

APPENDIX C CALIBRATION DOCUMENTS

1. SN3563 Probe Calibration Certificate
2. D5GHzV2 Dipole Calibration Certificate



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Zeughausstrasse 43, 8004 Zurich, Switzerland



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Accreditation No.: **SCS 108**

Client **EMC Technologies**

Certificate No: **EX3-3563_Jul07**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3563**

Calibration procedure(s) **QA CAL-01.v6 and QA CAL-14.v3
Calibration procedure for dosimetric E-field probes**

Calibration date: **July 13, 2007**

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 $(22 \pm 3)^{\circ}\text{C}$ 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 | 29-Mar-07 (METAS, No. 217-00670) | Mar-08 |
| Power sensor E4412A | MY41495277 | 29-Mar-07 (METAS, No. 217-00670) | Mar-08 |
| Power sensor E4412A | MY41498087 | 29-Mar-07 (METAS, No. 217-00670) | Mar-08 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 10-Aug-06 (METAS, No. 217-00592) | Aug-07 |
| Reference 20 dB Attenuator | SN: S5086 (20b) | 29-Mar-07 (METAS, No. 217-00671) | Mar-08 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 10-Aug-06 (METAS, No. 217-00593) | Aug-07 |
| Reference Probe ES3DV2 | SN: 3013 | 4-Jan-07 (SPEAG, No. ES3-3013_Jan07) | Jan-08 |
| DAE4 | SN: 654 | 20-Apr-07 (SPEAG, No. DAE4-654_Apr07) | Apr-08 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (SPEAG, in house check Nov-05) | In house check: Nov-07 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (SPEAG, in house check Oct-06) | In house check: Oct-07 |

| | | | |
|----------------|------------------------------|--------------------------------------|---------------|
| Calibrated by: | Name Katja Pokovic | Function Technical Manager | Signature |
| Approved by: | Name Niels Kuster | Function Quality Manager | Signature |

Issued: July 13, 2007

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Certificate No: EX3-3563_Jul07

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Glossary:

| | |
|--------------------------|--|
| TSL | tissue simulating liquid |
| NORM _{x,y,z} | sensitivity in free space |
| ConF | sensitivity in TSL / NORM _{x,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., $\vartheta = 0$ is normal to probe axis |

Calibration is Performed According to the Following Standards:

- 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
- 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:

- NORM_{x,y,z}**: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not effect the E^2 -field uncertainty inside TSL (see below *ConvF*).
- NORM(f)_{x,y,z} = NORM_{x,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*.
- DCP_{x,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 $f \leq 800$ 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 NORM_{x,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.



EX3DV4 SN:3563

July 13, 2007

Probe EX3DV4

SN:3563

| | |
|------------------|-------------------|
| Manufactured: | February 14, 2005 |
| Last calibrated: | July 14, 2006 |
| Recalibrated: | July 13, 2007 |

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)



Accreditation No. 5292

EX3DV4 SN:3563

July 13, 2007

DASY - Parameters of Probe: EX3DV4 SN:3563**Sensitivity in Free Space^A****Diode Compression^B**

| | | | | |
|-------|----------------------|-------------------------------------|-------|--------------|
| NormX | 0.380 ± 10.1% | $\mu\text{V}/(\text{V}/\text{m})^2$ | DCP X | 89 mV |
| NormY | 0.380 ± 10.1% | $\mu\text{V}/(\text{V}/\text{m})^2$ | DCP Y | 89 mV |
| NormZ | 0.480 ± 10.1% | $\mu\text{V}/(\text{V}/\text{m})^2$ | DCP Z | 89 mV |

Sensitivity in Tissue Simulating Liquid (Conversion Factors)

Please see Page 8.

Boundary Effect**TSL 3500 MHz Typical SAR gradient: 15 % per mm**

| | | | |
|---|------------------------------|---------------|---------------|
| Sensor Center to Phantom Surface Distance | | 2.0 mm | 3.0 mm |
| SAR _{be} [%] | Without Correction Algorithm | 5.8 | 2.9 |
| SAR _{be} [%] | With Correction Algorithm | | 0.1 |

TSL 5600 MHz Typical SAR gradient: 29 % per mm

| | | | |
|---|------------------------------|---------------|---------------|
| Sensor Center to Phantom Surface Distance | | 2.0 mm | 3.0 mm |
| SAR _{be} [%] | Without Correction Algorithm | 7.5 | 0.5 |
| SAR _{be} [%] | With Correction Algorithm | 0.0 | 0.1 |

Sensor OffsetProbe 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%.

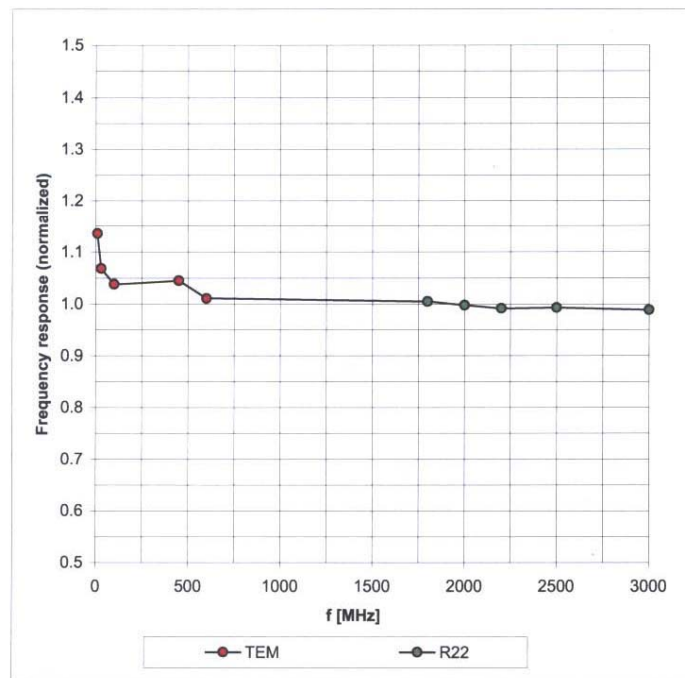
^A The uncertainties of NormX,Y,Z do not affect the E²-field uncertainty inside TSL (see Page 8).^B Numerical linearization parameter: uncertainty not required.

EX3DV4 SN:3563

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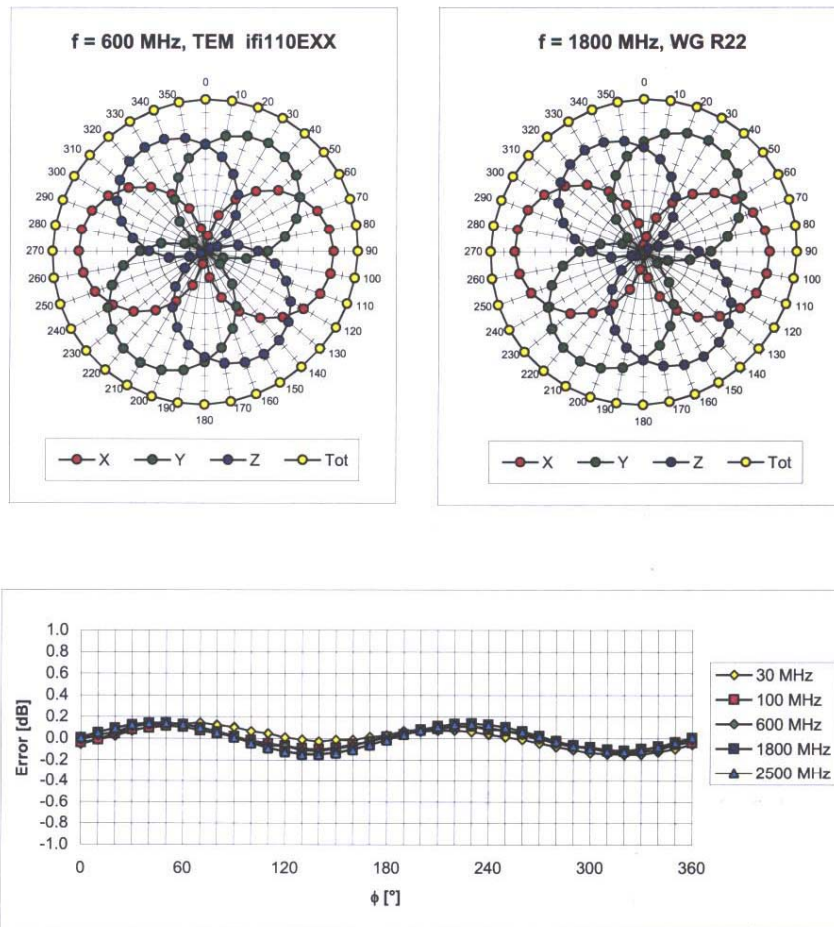
Frequency Response of E-Field

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

Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

EX3DV4 SN:3563

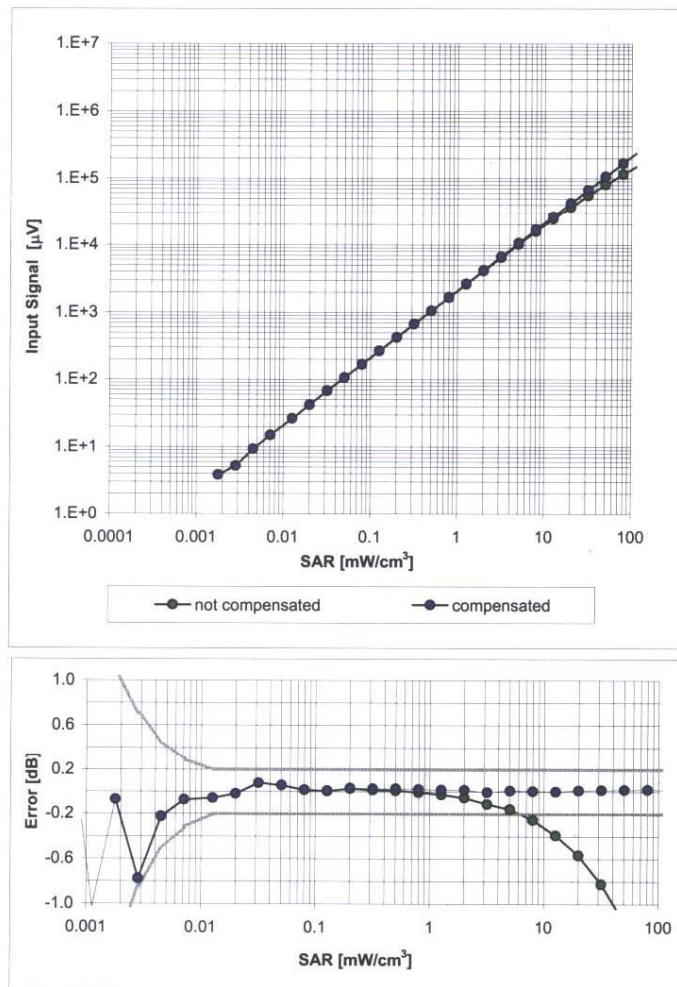
July 13, 2007

Receiving Pattern (ϕ), $\theta = 0^\circ$ **Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)**

EX3DV4 SN:3563

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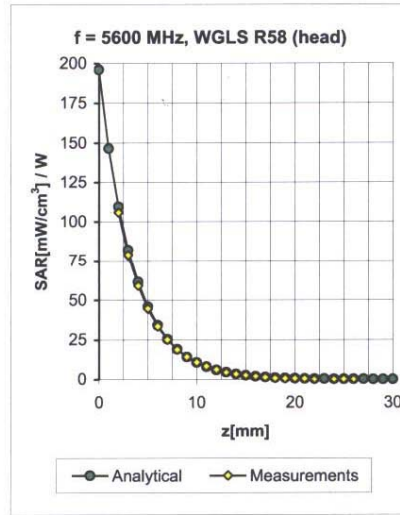
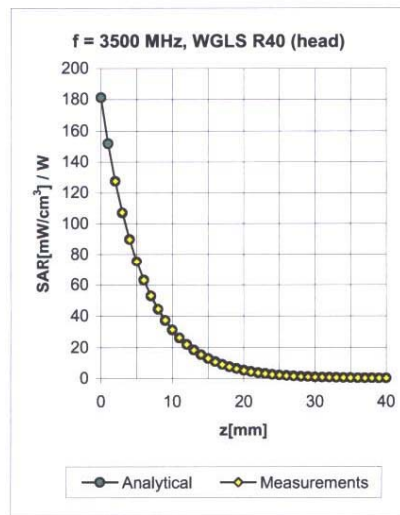
Dynamic Range $f(\text{SAR}_{\text{head}})$ (Waveguide R22, $f = 1800$ MHz)

Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

EX3DV4 SN:3563

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Conversion Factor Assessment



| f [MHz] | Validity [MHz] ^c | TSL | Permittivity | Conductivity | Alpha | Depth | ConvF Uncertainty |
|---------|-----------------------------|------|--------------|--------------|-------|-------|--------------------|
| 3500 | ± 50 / ± 100 | Head | 37.9 ± 5% | 2.91 ± 5% | 0.27 | 1.25 | 6.33 ± 13.1% (k=2) |
| 5200 | ± 50 / ± 100 | Head | 36.0 ± 5% | 4.66 ± 5% | 0.40 | 1.75 | 4.25 ± 13.1% (k=2) |
| 5600 | ± 50 / ± 100 | Head | 35.5 ± 5% | 5.07 ± 5% | 0.38 | 1.75 | 4.03 ± 13.1% (k=2) |
| 5800 | ± 50 / ± 100 | Head | 35.3 ± 5% | 5.27 ± 5% | 0.40 | 1.75 | 3.65 ± 13.1% (k=2) |
| 3500 | ± 50 / ± 100 | Body | 51.3 ± 5% | 3.31 ± 5% | 0.17 | 0.92 | 4.90 ± 13.1% (k=2) |
| 5200 | ± 50 / ± 100 | Body | 49.0 ± 5% | 5.30 ± 5% | 0.34 | 1.70 | 3.79 ± 13.1% (k=2) |
| 5600 | ± 50 / ± 100 | Body | 48.5 ± 5% | 5.77 ± 5% | 0.31 | 1.70 | 3.68 ± 13.1% (k=2) |
| 5800 | ± 50 / ± 100 | Body | 48.2 ± 5% | 6.00 ± 5% | 0.28 | 1.70 | 3.72 ± 13.1% (k=2) |

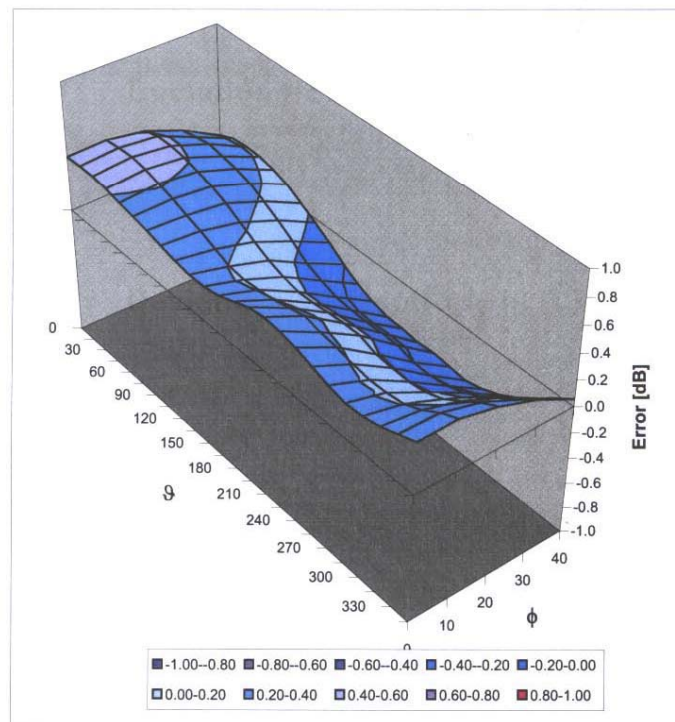
^c The validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2). The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.



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EX3DV4 SN:3563

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Deviation from Isotropy in HSLError (ϕ , θ), $f = 900$ MHzUncertainty of Spherical Isotropy Assessment: $\pm 2.6\%$ ($k=2$)

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Accreditation No.: **SCS 108**

Client **EMC Technologies**

Certificate No: **D5GHzV2-1008_Dec07**

CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN: 1008**

Calibration procedure(s) **QA CAL-22.v1
Calibration procedure for dipole validation kits between 3-6 GHz**

Calibration date: **December 07, 2007**

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 EPM-442A | GB37480704 | 04-Oct-07 (METAS, No. 217-00736) | Oct-08 |
| Power sensor HP 8481A | US37292783 | 04-Oct-07 (METAS, No. 217-00736) | Oct-08 |
| Reference 20 dB Attenuator | SN: S5072.1 (20g) | 07-Aug-07 (METAS, No 217-00718) | Aug-08 |
| Reference Probe EX3DV4 | SN: 3503 | 9-Mar-07 (SPEAG, No. EX3-3503_Mar07) | Mar-08 |
| DAE4 | SN 601 | 30-Jan-07 (SPEAG, No. DAE4-601_Jan07) | Jan-08 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| RF generator R&S SMT-06 | 100005 | 4-Aug-99 (SPEAG, in house check Oct-07) | In house check: Oct-09 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (SPEAG, in house check Oct-07) | In house check: Oct-08 |
| Power meter E4419B | GB43310788 | 13-Aug-03 (SPEAG, in house check Oct-07) | In house check: Oct-08 |
| Power sensor HP 8481A | MY41093315 | 10-Aug-03 (SPEAG, in house check Oct-07) | In house check: Oct-08 |

Calibrated by: **Name** **Function** **Signature**
Claudio Leubler **Laboratory Technician**

Approved by: **Katja Pokovic** **Technical Manager**

Issued: December 7, 2007

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Certificate No: D5GHzV2-1008_Dec07

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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:

- IEC Std 62209 Part 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", Draft Version 0.9, December 2004
- 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:

- DASY4 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.



Measurement Conditions

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

| | | |
|-------------------------------------|--|-------------|
| DASY Version | DASY4 | V4.7 |
| Extrapolation | Advanced Extrapolation | |
| Phantom | Modular Flat Phantom V5.0 | |
| Distance Dipole Center - TSL | 10 mm | with Spacer |
| Area Scan resolution | dx, dy = 10 mm | |
| Zoom Scan Resolution | dx, dy = 4.0 mm, dz = 2.5 mm | |
| Frequency | 5200 MHz \pm 1 MHz 5500 MHz \pm 1 MHz 5800 MHz \pm 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 \pm 0.2) °C | 36.0 \pm 6 % | 4.51 mho/m \pm 6 % |
| Head TSL temperature during test | (22.0 \pm 0.2) °C | --- | --- |

SAR result with Head TSL at 5200 MHz

| SAR averaged over 1 cm³ (1 g) of Head TSL | condition | |
|---|--------------------|--|
| SAR measured | 100 mW input power | 7.76 mW / g |
| SAR normalized | normalized to 1W | 77.6 mW / g |
| SAR for nominal Head TSL parameters ¹ | normalized to 1W | 77.6 mW / g \pm 19.9 % (k=2) |

| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
|---|--------------------|--|
| SAR measured | 100 mW input power | 2.19 mW / g |
| SAR normalized | normalized to 1W | 21.9 mW / g |
| SAR for nominal Head TSL parameters ¹ | normalized to 1W | 21.8 mW / g \pm 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 | 35.5 ± 6 % | 4.81 mho/m ± 6 % |
| Head TSL temperature during test | (22.0 ± 0.2) °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 | 7.98 mW / g |
| SAR normalized | normalized to 1W | 79.8 mW / g |
| SAR for nominal Head TSL parameters ¹ | normalized to 1W | 79.7 mW / g ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|-----------------------------------|
| SAR measured | 100 mW input power | 2.23 mW / g |
| SAR normalized | normalized to 1W | 22.3 mW / g |
| SAR for nominal Head TSL parameters ¹ | normalized to 1W | 22.2 mW / g ± 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 | 34.7 ± 6 % | 5.02 mho/m ± 6 % |
| Head TSL temperature during test | (22.0 ± 0.2) °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 | 7.63 mW / g |
| SAR normalized | normalized to 1W | 76.3 mW / g |
| SAR for nominal Head TSL parameters ¹ | normalized to 1W | 75.7 mW / g ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|-----------------------------------|
| SAR measured | 100 mW input power | 2.12 mW / g |
| SAR normalized | normalized to 1W | 21.2 mW / g |
| SAR for nominal Head TSL parameters ¹ | normalized to 1W | 21.0 mW / g ± 19.5 % (k=2) |

¹ Correction to nominal TSL parameters according to c), chapter "SAR Sensitivities"



Appendix

Antenna Parameters with Head TSL at 5200 MHz

| | |
|--------------------------------------|------------------------------|
| Impedance, transformed to feed point | $53.2 \Omega - 13.5 j\Omega$ |
| Return Loss | -17.5 dB |

Antenna Parameters with Head TSL at 5500 MHz

| | |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $46.8 \Omega - 5.3 j\Omega$ |
| Return Loss | -24.0 dB |

Antenna Parameters with Head TSL at 5800 MHz

| | |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $55.2 \Omega + 5.1 j\Omega$ |
| Return Loss | -23.2 dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.200 ns |
|----------------------------------|----------|

After long term use with 40 W 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.

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 | August 28, 2003 |



DASY4 Validation Report for Head TSL

Date/Time: 07.12.2007 13:06:45

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHz; Serial: D5GHzV2 - SN:1008

Communication System: CW-5GHz; Frequency: 5200 MHz Frequency: 5500 MHz Frequency: 5800 MHz;

Duty Cycle: 1:1

Medium: HSL 5800 MHz;

Medium parameters used: $f = 5200$ MHz; $\sigma = 4.51$ mho/m; $\epsilon_r = 36$; $\rho = 1000$ kg/m³Medium parameters used: $f = 5500$ MHz; $\sigma = 4.81$ mho/m; $\epsilon_r = 35.5$; $\rho = 1000$ kg/m³Medium parameters used: $f = 5800$ MHz; $\sigma = 5.02$ mho/m; $\epsilon_r = 34.7$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.56, 5.56, 5.56)ConvF(5.2, 5.2, 5.2)ConvF(4.97, 4.97, 4.97); Calibrated: 09.03.2007
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.01.2007
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; ;
- Measurement SW: DASY4, V4.7 Build 55; Postprocessing SW: SEMCAD, V1.8 Build 172

d=10mm, Pin=100mW, f=5200 MHz/Area Scan (91x91x1):

Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (interpolated) = 17.1 mW/g

d=10mm, Pin=100mW, f=5200 MHz/Zoom Scan (8x8x10), dist=2mm (8x8x10)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=2.5mm

Reference Value = 47.9 V/m; Power Drift = 0.021 dB

Peak SAR (extrapolated) = 28.5 W/kg

SAR(1 g) = 7.76 mW/g; SAR(10 g) = 2.19 mW/g

Maximum value of SAR (measured) = 15.2 mW/g

d=10mm, Pin=100mW, f=5500 MHz/Zoom Scan (8x8x10), dist=2mm 2 (8x8x10)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=2.5mm

Reference Value = 46.9 V/m; Power Drift = 0.049 dB

Peak SAR (extrapolated) = 31.5 W/kg

SAR(1 g) = 7.98 mW/g; SAR(10 g) = 2.23 mW/g

Maximum value of SAR (measured) = 16.1 mW/g

d=10mm, Pin=100mW, f=5800 MHz/Zoom Scan (8x8x10), dist=2mm (8x8x10)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=2.5mm

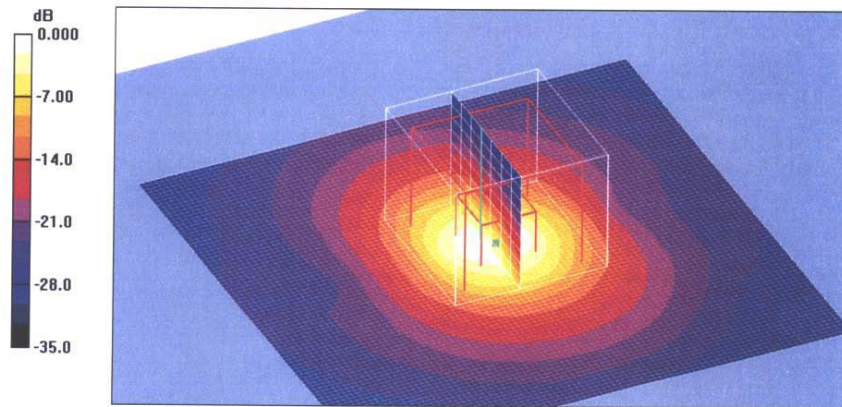
Reference Value = 44.6 V/m; Power Drift = 0.080 dB

Peak SAR (extrapolated) = 31.8 W/kg

SAR(1 g) = 7.63 mW/g; SAR(10 g) = 2.12 mW/g

Maximum value of SAR (measured) = 15.8 mW/g





0 dB = 15.8mW/g



