# Appendix C. DASY Calibration Certificate

The DASY calibration certificates are shown as follows.

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

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

Accredited by the Swiss Accreditation Service (SAS)
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 **Sporton (Auden)**

Certificate No: **D835V2-499_Mar10**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D835V2 - SN: 499 |
| Calibration procedure(s) | QA CAL-05.v7<br>Calibration procedure for dipole validation kits |
| Calibration date: | March 22, 2010 |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter EPM-442A | GB37480704 | 06-Oct-09 (No. 217-01086) | Oct-10 |
| Power sensor HP 8481A | US37292783 | 06-Oct-09 (No. 217-01086) | Oct-10 |
| Reference 20 dB Attenuator | SN: 5086 (20g) | 31-Mar-09 (No. 217-01025) | Mar-10 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 31-Mar-09 (No. 217-01029) | Mar-10 |
| Reference Probe ES3DV3 | SN: 3205 | 26-Jun-09 (No. ES3-3205_Jun09) | Jun-10 |
| DAE4 | SN: 601 | 02-Mar-10 (No. DAE4-601_Mar10) | Mar-11 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power sensor HP 8481A | MY41092317 | 18-Oct-02 (in house check Oct-09) | In house check: Oct-11 |
| RF generator R&S SMT-06 | 100005 | 4-Aug-99 (in house check Oct-09) | In house check: Oct-11 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-09) | In house check: Oct-10 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Dimce Iliev | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: March 22, 2010

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

## 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) 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
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) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

## Measurement Conditions

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

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V5.2 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom V4.9 | |
| **Distance Dipole Center - TSL** | 15 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 835 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 41.5 | 0.90 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 42.9 ± 6 % | 0.91 mho/m ± 6 % |
| **Head TSL temperature during test** | (22.0 ± 0.2) °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.43 mW / g |
| SAR normalized | normalized to 1W | 9.72 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **9.71 mW /g ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.58 mW / g |
| SAR normalized | normalized to 1W | 6.32 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **6.31 mW /g ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 55.2 | 0.97 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 55.3 ± 6 % | 1.01 mho/m ± 6 % |
| **Body TSL temperature during test** | (22.0 ± 0.2) °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.53 mW / g |
| SAR normalized | normalized to 1W | 10.1 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **9.82 mW / g ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.66 mW / g |
| SAR normalized | normalized to 1W | 6.64 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **6.49 mW / g ± 16.5 % (k=2)** |

## Appendix

## Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 52.2 Ω - 3.2 jΩ |
| Return Loss | - 28.4 dB |

## Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 50.1 Ω - 5.9 jΩ |
| Return Loss | - 24.7 dB |

## General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.391 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 10, 2003 |

## DASY5 Validation Report for Head TSL

Date/Time: 22.03.2010 10:17:58

Test Laboratory: SPEAG, Zurich, Switzerland

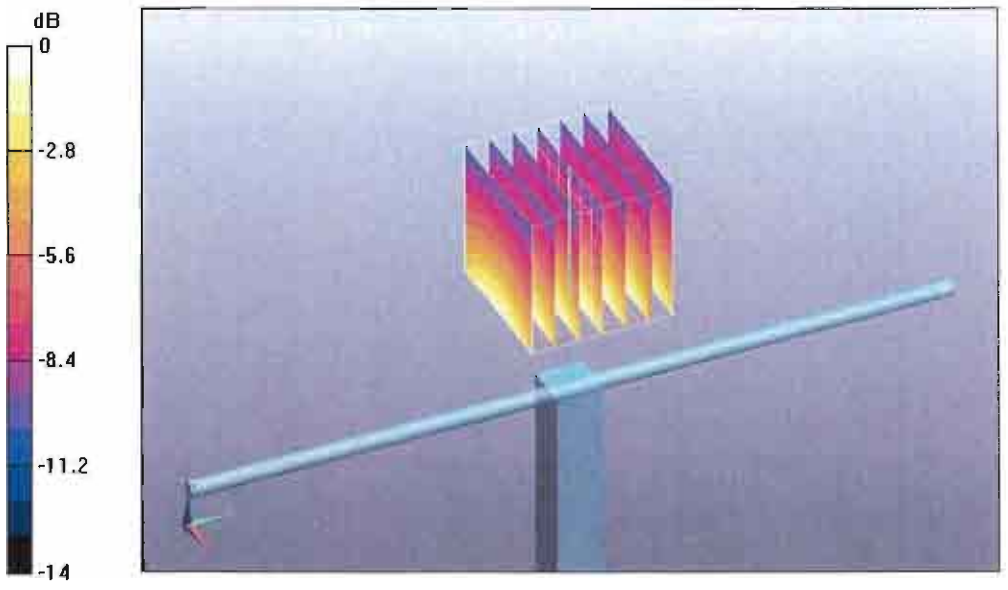
**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:499**

Communication System: CW; Frequency: 835 MHz; Duty Cycle: 1:1
Medium: HSL900
Medium parameters used: f = 835 MHz; $\sigma$ = 0.91 mho/m; $\varepsilon_r$ = 42.9; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

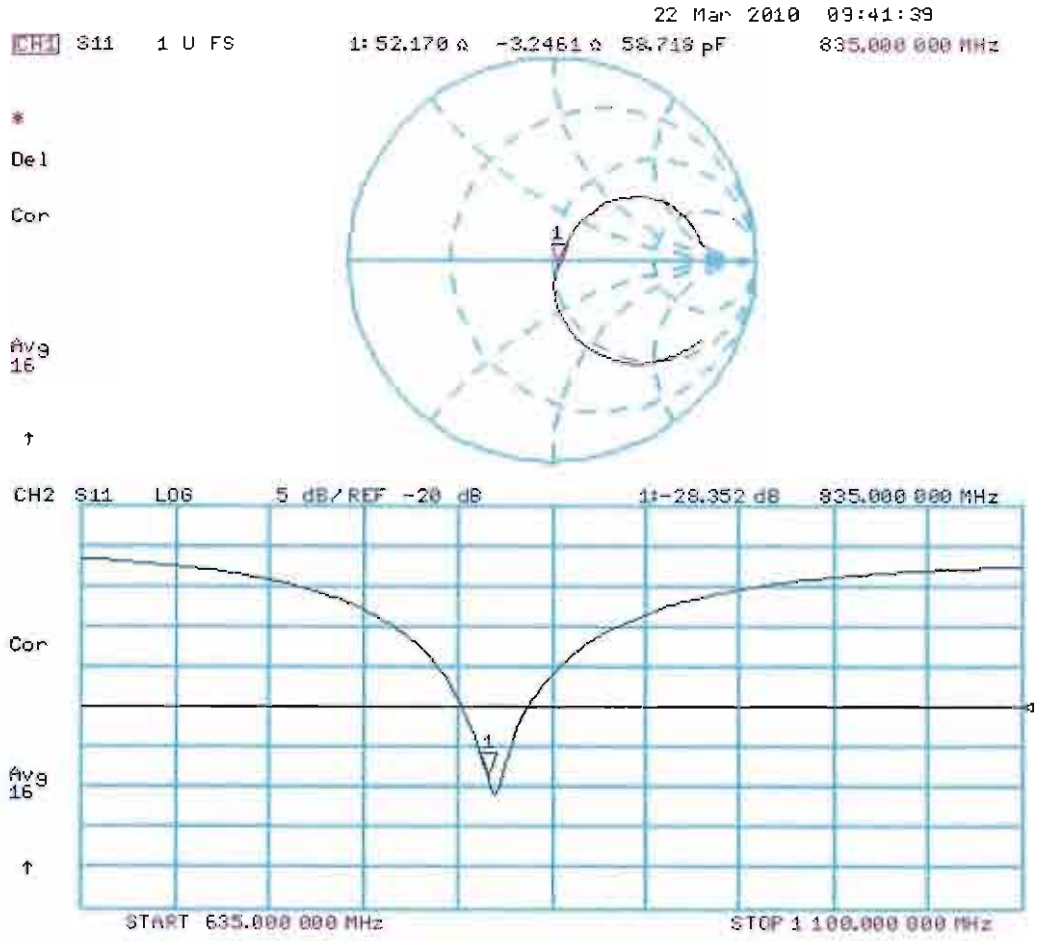
- Probe: ES3DV3 - SN3205; ConvF(6.04, 6.04, 6.04); Calibrated: 26.06.2009
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.03.2010
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- Measurement SW: DASY5, V5.2 Build 157; SEMCAD X Version 14.0 Build 57

**Pin=250 mW /d=15mm, dist=3.0mm (ES-Probe)/Zoom Scan (7x7x7) /Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 57.5 V/m; Power Drift = 0.00691 dB
Peak SAR (extrapolated) = 3.63 W/kg
**SAR(1 g) = 2.43 mW/g; SAR(10 g) = 1.58 mW/g**
Maximum value of SAR (measured) = 2.84 mW/g




0 dB = 2.84mW/g

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body

Date/Time: 22.03.2010 14:07:53

Test Laboratory: SPEAG, Zurich, Switzerland

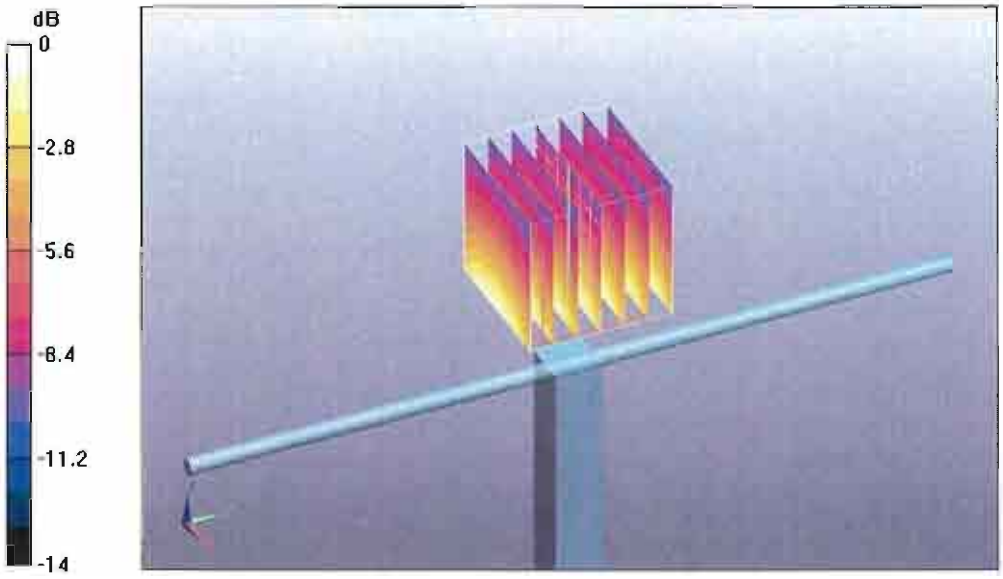
**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:499**

Communication System: CW; Frequency: 835 MHz; Duty Cycle: 1:1
Medium: MSL900
Medium parameters used: f = 835 MHz; $\sigma$ = 1.01 mho/m; $\varepsilon_r$ = 55.3; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

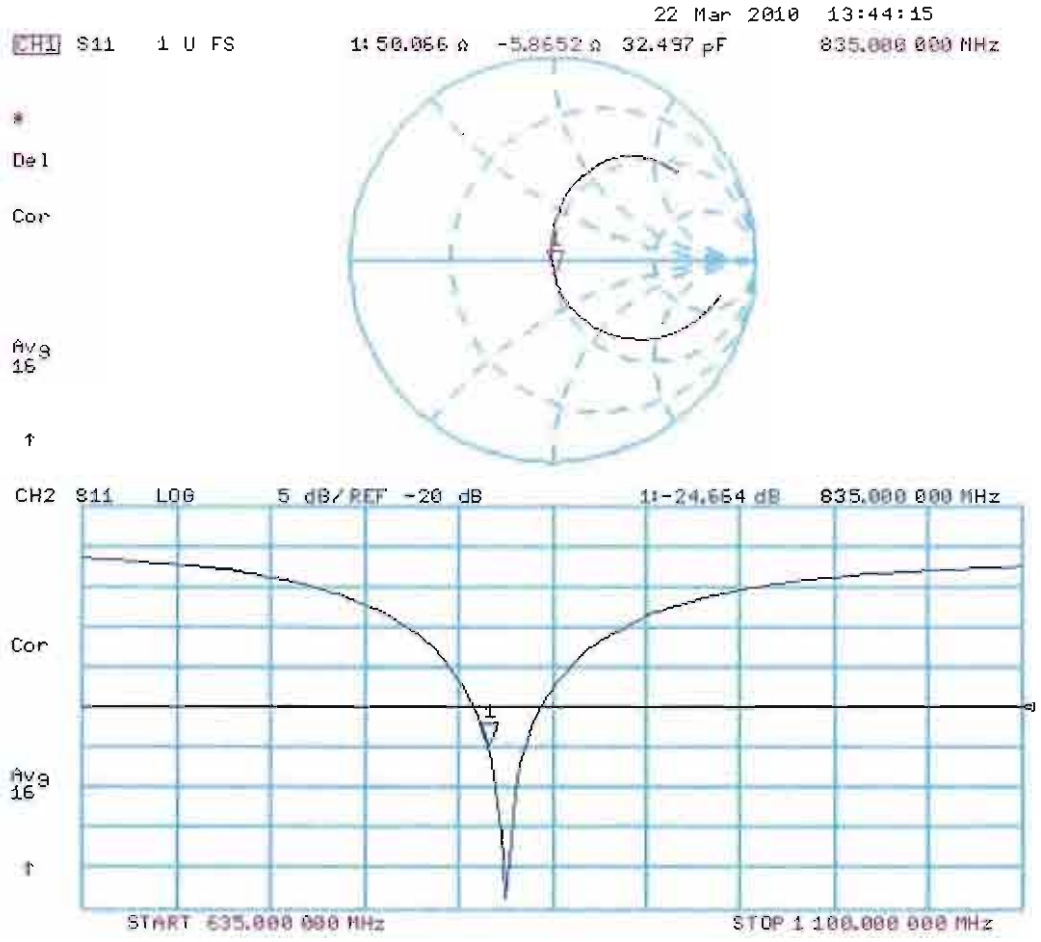
- Probe: ES3DV3 - SN3205; ConvF(5.97, 5.97, 5.97); Calibrated: 26.06.2009
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.03.2010
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- Measurement SW: DASY5, V5.2 Build 157; SEMCAD X Version 14.0 Build 57

**Pin250 mW /d=15mm, dist=3.0mm (ES-Probe)/Zoom Scan (7x7x7) /Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 55.6 V/m; Power Drift = 0.011 dB
Peak SAR (extrapolated) = 3.73 W/kg
**SAR(1 g) = 2.53 mW/g; SAR(10 g) = 1.66 mW/g**
Maximum value of SAR (measured) = 2.94 mW/g




0 dB = 2.94mW/g

## Impedance Measurement Plot for Body TSL



## D835V2, serial no. 499 Extended Dipole Calibrations

Referring to KDB 450824, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

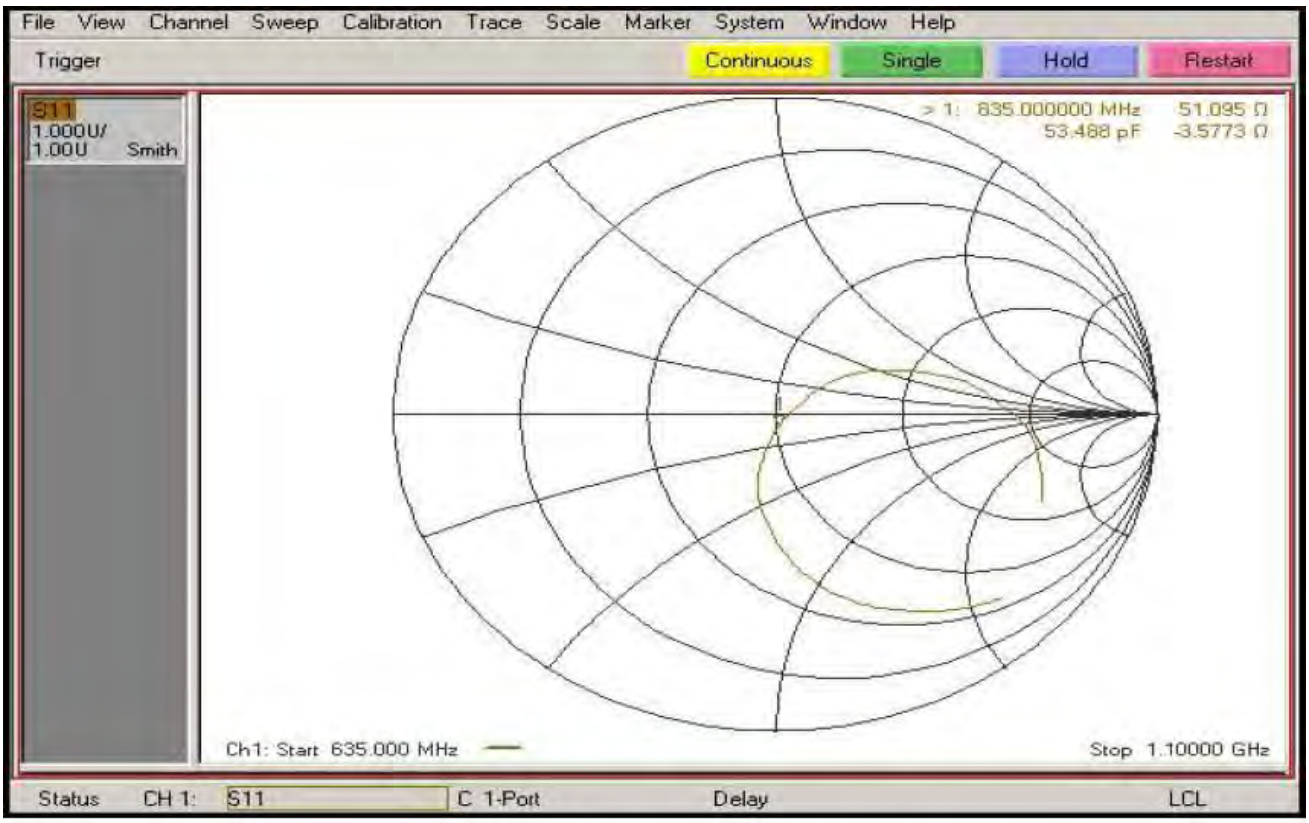
**<Justification of the extended calibration>**

| D**835**V2 – serial no. **499** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **835** Head | | | | | | **835** Body | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 3.22.2010 | -28.352 | | 52.17 | | -3.2461 | | -24.664 | | 50.066 | | -5.8652 | |
| 3.22.2011 | -28.323 | 0.102 | 51.095 | 1.075 | -3.5773 | 0.331 | -24.665 | -0.004 | 50.685 | -0.619 | -1.477 | -4.388 |

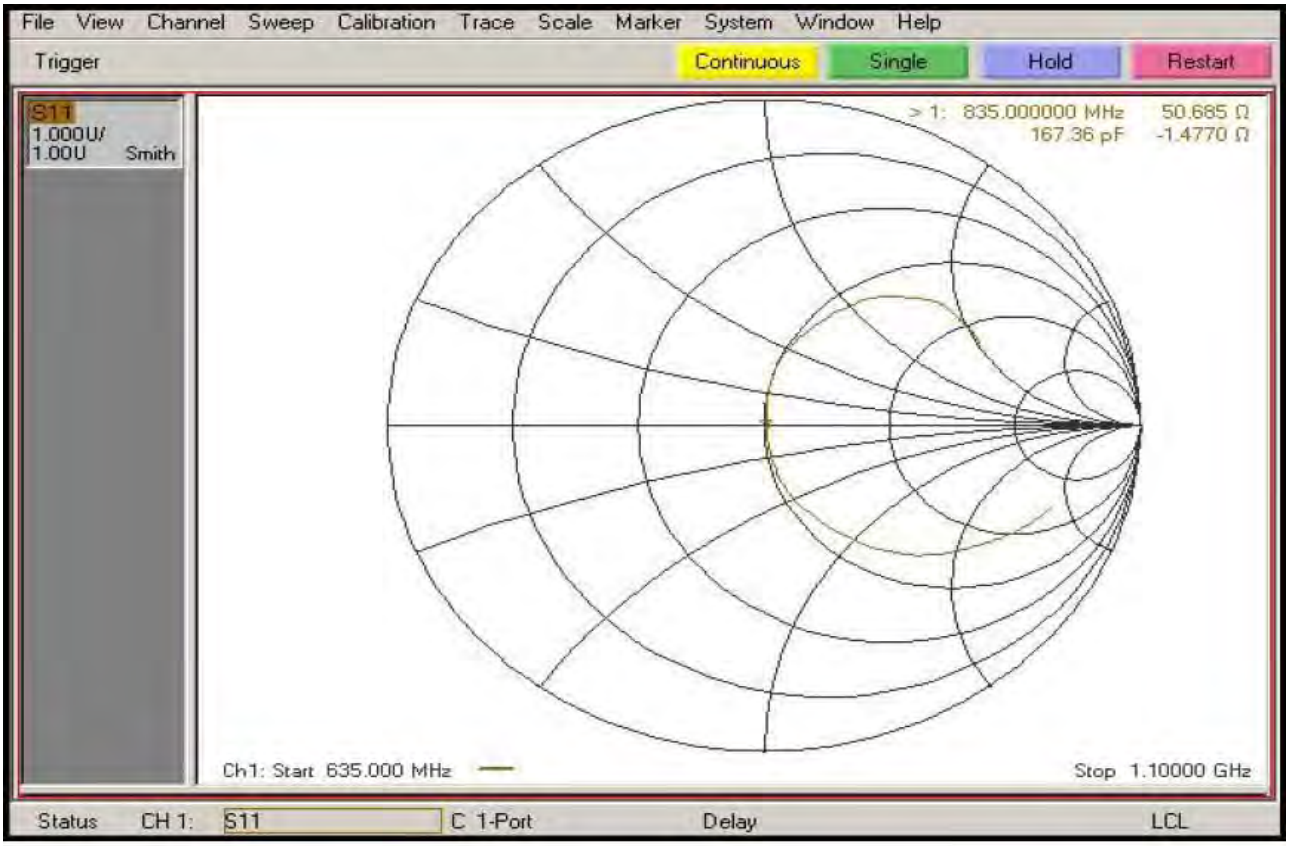
Therefore the verification result should support extended calibration.

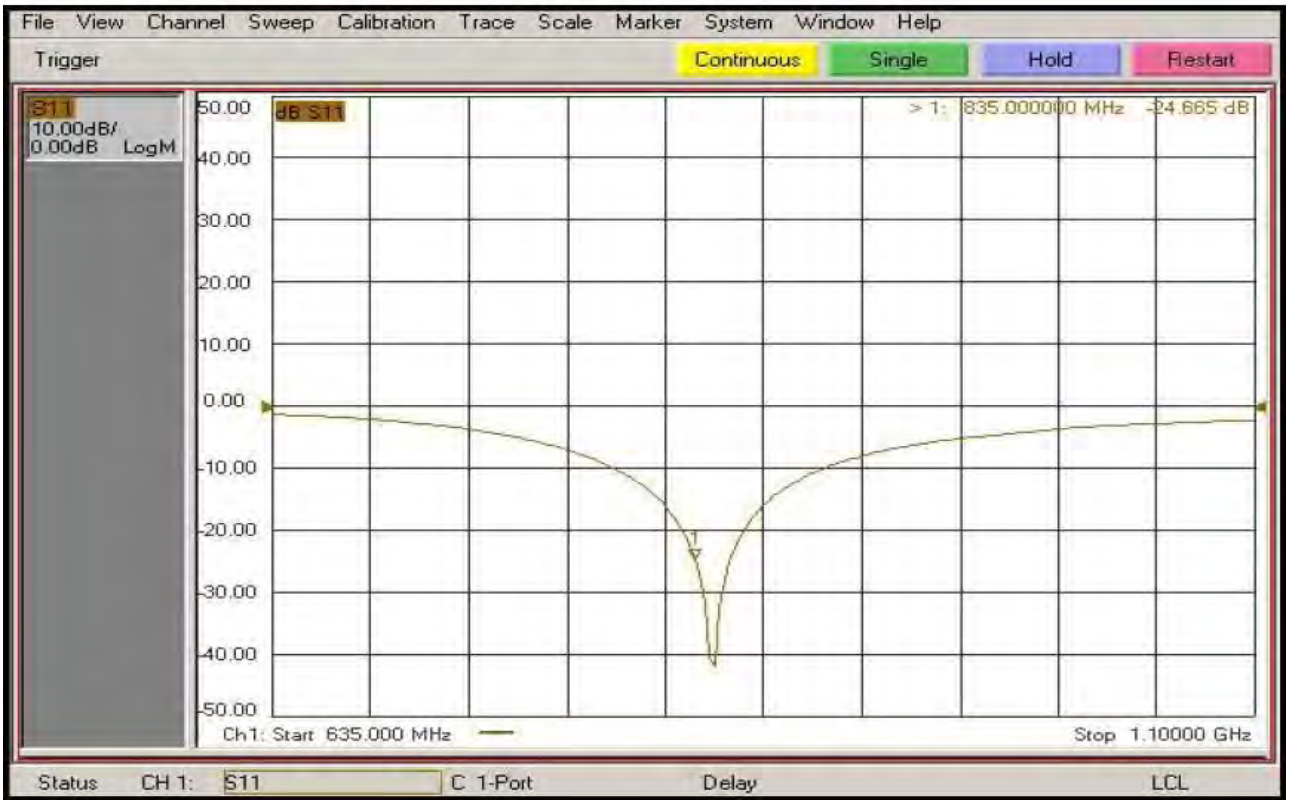
**<Dipole Verification Data> - D835 V2, serial no. 499 (Date of Measurement : 3.22.2011)**

**835 MHz - Head**



**835 MHz – Body**


File View Channel Sweep Calibration Trace Scale Marker System Window Help
Trigger
Continuous
Single
Hold
Restart
S11
1.000U/
1.00U Smith
> 1: 835.000000 MHz 50.685 Ω
167.36 pF -1.4770 Ω
Ch1: Start 635.000 MHz
Stop 1.10000 GHz
Status CH 1: S11 C 1-Port Delay LCL


File View Channel Sweep Calibration Trace Scale Marker System Window Help
Trigger
Continuous
Single
Hold
Restart
S11
10.00dB/
0.00dB LogM
dB S11
> 1: 835.000000 MHz -24.665 dB
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
Ch1: Start 635.000 MHz
Stop 1.10000 GHz
Status CH 1: S11 C 1-Port Delay LCL

## D835V2, serial no. 499 Extended Dipole Calibrations

Referring to KDB 450824, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

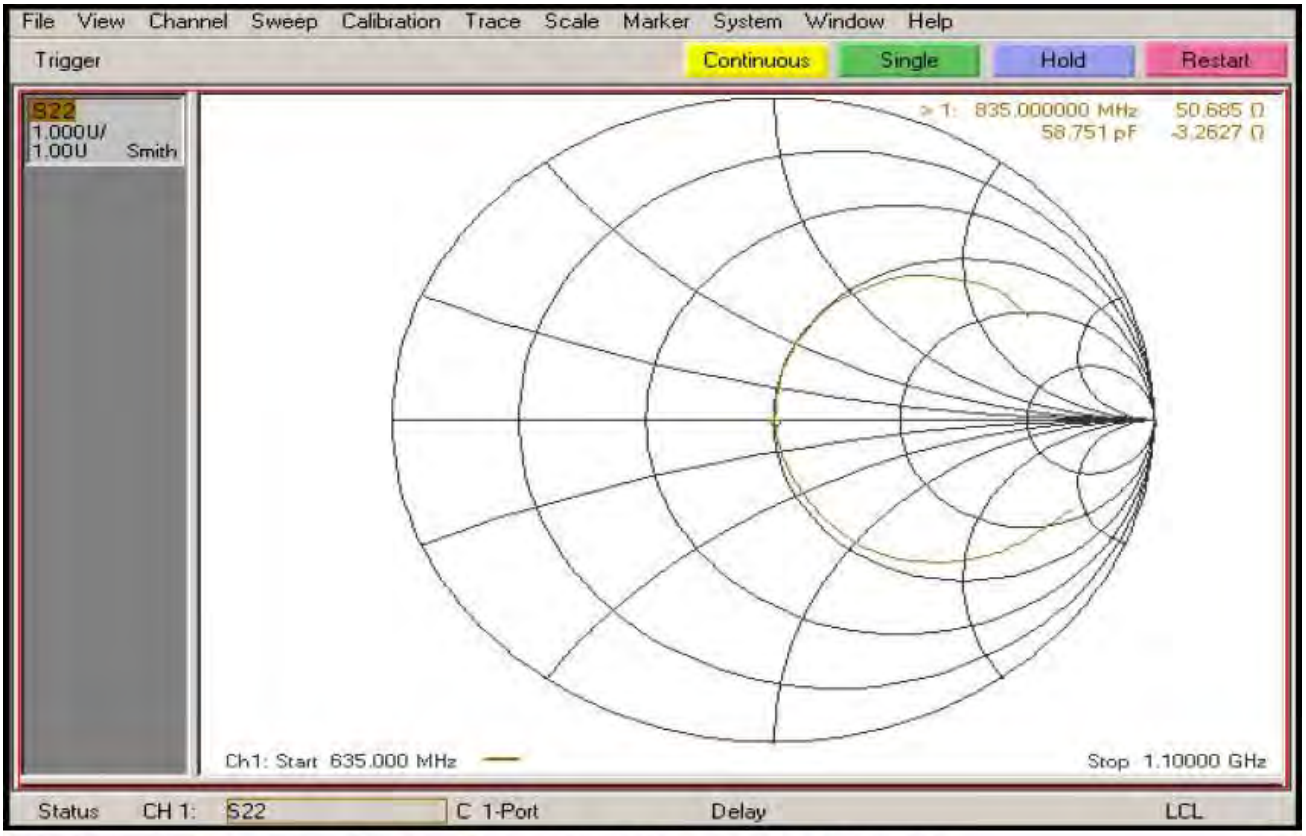
**<Justification of the extended calibration>**

| D**835**V2 – serial no. **499** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **835** Head | | | | | | **835** Body | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 3.22.2010 | -28.352 | | 52.17 | | -3.2461 | | -24.664 | | 50.066 | | -5.8652 | |
| 3.22.2011 | -28.323 | 0.102 | 51.095 | 1.075 | -3.5773 | 0.331 | -24.665 | -0.004 | 50.685 | -0.619 | -1.477 | -4.388 |
| 3.22.2012 | -28.265 | 0.307 | 50.685 | 1.485 | -3.2627 | 0.0166 | -23.821 | 3.42 | 50.977 | -0.911 | -3.2487 | -2.6165 |

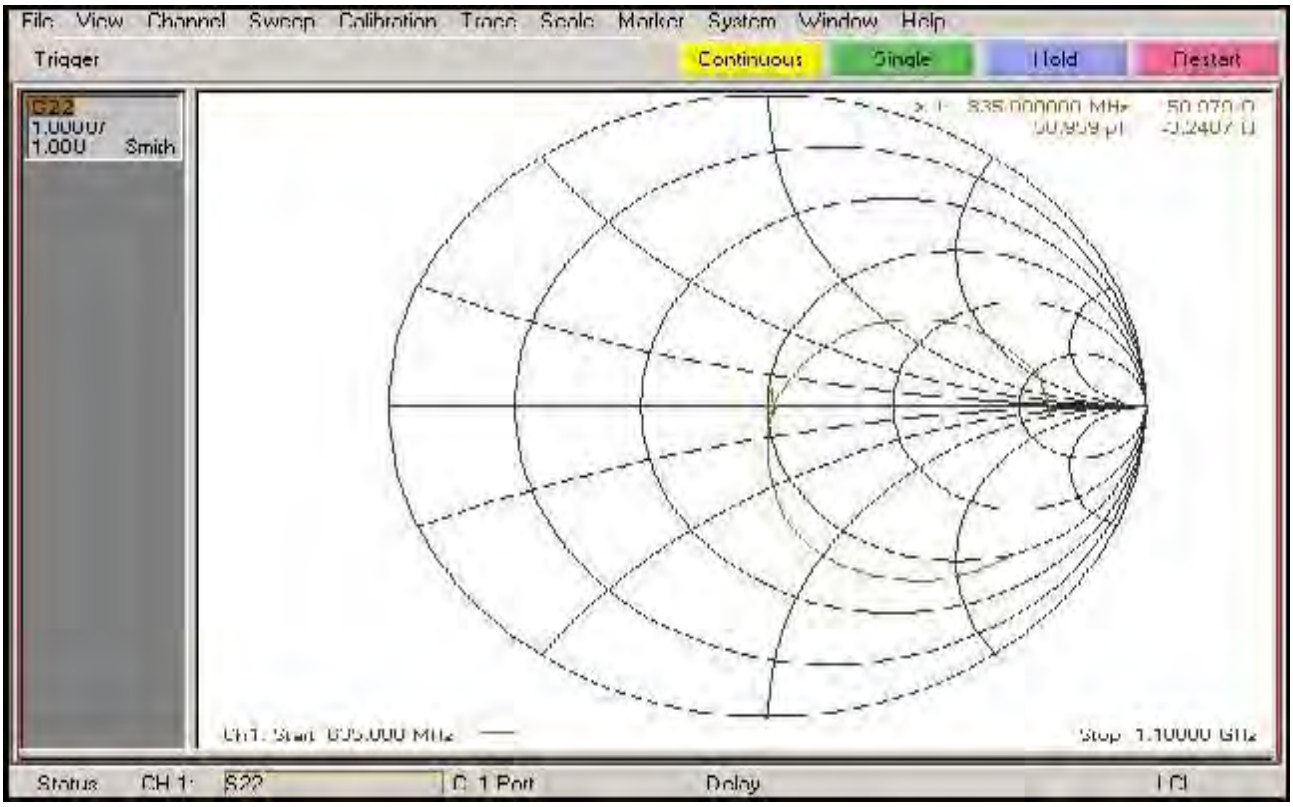
Therefore the verification result should support extended calibration.

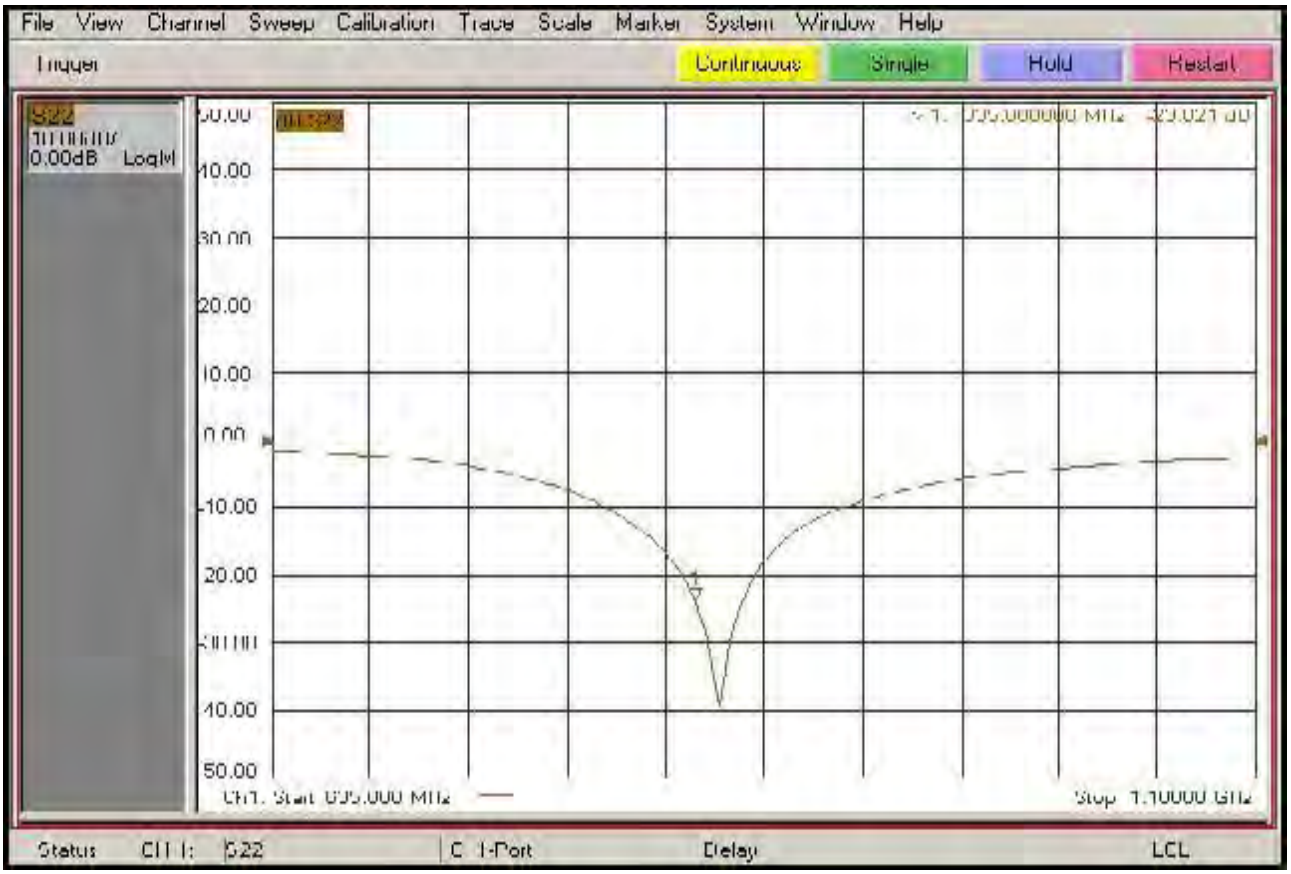
**<Dipole Verification Data> - D835 V2, serial no. 499 (Date of Measurement : 3.22.2012)**

**835 MHz - Head**



**835 MHz – Body**




***SPORTON INTERNATIONAL INC.***
TEL : 886-3-327-3456
FAX : 886-3-328-4978

**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
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
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 **Sporton (Auden)**

Certificate No: **D1900V2-5d041_Mar10**

# CALIBRATION CERTIFICATE

Object: D1900V2 - SN: 5d041

Calibration procedure(s): QA CAL-05.v7
Calibration procedure for dipole validation kits

Calibration date: March 23, 2010

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter EPM-442A | GB37480704 | 06-Oct-09 (No. 217-01086) | Oct-10 |
| Power sensor HP 8481A | US37292783 | 06-Oct-09 (No. 217-01086) | Oct-10 |
| Reference 20 dB Attenuator | SN: 5086 (20g) | 31-Mar-09 (No. 217-01025) | Mar-10 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 31-Mar-09 (No. 217-01029) | Mar-10 |
| Reference Probe ES3DV3 | SN: 3205 | 26-Jun-09 (No. ES3-3205_Jun09) | Jun-10 |
| DAE4 | SN: 601 | 02-Mar-10 (No. DAE4-601_Mar10) | Mar-11 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power sensor HP 8481A | MY41092317 | 18-Oct-02 (in house check Oct-09) | In house check: Oct-11 |
| RF generator R&S SMT-06 | 100005 | 4-Aug-99 (in house check Oct-09) | In house check: Oct-11 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-09) | In house check: Oct-10 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Dimce Iliev | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: March 23, 2010

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

## 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) 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
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) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

## Measurement Conditions

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

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V5.2 |
| **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** | 1900 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 40.0 | 1.40 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 41.1 ± 6 % | 1.45 mho/m ± 6 % |
| **Head TSL temperature during test** | (21.5 ± 0.2) °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 10.1 mW / g |
| SAR normalized | normalized to 1W | 40.4 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **39.8 mW /g ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 5.25 mW / g |
| SAR normalized | normalized to 1W | 21.0 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **20.9 mW /g ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 53.3 | 1.52 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 54.9 ± 6 % | 1.58 mho/m ± 6 % |
| **Body TSL temperature during test** | (21.5 ± 0.2) °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 10.4 mW / g |
| SAR normalized | normalized to 1W | 41.6 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **40.0 mW / g ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 5.57 mW / g |
| SAR normalized | normalized to 1W | 22.3 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **22.1 mW / g ± 16.5 % (k=2)** |

## Appendix

## Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 50.9 Ω + 5.9 jΩ |
| Return Loss | - 24.6 dB |

## Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 46.3 Ω + 5.7 jΩ |
| Return Loss | - 23.1 dB |

## General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.202 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 04, 2003 |

## DASY5 Validation Report for Head TSL

Date/Time: 23.03.2010 12:03:30

Test Laboratory: SPEAG, Zurich, Switzerland

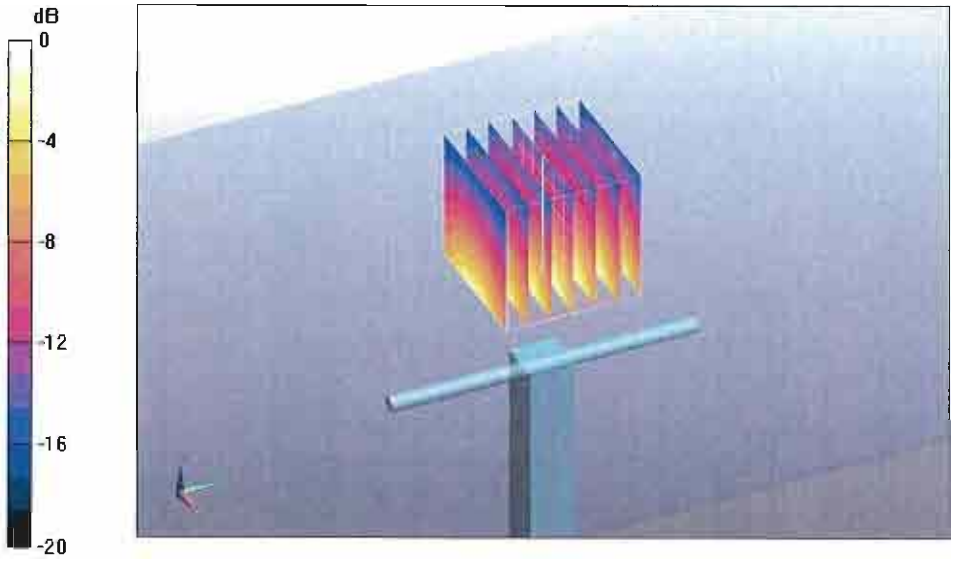
**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d041**

Communication System: CW; Frequency: 1900 MHz; Duty Cycle: 1:1
Medium: HSL U11 BB
Medium parameters used: f = 1900 MHz; $\sigma$ = 1.45 mho/m; $\varepsilon_r$ = 41.2; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

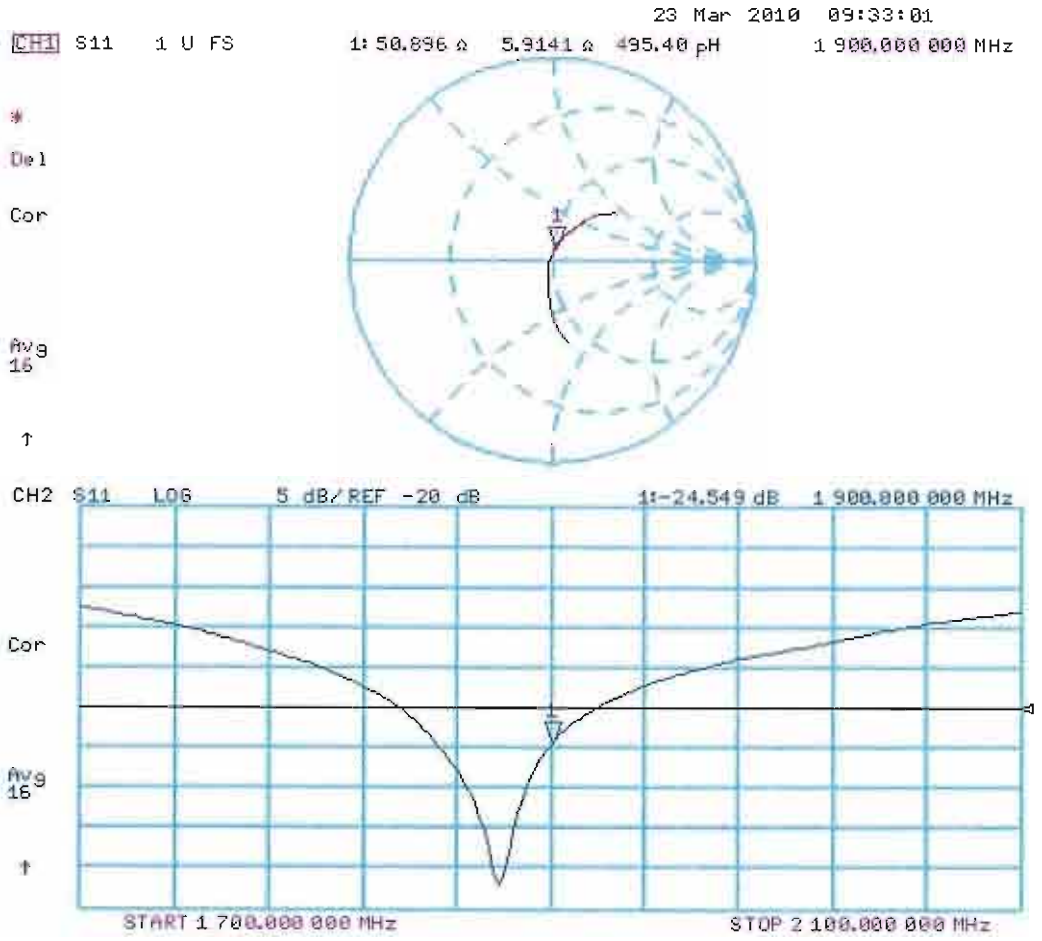
- Probe: ES3DV3 - SN3205; ConvF(5.09, 5.09, 5.09); Calibrated: 26.06.2009
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.03.2010
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- Measurement SW: DASY5, V5.2 Build 157; SEMCAD X Version 14.0 Build 57

**Pin=250 mW /d=10mm, dist=3.0mm (ES-Probe)/Zoom Scan (7x7x7) /Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 96.8 V/m; Power Drift = 0.040 dB
Peak SAR (extrapolated) = 18.4 W/kg
**SAR(1 g) = 10.1 mW/g; SAR(10 g) = 5.25 mW/g**
Maximum value of SAR (measured) = 12.7 mW/g




0 dB = 12.7mW/g

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body

Date/Time: 17.03.2010 12:43:32

Test Laboratory: SPEAG, Zurich, Switzerland

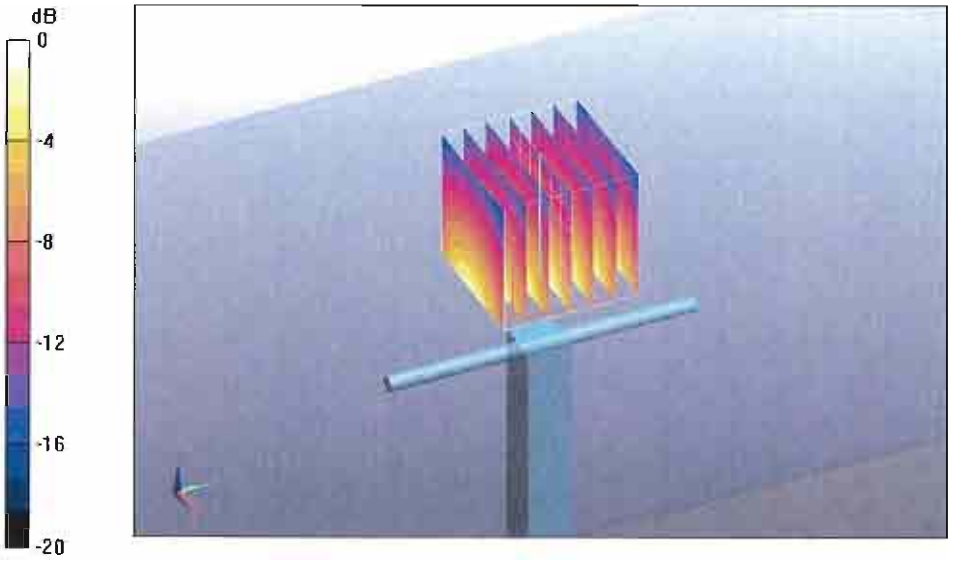
**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d041**

Communication System: CW; Frequency: 1900 MHz; Duty Cycle: 1:1
Medium: MSL U11 BB
Medium parameters used: f = 1900 MHz; $\sigma$ = 1.58 mho/m; $\varepsilon_r$ = 55; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

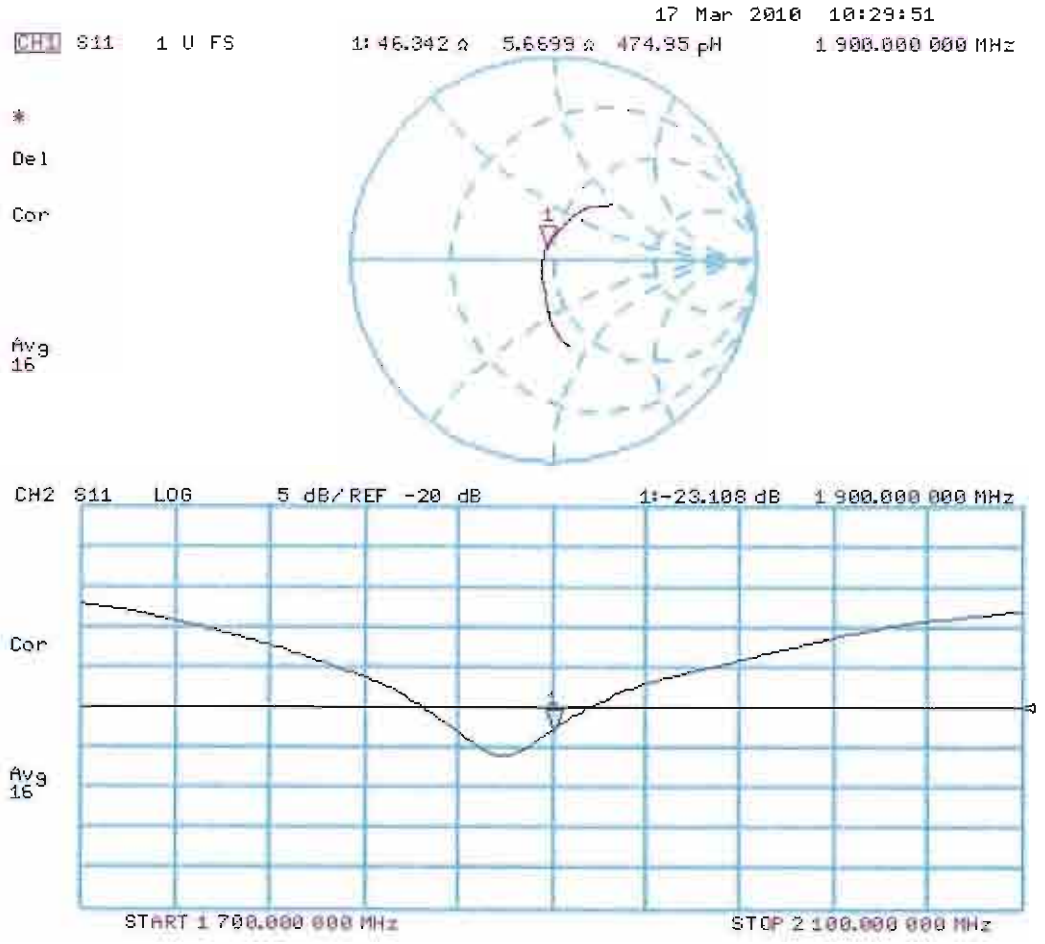
- Probe: ES3DV3 - SN3205; ConvF(4.59, 4.59, 4.59); Calibrated: 26.06.2009
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.03.2010
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- Measurement SW: DASY5, V5.2 Build 157; SEMCAD X Version 14.0 Build 57

**Pin250 mW /d=10mm, dist=3.0mm (ES-Probe)/Zoom Scan (7x7x7) /Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 96.1 V/m; Power Drift = 0.017 dB
Peak SAR (extrapolated) = 17.5 W/kg
**SAR(1 g) = 10.4 mW/g; SAR(10 g) = 5.57 mW/g**
Maximum value of SAR (measured) = 13.1 mW/g




0 dB = 13.1mW/g

## Impedance Measurement Plot for Body TSL



## D1900V2, serial no. 5D041 Extended Dipole Calibrations

Referring to KDB 450824, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

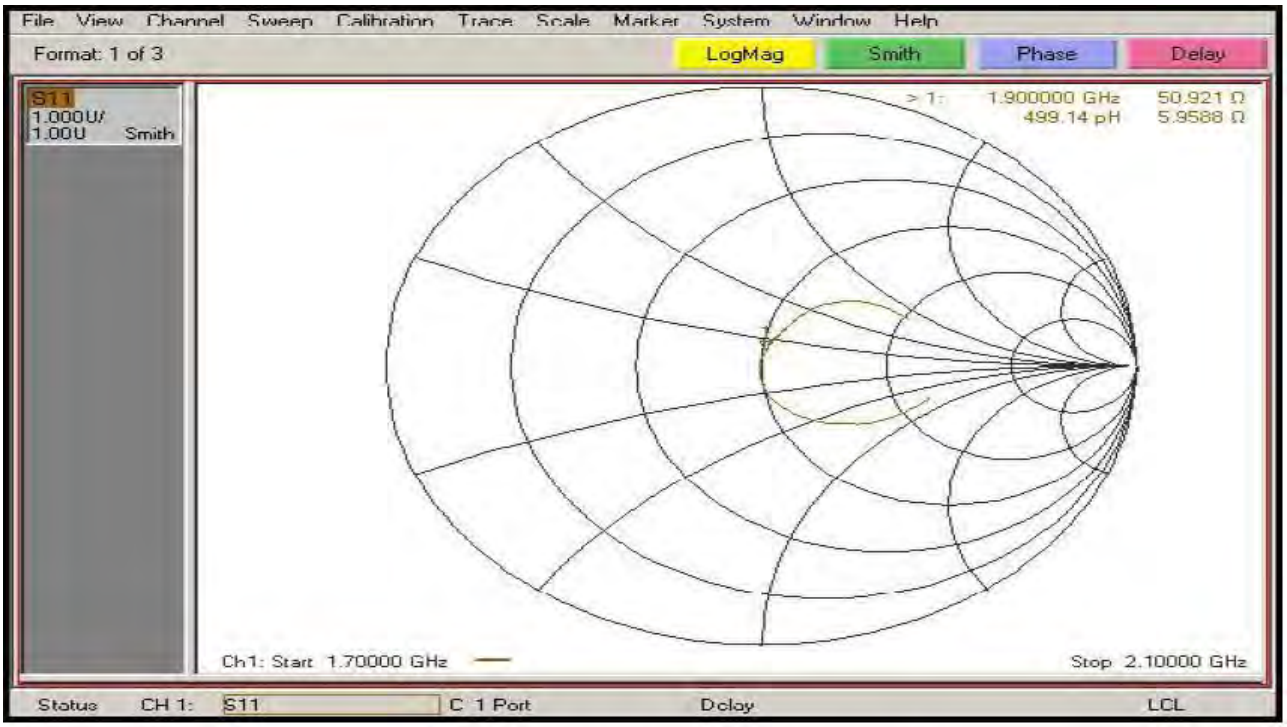
**<Justification of the extended calibration>**

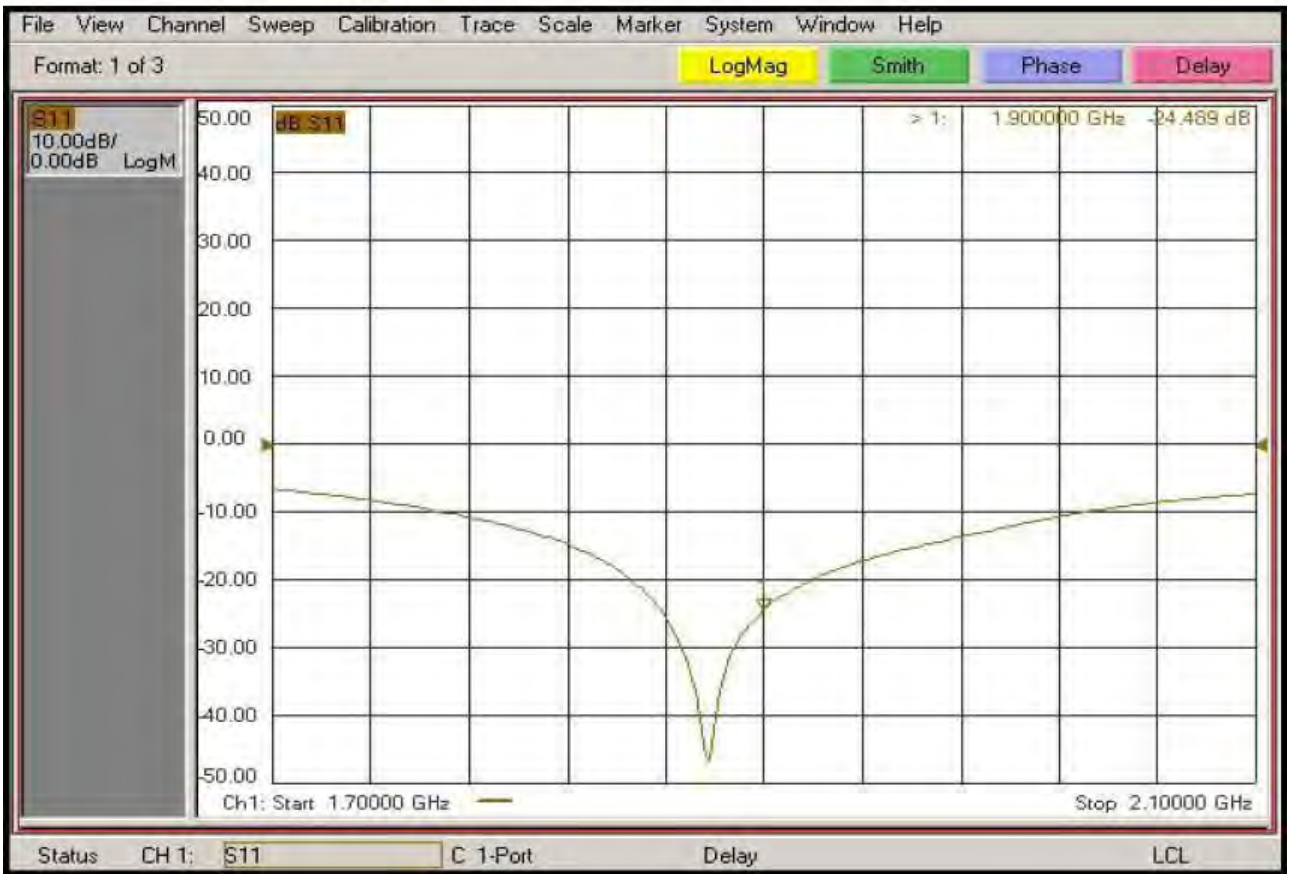
| D**1900**V2 – serial no. **5D041** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1900** Head | | | | | | **1900** Body | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 3.23.2010 | -24.549 | | 50.896 | | 5.9141 | | -23.108 | | 46.342 | | 5.669 | |
| 3.23.2011 | -24.489 | 0.244 | 50.921 | -0.025 | 5.9588 | -0.045 | -23.022 | 0.372 | 48.808 | -2.466 | 6.991 | -1.322 |

Therefore the verification result should support extended calibration.

**<Dipole Verification Data> - D1900 V2, serial no. 5D041 (Date of Measurement : 3.23.2011)**

**1900 MHz - Head**





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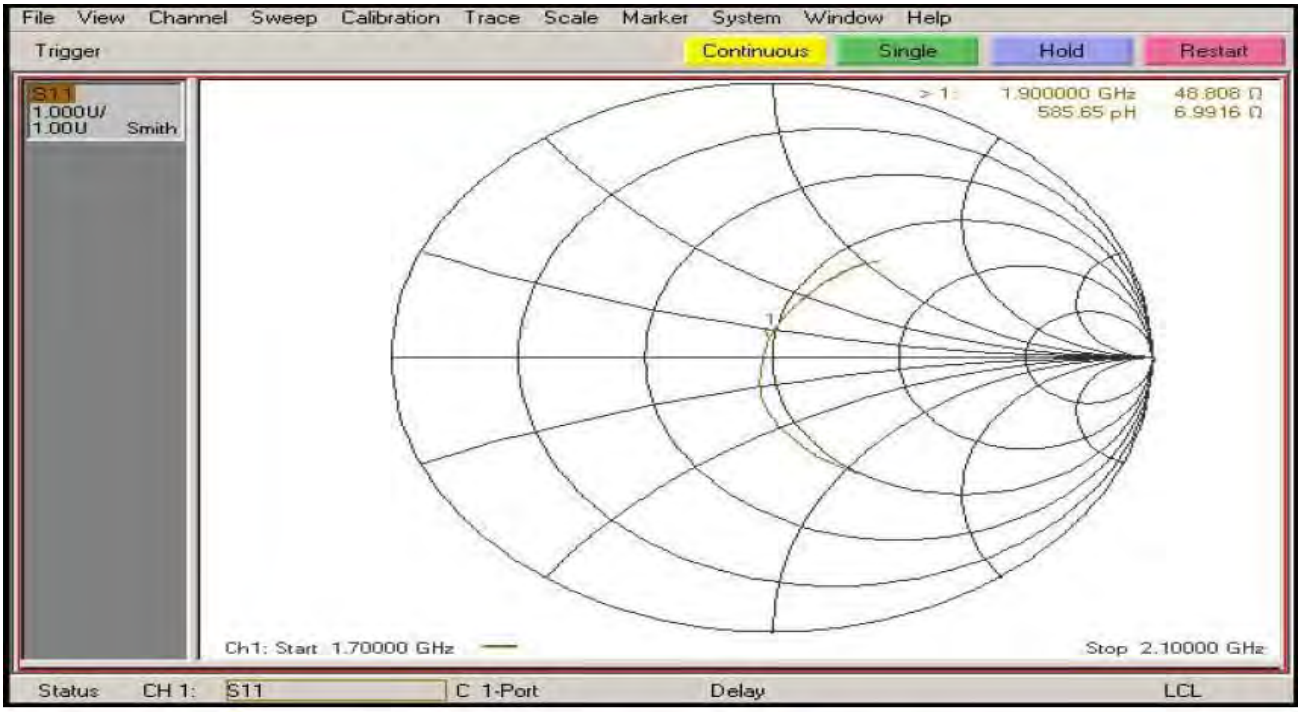
**1900 MHz – Body**



## D1900V2, serial no. 5D041 Extended Dipole Calibrations

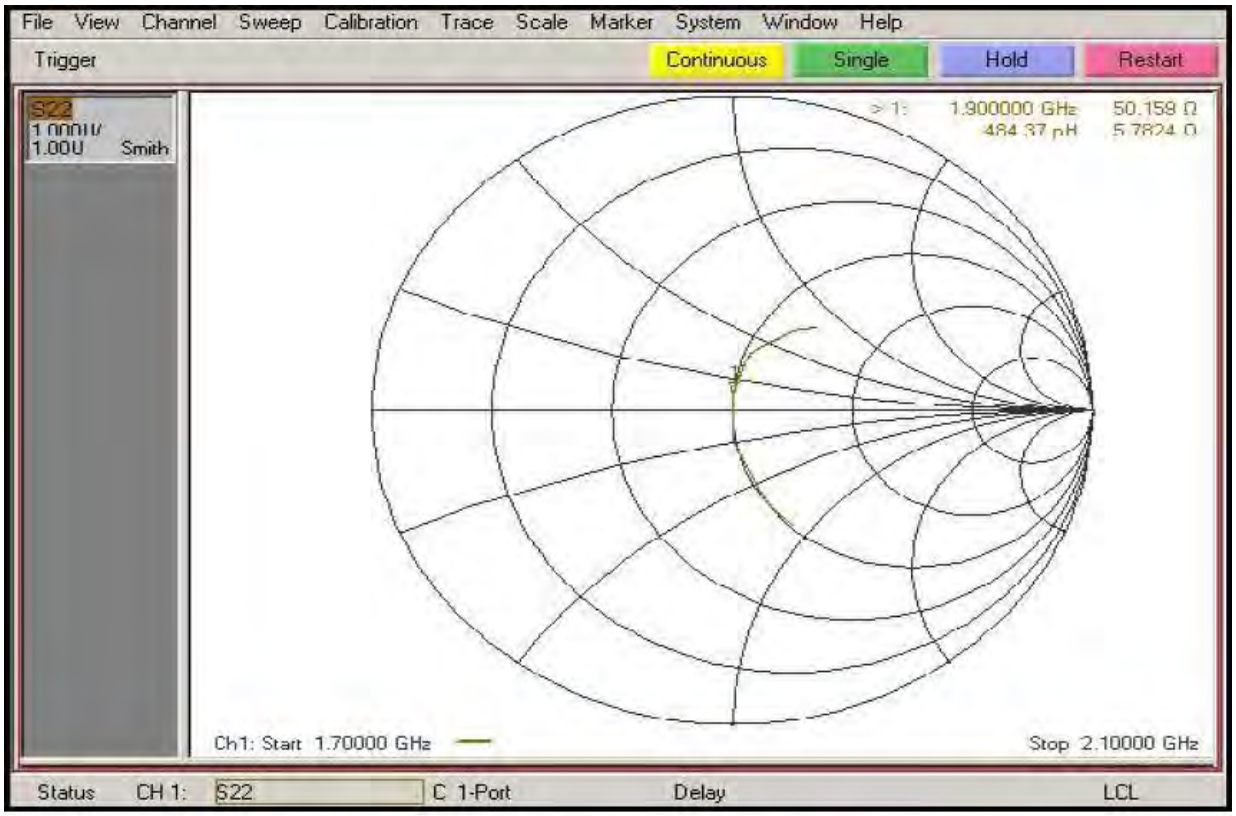
Referring to KDB 450824, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

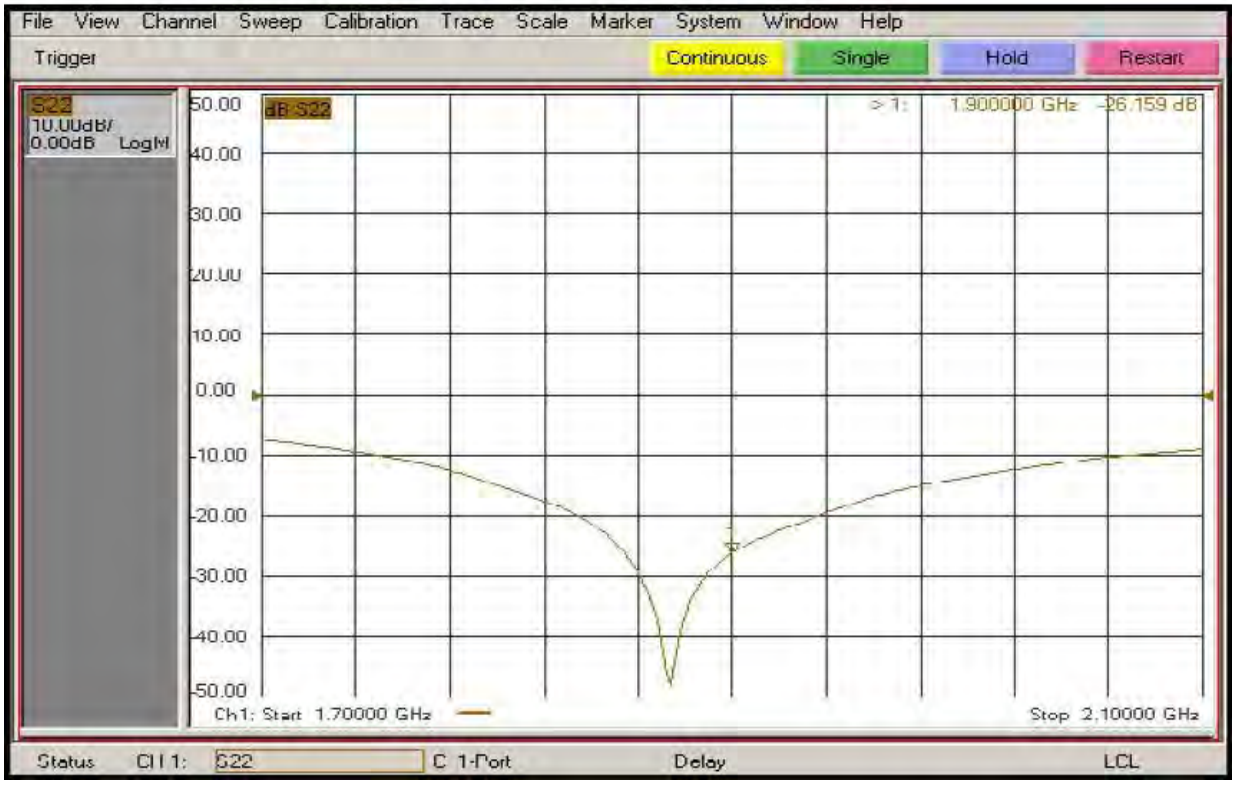
**<Justification of the extended calibration>**

| D**1900**V2 – serial no. **5D041** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1900** Head | | | | | | **1900** Body | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 3.23.2010 | -24.549 | | 50.896 | | 5.9141 | | -23.108 | | 46.342 | | 5.669 | |
| 3.23.2011 | -24.489 | 0.244 | 50.921 | -0.025 | 5.9588 | -0.045 | -23.022 | 0.372 | 48.808 | -2.466 | 6.991 | -1.322 |
| 3.23.2012 | -26.159 | 6.56 | 50.159 | 0.737 | 5.7824 | 0.1317 | -24.341 | 5.33 | 47.059 | -0.707 | 4.8668 | 0.8022 |

**<Dipole Verification Data> - D1900 V2, serial no. 5D041 (Date of Measurement : 3.23.2012)**

**1900 MHz - Head**





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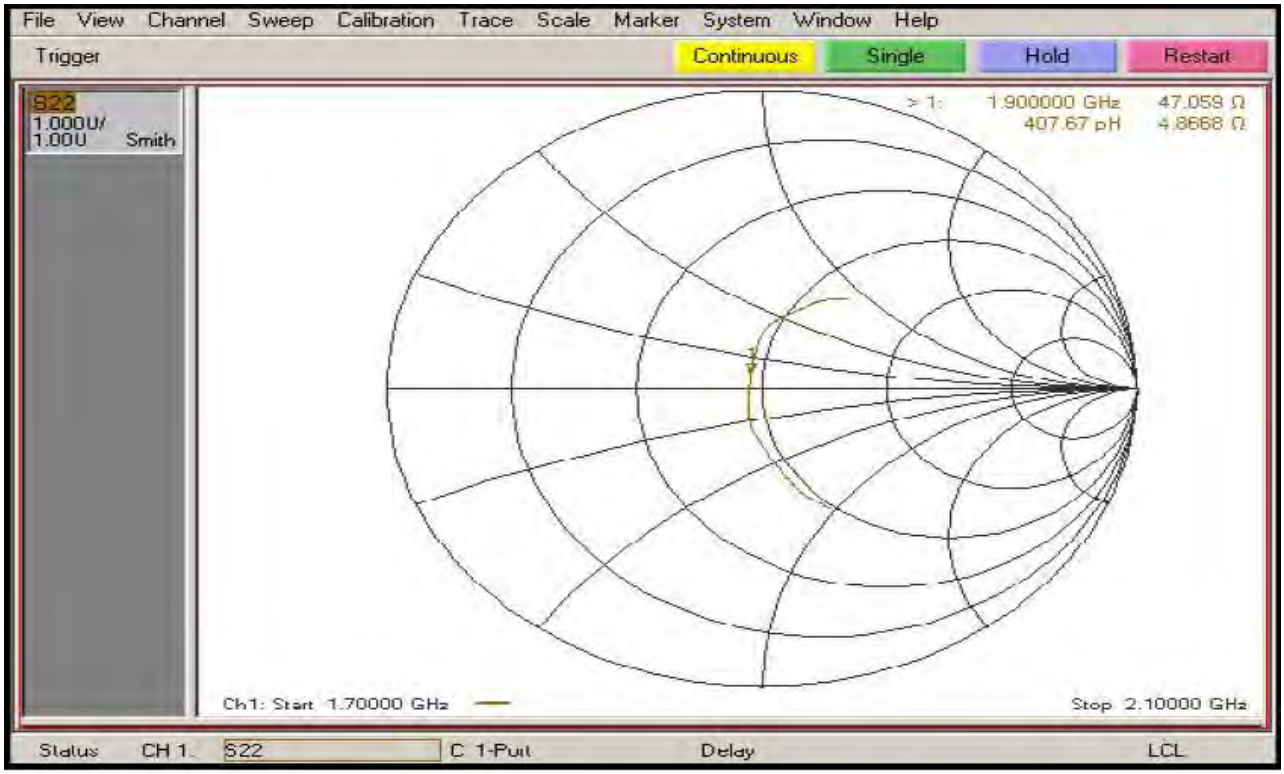
**1900 MHz - Body**



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FAX : 886-3-328-4978

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

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

Accredited by the Swiss Accreditation Service (SAS)
**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** **Sporton (Auden)**

**Certificate No: D2450V2-736_Jul11**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D2450V2 - SN: 736 |
| Calibration procedure(s) | QA CAL-05.v8<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | July 25, 2011 |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter EPM-442A | GB37480704 | 06-Oct-10 (No. 217-01266) | Oct-11 |
| Power sensor HP 8481A | US37292783 | 06-Oct-10 (No. 217-01266) | Oct-11 |
| Reference 20 dB Attenuator | SN: S5086 (20b) | 29-Mar-11 (No. 217-01367) | Apr-12 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 29-Mar-11 (No. 217-01371) | Apr-12 |
| Reference Probe ES3DV3 | SN: 3205 | 29-Apr-11 (No. ES3-3205_Apr11) | Apr-12 |
| DAE4 | SN: 601 | 04-Jul-11 (No. DAE4-601_Jul11) | Jul-12 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power sensor HP 8481A | MY41092317 | 18-Oct-02 (in house check Oct-09) | In house check: Oct-11 |
| RF generator R&S SMT-06 | 100005 | 04-Aug-99 (in house check Oct-09) | In house check: Oct-11 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-10) | In house check: Oct-11 |

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

Issued: July 25, 2011

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

## 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) 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
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) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

## Measurement Conditions

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

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.6.2 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom | |
| **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 | 38.9 ± 6 % | 1.85 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 13.9 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **54.8 mW /g ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 6.44 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **25.6 mW /g ± 16.5 % (k=2)** |

## 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 | 51.7 ± 6 % | 2.00 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 13.3 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **52.3 mW / g ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 6.18 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **24.5 mW / g ± 16.5 % (k=2)** |

## Appendix

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 54.4 Ω + 1.5 jΩ |
| Return Loss | - 27.0 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 50.8 Ω + 2.8 jΩ |
| Return Loss | - 30.7 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.159 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 | August 26, 2003 |

## DASY5 Validation Report for Head TSL

Date: 25.07.2011

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 736**

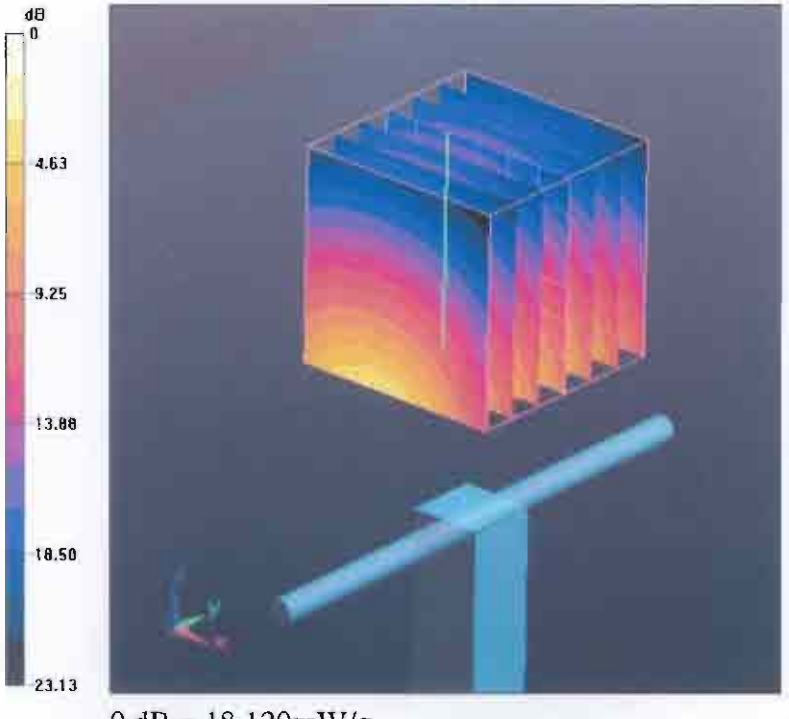
Communication System: CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; $\sigma$ = 1.85 mho/m; $\varepsilon_r$ = 38.9; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.45, 4.45, 4.45); Calibrated: 29.04.2011
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.07.2011
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.6.2(482); SEMCAD X 14.4.5(3634)

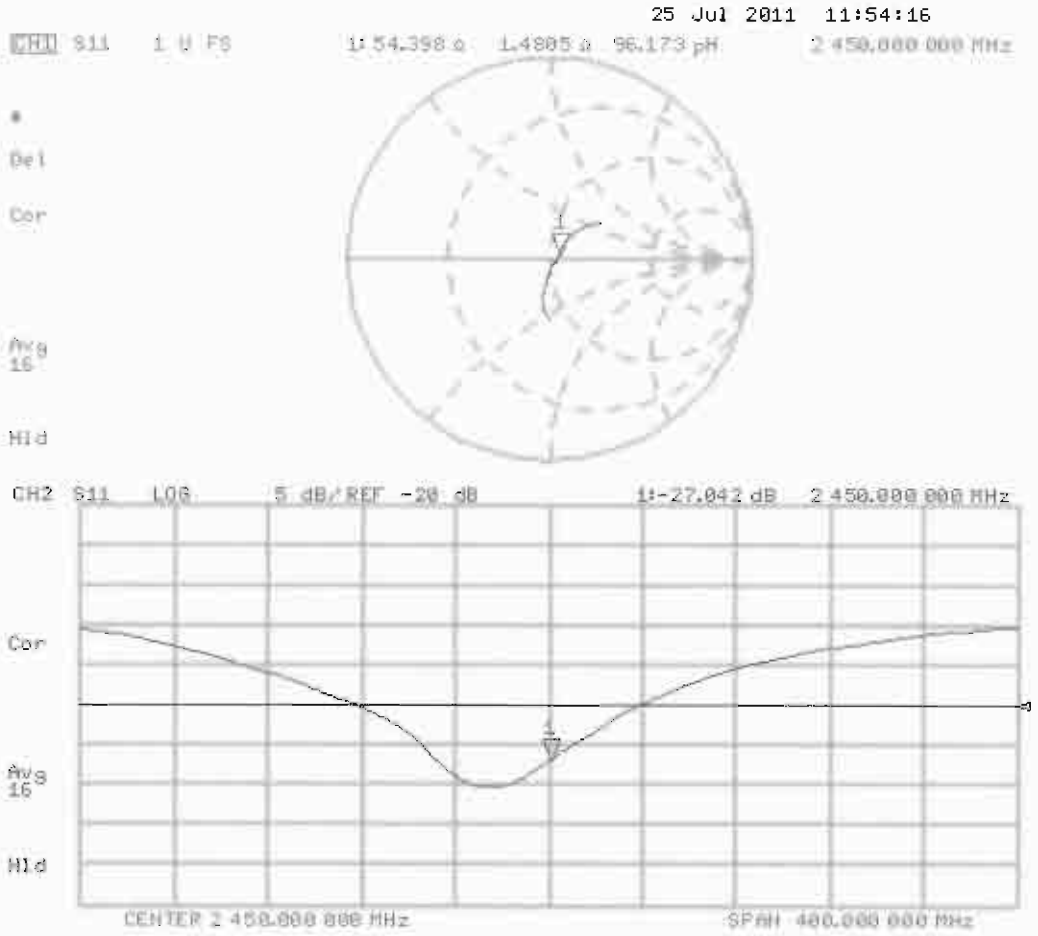
### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 98.095 V/m; Power Drift = 0.09 dB
Peak SAR (extrapolated) = 28.615 W/kg
**SAR(1 g) = 13.9 mW/g; SAR(10 g) = 6.44 mW/g**
Maximum value of SAR (measured) = 18.121 mW/g




0 dB = 18.120mW/g

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 25.07.2011

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 736**

Communication System: CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; $\sigma$ = 2 mho/m; $\varepsilon_r$ = 51.7; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

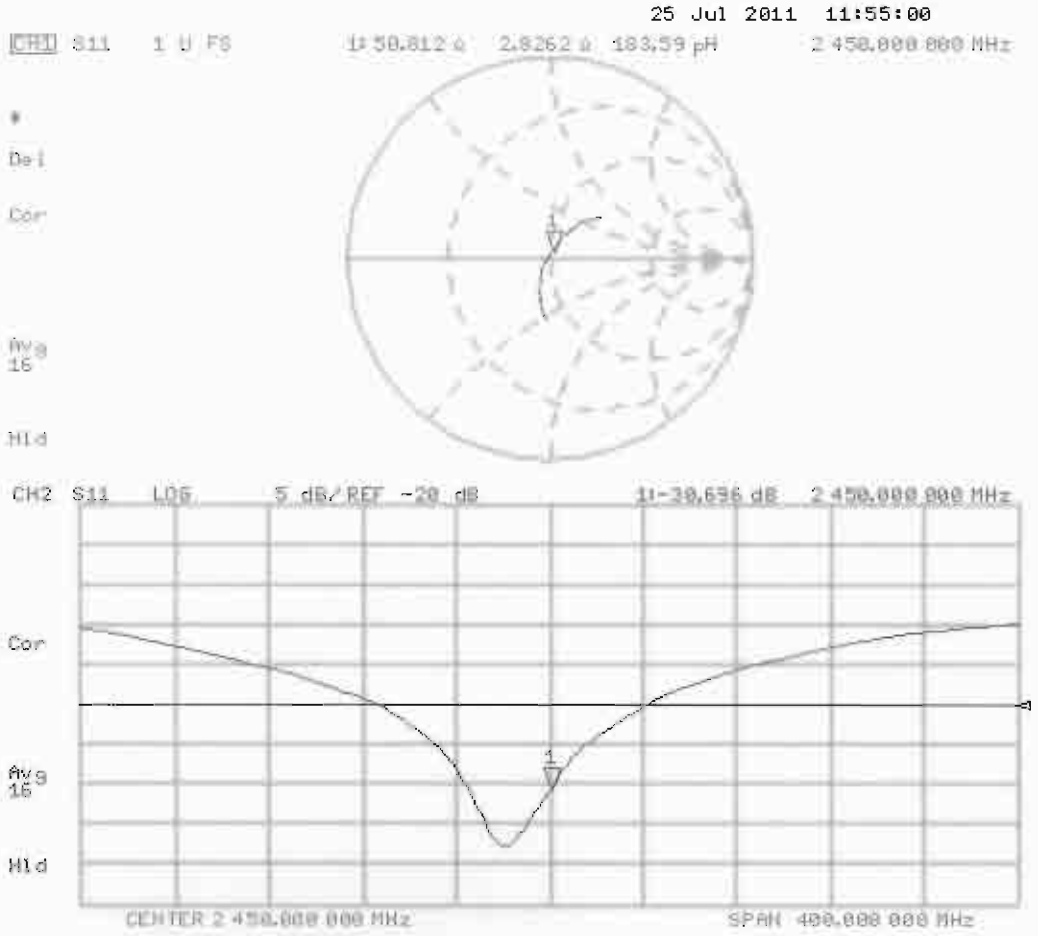
- Probe: ES3DV3 - SN3205; ConvF(4.26, 4.26, 4.26); Calibrated: 29.04.2011
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.07.2011
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.6.2(482); SEMCAD X 14.4.5(3634)

### Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 96.550 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 27.432 W/kg
**SAR(1 g) = 13.3 mW/g; SAR(10 g) = 6.18 mW/g**
Maximum value of SAR (measured) = 17.294 mW/g

0 dB = 17.290mW/g

## Impedance Measurement Plot for Body TSL



## D2450V2, serial no. 736 Extended Dipole Calibrations

Referring to KDB 450824, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

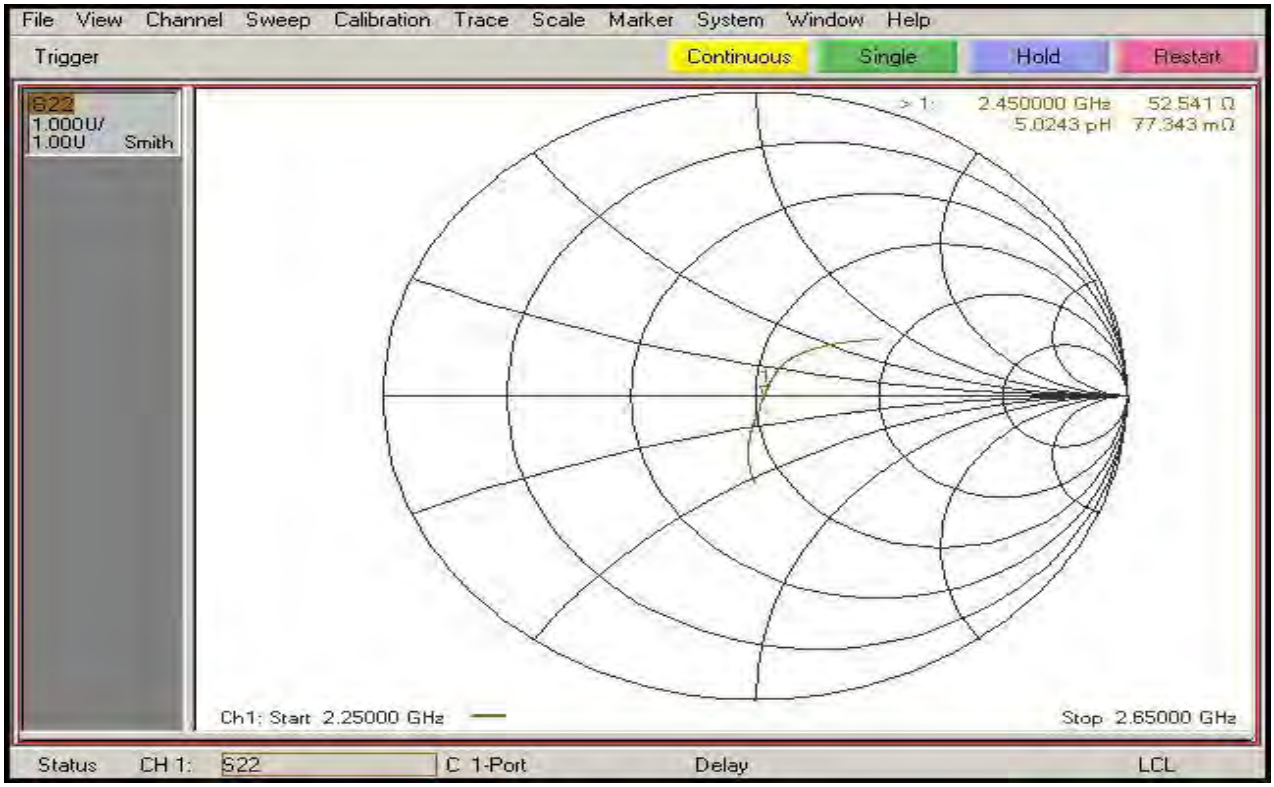
**<Justification of the extended calibration>**

| D**2450**V2 – serial no. **736** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2450** Head | | | | | | **2450** Body | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 7.25.2011 | -27.042 | | 54.398 | | 1.4805 | | -30.696 | | 50.812 | | 2.8262 | |
| 7.25.2012 | -27.950 | -3.365 | 52.541 | 1.857 | 0.77343 | 0.707 | -31.781 | -3.535 | 50.572 | 0.24 | 1.5953 | 1.2309 |

The return loss is < -20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

**<Dipole Verification Data> - D2450 V2, serial no. 736 (Date of Measurement : 7.25.2012)**

**2450 MHz - Head**



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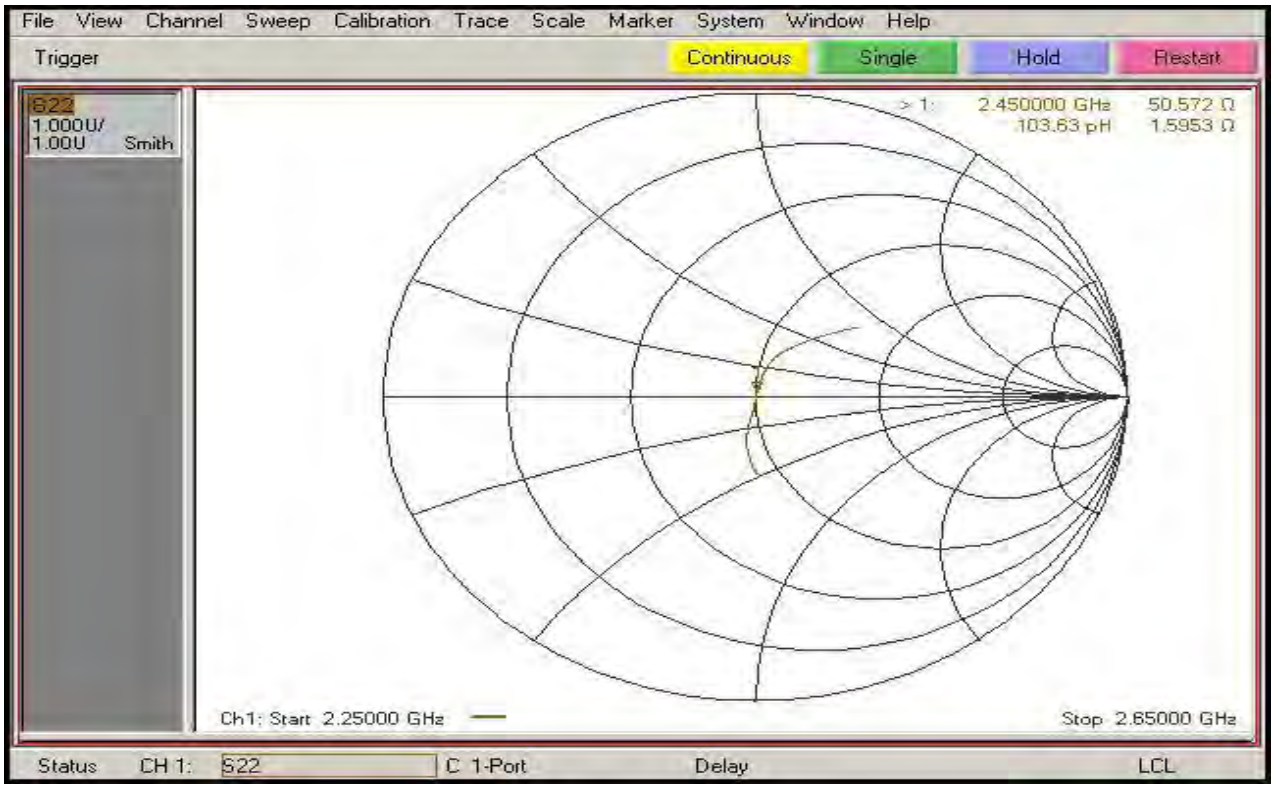
FAX : 886-3-328-4978

**2450 MHz – Body**



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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**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 **Sporton (Auden)**

Certificate No: **D5GHzV2-1006_Jan12**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D5GHzV2 - SN: 1006 |
| Calibration procedure(s) | QA CAL-22.v1<br>Calibration procedure for dipole validation kits between 3-6 GHz |
| Calibration date: | January 18, 2012 |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter EPM-442A | GB37480704 | 05-Oct-11 (No. 217-01451) | Oct-12 |
| Power sensor HP 8481A | US37292783 | 05-Oct-11 (No. 217-01451) | Oct-12 |
| Reference 20 dB Attenuator | SN: 5086 (20g) | 29-Mar-11 (No. 217-01368) | Apr-12 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 29-Mar-11 (No. 217-01371) | Apr-12 |
| Reference Probe EX3DV4 | SN: 3503 | 30-Dec-11 (No. EX3-3503_Dec11) | Dec-12 |
| DAE4 | SN: 601 | 04-Jul-11 (No. DAE4-601_Jul11) | Jul-12 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power sensor HP 8481A | MY41092317 | 18-Oct-02 (in house check Oct-11) | In house check: Oct-13 |
| RF generator R&S SMT-06 | 100005 | 04-Aug-99 (in house check Oct-11) | In house check: Oct-13 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-11) | In house check: Oct-12 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jelon Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: January 18, 2012

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

**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) 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
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) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

## Measurement Conditions

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

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.8.0 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom V5.0 | |
| **Distance Dipole Center - TSL** | 10 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy = 4.0 mm, dz = 1.4 mm | Graded Ratio = 1.4 (Z direction) |
| **Frequency** | 5200 MHz ± 1 MHz<br>5500 MHz ± 1 MHz<br>5800 MHz ± 1 MHz | |

## Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 36.0 | 4.66 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 36.3 ± 6 % | 4.60 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °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 | 7.91 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **79.2 mW /g ± 17.0 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.26 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **22.6 mW /g ± 16.5 % (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 | 35.8 ± 6 % | 4.90 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5500 MHz

| **SAR averaged over 1 cm³ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 8.52 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **85.2 mW / g ± 17.0 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.42 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **24.2 mW / g ± 16.5 % (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 | 35.3 ± 6 % | 5.22 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5800 MHz

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 7.90 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **79.0 mW / g ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.24 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | **22.4 mW / g ± 16.5 % (k=2)** |

## Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 49.0 | 5.30 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 49.2 ± 6 % | 5.46 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL at 5200 MHz

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 7.25 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **72.6 mW / g ± 18.1 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.04 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **20.5 mW / g ± 17.6 % (k=2)** |

## Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 48.6 | 5.65 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 48.7 ± 6 % | 5.86 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL at 5500 MHz

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 7.86 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **78.8 mW / g ± 18.1 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.19 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **21.9 mW / g ± 17.6 % (k=2)** |

## Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 48.2 | 6.00 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 48.2 ± 6 % | 6.28 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL at 5800 MHz

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 7.30 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **73.1 mW / g ± 18.1 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.03 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | **20.3 mW / g ± 17.6 % (k=2)** |

## Appendix

### Antenna Parameters with Head TSL at 5200 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 52.3 Ω - 9.6 jΩ |
| Return Loss | - 20.3 dB |

### Antenna Parameters with Head TSL at 5500 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 50.8 Ω - 2.8 jΩ |
| Return Loss | - 30.7 dB |

### Antenna Parameters with Head TSL at 5800 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 58.1 Ω + 1.6 jΩ |
| Return Loss | - 22.4 dB |

### Antenna Parameters with Body TSL at 5200 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 52.7 Ω - 9.1 jΩ |
| Return Loss | - 20.7 dB |

### Antenna Parameters with Body TSL at 5500 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 48.9 Ω + 0.1 jΩ |
| Return Loss | - 39.3 dB |

### Antenna Parameters with Body TSL at 5800 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 60.1 Ω - 1.1 jΩ |
| Return Loss | - 20.7 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.104 ns |

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

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

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | August 28, 2003 |

## DASY5 Validation Report for Head TSL

Date: 17.01.2012

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1006**

Communication System: CW; Frequency: 5200 MHz, Frequency: 5500 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; $\sigma$ = 4.6 mho/m; $\varepsilon_r$ = 36.3; $\rho$ = 1000 kg/m$^3$ , Medium parameters used: f = 5500 MHz; $\sigma$ = 4.9 mho/m; $\varepsilon_r$ = 35.8; $\rho$ = 1000 kg/m$^3$ , Medium parameters used: f = 5800 MHz; $\sigma$ = 5.22 mho/m; $\varepsilon_r$ = 35.3; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

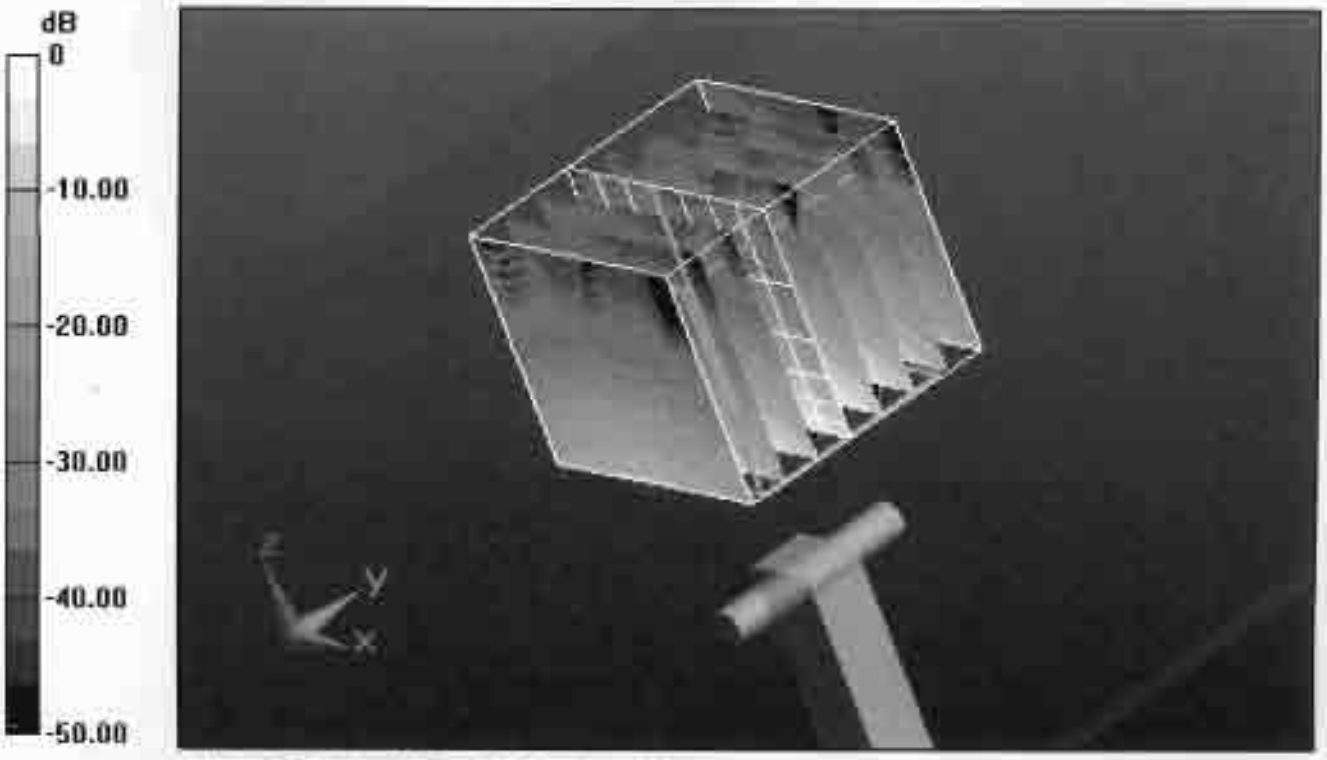
DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.41, 5.41, 5.41), ConvF(4.91, 4.91, 4.91), ConvF(4.81, 4.81, 4.81); Calibrated: 30.12.2011
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.07.2011
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.0(692); SEMCAD X 14.6.4(4989)

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 63.826 V/m; Power Drift = 0.09 dB
Peak SAR (extrapolated) = 29.2570
**SAR(1 g) = 7.91 mW/g; SAR(10 g) = 2.26 mW/g**
Maximum value of SAR (measured) = 17.937 mW/g

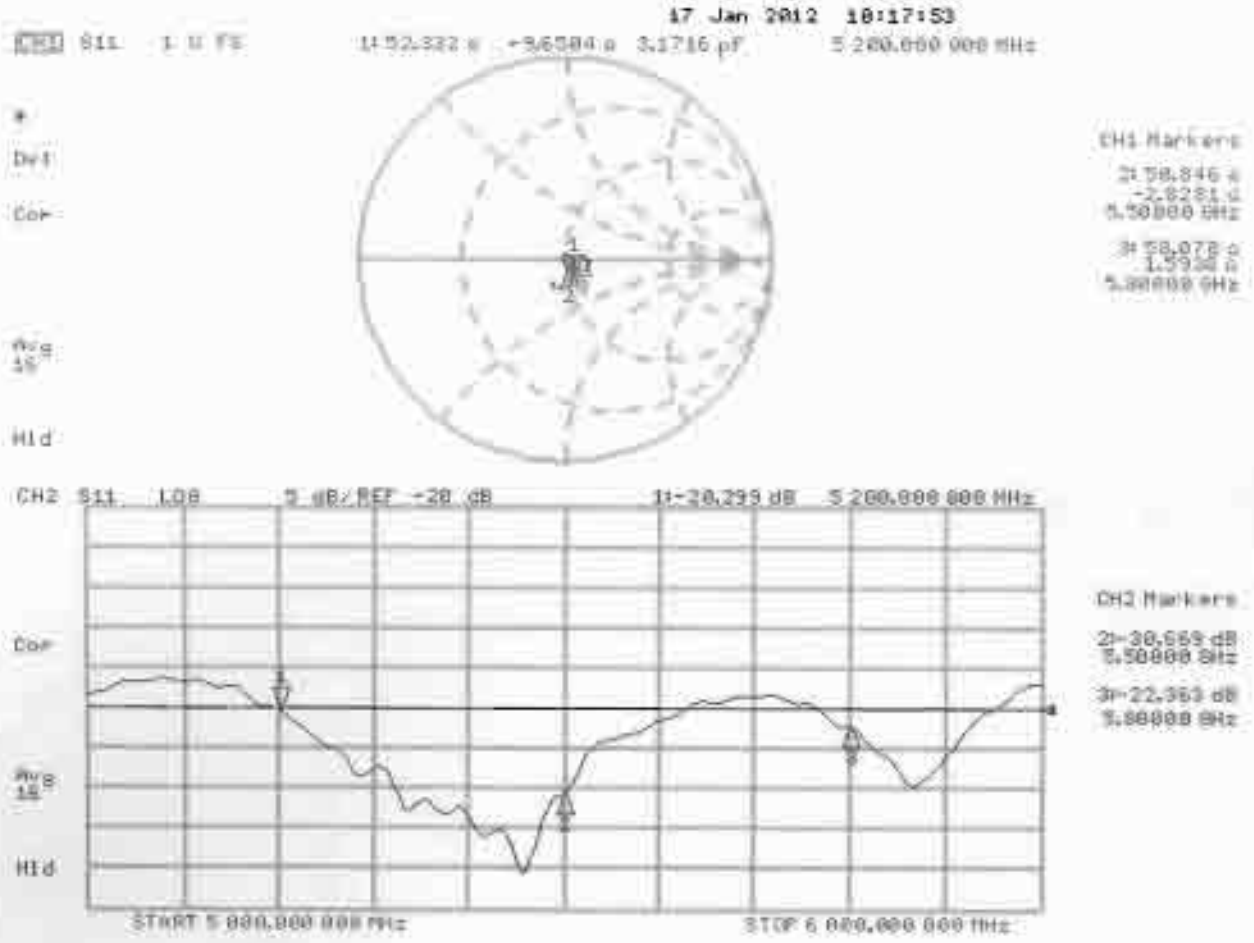
**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.861 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 33.9880
**SAR(1 g) = 8.52 mW/g; SAR(10 g) = 2.42 mW/g**
Maximum value of SAR (measured) = 19.922 mW/g

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 61.585 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 33.3960
**SAR(1 g) = 7.9 mW/g; SAR(10 g) = 2.24 mW/g**
Maximum value of SAR (measured) = 18.961 mW/g




0 dB = 18.960mW/g = 25.56 dB mW/g

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 18.01.2012

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1006**

Communication System: CW; Frequency: 5200 MHz, Frequency: 5500 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; $\sigma$ = 5.46 mho/m; $\varepsilon_r$ = 49.2; $\rho$ = 1000 kg/m$^3$ , Medium parameters used: f = 5500 MHz; $\sigma$ = 5.86 mho/m; $\varepsilon_r$ = 48.7; $\rho$ = 1000 kg/m$^3$ , Medium parameters used: f = 5800 MHz; $\sigma$ = 6.28 mho/m; $\varepsilon_r$ = 48.2; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

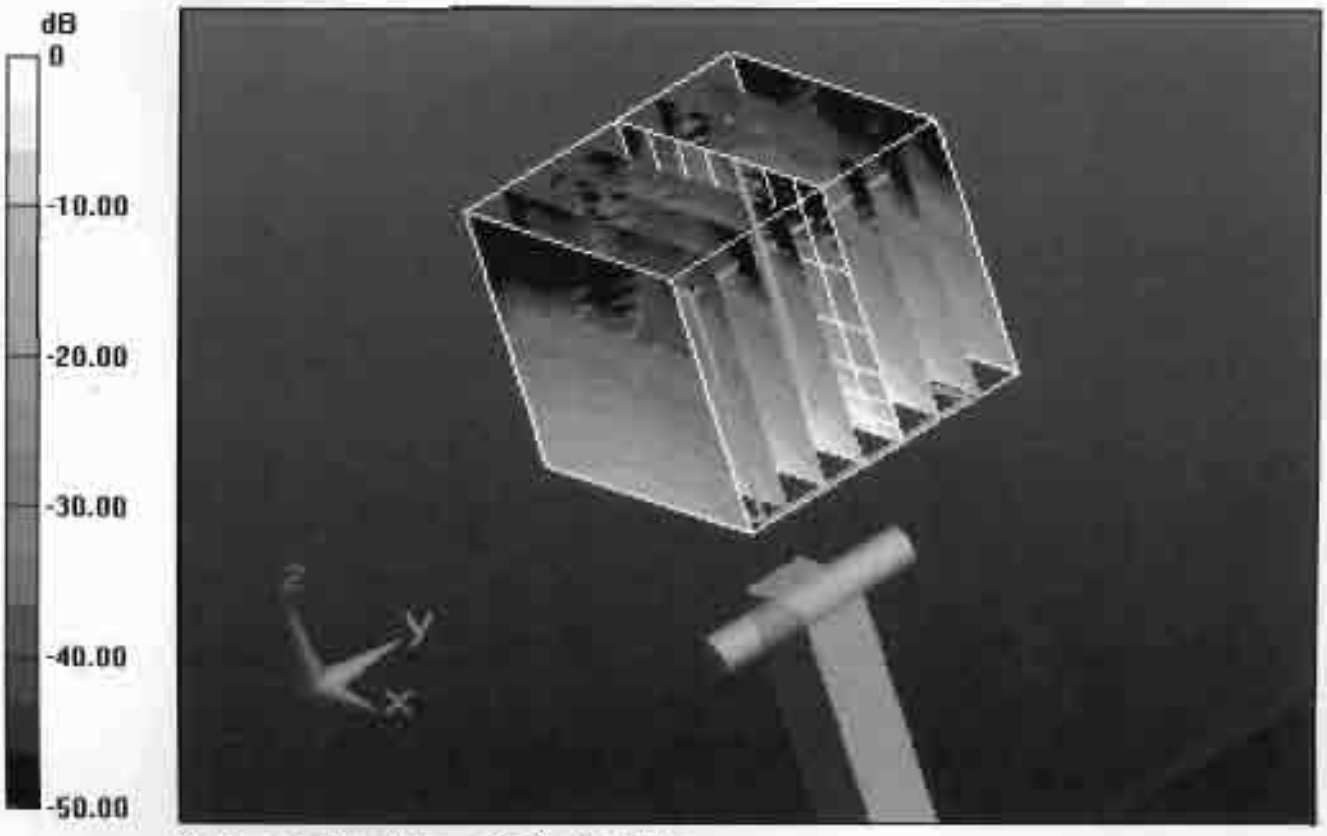
DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(4.91, 4.91, 4.91), ConvF(4.43, 4.43, 4.43), ConvF(4.38, 4.38, 4.38); Calibrated: 30.12.2011
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.07.2011
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.0(692); SEMCAD X 14.6.4(4989)

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 57.425 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 28.4360
**SAR(1 g) = 7.25 mW/g; SAR(10 g) = 2.04 mW/g**
Maximum value of SAR (measured) = 17.037 mW/g

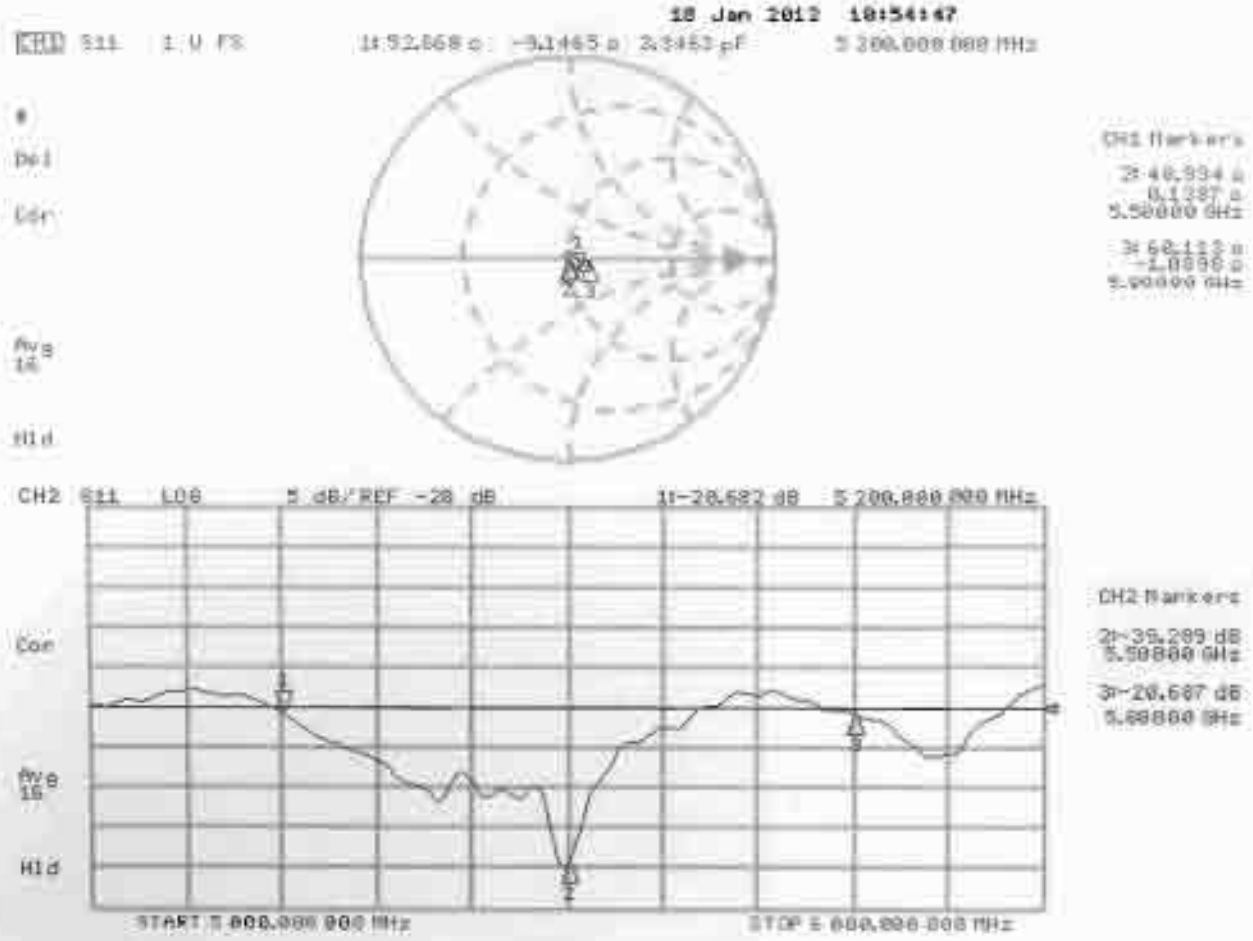
**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 57.904 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 33.5870
**SAR(1 g) = 7.86 mW/g; SAR(10 g) = 2.19 mW/g**
Maximum value of SAR (measured) = 19.044 mW/g

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 54.193 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 33.8240
**SAR(1 g) = 7.3 mW/g; SAR(10 g) = 2.03 mW/g**
Maximum value of SAR (measured) = 18.191 mW/g




0 dB = 18.190mW/g = 25.20 dB mW/g

## Impedance Measurement Plot for Body TSL



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**S** Swiss Calibration Service

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**Accreditation No.: SCS 108**

**Client** Sporton

Certificate No: **DAE3-577_Jun12**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | DAE3 - SD 000 D03 AA - SN: 577 |
| Calibration procedure(s) | QA CAL-06.v24<br>Calibration procedure for the data acquisition electronics (DAE) |
| Calibration date: | June 06, 2012 |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Keithley Multimeter Type 2001 | SN: 0810278 | 28-Sep-11 (No:11450) | Sep-12 |
| **Secondary Standards** | **ID #** | **Check Date (in house)** | **Scheduled Check** |
| Calibrator Box V2.1 | SE UWS 053 AA 1001 | 05-Jan-12 (in house check) | In house check: Jan-13 |

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

Issued: June 6, 2012

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

## 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 as documented in the Appendix 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:* Typical value for information: 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 = 6.1μV , full range = -100...+300 mV

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

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

| Calibration Factors | X | Y | Z |
|---|---|---|---|
| **High Range** | 404.058 ± 0.1% (k=2) | 403.945 ± 0.1% (k=2) | 404.061 ± 0.1% (k=2) |
| **Low Range** | 3.93352 ± 0.7% (k=2) | 3.95384 ± 0.7% (k=2) | 3.95036 ± 0.7% (k=2) |

## Connector Angle

| | |
|---|---|
| **Connector Angle** to be used in DASY system | 111.5 ° ± 1 ° |

## Appendix

### 1. DC Voltage Linearity

| High Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 199995.54 | -0.89 | -0.00 |
| Channel X | + Input | 20002.00 | 1.99 | 0.01 |
| Channel X | - Input | -19998.81 | 2.31 | -0.01 |
| Channel Y | + Input | 199996.22 | -0.29 | -0.00 |
| Channel Y | + Input | 19999.47 | -0.49 | -0.00 |
| Channel Y | - Input | -20001.10 | 0.06 | -0.00 |
| Channel Z | + Input | 199994.90 | -1.65 | -0.00 |
| Channel Z | + Input | 20001.77 | 1.80 | 0.01 |
| Channel Z | - Input | -19999.69 | 1.56 | -0.01 |

| Low Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 2000.56 | 0.24 | 0.01 |
| Channel X | + Input | 200.49 | -0.28 | -0.14 |
| Channel X | - Input | -198.35 | 0.69 | -0.35 |
| Channel Y | + Input | 2000.53 | 0.31 | 0.02 |
| Channel Y | + Input | 200.35 | -0.44 | -0.22 |
| Channel Y | - Input | -199.12 | 0.17 | -0.08 |
| Channel Z | + Input | 1999.73 | -0.51 | -0.03 |
| Channel Z | + Input | 199.96 | -0.76 | -0.38 |
| Channel Z | - Input | -200.14 | -0.91 | 0.46 |

### 2. Common mode sensitivity

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

| | Common mode Input Voltage (mV) | High Range Average Reading (μV) | Low Range Average Reading (μV) |
|---|---|---|---|
| Channel X | 200 | -8.13 | -11.22 |
| | - 200 | 12.49 | 10.42 |
| Channel Y | 200 | 10.28 | 10.45 |
| | - 200 | -12.29 | -11.56 |
| Channel Z | 200 | 7.71 | 8.46 |
| | - 200 | -10.39 | -10.87 |

### 3. Channel separation

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

| | Input Voltage (mV) | Channel X (μV) | Channel Y (μV) | Channel Z (μV) |
|---|---|---|---|---|
| Channel X | 200 | - | -0.16 | -3.68 |
| Channel Y | 200 | 6.63 | - | 0.62 |
| Channel Z | 200 | 5.48 | 4.85 | - |

## 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** | 16237 | 16308 |
| **Channel Y** | 16451 | 16683 |
| **Channel Z** | 15995 | 16468 |

## 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

| | Average (μV) | min. Offset (μV) | max. Offset (μV) | Std. Deviation (μV) |
|---|---|---|---|---|
| **Channel X** | -0.65 | -2.12 | 0.66 | 0.54 |
| **Channel Y** | 0.02 | -1.35 | 1.15 | 0.59 |
| **Channel Z** | -2.84 | -3.96 | -1.77 | 0.47 |

## 6. Input Offset Current

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

## 7. Input Resistance (Typical values for information)

| | Zeroing (kOhm) | Measuring (MOhm) |
|---|---|---|
| **Channel X** | 200 | 200 |
| **Channel Y** | 200 | 200 |
| **Channel Z** | 200 | 200 |

## 8. Low Battery Alarm Voltage (Typical values for information)

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

## 9. Power Consumption (Typical values for information)

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

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

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

Accredited by the Swiss Accreditation Service (SAS)
**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** Amphenol (Auden)

**Certificate No:** DAE3-495_Apr12

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | DAE3 - SD 000 D03 AD - SN: 495 |
| Calibration procedure(s) | QA CAL-06.v24<br>Calibration procedure for the data acquisition electronics (DAE) |
| Calibration date: | April 23, 2012 |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Keithley Multimeter Type 2001 | SN: 0810278 | 28-Sep-11 (No:11450) | Sep-12 |
| **Secondary Standards** | **ID #** | **Check Date (in house)** | **Scheduled Check** |
| Calibrator Box V2.1 | SE UWS 053 AA 1001 | 05-Jan-12 (in house check) | In house check: Jan-13 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Eric Hainfeld | Technician | |
| Approved by: | Fin Bomholt | R&D Director | i.V. |

Issued: April 23, 2012

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

## 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 as documented in the Appendix 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:* Typical value for information: 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 = | 6.1μV , | full range = | -100...+300 mV |
| Low Range: | 1LSB = | 61nV , | full range = | -1.....+3mV |

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

| Calibration Factors | X | Y | Z |
|---|---|---|---|
| **High Range** | 404.352 ± 0.1% (k=2) | 405.327 ± 0.1% (k=2) | 405.654 ± 0.1% (k=2) |
| **Low Range** | 3.95463 ± 0.7% (k=2) | 3.99214 ± 0.7% (k=2) | 3.96716 ± 0.7% (k=2) |

## Connector Angle

| | |
|---|---|
| **Connector Angle** to be used in DASY system | 147.5 ° ± 1 ° |

## Appendix

### 1. DC Voltage Linearity

| High Range | | Reading (µV) | Difference (µV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 199997.08 | -0.41 | -0.00 |
| Channel X | + Input | 20003.46 | 2.34 | 0.01 |
| Channel X | - Input | -19997.49 | 2.47 | -0.01 |
| Channel Y | + Input | 199999.33 | 2.06 | 0.00 |
| Channel Y | + Input | 20001.56 | 0.65 | 0.00 |
| Channel Y | - Input | -19999.50 | 0.75 | -0.00 |
| Channel Z | + Input | 199996.88 | -0.61 | -0.00 |
| Channel Z | + Input | 20002.89 | 1.96 | 0.01 |
| Channel Z | - Input | -19998.27 | 1.91 | -0.01 |

| Low Range | | Reading (µV) | Difference (µV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 2003.09 | 1.65 | 0.08 |
| Channel X | + Input | 202.47 | 0.71 | 0.35 |
| Channel X | - Input | -197.92 | 0.18 | -0.09 |
| Channel Y | + Input | 2001.21 | 0.06 | 0.00 |
| Channel Y | + Input | 201.12 | -0.45 | -0.22 |
| Channel Y | - Input | -199.11 | -0.70 | 0.35 |
| Channel Z | + Input | 2002.44 | 1.11 | 0.06 |
| Channel Z | + Input | 200.50 | -1.13 | -0.56 |
| Channel Z | - Input | -198.21 | -0.02 | 0.01 |

### 2. Common mode sensitivity

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

| | Common mode Input Voltage (mV) | High Range Average Reading (µV) | Low Range Average Reading (µV) |
|---|---|---|---|
| Channel X | 200 | 3.65 | 2.03 |
| | - 200 | -1.07 | -2.24 |
| Channel Y | 200 | -0.86 | -1.37 |
| | - 200 | 0.62 | 0.64 |
| Channel Z | 200 | 1.94 | 1.92 |
| | - 200 | -2.48 | -2.59 |

### 3. Channel separation

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

| | Input Voltage (mV) | Channel X (µV) | Channel Y (µV) | Channel Z (µV) |
|---|---|---|---|---|
| Channel X | 200 | - | -2.83 | -1.94 |
| Channel Y | 200 | 4.87 | - | -5.00 |
| Channel Z | 200 | 14.63 | -0.87 | - |

## 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** | 15807 | 16448 |
| **Channel Y** | 15754 | 16462 |
| **Channel Z** | 15889 | 15649 |

## 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

| | Average (μV) | min. Offset (μV) | max. Offset (μV) | Std. Deviation (μV) |
|---|---|---|---|---|
| **Channel X** | -0.14 | -1.77 | 1.06 | 0.51 |
| **Channel Y** | 0.58 | -1.02 | 2.16 | 0.57 |
| **Channel Z** | -0.65 | -2.31 | 1.22 | 0.68 |

## 6. Input Offset Current

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

## 7. Input Resistance (Typical values for information)

| | Zeroing (kOhm) | Measuring (MOhm) |
|---|---|---|
| **Channel X** | 200 | 200 |
| **Channel Y** | 200 | 200 |
| **Channel Z** | 200 | 200 |

## 8. Low Battery Alarm Voltage (Typical values for information)

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

## 9. Power Consumption (Typical values for information)

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