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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **CCS-TW (Auden)**

Certificate No: **DAE4-558_Jul13**

CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BM - SN: 558**

Calibration procedure(s) **QA CAL-06.v26
 Calibration procedure for the data acquisition electronics (DAE)**

Calibration date: **July 25, 2013**

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 | 02-Oct-12 (No:12728) | Oct-13 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| Auto DAE Calibration Unit | SE UWS 053 AA 1001 | 07-Jan-13 (in house check) | In house check: Jan-14 |
| Calibrator Box V2.1 | SE UMS 006 AA 1002 | 07-Jan-13 (in house check) | In house check: Jan-14 |

| | | | |
|----------------|---------------------------|--------------------------|---------------|
| Calibrated by: | Name Dominique Steffen | Function Technician | Signature |
| Approved by: | Fin Bomholt | Deputy Technical Manager | |

Issued: July 25, 2013

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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 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 = 6.1 μ V, 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 | 404.834 \pm 0.02% (k=2) | 404.719 \pm 0.02% (k=2) | 404.888 \pm 0.02% (k=2) |
| Low Range | 3.96252 \pm 1.50% (k=2) | 3.93898 \pm 1.50% (k=2) | 3.98830 \pm 1.50% (k=2) |

Connector Angle

| | |
|---|-------------------------------------|
| Connector Angle to be used in DASY system | 226.5 $^{\circ}$ \pm 1 $^{\circ}$ |
|---|-------------------------------------|

Appendix

1. DC Voltage Linearity

| High Range | Reading (μV) | Difference (μV) | Error (%) |
|-------------------|---------------------------|------------------------------|-----------|
| Channel X + Input | 199999.87 | 2.22 | 0.00 |
| Channel X + Input | 20007.13 | 6.49 | 0.03 |
| Channel X - Input | -19995.23 | 5.84 | -0.03 |
| Channel Y + Input | 199999.72 | 2.06 | 0.00 |
| Channel Y + Input | 20004.76 | 4.02 | 0.02 |
| Channel Y - Input | -19995.40 | 5.45 | -0.03 |
| Channel Z + Input | 199999.60 | 2.04 | 0.00 |
| Channel Z + Input | 20002.08 | 1.38 | 0.01 |
| Channel Z - Input | -20000.87 | 0.09 | -0.00 |

| Low Range | Reading (μV) | Difference (μV) | Error (%) |
|-------------------|---------------------------|------------------------------|-----------|
| Channel X + Input | 2000.97 | 0.18 | 0.01 |
| Channel X + Input | 201.57 | 0.30 | 0.15 |
| Channel X - Input | -198.13 | 0.50 | -0.25 |
| Channel Y + Input | 2001.13 | 0.17 | 0.01 |
| Channel Y + Input | 201.02 | -0.49 | -0.24 |
| Channel Y - Input | -198.55 | -0.05 | 0.02 |
| Channel Z + Input | 2000.94 | -0.06 | -0.00 |
| Channel Z + Input | 200.15 | -1.21 | -0.60 |
| Channel Z - Input | -199.64 | -1.04 | 0.52 |

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 | 1.27 | -0.63 |
| | - 200 | 1.15 | -0.57 |
| Channel Y | 200 | 8.66 | 8.49 |
| | - 200 | -9.25 | -9.75 |
| Channel Z | 200 | 3.62 | 3.94 |
| | - 200 | -5.72 | -5.74 |

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 | - | 5.21 | -0.00 |
| Channel Y | 200 | 9.58 | - | 5.96 |
| Channel Z | 200 | 7.07 | 7.92 | - |

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 | 16226 | 15249 |
| Channel Y | 15710 | 15696 |
| Channel Z | 16055 | 16722 |

5. Input Offset Measurement

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

Input 10M Ω

| | Average (μ V) | min. Offset (μ V) | max. Offset (μ V) | Std. Deviation (μ V) |
|-----------|--------------------|------------------------|------------------------|---------------------------|
| Channel X | 0.52 | -0.76 | 1.55 | 0.43 |
| Channel Y | -0.06 | -1.00 | 1.38 | 0.46 |
| Channel Z | -0.89 | -1.79 | 0.54 | 0.46 |

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 |



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Accreditation No.: **SCS 108**

Client **CCS-CN (Auden)**

Certificate No: **D2450V2-728_May13**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 728**

Calibration procedure(s) **QA CAL-05.v9
Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **May 02, 2013**

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 | 01-Nov-12 (No. 217-01640) | Oct-13 |
| Power sensor HP 8481A | US37292783 | 01-Nov-12 (No. 217-01640) | Oct-13 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 04-Apr-13 (No. 217-01736) | Apr-14 |
| Type-N mismatch combination | SN: 5047.3 / 06327 | 04-Apr-13 (No. 217-01739) | Apr-14 |
| Reference Probe ES3DV3 | SN: 3205 | 28-Dec-12 (No. ES3-3205_Dec12) | Dec-13 |
| DAE4 | SN: 601 | 25-Apr-13 (No. DAE4-601_Apr13) | Apr-14 |
| 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-12) | In house check: Oct-13 |

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

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

Signature

Issued: May 2, 2013

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Accreditation No.: **SCS 108**

Glossary:

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

Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- 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:

- DASY4/5 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.

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%.

Measurement Conditions

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

| | | |
|-------------------------------------|------------------------|-------------|
| DASY Version | DASY5 | V52.8.6 |
| 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 | 37.7 ± 6 % | 1.83 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Head TSL

| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR measured | 250 mW input power | 13.6 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 53.5 W/kg ± 17.0 % (k=2) |

| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 250 mW input power | 6.32 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 25.0 W/kg ± 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 | 51.2 ± 6 % | 2.03 mho/m ± 6 % |
| Body TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Body TSL

| SAR averaged over 1 cm³ (1 g) of Body TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR measured | 250 mW input power | 13.1 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 51.1 W/kg ± 17.0 % (k=2) |

| SAR averaged over 10 cm³ (10 g) of Body TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 250 mW input power | 6.07 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 23.9 W/kg ± 16.5 % (k=2) |

Appendix

Antenna Parameters with Head TSL

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 56.7 Ω + 5.4 j Ω |
| Return Loss | - 21.9 dB |

Antenna Parameters with Body TSL

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 52.4 Ω + 7.6 j Ω |
| Return Loss | - 22.2 dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.153 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 | January 09, 2003 |

DASY5 Validation Report for Head TSL

Date: 02.05.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 728

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.83$ S/m; $\epsilon_r = 37.7$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.52, 4.52, 4.52); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.6(1115); SEMCAD X 14.6.9(7117)

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

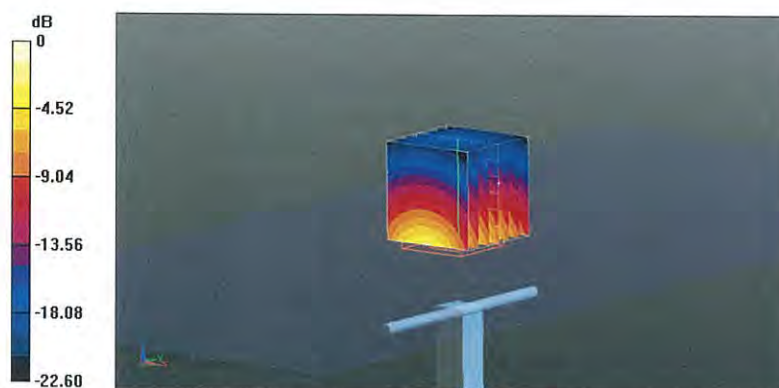
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 94.919 V/m; Power Drift = 0.09 dB

Peak SAR (extrapolated) = 28.3 W/kg

SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.32 W/kg

Maximum value of SAR (measured) = 17.6 W/kg



Impedance Measurement Plot for Head TSL

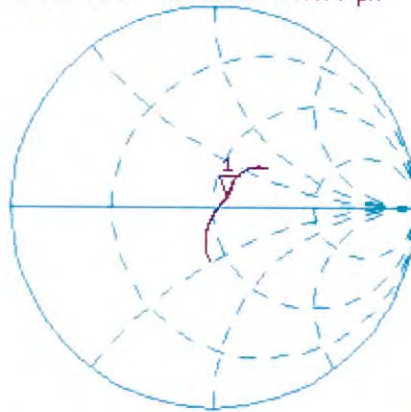
2 May 2013 10:07:32
[CH1] S11 1 U FS 1: 56.693 Ω 5.3535 Ω 347.77 pF 2 450.000 000 MHz

*
De1

CA

Avg
6

H1 d

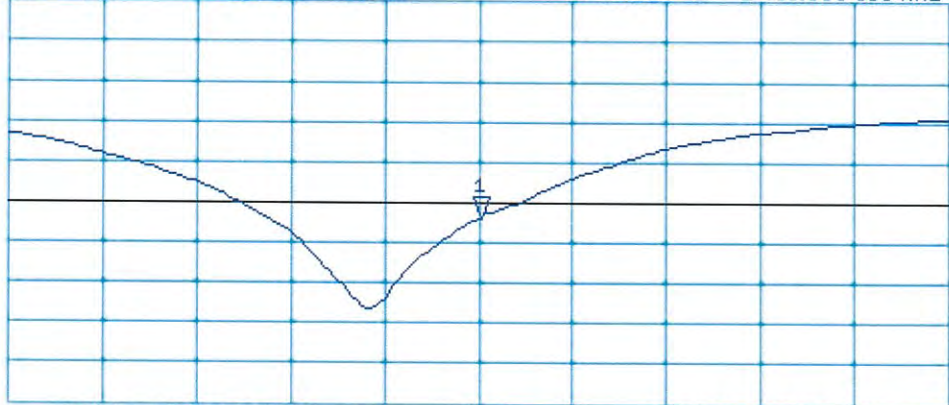


CH2 S11 LOG 5 dB/REF -20 dB 1:-21.914 dB 2 450.000 000 MHz

CA

Avg
6

H1 d



START 2 250.000 000 MHz

STOP 2 650.000 000 MHz

DASY5 Validation Report for Body TSL

Date: 02.05.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 728

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 2.03$ S/m; $\epsilon_r = 51.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.42, 4.42, 4.42); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.6(1115); SEMCAD X 14.6.9(7117)

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

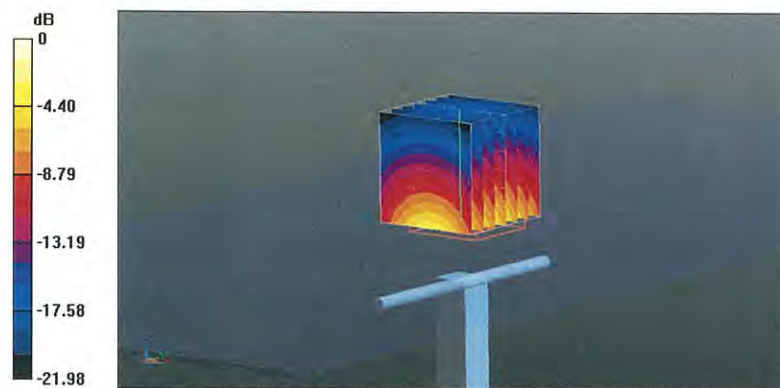
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 94.919 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 27.5 W/kg

SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.07 W/kg

Maximum value of SAR (measured) = 17.2 W/kg



0 dB = 17.2 W/kg = 12.36 dBW/kg

Impedance Measurement Plot for Body TSL

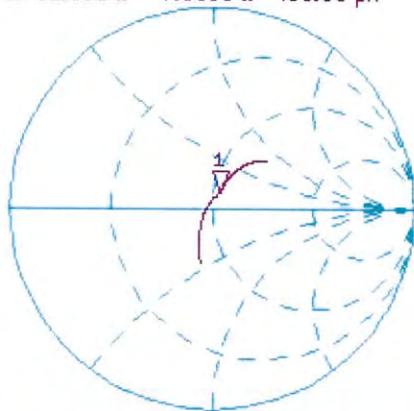
2 May 2013 10:06:50
CH1 S11 1 U FS 1: 52.355 Ω 7.5938 Ω 493.30 μH 2 450.000 000 MHz

*
De1

CΔ

Avg
16

H1d

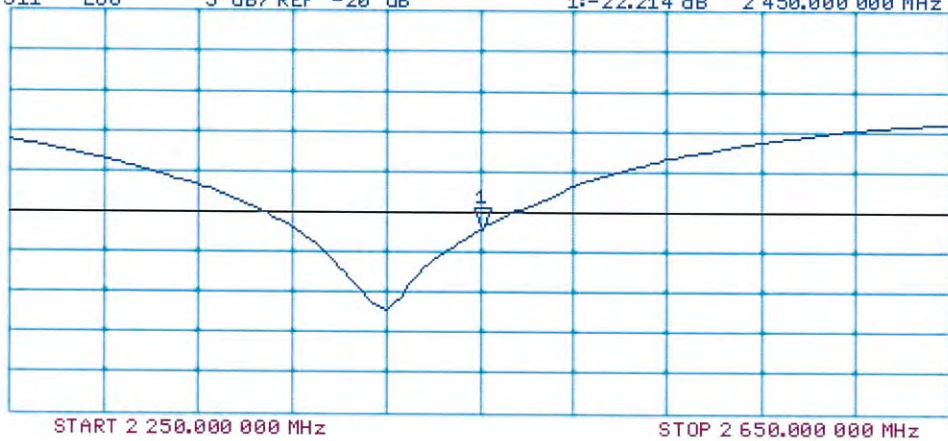


CH2 S11 LOG 5 dB/REF -20 dB 1:-22.214 dB 2 450.000 000 MHz

CΔ

Avg
16

H1d





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Accreditation No.: **SCS 108**

Client **CCS-TW (Auden)**

Certificate No: **D5GHzV2-1004_Nov12**

CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN: 1004**

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

Calibration date: **November 16, 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 $(22 \pm 3)^\circ\text{C}$ and humidity $< 70\%$.

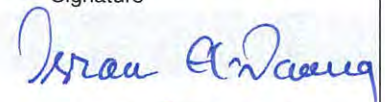

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|-----------------------------|--------------------|--------------------------------|-----------------------|
| Power meter EPM-442A | GB37480704 | 01-Nov-12 (No. 217-01640) | Oct-13 |
| Power sensor HP 8481A | US37292783 | 01-Nov-12 (No. 217-01640) | Oct-13 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 27-Mar-12 (No. 217-01530) | Apr-13 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 27-Mar-12 (No. 217-01533) | Apr-13 |
| Reference Probe EX3DV4 | SN: 3503 | 30-Dec-11 (No. EX3-3503_Dec11) | Dec-12 |
| DAE4 | SN: 601 | 27-Jun-12 (No. DAE4-601_Jun12) | Jun-13 |

| 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-12) | In house check: Oct-13 |

Calibrated by: **Israe El-Naouq** Name: **Israe El-Naouq** Function: **Laboratory Technician**

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

Signature



Issued: November 16, 2012

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Accreditation No.: **SCS 108**

Glossary:

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

Calibration is Performed According to the Following Standards:

- a) IEC 62209-2, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures"; Part 2: "Procedure to determine the Specific Absorption Rate (SAR) for including accessories and multiple transmitters", March 2010
- b) 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:

- c) 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.

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%.

Measurement Conditions

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

| | | |
|-------------------------------------|--|----------------------------------|
| DASY Version | DASY5 | V52.8.3 |
| 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 5300 MHz ± 1 MHz 5600 MHz ± 1 MHz 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 | 34.8 ± 6 % | 4.53 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 | 7.84 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 77.8 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.23 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 22.1 W/kg ± 19.5 % (k=2) |

Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|--|-----------------|--------------|------------------|
| Nominal Head TSL parameters | 22.0 °C | 35.9 | 4.76 mho/m |
| Measured Head TSL parameters | (22.0 ± 0.2) °C | 34.7 ± 6 % | 4.63 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Head TSL at 5300 MHz

| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
|---|--------------------|-----------------------------------|
| SAR measured | 100 mW input power | 8.45 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 83.9 W / kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.42 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 24.0 W/kg ± 19.5 % (k=2) |

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|-----------------|--------------|------------------|
| Nominal Head TSL parameters | 22.0 °C | 35.5 | 5.07 mho/m |
| Measured Head TSL parameters | (22.0 ± 0.2) °C | 34.2 ± 6 % | 4.93 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Head TSL at 5600 MHz

| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 8.41 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 83.3 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.39 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 23.6 W/kg ± 19.5 % (k=2) |

Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|-----------------|--------------|------------------|
| Nominal Head TSL parameters | 22.0 °C | 35.3 | 5.27 mho/m |
| Measured Head TSL parameters | (22.0 ± 0.2) °C | 34.0 ± 6 % | 5.15 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 | 8.05 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 79.8 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.29 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 22.7 W/kg ± 19.5 % (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 | 46.8 ± 6 % | 5.35 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 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 71.8 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Body TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.03 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 20.1 W/kg ± 19.5 % (k=2) |

Body TSL parameters at 5300 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|-----------------|--------------|------------------|
| Nominal Body TSL parameters | 22.0 °C | 48.9 | 5.42 mho/m |
| Measured Body TSL parameters | (22.0 ± 0.2) °C | 46.7 ± 6 % | 5.47 mho/m ± 6 % |
| Body TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Body TSL at 5300 MHz

| SAR averaged over 1 cm ³ (1 g) of Body TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 7.61 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 75.4 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Body TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.14 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 21.2 W/kg ± 19.5 % (k=2) |

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|-----------------|--------------|------------------|
| Nominal Body TSL parameters | 22.0 °C | 48.5 | 5.77 mho/m |
| Measured Body TSL parameters | (22.0 ± 0.2) °C | 46.2 ± 6 % | 5.86 mho/m ± 6 % |
| Body TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Body TSL at 5600 MHz

| SAR averaged over 1 cm ³ (1 g) of Body TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 7.95 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 78.8 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Body TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.21 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 21.8 W/kg ± 19.5 % (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 | 45.9 ± 6 % | 6.13 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 | 7.42 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 73.5 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Body TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.06 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 20.4 W/kg ± 19.5 % (k=2) |

Appendix

Antenna Parameters with Head TSL at 5200 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 50.9 Ω - 9.7 j Ω |
| Return Loss | - 20.3 dB |

Antenna Parameters with Head TSL at 5300 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 52.6 Ω - 6.2 j Ω |
| Return Loss | - 23.6 dB |

Antenna Parameters with Head TSL at 5600 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 54.5 Ω - 4.9 j Ω |
| Return Loss | - 23.9 dB |

Antenna Parameters with Head TSL at 5800 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 60.2 Ω - 2.6 j Ω |
| Return Loss | - 20.4 dB |

Antenna Parameters with Body TSL at 5200 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 49.5 Ω - 8.1 j Ω |
| Return Loss | - 21.8 dB |

Antenna Parameters with Body TSL at 5300 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 52.3 Ω - 4.5 j Ω |
| Return Loss | - 26.2 dB |

Antenna Parameters with Body TSL at 5600 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 55.2 Ω - 3.5 j Ω |
| Return Loss | - 24.5 dB |

Antenna Parameters with Body TSL at 5800 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 59.8 Ω - 2.0 j Ω |
| Return Loss | - 20.8 dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.154 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 | July 08, 2003 |

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1004

Communication System: CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5200$ MHz; $\sigma = 4.53$ mho/m; $\epsilon_r = 34.8$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5300$ MHz; $\sigma = 4.63$ mho/m; $\epsilon_r = 34.7$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5600$ MHz; $\sigma = 4.93$ mho/m; $\epsilon_r = 34.2$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5800$ MHz; $\sigma = 5.15$ mho/m; $\epsilon_r = 34$; $\rho = 1000$ kg/m³

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); Calibrated: 30.12.2011, ConvF(5.1, 5.1, 5.1); Calibrated: 30.12.2011, ConvF(4.76, 4.76, 4.76); Calibrated: 30.12.2011, ConvF(4.81, 4.81, 4.81); Calibrated: 30.12.2011;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.06.2012
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.3(988); SEMCAD X 14.6.7(6848)

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 = 64.614 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 29.0 W/kg

SAR(1 g) = 7.84 W/kg; SAR(10 g) = 2.23 W/kg

Maximum value of SAR (measured) = 18.4 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 65.075 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 31.8 W/kg

SAR(1 g) = 8.45 W/kg; SAR(10 g) = 2.42 W/kg

Maximum value of SAR (measured) = 19.9 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 63.984 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 33.4 W/kg

SAR(1 g) = 8.41 W/kg; SAR(10 g) = 2.39 W/kg

Maximum value of SAR (measured) = 20.2 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan,

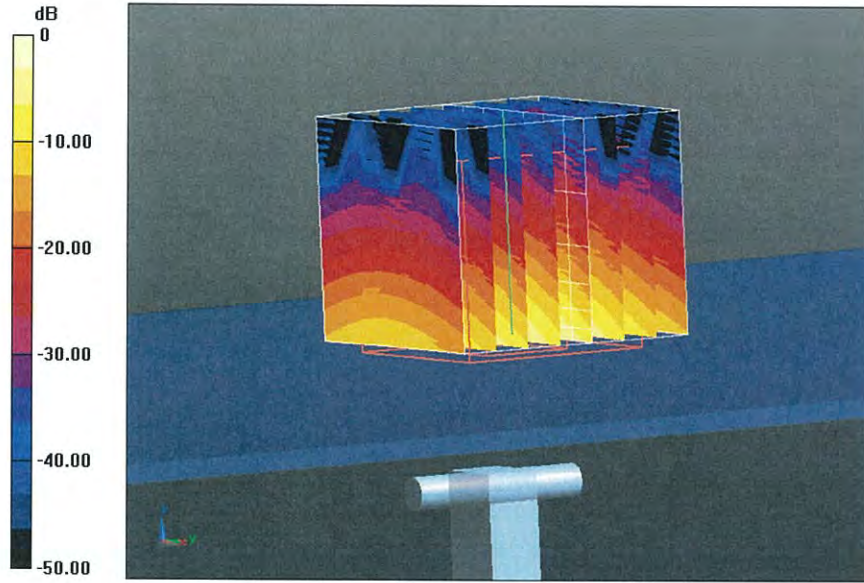
dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 61.212 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 33.5 W/kg

SAR(1 g) = 8.05 W/kg; SAR(10 g) = 2.29 W/kg

Maximum value of SAR (measured) = 19.6 W/kg



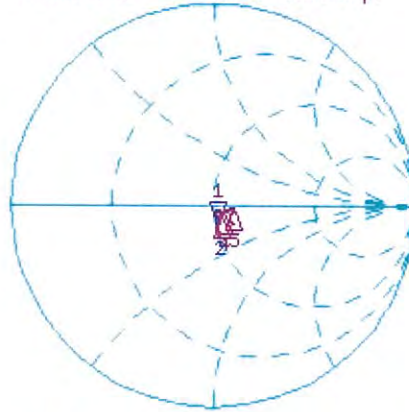
0 dB = 19.6 W/kg = 12.92 dBW/kg

Impedance Measurement Plot for Head TSL

16 Nov 2012 17:32:44

CH1 S11 1 U FS 1: 50.922 Ω -9.7402 Ω 3.1423 pF 5 200.000 000 MHz

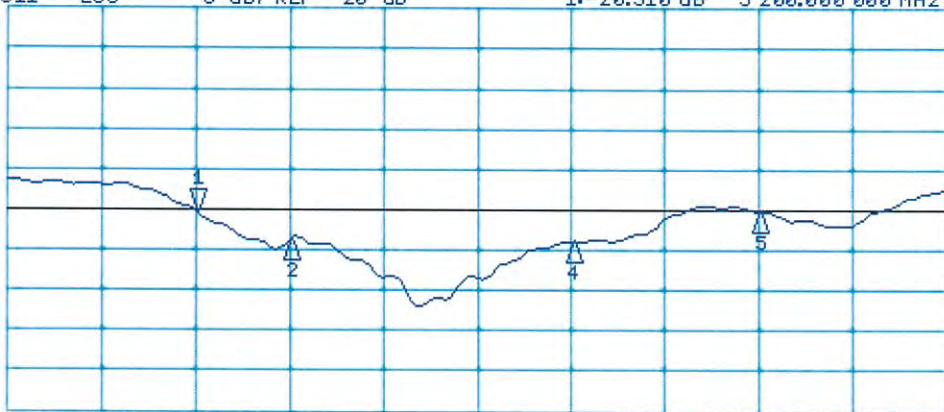
*
De1
Cor
Avg
16
H1d



CH1 Markers
2: 52.570 Ω
-6.2402 Ω
5.30000 GHz
4: 54.541 Ω
-4.8613 Ω
5.60000 GHz
5: 60.242 Ω
-2.5625 Ω
5.80000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1: -20.310 dB 5 200.000 000 MHz

Cor
Avg
16
H1d



CH2 Markers
2: -23.647 dB
5.30000 GHz
4: -23.937 dB
5.60000 GHz
5: -20.376 dB
5.80000 GHz

START 5 000.000 000 MHz

STOP 6 000.000 000 MHz

DASY5 Validation Report for Body TSL

Date: 14.11.2012

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1004

Communication System: CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5200$ MHz; $\sigma = 5.35$ mho/m; $\epsilon_r = 46.8$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5300$ MHz; $\sigma = 5.47$ mho/m; $\epsilon_r = 46.7$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5600$ MHz; $\sigma = 5.86$ mho/m; $\epsilon_r = 46.2$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5800$ MHz; $\sigma = 6.13$ mho/m; $\epsilon_r = 45.9$; $\rho = 1000$ kg/m³

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); Calibrated: 30.12.2011, ConvF(4.67, 4.67, 4.67); Calibrated: 30.12.2011, ConvF(4.22, 4.22, 4.22); Calibrated: 30.12.2011, ConvF(4.38, 4.38, 4.38); Calibrated: 30.12.2011;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.06.2012
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.3(988); SEMCAD X 14.6.7(6848)

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 = 58.275 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 28.8 W/kg

SAR(1 g) = 7.25 W/kg; SAR(10 g) = 2.03 W/kg

Maximum value of SAR (measured) = 17.1 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 58.841 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 31.0 W/kg

SAR(1 g) = 7.61 W/kg; SAR(10 g) = 2.14 W/kg

Maximum value of SAR (measured) = 18.1 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

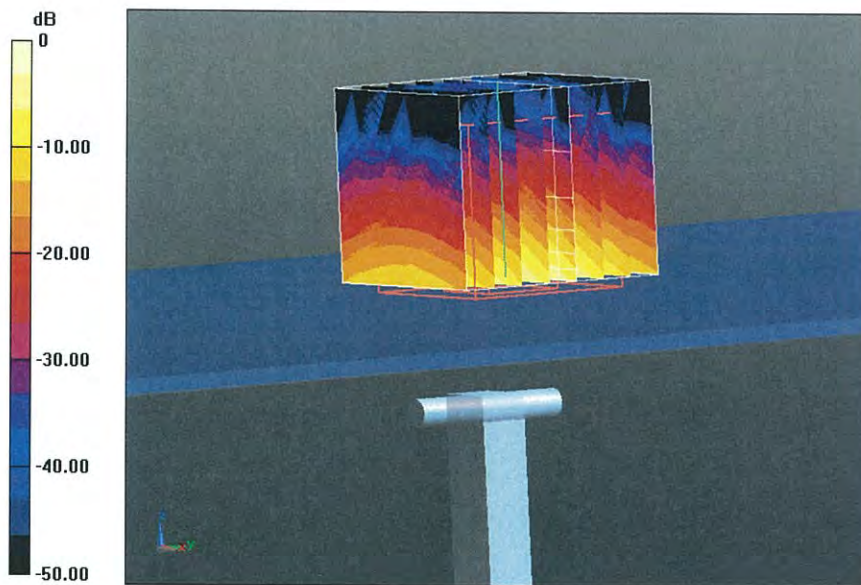
Reference Value = 58.396 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 35.4 W/kg

SAR(1 g) = 7.95 W/kg; SAR(10 g) = 2.21 W/kg

Maximum value of SAR (measured) = 19.5 W/kg

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 = 55.539 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 34.8 W/kg
SAR(1 g) = 7.42 W/kg; SAR(10 g) = 2.06 W/kg
Maximum value of SAR (measured) = 18.3 W/kg



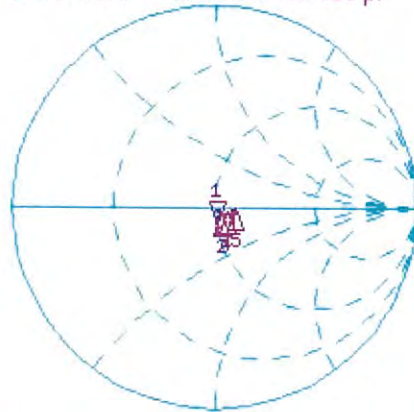
0 dB = 18.3 W/kg = 12.62 dBW/kg

Impedance Measurement Plot for Body TSL

14 Nov 2012 10:24:27

CH1 S11 1 U FS 1: 49.490 Ω -8.1348 Ω 3.7625 pF 5 200.000 000 MHz

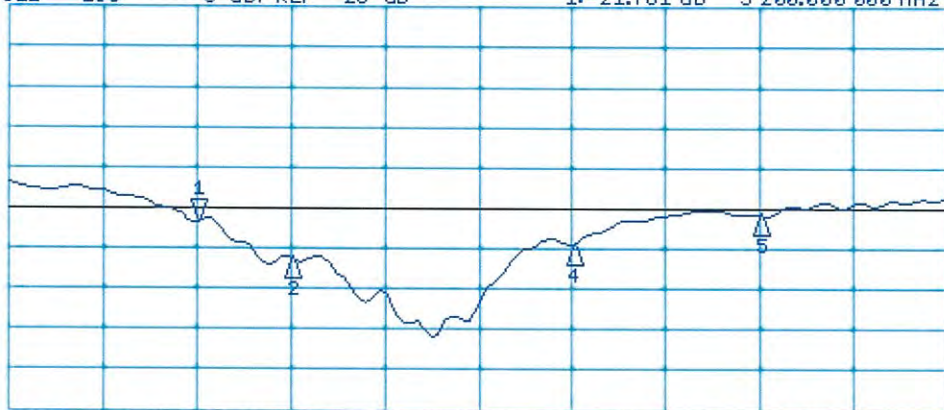
*
De1
Cor
Avg
16
H1d



CH1 Markers
2: 52.301 Ω
-4.4766 Ω
5.30000 GHz
4: 55.236 Ω
-3.4668 Ω
5.60000 GHz
5: 59.846 Ω
-1.9766 Ω
5.80000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1: -21.761 dB 5 200.000 000 MHz

Cor
Avg
16
H1d



CH2 Markers
2: -26.170 dB
5.30000 GHz
4: -24.483 dB
5.60000 GHz
5: -20.782 dB
5.80000 GHz