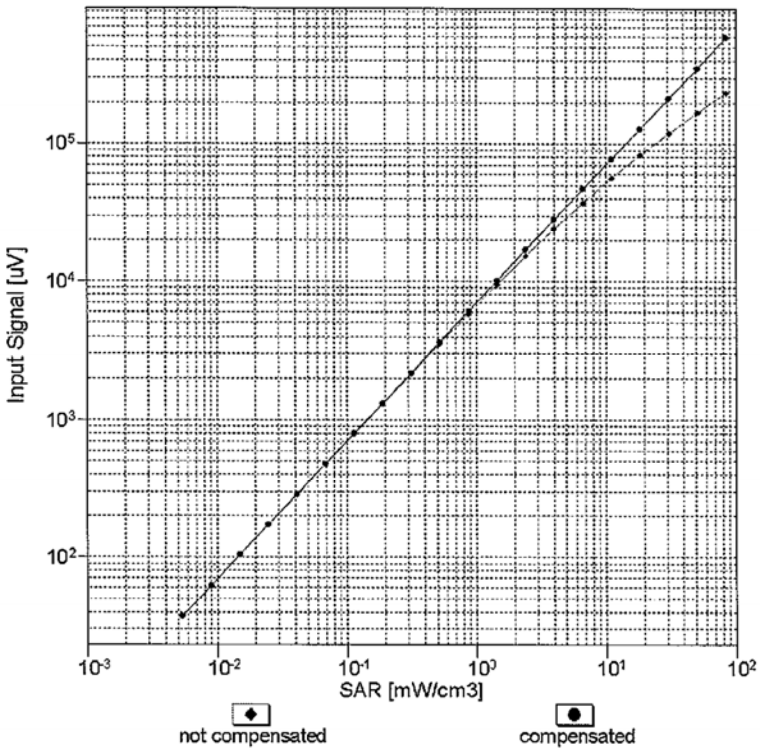
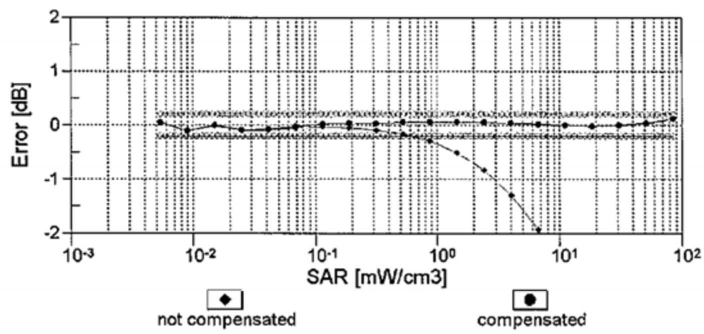
Appendix 3-12: Calibration certificate: E-Field Probe (EX3DV4) (sn:3679) (cont'd)

EX3DV4– SN:3679 June 21, 2012

Dynamic Range f(SAR_{head})

(TEM cell , f = 900 MHz)





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

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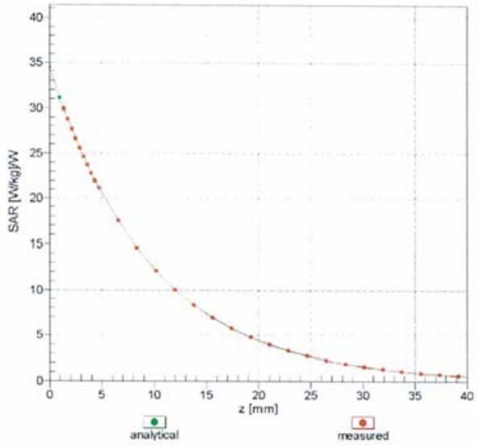
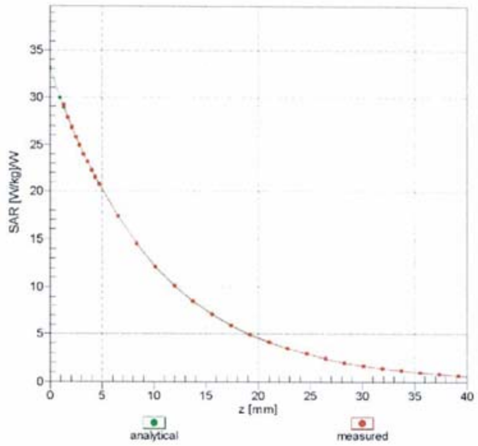
Appendix 3-12: Calibration certificate: E-Field Probe (EX3DV4) (sn:3679) (cont'd)

EX3DV4– SN:3679

June 21, 2012

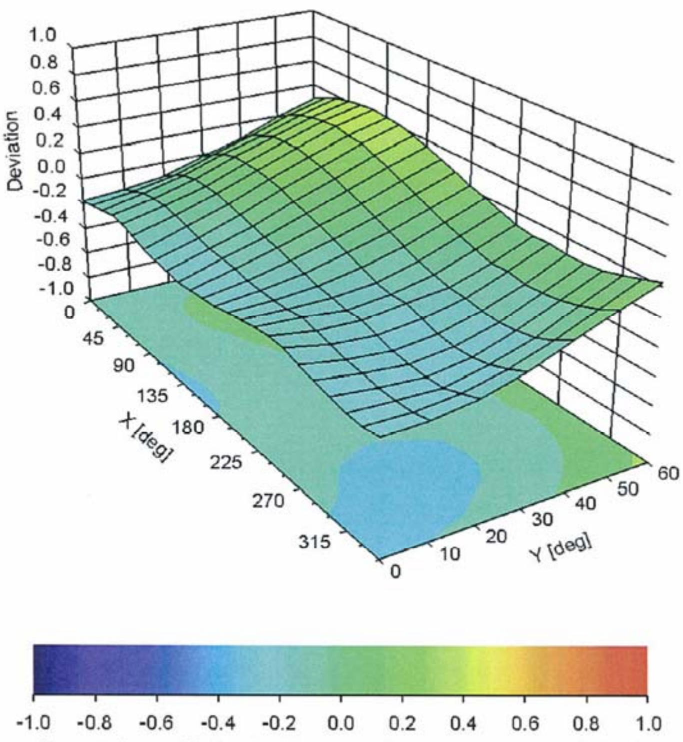
Conversion Factor Assessment





Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



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

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Appendix 3-12: Calibration certificate: E-Field Probe (EX3DV4) (sn:3679) (cont'd)

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3679

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-169.6
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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END OF REPORT