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Accreditation No.: **SCS 108**

Client **ATL (Auden)**

Certificate No: **D450V2-1021\_Mar06**

## CALIBRATION CERTIFICATE

Object **D450V2 - SN: 1021**

Calibration procedure(s) **QA CAL-15.v4**  
**Calibration Procedure for dipole validation kits below 800 MHz**

Calibration date: **March 17, 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  $(22 \pm 3)^{\circ}\text{C}$  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      | 3-May-05 (METAS, No. 251-00466)           | May-06                |
| Power sensor E4412A        | MY41495277      | 3-May-05 (METAS, No. 251-00466)           | May-06                |
| Power sensor E4412A        | MY41498087      | 3-May-05 (METAS, No. 251-00466)           | May-06                |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 11-Aug-05 (METAS, No. 251-00499)          | Aug-06                |
| Reference 20 dB Attenuator | SN: S5086 (20b) | 3-May-05 (METAS, No. 251-00467)           | May-06                |
| Reference Probe ET3DV6     | SN 1507         | 11-Jul-05 (SPEAG, No. ET3-1507_Jul05)     | Jul-06                |
| DAE4                       | SN 601          | 15-Dec-05 (SPEAG, No. DAE4-601_Dec05)     | Dec-06                |

| 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 Nov-05) | In house check: Nov 06 |

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

Issued: March 17, 2006

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**Glossary:**

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

**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
- 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
- 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.

|                                     |                        |                                 |
|-------------------------------------|------------------------|---------------------------------|
| <b>DASY Version</b>                 | DASY4                  | V4.7                            |
| <b>Extrapolation</b>                | Advanced Extrapolation |                                 |
| <b>Phantom</b>                      | Flat Phantom V4.4      | Shell thickness: $6 \pm 0.2$ mm |
| <b>Distance Dipole Center - TSL</b> | 15 mm                  | with Spacer                     |
| <b>Area Scan resolution</b>         | dx, dy = 15 mm         |                                 |
| <b>Zoom Scan Resolution</b>         | dx, dy, dz = 5 mm      |                                 |
| <b>Frequency</b>                    | 450 MHz $\pm$ 1 MHz    |                                 |

## Head TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| <b>Nominal Head TSL parameters</b>      | 22.0 °C             | 43.5           | 0.87 mho/m           |
| <b>Measured Head TSL parameters</b>     | (22.0 $\pm$ 0.2) °C | 44.6 $\pm$ 6 % | 0.86 mho/m $\pm$ 6 % |
| <b>Head TSL temperature during test</b> | (22.0 $\pm$ 0.2) °C | ---            | ---                  |

## SAR result with Head TSL

| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | condition          |                                                  |
|-------------------------------------------------------------|--------------------|--------------------------------------------------|
| SAR measured                                                | 398 mW input power | 1.96 mW / g                                      |
| SAR normalized                                              | normalized to 1W   | 4.92 mW / g                                      |
| SAR for nominal Head TSL parameters <sup>1</sup>            | normalized to 1W   | <b>5.01 mW / g <math>\pm</math> 18.1 % (k=2)</b> |

| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition          |                                                  |
|---------------------------------------------------------------|--------------------|--------------------------------------------------|
| SAR measured                                                  | 398 mW input power | 1.32 mW / g                                      |
| SAR normalized                                                | normalized to 1W   | 3.32 mW / g                                      |
| SAR for nominal Head TSL parameters <sup>1</sup>              | normalized to 1W   | <b>3.36 mW / g <math>\pm</math> 17.6 % (k=2)</b> |

<sup>1</sup> Correction to nominal TSL parameters according to d), chapter "SAR Sensitivities"

## Body TSL parameters

The following parameters and calculations were applied.

|                                  | Temperature     | Permittivity | Conductivity     |
|----------------------------------|-----------------|--------------|------------------|
| Nominal Body TSL parameters      | 22.0 °C         | 56.7         | 0.94 mho/m       |
| Measured Body TSL parameters     | (22.0 ± 0.2) °C | 55.9 ± 6 %   | 0.94 mho/m ± 6 % |
| Body TSL temperature during test | (22.0 ± 0.2) °C | ----         | ----             |

## SAR result with Body TSL

| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | condition          |                            |
|-------------------------------------------------------|--------------------|----------------------------|
| SAR measured                                          | 398 mW input power | 1.86 mW / g                |
| SAR normalized                                        | normalized to 1W   | 4.67 mW / g                |
| SAR for nominal Body TSL parameters <sup>1</sup>      | normalized to 1W   | 4.64 mW / g ± 18.1 % (k=2) |

| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                            |
|---------------------------------------------------------|--------------------|----------------------------|
| SAR measured                                            | 398 mW input power | 1.26 mW / g                |
| SAR normalized                                          | normalized to 1W   | 3.17 mW / g                |
| SAR for nominal Body TSL parameters <sup>1</sup>        | normalized to 1W   | 3.14 mW / g ± 17.6 % (k=2) |

## Appendix

### Antenna Parameters with Head TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 56.1 $\Omega$ - 4.6 j $\Omega$ |
| Return Loss                          | - 22.6 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                 |
|--------------------------------------|---------------------------------|
| Impedance, transformed to feed point | 50.7 $\Omega$ - 11.6 j $\Omega$ |
| Return Loss                          | - 19.0 dB                       |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.349 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 | February 4, 2004 |

## DASY4 Validation Report for Head TSL

Date/Time: 17.03.2006 19:01:30

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 450 MHz; Type: D450V2; Serial: D450V2 - SN:1021**

Communication System: CW; Frequency: 450 MHz; Duty Cycle: 1:1

Medium: HSL450;

Medium parameters used:  $f = 450$  MHz;  $\sigma = 0.86$  mho/m;  $\epsilon_r = 44.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY4 (High Precision Assessment)

### DASY4 Configuration:

- Probe: ET3DV6 - SN1507 (LF); ConvF(6.59, 6.59, 6.59); Calibrated: 11.07.2005
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 15.12.2005
- Phantom: Flat Phantom 4.4; Type: Flat Phantom 4.4
- Measurement SW: DASY4, V4.7 Build 14; Postprocessing SW: SEMCAD, V1.8 Build 165

**d=15mm, Pin=398mW/Area Scan (61x201x1):** Measurement grid: dx=15mm, dy=15mm  
Maximum value of SAR (interpolated) = 2.09 mW/g

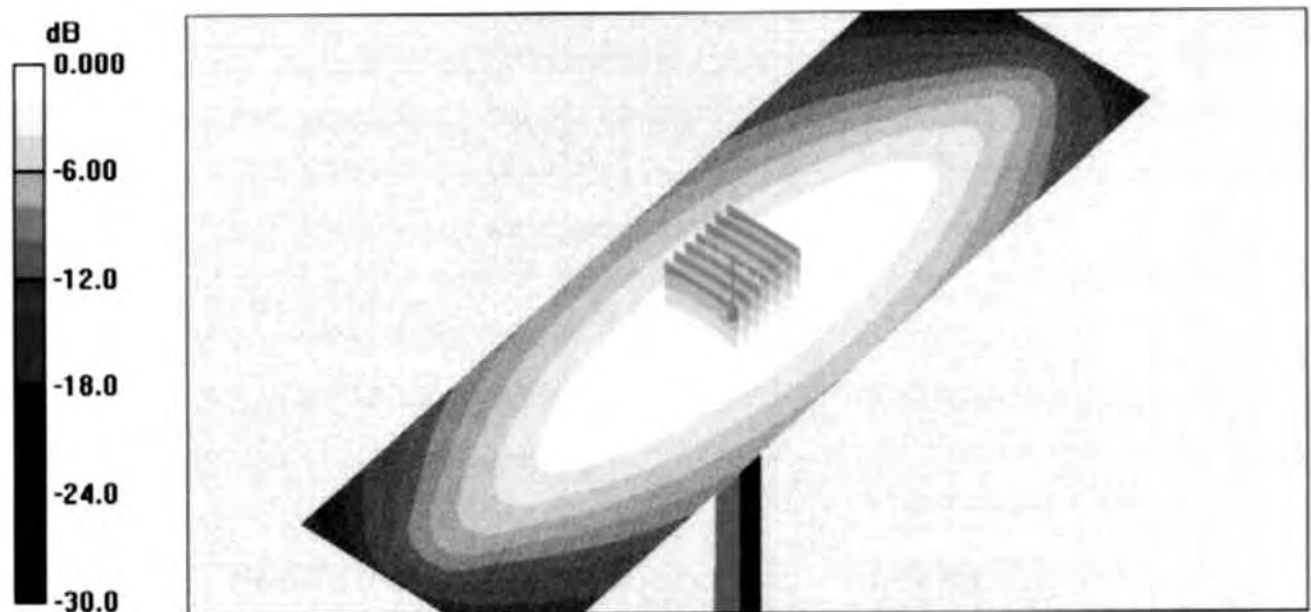
**d=15mm, Pin=398mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 51.8 V/m; Power Drift = 0.000 dB

Peak SAR (extrapolated) = 2.83 W/kg

**SAR(1 g) = 1.96 mW/g; SAR(10 g) = 1.32 mW/g**

Maximum value of SAR (measured) = 2.11 mW/g

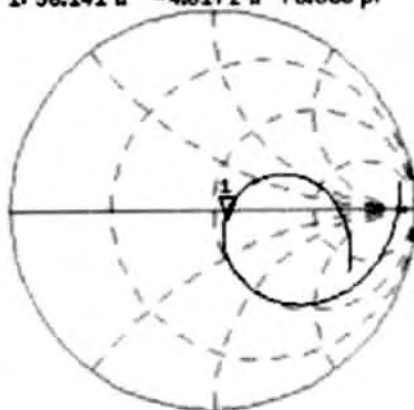


0 dB = 2.11mW/g

# Impedance Measurement Plot for Head TSL

17 Mar 2006 19:01:46  
 CH1 S11 1 U FS 1: 56.141  $\Omega$  -4.6172  $\Omega$  76.600 pF 450.000 000 MHz

De1  
 Sma  
 Cor



Avg  
 16

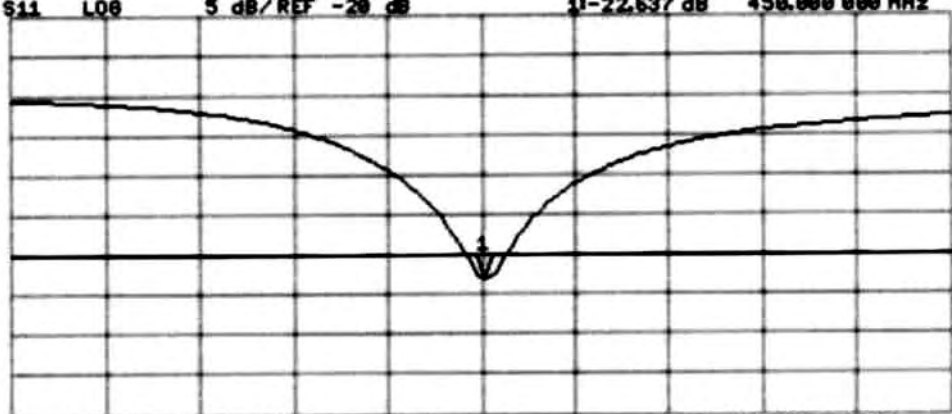
↑

CH2 S11 L00 5 dB/REF -20 dB 1: -22.637 dB 450.000 000 MHz

Sma  
 Cor

Avg  
 16

↑



CENTER 450.000 000 MHz

SPAN 400.000 000 MHz



## DASY4 Validation Report for Body TSL

Date/Time: 17.03.2006 17:20:29

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 450 MHz; Type: D450V2; Serial: D450V2 - SN:1021**

Communication System: CW; Frequency: 450 MHz; Duty Cycle: 1:1

Medium: MSL450;

Medium parameters used:  $f = 450 \text{ MHz}$ ;  $\sigma = 0.94 \text{ mho/m}$ ;  $\epsilon_r = 55.9$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

Measurement Standard: DASY4 (High Precision Assessment)

### DASY4 Configuration:

- Probe: ET3DV6 - SN1507 (LF); ConvF(6.94, 6.94, 6.94); Calibrated: 11.07.2005
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 15.12.2005
- Phantom: Flat Phantom 4.4; Type: Flat Phantom 4.4
- Measurement SW: DASY4, V4.7 Build 14; Postprocessing SW: SEMCAD, V1.8 Build 165

**d=15mm, Pin=398mW/Area Scan (61x201x1):** Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (interpolated) = 2.01 mW/g

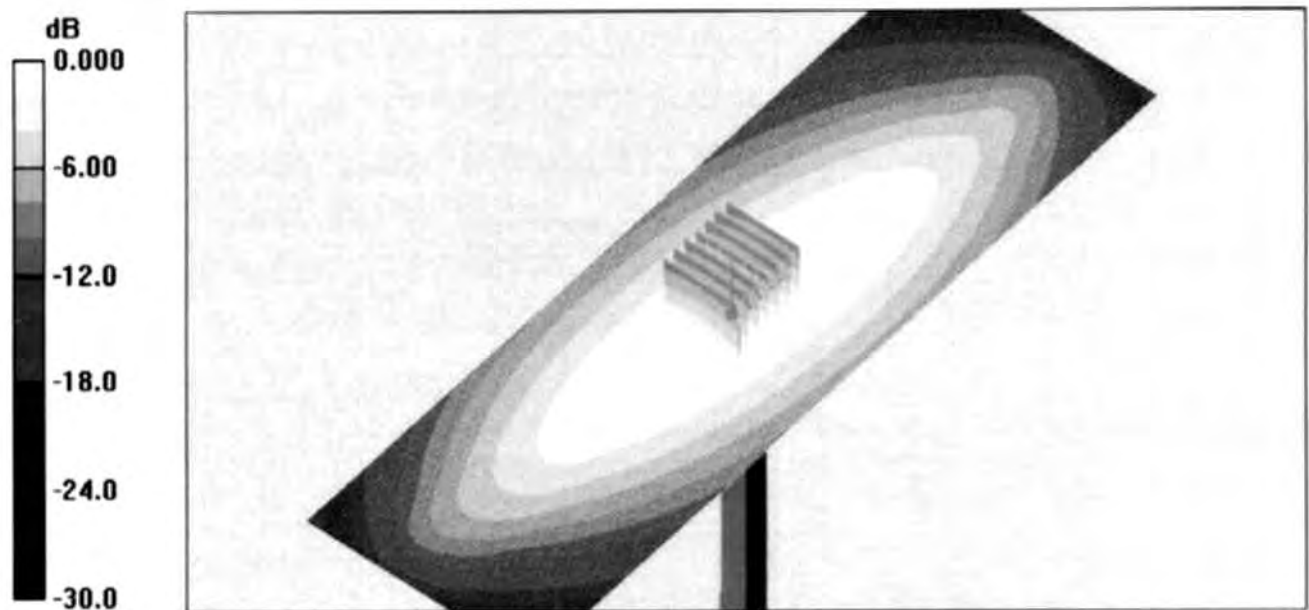
**d=15mm, Pin=398mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 48.5 V/m; Power Drift = -0.016 dB

Peak SAR (extrapolated) = 2.62 W/kg

**SAR(1 g) = 1.86 mW/g; SAR(10 g) = 1.26 mW/g**

Maximum value of SAR (measured) = 2.02 mW/g



0 dB = 2.02mW/g

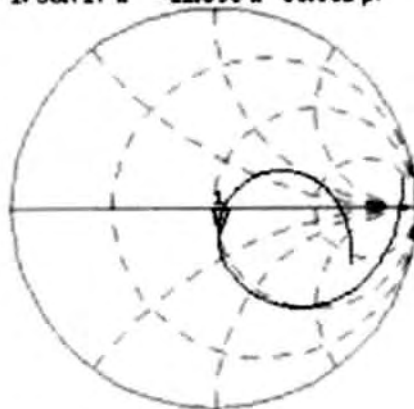


# Impedance Measurement Plot for Body TSL

17 Mar 2006 17:23:25  
 [CH1] S11 1 U FS 1: 58.717  $\Omega$  -11.596  $\Omega$  38.501 pF 458.000 000 MHz

De1  
 Smo  
 Cor

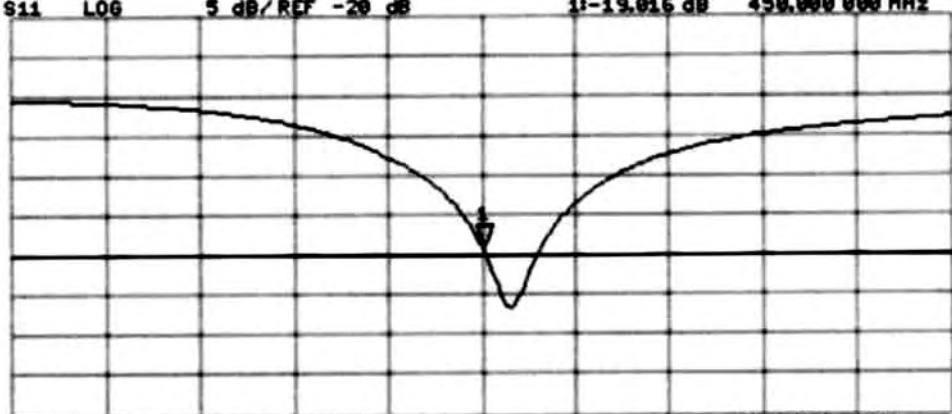
avg  
 16



CH2 S11 LOG 5 dB/REF -20 dB 1: -19.016 dB 458.000 000 MHz

Smo  
 Cor

avg  
 16



CENTER 458.000 000 MHz

SPAN 400.000 000 MHz



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Accreditation No.: **SCS 108**

Client **ATL (Auden)**

Certificate No: **ET3-1530\_Sep06**

## CALIBRATION CERTIFICATE

Object **ET3DV6 - SN:1530**

Calibration procedure(s) **QA CAL-01.v5 and QA CAL-12.v4**  
**Calibration procedure for dosimetric E-field probes**

Calibration date: **September 21, 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  $(22 \pm 3)^\circ\text{C}$  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      | 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        | 2-Jan-06 (SPEAG, No. ES3-3013_Jan06)      | Jan-07                 |
| 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 Nov-05)  | In house check: Nov 06 |

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

Issued: September 21, 2006

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### Glossary:

|                          |                                                                                                                                                      |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| TSL                      | tissue simulating liquid                                                                                                                             |
| NORM <sub>x,y,z</sub>    | sensitivity in free space                                                                                                                            |
| ConF                     | sensitivity in TSL / NORM <sub>x,y,z</sub>                                                                                                           |
| DCP                      | diode compression point                                                                                                                              |
| Polarization $\phi$      | $\phi$ rotation around probe axis                                                                                                                    |
| Polarization $\vartheta$ | $\vartheta$ 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
- 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:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not effect the E<sup>2</sup>-field uncertainty inside TSL (see below *ConvF*).
- NORM(f)<sub>x,y,z</sub>** = NORM<sub>x,y,z</sub> \* *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<sub>x,y,z</sub>**: 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<sub>x,y,z</sub> \* *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  $\pm 50$  MHz to  $\pm 100$  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 ET3DV6

## SN:1530

|                  |                    |
|------------------|--------------------|
| Manufactured:    | July 15, 2000      |
| Last calibrated: | September 6, 2005  |
| Modified:        | September 12, 2006 |
| Recalibrated:    | September 21, 2006 |

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)



## DASY - Parameters of Probe: ET3DV6 SN:1530

### Sensitivity in Free Space<sup>A</sup>

### Diode Compression<sup>B</sup>

|       |              |                                     |       |       |
|-------|--------------|-------------------------------------|-------|-------|
| NormX | 1.48 ± 10.1% | $\mu\text{V}/(\text{V}/\text{m})^2$ | DCP X | 92 mV |
| NormY | 1.58 ± 10.1% | $\mu\text{V}/(\text{V}/\text{m})^2$ | DCP Y | 95 mV |
| NormZ | 1.38 ± 10.1% | $\mu\text{V}/(\text{V}/\text{m})^2$ | DCP Z | 92 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 |                              | <b>3.7 mm</b> | <b>4.7 mm</b> |
| SAR <sub>be</sub> [%]                     | Without Correction Algorithm | 10.0          | 5.4           |
| SAR <sub>be</sub> [%]                     | With Correction Algorithm    | 0.1           | 0.2           |

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

|                                           |                              |               |               |
|-------------------------------------------|------------------------------|---------------|---------------|
| Sensor Center to Phantom Surface Distance |                              | <b>3.7 mm</b> | <b>4.7 mm</b> |
| SAR <sub>be</sub> [%]                     | Without Correction Algorithm | 11.8          | 7.0           |
| SAR <sub>be</sub> [%]                     | With Correction Algorithm    | 0.2           | 4.0           |

### Sensor Offset

Probe Tip to Sensor Center                      **2.7 mm**

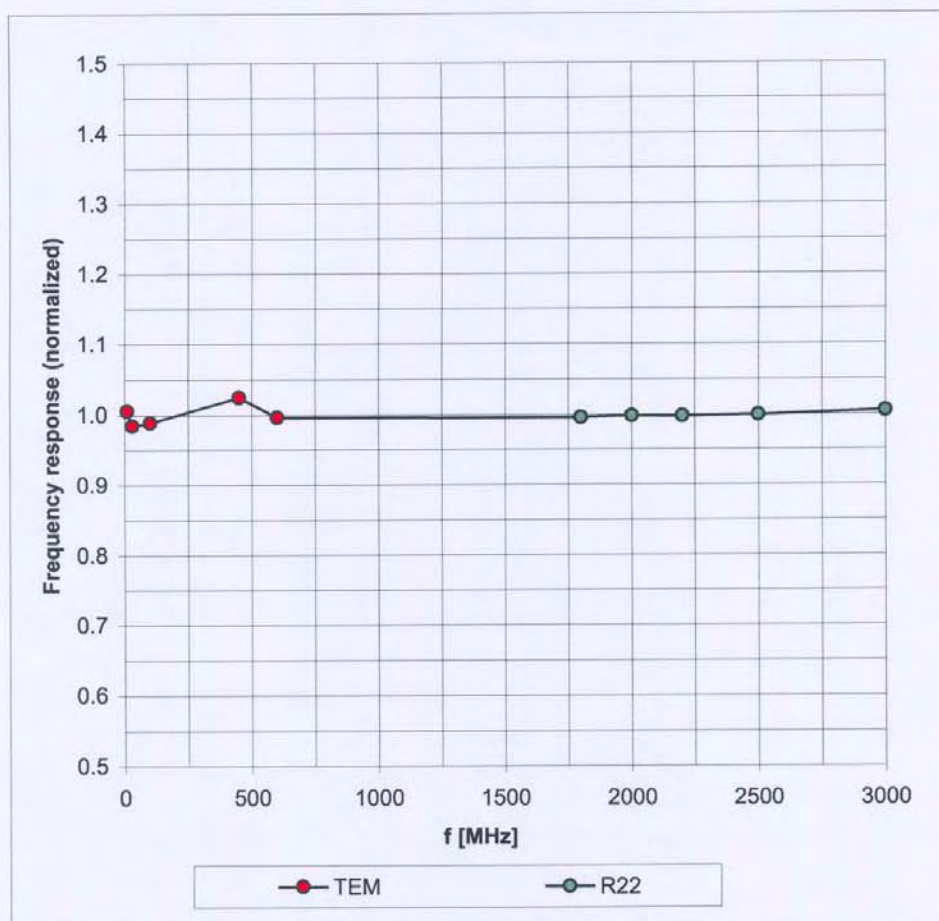
The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

<sup>A</sup> The uncertainties of NormX,Y,Z do not affect the E<sup>2</sup>-field uncertainty inside TSL (see Page 8).

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

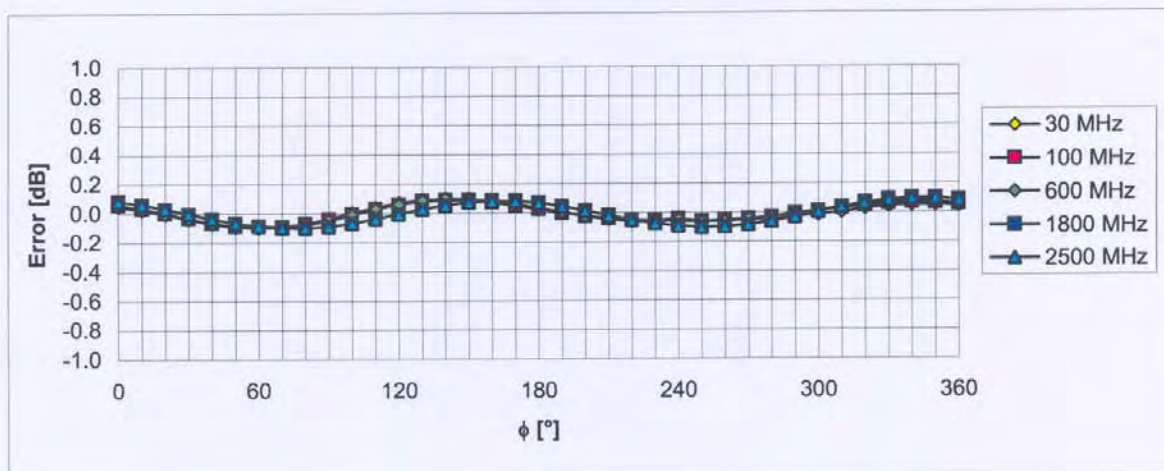
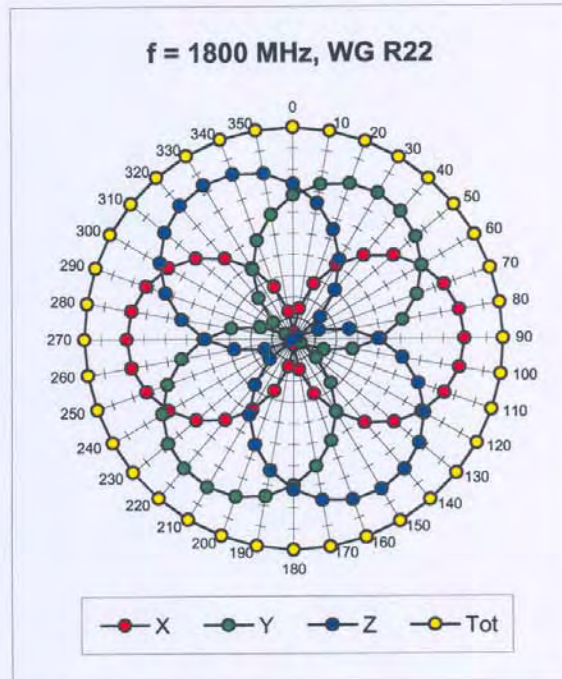
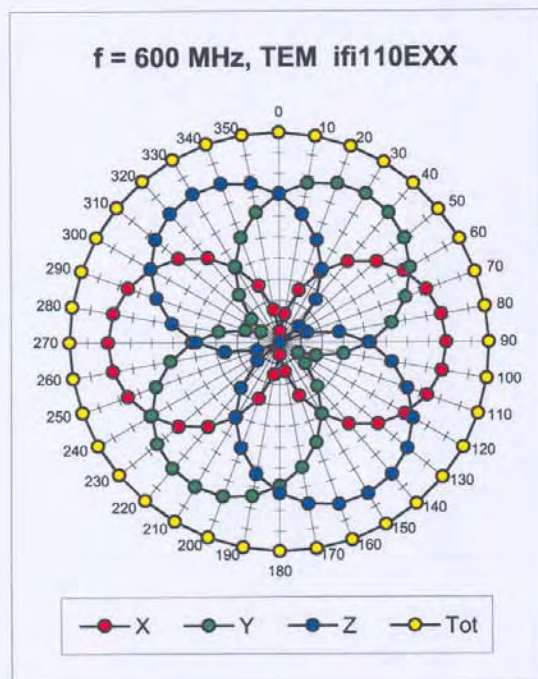
## Frequency Response of E-Field

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



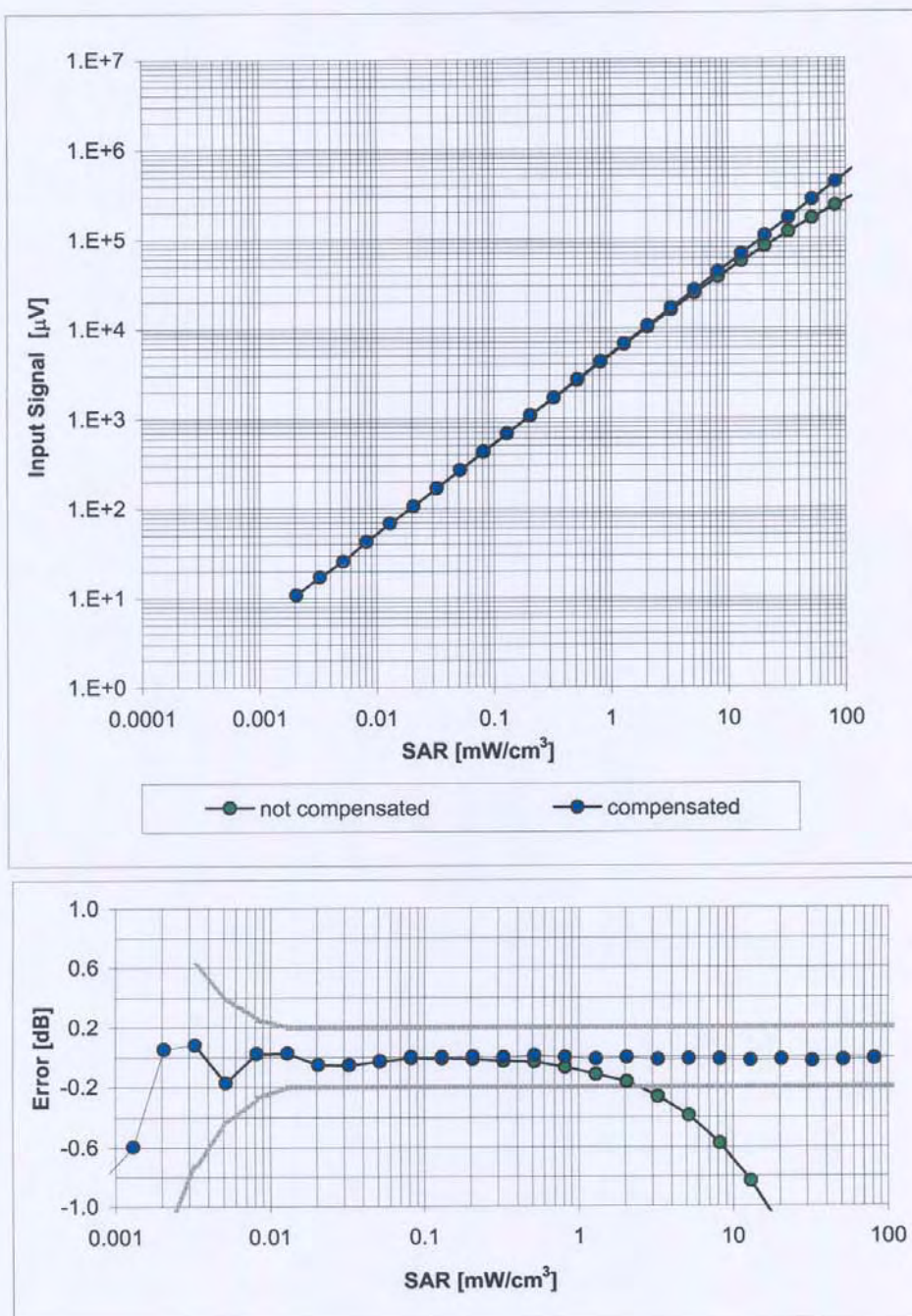
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )



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

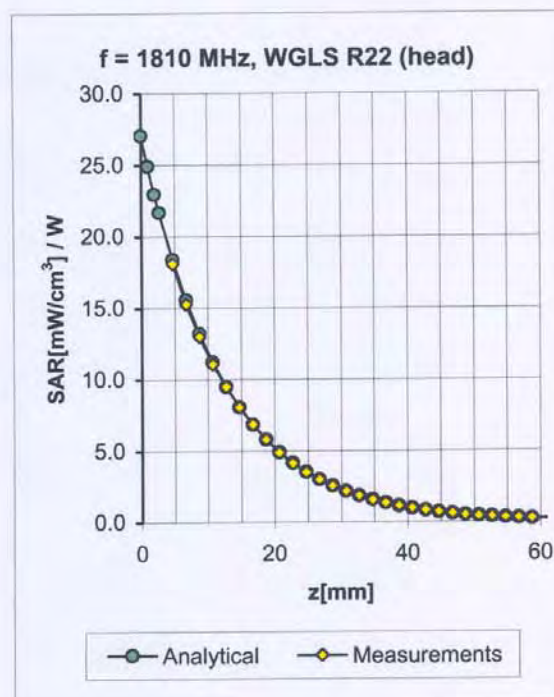
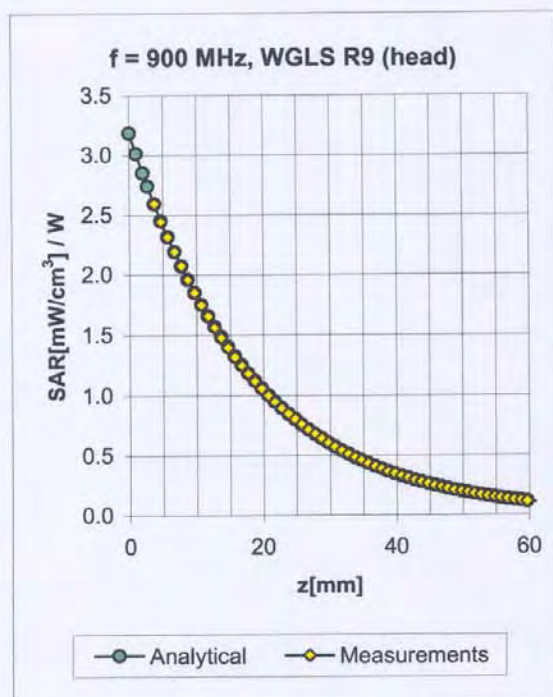


# Dynamic Range $f(\text{SAR}_{\text{head}})$ (Waveguide R22, $f = 1800$ MHz)



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

## Conversion Factor Assessment



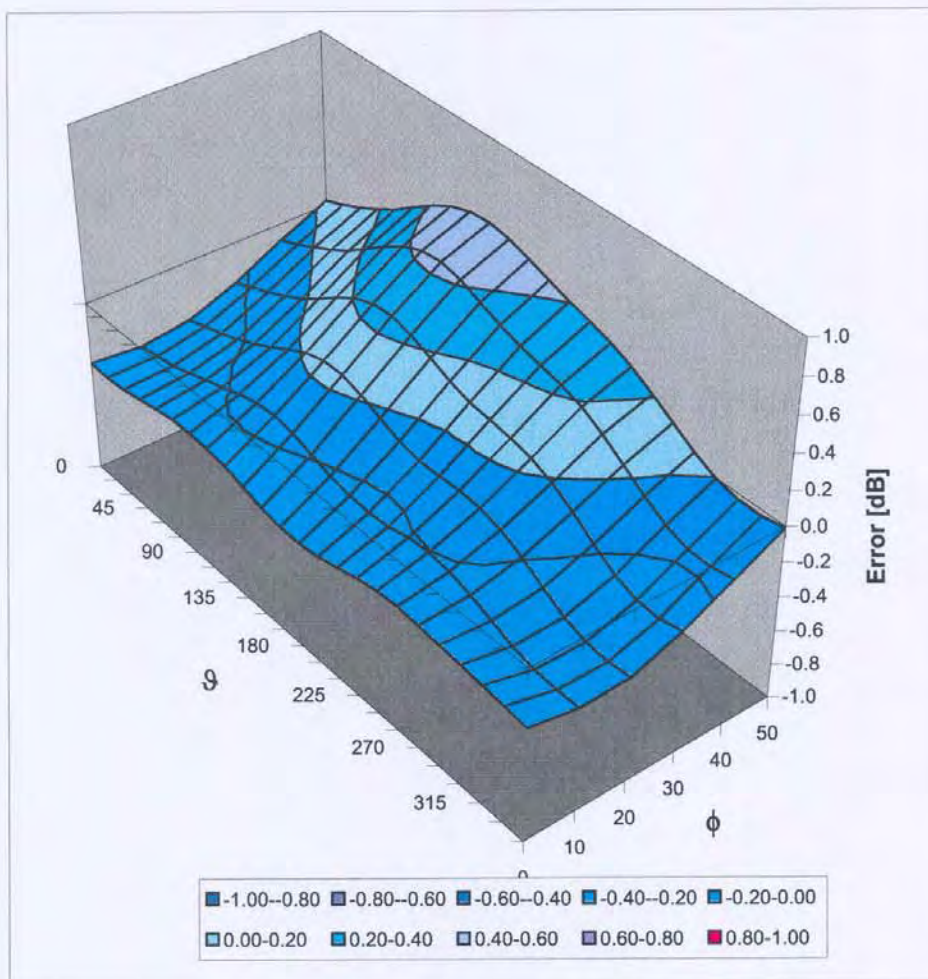
| f [MHz] | Validity [MHz] <sup>c</sup> | TSL  | Permittivity | Conductivity | Alpha | Depth | ConvF Uncertainty  |
|---------|-----------------------------|------|--------------|--------------|-------|-------|--------------------|
| 450     | ± 50 / ± 100                | Head | 43.5 ± 5%    | 0.87 ± 5%    | 0.38  | 1.96  | 6.80 ± 13.3% (k=2) |
| 900     | ± 50 / ± 100                | Head | 41.5 ± 5%    | 0.97 ± 5%    | 0.66  | 1.86  | 5.91 ± 11.0% (k=2) |
| 1810    | ± 50 / ± 100                | Head | 40.0 ± 5%    | 1.40 ± 5%    | 0.55  | 2.77  | 4.86 ± 11.0% (k=2) |
| 2000    | ± 50 / ± 100                | Head | 40.0 ± 5%    | 1.40 ± 5%    | 0.64  | 2.67  | 4.56 ± 11.0% (k=2) |
| 2450    | ± 50 / ± 100                | Head | 39.2 ± 5%    | 1.80 ± 5%    | 0.60  | 2.45  | 4.32 ± 11.8% (k=2) |
|         |                             |      |              |              |       |       |                    |
| 450     | ± 50 / ± 100                | Body | 56.7 ± 5%    | 0.94 ± 5%    | 0.33  | 1.97  | 7.59 ± 13.3% (k=2) |
| 900     | ± 50 / ± 100                | Body | 55.0 ± 5%    | 1.05 ± 5%    | 0.59  | 2.03  | 5.66 ± 11.0% (k=2) |
| 1810    | ± 50 / ± 100                | Body | 53.3 ± 5%    | 1.52 ± 5%    | 0.68  | 2.68  | 4.40 ± 11.0% (k=2) |
| 2000    | ± 50 / ± 100                | Body | 53.3 ± 5%    | 1.52 ± 5%    | 0.75  | 2.34  | 4.21 ± 11.0% (k=2) |
| 2450    | ± 50 / ± 100                | Body | 52.7 ± 5%    | 1.95 ± 5%    | 0.65  | 2.09  | 3.94 ± 11.8% (k=2) |

<sup>c</sup> 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.



## Deviation from Isotropy in HSL

Error ( $\phi$ ,  $\vartheta$ ),  $f = 900$  MHz



Uncertainty of Spherical Isotropy Assessment:  $\pm 2.6\%$  ( $k=2$ )





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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **ATL (Auden)**

Certificate No: **DAE3-393\_Sep06**

## CALIBRATION CERTIFICATE

Object **DAE3 - SD 000 D03 AA - SN: 393**

Calibration procedure(s) **QA CAL-06.v12**  
**Calibration procedure for the data acquisition electronics (DAE)**

Calibration date: **September 05, 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  $(22 \pm 3)^{\circ}\text{C}$  and humidity  $< 70\%$ .

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards                 | ID #               | Cal Date (Calibrated by, Certificate No.) | Scheduled Calibration |
|-----------------------------------|--------------------|-------------------------------------------|-----------------------|
| Fluke Process Calibrator Type 702 | SN: 6295803        | 7-Oct-05 (Sintrel, No.E-050073)           | Oct-06                |
| Secondary Standards               | ID #               | Check Date (in house)                     | Scheduled Check       |
| Calibrator Box V1.1               | SE UMS 006 AB 1002 | 15-Jun-06 (SPEAG, in house check)         | In house check Jun-07 |

|                |                   |              |           |
|----------------|-------------------|--------------|-----------|
|                | Name              | Function     | Signature |
| Calibrated by: | Daniel Steinacher | Technician   |           |
| Approved by:   | Fin Bomholt       | R&D Director |           |

Issued: September 5, 2006

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





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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

## Glossary

**DAE** data acquisition electronics  
**Connector angle** information used in DASY system to align probe sensor X to the robot coordinate system.

## Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters contain technical information as a result from the performance test and require no uncertainty.
- *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
- *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
- *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
- *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
- *Input Offset Measurement:* Output voltage and statistical results over a large number of zero voltage measurements.
- *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
- *Input resistance:* DAE input resistance at the connector, during internal auto-zeroing and during measurement.
- *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
- *Power consumption:* Typical value for information. Supply currents in various operating modes.

## DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1  $\mu$ V , full range = -100...+300 mV

Low Range: 1LSB = 61 nV , full range = -1.....+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X                        | Y                        | Z                        |
|---------------------|--------------------------|--------------------------|--------------------------|
| High Range          | 403.920 $\pm$ 0.1% (k=2) | 404.171 $\pm$ 0.1% (k=2) | 404.090 $\pm$ 0.1% (k=2) |
| Low Range           | 3.96928 $\pm$ 0.7% (k=2) | 3.94931 $\pm$ 0.7% (k=2) | 3.95209 $\pm$ 0.7% (k=2) |

## Connector Angle

|                                           |                 |
|-------------------------------------------|-----------------|
| Connector Angle to be used in DASY system | 305 ° $\pm$ 1 ° |
|-------------------------------------------|-----------------|



## Appendix

### 1. DC Voltage Linearity

| High Range        | Input ( $\mu\text{V}$ ) | Reading ( $\mu\text{V}$ ) | Error (%) |
|-------------------|-------------------------|---------------------------|-----------|
| Channel X + Input | 200000                  | 200000.5                  | 0.00      |
| Channel X + Input | 20000                   | 20004.49                  | 0.02      |
| Channel X - Input | 20000                   | -19996.62                 | -0.02     |
| Channel Y + Input | 200000                  | 200000.3                  | 0.00      |
| Channel Y + Input | 20000                   | 20001.50                  | 0.01      |
| Channel Y - Input | 20000                   | -19996.54                 | -0.02     |
| Channel Z + Input | 200000                  | 200000.7                  | 0.00      |
| Channel Z + Input | 20000                   | 20001.66                  | 0.01      |
| Channel Z - Input | 20000                   | -20008.81                 | 0.04      |

| Low Range         | Input ( $\mu\text{V}$ ) | Reading ( $\mu\text{V}$ ) | Error (%) |
|-------------------|-------------------------|---------------------------|-----------|
| Channel X + Input | 2000                    | 2000.1                    | 0.00      |
| Channel X + Input | 200                     | 200.37                    | 0.19      |
| Channel X - Input | 200                     | -200.51                   | 0.25      |
| Channel Y + Input | 2000                    | 2000.0                    | 0.00      |
| Channel Y + Input | 200                     | 199.66                    | -0.17     |
| Channel Y - Input | 200                     | -200.62                   | 0.31      |
| Channel Z + Input | 2000                    | 2000.1                    | 0.00      |
| Channel Z + Input | 200                     | 199.59                    | -0.20     |
| Channel Z - Input | 200                     | -200.58                   | 0.29      |

### 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

|           | Common mode<br>Input Voltage (mV) | High Range<br>Average Reading ( $\mu\text{V}$ ) | Low Range<br>Average Reading ( $\mu\text{V}$ ) |
|-----------|-----------------------------------|-------------------------------------------------|------------------------------------------------|
| Channel X | 200                               | 12.89                                           | 11.36                                          |
|           | - 200                             | -10.22                                          | -11.53                                         |
| Channel Y | 200                               | 9.88                                            | 9.80                                           |
|           | - 200                             | -10.79                                          | -11.07                                         |
| Channel Z | 200                               | 3.81                                            | 3.86                                           |
|           | - 200                             | -5.02                                           | -5.47                                          |

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

|           | Input Voltage (mV) | Channel X ( $\mu\text{V}$ ) | Channel Y ( $\mu\text{V}$ ) | Channel Z ( $\mu\text{V}$ ) |
|-----------|--------------------|-----------------------------|-----------------------------|-----------------------------|
| Channel X | 200                | -                           | 2.88                        | -0.01                       |
| Channel Y | 200                | 0.97                        | -                           | 5.82                        |
| Channel Z | 200                | -1.14                       | 0.94                        | -                           |

#### 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

|           | High Range (LSB) | Low Range (LSB) |
|-----------|------------------|-----------------|
| Channel X | 16146            | 16673           |
| Channel Y | 16012            | 16399           |
| Channel Z | 16451            | 16677           |

#### 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Input 10M $\Omega$

|           | Average ( $\mu$ V) | min. Offset ( $\mu$ V) | max. Offset ( $\mu$ V) | Std. Deviation ( $\mu$ V) |
|-----------|--------------------|------------------------|------------------------|---------------------------|
| Channel X | 0.73               | -0.21                  | 1.54                   | 0.29                      |
| Channel Y | -1.32              | -2.41                  | -0.14                  | 0.37                      |
| Channel Z | -0.83              | -1.90                  | 0.54                   | 0.48                      |

#### 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

#### 7. Input Resistance

|           | Zeroing (MOhm) | Measuring (MOhm) |
|-----------|----------------|------------------|
| Channel X | 0.2000         | 199.0            |
| Channel Y | 0.2000         | 198.6            |
| Channel Z | 0.2001         | 198.5            |

#### 8. Low Battery Alarm Voltage (verified during pre test)

| Typical values | Alarm Level (VDC) |
|----------------|-------------------|
| Supply (+ Vcc) | +7.9              |
| Supply (- Vcc) | -7.6              |

#### 9. Power Consumption (verified during pre test)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|----------------|-------------------|---------------|-------------------|
| Supply (+ Vcc) | +0.0              | +6            | +14               |
| Supply (- Vcc) | -0.01             | -8            | -9                |