# APPENDIX 3 : Test instruments

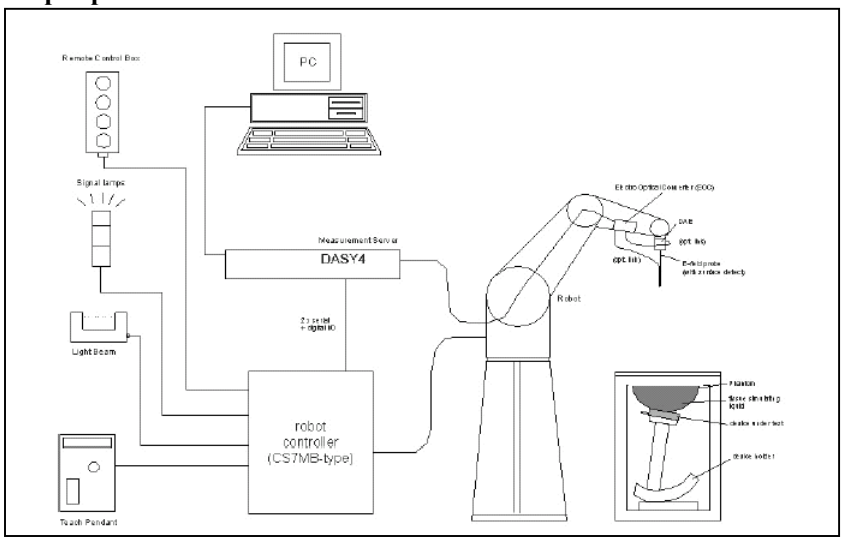
## 1. Equipment used

| Control No. | Name of Equipment | Manufacture | Model number | Serial number | Calibration | |
|---|---|---|---|---|---|---|
| | | | | | Last Cal | due date |
| MPM-01 | Power Meter | Agilent | E4417A | GB41290639 | 2007/01/10 | 2008/01/31 |
| MPSE-01 | Power Sensor | Agilent | E9300B | US40010300 | 2006/12/20 | 2007/12/31 |
| MPSE-03 | Power sensor | Agilent | E9327A | US40440576 | 2007/01/10 | 2008/01/31 |
| MSG-04 | Signal Genelator | Rohde & Schwarz | SML03 | 10185 | 2006/10/21 | 2007/10/31 |
| MRFA-02 | RF Amplifier | OPHIR | 5056F | 1005 | 2006/05/24 | 2007/05/31 |
| MHDC-11 | Directional Coupler & Microwave Cable | Hewlett Packard | 87300C OPT020 | 3239A01236 | N/A | N/A |
| MCC-26 | Microwave Cable 1G-26.5GHz | Suhner | SUCOFLEX104 | 10526/4 | 2006/08/29 | 2007/08/31 |
| MPM-09 | Power Meter | Anritsu | ML2495A | 6K00003348 | 2006/09/20 | 2007/09/30 |
| MPSE-12 | Power sensor | Anritsu | MA2411B | 011598 | 2006/09/20 | 2007/09/30 |
| MAT-23 | Attenuator(10dB) DC-18GHz | Orient Microwave | BX10-0476-00 | BX10-0476-00 | 2007/03/07 | 2008/03/31 |
| MNA-01 | Network Analyzer | Agilent | E8358A | US41080381 | 2006/02/10 | 2009/02/09 |
| MRENT-50 | Dosimetric E-Field Probe | Schmid&Partner Engineering AG | EX3DV4 | 3540 | 2007/01/19 | 2008/01/31 |
| MDAE-01 | Data Acquisition Electronics | Schmid&Partner Engineering AG | DAE3 V1 | 509 | 2006/06/15 | 2007/06/14 |
| MSTW-16 | SAR measurement System | Schmid&Partner Engineering AG | DASY4 | I021834 | N/A | N/A |
| MDA-07 | 2.45GHz System Validation Dipole | Schmid&Partner Engineering AG | D2.45GHzV2 | 713 | 2006/09/27 | 2008/0926 |
| MPS-01 | SAM Phantom | Schmid&Partner Engineering AG | SAM Twin Phantom V4.0 | 1196 | N/A | N/A |
| MOS-05 | Thermo-Hygrometer | Custom | CTH-190 | 810201 | 2006/04/25 | 2008/04/24 |
| MOS-10 | Digtal thermometer | HANNA | Checktemp-2 | MOS-10 | 2007/03/23 | 2009/03/31 |
| - | Head 2450 | N/A | N/A | N/A | Daily check | Target value ± 5% |
| - | Body 2450 | N/A | N/A | N/A | Daily check | Target value ± 5% |
| - | SAR room | - | - | - | Daily check Ambient Noise <0.012W/kg | |

**2. Dosimetry assessment setup**

These measurements were performed with the automated near-field scanning system DASY4 from Schmid & Partner Engineering AG (SPEAG). The system is based on a high precision robot (working range greater than 0.9 m), which positions the probes with a positional repeatability of better than +/- 0.02 mm. Special E- and H-field probes have been developed for measurements close to material discontinuity, the sensors of which are directly loaded with a Schottky diode and connected via highly resistive lines to the data acquisition unit. The SAR measurements were conducted with the dosimetry probe EX3DV3, SN: 3507 (manufactured by SPEAG), designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe has been calibrated according to the procedure described in [2] with accuracy of better than +/-10%. The spherical isotropy was evaluated with the procedure described in [3] and found to be better than +/-0.25 dB. The phantom used was the
SAM Twin Phantom as described in FCC supplement C, IEEE P1528 and CENELEC EN50361.

**3. Configuration and peripherals**




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

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

2. A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.

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

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

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

6. A probe alignment unit which improves the (absolute) accuracy of the probe positioning.

7. A computer operating Windows 2000.

8. DASY4 software.

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

10. The SAM twin phantom enabling testing left-hand and right-hand usage.

11. The device holder for handheld mobile phones.

12. Tissue simulating liquid mixed according to the given recipes.

13. Validation dipole kits allowing to validate the proper functioning of the system.

**4. System components**

### 4.2.1 EX3DV4 Probe Specification

**Construction:**
Symmetrical design with triangular core
Built-in shielding against static charges
PEEK enclosure material (resistant to organic solvents, e.g., glycol ether)
**Calibration:**
Basic Broad Band Calibration in air : 10-3000 MHz
Conversion Factors(Head and Body):900 MHz, 1.8 GHz ,2.45GHz, 5.2GHz and 5.8GHz

**Frequency:**
10 MHz to > 6GHz; Linearity: +/-0.2 dB(30 MHz to 3 GHz)

**Directivity:**
+/-0.3 dB in HSL (rotation around probe axis)
+/-0.5 dB in tissue material (rotation normal probe axis)

**Dynamic Range:**
10uW/g to > 100 mW/g;Linearity: +/-0.2 dB(noise: typically < 1uW/g)

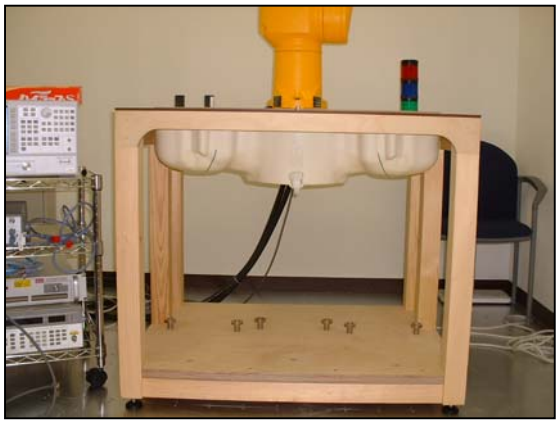
**Dimensions:**
Overall length: 330 mm (Tip: 20 mm)
Tip diameter: 2.5mm (Body: 12 mm)
Typical distance from probe tip to dipole centers: 1 mm

**Application:**
Highprecision dosimetric measurement in any exposure scenario
(e.g., very strong gradient fields).Only probe which enables compliance
testing for frequencies up to 6GHz with precision of better 30%.

**EX3DV4 E-field Probe**

**SAM Twin Phantom**

**Construction:**
The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528-200X, CENELEC EN 50361 and IEC 62209. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points with the robot.
**Shell Thickness:**
2 +/-0.2 mm
**Filling Volume:**
Approx. 25 liters
**Dimensions:**
(H x L x W): 810 x 1000 x 500 mm



**SAM Twin Phantom**

**Device Holder for Transmitters**

In combination with the SAM Twin Phantom V4.0, the Mounting Device enables the rotation of the mounted transmitter
in spherical coordinates whereby the rotation points is the ear opening. The devices can be easily, accurately, and repeatedly positioned according to the FCC and CENELEC specifications. The device holder can be locked at different phantom locations (left head, right head,flat phantom).
* Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produced infinite number of configurations.
To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

Device holder couldn't be used at this SAR measurement.

**Device Holder**

## 5. Test system specifications

**Robot RX60L**

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

**DASY4 Measurement server**

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

**Data Acquisition Electronic (DAE)**

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

**Software**

| | | |
|---|---|---|
| **Item** | : | Dosimetric Assesment System DASY4 |
| **Type No.** | : | SD 000 401A, SD 000 402A |
| **Software version No.** | : | 4.6 |
| **Manufacture / Origin** | : | Schimid & Partner Engineering AG |

**E-Field Probe**

| | | |
|---|---|---|
| **Model** | : | EX3DV4 |
| **Serial No.** | : | 3540 |
| **Construction** | : | Symmetrical design with triangular core |
| **Frequency** | : | 10 MHz to 6 GHz |
| **Linearity** | : | +/-0.2 dB (30 MHz to 3 GHz) |
| **Manufacture** | : | Schimid & Partner Engineering AG |

**Phantom**

| | | |
|---|---|---|
| **Type** | : | SAM Twin Phantom V4.0 |
| **Shell Material** | : | Fiberglass |
| **Thickness** | : | 2.0 +/-0.2 mm |
| **Volume** | : | Approx. 25 liters |
| **Manufacture** | : | Schimid & Partner Engineering AG |

**6. Simulated Tissues Composition of 2450MHz**

| Ingredient | MIXTURE(%) | |
|---|---|---|
| | Head 2450MHz | Muscle 2450MHz |
| Water | 45.0 | 69.83 |
| DGMBE | 55.0 | 30.2 |

Note:DGMBE(Diethylenglycol-monobuthyl ether)

**7. Validation Measurement**

**Simulated tissue liquid parameter**

**7-a Simulated Tissue Liquid Parameter confirmation**

The dielectric parameters were checked prior to assessment using the HP85070D dielectric probe kit.
The dielectric parameters measurement are reported in each correspondent section.

**7-b Head 2450 MHz**

Type of liquid : **Head 2450 MHz**
Ambient temperature (deg.c.) : **25.0**
Relative Humidity (%) : **40**
Liquid depth (cm) : **15.0**

| DIELECTRIC PARAMETERS MEASUREMENT RESULTS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Date | Frequency | Liquid Temp [deg.c] | | Parameters | Target Value | Measured | Deviation [%] | Limit [%] |
| | | Before | After | | | | | |
| 19-Apr | 2450 | 24.5 | 24.5 | Relative Permittivity εr | 39.2 | 37.5 | -4.3 | +/-5 |
| | | | | Coductivity σ [mho/m] | 1.80 | 1.86 | 3.3 | +/-5 |

**7-c Muscle 2450 MHz**

Type of liquid : **Muscle 2450 MHz**
Ambient temperature (deg.c.) : **25.0**
Relative Humidity (%) : **40**
Liquid depth (cm) : **15.1**

| DIELECTRIC PARAMETERS MEASUREMENT RESULTS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Date | Frequency | Liquid Temp [deg.c] | | Parameters | Target Value | Measured | Deviation [%] | Limit [%] |
| | | Before | After | | | | | |
| 19-Apr | 2450 | 24.6 | 24.6 | Relative Permittivity εr | 52.7 | 50.8 | -3.6 | +/-5 |
| | | | | Coductivity σ [mho/m] | 1.95 | 2.01 | 3.1 | +/-5 |

## 8. System validation data

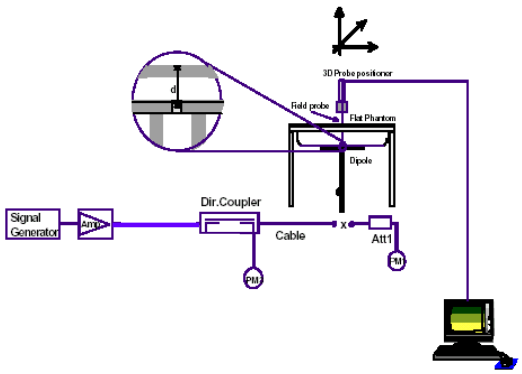
Prior to the assessment, the system validation kit was used to test whether the system was operating within its specifications of +/-10%. The validation results are in the table below. Please refer to APPENDIX3.

**System validation of 2450MHz**

| | | |
|---|---|---|
| Type of liquid | : | **HEAD 2450MHz** |
| Frequenc | : | **2450MHz** |
| Ambient temperature (deg.c.) | : | **25.0** |
| Relative Humidity (%) | : | **40** |
| Dipole | : | **D2450V2 SN:713** |
| Power | : | **250mW** |

| SYSTEM PERFORMANCE CHECK | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Liquid (HEAD 2450MHz) | | | | | | System dipole validation target & measured | | | |
| | Liquid Temp [deg.c.] | | Relative Permittivity εr | | Conductivity σ [mho/m] | | SAR 1g [W/kg] | | Deviation [%] | Limit [%] |
| | Before | After | Target | Measured | Target | Measured | Target | Measured | | |
| 19-Apr | 24.5 | 24.5 | 39.2 | 37.5 | 1.80 | 1.86 | 13.1 | 13.7 | 4.6 | +/-10 |

Note: Please refer to Attachment for the result representation in plot format



**2450MHz System performance check setup**

**Test system for the system performance check setup diagram**

**9. Validation uncertainty**

The uncertainty budget has been determined for the DASY4 measurement system according to the SPEAG documents[6][7] and is given in the following Table.

| Error Description | Uncertainty value ± % | Probability distribution | divisor | (ci) 1g | Standard Uncertainty (1g) | vi or veff |
|---|---|---|---|---|---|---|
| **Measurement System** | | | | | | |
| Probe calibration | ±6.8 | Normal | 1 | 1 | ±6.8 | ∞ |
| Axial isotropy of the probe | ±4.7 | Rectangular | √3 | 1 | ±2.7 | ∞ |
| Spherical isotropy of the probe | ±9.6 | Rectangular | 0 | 0 | 0 | ∞ |
| Boundary effects | ±2.0 | Rectangular | √3 | 1 | ±1.2 | ∞ |
| Probe linearity | ±4.7 | Rectangular | √3 | 1 | ±2.7 | ∞ |
| Detection limit | ±1.0 | Rectangular | √3 | 1 | ±0.6 | ∞ |
| Readout electronics | ±0.3 | Normal | 1 | 1 | ±0.3 | ∞ |
| Response time | 0 | Rectangular | √3 | 1 | 0 | ∞ |
| Integration time | 0 | Rectangular | √3 | 1 | 0 | ∞ |
| RF ambient Noise | ±3.0 | Rectangular | √3 | 1 | ±1.7 | ∞ |
| RF ambient Reflections | ±3.0 | Rectangular | √3 | 1 | ±1.7 | ∞ |
| Probe Positioner | ±0.8 | Rectangular | √3 | 1 | ±0.5 | ∞ |
| Probe positioning | ±9.9 | Rectangular | 1 | 1 | ±5.7 | ∞ |
| Algorithms for Max.SAR Eval. | ±4.0 | Rectangular | √3 | 1 | ±2.3 | ∞ |
| **Dipole** | | | | | | |
| Dipole Axis to Liquid Distance | ±2.0 | Rectangular | √3 | 1 | ±1.2 | ∞ |
| Input power and SAR drift meas. | ±4.7 | Rectangular | √3 | 1 | ±2.7 | ∞ |
| **Phantom and Setup** | | | | | | |
| Phantom uncertainty | ±4.0 | Rectangular | √3 | 1 | ±2.3 | ∞ |
| Liquid conductivity (target) | ±5.0 | Rectangular | √3 | 0.64 | ±1.8 | ∞ |
| Liquid conductivity (meas.) | ±5.0 | Rectangular | 1 | 0.64 | ±3.2 | ∞ |
| Liquid permittivity (target) | ±5.0 | Rectangular | √3 | 0.6 | ±1.7 | ∞ |
| Liquid permittivity (meas.) | ±5.0 | Rectangular | 1 | 0.6 | ±3.0 | ∞ |
| | | | | | | |
| **Combined Standard Uncertainty** | | | | | **±12.079** | |
| **Expanded Uncertainty (k=2)** | | | | | **±24.2** | |

**10. Validation Measurement data**

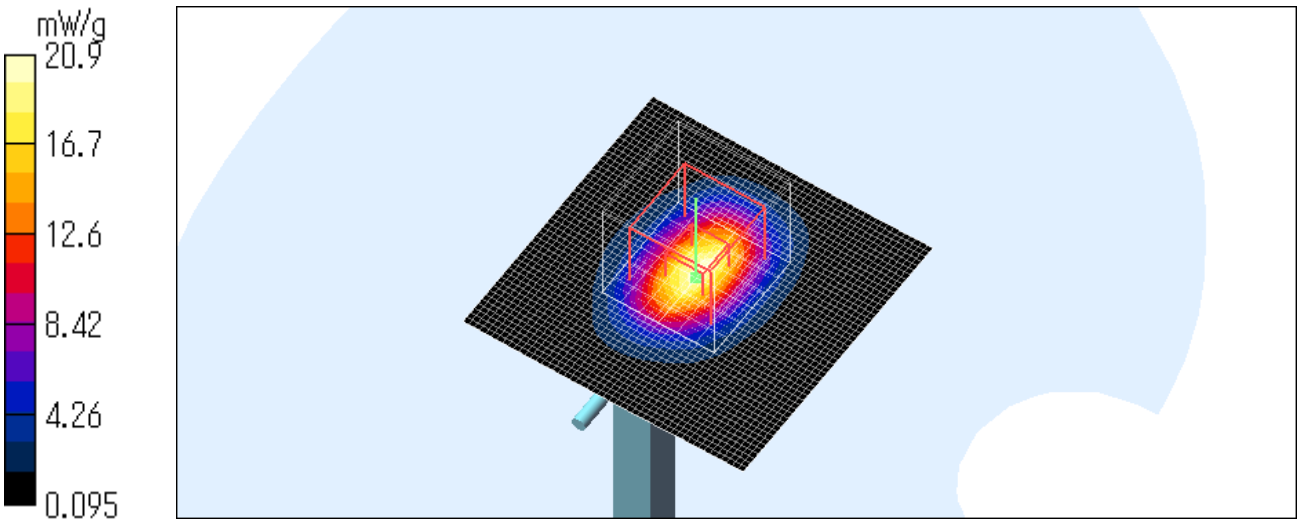
## System Validation / Dipole 2450 MHz / Forward Conducted Power : 250mW

**Dipole 2450 MHz; Type: D2450V2; Serial: SN:713**
Communication System: CW; Frequency: 2450 MHz;Crest factor:1
Medium: HSL2450 Medium parameters used: f = 2450 MHz; $\sigma$ = 1.86 mho/m; $\varepsilon_r$ = 37.5; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
DUT: Dipole 2450 MHz;
- Type: D2450V2; Serial: D2450V2 - SN:xxx

DASY4 Configuration:
- Probe: EX3DV4 - SN3540; ConvF(7.76, 7.76, 7.76); Calibrated: 2007/01/19
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Phantom: SAM 1196
- Measurement SW: DASY4, V4.6 Build 23; Postprocessing SW: SEMCAD, V1.8 Build 160

**Area Scan (51x51x1):** Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (interpolated) = 24.6 mW/g

**Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 108.6 V/m; Power Drift = 0.032 dB
Peak SAR (extrapolated) = 28.4 W/kg
**SAR(1 g) = 13.7 mW/g; SAR(10 g) = 6.24 mW/g**
Maximum value of SAR (measured) = 20.9 mW/g
Test date = 04//19/07
Ambient Temperature = 25.0 degree.c
Liquid Temperature = Before 24.5 degree.C , After 24.5 degree.C



## 11. System Validation Dipole (D2450V2,S/N: 713)

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S 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** ULA-pex (MTT) **Certificate No:** D2450V2-713_Sep06

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D2450V2 - SN: 713 |
| Calibration procedure(s) | QA CAL-05.v6<br>Calibration procedure for dipole validation kits |
| Calibration date: | September 27, 2006 |
| 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-05 (METAS, No. 251-00516) | Oct-06 |
| Power sensor HP 8481A | US37292783 | 04-Oct-05 (METAS, No. 251-00516) | Oct-06 |
| Reference 20 dB Attenuator | SN: 5086 (20g) | 10-Aug-06 (METAS, No 217-00591) | Aug-07 |
| Reference 10 dB Attenuator | SN: 5047.2 (10r) | 10-Aug-06 (METAS, No 217-00591) | Aug-07 |
| Reference Probe ES3DV2 | SN 3025 | 28-Oct-05 (SPEAG, No. ES3-3025_Oct05) | Oct-06 |
| DAE4 | SN 601 | 15-Dec-05 (SPEAG, No. DAE4-601_Dec05) | Dec-06 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power sensor HP 8481A | MY41092317 | 18-Oct-02 (SPEAG, in house check Oct-05) | In house check: Oct-07 |
| RF generator Agilent E4421B | MY41000675 | 11-May-05 (SPEAG, in house check Nov-05) | In house check: Nov-07 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (SPEAG, in house check Nov-05) | In house check: Nov-06 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Claudio Leubler | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: September 28, 2006

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

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

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**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 108**

**Glossary:**

| | |
|---|---|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORM x,y,z |
| N/A | not applicable or not measured |

**Calibration is Performed According to the Following Standards:**

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) 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
c) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

**Additional Documentation:**

d) DASY4 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 |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 2450 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 39.2 | 1.80 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 37.8 ± 6 % | 1.77 mho/m ± 6 % |
| **Head TSL temperature during test** | (22.0 ± 0.2) °C | ------- | ------ |

## SAR result with Head TSL

| **SAR averaged over 1 cm³ (1 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 13.7 mW / g |
| SAR normalized | normalized to 1W | 54.8 mW / g |
| SAR for nominal Head TSL parameters [1] | normalized to 1W | **54.2 mW / g ± 17.0 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 6.39 mW / g |
| SAR normalized | normalized to 1W | 25.6 mW / g |
| SAR for nominal Head TSL parameters [1] | normalized to 1W | **25.3 mW / g ± 16.5 % (k=2)** |

[1] Correction to nominal TSL parameters according to d), chapter "SAR Sensitivities"



**UL Japan, Inc.**
**Head Office EMC Lab.**
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN
Telephone : +81 596 24 8116
Facsimile : +81 596 24 8124

## Body TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 52.7 | 1.95 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 52.1 ± 6 % | 1.97 mho/m ± 6 % |
| **Body TSL temperature during test** | (21.7 ± 0.2) °C | ----- | ----- |

## SAR result with Body TSL

| **SAR averaged over 1 cm³ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 13.7 mW / g |
| SAR normalized | normalized to 1W | 54.8 mW / g |
| SAR for nominal Body TSL parameters [2] | normalized to 1W | **54.1 mW / g ± 17.0 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 6.34 mW / g |
| SAR normalized | normalized to 1W | 25.4 mW / g |
| SAR for nominal Body TSL parameters [2] | normalized to 1W | **25.2 mW / g ± 16.5 % (k=2)** |

[2] Correction to nominal TSL parameters according to d), chapter "SAR Sensitivities"



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**Head Office EMC Lab.**
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN
Telephone : +81 596 24 8116
Facsimile : +81 596 24 8124

## Appendix

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 51.2 Ω + 3.3 jΩ |
| Return Loss | – 29.3 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 47.7 Ω + 4.0 jΩ |
| Return Loss | – 26.5 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.160 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.
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 | July 5, 2002 |



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## DASY4 Validation Report for Head TSL

Date/Time: 27.09.2006 11:36:11

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 – SN713**

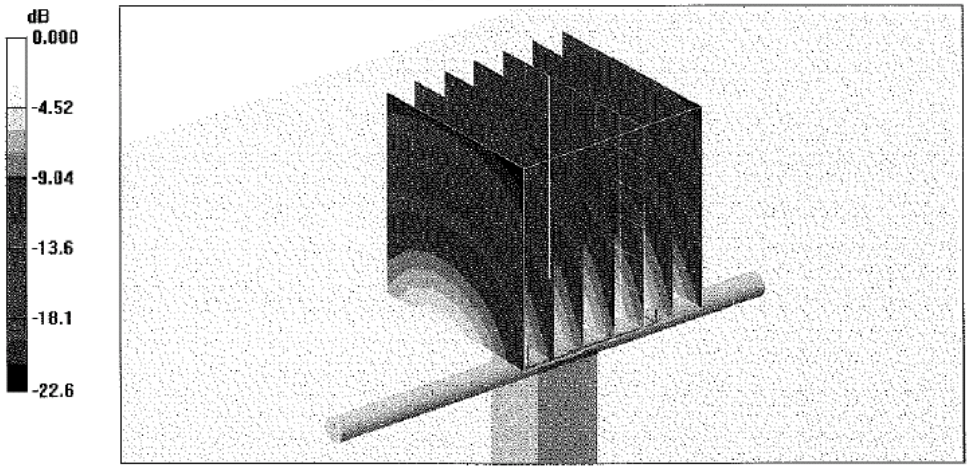
Communication System: CW-2450; Frequency: 2450 MHz;Duty Cycle: 1:1
Medium: HSL U10 BB
Medium parameters used: f = 2450 MHz; $\sigma$ = 1.77 mho/m; $\varepsilon_r$ = 37.8; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: ES3DV2 - SN3025 (HF); ConvF(4.4, 4.4, 4.4); Calibrated: 28.10.2005
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 15.12.2005
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; ;
- Measurement SW: DASY4, V4.7 Build 44; Postprocessing SW: SEMCAD, V1.8 Build 171

### Pin = 250 mW; d = 10 mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 91.5 V/m; Power Drift = 0.078 dB
Peak SAR (extrapolated) = 28.5 W/kg
**SAR(1 g) = 13.7 mW/g; SAR(10 g) = 6.39 mW/g**
Maximum value of SAR (measured) = 15.0 mW/g




0 dB = 15.0mW/g



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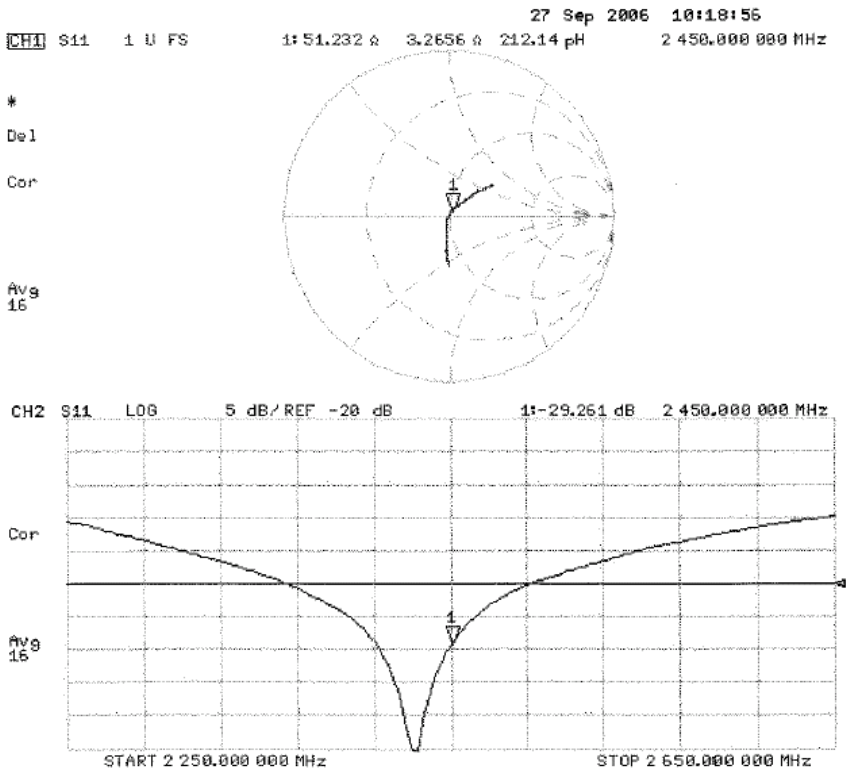
## Impedance Measurement Plot for Head TSL



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## DASY4 Validation Report for Body TSL

Date/Time: 27.09.2006 14:23:31

Test Laboratory: SPEAG, Zurich, Switzerland

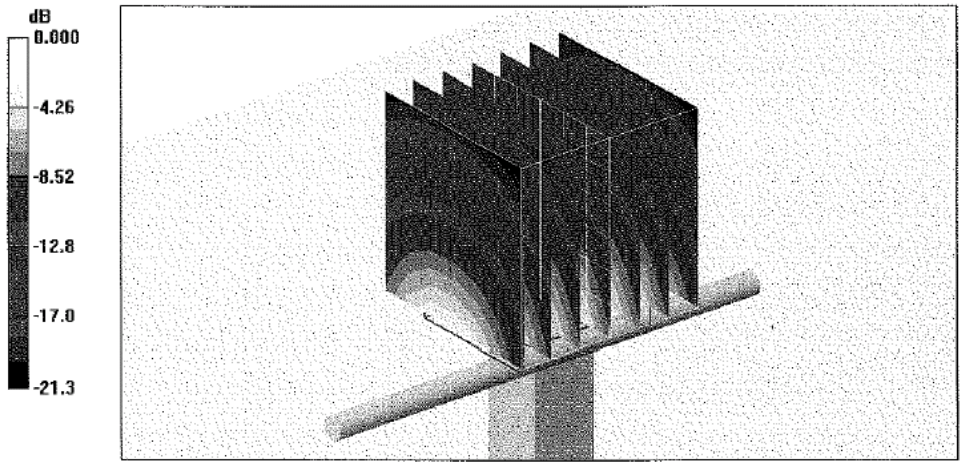
**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 – SN713**

Communication System: CW-2450; Frequency: 2450 MHz;Duty Cycle: 1:1
Medium: MSL U10 BB;
Medium parameters used: f = 2450 MHz; $\sigma$ = 1.97 mho/m; $\varepsilon_r$ = 52.2; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: ES3DV2 - SN3025 (HF); ConvF(4.06, 4.06, 4.06); Calibrated: 28.10.2005
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 15.12.2005
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; ;
- Measurement SW: DASY4, V4.7 Build 44; Postprocessing SW: SEMCAD, V1.8 Build 171

**Pin = 250 mW; d = 10 mm/Zoom Scan (7x7x7)/Cube 0:**
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 89.4 V/m; Power Drift = -0.054 dB
Peak SAR (extrapolated) = 28.5 W/kg
**SAR(1 g) = 13.7 mW/g; SAR(10 g) = 6.34 mW/g**
Maximum value of SAR (measured) = 15.4 mW/g




0 dB = 15.4mW/g



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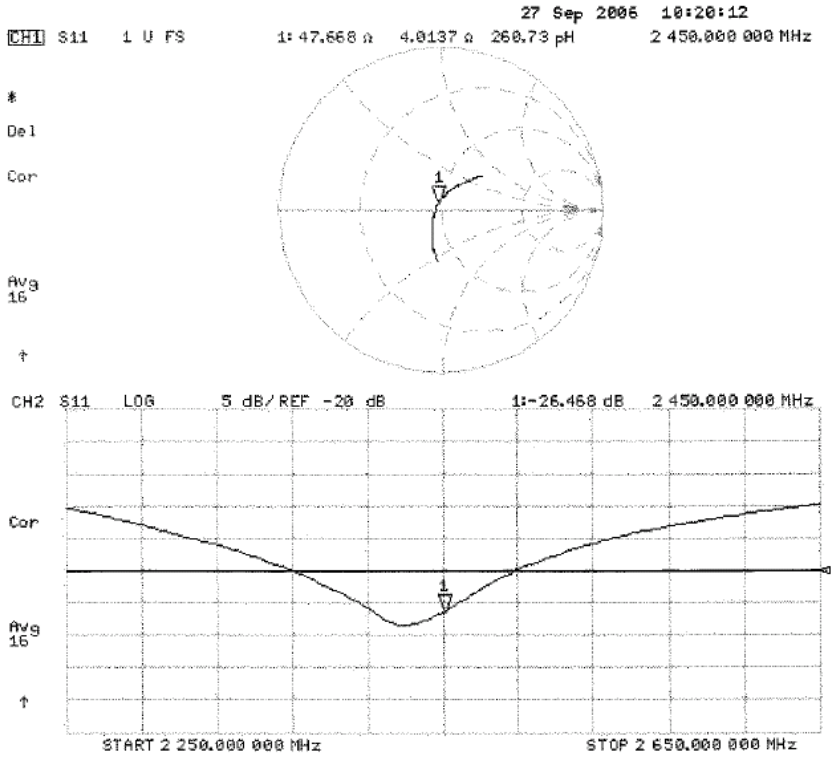
## Impedance Measurement Plot for Body TSL



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Telephone : +81 596 24 8116
Facsimile : +81 596 24 8124

## 12. Dosimetric E-Field Probe Calibration (EX3DV4,S/N: 3540)

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S 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_Jan07

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | EX3DV4 - SN:3540 |
| Calibration procedure(s) | QA CAL-01.v5, QA CAL-12.v4 and QA CAL-14.v3<br>Calibration procedure for dosimetric E-field probes |
| Calibration date: | January 19, 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 E4419B | GB41293874 | 5-Apr-06 (METAS, No. 251-00557) | Apr-07 |
| Power sensor E4412A | MY41495277 | 5-Apr-06 (METAS, No. 251-00557) | Apr-07 |
| Power sensor E4412A | MY41498087 | 5-Apr-06 (METAS, No. 251-00557) | Apr-07 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 10-Aug-06 (METAS, No. 217-00592) | Aug-07 |
| Reference 20 dB Attenuator | SN: S5086 (20b) | 4-Apr-06 (METAS, No. 251-00558) | Apr-07 |
| 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 | 21-Jun-06 (SPEAG, No. DAE4-654_Jun06) | Jun-07 |

| 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 |

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

Issued: January 19, 2007

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

Certificate No: EX3-3540_Jan07 Page 1 of 9

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

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

**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 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.

# Probe EX3DV4

## SN:3540

| | |
|---|---|
| Manufactured: | August 23, 2005 |
| Last calibrated: | January 18, 2006 |
| Recalibrated: | January 19, 2007 |

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)



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**Head Office EMC Lab.**
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN
Telephone : +81 596 24 8116
Facsimile : +81 596 24 8124

EX3DV4 SN:3540 January 19, 2007

# DASY - Parameters of Probe: EX3DV4 SN:3540

## Sensitivity in Free Space[A] Diode Compression[B]

| | | | | |
|---|---|---|---|---|
| NormX | **0.440** ± 10.1% | $\mu V/(V/m)^2$ | DCP X | **92** mV |
| NormY | **0.500** ± 10.1% | $\mu V/(V/m)^2$ | DCP Y | **91** mV |
| NormZ | **0.580** ± 10.1% | $\mu V/(V/m)^2$ | DCP Z | **93** mV |

## Sensitivity in Tissue Simulating Liquid (Conversion Factors)

**Please see Page 8.**

## 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 8).

[B] Numerical linearization parameter: uncertainty not required.



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**Head Office EMC Lab.**
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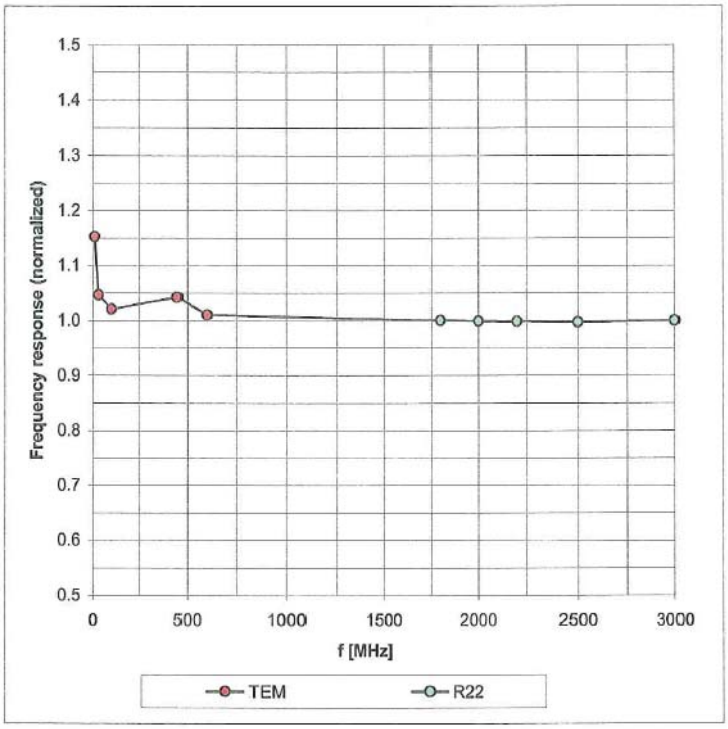
## Frequency Response of E-Field

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




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



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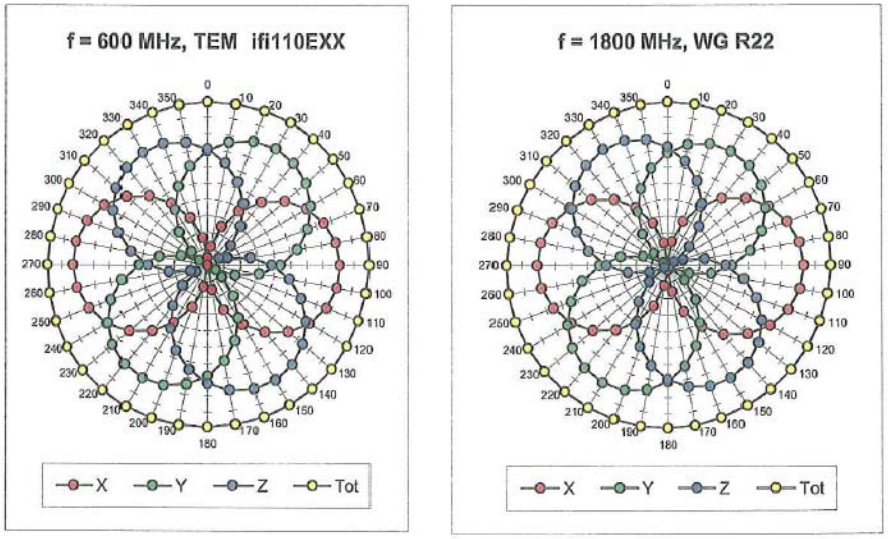
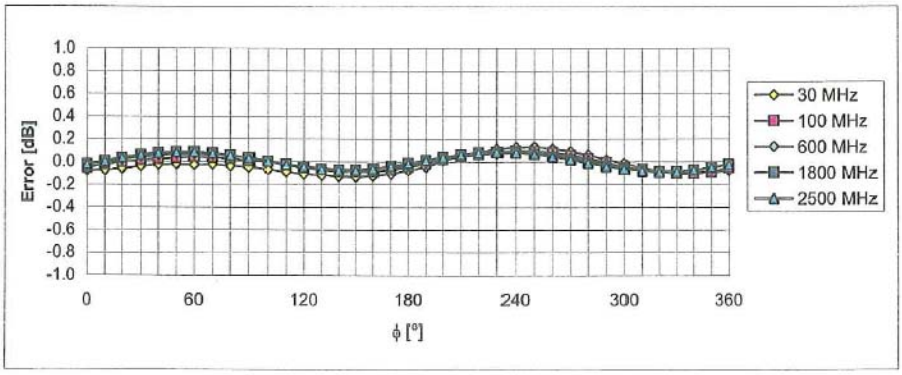
## Receiving Pattern (ϕ), ϑ = 0°




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



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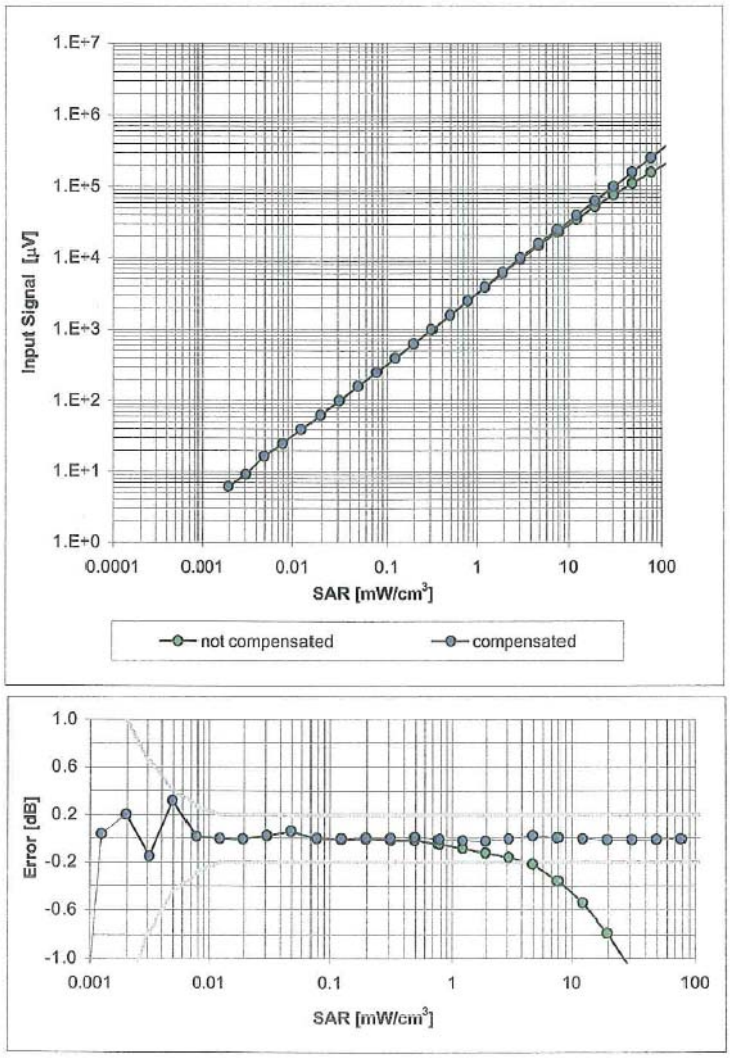
## Dynamic Range f($SAR_{head}$)

(Waveguide R22, f = 1800 MHz)




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



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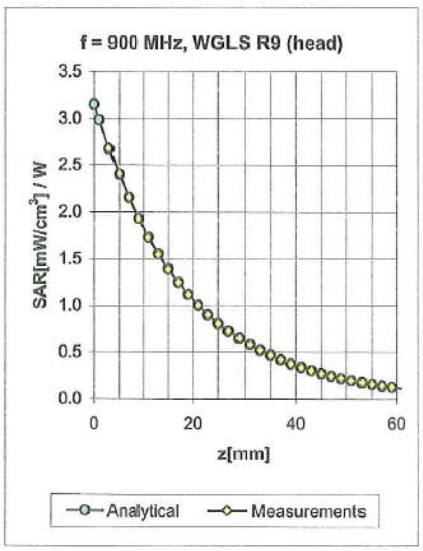
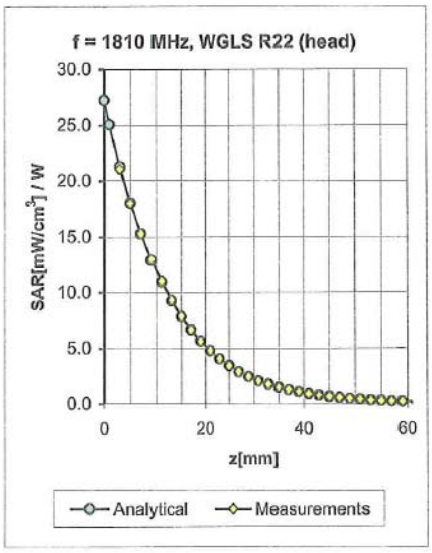
## Conversion Factor Assessment




| f [MHz] | Validity [MHz][c] | TSL | Permittivity | Conductivity | Alpha | Depth | ConvF Uncertainty |
|---|---|---|---|---|---|---|---|
| 450 | ± 50 / ± 100 | Head | 43.5 ± 5% | 0.87 ± 5% | 0.40 | 0.71 | 10.60 ± 13.3% (k=2) |
| 900 | ± 50 / ± 100 | Head | 41.5 ± 5% | 0.97 ± 5% | 0.50 | 0.80 | 10.07 ± 11.0% (k=2) |
| 1810 | ± 50 / ± 100 | Head | 40.0 ± 5% | 1.40 ± 5% | 0.21 | 1.27 | 8.62 ± 11.0% (k=2) |
| 2450 | ± 50 / ± 100 | Head | 39.2 ± 5% | 1.80 ± 5% | 0.32 | 1.14 | 7.76 ± 11.8% (k=2) |
| 5200 | ± 50 / ± 100 | Head | 36.0 ± 5% | 4.66 ± 5% | 0.36 | 1.60 | 4.96 ± 13.1% (k=2) |
| 5500 | ± 50 / ± 100 | Head | 35.6 ± 5% | 4.96 ± 5% | 0.35 | 1.60 | 4.77 ± 13.1% (k=2) |
| 5800 | ± 50 / ± 100 | Head | 35.3 ± 5% | 5.27 ± 5% | 0.36 | 1.60 | 4.69 ± 13.1% (k=2) |
| 450 | ± 50 / ± 100 | Body | 56.7 ± 5% | 0.94 ± 5% | 0.71 | 0.40 | 11.61 ± 13.3% (k=2) |
| 900 | ± 50 / ± 100 | Body | 55.0 ± 5% | 1.05 ± 5% | 0.45 | 0.90 | 10.06 ± 11.0% (k=2) |
| 1810 | ± 50 / ± 100 | Body | 53.3 ± 5% | 1.52 ± 5% | 0.15 | 1.36 | 8.46 ± 11.0% (k=2) |
| 2450 | ± 50 / ± 100 | Body | 52.7 ± 5% | 1.95 ± 5% | 0.35 | 1.00 | 7.80 ± 11.8% (k=2) |
| 5200 | ± 50 / ± 100 | Body | 49.0 ± 5% | 5.30 ± 5% | 0.35 | 1.60 | 4.41 ± 13.1% (k=2) |
| 5500 | ± 50 / ± 100 | Body | 48.6 ± 5% | 5.65 ± 5% | 0.35 | 1.60 | 4.13 ± 13.1% (k=2) |
| 5800 | ± 50 / ± 100 | Body | 48.2 ± 5% | 6.00 ± 5% | 0.32 | 1.70 | 4.23 ± 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.



**UL Japan, Inc.**
**Head Office EMC Lab.**
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN
Telephone : +81 596 24 8116
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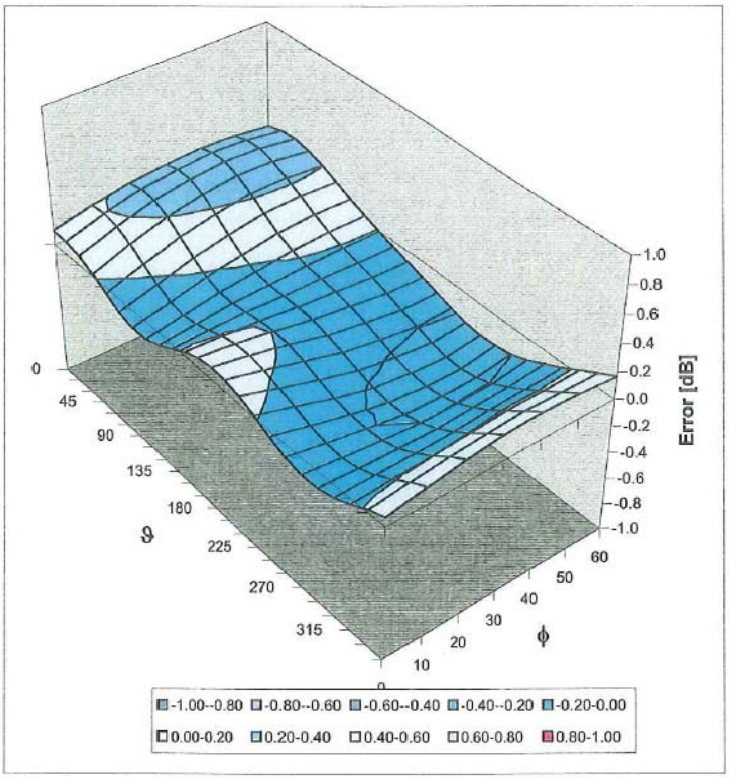
## Deviation from Isotropy in HSL

Error (ϕ, ϑ), f = 900 MHz




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



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**Head Office EMC Lab.**
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**13. References**

[1]ANSI, ANSI/IEEE C95.1-1992: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, The Institute of Electrical and Electronics Engineers, Inc., New York, NY 10017, 1992.
[2] Katja Pokovic, Thomas Schmid, and Niels Kuster, "Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequencies", in ICECOM '97, Dubrovnik, October 15-17, 1997, pp. 120-124.
[3] Katja Pokovic, Thomas Schmid, and Niels Kuster, "E-_field probe with improved isotropy in brain simulating liquids", in Proceedings of the ELMAR, Zadar, Croatia, 23-25 June, 1996, pp.172-175.
[4] W. Gander, Computermathematik, Birkhaeuser, Basel, 1992.
[5] W. H. Press, S. A. Teukolsky,W. T. Vetterling, and B. P. Flannery, Numerical Recepies in C, The Art of Scientific Computing, Second Edition, Cambridge University Press, 1992.
[6]SPEAG uncertainty document for DASY 4 System from SPEAG (Shimid & Partner Engineering AG).
[7]SPEAG uncertainty document for "the 5-6GHz Extension" from SPEAG (Shimid & Partner Engineering AG).