APPENDIX 6 : System Validation Dipole (D5GHzV2,S/N: 1020)

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IMPORTANT NOTICE

DIPOLE TRANSPORTATION CASE

Important Note:

Please use only this suitcase for any future dipole transportation!

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Schmid & Partner Engineering AG

June 2003

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

Client UL A-Pex (MTT)

CALIBRATION CERTIFICATE

Object(s)	D5GHzV2 - SN:1020
Calibration procedure(s)	QA CAL-05 v2 Calibration procedure for dipole validation kits
Calibration date:	February 23, 2004
Condition of the calibrated item	In Tolerance (according to the specific calibration document)

This calibration statement documents traceability of M&TE used in the calibration procedures and conformity of the procedures with the ISO/IEC 17025 international standard.

All calibrations have been conducted in the closed laboratory facility: environment temperature 22 +/- 2 degrees Celsius and humidity < 75%.

Calibration Equipment used (M&TE critical for calibration)

Model Type	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Power meter EPM E4419B	GB41293874	2-Apr-03 (METAS, No 252-0250)	Apr-04
Power sensor E4412A	MY41495277	2-Apr-03 (METAS, No 252-0250)	Apr-04
Power sensor HP 8481A	MY41092317	18-Oct-02 (Agilent, No. 20021018)	Oct-04
RF generator R&S SMT06	100058	23-May-01 (SPEAG, in house check May-03)	In house check: May-05
Network Analyzer HP 8753E	US37390585	18-Oct-01 (SPEAG, in house check Nov-03)	In house check: Oct 05

	Name	Function	Signature
Calibrated by:	Katja Pokovic	Laboratory Director	
Approved by:	Fin Bomholt	R&D Director	

Date issued: February 26, 2004

This calibration certificate is issued as an intermediate solution until the accreditation process (based on ISO/IEC 17025 International Standard) for Calibration Laboratory of Schmid & Partner Engineering AG is completed.

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DASY

Dipole Validation Kit

Type: D5GHzV2

Serial: 1020

Manufactured: February 5, 2004
Calibrated: February 23, 2004

1. Measurement Conditions

The measurements were performed in the flat section of the SAM twin phantom filled with **head simulating solution** of the following electrical parameters:

Frequency:	**5200 MHz**	
Relative Dielectricity	**36.3**	± 5%
Conductivity	**4.57 mho/m**	± 5%
Frequency:	**5800 MHz**	
Relative Dielectricity	**35.4**	± 5%
Conductivity	**5.20 mho/m**	± 5%

The DASY4 System with a dosimetric E-field probe EX3DV3 - SN:3503 was used for the measurements. The dipole was mounted on the small tripod so that the dipole feedpoint was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10mm from dipole center to the solution surface. Lossless spacer was used during measurements for accurate distance positioning.

The coarse grid with a grid spacing of 10mm was aligned with the dipole. Special 8x8x8 fine cube was chosen for cube integration (dx=dy=4.3mm, dz=3mm). Distance between probe sensors and phantom surface was set to 2.5 mm. The dipole input power (forward power) was 250 mW ± 3 %. The results are normalized to 1W input power.

2. SAR Measurement with DASY System

Standard SAR-measurements were performed according to the measurement conditions described in section 1. The results (see figures supplied) have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR-values measured at **5200 MHz (Head Tissue)** with the dosimetric probe EX3DV3 SN:3503 and applying the advanced extrapolation are:

averaged over 1 cm^3 (1 g) of tissue: **87.6 mW/g** ± 20.3 % (k=2)[1]

averaged over 10 cm^3 (10 g) of tissue: **24.5 mW/g** ± 19.8 % (k=2)[1]

The resulting averaged SAR-values measured **at 5800 MHz (Head Tissue)** with the dosimetric probe EX3DV3 SN:3503 and applying the advanced extrapolation are:

averaged over 1 cm^3 (1 g) of tissue: **86.8 mW/g** ± 20.3 % (k=2)[2]

averaged over 10 cm^3 (10 g) of tissue: **24.2 mW/g** ± 19.8 % (k=2)[2]

[1] Target dipole values determined by FDTD (feedpoint impedance set to 50 Ohm). The values are SAR_1g=76.5 mW/g, SAR_10g=21.6 mW/g and SAR_peak=310.3 mW/g.

[2] Target dipole values determined by FDTD (feedpoint impedance set to 50 Ohm). The values are SAR_1g=78.0 mW/g, SAR_10g=21.9 mW/g and SAR_peak=340.9 mW/g.

3. Dipole Transformation Parameters

The impedance was measured at the SMA-connector with a network analyzer and numerically transformed to the dipole feedpoint (please refer to the graphics attached to this document). The transformation parameters from the SMA-connector to the dipole feedpoint are:

Electrical delay:	**1. 200 ns**	(one direction)
Transmission factor:	**0.974**	(voltage transmission, one direction)

4. Measurement Conditions

The measurements were performed in the flat section of the SAM twin phantom filled with **body simulating solution** of the following electrical parameters:

Frequency:	**5200 MHz**	
Relative Dielectricity	**49.7**	± 5%
Conductivity	**5.18 mho/m**	± 5%
Frequency:	**5800 MHz**	
Relative Dielectricity	**48.5**	± 5%
Conductivity	**6.01 mho/m**	± 5%

The DASY3 System with a dosimetric E-field probe EX3DV3 - SN:3503 was used for the measurements. The dipole was mounted on the small tripod so that the dipole feedpoint was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10mm from dipole center to the solution surface. Lossless spacer was used during measurements for accurate distance positioning.

The coarse grid with a grid spacing of 10mm was aligned with the dipole. The 8x8x8 fine cube was chosen for cube integration (dx=dy=4.3mm, dz=3mm). Distance between probe sensors and phantom surface was set to 2.5 mm. The dipole input power (forward power) was 250 mW ± 3 %. The results are normalized to 1W input power.

5. SAR Measurement with DASY System

Standard SAR-measurements were performed according to the measurement conditions described in section 4. The results (see figures supplied) have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR-values measured at **5200 MHz (Body Tissue)** with the dosimetric probe EX3DV3 SN:3503 and applying the advanced extrapolation are:

averaged over 1 cm^3 (1 g) of tissue: **82.0 mW/g** ± 20.3 % (k=2)[3]

averaged over 10 cm^3 (10 g) of tissue: **23.0 mW/g** ± 19.8 % (k=2)[3]

The resulting averaged SAR-values measured **at 5800 MHz (Body Tissue)** with the dosimetric probe EX3DV3 SN:3503 and applying the advanced extrapolation are:

averaged over 1 cm^3 (1 g) of tissue: **78.4 mW/g** ± 20.3 % (k=2)[4]

averaged over 10 cm^3 (10 g) of tissue: **21.5 mW/g** ± 19.8 % (k=2)[4]

6. Handling

Do not apply excessive force to the dipole arms, because they might bend. Bending of the dipole arms stresses the soldered connections near the feedpoint leading to a damage of the dipole.

7. Design

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.

Small end caps have been added to the dipole arms in order to increase frequency bandwidth at the position as explained in Sections 1and 4.

8. Power Test

After long term use with 40W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

[3] Target dipole values determined by FDTD (feedpoint impedance set to 50 Ohm). The values are SAR_1g=71.8 mW/g, SAR_10g=20.1 mW/g and SAR_peak=284.7 mW/g.

[4] Target dipole values determined by FDTD (feedpoint impedance set to 50 Ohm). The values are SAR_1g=74.1 mW/g, SAR_10g=20.5 mW/g and SAR_peak=324.7 mW/g.

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Date/Time: 02/20/04 17:12:14

Test Laboratory: SPEAG, Zurich, Switzerland

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

Communication System: CW-5GHz;Duty Cycle: 1:1;Medium: HSL5800
Medium parameters used: f = 5200 MHz; σ = 4.57 mho/m; ε_r = 36.3; ρ = 1000 kg/m^3
Medium parameters used: f = 5800 MHz; σ = 5.2 mho/m; ε_r = 35.4; ρ = 1000 kg/m^3

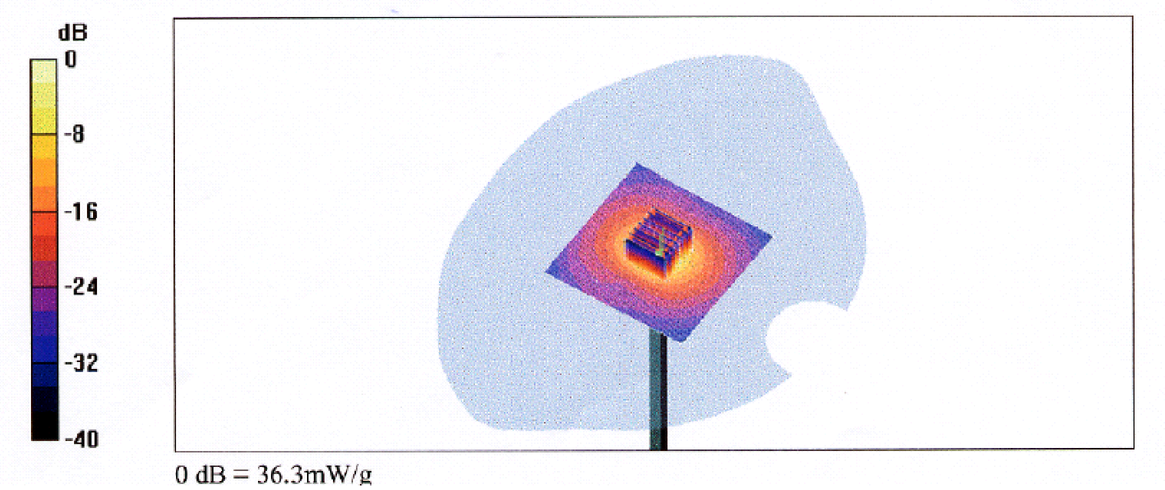
DASY4 Configuration:

- Probe: EX3DV3 - SN3503; ConvF(5.7, 5.7, 5.7) ConvF(5, 5, 5); Calibrated: 6/27/2003
- Sensor-Surface: 2.5mm (Mechanical Surface Detection)
- Electronics: DAE4 600; Calibrated: 9/30/2003
- Phantom: SAM with CRP - TP:1312; Phantom section: Flat Section
- Measurement SW: DASY4, V4.2 Build 30; Postprocessing SW: SEMCAD, V1.8 Build 98

d=10mm, Pin=250mW, f=5200 MHz/Area Scan (91x91x1): Measurement grid: dx=10mm, dy=10mm
Reference Value = 97.3 V/m
Power Drift = 0.0 dB
Maximum value of SAR = 40.4 mW/g

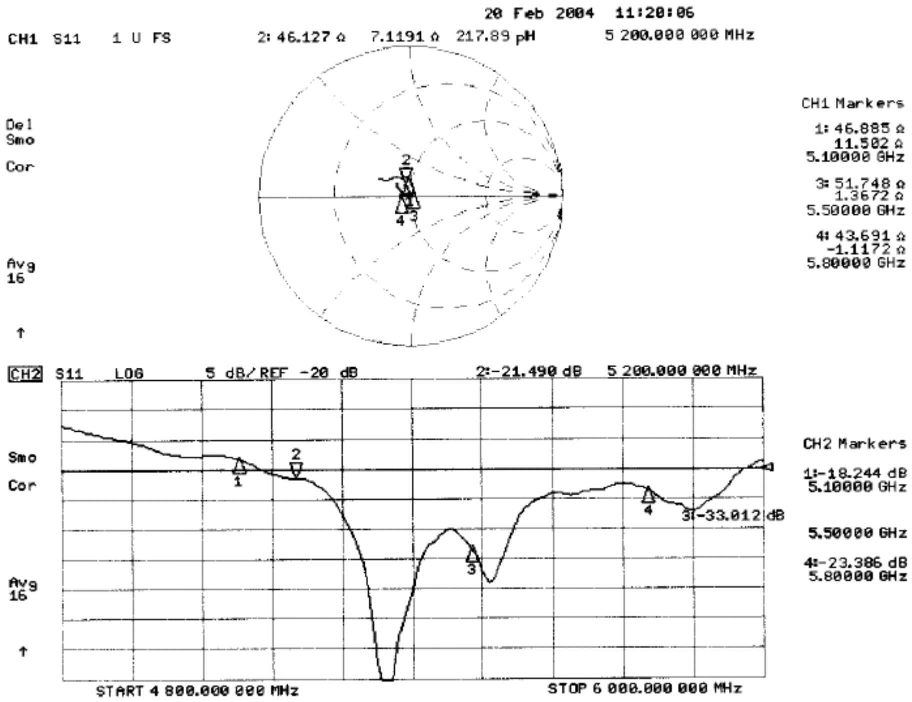
d=10mm, Pin=250mW, f=5800 MHz 2/Zoom Scan (8x8x8), dist=2.5mm (7x7x8)/Cube 0:
Measurement grid: dx=4.3mm, dy=4.3mm, dz=3mm
Peak SAR (extrapolated) = 89.6 W/kg
SAR(1 g) = 21.5 mW/g; SAR(10 g) = 6.05 mW/g

d=10mm, Pin=250mW, f=5200 MHz/Zoom Scan (8x8x8), dist=2.5mm (7x7x8)/Cube 0:
Measurement grid: dx=4.3mm, dy=4.3mm, dz=3mm
Peak SAR (extrapolated) = 85 W/kg
SAR(1 g) = 21.9 mW/g; SAR(10 g) = 6.12 mW/g



0 dB = 36.3mW/g

Head


20 Feb 2004 11:28:06
CH1 S11 1 U FS 2: 46.127 Ω 7.1191 Ω 217.89 pH 5 200.000 000 MHz
Del
Smo
Cor
Avg
16
CH1 Markers
1: 46.885 Ω
11.502 Ω
5.10000 GHz
3: 51.748 Ω
1.3672 Ω
5.50000 GHz
4: 43.691 Ω
-1.1172 Ω
5.80000 GHz
CH2 S11 LOG 5 dB/REF -20 dB 2:-21.490 dB 5 200.000 000 MHz
Smo
Cor
Avg
16
CH2 Markers
1:-18.244 dB
5.10000 GHz
3:-33.012 dB
5.50000 GHz
4:-23.386 dB
5.80000 GHz
START 4 800.000 000 MHz
STOP 6 000.000 000 MHz

Page 1 of 1

Date/Time: 02/23/04 19:20:57

Test Laboratory: SPEAG, Zurich, Switzerland

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

Communication System: CW-5GHz;Duty Cycle: 1:1;Medium: MSL5800
Medium parameters used: f = 5200 MHz; σ = 5.18 mho/m; ε_r = 49.7; ρ = 1000 kg/m^3
Medium parameters used: f = 5800 MHz; σ = 6.01 mho/m; ε_r = 48.5; ρ = 1000 kg/m^3

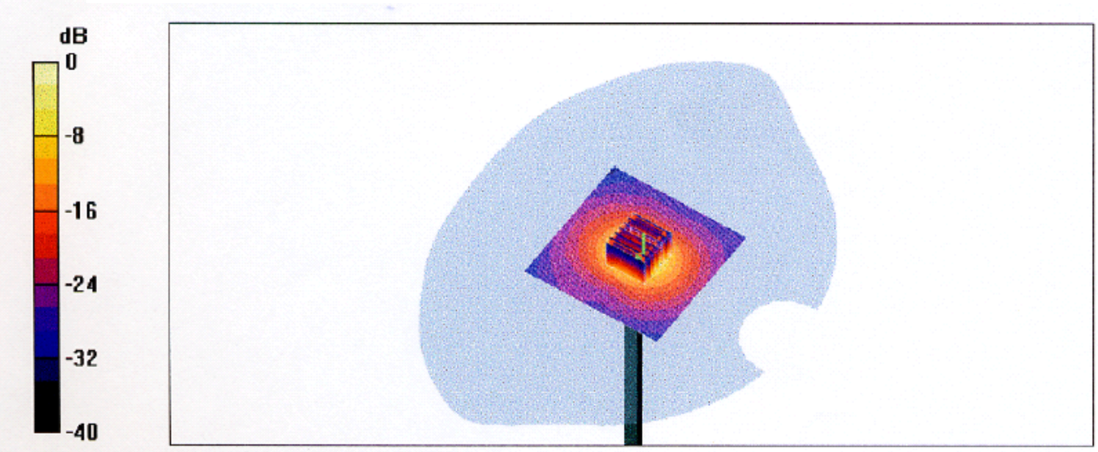
DASY4 Configuration:

- Probe: EX3DV3 - SN3503; ConvF(5, 5, 5)
  ConvF(4.6, 4.6, 4.6); Calibrated: 6/27/2003
- Sensor-Surface: 2.5mm (Mechanical Surface Detection)
- Electronics: DAE4 600; Calibrated: 9/30/2003
- Phantom: SAM with CRP - TP:1312; Phantom section: Flat Section
- Measurement SW: DASY4, V4.2 Build 34; Postprocessing SW: SEMCAD, V1.8 Build 105

d=10mm, Pin=250mW, f=5200 MHz/Area Scan (91x91x1): Measurement grid: dx=10mm, dy=10mm
Reference Value = 80.3 V/m; Power Drift = 0.0 dB
Maximum value of SAR (interpolated) = 37.5 mW/g

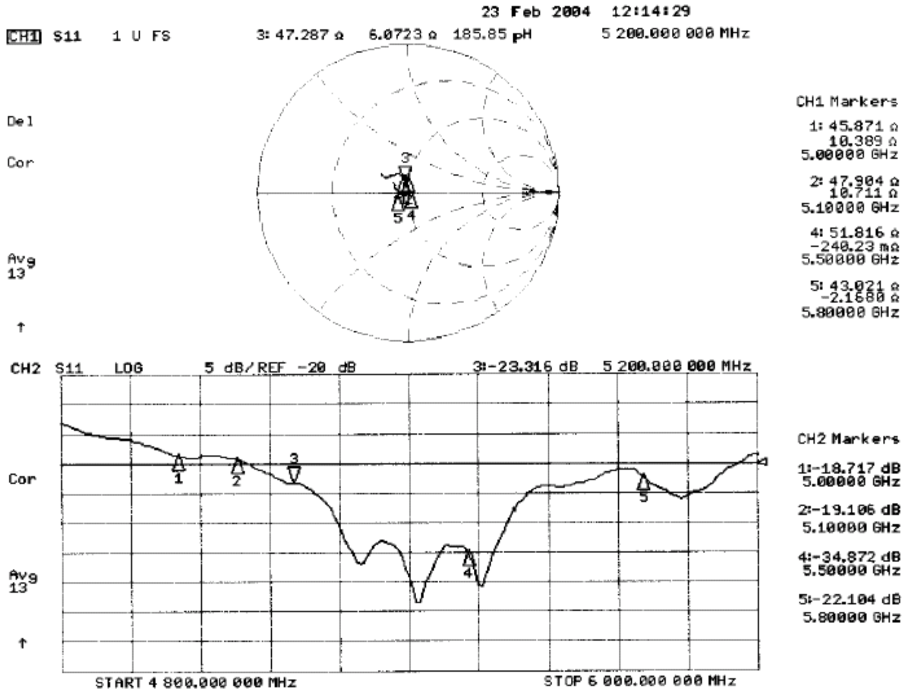
d=10mm, Pin=250mW, f=5800 MHz/Zoom Scan (8x8x8), dist=2.5mm (7x7x8)/Cube 0:
Measurement grid: dx=4.3mm, dy=4.3mm, dz=3mm
Peak SAR (extrapolated) = 80.6 W/kg
SAR(1 g) = 19.6 mW/g; SAR(10 g) = 5.38 mW/g

d=10mm, Pin=250mW, f=5200 MHz/Zoom Scan (8x8x8), dist=2.5mm (7x7x8)/Cube 0:
Measurement grid: dx=4.3mm, dy=4.3mm, dz=3mm
Peak SAR (extrapolated) = 71.6 W/kg
SAR(1 g) = 20.5 mW/g; SAR(10 g) = 5.74 mW/g



0 dB = 33.6mW/g

Body


23 Feb 2004 12:14:29
CH1 S11 1 U FS
3: 47.287 Ω 6.0723 Ω 185.85 pH 5 200.000 000 MHz
Del
Cor
Avg 13
CH1 Markers
1: 45.871 Ω 10.389 Ω 5.00000 GHz
2: 47.904 Ω 10.711 Ω 5.10000 GHz
4: 51.816 Ω -240.23 mΩ 5.50000 GHz
5: 43.021 Ω -2.1680 Ω 5.80000 GHz
CH2 S11 LOG 5 dB/REF -20 dB 3:-23.316 dB 5 200.000 000 MHz
Cor
Avg 13
CH2 Markers
1:-18.717 dB 5.00000 GHz
2:-19.106 dB 5.10000 GHz
4:-34.872 dB 5.50000 GHz
5:-22.104 dB 5.80000 GHz
START 4 800.000 000 MHz
STOP 6 000.000 000 MHz

APPENDIX 7 : Dosimetric E-field Probe Calibration (EX3DV4, S/N:3540)

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S **Schweizerischer Kalibrierdienst**
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Swiss Calibration Service

Accredited by the Swiss Federal Office of Metrology and Accreditation
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 **MTT**

Certificate No: EX3-3540_Jan05

CALIBRATION CERTIFICATE

Object	**EX3DV4 - SN:3540**
Calibration procedure(s)	**QA CAL-01.v6** **Calibration procedure for dosimetric E-field probes**
Calibration date:	**January 14, 2005**
Condition of the calibrated item	**In Tolerance**

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 (Calibrated by, Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	5-May-04 (METAS, No. 251-00388)	May-05
Power sensor E4412A	MY41495277	5-May-04 (METAS, No. 251-00388)	May-05
Reference 3 dB Attenuator	SN: S5054 (3c)	10-Aug-04 (METAS, No. 251-00403)	Aug-05
Reference 20 dB Attenuator	SN: S5086 (20b)	3-May-04 (METAS, No. 251-00389)	May-05
Reference 30 dB Attenuator	SN: S5129 (30b)	10-Aug-04 (METAS, No. 251-00404)	Aug-05
Reference Probe ES3DV2	SN: 3013	7-Jan-05 (SPEAG, No. ES3-3013_Jan05)	Jan-06
DAE4	SN: 617	29-Sep-04 (SPEAG, No. DAE4-617_Sep04)	Sep-05

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP 8481A	MY41092180	18-Sep-02 (SPEAG, in house check Oct-03)	In house check: Oct 05
RF generator HP 8648C	US3642U01700	4-Aug-99 (SPEAG, in house check Dec-03)	In house check: Dec-05
Network Analyzer HP 8753E	US37390585	18-Oct-01 (SPEAG, in house check Nov-04)	In house check: Nov 05

	Name	Function	Signature
Calibrated by:	Katja Pokovic	Technical Manager	
Approved by:	Fin Bomholt	R&D Manager	

Issued: January 14, 2005

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

Certificate No: EX3-3540_Jan05 Page 1 of 9

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
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) CENELEC EN 50361, "Basic standard for the measurement of Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones (300 MHz - 3 GHz), July 2001

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 effect 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 (no uncertainty required). DCP does not depend on frequency nor media.
- *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 4.3 B17 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:3540

Manufactured:	August 23, 2004
Calibrated:	January 14, 2005

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

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DASY - Parameters of Probe: EX3DV4 SN:3540

Sensitivity in Free Space[A]

NormX	**0.47** ± 10.1%	$\mu V/(V/m)^2$
NormY	**0.54** ± 10.1%	$\mu V/(V/m)^2$
NormZ	**0.49** ± 10.1%	$\mu V/(V/m)^2$

Diode Compression[B]

DCP X	**92** mV
DCP Y	**92** mV
DCP Z	**92** mV

Sensitivity in Tissue Simulating Liquid (Conversion Factors)

Please see Page 9.

Boundary Effect

TSL **900 MHz** **Typical SAR gradient: 5 % per mm**

Sensor Center to Phantom Surface Distance		**2.0 mm**	**3.0 mm**
SAR_{be} [%]	Without Correction Algorithm	3.5	1.3
SAR_{be} [%]	With Correction Algorithm	0.2	0.5

TSL **1810 MHz** **Typical SAR gradient: 10 % per mm**

Sensor Center to Phantom Surface Distance		**2.0 mm**	**3.0 mm**
SAR_{be} [%]	Without Correction Algorithm	4.4	2.5
SAR_{be} [%]	With Correction Algorithm	1.0	0.6

Sensor Offset

Probe Tip to Sensor Center **1.0** mm

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 Page 9).

[B] Numerical linearization parameter: uncertainty not required.

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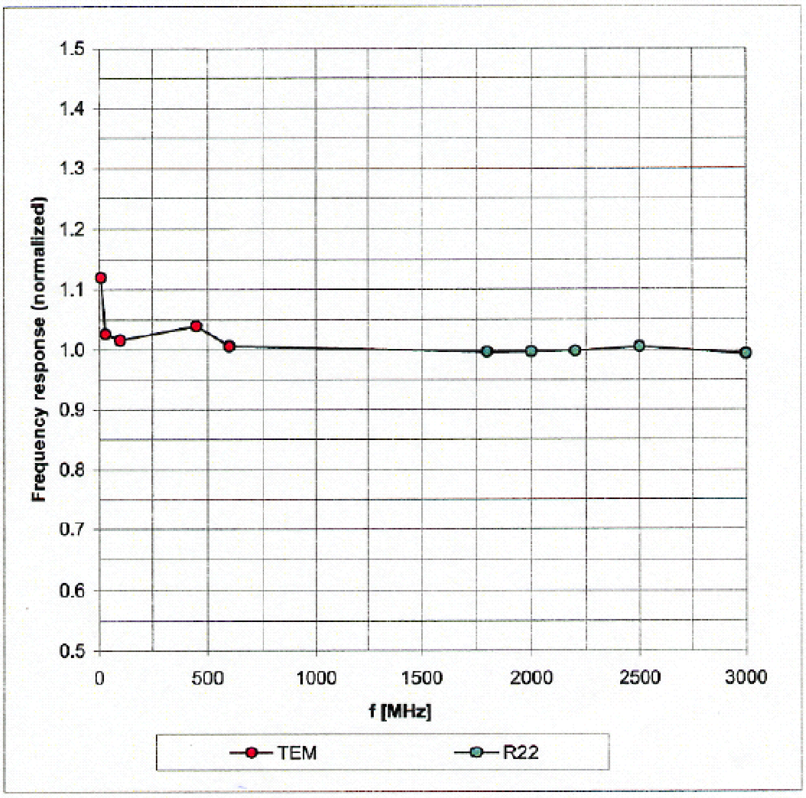
EX3DV4 SN:3540 January 14, 2005

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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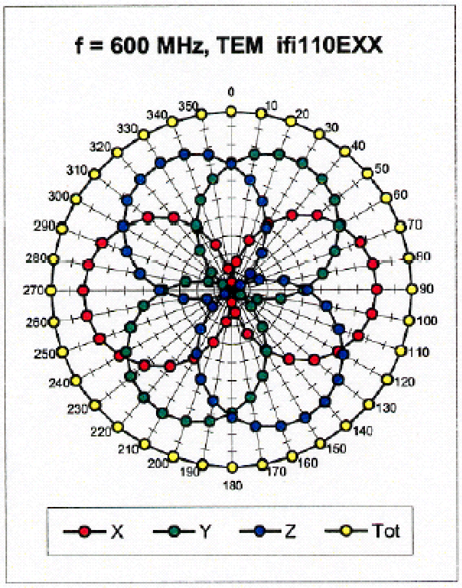
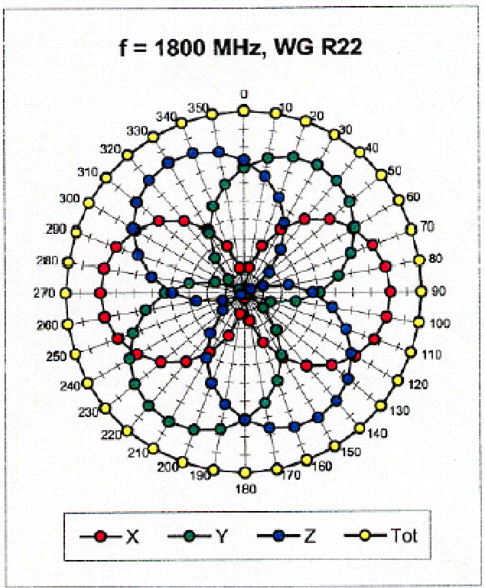
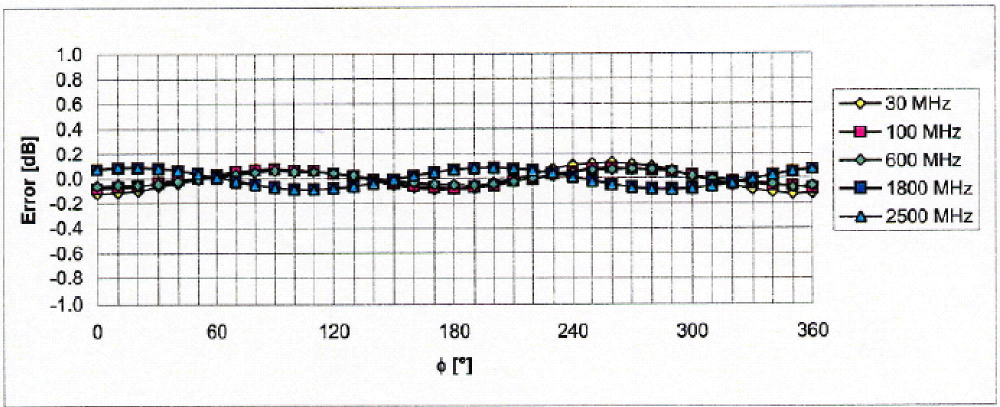
EX3DV4 SN:3540 January 14, 2005

Receiving Pattern (ϕ), ϑ = 0°







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

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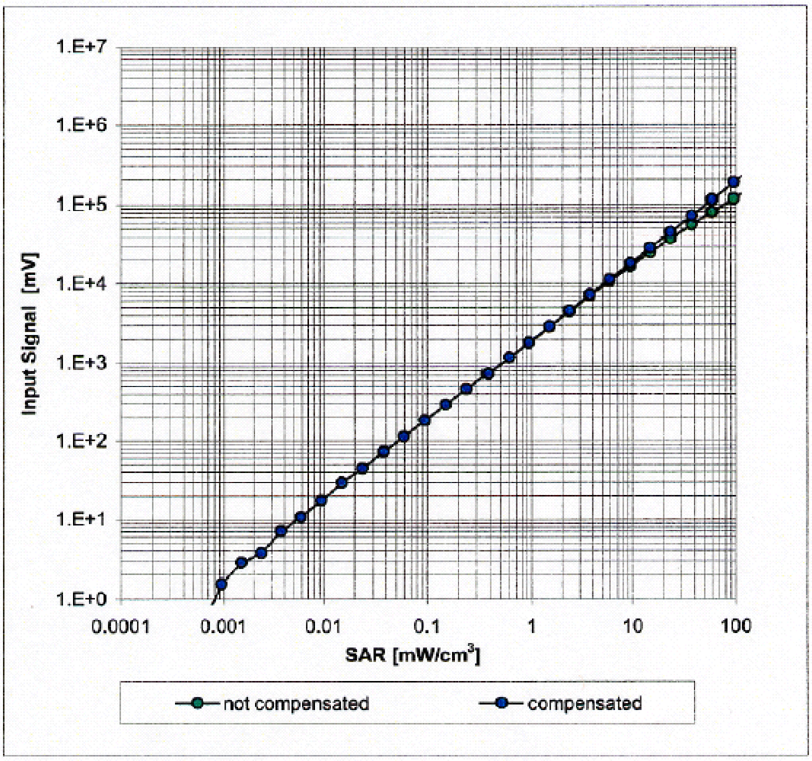
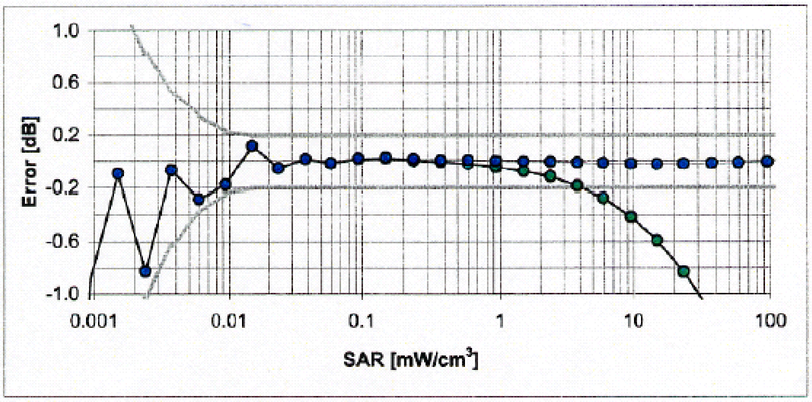
EX3DV4 SN:3540 January 14, 2005

Dynamic Range f(SAR_{head})

(Waveguide R22, f = 1800 MHz)





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

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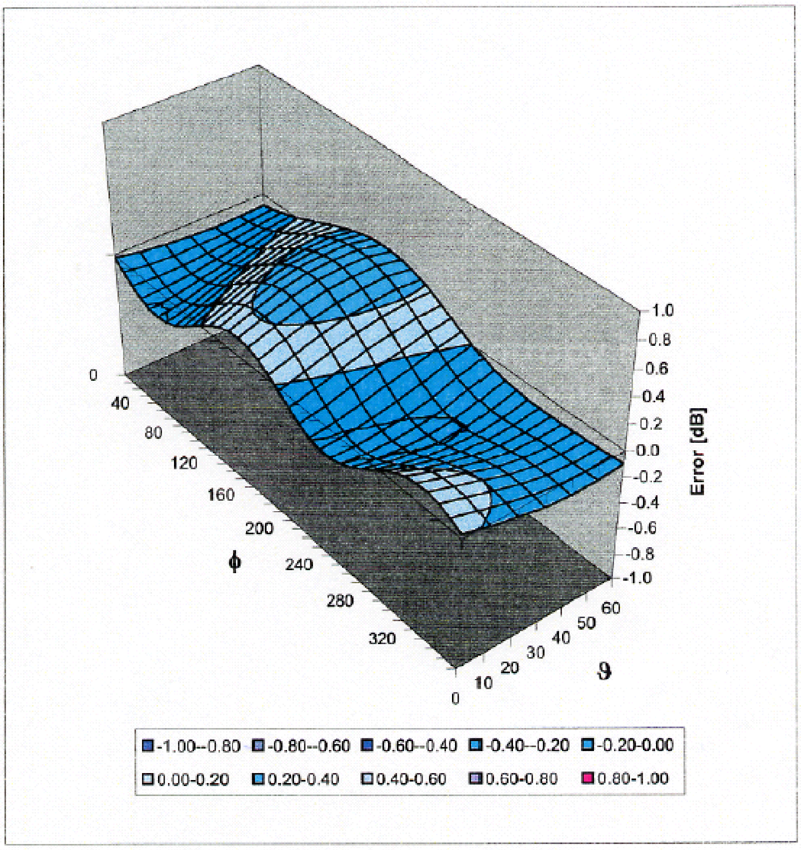
EX3DV4 SN:3540 January 14, 2005

Deviation from Isotropy in HSL

Error (ϕ, ϑ), f = 900 MHz



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

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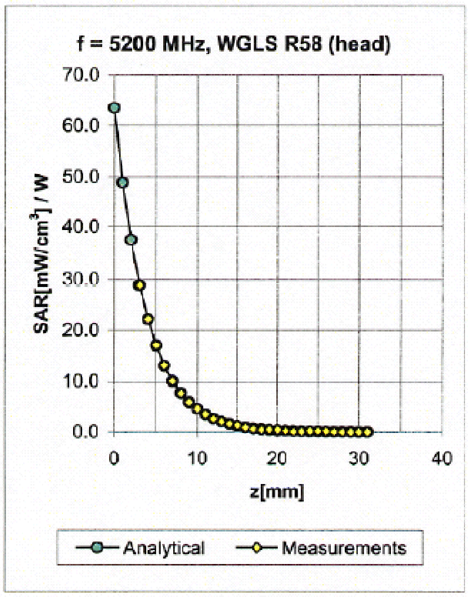
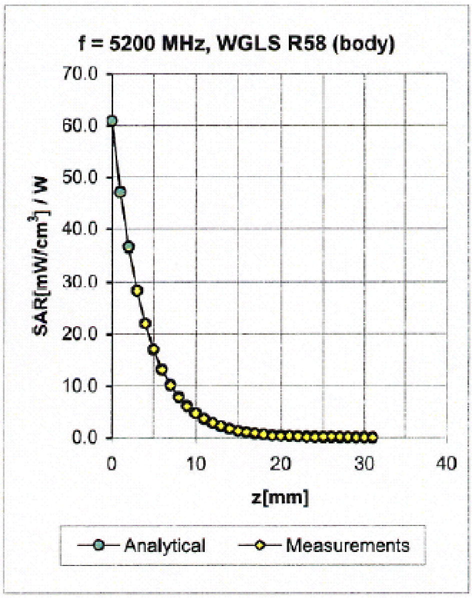
Appendix[D]





f [MHz][D]	Validity [MHz]	TSL	Permittivity	Conductivity	Alpha	Depth	ConvF	Uncertainty
5200	± 50	Head	36.0 ± 5%	4.76 ± 5%	0.45	1.80	4.79	± 13.6% (k=2)
5800	± 50	Head	35.3 ± 5%	5.27 ± 5%	0.45	1.80	4.34	± 13.6% (k=2)
5200	± 50	Body	49.0 ± 5%	5.30 ± 5%	0.45	1.90	4.40	± 13.6% (k=2)
5800	± 50	Body	48.2 ± 5%	6.00 ± 5%	0.43	1.90	4.06	± 13.6% (k=2)

[D] Accreditation for ConvF assessment above 3000 MHz is currently applied for. Accreditation is expected at the beginning of 2005.

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APPENDIX 8 : The 5-6GHz Extension (SPEAG information)

Chapter 26

The 5-6 GHz Extension

26.1 Introduction

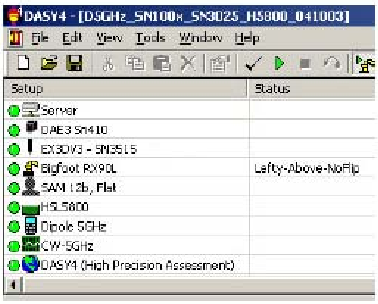
In July 2003, the SPEAG calibration laboratory and its service center released extension for conducting SAR assessments with DASY4 in the frequency range 5-6 GHz. In addition, in January 2004, SPEAG released the smallest dosimetric probe EX3DV3 which allowed a significant improvement of the extension with respect to the measurement accuracy.

These new items and services enable the user to perform routine evaluations of compliance with exposure guidelines operating in the 5 GHz frequency band, as defined in the supplement IEEE 802.11a (1999) and HiperLAN/2 standards with an uncertainty of less than ±30 %.

The new extension for the higher frequency range meets the same requirements for SAR evaluations as described in IEEE 1528 [1], CENELEC EN50361 [2], IEC 62209 [3] for lower frequencies (300 MHz - 3 GHz). The performance of the new setup has been validated by the Foundation for Research on Information Technologies in Society IT'IS.

DASY Software Settings

The recommended usage of a DASY system and its components in the frequency range 300 MHz - 3 GHz is described in detail in the previous Chapters. This Chapter provides all additions and deviations needed for the frequency range 5-6 GHz. If nothing is stated in this Chapter, the requirements, procedures and methods of the previous Chapters are applicable.



Most of the DASY items and requirements do not deviate from those for the frequency range below 3 GHz. However, due to the stronger gradients of the field distribution in the 5-6 GHz frequency range, adaptation is required for the scanning method as well as for the dosimetric probe type.

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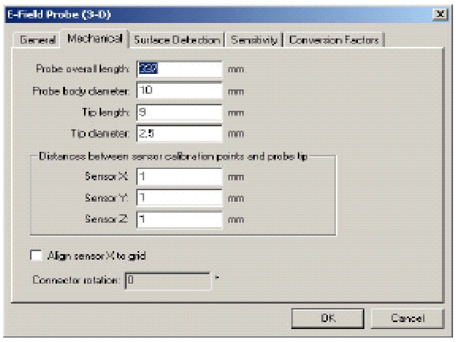
26.2 Smallest Dosimetric Probe (EX3DV3)

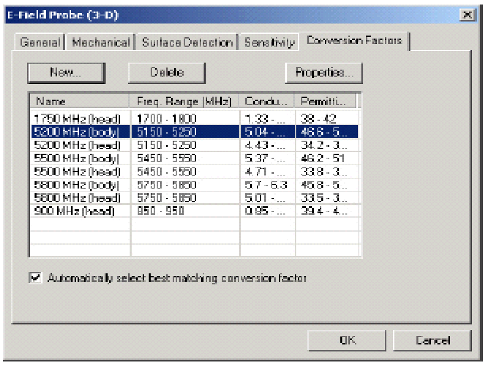
Within the framework of the new EUREKA project No. 2915 (SARSYS-BWP), SPEAG developed a new probe optimized for this frequency range. The new probe has a Tip diameter of 2.5 mm and a distance between sensor calibration point and probe tip (Sensor X,Y and Z) of 1.0 mm. With these dimensions, the EX3DV3 probe has superior performance for high precision measurements in field distributions with steep gradients.

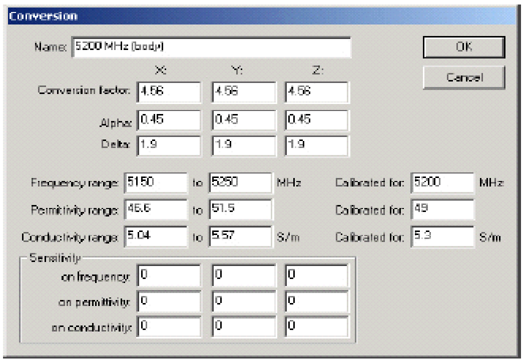
The EX3DV3 probe is fully compatible with the latest draft of IEC 62209 Part 2. It is the only probe enabling measurements at 5-6 GHz with a precision of better than 30% (uncertainty assessed according to the standards). The EX3DV3 probe is universally applicable for dosimetric assessments and is fully compatible with the mechanical detection system of DASY4.



The dimensions of the smallest dosimetric EX3DV3 probe are shown in the Mechanical tab in the dialog. Compared to the standard dosimetric probe, the EX3DV3 type has a reduced Tip diameter as well as smaller distance between sensor calibration point and probe tip (Sensor X,Y and Z) enabling SAR assessments as close as 1.5 mm from the shell-liquid interface.

Note: Please note that the standard ES3DV3 and especially the ET3DV6 dosimetric probes are not suitable for this frequency range. With these probes, the SAR measurement uncertainty can significantly exceed ±30%.





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The probe conversion factors in the 5-6 GHz frequency range were assessed in the setup based on the vertically standing waveguide type R58 (frequency band: 4.9 - 7.05 GHz). Due to the small waveguide dimensions, field disturbance by the probe could not be excluded and needs to be added to the uncertainty budget. Together with other error sources, the resulting probe calibration uncertainty for the EX3DV3 probe type was assessed to be ±6.6% (k=1) at Calibration Frequency and ±13.6% (k=1) for a narrow-band conversion factor (±50 MHz).

26.3 Tissue Simulating Liquids

In the current guidelines and draft standards for compliance testing of mobile phones (e.g., IEEE P1528, OET 65 Supplement C), the dielectric parameters suggested for head and body tissue simulating liquid are given only at 3.0 GHz and 5.8 GHz. As an intermediate solution, dielectric parameters for the frequencies between 5 to 5.8 GHz were obtained using linear interpolation (see Table 26.1).

SPEAG has developed suitable head (HSL5800) and body (MSL5800) tissue simulating liquids consisting of the following ingredients: deionized water, salt and a special composition including mineral oil and an emulgator. Dielectric parameters of these liquids were measured using a HP 85070B Dielectric Probe Kit in conjunction with HP 8753E Network Analyzer (30 kHz - 6 GHz). The differences with respect to the interpolated values were well within desired ± 5% for the whole 5 to 5.8 GHz range.

f (GHz)	Head Tissue		Body Tissue		Reference
	ϵ	σ	ϵ	σ	
3.0	38.5	2.40	52.0	2.73	Standard
5.8	35.3	5.27	48.2	6.00	Standard
5.0	36.2	4.45	49.3	5.07	Interpolated
5.1	36.1	4.55	49.1	5.18	Interpolated
5.2	36.0	4.66	49.0	5.30	Interpolated
5.3	35.9	4.76	48.9	5.42	Interpolated
5.4	35.8	4.86	48.7	5.53	Interpolated
5.5	35.6	4.96	48.6	5.65	Interpolated
5.6	35.5	5.07	48.5	5.77	Interpolated
5.7	35.4	5.17	48.3	5.88	Interpolated

Table 26.1: Standard and interpolated dielectric parameters for head and body tissue simulating liquid in the frequency range 3 to 5.8 GHz.

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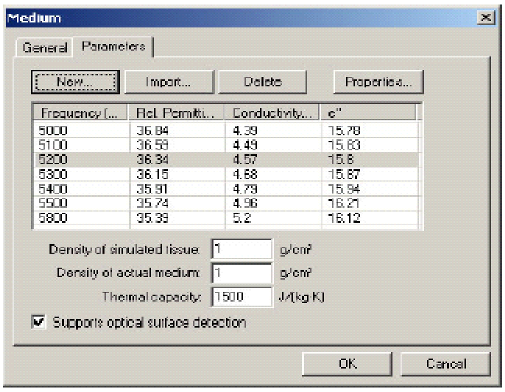

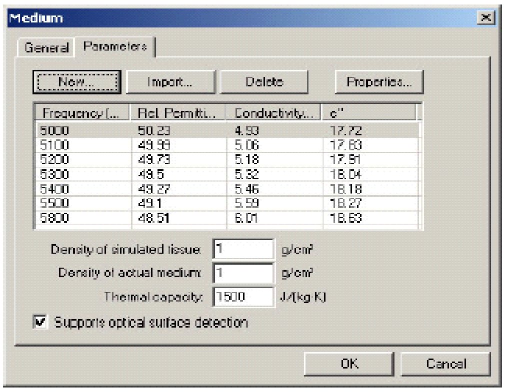

26.4 SAR Evaluation

26.4.1 Area Scan job

Due to the reduced penetration depth in the corresponding liquid (6.0 mm at 6 GHz), the distance between the measured points and phantom surface during the Area Scan needs to be reduced as well as the tolerance, i.e., it should be less than 4.0 mm with a variation of less than ± 0.5 mm during the entire scan.

The recommend distance between the probe sensor and phantom surface is 1.5-2.0 mm.

26.4.2 Zoom Scan job

The strong decay would require that at least two measurement points are taken within the first 5 mm from the liquid-shell interface. The following setting for the Zoom Scan job are recommended for the best time vs. accuracy ratio:

- Grid Step size X and Y 4.3 mm
- Grid Step size Z 3.0 mm
- Grid Extent Z 21.0 mm
- Minimum distance of probe sensor to surface 1.5-2.0 mm

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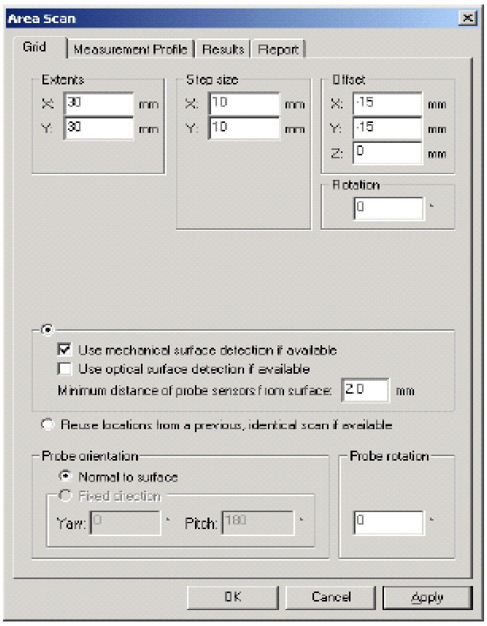

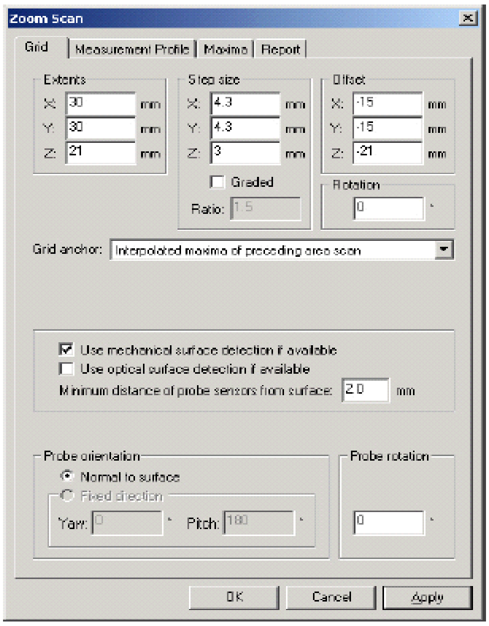

26.5 System Performance Check

For the preparation of the setup please refer to Chapter 15 System Performance Check.

Reference SAR values

The reference SAR values were calculated using finite-difference time-domain FDTD method (feed-point impedance set to 50 Ω) and the mechanical dimensions of the D5GHzV2 dipole (manufactured by SPEAG).

f (GHz)	Head Tissue			Body Tissue		
	SAR_{1g}	SAR_{10g}	SAR_{peak}	SAR_{1g}	SAR_{10g}	SAR_{peak}
5.0	72.9	20.7	285.6	68.1	19.2	260.3
5.1	74.6	21.1	297.5	78.8	19.6	272.3
5.2	76.5	21.6	310.3	71.8	20.1	284.7
5.8	78.0	21.9	340.9	74.1	20.5	324.7

Table 26.2: Numerical reference SAR values for D5GHzV2 dipole and flat phantom.

Uncertainty Budget for System Performance Check

The extended frequency range requires the same documentation including evaluation of the same uncertainty sources. In the following table, an updated uncertainty budget for the system performance check in the frequency range between 5-6 GHz is given.

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System Performance Check
for the 5 - 6 GHz range

Error Description	Tol. (± %)	Prob. dist.	Div.	(c_i) (1g)	(c_i) (10g)	Std. unc. (1g)	Std. unc. (10g)	(v_i)
Measurement System								
Probe Calibration	±6.6	N	1	1	1	±4.8 %	±6.6 %	∞
Axial Isotropy	±4.7	R	$\sqrt{3}$	1	1	±2.7 %	±2.7 %	∞
Hemispherical Isotropy	0	R	$\sqrt{3}$	1	1	0	0	∞
Boundary Effects	2.0	R	$\sqrt{3}$	1	1	±1.2 %	±1.2 %	∞
Linearity	±4.7	R	$\sqrt{3}$	1	1	±2.7 %	±2.7 %	∞
System Detection Limit	±1.0	R	$\sqrt{3}$	1	1	±0.6 %	±0.6 %	∞
Readout Electronics	±1.0	N	1	1	1	±1.0 %	±1.0 %	∞
Response Time	0	R	$\sqrt{3}$	1	1	0	0	∞
Integration Time	0	R	$\sqrt{3}$	1	1	0	0	∞
RF Ambient Conditions	±3.0	R	$\sqrt{3}$	1	1	±1.7 %	±1.7 %	∞
Probe Positioner	±0.8	R	$\sqrt{3}$	1	1	±0.5 %	±0.5 %	∞
Probe Positioning	±5.7	N	1	1	1	±5.7 %	±5.7 %	∞
Algorithms for Max. SAR Eval.	±4.0	R	$\sqrt{3}$	1	1	±2.3 %	±2.3 %	∞
Dipole								
Dipole Axis to Liquid Distance	±2.0	R	$\sqrt{3}$	1	1	±1.2 %	±1.2 %	∞
Input power and SAR drift meas.	±4.7	R	$\sqrt{3}$	1	1	±2.7 %	±2.7 %	∞
Phantom and Tissue Param.								
Phantom Uncertainty	±4.0	R	$\sqrt{3}$	1	1	±2.3 %	±2.3 %	∞
Liquid Conductivity (target)	±5.0	R.	$\sqrt{3}$	0.64	0.43	±1.8 %	±1.2 %	∞
Liquid Conductivity (meas.)	±2.5	N	1	0.64	0.43	±1.6 %	±1.1 %	∞
Liquid Permittivity (target)	±5.0	R	$\sqrt{3}$	0.6	0.49	±1.7 %	±1.4 %	∞
Liquid Permittivity (meas.)	±2.5	N	1	0.6	0.49	±1.5 %	±1.2 %	∞
Combined Standard Uncertainty						±11.3 %	±11.1 %	∞
Coverage Factor for 95%		**kp=2**						
Expanded Uncertainty						**±22.6 %**	**±22.1 %**	

Table 26.3: Uncertainty of the system performance check in the 5-6 GHz range. Probe calibration error reflects uncertainty of the EX3DV3 probe conversion factor at Calibration Frequency.

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26.6 Uncertainty Budget for Compliance Testings

The updated uncertainty budget for the compliance testing in the frequency range between 5-6 GHz is given in the table below.

DASY4 Uncertainty Budget
for the 5 - 6 GHz range

Error Description	Uncertainty value	Prob. Dist.	Div.	(c_i) 1g	(c_i) 10g	Std. Unc. (1g)	Std. Unc. (10g)	(v_i) v_{eff}
Measurement System								
Probe Calibration	±6.8 %	N	1	1	1	±6.8 %	±6.8 %	∞
Axial Isotropy	±4.7 %	R	$\sqrt{3}$	0.7	0.7	±1.9 %	±1.9 %	∞
Hemispherical Isotropy	±9.6 %	R	$\sqrt{3}$	0.7	0.7	±3.9 %	±3.9 %	∞
Boundary Effects	±2.0 %	R	$\sqrt{3}$	1	1	±1.2 %	±1.2 %	∞
Linearity	±4.7 %	R	$\sqrt{3}$	1	1	±2.7 %	±2.7 %	∞
System Detection Limits	±1.0 %	R	$\sqrt{3}$	1	1	±0.6 %	±0.6 %	∞
Readout Electronics	±1.0 %	N	1	1	1	±1.0 %	±1.0 %	∞
Response Time	±0.8 %	R	$\sqrt{3}$	1	1	±0.5 %	±0.5 %	∞
Integration Time	±2.6 %	R	$\sqrt{3}$	1	1	±1.5 %	±1.5 %	∞
RF Ambient Conditions	±3.0 %	R	$\sqrt{3}$	1	1	±1.7 %	±1.7 %	∞
Probe Positioner	±0.8 %	R	$\sqrt{3}$	1	1	±0.5 %	±0.5 %	∞
Probe Positioning	±5.7 %	N	1	1	1	±5.7 %	±5.7 %	∞
Max. SAR Eval.	±4.0 %	R	$\sqrt{3}$	1	1	±2.3 %	±2.3 %	∞
Test Sample Related								
Device Positioning	±2.9 %	N	1	1	1	±2.9 %	±2.9 %	145
Device Holder	±3.6 %	N	1	1	1	±3.6 %	±3.6 %	5
Power Drift	±5.0 %	R	$\sqrt{3}$	1	1	±2.9 %	±2.9 %	∞
Phantom and Setup								
Phantom Uncertainty	±4.0 %	R	$\sqrt{3}$	1	1	±2.3 %	±2.3 %	∞
Liquid Conductivity (target)	±5.0 %	R	$\sqrt{3}$	0.64	0.43	±1.8 %	±1.2 %	∞
Liquid Conductivity (meas.)	±2.5 %	N	1	0.64	0.43	±1.6 %	±1.1 %	∞
Liquid Permittivity (target)	±5.0 %	R	$\sqrt{3}$	0.6	0.49	±1.7 %	±1.4 %	∞
Liquid Permittivity (meas.)	±2.5 %	N	1	0.6	0.49	±1.5 %	±1.2 %	∞
Combined Std. Uncertainty						±12.8 %	±12.7 %	330
Expanded STD Uncertainty						**±25.7 %**	**±25.3 %**	

Table 26.4: Worst-Case uncertainty budget for DASY4 valid for the frequency range 5 - 6 GHz. Probe calibration error reflects uncertainty of the narrow-bandwidth EX3DV3 probe conversion factor (±50 MHz).

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26.7 References

[1] IEEE Std. 1528-200X, *Draft CD 1.1* "Recommended Practice for Determining the Spatial-Peak Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques", December 2002.

[2] CENELEC EN 50361, "Basic Standard for the measurement of Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones", July 2001.

[3] IEC 62209, *Draft CD* "Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices in the frequency range of 300 MHz to 3 GHz", November 2002.

[4] NIST, "Guidelines for evaluating and expressing the uncertainty of NIST measurement results", Technical Note 1297 (TN 1297), United States Department of Commerce Technology Administration, National Institute of Standards and Technology, Gaithersburg, MD, 1994.

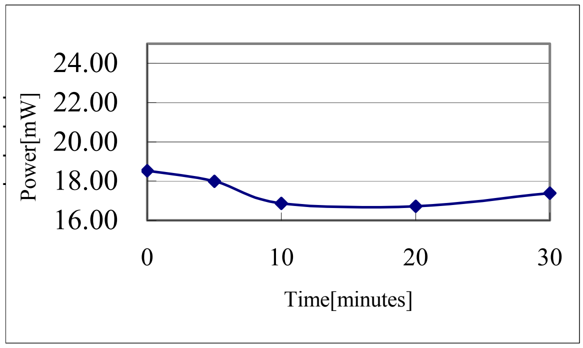
[5] NIS 81, "The Treatment of Uncertainty in EMC measurements", Edition 1, NAMAS Executive, National Physical Laboratory, Teddington, Middlesex, TW11 0LW, England, 1994.

APPENDIX 9 : Power drift measurement

The power drift in the elapsed time was performed because the power drift effects the uncertainty of SAR measurement.
The average power was measured under the condition of Max. power of each frequency band.
The test result shows that the power drift exceeded 5%. Therefore, the uncertainty of power drift expanded to 10%.

5210 MHz Turbo mode

Time [Minutes]	Result [dBm]	Converted [mW]	Diviation [%]
0	12.68	18.54	-
5	12.55	17.99	-2.9
10	12.27	16.87	-9.0
20	12.23	16.71	-9.8
30	12.4	17.38	-6.2



5745 MHz Normal mode

Time [Minutes]	Result [dBm]	Converted [mW]	Diviation [%]
0	10.52	11.27	-
5	10.46	11.12	-1.4
10	10.09	10.21	-9.4
20	10.29	10.69	-5.2
30	10.11	10.26	-9.0