

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



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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 108

Glossary:

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

Calibration is Performed According to the Following Standards:

- 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.

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 | |
| 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 | 41.0 ± 6 % | 0.89 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 | 2.33 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | 9.37 mW /g ± 17.0 % (k=2) |

| | | |
|---|--------------------|---------------------------|
| SAR averaged over 10 cm³ (10 g) of Head TSL | Condition | |
| SAR measured | 250 mW input power | 1.52 mW / g |
| SAR for nominal Head TSL parameters | normalized to 1W | 6.11 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 | 55.7 ± 6 % | 1.01 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 | 2.44 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | 9.49 mW / g ± 17.0 % (k=2) |

| | | |
|---|--------------------|----------------------------|
| SAR averaged over 10 cm³ (10 g) of Body TSL | Condition | |
| SAR measured | 250 mW input power | 1.60 mW / g |
| SAR for nominal Body TSL parameters | normalized to 1W | 6.26 mW / g ± 16.5 % (k=2) |

Appendix

Antenna Parameters with Head TSL

| | |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 52.7 Ω - 2.1 $j\Omega$ |
| Return Loss | - 29.6 dB |

Antenna Parameters with Body TSL

| | |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 47.1 Ω - 4.6 $j\Omega$ |
| Return Loss | - 25.0 dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.398 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 22, 2011 |

DASY5 Validation Report for Head TSL

Date: 27.02.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d134

Communication System: CW; Frequency: 835 MHz

Medium parameters used: $f = 835$ MHz; $\sigma = 0.89$ mho/m; $\epsilon_r = 41$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY5 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.07, 6.07, 6.07); Calibrated: 30.12.2012
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.07.2012
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY5 52.8.0(692); SEMCAD X 14.6.4(4989)

Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

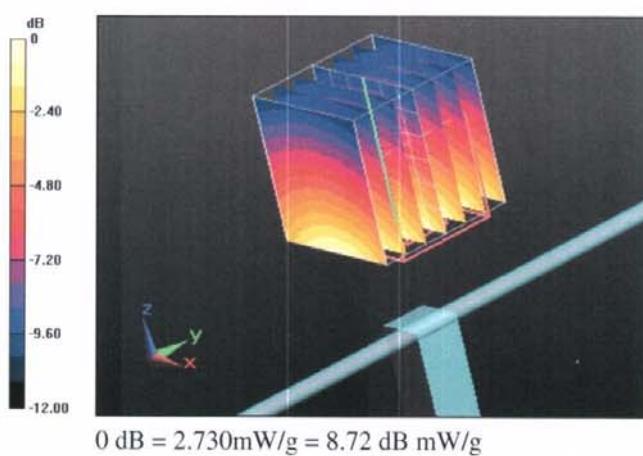
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 57.043 V/m; Power Drift = 0.02 dB

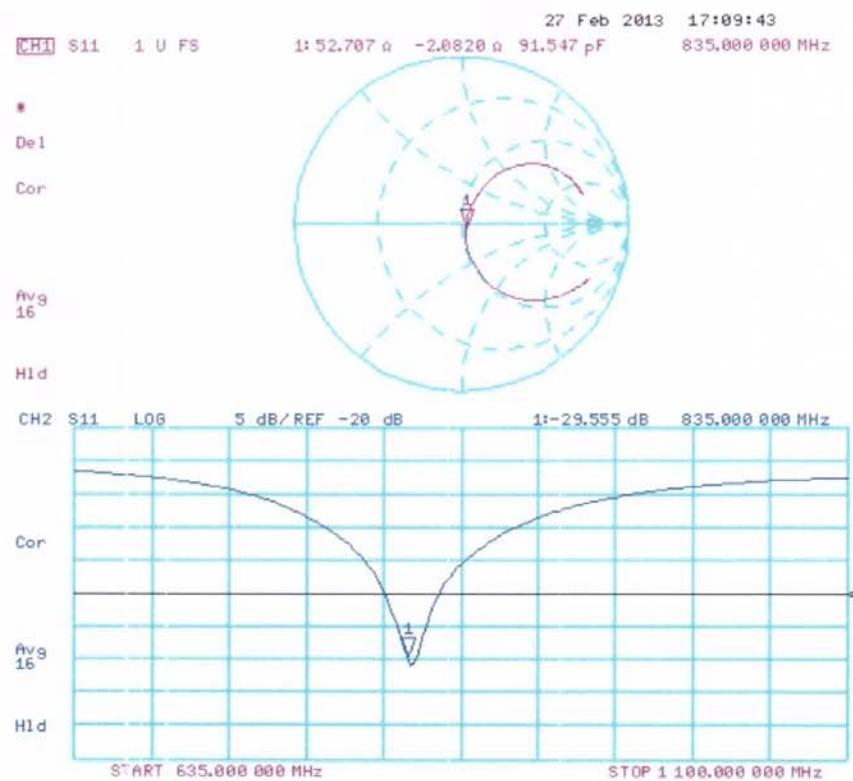
Peak SAR (extrapolated) = 3.4280

SAR(1 g) = 2.33 mW/g; SAR(10 g) = 1.52 mW/g

Maximum value of SAR (measured) = 2.725 mW/g



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 27.02.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d134

Communication System: CW; Frequency: 835 MHz

Medium parameters used: $f = 835$ MHz; $\sigma = 1.01$ mho/m; $\epsilon_r = 55.7$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.02, 6.02, 6.02); Calibrated: 30.12.2012
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.07.2012
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.0(692); SEMCAD X 14.6.4(4989)

Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

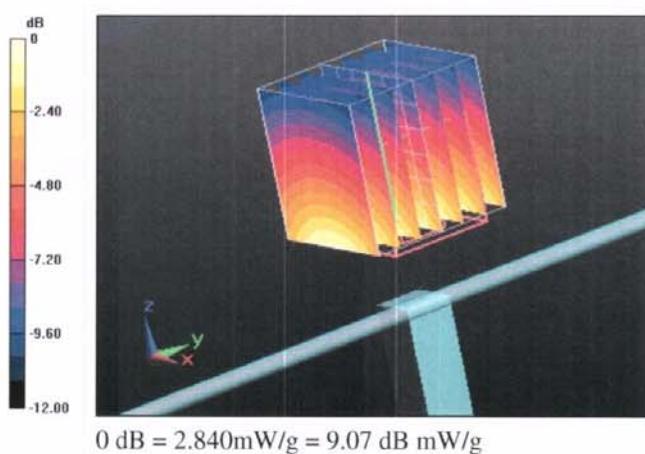
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 54.902 V/m; Power Drift = 0.0055 dB

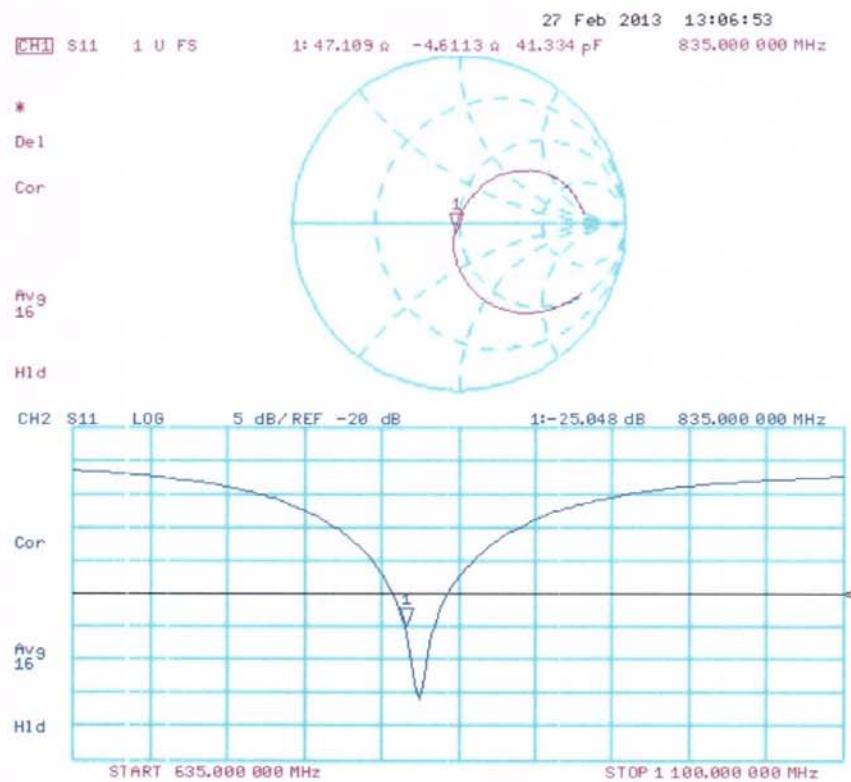
Peak SAR (extrapolated) = 3.5280

SAR(1 g) = 2.44 mW/g; SAR(10 g) = 1.6 mW/g

Maximum value of SAR (measured) = 2.838 mW/g



Impedance Measurement Plot for Body TSL



6.3. DAE4 Calibration Certificate

Calibration Laboratory of
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Accreditation No.: **SCS 108**Client **CIQ SZ (Auden)**Certificate No: **DAE4-1315_Feb13**

CALIBRATION CERTIFICATE

| | |
|--------|---------------------------------|
| Object | DAE4 - SD 000 D04 BJ - SN: 1315 |
|--------|---------------------------------|

| | |
|--------------------------|---|
| Calibration procedure(s) | QA CAL-06.v24 Calibration procedure for the data acquisition electronics (DAE) |
|--------------------------|---|

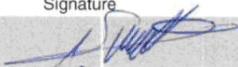
| | |
|-------------------|-------------------|
| Calibration date: | February 27, 2013 |
|-------------------|-------------------|

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 $(22 \pm 3)^\circ\text{C}$ and humidity $< 70\%$.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|-------------------------------|--------------------|----------------------------|------------------------|
| Keithley Multimeter Type 2001 | SN: 0810278 | 28-Sep-12 (No:11450) | Sep-13 |
| 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 |

| | | | |
|----------------|-----------------------|------------------------|--|
| Calibrated by: | Name Andrea Guntli | Function Technician | Signature  |
|----------------|-----------------------|------------------------|--|

| | | | |
|--------------|-------------|--------------|---|
| Approved by: | Fin Bomholt | R&D Director |  |
|--------------|-------------|--------------|---|

Issued: February 27, 2013

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

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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 | $405.194 \pm 0.1\% \text{ (k=2)}$ | $405.031 \pm 0.1\% \text{ (k=2)}$ | $405.006 \pm 0.1\% \text{ (k=2)}$ |
| Low Range | $4.00179 \pm 0.7\% \text{ (k=2)}$ | $3.99504 \pm 0.7\% \text{ (k=2)}$ | $4.00535 \pm 0.7\% \text{ (k=2)}$ |

Connector Angle

| | |
|---|--------------------------|
| Connector Angle to be used in DASY system | $20.0^\circ \pm 1^\circ$ |
|---|--------------------------|

Appendix

1. DC Voltage Linearity

| High Range | | Reading (µV) | Difference (µV) | Error (%) |
|------------|---------|--------------|-----------------|-----------|
| Channel X | + Input | 199993.07 | -0.46 | -0.00 |
| Channel X | + Input | 19998.21 | 0.29 | 0.00 |
| Channel X | - Input | -19997.04 | 5.94 | -0.03 |
| Channel Y | + Input | 199992.78 | -1.05 | -0.00 |
| Channel Y | + Input | 19995.99 | -1.88 | -0.01 |
| Channel Y | - Input | -20001.41 | 1.50 | -0.01 |
| Channel Z | + Input | 199996.23 | 3.02 | 0.00 |
| Channel Z | + Input | 19996.75 | -0.72 | -0.00 |
| Channel Z | - Input | -20003.50 | -0.24 | 0.00 |

| Low Range | | Reading (µV) | Difference (µV) | Error (%) |
|-----------|---------|--------------|-----------------|-----------|
| Channel X | + Input | 1999.32 | -1.73 | -0.09 |
| Channel X | + Input | 200.22 | -1.03 | -0.51 |
| Channel X | - Input | -198.55 | 0.32 | -0.16 |
| Channel Y | + Input | 1997.53 | -3.28 | -0.16 |
| Channel Y | + Input | 199.64 | -1.21 | -0.60 |
| Channel Y | - Input | -199.77 | -0.78 | 0.39 |
| Channel Z | + Input | 1997.90 | -2.04 | -0.10 |
| Channel Z | + Input | 199.23 | -1.21 | -0.61 |
| Channel Z | - Input | -200.63 | -1.12 | 0.56 |

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 | -1.10 | -3.09 |
| | -200 | 4.35 | 3.23 |
| Channel Y | 200 | -22.09 | -22.46 |
| | -200 | 21.74 | 22.31 |
| Channel Z | 200 | -4.46 | -4.92 |
| | -200 | 3.65 | 2.86 |

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 | - | -2.62 | -3.29 |
| Channel Y | 200 | 6.73 | - | -2.17 |
| Channel Z | 200 | 8.11 | 5.38 | - |

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 | 16132 | 15682 |
| Channel Y | 16251 | 15151 |
| Channel Z | 15551 | 15659 |

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 | 1.32 | 0.22 | 2.38 | 0.46 |
| Channel Y | -1.23 | -2.04 | -0.58 | 0.36 |
| Channel Z | -1.89 | -3.56 | -1.12 | 0.39 |

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 |

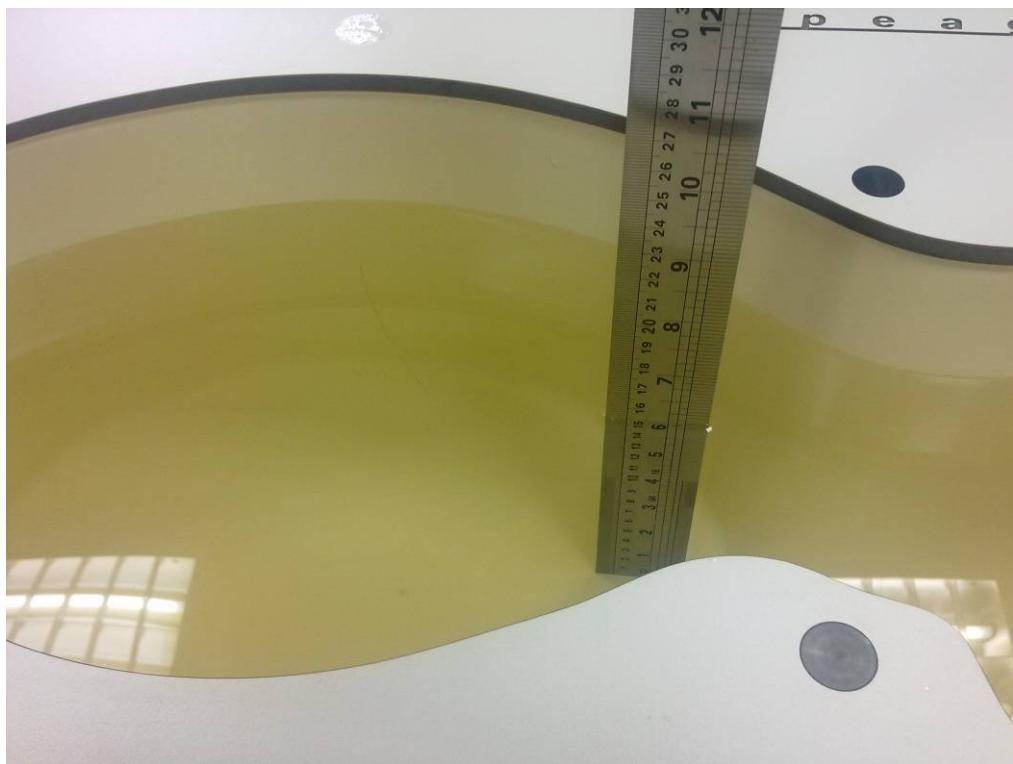
8. Low Battery Alarm Voltage (Typical values for information)

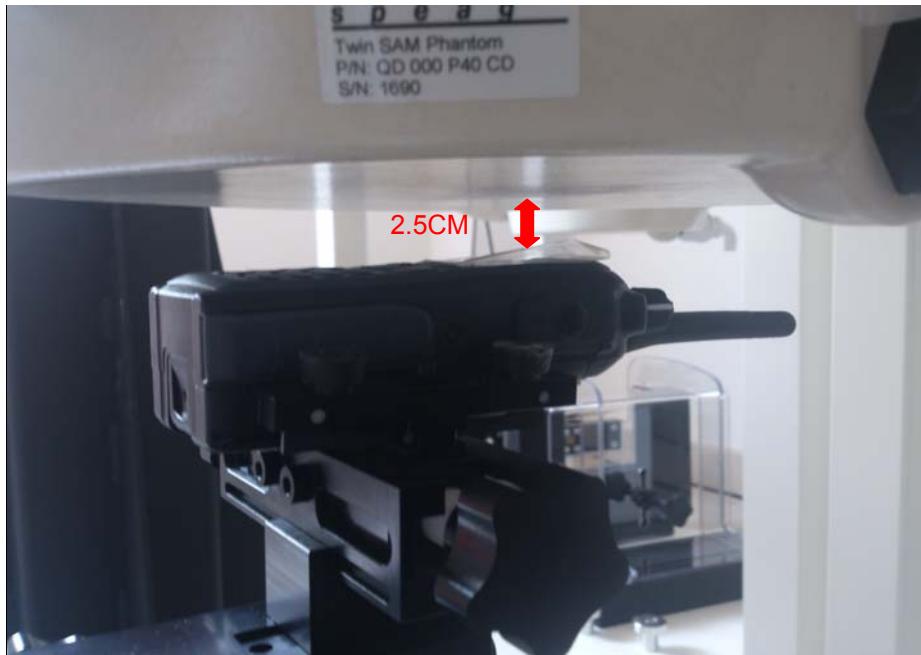
| Typical values | Alarm Level (VDC) |
|----------------|-------------------|
| Supply (+ Vcc) | +7.9 |
| Supply (- Vcc) | -7.6 |

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 |

7. Test Setup Photos





Face-held with Thicker Battery, the front of the EUT towards phantom



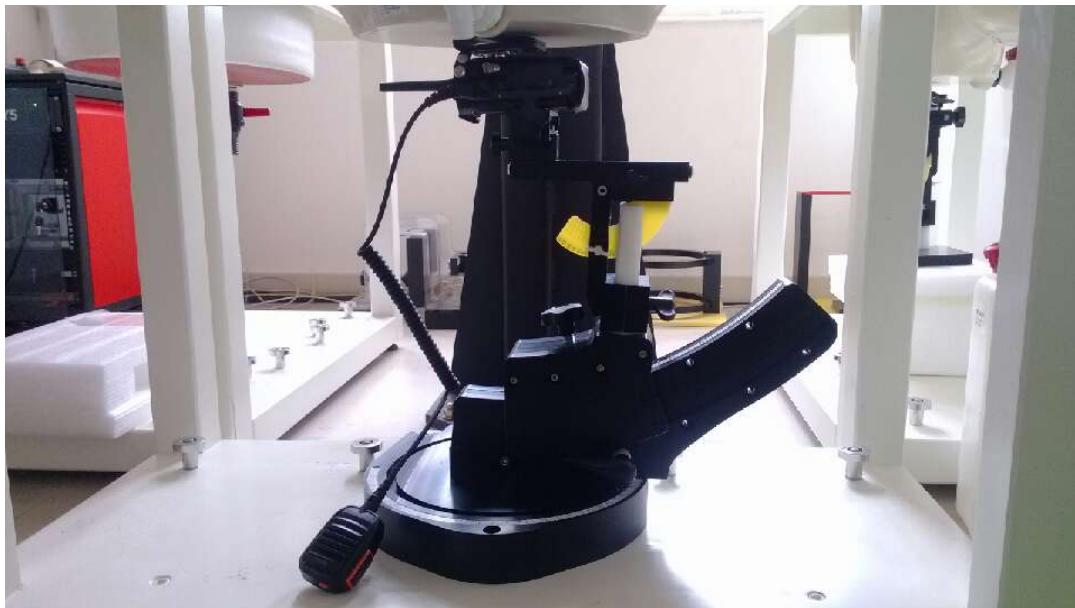
Face-held with Thinner Battery, the front of the EUT towards phantom



Body-worn with Thinner Battery,Belt, the front of the EUT towards ground



Body-worn with Thicker Battery,Belt, the front of the EUT towards ground



Body-worn with Thinner Battery,Pocket, the front of the EUT towards ground

8. EUT Photos



Battery Thicker:BL2503



Battery Thinner:BL2006



Belt:BC19



Pocket:LCY003



Earphone 1: ESS07



Earphone 2: ESS08



Earphone 3: EH-02



Earphone 4: EH-01



Earphone 5: ES-02



Earphone 6: ES-01



Accessory 1: SM18N2



Audio Accessory 2: ACN-01



Audio Accessory 3: EAN16



Audio Accessory 4: EAN18



Audio Accessory 5: ESN10



Audio Accessory 6: EHN12



Audio Accessory 7:EWN09



LCBN13



.....End of Report.....