Appendix 3-8: Calibration certificate: E-Field Probe (EX3DV4)

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

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Swiss Calibration Service

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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 3-8: Calibration certificate: E-Field Probe (EX3DV4) (cont'd)

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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.

Appendix 3-8: Calibration certificate: E-Field Probe (EX3DV4) (cont'd)

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 3-8: Calibration certificate: E-Field Probe (EX3DV4) (cont'd)

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 3-8: Calibration certificate: E-Field Probe (EX3DV4) (cont'd)

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 3-8: Calibration certificate: E-Field Probe (EX3DV4) (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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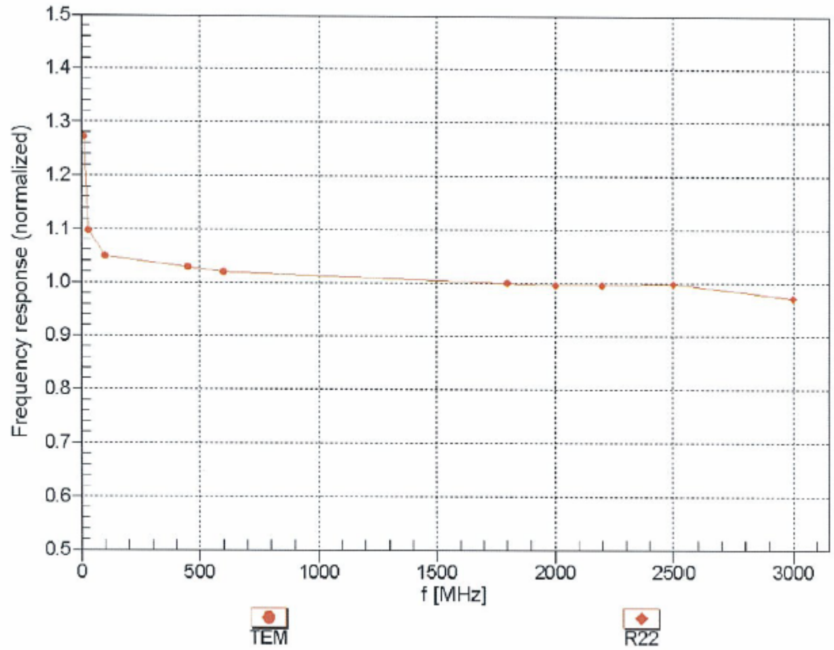
Appendix 3-8: Calibration certificate: E-Field Probe (EX3DV4) (cont'd)

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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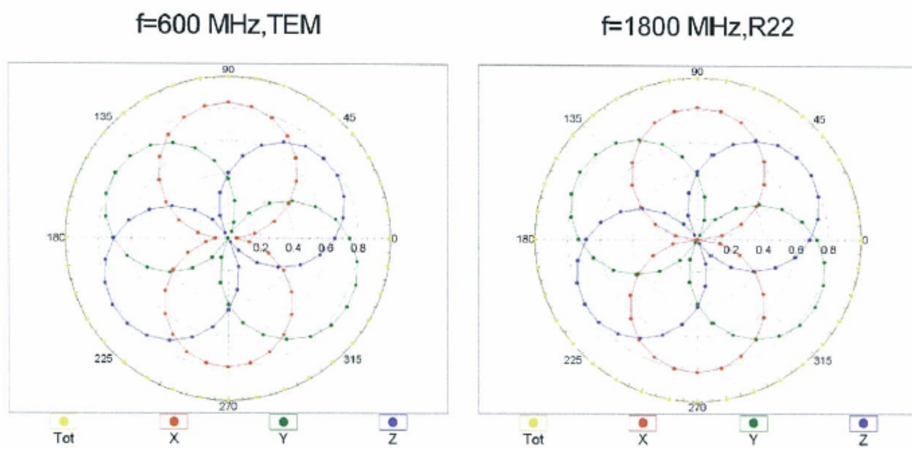
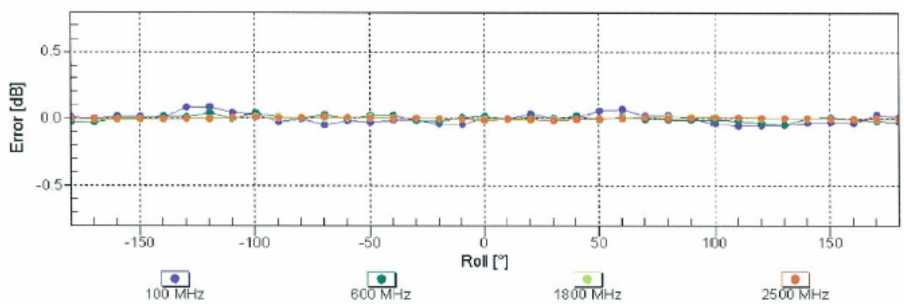
Appendix 3-8: Calibration certificate: E-Field Probe (EX3DV4) (cont'd)

Receiving Pattern (ϕ), ϑ = 0°





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

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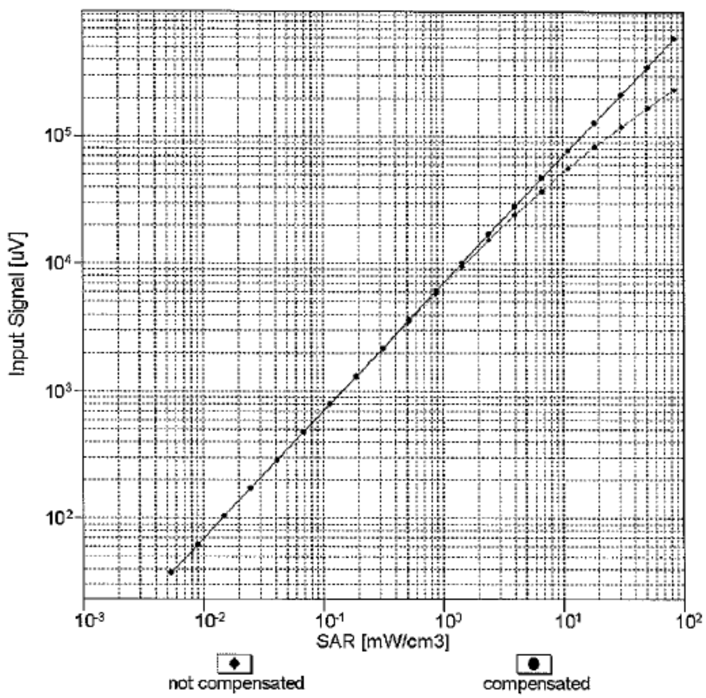
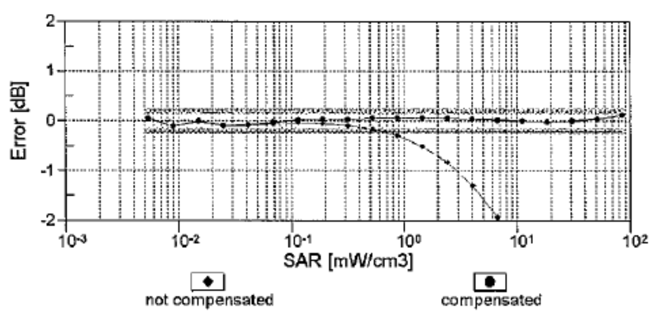
Appendix 3-8: Calibration certificate: E-Field Probe (EX3DV4) (cont'd)

Dynamic Range f(SAR_{head})

(TEM cell , f = 900 MHz)





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

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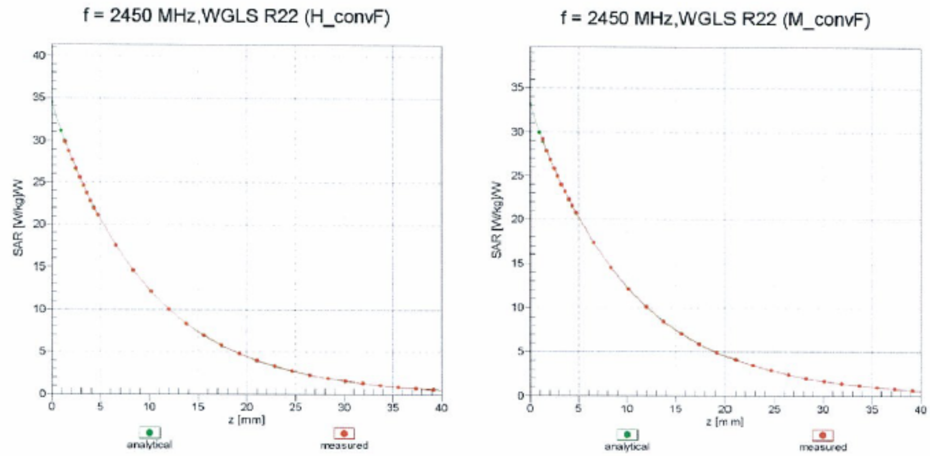
Appendix 3-8: Calibration certificate: E-Field Probe (EX3DV4) (cont'd)

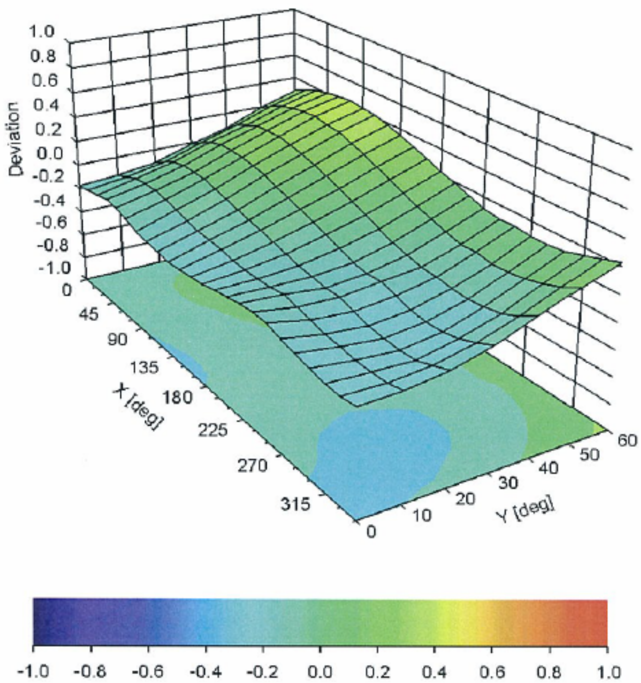
EX3DV4– SN:3679 June 21, 2012

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 3-8: Calibration certificate: E-Field Probe (EX3DV4) (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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Appendix 3-9: Calibration certificate: Dipole (D5GHzV2)

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Accreditation No.: SCS 108

Client UL Japan Shonan (PTT)

Certificate No: D5GHzV2-1070_Mar13

CALIBRATION CERTIFICATE

Object: D5GHzV2 - SN: 1070

Calibration procedure(s): QA CAL-22.v2
Calibration procedure for dipole validation kits between 3-6 GHz

Calibration date: March 14, 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. EX3-3503_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:	Claudio Leubler	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: March 14, 2013

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

Certificate No: D5GHzV2-1070_Mar13 Page 1 of 20

Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

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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%.

Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

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 5300 MHz ± 1 MHz 5500 MHz ± 1 MHz 5600 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	34.4 ± 6 %	4.52 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	7.97 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**78.9 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.5 W/kg ± 19.5 % (k=2)**

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Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.3 ± 6 %	4.62 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.27 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**81.9 W / kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.5 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	34.0 ± 6 %	4.80 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	8.52 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**84.3 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.42 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.9 W/kg ± 19.5 % (k=2)**

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Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	33.9 ± 6 %	4.91 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.36 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**82.9 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.6 W/kg ± 19.5 % (k=2)**

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	33.6 ± 6 %	5.11 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	7.88 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**77.9 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.25 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.2 W/kg ± 19.5 % (k=2)**

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Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

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	7.41 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**73.5 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.08 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.6 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.9 ± 6 %	5.55 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5300 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.56 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**75.0 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.12 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.0 W/kg ± 19.5 % (k=2)**

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Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

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 %	5.80 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	7.92 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**78.6 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.20 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.8 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.4 ± 6 %	5.94 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.99 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**79.3 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.22 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**22.0 W/kg ± 19.5 % (k=2)**

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Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

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	46.1 ± 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	7.39 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**73.3 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.05 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.3 W/kg ± 19.5 % (k=2)**

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Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

Appendix

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	50.7 Ω - 12.5 jΩ
Return Loss	- 18.2 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	51.9 Ω - 6.5 jΩ
Return Loss	- 23.6 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	49.2 Ω - 7.4 jΩ
Return Loss	- 22.5 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	55.6 Ω - 9.9 jΩ
Return Loss	- 19.4 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	53.9 Ω - 4.8 jΩ
Return Loss	- 24.6 dB

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Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	49.8 Ω - 12.4 jΩ
Return Loss	- 18.2 dB

Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	51.3 Ω - 5.0 jΩ
Return Loss	- 25.8 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	49.3 Ω - 5.6 jΩ
Return Loss	- 24.9 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	54.5 Ω - 8.2 jΩ
Return Loss	- 21.0 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	54.5 Ω - 2.5 jΩ
Return Loss	- 26.2 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.203 ns

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

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	September 26, 2008

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Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

DASY5 Validation Report for Head TSL

Date: 13.03.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1070

Communication System: CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 4.52 S/m; ε_r = 34.4; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5300 MHz; σ = 4.62 S/m; ε_r = 34.3; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5500 MHz; σ = 4.8 S/m; ε_r = 34; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5600 MHz; σ = 4.91 S/m; ε_r = 33.9; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5800 MHz; σ = 5.11 S/m; ε_r = 33.6; 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(5.1, 5.1, 5.1); Calibrated: 28.12.2012, ConvF(4.91, 4.91, 4.91); Calibrated: 28.12.2012, ConvF(4.76, 4.76, 4.76); 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 = 64.581 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 29.6 W/kg
SAR(1 g) = 7.97 W/kg; SAR(10 g) = 2.28 W/kg
Maximum value of SAR (measured) = 18.9 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.313 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 31.4 W/kg
SAR(1 g) = 8.27 W/kg; SAR(10 g) = 2.38 W/kg
Maximum value of SAR (measured) = 19.8 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 = 65.127 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 33.9 W/kg
SAR(1 g) = 8.52 W/kg; SAR(10 g) = 2.42 W/kg
Maximum value of SAR (measured) = 20.9 W/kg

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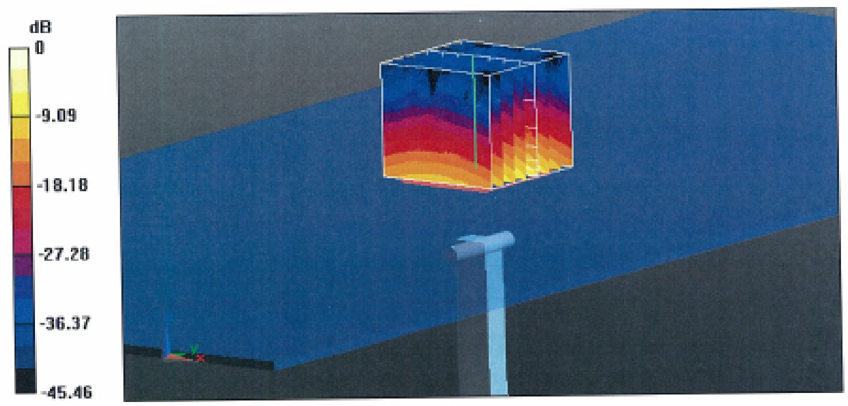
Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.687 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 33.4 W/kg
SAR(1 g) = 8.38 W/kg; SAR(10 g) = 2.39 W/kg
Maximum value of SAR (measured) = 20.5 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 = 61.292 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 32.8 W/kg
SAR(1 g) = 7.88 W/kg; SAR(10 g) = 2.25 W/kg
Maximum value of SAR (measured) = 19.7 W/kg



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

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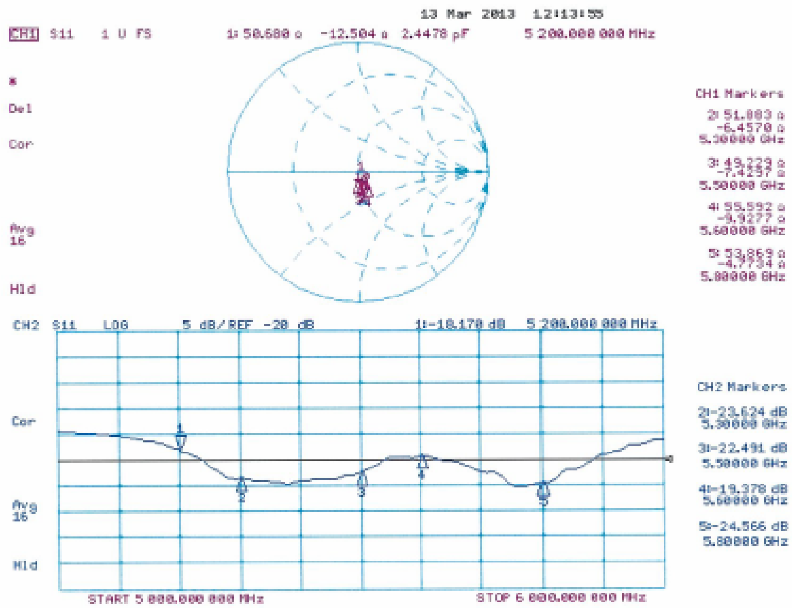
Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

Impedance Measurement Plot for Head TSL



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Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

DASY5 Validation Report for Body TSL

Date: 14.03.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1070

Communication System: CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 5.42 S/m; ε_r = 47; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5300 MHz; σ = 5.55 S/m; ε_r = 46.9; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5500 MHz; σ = 5.8 S/m; ε_r = 46.5; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5600 MHz; σ = 5.94 S/m; ε_r = 46.4; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5800 MHz; σ = 6.21 S/m; ε_r = 46.1; ρ = 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(4.67, 4.67, 4.67); Calibrated: 28.12.2012, ConvF(4.43, 4.43, 4.43); Calibrated: 28.12.2012, ConvF(4.22, 4.22, 4.22); 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 = 59.030 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 28.9 W/kg
SAR(1 g) = 7.41 W/kg; SAR(10 g) = 2.08 W/kg
Maximum value of SAR (measured) = 17.5 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 58.855 V/m; Power Drift = 0.00 dB
Peak SAR (extrapolated) = 30.4 W/kg
SAR(1 g) = 7.56 W/kg; SAR(10 g) = 2.12 W/kg
Maximum value of SAR (measured) = 18.0 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 = 58.871 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 34.0 W/kg
SAR(1 g) = 7.92 W/kg; SAR(10 g) = 2.2 W/kg
Maximum value of SAR (measured) = 19.4 W/kg

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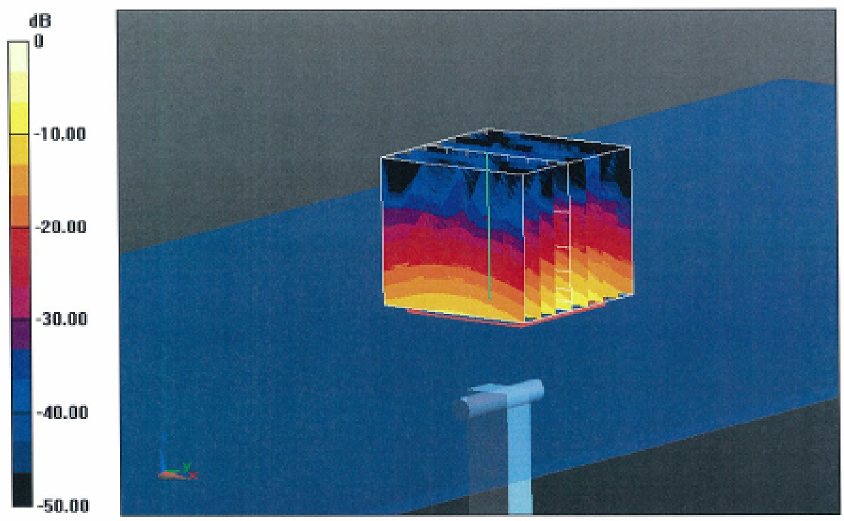
Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 58.618 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 35.1 W/kg
SAR(1 g) = 7.99 W/kg; SAR(10 g) = 2.22 W/kg
Maximum value of SAR (measured) = 19.7 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 = 55.394 V/m; Power Drift = 0.00 dB
Peak SAR (extrapolated) = 34.3 W/kg
SAR(1 g) = 7.39 W/kg; SAR(10 g) = 2.05 W/kg
Maximum value of SAR (measured) = 18.5 W/kg



0 dB = 18.5 W/kg = 12.67 dBW/kg

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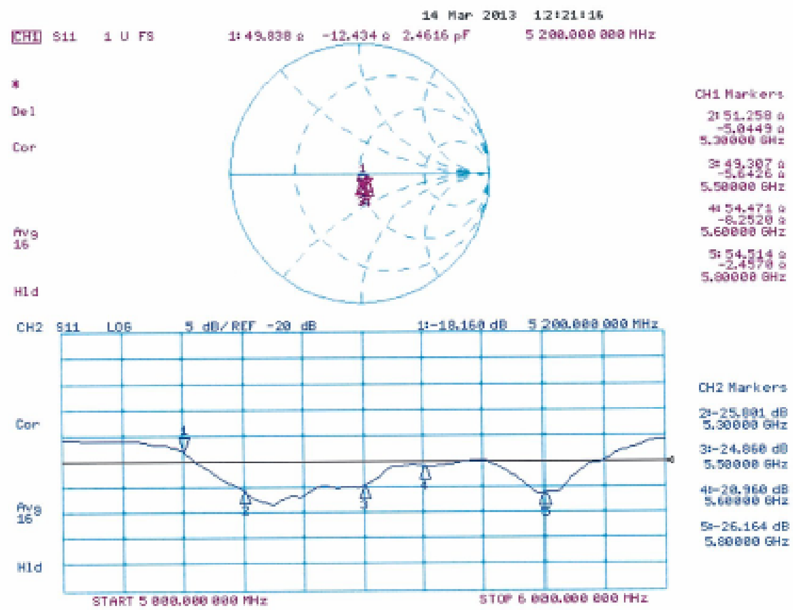
Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

Impedance Measurement Plot for Body TSL



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Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

Appendix B: Additional Measurements

Upon customer request, additional antenna parameter measurements were done using customer spacers, for Head and Body conditions. Results are summarized on the following pages.

Antenna Parameters with Head TSL at 5200 MHz

New spacer	50.7 Ω - 12.5 jΩ	- 18.2 dB
UL spacer #1	51.0 Ω - 12.2 jΩ	- 18.4 dB
UL spacer #2	51.2 Ω - 12.0 jΩ	- 18.6 dB

Antenna Parameters with Head TSL at 5300 MHz

New spacer	51.9 Ω - 6.5 jΩ	- 23.6 dB
UL spacer #1	51.9 Ω - 6.3 jΩ	- 23.8 dB
UL spacer #2	52.0 Ω - 6.0 jΩ	- 24.1 dB

Antenna Parameters with Head TSL at 5500 MHz

New spacer	49.2 Ω - 7.4 jΩ	- 22.5 dB
UL spacer #1	49.6 Ω - 7.6 jΩ	- 22.4 dB
UL spacer #2	50.0 Ω - 7.0 jΩ	- 23.1 dB

Antenna Parameters with Head TSL at 5600 MHz

New spacer	55.6 Ω - 9.9 jΩ	- 19.4 dB
UL spacer #1	55.7 Ω - 9.2 jΩ	- 19.8 dB
UL spacer #2	55.6 Ω - 8.8 jΩ	- 20.1 dB

Antenna Parameters with Head TSL at 5800 MHz

New spacer	53.9 Ω - 4.8 jΩ	- 24.6 dB
UL spacer #1	54.2 Ω - 4.7 jΩ	- 24.4 dB
UL spacer #2	54.6 Ω - 3.9 jΩ	- 24.8 dB

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Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

Antenna Parameters with Body TSL at 5200 MHz

New spacer	49.8 Ω - 12.4 jΩ	- 18.2 dB
UL spacer #1	49.9 Ω - 12.4 jΩ	- 18.2 dB
UL spacer #2	50.1 Ω - 12.3 jΩ	- 18.3 dB

Antenna Parameters with Body TSL at 5300 MHz

New spacer	51.3 Ω - 5.0 jΩ	- 25.8 dB
UL spacer #1	51.4 Ω - 5.0 jΩ	- 25.8 dB
UL spacer #2	51.5 Ω - 4.8 jΩ	- 26.2 dB

Antenna Parameters with Body TSL at 5500 MHz

New spacer	49.3 Ω - 5.6 jΩ	- 24.9 dB
UL spacer #1	49.2 Ω - 5.6 jΩ	- 24.9 dB
UL spacer #2	49.5 Ω - 5.4 jΩ	- 25.2 dB

Antenna Parameters with Body TSL at 5600 MHz

New spacer	54.5 Ω - 8.2 jΩ	- 21.0 dB
UL spacer #1	54.7 Ω - 8.2 jΩ	- 20.9 dB
UL spacer #2	54.8 Ω - 7.8 jΩ	- 21.2 dB

Antenna Parameters with Body TSL at 5800 MHz

New spacer	54.5 Ω - 2.5 jΩ	- 26.2 dB
UL spacer #1	54.4 Ω - 2.2 jΩ	- 26.5 dB
UL spacer #2	54.8 Ω - 1.8 jΩ	- 26.2 dB

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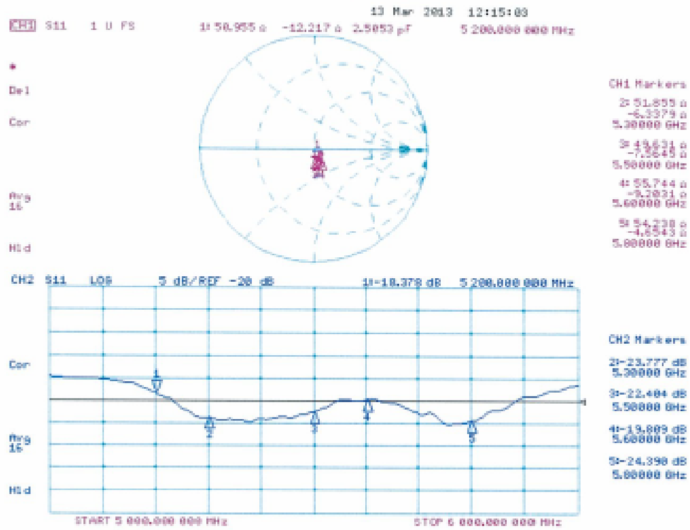
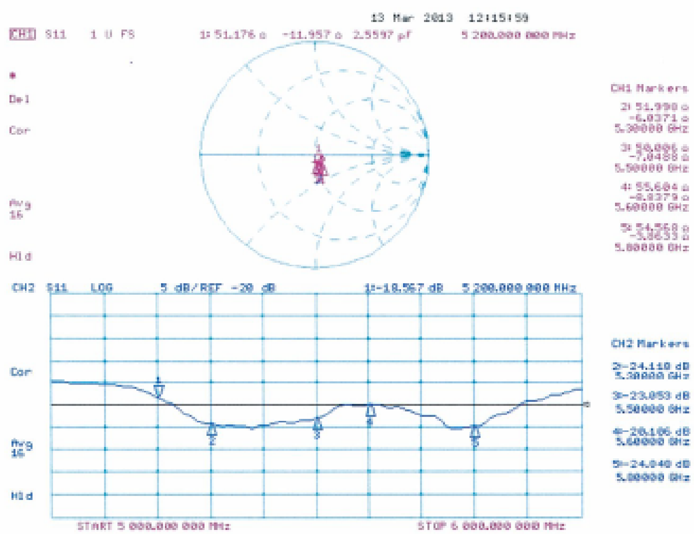
Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

Impedance Measurement Plot for Head TSL (UL Spacer #1)

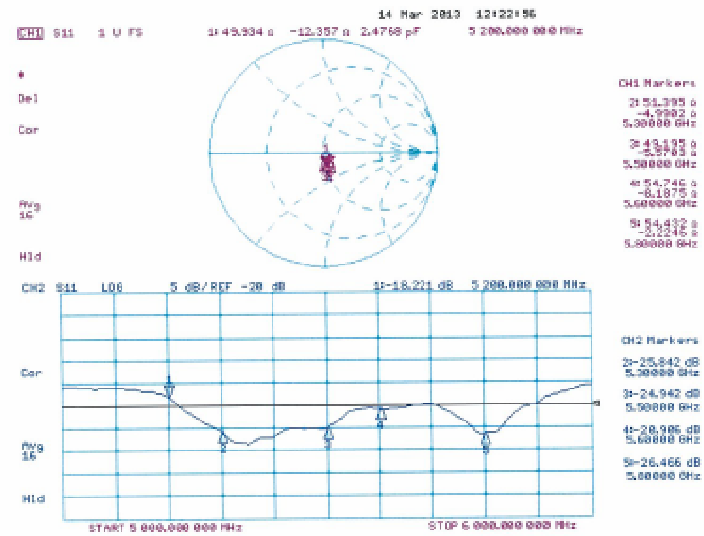


Impedance Measurement Plot for Head TSL (UL Spacer #2)

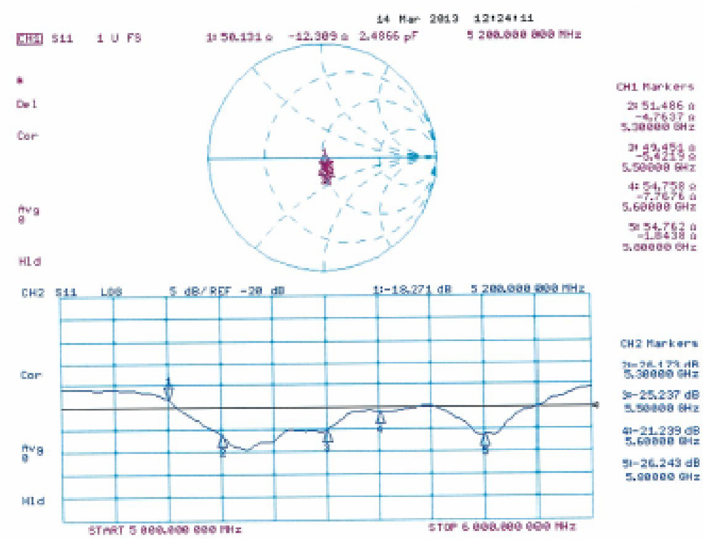


Appendix 3-9: Calibration certificate: Dipole (D5GHzV2) (cont'd)

Impedance Measurement Plot for Body TSL (UL Spacer #1)



Impedance Measurement Plot for Body TSL (UL Spacer #2)



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