# FCC SAR Test Report

| | |
|---|---|
| APPLICANT | : HMD Global Oy |
| EQUIPMENT | : Smart Phone |
| BRAND NAME | : NOKIA |
| MODEL NAME | : TA-1032 |
| FCC ID | : 2AJOTTA-1032 |
| STANDARD | : FCC 47 CFR Part 2 (2.1093)<br>ANSI/IEEE C95.1-1992<br>IEEE 1528-2013 |

**We, Sporton International (KunShan) INC., would like to declare that the tested sample has been evaluated in accordance with the procedures and had been in compliance with the applicable technical standards.**

**The test results in this report apply exclusively to the tested model / sample. Without written approval of Sporton International (KunShan) INC., the test report shall not be reproduced except in full.**

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# Revision History

| REPORT NO. | VERSION | DESCRIPTION | ISSUED DATE |
|---|---|---|---|
| FA711304 | Rev. 01 | Initial issue of report | Mar. 15, 2017 |
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# 1. Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for **HMD Global Oy, Smart Phone, TA-1032** are as follows.

| Equipment Class | Frequency Band | | Highest SAR Summary | | | Highest Simultaneous Transmission 1g SAR (W/kg) |
|---|---|---|---|---|---|---|
| | | | Head (Separation 0mm) | Body-worn (Separation 15mm) | Hotspot (Separation 10mm) | |
| | | | 1g SAR (W/kg) | | | |
| Licensed | GSM | GSM850 | 0.48 | 0.68 | 1.17 | 1.34 |
| | | GSM1900 | 0.15 | 0.63 | **1.19** | |
| | WCDMA | Band II | 0.22 | **0.94** | 1.03 | |
| | | Band V | 0.35 | 0.47 | 0.70 | |
| | LTE | Band 5 | 0.32 | 0.51 | 0.64 | |
| | | Band 7 | 0.14 | 0.56 | 0.66 | |
| | | Band 38 | <0.10 | 0.28 | 1.04 | |
| DTS | WLAN | 2.4GHz WLAN | **0.76** | <0.10 | 0.17 | 1.34 |
| NII | | 5GHz WLAN | <0.10 | <0.10 | | 0.95 |
| Date of Testing: | | | 2017/1/24 ~ 2017/2/8 | | | |

This device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (1.6 W/kg) specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1992, and had been tested in accordance with the measurement methods and procedures specified in IEEE 1528-2013 and FCC KDB publications.

## 2. Administration Data

| Testing Site | |
|---|---|
| Test Site | Sporton International (KunShan) INC. |
| Test Site Location | No.3-2, Pingxiang Road, Kunshan Development Zone, Jiangsu, China<br>TEL: +86-0512-5790-0158<br>FAX: +86-0512-5790-0958 |

| Applicant | |
|---|---|
| Company Name | HMD Global Oy |
| Address | Karaportti 2, 02610 Espoo, Finland |

| Manufacturer | |
|---|---|
| Company Name | HMD Global Oy |
| Address | Karaportti 2, 02610 Espoo, Finland |

## 3. Guidance Applied

The Specific Absorption Rate (SAR) testing specification, method, and procedure for this device is in accordance with the following standards:

- FCC 47 CFR Part 2 (2.1093)
- ANSI/IEEE C95.1-1992
- IEEE 1528-2013
- FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04
- FCC KDB 865664 D02 SAR Reporting v01r02
- FCC KDB 447498 D01 General RF Exposure Guidance v06
- FCC KDB 648474 D04 SAR Evaluation Considerations for Wireless Handsets v01r03
- FCC KDB 248227 D01 802.11 Wi-Fi SAR v02r02
- FCC KDB 941225 D01 3G SAR Procedures v03r01
- FCC KDB 941225 D05 SAR for LTE Devices v02r05
- FCC KDB 941225 D06 Hotspot Mode SAR v02r01

# 4. Equipment Under Test (EUT) Information

## 4.1 General Information

| Product Feature & Specification | |
|---|---|
| Equipment Name | Smart Phone |
| Brand Name | NOKIA |
| Model Name | TA-1032 |
| FCC ID | 2AJOTTA-1032 |
| IMEI Code | For LTE Band 5:<br>SIM1: 356805080008412<br>SIM2: 356805080008404<br>For Other WWAN Bands:<br>SIM1: 356805080000765<br>SIM2: 356805080000773<br>For WLAN Bands:<br>SIM1: 356805080001680<br>SIM2: 356805080001698 |
| Wireless Technology and Frequency Range | GSM850: 824.2 MHz ~ 848.8 MHz<br>GSM1900: 1850.2 MHz ~ 1909.8 MHz<br>WCDMA Band II: 1852.4 MHz ~ 1907.6 MHz<br>WCDMA Band V: 826.4 MHz ~ 846.6 MHz<br>LTE Band 5: 824.7 MHz ~ 848.3 MHz<br>LTE Band 7: 2502.5 MHz ~ 2567.5 MHz<br>LTE Band 38: 2572.5 MHz ~ 2617.5 MHz<br>WLAN 2.4GHz Band: 2412 MHz ~ 2462 MHz<br>WLAN 5.2GHz Band: 5180 MHz ~ 5240 MHz<br>WLAN 5.3GHz Band: 5260 MHz ~ 5320 MHz<br>WLAN 5.5GHz Band: 5500 MHz ~ 5700 MHz<br>WLAN 5.8GHz Band: 5745 MHz ~ 5825 MHz<br>Bluetooth: 2402 MHz ~ 2480 MHz<br>NFC : 13.56 MHz |
| Mode | . GSM/GPRS/EGPRS<br>. RMC/AMR 12.2Kbps<br>. HSDPA<br>. HSUPA<br>. DC-HSDPA<br>. HSPA+<br>. LTE: QPSK, 16QAM<br>. WLAN 2.4GHz 802.11b/g/n HT20<br>. WLAN 5GHz 802.11a/n HT20/HT40<br>. Bluetooth v3.0+EDR, Bluetooth v4.0 LE, Bluetooth v4.1 LE, Bluetooth v4.2 LE<br>. NFC:ASK |
| HW Version | DVT1.5 |
| SW Version | 000C_1_26A |
| GSM / (E)GPRS Transfer | Class B – EUT cannot support Packet Switched and Circuit Switched Network |
| EUT Stage | Production Unit |

**Remark:**

1. 802.11n-HT40 is not supported in 2.4GHz WLAN.
2. This device 2.4GHz WLAN support hotspot operation.
3. This device 5GHz WLAN not support hotspot operation, and 5.2GHz WLAN/5.8GHz WLAN supports WiFi Direct (GC/GO), and 5.3GHz / 5.5GHz supports WiFi Direct (GC only).
4. This device supported VoIP in GPRS, EGRPS, WCDMA and LTE (e.g. 3rd party VoIP) and LTE supports VoLTE operation.
5. This device supports GRPS/EGRPS mode up to multi-slot class 12.
6. This device does not support DTM operation.
7. When hotspot mode is enabled, power reduction will be activated to limit the maximum power of GSM1900, WCDMA Band II and LTE Band 7.
8. This device has 2 SIM slots and supports dual SIM dual standby. The WWAN radio transmission will be enabled by either one SIM at a time (Single active). After pre-scan two SIM cards power, we found test result of the SIM1 was the worse, so we chose SIM1 slot to perform all tests.
9. 5600~5650MHz is notched.

## 4.2 General LTE SAR Test and Reporting Considerations

| Summarized necessary items addressed in KDB 941225 D05 v02r05 | |
|---|---|
| FCC ID | 2AJOTTA-1032 |
| Equipment Name | Smart Phone |
| Operating Frequency Range of each LTE transmission band | LTE Band 5: 824.7 MHz ~ 848.3 MHz<br>LTE Band 7: 2502.5 MHz ~ 2567.5 MHz<br>LTE Band 38: 2572.5 MHz ~ 2617.5 MHz |
| Channel Bandwidth | LTE Band 5:1.4MHz, 3MHz, 5MHz, 10MHz<br>LTE Band 7: 5MHz, 10MHz, 15MHz, 20MHz<br>LTE Band 38: 5MHz, 10MHz, 15MHz, 20MHz |
| uplink modulations used | QPSK, and 16QAM |
| LTE Voice / Data requirements | Voice and Data |
| LTE MPR permanently built-in by design | Table 6.2.3-1: Maximum Power Reduction (MPR) for Power Class 3<br>Modulation \| Channel bandwidth / Transmission bandwidth (RB) \| MPR (dB)<br>1.4 MHz \| 3.0 MHz \| 5 MHz \| 10 MHz \| 15 MHz \| 20 MHz<br>QPSK \| > 5 \| > 4 \| > 8 \| > 12 \| > 16 \| > 18 \| ≤ 1<br>16 QAM \| ≤ 5 \| ≤ 4 \| ≤ 8 \| ≤ 12 \| ≤ 16 \| ≤ 18 \| ≤ 1<br>16 QAM \| > 5 \| > 4 \| > 8 \| > 12 \| > 16 \| > 18 \| ≤ 2 |
| LTE A-MPR | In the base station simulator configuration, Network Setting value is set to NS_01 to disable A-MPR during SAR testing and the LTE SAR tests was transmitting on all TTI frames (Maximum TTI) |
| Spectrum plots for RB configuration | A properly configured base station simulator was used for the SAR and power measurement; therefore, spectrum plots for each RB allocation and offset configuration are not included in the SAR report. |
| Power reduction applied to satisfy SAR compliance | Yes, when operating in hotspot mode that GSM1900, WCDMA Band II and LTE Band 7 power reduction applied to satisfy SAR compliance. |
| LTE Release Version | R9, Cat 3 |
| CA Support | Not Supported |

| Transmission (H, M, L) channel numbers and frequencies in each LTE band | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| LTE Band 5 | | | | | | | | |
| | Bandwidth 1.4 MHz | | Bandwidth 3 MHz | | Bandwidth 5 MHz | | Bandwidth 10 MHz | |
| | Ch. # | Freq. (MHz) | Ch. # | Freq. (MHz) | Ch. # | Freq. (MHz) | Ch. # | Freq. (MHz) |
| L | 20407 | 824.7 | 20415 | 825.5 | 20425 | 826.5 | 20450 | 829 |
| M | 20525 | 836.5 | 20525 | 836.5 | 20525 | 836.5 | 20525 | 836.5 |
| H | 20643 | 848.3 | 20635 | 847.5 | 20625 | 846.5 | 20600 | 844 |
| LTE Band 7 | | | | | | | | |
| | Bandwidth 5 MHz | | Bandwidth 10 MHz | | Bandwidth 15 MHz | | Bandwidth 20 MHz | |
| | Ch. # | Freq. (MHz) | Ch. # | Freq. (MHz) | Ch. # | Freq. (MHz) | Ch. # | Freq. (MHz) |
| L | 20775 | 2502.5 | 20800 | 2505 | 20825 | 2507.5 | 20850 | 2510 |
| M | 21100 | 2535 | 21100 | 2535 | 21100 | 2535 | 21100 | 2535 |
| H | 21425 | 2567.5 | 21400 | 2565 | 21375 | 2562.5 | 21350 | 2560 |
| LTE Band 38 | | | | | | | | |
| | Bandwidth 5 MHz | | Bandwidth 10 MHz | | Bandwidth 15 MHz | | Bandwidth 20 MHz | |
| | Ch. # | Freq. (MHz) | Ch. # | Freq. (MHz) | Ch. # | Freq. (MHz) | Ch. # | Freq. (MHz) |
| L | 37775 | 2572.5 | 37800 | 2575 | 37825 | 2577.5 | 37850 | 2580 |
| M | 38000 | 2595 | 38000 | 2595 | 38000 | 2595 | 38000 | 2595 |
| H | 38225 | 2617.5 | 38200 | 2615 | 38175 | 2612.5 | 38150 | 2610 |

# 5. Re-use of Measured Data

## 5.1 Introduction Section

This application re-uses data collected on a similar device. The subject device of this application (Model: TA-1032, FCC ID: 2AJOTTA-1032) is electrically identical to the reference device (Model: TA-1038, FCC ID: 2AJOTTA-1038) for the portions of the circuitry corresponding to the data being re-used, as treated by KDB Publication 178919 D01.

## 5.2 Difference Section

For details concerning the similarity with respect to component placement, mechanical/electrical design etc., please refer to the Product Equality Declaration “PED” file.

The re-used RF data includes the following bands provided in Appendix F (Sporton SAR Report No. FA711304-01 for the reference device Model: TA-1038, FCC ID: 2AJOTTA-1038):

- GSM850/1900
- WCDMA Band V/II
- LTE Band 7/38
- 2.4G/5GHz WLAN
- Bluetooth

LTE Band 5 full SAR test, Spot check for other WWAN bands and WLAN are performed for ensure that SAR measurement for both device are the same. So, the original SAR value can represent this application.

## 5.3 Spot Check Verification Data Section

| Band | BW (MHz) | Modulation | RB Size | RB offset | Mode | Test Position | Gap (mm) | Ch. | Freq. (MHz) | Original model (FCC ID: 2AJOTTA-1038) | | | | Spot check model (FCC ID: 2AJOTTA-1032) | | | | Deviation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Average Power (dBm) | Tune-Up Limit (dBm) | Measured 1g SAR (W/kg) | Reported 1g SAR (W/kg) | Average Power (dBm) | Tune-Up Limit (dBm) | Measured 1g SAR (W/kg) | Reported 1g SAR (W/kg) | |
| WLAN2.4GHz | - | - | - | - | 802.11b 1Mbps | Right Cheek | 0 | 6 | 2437 | 15.94 | 16.5 | 0.668 | 0.760 | 15.94 | 16.5 | 0.763 | 0.868 | 12.44% |
| WLAN 5.3GHz | - | - | - | - | 802.11a 6Mbps | Right Cheek | 0 | 64 | 5320 | 8.72 | 9.5 | 0.026 | 0.033 | 8.72 | 9.5 | 0.025 | 0.031 | -6.45% |
| WLAN5.5GHz | - | - | - | - | 802.11a 6Mbps | Right Cheek | 0 | 100 | 5500 | 8.82 | 9.5 | 0.035 | 0.042 | 8.82 | 9.5 | 0.038 | 0.046 | 8.70% |
| WLAN 5.8GHz | - | - | - | - | 802.11a 6Mbps | Right Cheek | 0 | 157 | 5785 | 8.02 | 9.5 | 0.064 | 0.092 | 8.02 | 9.5 | 0.059 | 0.085 | -9.41% |
| GSM850 | - | - | - | - | GPRS 4 Tx slots | Left Side | 10 | 189 | 836.4 | 29.59 | 30 | 1.060 | 1.165 | 29.59 | 30 | 1.060 | 1.165 | 0.00% |
| GSM1900 | - | - | - | - | GPRS 3 Tx slots | Bottom Side | 10 | 512 | 1850.2 | 26.1 | 27 | 0.966 | 1.188 | 26.1 | 27 | 0.873 | 1.074 | -10.61% |
| WCDMA Band V | - | - | - | - | RMC12.2Kbps | Left Side | 10 | 4233 | 846.6 | 24.18 | 24.5 | 0.651 | 0.701 | 24.18 | 24.5 | 0.813 | 0.875 | 19.89% |
| WCDMA Band II | - | - | - | - | RMC12.2Kbps | Bottom Side | 10 | 9262 | 1852.4 | 19.66 | 20.5 | 0.845 | 1.025 | 19.66 | 20.5 | 0.828 | 1.005 | -1.99% |
| LTE Band 7 | 20M | QPSK | 50 | 0 | - | Bottom Side | 10 | 21100 | 2535 | 19.59 | 20 | 0.601 | 0.661 | 19.59 | 20 | 0.534 | 0.587 | -12.61% |
| LTE Band 38 | 20M | QPSK | 1 | 0 | - | Bottom Side | 10 | 38000 | 2595 | 23.45 | 24 | 0.907 | 1.036 | 23.45 | 24 | 0.834 | 0.952 | -8.82% |

**Note:** In the table above, all the deviation of SAR test results are compliant with uncertainty budget.

## 5.4 Reference detail Section

| Equipment Class | Reference FCC ID | Folder Test/RF Exposure | Report Title/Section |
|---|---|---|---|
| PCE | 2AJOTTA-1038 | RF Exposure(FA711304-01) | All sections applicable |
| DSS | 2AJOTTA-1038 | RF Exposure(FA711304-01) | All sections applicable |
| DTS (BLE) | 2AJOTTA-1038 | RF Exposure(FA711304-01) | All sections applicable |
| DTS (WLAN 2.4GHz) | 2AJOTTA-1038 | RF Exposure(FA711304-01) | All sections applicable |
| NIII (WLAN 5GHz) | 2AJOTTA-1038 | RF Exposure(FA711304-01) | All sections applicable |

# 6. RF Exposure Limits

## 6.1 Uncontrolled Environment

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

## 6.2 Controlled Environment

Controlled Environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. The exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

**Limits for Occupational/Controlled Exposure (W/kg)**

| Whole-Body | Partial-Body | Hands, Wrists, Feet and Ankles |
|---|---|---|
| 0.4 | 8.0 | 20.0 |

**Limits for General Population/Uncontrolled Exposure (W/kg)**

| Whole-Body | Partial-Body | Hands, Wrists, Feet and Ankles |
|---|---|---|
| 0.08 | 1.6 | 4.0 |

Whole-Body SAR is averaged over the entire body, partial-body SAR is averaged over any 1gram of tissue defined as a tissue volume in the shape of a cube. SAR for hands, wrists, feet and ankles is averaged over any 10 grams of tissue defined as a tissue volume in the shape of a cube.

# 7. Specific Absorption Rate (SAR)

## 7.1 Introduction

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

## 7.2 SAR Definition

The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density (ρ). The equation description is as below:

$$\mathbf{SAR} = \frac{\mathbf{d}}{\mathbf{dt}}\left(\frac{\mathbf{dW}}{\mathbf{dm}}\right) = \frac{\mathbf{d}}{\mathbf{dt}}\left(\frac{\mathbf{dW}}{\boldsymbol{\rho}\mathbf{dv}}\right)$$

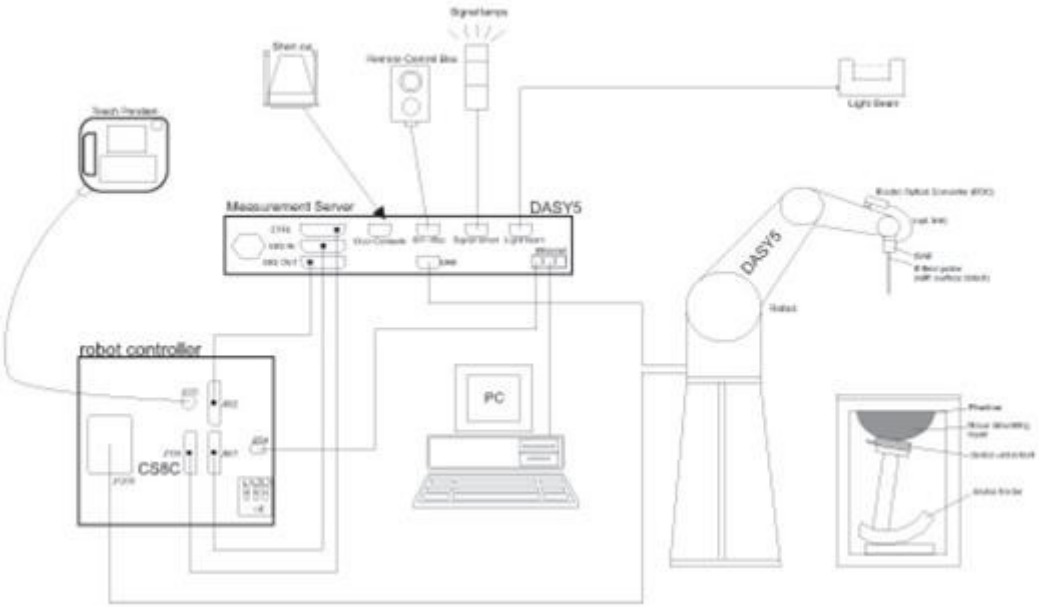
SAR is expressed in units of Watts per kilogram (W/kg)

$$\mathbf{SAR} = \frac{\boldsymbol{\sigma}|\mathbf{E}|^2}{\boldsymbol{\rho}}$$

Where: σ is the conductivity of the tissue, ρ is the mass density of the tissue and E is the RMS electrical field strength.

# 8. System Description and Setup

**The DASY system used for performing compliance tests consists of the following items:**




- A standard high precision 6-axis robot with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic Field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP or Win7 and the DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

## 8.1 E-Field Probe

The SAR measurement is conducted with the dosimetric probe (manufactured by SPEAG).The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency. This probe has a built in optical surface detection system to prevent from collision with phantom.

**<EX3DV4 Probe>**

| | | |
|---|---|---|
| **Construction** | Symmetric design with triangular core<br>Built-in shielding against static charges<br>PEEK enclosure material (resistant to organic solvents, e.g., DGBE) | |
| **Frequency** | 10 MHz – >6 GHz<br>Linearity: ±0.2 dB (30 MHz – 6 GHz) | |
| **Directivity** | ±0.3 dB in TSL (rotation around probe axis)<br>±0.5 dB in TSL (rotation normal to probe axis) | |
| **Dynamic Range** | 10 µW/g – >100 mW/g<br>Linearity: ±0.2 dB (noise: typically <1 µW/g) | |
| **Dimensions** | Overall length: 337 mm (tip: 20 mm)<br>Tip diameter: 2.5 mm (body: 12 mm)<br>Typical distance from probe tip to dipole centers: 1 mm | |

## 8.2 Data Acquisition Electronics (DAE)

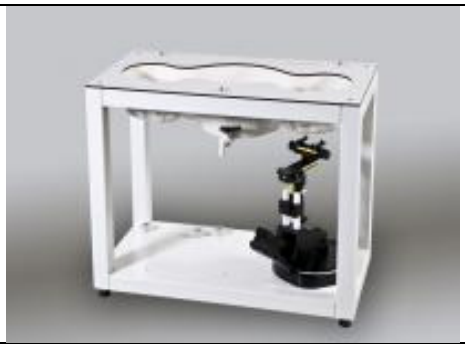
The data acquisition electronics (DAE) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock.

The input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

**Fig 5.1 Photo of DAE**

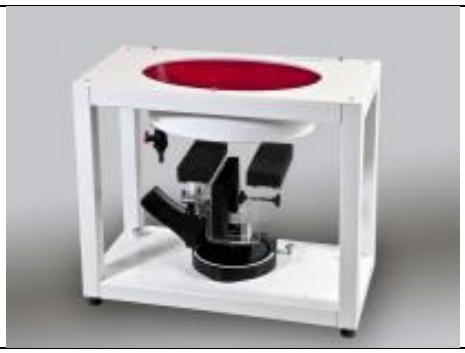
## 8.3 Phantom

**<SAM Twin Phantom>**

| | | |
|---|---|---|
| **Shell Thickness** | 2 ± 0.2 mm;<br>Center ear point: 6 ± 0.2 mm |  |
| **Filling Volume** | Approx. 25 liters | |
| **Dimensions** | Length: 1000 mm; Width: 500 mm; Height: adjustable feet | |
| **Measurement Areas** | Left Hand, Right Hand, Flat Phantom | |

The bottom plate contains three pair of bolts for locking the device holder. The device holder positions are adjusted to the standard measurement positions in the three sections. A white cover is provided to tap the phantom during off-periods to prevent water evaporation and changes in the liquid parameters. On the phantom top, three reference markers are provided to identify the phantom position with respect to the robot.

**<ELI Phantom>**

| | | |
|---|---|---|
| **Shell Thickness** | 2 ± 0.2 mm (sagging: <1%) |  |
| **Filling Volume** | Approx. 30 liters | |
| **Dimensions** | Major ellipse axis: 600 mm<br>Minor axis: 400 mm | |

The ELI phantom is intended for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI4 is fully compatible with standard and all known tissue simulating liquids.

## 8.4 Device Holder

**<Mounting Device for Hand-Held Transmitter>**

In combination with the Twin SAM V5.0/V5.0c or ELI phantoms, the Mounting Device for Hand-Held Transmitters enables rotation of the mounted transmitter device to specified spherical coordinates. At the heads, the rotation axis is at the ear opening. Transmitter devices can be easily and accurately positioned according to IEC 62209-1, IEEE 1528, FCC, or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat). And upgrade kit to Mounting Device to enable easy mounting of wider devices like big smart-phones, e-books, small tablets, etc. It holds devices with width up to 140 mm.

Mounting Device for Hand-Held Transmitters

Mounting Device Adaptor for Wide-Phones

**<Mounting Device for Laptops and other Body-Worn Transmitters>**

The extension is lightweight and made of POM, acrylic glass and foam. It fits easily on the upper part of the mounting device in place of the phone positioned. The extension is fully compatible with the SAM Twin and ELI phantoms.

Mounting Device for Laptops

# 9. Measurement Procedures

The measurement procedures are as follows:

<Conducted power measurement>

(a) For WWAN power measurement, use base station simulator to configure EUT WWAN transmission in conducted connection with RF cable, at maximum power in each supported wireless interface and frequency band.
(b) Read the WWAN RF power level from the base station simulator.
(c) For WLAN/BT power measurement, use engineering software to configure EUT WLAN/BT continuously transmission, at maximum RF power in each supported wireless interface and frequency band
(d) Connect EUT RF port through RF cable to the power meter, and measure WLAN/BT output power

<SAR measurement>

(a) Use base station simulator to configure EUT WWAN transmission in radiated connection, and engineering software to configure EUT WLAN/BT continuously transmission, at maximum RF power, in the highest power channel.
(b) Place the EUT in the positions as Appendix D demonstrates.
(c) Set scan area, grid size and other setting on the DASY software.
(d) Measure SAR results for the highest power channel on each testing position.
(e) Find out the largest SAR result on these testing positions of each band
(f) Measure SAR results for other channels in worst SAR testing position if the reported SAR of highest power channel is larger than 0.8 W/kg

According to the test standard, the recommended procedure for assessing the peak spatial-average SAR value consists of the following steps:

(a) Power reference measurement
(b) Area scan
(c) Zoom scan
(d) Power drift measurement

## 9.1 Spatial Peak SAR Evaluation

The procedure for spatial peak SAR evaluation has been implemented according to the test standard. It can be conducted for 1g and 10g, as well as for user-specific masses. The DASY software includes all numerical procedures necessary to evaluate the spatial peak SAR value.

The base for the evaluation is a "cube" measurement. The measured volume must include the 1g and 10g cubes with the highest averaged SAR values. For that purpose, the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan.

The entire evaluation of the spatial peak values is performed within the post-processing engine (SEMCAD). The system always gives the maximum values for the 1g and 10g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

(a) Extraction of the measured data (grid and values) from the Zoom Scan
(b) Calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
(c) Generation of a high-resolution mesh within the measured volume
(d) Interpolation of all measured values form the measurement grid to the high-resolution grid
(e) Extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
(f) Calculation of the averaged SAR within masses of 1g and 10g

## 9.2 Power Reference Measurement

The Power Reference Measurement and Power Drift Measurements are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

## 9.3 Area Scan

The area scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum found in the scanned area, within a range of the global maximum. The range (in dB0 is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE standard 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan), if only one zoom scan follows the area scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of zoom scans has to be increased accordingly.

Area scan parameters extracted from FCC KDB 865664 D01v01r04 SAR measurement 100 MHz to 6 GHz.

| | ≤ 3 GHz | > 3 GHz |
|---|---|---|
| Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface | 5 ± 1 mm | ½·δ·ln(2) ± 0.5 mm |
| Maximum probe angle from probe axis to phantom surface normal at the measurement location | 30° ± 1° | 20° ± 1° |
| Maximum area scan spatial resolution: $\Delta x_{Area}$, $\Delta y_{Area}$ | ≤ 2 GHz: ≤ 15 mm<br>2 – 3 GHz: ≤ 12 mm | 3 – 4 GHz: ≤ 12 mm<br>4 – 6 GHz: ≤ 10 mm |
| | When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device. | |

## 9.4 Zoom Scan

Zoom scans are used assess the peak spatial SAR values within a cubic averaging volume containing 1 gram and 10 gram of simulated tissue. The zoom scan measures points (refer to table below) within a cube shoes base faces are centered on the maxima found in a preceding area scan job within the same procedure. When the measurement is done, the zoom scan evaluates the averaged SAR for 1 gram and 10 gram and displays these values next to the job's label.

Zoom scan parameters extracted from FCC KDB 865664 D01v01r04 SAR measurement 100 MHz to 6 GHz.

| | | | ≤ 3 GHz | > 3 GHz |
|---|---|---|---|---|
| Maximum zoom scan spatial resolution: $\Delta x_{Zoom}$, $\Delta y_{Zoom}$ | | | ≤ 2 GHz: ≤ 8 mm<br>2 – 3 GHz: ≤ 5 mm* | 3 – 4 GHz: ≤ 5 mm*<br>4 – 6 GHz: ≤ 4 mm* |
| Maximum zoom scan spatial resolution, normal to phantom surface | uniform grid: $\Delta z_{Zoom}(n)$ | | ≤ 5 mm | 3 – 4 GHz: ≤ 4 mm<br>4 – 5 GHz: ≤ 3 mm<br>5 – 6 GHz: ≤ 2 mm |
| | graded grid | $\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface | ≤ 4 mm | 3 – 4 GHz: ≤ 3 mm<br>4 – 5 GHz: ≤ 2.5 mm<br>5 – 6 GHz: ≤ 2 mm |
| | | $\Delta z_{Zoom}(n>1)$: between subsequent points | $\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$ | |
| Minimum zoom scan volume | x, y, z | | ≥ 30 mm | 3 – 4 GHz: ≥ 28 mm<br>4 – 5 GHz: ≥ 25 mm<br>5 – 6 GHz: ≥ 22 mm |

Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.

* When zoom scan is required and the *reported* SAR from the *area scan based 1-g SAR estimation* procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.

## 9.5 Volume Scan Procedures

The volume scan is used for assess overlapping SAR distributions for antennas transmitting in different frequency bands. It is equivalent to an oversized zoom scan used in standalone measurements. The measurement volume will be used to enclose all the simultaneous transmitting antennas. For antennas transmitting simultaneously in different frequency bands, the volume scan is measured separately in each frequency band. In order to sum correctly to compute the 1g aggregate SAR, the EUT remain in the same test position for all measurements and all volume scan use the same spatial resolution and grid spacing. When all volume scan were completed, the software, SEMCAD postprocessor can combine and subsequently superpose these measurement data to calculating the multiband SAR.

## 9.6 Power Drift Monitoring

All SAR testing is under the EUT install full charged battery and transmit maximum output power. In DASY measurement software, the power reference measurement and power drift measurement procedures are used for monitoring the power drift of EUT during SAR test. Both these procedures measure the field at a specified reference position before and after the SAR testing. The software will calculate the field difference in dB. If the power drifts more than 5%, the SAR will be retested.

# 10. Test Equipment List

| Manufacturer | Name of Equipment | Type/Model | Serial Number | Calibration | |
|---|---|---|---|---|---|
| | | | | Last Cal. | Due Date |
| SPEAG | 835MHz System Validation Kit | D835V2 | 4d151 | 2016/3/16 | 2017/3/15 |
| SPEAG | Data Acquisition Electronics | DAE4 | 1279 | 2016/4/4 | 2017/4/3 |
| SPEAG | Dosimetric E-Field Probe | EX3DV4 | 3954 | 2016/11/28 | 2017/11/27 |
| SPEAG | Phone Positioner | N/A | N/A | NCR | NCR |
| SPEAG | SAM Twin Phantom | QD 000 P40 CB | TP-1542 | NCR | NCR |
| Anritsu | Radio communication analyzer | MT8820C | 6201563814 | 2016/3/21 | 2017/3/20 |
| Agilent | Wireless Communication Test Set | E5515C | MY52102706 | 2016/4/22 | 2017/4/21 |
| Agilent | ENA Series Network Analyzer | E5071C | MY46111157 | 2016/4/22 | 2017/4/21 |
| SPEAG | DAK Kit | DAK3.5 | 1144 | 2016/11/23 | 2017/11/22 |
| R&S | Signal Generator | SMR40 | 100455 | 2017/1/19 | 2018/1/18 |
| Anritsu | Power Senor | MA2411B | 1644003 | 2016/12/23 | 2017/12/22 |
| Anritsu | Power Meter | ML2495A | 1531197 | 2016/12/23 | 2017/12/22 |
| Anritsu | Power Senor | MA2411B | 1644004 | 2016/12/23 | 2017/12/22 |
| Anritsu | Power Meter | ML2495A | 1531198 | 2016/12/23 | 2017/12/22 |
| R&S | CBT BLUETOOTH TESTER | CBT | 101137 | 2016/8/9 | 2017/8/8 |
| R&S | Spectrum Analyzer | FSV7 | 101631 | 2016/8/8 | 2017/8/7 |
| ARRA | Power Divider | A3200-2 | NA | Note1 | |
| Agilent | Dual Directional Coupler | 778D | 50422 | Note1 | |
| PASTERNACK | Dual Directional Coupler | PE2214-10 | N/A | Note1 | |
| AR | Amplifier | 5S1G4 | 333096 | Note1 | |
| MCL | Attenuation1 | BW-S10W5+ | N/A | Note1 | |
| MCL | Attenuation2 | BW-S10W5+ | N/A | Note1 | |
| MCL | Attenuation3 | BW-S10W5+ | N/A | Note1 | |

**General Note:**

1. Prior to system verification and validation, the path loss from the signal generator to the system check source and the power meter, which includes the amplifier, cable, attenuator and directional coupler, was measured by the network analyzer. The reading of the power meter was offset by the path loss difference between the path to the power meter and the path to the system check source to monitor the actual power level fed to the system check source.

# 11. System Verification

## 11.1 Tissue Simulating Liquids

For the measurement of the field distribution inside the SAM phantom with DASY, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. For head SAR testing, the liquid height from the ear reference point (ERP) of the phantom to the liquid top surface is larger than 15 cm, which is shown in Fig. 10.1. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm, which is shown in Fig. 10.2.

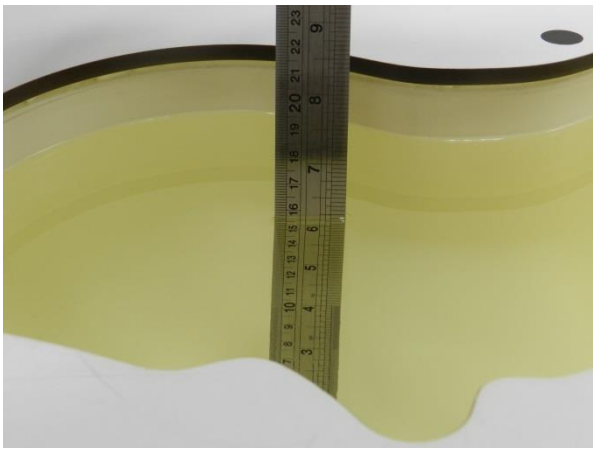


**Fig 10.1Photo of Liquid Height for Head SAR**

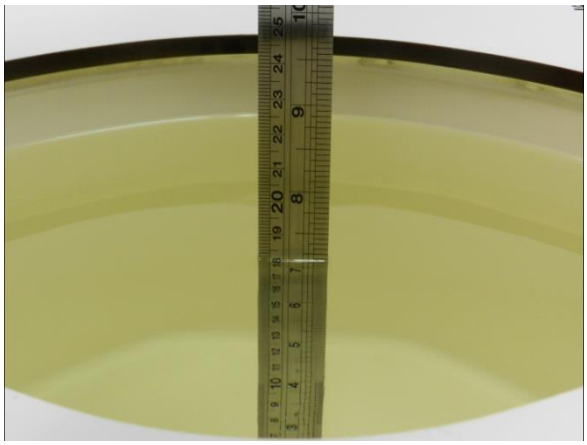


**Fig 10.2 Photo of Liquid Height for Body SAR**

## 11.2 Tissue Verification

The following tissue formulations are provided for reference only as some of the parameters have not been thoroughly verified. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation.

| Frequency (MHz) | Water (%) | Sugar (%) | Cellulose (%) | Salt (%) | Preventol (%) | DGBE (%) | Conductivity (σ) | Permittivity (εr) |
|---|---|---|---|---|---|---|---|---|
| For Head | | | | | | | | |
| 835 | 40.3 | 57.9 | 0.2 | 1.4 | 0.2 | 0 | 0.90 | 41.5 |
| For Body | | | | | | | | |
| 835 | 50.8 | 48.2 | 0 | 0.9 | 0.1 | 0 | 0.97 | 55.2 |

### <Tissue Dielectric Parameter Check Results>

| Frequency (MHz) | Tissue Type | Liquid Temp. (℃) | Conductivity (σ) | Permittivity ($\varepsilon_r$) | Conductivity Target (σ) | Permittivity Target ($\varepsilon_r$) | Delta (σ) (%) | Delta ($\varepsilon_r$) (%) | Limit (%) | Date |
|---|---|---|---|---|---|---|---|---|---|---|
| 835 | Head | 22.9 | 0.887 | 40.927 | 0.90 | 41.50 | -1.44 | -1.38 | ±5 | 2017.2.8 |
| 835 | Body | 22.8 | 0.989 | 56.278 | 0.97 | 55.20 | 1.96 | 1.95 | ±5 | 2017.1.24 |

## 11.3 System Performance Check Results

Comparing to the original SAR value provided by SPEAG, the verification data should be within its specification of 10 %. Below table shows the target SAR and measured SAR after normalized to 1W input power. The table below indicates the system performance check can meet the variation criterion and the plots can be referred to Appendix A of this report.

| Date | Frequency (MHz) | Tissue Type | Input Power (mW) | Dipole S/N | Probe S/N | DAE S/N | Measured 1g SAR (W/kg) | Targeted 1g SAR (W/kg) | Normalized 1g SAR (W/kg) | Deviation (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 2017.2.8 | 835 | Head | 250 | 4d151 | 3954 | 1279 | 2.22 | 9.26 | 8.88 | -4.10 |
| 2017.1.24 | 835 | Body | 250 | 4d151 | 3954 | 1279 | 2.54 | 9.52 | 10.16 | 6.72 |

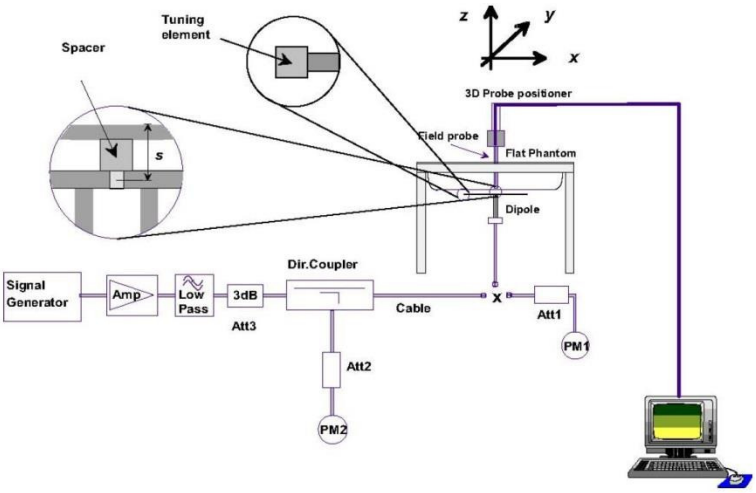



Fig 8.3.1 System Performance Check Setup

Fig 8.3.2 Setup Photo

# 12. RF Exposure Positions

## 12.1 Ear and handset reference point

Figure 9.1.1 shows the front, back, and side views of the SAM phantom. The center-of-mouth reference point is labeled “M,” the left ear reference point (ERP) is marked “LE,” and the right ERP is marked “RE.” Each ERP is 15 mm along the B-M (back-mouth) line behind the entrance-to-ear-canal (EEC) point, as shown in Figure 9.1.2 The Reference Plane is defined as passing through the two ear reference points and point M. The line N-F (neck-front), also called the reference pivoting line, is normal to the Reference Plane and perpendicular to both a line passing through RE and LE and the B-M line (see Figure 9.1.3). Both N-F and B-M lines should be marked on the exterior of the phantom shell to facilitate handset positioning. Posterior to the N-F line the ear shape is a flat surface with 6 mm thickness at each ERP, and forward of the N-F line the ear is truncated, as illustrated in Figure 9.1.2. The ear truncation is introduced to preclude the ear lobe from interfering with handset tilt, which could lead to unstable positioning at the cheek.

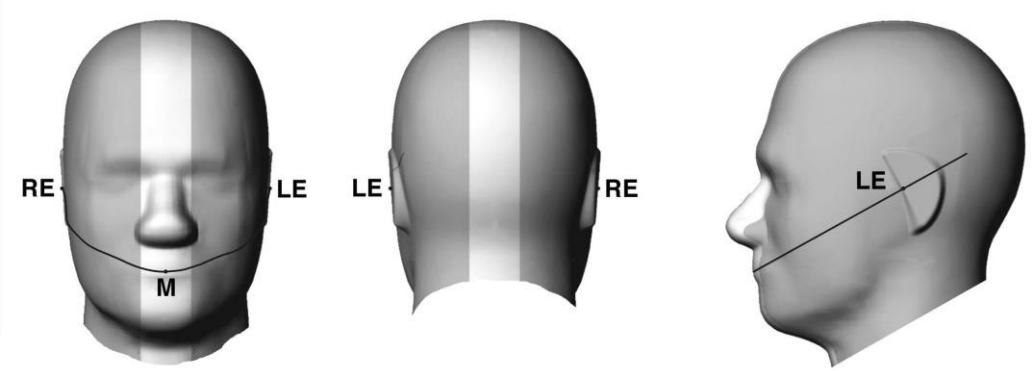



**Fig 9.1.1 Front, back, and side views of SAM twin phantom**

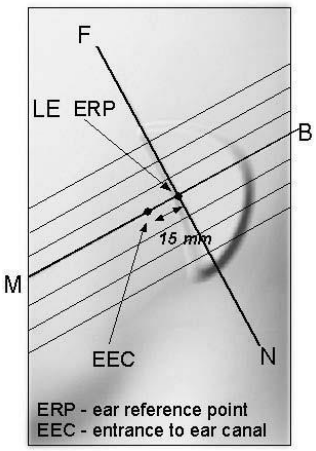



**Fig 9.1.2 Close-up side view of phantom showing the ear region.**

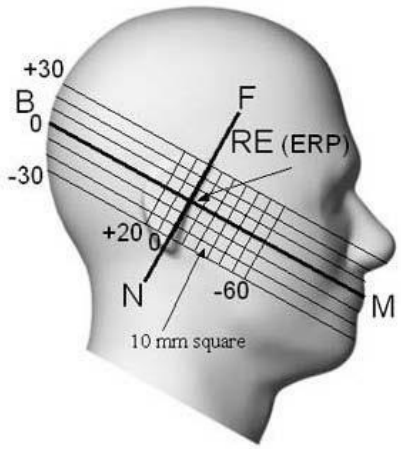



**Fig 9.1.3 Side view of the phantom showing relevant markings and seven cross-sectional plane locations**

## 12.2 Definition of the cheek position

1. Ready the handset for talk operation, if necessary. For example, for handsets with a cover piece (flip cover), open the cover. If the handset can transmit with the cover closed, both configurations must be tested.
2. Define two imaginary lines on the handset—the vertical centerline and the horizontal line. The vertical centerline passes through two points on the front side of the handset—the midpoint of the width wt of the handset at the level of the acoustic output (point A in Figure 9.2.1 and Figure 9.2.2), and the midpoint of the width wb of the bottom of the handset (point B). The horizontal line is perpendicular to the vertical centerline and passes through the center of the acoustic output (see Figure 9.2.1). The two lines intersect at point A. Note that for many handsets, point A coincides with the center of the acoustic output; however, the acoustic output may be located elsewhere on the horizontal line. Also note that the vertical centerline is not necessarily parallel to the front face of the handset (see Figure 9.2.2), especially for clamshell handsets, handsets with flip covers, and other irregularly-shaped handsets.
3. Position the handset close to the surface of the phantom such that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Figure 9.2.3), such that the plane defined by the vertical centerline and the horizontal line of the handset is approximately parallel to the sagittal plane of the phantom.
4. Translate the handset towards the phantom along the line passing through RE and LE until handset point A touches the pinna at the ERP.
5. While maintaining the handset in this plane, rotate it around the LE-RE line until the vertical centerline is in the plane normal to the plane containing B-M and N-F lines, i.e., the Reference Plane.
6. Rotate the handset around the vertical centerline until the handset (horizontal line) is parallel to the N-F line.
7. While maintaining the vertical centerline in the Reference Plane, keeping point A on the line passing through RE and LE, and maintaining the handset contact with the pinna, rotate the handset about the N-F line until any point on the handset is in contact with a phantom point below the pinna on the cheek. See Figure 9.2.3. The actual rotation angles should be documented in the test report.

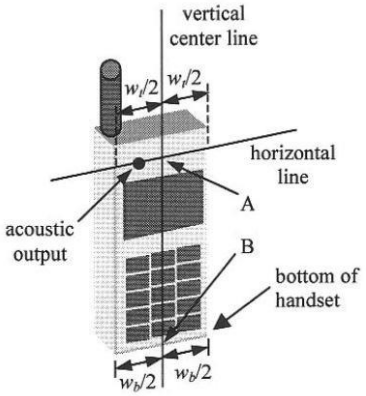



**Fig 9.2.1 Handset vertical and horizontal reference lines—"fixed case**

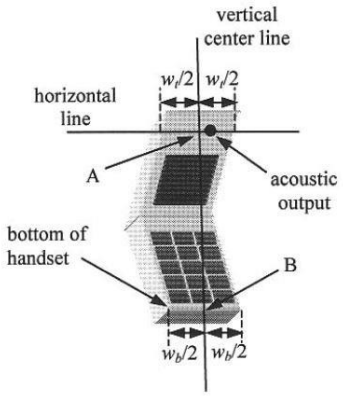



**Fig 9.2.2 Handset vertical and horizontal reference lines—"clam-shell case"**

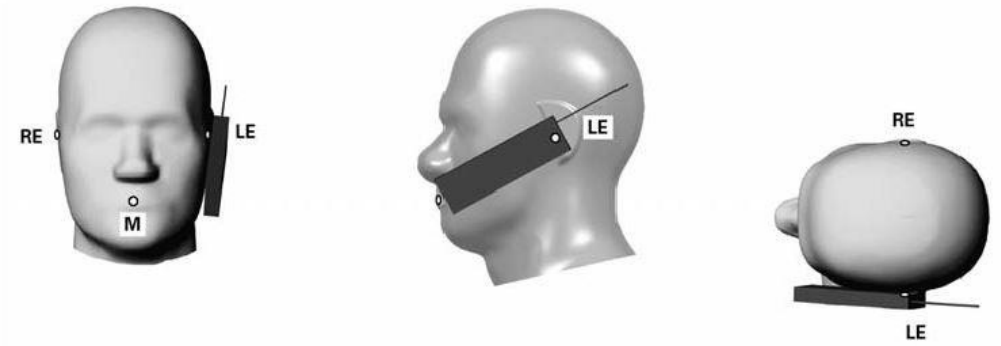



**Fig 9.2.3 cheek or touch position. The reference points for the right ear (RE), left ear (LE), and mouth (M), which establish the Reference Plane for handset positioning, are indicated.**

## 12.3 Definition of the tilt position

1. Ready the handset for talk operation, if necessary. For example, for handsets with a cover piece (flip cover), open the cover. If the handset can transmit with the cover closed, both configurations must be tested.
2. While maintaining the orientation of the handset, move the handset away from the pinna along the line passing through RE and LE far enough to allow a rotation of the handset away from the cheek by 15°.
3. Rotate the handset around the horizontal line by 15°.
4. While maintaining the orientation of the handset, move the handset towards the phantom on the line passing through RE and LE until any part of the handset touches the ear. The tilt position is obtained when the contact point is on the pinna. See Figure 9.3.1. If contact occurs at any location other than the pinna, e.g., the antenna at the back of the phantom head, the angle of the handset should be reduced. In this case, the tilt position is obtained if any point on the handset is in contact with the pinna and a second point

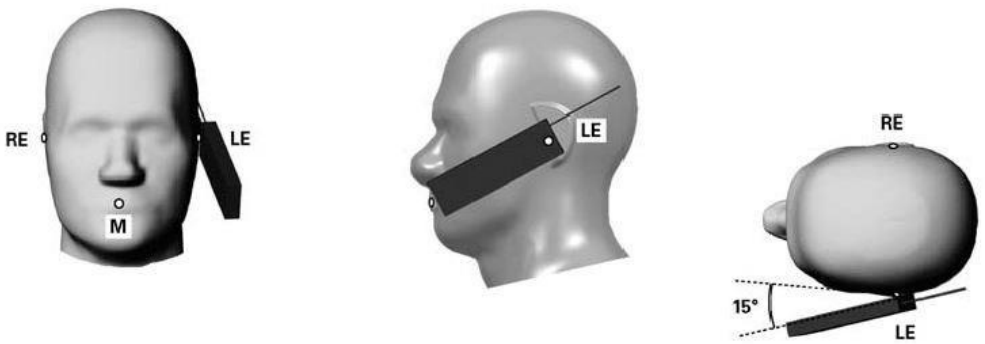



**Fig 9.3.1 Tilt position. The reference points for the right ear (RE), left ear (LE), and mouth (M), which define the Reference Plane for handset positioning, are indicated.**

## 12.4 Body Worn Accessory

Body-worn operating configurations are tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in a normal use configuration (see Figure 9.4). Per KDB648474 D04v01r03, body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories. The body-worn accessory procedures in FCC KDB 447498 D01v06 should be used to test for body-worn accessory SAR compliance, without a headset connected to it. This enables the test results for such configuration to be compatible with that required for hotspot mode when the body-worn accessory test separation distance is greater than or equal to that required for hotspot mode, when applicable. When the reported SAR for body-worn accessory, measured without a headset connected to the handset is > 1.2 W/kg, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for that body-worn accessory with a handset attached to the handset.

Accessories for body-worn operation configurations are divided into two categories: those that do not contain metallic components and those that do contain metallic components and those that do contain metallic components. When multiple accessories that do not contain metallic components are supplied with the device, the device is tested with only the accessory that dictates the closest spacing to the body. Then multiple accessories that contain metallic components are test with the device with each accessory. If multiple accessories share an identical metallic component (i.e. the same metallic belt-chip used with different holsters with no other metallic components) only the accessory that dictates the closest spacing to the body is tested.

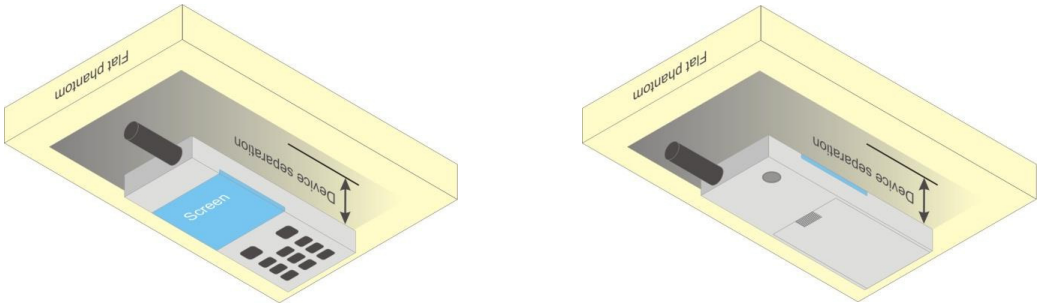



**Fig 9.4 Body Worn Position**

## 12.5 Wireless Router

Some battery-operated handsets have the capability to transmit and receive user through simultaneous transmission of WIFI simultaneously with a separate licensed transmitter. The FCC has provided guidance in FCC KDB Publication 941225 D06 v02r01 where SAR test considerations for handsets (L x W ≥ 9 cm x 5 cm) are based on a composite test separation distance of 10mm from the front, back and edges of the device containing transmitting antennas within 2.5cm of their edges, determined form general mixed use conditions for this type of devices. Since the hotspot SAR results may overlap with the body-worn accessory SAR requirements, the more conservative configurations can be considered, thus excluding some body-worn accessory SAR tests.

When the user enables the personal wireless router functions for the handset, actual operations include simultaneous transmission of both the WIFI transmitter and another licensed transmitter. Both transmitters often do not transmit at the same transmitting frequency and thus cannot be evaluated for SAR under actual use conditions due to the limitations of the SAR assessment probes. Therefore, SAR must be evaluated for each frequency transmission and mode separately and spatially summed with the WIFI transmitter according to FCC KDB Publication 447498 D01v06 publication procedures. The “Portable Hotspot” feature on the handset was NOT activated during SAR assessments, to ensure the SAR measurements were evaluated for a single transmission frequency RF signal at a time.

# 13. Conducted RF Output Power (Unit: dBm)

## <LTE Conducted Power>

**General Note:**

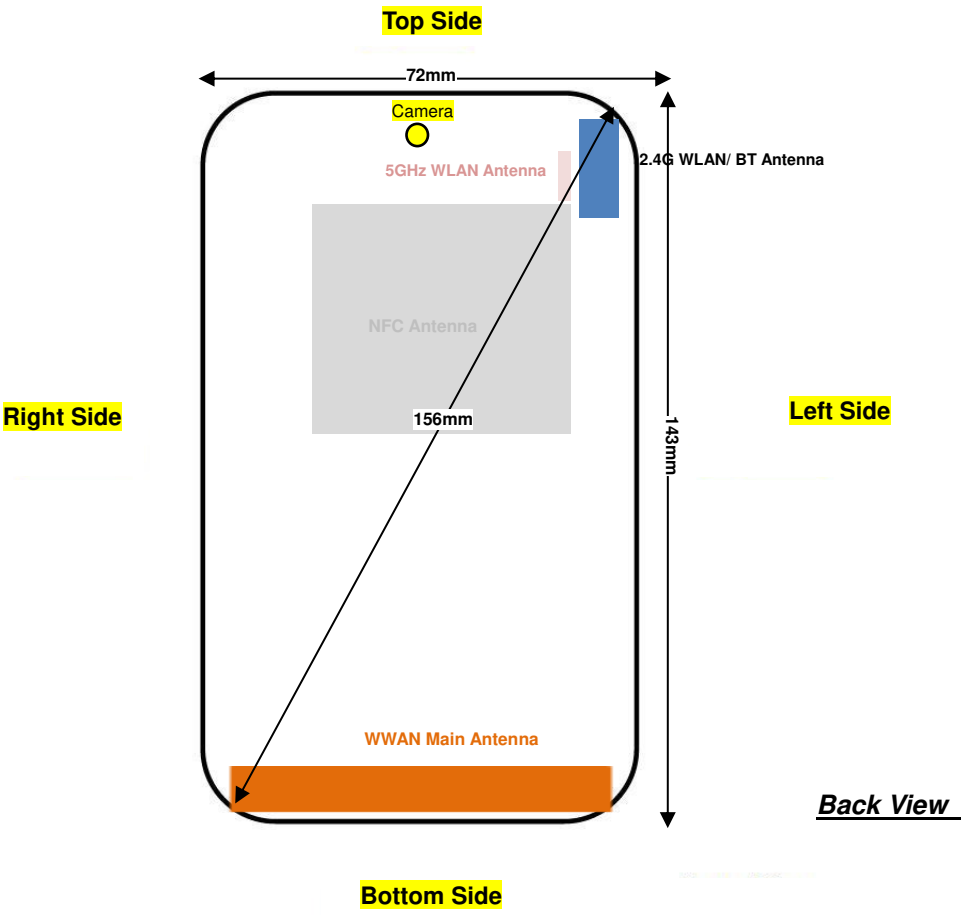
1. Anritsu MT8820C base station simulator was used to setup the connection with EUT; the frequency band, channel bandwidth, RB allocation configuration, modulation type are set in the base station simulator to configure EUT transmitting at maximum power and at different configurations which are requested to be reported to FCC, for conducted power measurement and SAR testing.
2. Per KDB 941225 D05v02r05, when a properly configured base station simulator is used for the SAR and power measurements, spectrum plots for each RB allocation and offset configuration is not required.
3. Per KDB 941225 D05v02r05, start with the largest channel bandwidth and measure SAR for QPSK with 1 RB allocation, using the RB offset and required test channel combination with the highest maximum output power for RB offsets at the upper edge, middle and lower edge of each required test channel.
4. Per KDB 941225 D05v02r05, 50% RB allocation for QPSK SAR testing follows 1RB QPSK allocation procedure.
5. Per KDB 941225 D05v02r05, For QPSK with 100% RB allocation, SAR is not required when the highest maximum output power for 100 % RB allocation is less than the highest maximum output power in 50% and 1 RB allocations and the highest reported SAR for 1 RB and 50% RB allocation are ≤ 0.8 W/kg. Otherwise, SAR is measured for the highest output power channel; and if the reported SAR is > 1.45 W/kg, the remaining required test channels must also be tested.
6. Per KDB 941225 D05v02r05, 16QAM output power for each RB allocation configuration is > not ½ dB higher than the same configuration in QPSK and the reported SAR for the QPSK configuration is ≤ 1.45 W/kg; Per KDB 941225 D05v02r05, 16QAM SAR testing is not required.
7. Per KDB 941225 D05v02r05, Smaller bandwidth output power for each RB allocation configuration is > not ½ dB higher than the same configuration in the largest supported bandwidth, and the reported SAR for the largest supported bandwidth is ≤ 1.45 W/kg; Per KDB 941225 D05v02r05, smaller bandwidth SAR testing is not required.
8. For LTE B5/B38 the maximum bandwidth does not support three non-overlapping channels, per KDB 941225 D05v02r05, when a device supports overlapping channel assignment in a channel bandwidth configuration, the middle channel of the group of overlapping channels should be selected for testing.

**<LTE Band 5>**

| BW [MHz] | Modulation | RB Size | RB Offset | Power Low Ch. / Freq. | Power Middle Ch. / Freq. | Power High Ch. / Freq. | Tune-up limit (dBm) | MPR (dB) |
|---|---|---|---|---|---|---|---|---|
| Channel | | | | 20450 | 20525 | 20600 | | |
| Frequency (MHz) | | | | 829 | 836.5 | 844 | | |
| 10 | QPSK | 1 | 0 | 24.18 | 24.13 | 24.17 | 24.50 | 0 |
| 10 | QPSK | 1 | 25 | 24.17 | 24.12 | 24.16 | | |
| 10 | QPSK | 1 | 49 | 23.15 | 24.04 | 24.13 | | |
| 10 | QPSK | 25 | 0 | 23.26 | 23.20 | 23.25 | 23.50 | 1 |
| 10 | QPSK | 25 | 12 | 23.24 | 23.00 | 23.22 | | |
| 10 | QPSK | 25 | 25 | 23.23 | 23.16 | 23.21 | | |
| 10 | QPSK | 50 | 0 | 23.28 | 23.20 | 23.27 | | |
| 10 | 16QAM | 1 | 0 | 23.41 | 23.43 | 23.41 | 23.50 | 1 |
| 10 | 16QAM | 1 | 25 | 23.36 | 23.49 | 23.39 | | |
| 10 | 16QAM | 1 | 49 | 23.44 | 23.35 | 23.37 | | |
| 10 | 16QAM | 25 | 0 | 22.21 | 22.21 | 22.18 | 22.50 | 2 |
| 10 | 16QAM | 25 | 12 | 22.19 | 22.21 | 22.17 | | |
| 10 | 16QAM | 25 | 25 | 22.20 | 22.17 | 22.23 | | |
| 10 | 16QAM | 50 | 0 | 22.23 | 22.20 | 22.23 | | |
| Channel | | | | 20425 | 20525 | 20625 | Tune-up limit (dBm) | MPR (dB) |
| Frequency (MHz) | | | | 826.5 | 836.5 | 846.5 | | |
| 5 | QPSK | 1 | 0 | 24.18 | 24.10 | 24.14 | 24.50 | 0 |
| 5 | QPSK | 1 | 12 | 24.20 | 24.13 | 24.18 | | |
| 5 | QPSK | 1 | 24 | 24.08 | 24.01 | 24.11 | | |
| 5 | QPSK | 12 | 0 | 23.31 | 23.24 | 23.27 | 23.50 | 1 |
| 5 | QPSK | 12 | 7 | 23.29 | 23.24 | 23.28 | | |
| 5 | QPSK | 12 | 13 | 23.28 | 23.24 | 23.28 | | |
| 5 | QPSK | 25 | 0 | 23.25 | 23.16 | 23.24 | | |
| 5 | 16QAM | 1 | 0 | 23.40 | 23.45 | 23.35 | 23.50 | 1 |
| 5 | 16QAM | 1 | 12 | 23.43 | 23.48 | 23.39 | | |
| 5 | 16QAM | 1 | 24 | 23.30 | 23.35 | 23.32 | | |
| 5 | 16QAM | 12 | 0 | 22.28 | 22.26 | 22.23 | 22.50 | 2 |
| 5 | 16QAM | 12 | 7 | 22.27 | 22.27 | 22.25 | | |
| 5 | 16QAM | 12 | 13 | 22.24 | 22.26 | 22.25 | | |
| 5 | 16QAM | 25 | 0 | 22.20 | 22.18 | 22.19 | | |

| Channel | | | | 20415 | 20525 | 20635 | Tune-up limit (dBm) | MPR (dB) |
|---|---|---|---|---|---|---|---|---|
| Frequency (MHz) | | | | 825.5 | 836.5 | 847.5 | | |
| 3 | QPSK | 1 | 0 | 24.10 | 24.04 | 24.07 | 24.50 | 0 |
| 3 | QPSK | 1 | 8 | 24.18 | 24.06 | 24.13 | | |
| 3 | QPSK | 1 | 14 | 24.10 | 24.00 | 24.07 | | |
| 3 | QPSK | 8 | 0 | 23.28 | 23.23 | 23.24 | 23.50 | 1 |
| 3 | QPSK | 8 | 4 | 23.25 | 23.21 | 23.25 | | |
| 3 | QPSK | 8 | 7 | 23.24 | 23.19 | 23.25 | | |
| 3 | QPSK | 15 | 0 | 23.30 | 23.20 | 23.29 | | |
| 3 | 16QAM | 1 | 0 | 23.33 | 23.39 | 23.30 | 23.50 | 1 |
| 3 | 16QAM | 1 | 8 | 23.37 | 23.44 | 23.38 | | |
| 3 | 16QAM | 1 | 14 | 23.28 | 23.38 | 23.30 | | |
| 3 | 16QAM | 8 | 0 | 22.28 | 22.30 | 22.26 | 22.50 | 2 |
| 3 | 16QAM | 8 | 4 | 22.26 | 22.28 | 22.25 | | |
| 3 | 16QAM | 8 | 7 | 22.25 | 22.28 | 22.28 | | |
| 3 | 16QAM | 15 | 0 | 22.23 | 22.21 | 22.24 | | |
| Channel | | | | 20407 | 20525 | 20643 | Tune-up limit (dBm) | MPR (dB) |
| Frequency (MHz) | | | | 824.7 | 836.5 | 848.3 | | |
| 1.4 | QPSK | 1 | 0 | 24.14 | 24.07 | 24.13 | 24.50 | 0 |
| 1.4 | QPSK | 1 | 3 | 24.22 | 24.13 | 24.19 | | |
| 1.4 | QPSK | 1 | 5 | 24.14 | 24.04 | 24.12 | | |
| 1.4 | QPSK | 3 | 0 | 24.26 | 24.17 | 24.23 | | |
| 1.4 | QPSK | 3 | 1 | 24.21 | 24.11 | 24.19 | | |
| 1.4 | QPSK | 3 | 3 | 24.21 | 24.11 | 24.19 | | |
| 1.4 | QPSK | 6 | 0 | 23.26 | 23.21 | 23.24 | 23.50 | 1 |
| 1.4 | 16QAM | 1 | 0 | 23.38 | 23.44 | 23.36 | 23.50 | 1 |
| 1.4 | 16QAM | 1 | 3 | 23.47 | 23.49 | 23.44 | | |
| 1.4 | 16QAM | 1 | 5 | 23.39 | 23.40 | 23.34 | | |
| 1.4 | 16QAM | 3 | 0 | 23.24 | 23.27 | 23.24 | | |
| 1.4 | 16QAM | 3 | 1 | 23.20 | 23.23 | 23.19 | | |
| 1.4 | 16QAM | 3 | 3 | 23.19 | 23.22 | 23.18 | | |
| 1.4 | 16QAM | 6 | 0 | 22.29 | 22.32 | 22.27 | 22.50 | 2 |

# 14. Antenna Location




| Distance of the Antenna to the EUT surface/edge | | | | | | |
|---|---|---|---|---|---|---|
| Antennas | Back | Front | Top Side | Bottom Side | Right Side | Left Side |
| WWAN Main Antenna | ≤ 25mm | ≤ 25mm | >25mm | ≤ 25mm | ≤ 25mm | ≤ 25mm |
| 2.4GHz WLAN/BT Antenna | ≤ 25mm | ≤ 25mm | ≤ 25mm | >25mm | >25mm | ≤ 25mm |

| Positions for SAR tests; Hotspot mode | | | | | | |
|---|---|---|---|---|---|---|
| Antennas | Back | Front | Top Side | Bottom Side | Right Side | Left Side |
| WWAN Main Antenna | Yes | Yes | No | Yes | Yes | Yes |
| 2.4GHz WLAN/BT Antenna | Yes | Yes | Yes | No | No | Yes |

**General Note:**
Referring to KDB 941225 D06 v02r01, when the overall device length and width are ≥ 9cm*5cm, the test distance is 10 mm. SAR must be measured for all sides and surfaces with a transmitting antenna located within 25mm from that surface or edge.

# 15. SAR Test Results

**General Note:**

1. Per KDB 447498 D01v06, the reported SAR is the measured SAR value adjusted for maximum tune-up tolerance.
   a. Tune-up scaling Factor = tune-up limit power (mW) / EUT RF power (mW), where tune-up limit is the maximum rated power among all production units.
   b. Reported SAR(W/kg)= Measured SAR(W/kg)*Tune-up Scaling Factor
2. Per KDB 447498 D01v06, for each exposure position, testing of other required channels within the operating mode of a frequency band is not required when the *reported* 1-g or 10-g SAR for the mid-band or highest output power channel is:
   - ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz
   - ≤ 0.6 W/kg or 1.5 W/kg, for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz
   - ≤ 0.4 W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≥ 200 MHz
3. Per KDB 865664 D01v01r04, for each frequency band, repeated SAR measurement is not required only when the measured SAR is < 0.8W/kg.
4. Per KDB 648474 D04v01r03, when the reported SAR for a body-worn accessory measured without a headset connected to the handset is ≤ 1.2 W/kg, SAR testing with a headset connected to the handset is not required.

**LTE Note:**

1. Per KDB 941225 D05v02r05, start with the largest channel bandwidth and measure SAR for QPSK with 1 RB allocation, using the RB offset and required test channel combination with the highest maximum output power for RB offsets at the upper edge, middle and lower edge of each required test channel.
2. Per KDB 941225 D05v02r05, 50% RB allocation for QPSK SAR testing follows 1RB QPSK allocation procedure.
3. Per KDB 941225 D05v02r05, For QPSK with 100% RB allocation, SAR is not required when the highest maximum output power for 100 % RB allocation is less than the highest maximum output power in 50% and 1 RB allocations and the highest reported SAR for 1 RB and 50% RB allocation are ≤ 0.8 W/kg. Otherwise, SAR is measured for the highest output power channel; and if the reported SAR is > 1.45 W/kg, the remaining required test channels must also be tested.
4. Per KDB 941225 D05v02r05, 16QAM output power for each RB allocation configuration is > not ½ dB higher than the same configuration in QPSK and the reported SAR for the QPSK configuration is ≤ 1.45 W/kg; Per KDB 941225 D05v02r05, 16QAM SAR testing is not required.
5. Per KDB 941225 D05v02r05, Smaller bandwidth output power for each RB allocation configuration is > not ½ dB higher than the same configuration in the largest supported bandwidth, and the reported SAR for the largest supported bandwidth is ≤ 1.45 W/kg; Per KDB 941225 D05v02r05, smaller bandwidth SAR testing is not required.
6. For LTE B5/B38 the maximum bandwidth does not support three non-overlapping channels, per KDB 941225 D05v02r05, when a device supports overlapping channel assignment in a channel bandwidth configuration, the middle channel of the group of overlapping channels should be selected for testing.

## 15.1 Head SAR

**<LTE SAR>**

| Plot No. | Band | BW (MHz) | Modulation | RB Size | RB offset | Test Position | Ch. | Freq. (MHz) | Average Power (dBm) | Tune-Up Limit (dBm) | Tune-up Scaling Factor | Power Drift (dB) | Measured 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LTE Band 5 | 10M | QPSK | 1RB | 0Offset | Right Cheek | 20525 | 836.5 | 24.13 | 24.50 | 1.089 | 0.13 | 0.237 | 0.258 |
| | LTE Band 5 | 10M | QPSK | 25RB | 0Offset | Right Cheek | 20525 | 836.5 | 23.20 | 23.50 | 1.072 | 0.11 | 0.180 | 0.193 |
| | LTE Band 5 | 10M | QPSK | 1RB | 0Offset | Right Tilted | 20525 | 836.5 | 24.13 | 24.50 | 1.089 | 0.02 | 0.251 | 0.273 |
| | LTE Band 5 | 10M | QPSK | 25RB | 0Offset | Right Tilted | 20525 | 836.5 | 23.20 | 23.50 | 1.072 | 0.04 | 0.252 | 0.270 |
| 01 | LTE Band 5 | 10M | QPSK | 1RB | 0Offset | Left Cheek | 20525 | 836.5 | 24.13 | 24.50 | 1.089 | 0.07 | 0.293 | **0.319** |
| | LTE Band 5 | 10M | QPSK | 25RB | 0Offset | Left Cheek | 20525 | 836.5 | 23.20 | 23.50 | 1.072 | 0.11 | 0.232 | 0.249 |
| | LTE Band 5 | 10M | QPSK | 1RB | 0Offset | Left Tilted | 20525 | 836.5 | 24.13 | 24.50 | 1.089 | 0.04 | 0.227 | 0.247 |
| | LTE Band 5 | 10M | QPSK | 25RB | 0Offset | Left Tilted | 20525 | 836.5 | 23.20 | 23.50 | 1.072 | -0.08 | 0.183 | 0.196 |

## 15.2 Hotspot SAR

**<LTE SAR>**

| Plot No. | Band | BW (MHz) | Modulation | RB Size | RB offset | Test Position | Gap (mm) | Ch. | Freq. (MHz) | Average Power (dBm) | Tune-Up Limit (dBm) | Tune-up Scaling Factor | Power Drift (dB) | Measured 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LTE Band 5 | 10M | QPSK | 1RB | 0Offset | Front | 10 | 20525 | 836.5 | 24.13 | 24.50 | 1.089 | -0.01 | 0.496 | 0.540 |
| | LTE Band 5 | 10M | QPSK | 25RB | 0Offset | Front | 10 | 20525 | 836.5 | 23.20 | 23.50 | 1.072 | 0.02 | 0.399 | 0.428 |
| | LTE Band 5 | 10M | QPSK | 1RB | 0Offset | Back | 10 | 20525 | 836.5 | 24.13 | 24.50 | 1.089 | -0.07 | 0.493 | 0.537 |
| | LTE Band 5 | 10M | QPSK | 25RB | 0Offset | Back | 10 | 20525 | 836.5 | 23.20 | 23.50 | 1.072 | -0.01 | 0.394 | 0.422 |
| 02 | LTE Band 5 | 10M | QPSK | 1RB | 0Offset | Left Side | 10 | 20525 | 836.5 | 24.13 | 24.50 | 1.089 | 0.03 | 0.583 | **0.635** |
| | LTE Band 5 | 10M | QPSK | 25RB | 0Offset | Left Side | 10 | 20525 | 836.5 | 23.20 | 23.50 | 1.072 | 0.01 | 0.468 | 0.501 |
| | LTE Band 5 | 10M | QPSK | 1RB | 0Offset | Right Side | 10 | 20525 | 836.5 | 24.13 | 24.50 | 1.089 | 0.02 | 0.227 | 0.247 |
| | LTE Band 5 | 10M | QPSK | 25RB | 0Offset | Right Side | 10 | 20525 | 836.5 | 23.20 | 23.50 | 1.072 | 0.02 | 0.174 | 0.186 |
| | LTE Band 5 | 10M | QPSK | 1RB | 0Offset | Bottom Side | 10 | 20525 | 836.5 | 24.13 | 24.50 | 1.089 | 0.16 | 0.220 | 0.240 |
| | LTE Band 5 | 10M | QPSK | 25RB | 0Offset | Bottom Side | 10 | 20525 | 836.5 | 23.20 | 23.50 | 1.072 | 0.1 | 0.183 | 0.196 |

## 15.3 Body Worn Accessory SAR

**<LTE SAR>**

| Plot No. | Band | BW (MHz) | Modulation | RB Size | RB offset | Test Position | Gap (mm) | Ch. | Freq. (MHz) | Average Power (dBm) | Tune-Up Limit (dBm) | Tune-up Scaling Factor | Power Drift (dB) | Measured 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LTE Band 5 | 10M | QPSK | 1RB | 0Offset | Front | 15 | 20525 | 836.5 | 24.13 | 24.50 | 1.089 | -0.01 | 0.424 | 0.462 |
| | LTE Band 5 | 10M | QPSK | 25RB | 0Offset | Front | 15 | 20525 | 836.5 | 23.20 | 23.50 | 1.072 | 0.06 | 0.336 | 0.360 |
| 03 | LTE Band 5 | 10M | QPSK | 1RB | 0Offset | Back | 15 | 20525 | 836.5 | 24.13 | 24.50 | 1.089 | -0.01 | 0.464 | **0.505** |
| | LTE Band 5 | 10M | QPSK | 25RB | 0Offset | Back | 15 | 20525 | 836.5 | 23.20 | 23.50 | 1.072 | -0.04 | 0.328 | 0.351 |

# 16. Simultaneous Transmission Analysis

| NO. | Simultaneous Transmission Configurations | Portable Handset | | | Note |
|---|---|---|---|---|---|
| | | Head | Body-worn | Hotspot | |
| 1. | GSM Voice + WLAN2.4GHz | Yes | Yes | | |
| 2. | GPRS/EDGE + WLAN2.4GHz | Yes | Yes | Yes | Hotspot |
| 3. | WCDMA + WLAN2.4GHz | Yes | Yes | Yes | Hotspot |
| 4. | LTE + WLAN2.4GHz | Yes | Yes | Yes | Hotspot |
| 5. | GSM Voice + WLAN5GHz | Yes | Yes | | |
| 6. | GPRS/EDGE + WLAN5GHz | Yes | Yes | | WWAN VoIP |
| 7. | WCDMA + WLAN5GHz | Yes | Yes | | WWAN VoIP |
| 8. | LTE + WLAN5GHz | Yes | Yes | | WWAN VoIP |
| 9. | GSM Voice + Bluetooth | | Yes | | |
| 10. | GPRS/EDGE + Bluetooth | | Yes | | WWAN VoIP |
| 11. | WCDMA+ Bluetooth | | Yes | | WWAN VoIP |
| 12. | LTE + Bluetooth | | Yes | | WWAN VoIP |

## 16.1 Head Exposure Conditions

| WWAN Band | | Exposure Position | 1 WWAN 1g SAR (W/kg) | 2 2.4GHz WLAN 1g SAR (W/kg) | 3 5GHz WLAN 1g SAR (W/kg) | 1+2 Summed 1g SAR (W/kg) | 1+3 Summed 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|
| GSM | GSM850 | Right Cheek | 0.410 | 0.760 | 0.092 | 1.17 | 0.50 |
| | | Right Tilted | 0.436 | 0.760 | 0.092 | 1.20 | 0.53 |
| | | Left Cheek | 0.482 | 0.760 | 0.092 | 1.24 | 0.57 |
| | | Left Tilted | 0.363 | 0.760 | 0.092 | 1.12 | 0.46 |
| | GSM1900 | Right Cheek | 0.109 | 0.760 | 0.092 | 0.87 | 0.20 |
| | | Right Tilted | 0.021 | 0.760 | 0.092 | 0.78 | 0.11 |
| | | Left Cheek | 0.152 | 0.760 | 0.092 | 0.91 | 0.24 |
| | | Left Tilted | 0.055 | 0.760 | 0.092 | 0.82 | 0.15 |
| WCDMA | Band II | Right Cheek | 0.161 | 0.760 | 0.092 | 0.92 | 0.25 |
| | | Right Tilted | 0.034 | 0.760 | 0.092 | 0.79 | 0.13 |
| | | Left Cheek | 0.220 | 0.760 | 0.092 | 0.98 | 0.31 |
| | | Left Tilted | 0.083 | 0.760 | 0.092 | 0.84 | 0.18 |
| | Band V | Right Cheek | 0.249 | 0.760 | 0.092 | 1.01 | 0.34 |
| | | Right Tilted | 0.263 | 0.760 | 0.092 | 1.02 | 0.36 |
| | | Left Cheek | 0.354 | 0.760 | 0.092 | 1.11 | 0.45 |
| | | Left Tilted | 0.291 | 0.760 | 0.092 | 1.05 | 0.38 |
| LTE | Band 5 | Right Cheek | 0.258 | 0.760 | 0.092 | 1.02 | 0.35 |
| | | Right Tilted | 0.273 | 0.760 | 0.092 | 1.03 | 0.37 |
| | | Left Cheek | 0.319 | 0.760 | 0.092 | 1.08 | 0.41 |
| | | Left Tilted | 0.247 | 0.760 | 0.092 | 1.01 | 0.34 |
| | Band 7 | Right Cheek | 0.075 | 0.760 | 0.092 | 0.84 | 0.17 |
| | | Right Tilted | 0.024 | 0.760 | 0.092 | 0.78 | 0.12 |
| | | Left Cheek | 0.143 | 0.760 | 0.092 | 0.90 | 0.24 |
| | | Left Tilted | 0.039 | 0.760 | 0.092 | 0.80 | 0.13 |
| | Band 38 | Right Cheek | 0.031 | 0.760 | 0.092 | 0.79 | 0.12 |
| | | Right Tilted | 0.013 | 0.760 | 0.092 | 0.77 | 0.11 |
| | | Left Cheek | 0.089 | 0.760 | 0.092 | 0.85 | 0.18 |
| | | Left Tilted | 0.015 | 0.760 | 0.092 | 0.78 | 0.11 |

## 16.2 Hotspot Exposure Conditions

| WWAN Band | | Exposure Position | 1 WWAN 1g SAR (W/kg) | 2 2.4GHz WLAN 1g SAR (W/kg) | 1+2 Summed 1g SAR (W/kg) |
|---|---|---|---|---|---|
| GSM | GSM850 | Front | 0.851 | 0.173 | 1.02 |
| | | Back | 0.902 | 0.173 | 1.08 |
| | | Left side | 1.165 | 0.173 | 1.34 |
| | | Right side | 0.393 | | 0.39 |
| | | Top side | | 0.173 | 0.17 |
| | | Bottom side | 0.379 | | 0.38 |
| | GSM1900 | Front | 0.927 | 0.173 | 1.10 |
| | | Back | 0.907 | 0.173 | 1.08 |
| | | Left side | 0.229 | 0.173 | 0.40 |
| | | Right side | 0.013 | | 0.01 |
| | | Top side | | 0.173 | 0.17 |
| | | Bottom side | 1.188 | | 1.19 |
| WCDMA | Band II | Front | 0.586 | 0.173 | 0.76 |
| | | Back | 0.551 | 0.173 | 0.72 |
| | | Left side | 0.173 | 0.173 | 0.35 |
| | | Right side | 0.010 | | 0.01 |
| | | Top side | | 0.173 | 0.17 |
| | | Bottom side | 1.025 | | 1.03 |
| | Band V | Front | 0.565 | 0.173 | 0.74 |
| | | Back | 0.664 | 0.173 | 0.84 |
| | | Left side | 0.701 | 0.173 | 0.87 |
| | | Right side | 0.145 | | 0.15 |
| | | Top side | | 0.173 | 0.17 |
| | | Bottom side | 0.288 | | 0.29 |
| LTE | Band 5 | Front | 0.540 | 0.173 | 0.713 |
| | | Back | 0.537 | 0.173 | 0.710 |
| | | Left side | 0.635 | 0.173 | 0.808 |
| | | Right side | 0.247 | | 0.247 |
| | | Top side | | 0.173 | 0.173 |
| | | Bottom side | 0.240 | | 0.240 |
| | Band 7 | Front | 0.337 | 0.173 | 0.51 |
| | | Back | 0.325 | 0.173 | 0.50 |
| | | Left side | 0.049 | 0.173 | 0.22 |
| | | Right side | 0.120 | | 0.12 |
| | | Top side | | 0.173 | 0.17 |
| | | Bottom side | 0.661 | | 0.66 |
| | Band 38 | Front | 0.542 | 0.173 | 0.72 |
| | | Back | 0.499 | 0.173 | 0.67 |
| | | Left side | 0.074 | 0.173 | 0.25 |
| | | Right side | 0.217 | | 0.22 |
| | | Top side | | 0.173 | 0.17 |
| | | Bottom side | 1.036 | | 1.04 |

## 16.3 Body-Worn Accessory Exposure Conditions

| WWAN Band | | Exposure Position | 1 | 2 | 3 | 4 | 1+2 Summed 1g SAR (W/kg) | 1+3 Summed 1g SAR (W/kg) | 1+4 Summed 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| | | | WWAN | 2.4GHz WLAN | 5GHz WLAN | Bluetooth | | | |
| | | | 1g SAR (W/kg) | 1g SAR (W/kg) | 1g SAR (W/kg) | Estimated 1g SAR (W/kg) | | | |
| GSM | GSM850 | Front | 0.611 | 0.086 | 0.007 | 0.084 | 0.70 | 0.62 | 0.70 |
| | | Back | 0.684 | 0.086 | 0.007 | 0.084 | 0.77 | 0.69 | 0.77 |
| | GSM1900 | Front | 0.626 | 0.086 | 0.007 | 0.084 | 0.71 | 0.63 | 0.71 |
| | | Back | 0.578 | 0.086 | 0.007 | 0.084 | 0.66 | 0.59 | 0.66 |
| WCDMA | Band II | Front | 0.938 | 0.086 | 0.007 | 0.084 | 1.02 | **0.95** | 1.02 |
| | | Back | 0.897 | 0.086 | 0.007 | 0.084 | 0.98 | 0.90 | 0.98 |
| | Band V | Front | 0.427 | 0.086 | 0.007 | 0.084 | 0.51 | 0.43 | 0.51 |
| | | Back | 0.471 | 0.086 | 0.007 | 0.084 | 0.56 | 0.48 | 0.56 |
| LTE | Band 5 | Front | 0.462 | 0.086 | 0.007 | 0.084 | 0.55 | 0.47 | 0.55 |
| | | Back | 0.505 | 0.086 | 0.007 | 0.084 | 0.59 | 0.51 | 0.59 |
| | Band 7 | Front | 0.562 | 0.086 | 0.007 | 0.084 | 0.65 | 0.57 | 0.65 |
| | | Back | 0.508 | 0.086 | 0.007 | 0.084 | 0.59 | 0.52 | 0.59 |
| | Band 38 | Front | 0.277 | 0.086 | 0.007 | 0.084 | 0.36 | 0.28 | 0.36 |
| | | Back | 0.266 | 0.086 | 0.007 | 0.084 | 0.35 | 0.27 | 0.35 |

**Test Engineer：** Nick Hu

# 17. Uncertainty Assessment

The component of uncertainly may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainly by the statistical analysis of a series of observations is termed a Type An evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience, and knowledge of the behavior and properties of relevant materials and instruments, manufacture's specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in table below.

| Uncertainty Distributions | Normal | Rectangular | Triangular | U-Shape |
|---|---|---|---|---|
| Multi-plying Factor[(a)] | 1/k[(b)] | $1/\sqrt{3}$ | $1/\sqrt{6}$ | $1/\sqrt{2}$ |

(a) standard uncertainty is determined as the product of the multiplying factor and the estimated range of variations in the measured quantity

(b) $\kappa$ is the coverage factor

**Table 17.1. Standard Uncertainty for Assumed Distribution**

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual "root-sum-squares" (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is shown in the following tables.

| Error Description | Uncertainty Value (±%) | Probability | Divisor | (Ci) 1g | (Ci) 10g | Standard Uncertainty (1g) (±%) | Standard Uncertainty (10g) (±%) |
|---|---|---|---|---|---|---|---|
| **Measurement System** | | | | | | | |
| Probe Calibration | 6.0 | N | 1 | 1 | 1 | 6.0 | 6.0 |
| Axial Isotropy | 4.7 | R | 1.732 | 0.7 | 0.7 | 1.9 | 1.9 |
| Hemispherical Isotropy | 9.6 | R | 1.732 | 0.7 | 0.7 | 3.9 | 3.9 |
| Boundary Effects | 1.0 | R | 1.732 | 1 | 1 | 0.6 | 0.6 |
| Linearity | 4.7 | R | 1.732 | 1 | 1 | 2.7 | 2.7 |
| System Detection Limits | 1.0 | R | 1.732 | 1 | 1 | 0.6 | 0.6 |
| Modulation Response | 3.2 | R | 1.732 | 1 | 1 | 1.8 | 1.8 |
| Readout Electronics | 0.3 | N | 1 | 1 | 1 | 0.3 | 0.3 |
| Response Time | 0.0 | R | 1.732 | 1 | 1 | 0.0 | 0.0 |
| Integration Time | 2.6 | R | 1.732 | 1 | 1 | 1.5 | 1.5 |
| RF Ambient Noise | 3.0 | R | 1.732 | 1 | 1 | 1.7 | 1.7 |
| RF Ambient Reflections | 3.0 | R | 1.732 | 1 | 1 | 1.7 | 1.7 |
| Probe Positioner | 0.4 | R | 1.732 | 1 | 1 | 0.2 | 0.2 |
| Probe Positioning | 2.9 | R | 1.732 | 1 | 1 | 1.7 | 1.7 |
| Max. SAR Eval. | 2.0 | R | 1.732 | 1 | 1 | 1.2 | 1.2 |
| **Test Sample Related** | | | | | | | |
| Device Positioning | 3.0 | N | 1 | 1 | 1 | 3.0 | 3.0 |
| Device Holder | 3.6 | N | 1 | 1 | 1 | 3.6 | 3.6 |
| Power Drift | 5.0 | R | 1.732 | 1 | 1 | 2.9 | 2.9 |
| Power Scaling | 0.0 | R | 1.732 | 1 | 1 | 0.0 | 0.0 |
| **Phantom and Setup** | | | | | | | |
| Phantom Uncertainty | 6.1 | R | 1.732 | 1 | 1 | 3.5 | 3.5 |
| SAR correction | 0.0 | R | 1.732 | 1 | 0.84 | 0.0 | 0.0 |
| Liquid Conductivity Repeatability | 0.2 | N | 1 | 0.78 | 0.71 | 0.1 | 0.1 |
| Liquid Conductivity (target) | 5.0 | R | 1.732 | 0.78 | 0.71 | 2.3 | 2.0 |
| Liquid Conductivity (mea.) | 2.5 | R | 1.732 | 0.78 | 0.71 | 1.1 | 1.0 |
| Temp. unc. - Conductivity | 3.4 | R | 1.732 | 0.78 | 0.71 | 1.5 | 1.4 |
| Liquid Permittivity Repeatability | 0.15 | N | 1 | 0.23 | 0.26 | 0.0 | 0.0 |
| Liquid Permittivity (target) | 5.0 | R | 1.732 | 0.23 | 0.26 | 0.7 | 0.8 |
| Liquid Permittivity (mea.) | 2.5 | R | 1.732 | 0.23 | 0.26 | 0.3 | 0.4 |
| Temp. unc. - Permittivity | 0.83 | R | 1.732 | 0.23 | 0.26 | 0.1 | 0.1 |
| **Combined Std. Uncertainty** | | | | | | 11.4% | 11.4% |
| **Coverage Factor for 95 %** | | | | | | K=2 | K=2 |
| **Expanded STD Uncertainty** | | | | | | 22.9% | 22.7% |

**Table 17.2. Uncertainty Budget for frequency range 300 MHz to 3 GHz**

| Error Description | Uncertainty Value (±%) | Probability | Divisor | (Ci) 1g | (Ci) 10g | Standard Uncertainty (1g) (±%) | Standard Uncertainty (10g) (±%) |
|---|---|---|---|---|---|---|---|
| **Measurement System** | | | | | | | |
| Probe Calibration | 6.55 | N | 1 | 1 | 1 | 6.6 | 6.6 |
| Axial Isotropy | 4.7 | R | 1.732 | 0.7 | 0.7 | 1.9 | 1.9 |
| Hemispherical Isotropy | 9.6 | R | 1.732 | 0.7 | 0.7 | 3.9 | 3.9 |
| Boundary Effects | 2.0 | R | 1.732 | 1 | 1 | 1.2 | 1.2 |
| Linearity | 4.7 | R | 1.732 | 1 | 1 | 2.7 | 2.7 |
| System Detection Limits | 1.0 | R | 1.732 | 1 | 1 | 0.6 | 0.6 |
| Modulation Response | 3.2 | R | 1.732 | 1 | 1 | 1.8 | 1.8 |
| Readout Electronics | 0.3 | N | 1 | 1 | 1 | 0.3 | 0.3 |
| Response Time | 0.0 | R | 1.732 | 1 | 1 | 0.0 | 0.0 |
| Integration Time | 2.6 | R | 1.732 | 1 | 1 | 1.5 | 1.5 |
| RF Ambient Noise | 3.0 | R | 1.732 | 1 | 1 | 1.7 | 1.7 |
| RF Ambient Reflections | 3.0 | R | 1.732 | 1 | 1 | 1.7 | 1.7 |
| Probe Positioner | 0.4 | R | 1.732 | 1 | 1 | 0.2 | 0.2 |
| Probe Positioning | 6.7 | R | 1.732 | 1 | 1 | 3.9 | 3.9 |
| Max. SAR Eval. | 4.0 | R | 1.732 | 1 | 1 | 2.3 | 2.3 |
| **Test Sample Related** | | | | | | | |
| Device Positioning | 3.0 | N | 1 | 1 | 1 | 3.0 | 3.0 |
| Device Holder | 3.6 | N | 1 | 1 | 1 | 3.6 | 3.6 |
| Power Drift | 5.0 | R | 1.732 | 1 | 1 | 2.9 | 2.9 |
| Power Scaling | 0.0 | R | 1.732 | 1 | 1 | 0.0 | 0.0 |
| **Phantom and Setup** | | | | | | | |
| Phantom Uncertainty | 6.6 | R | 1.732 | 1 | 1 | 3.8 | 3.8 |
| SAR correction | 0.0 | R | 1.732 | 1 | 0.84 | 0.0 | 0.0 |
| Liquid Conductivity Repeatability | 0.2 | N | 1 | 0.78 | 0.71 | 0.1 | 0.1 |
| Liquid Conductivity (target) | 5.0 | R | 1.732 | 0.78 | 0.71 | 2.3 | 2.0 |
| Liquid Conductivity (mea.) | 2.5 | R | 1.732 | 0.78 | 0.71 | 1.1 | 1.0 |
| Temp. unc. - Conductivity | 3.4 | R | 1.732 | 0.78 | 0.71 | 1.5 | 1.4 |
| Liquid Permittivity Repeatability | 0.15 | N | 1 | 0.23 | 0.26 | 0.0 | 0.0 |
| Liquid Permittivity (target) | 5.0 | R | 1.732 | 0.23 | 0.26 | 0.7 | 0.8 |
| Liquid Permittivity (mea.) | 2.5 | R | 1.732 | 0.23 | 0.26 | 0.3 | 0.4 |
| Temp. unc. - Permittivity | 0.83 | R | 1.732 | 0.23 | 0.26 | 0.1 | 0.1 |
| **Combined Std. Uncertainty** | | | | | | 12.5% | 12.5% |
| **Coverage Factor for 95 %** | | | | | | K=2 | K=2 |
| **Expanded STD Uncertainty** | | | | | | 25.1% | 25.0% |

**Table 17.3. Uncertainty Budget for frequency range 3 GHz to 6 GHz**

# 18. References


[1] FCC 47 CFR Part 2 “Frequency Allocations and Radio Treaty Matters; General Rules and Regulations”

[2] ANSI/IEEE Std. C95.1-1992, “IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz”, September 1992

[3] IEEE Std. 1528-2013, “IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques”, Sep 2013

[4] SPEAG DASY System Handbook

[5] FCC KDB 865664 D01 v01r04, "SAR Measurement Requirements for 100 MHz to 6 GHz", Aug 2015.

[6] FCC KDB 865664 D02 v01r02, “RF Exposure Compliance Reporting and Documentation Considerations” Oct 2015.

[7] FCC KDB 447498 D01 v06, “Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies”, Oct 2015

[8] FCC KDB 648474 D04 v01r03, “SAR Evaluation Considerations for Wireless Handsets”, Oct 2015.

[9] FCC KDB 248227 D01 v02r02, “SAR Guidance for IEEE 802.11 (WiFi) Transmitters”, Oct 2015.

[10] FCC KDB 941225 D01 v03r01, “3G SAR MEAUREMENT PROCEDURES”, Oct 2015

[11] FCC KDB 941225 D05 v02r05, “SAR Evaluation Considerations for LTE Devices”, Dec 2015

[12] FCC KDB 941225 D06 v02r01, "SAR Evaluation Procedures for Portable Devices with Wireless Router Capabilities", Oct 2015.

# Appendix A. Plots of System Performance Check

The plots are shown as follows.

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2017.2.8

**System Check_Head_835MHz**

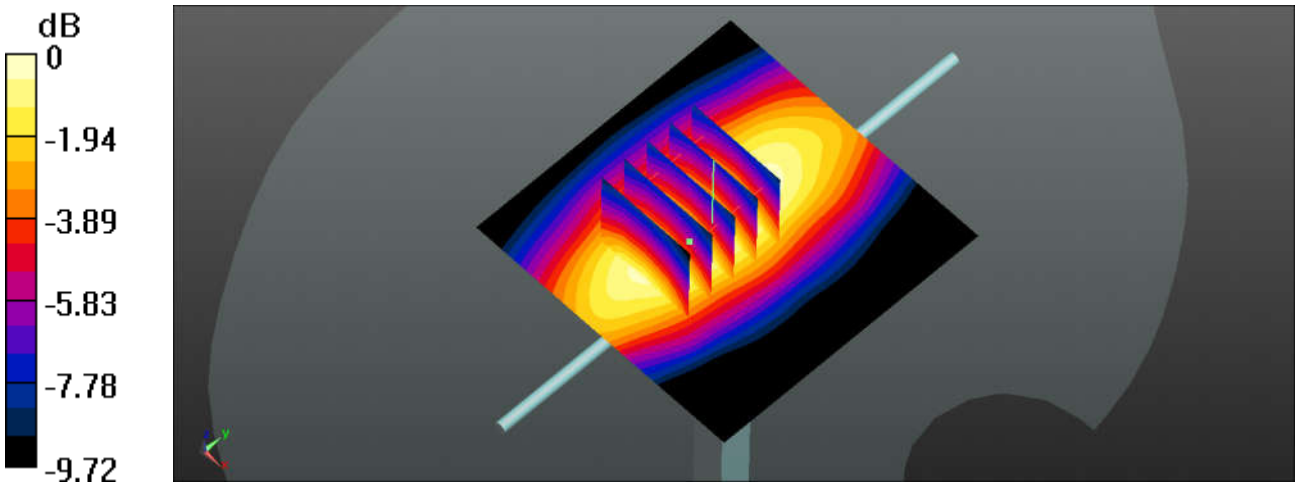
**DUT: D835V2 - SN:4d151**

Communication System: UID 0, CW (0); Frequency: 835 MHz;Duty Cycle: 1:1
Medium: HSL_835 Medium parameters used: f = 835 MHz; $\sigma$ = 0.887 S/m; $\varepsilon_r$ = 40.927; $\rho$ = 1000 kg/m$^3$
Ambient Temperature：23.2 ℃; Liquid Temperature：22.9 ℃

DASY5 Configuration:
- Probe: EX3DV4 - SN3954; ConvF(10.52, 10.52, 10.52); Calibrated: 2016.11.28;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1279; Calibrated: 2016.4.4
- Phantom: SAM2; Type: SAM; Serial: TP-1542
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Pin=250mW/Area Scan (61x61x1):** Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 2.79 W/kg

**Pin=250mW/Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 49.75 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 2.91 W/kg
**SAR(1 g) = 2.22 W/kg; SAR(10 g) = 1.54 W/kg**
Maximum value of SAR (measured) = 2.64 W/kg




0 dB = 2.64 W/kg = 4.22 dBW/kg

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2017.1.24

**System Check_Body_835MHz**

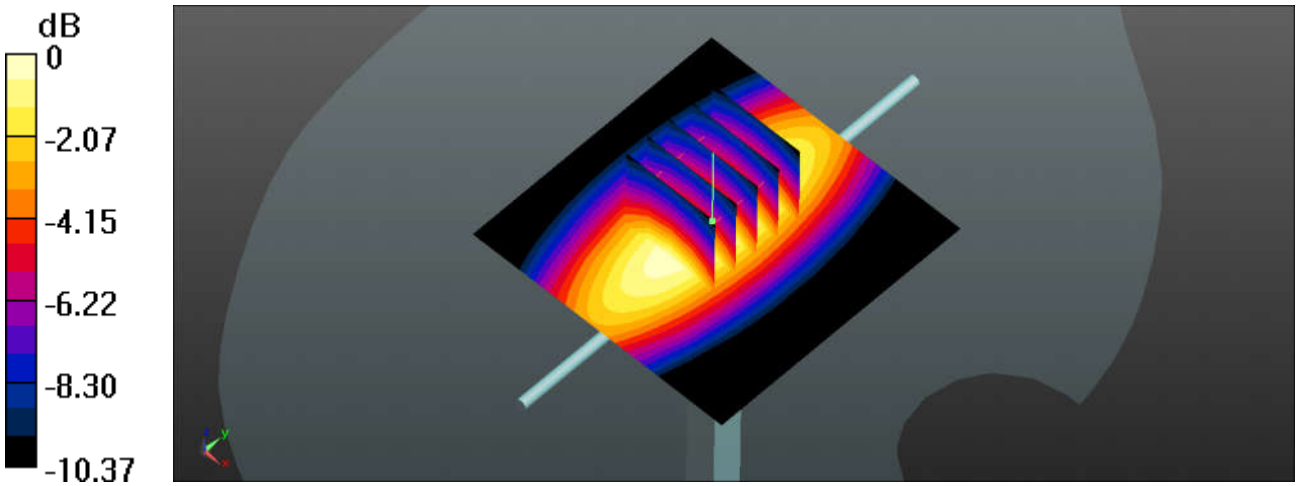
**DUT: D835V2 - SN:4d151**

Communication System: UID 0, CW (0); Frequency: 835 MHz;Duty Cycle: 1:1
Medium: MSL_835 Medium parameters used: f = 835 MHz; $\sigma$ = 0.989 S/m; $\varepsilon_r$ = 56.278; $\rho$ = 1000 kg/m$^3$
Ambient Temperature：23.3 ℃; Liquid Temperature：22.8 ℃

DASY5 Configuration:
- Probe: EX3DV4 - SN3954; ConvF(10.32, 10.32, 10.32); Calibrated: 2016.11.28;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1279; Calibrated: 2016.4.4
- Phantom: SAM2; Type: SAM; Serial: TP-1542
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Pin=250mW/Area Scan (61x61x1):** Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 3.23 W/kg

**Pin=250mW/Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 52.15 V/m; Power Drift = -0.14 dB
Peak SAR (extrapolated) = 3.74 W/kg
**SAR(1 g) = 2.54 W/kg; SAR(10 g) = 1.67 W/kg**
Maximum value of SAR (measured) = 3.21 W/kg




0 dB = 3.21 W/kg = 5.07 dBW/kg

# Appendix B. Plots of High SAR Measurement

The plots are shown as follows.

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2017.2.8

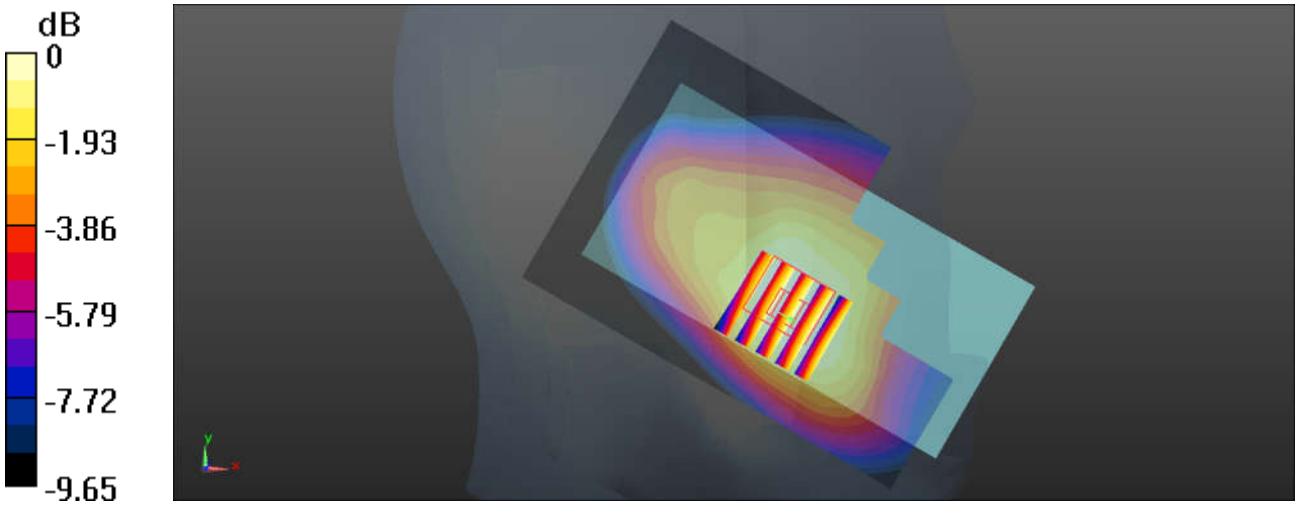
**01_LTE Band 5_10M_QPSK_1RB_0Offset_Left Cheek_0mm_Ch20525**

Communication System: UID 0, FDD_LTE (0); Frequency: 836.5 MHz;Duty Cycle: 1:1
Medium: HSL_835 Medium parameters used : f = 836.5 MHz; $\sigma$ = 0.889 S/m; $\varepsilon_r$ = 40.905; $\rho$ = 1000 kg/m$^3$
Ambient Temperature：23.2 ℃； Liquid Temperature：22.9 ℃

DASY5 Configuration:
- Probe: EX3DV4 - SN3954; ConvF(10.52, 10.52, 10.52); Calibrated: 2016.11.28;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1279; Calibrated: 2016.4.4
- Phantom: SAM2; Type: SAM; Serial: TP-1542
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Ch20525/Area Scan (71x111x1):** Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.346 W/kg

**Ch20525/Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 11.66 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 0.369 W/kg
**SAR(1 g) = 0.293 W/kg; SAR(10 g) = 0.227 W/kg**
Maximum value of SAR (measured) = 0.332 W/kg




0 dB = 0.332 W/kg = -4.79 dBW/kg

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2017.1.24

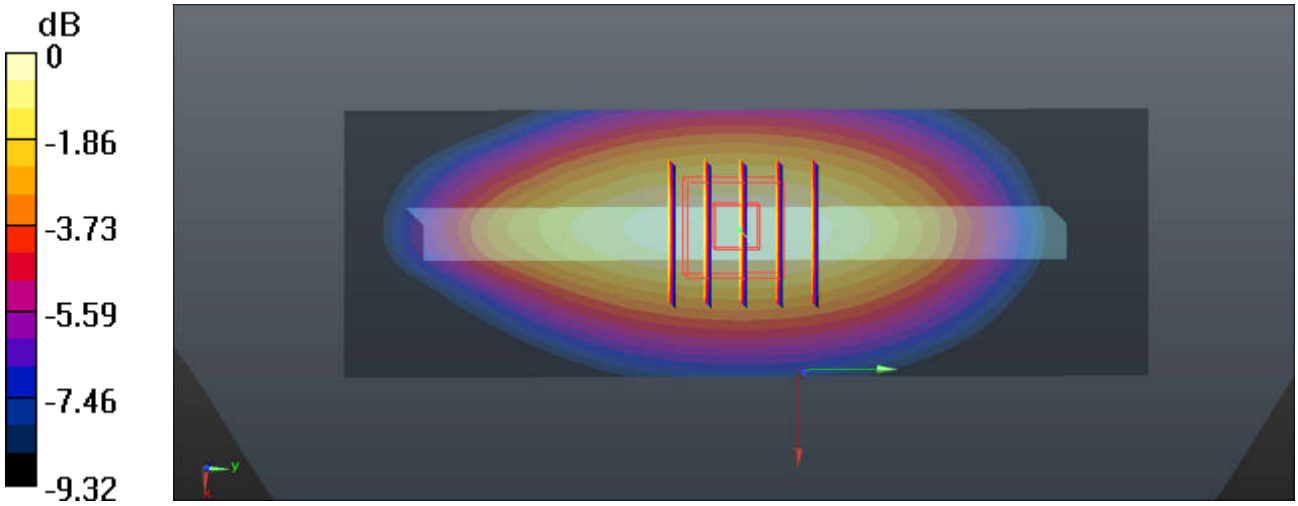
**02_LTE Band 5_10M_QPSK_1RB_0Offset_Left Side_10mm_Ch20525**

Communication System: UID 0, FDD_LTE (0); Frequency: 836.5 MHz;Duty Cycle: 1:1
Medium: MSL_835 Medium parameters used: f = 836.5 MHz; $\sigma$ = 0.99 S/m; $\varepsilon_r$ = 56.262; $\rho$ = 1000 kg/m$^3$
Ambient Temperature：23.3 ℃； Liquid Temperature：22.8 ℃

DASY5 Configuration:
- Probe: EX3DV4 - SN3954; ConvF(10.32, 10.32, 10.32); Calibrated: 2016.11.28;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1279; Calibrated: 2016.4.4
- Phantom: SAM2; Type: SAM; Serial: TP-1542
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Ch20525/Area Scan (41x121x1):** Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.715 W/kg

**Ch20525/Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 27.04 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 0.831 W/kg
**SAR(1 g) = 0.583 W/kg; SAR(10 g) = 0.403 W/kg**
Maximum value of SAR (measured) = 0.719 W/kg




0 dB = 0.719 W/kg = -1.43 dBW/kg

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2017.1.24

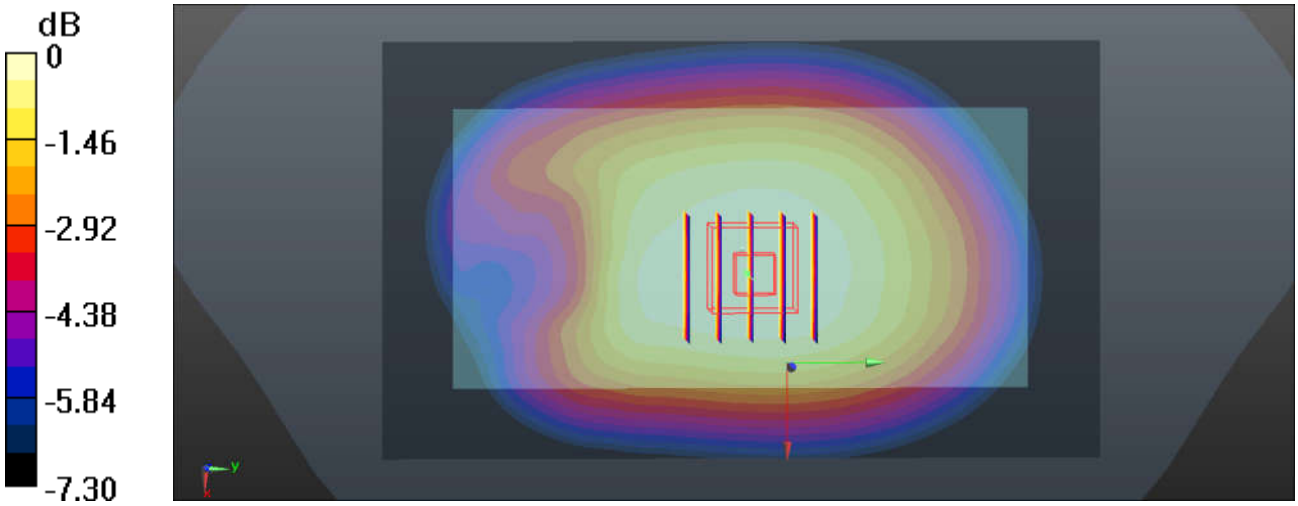
**03_LTE Band 5_10M_QPSK_1RB_0Offset_Back_15mm_Ch20525**

Communication System: UID 0, FDD_LTE (0); Frequency: 836.5 MHz;Duty Cycle: 1:1
Medium: MSL_835 Medium parameters used : f = 836.5 MHz; $\sigma$ = 0.99 S/m; $\varepsilon_r$ = 56.262; $\rho$ = 1000
kg/m$^3$
Ambient Temperature：23.3 ℃; Liquid Temperature：22.8 ℃

DASY5 Configuration:
- Probe: EX3DV4 - SN3954; ConvF(10.32, 10.32, 10.32); Calibrated: 2016.11.28;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1279; Calibrated: 2016.4.4
- Phantom: SAM2; Type: SAM; Serial: TP-1542
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Ch20525/Area Scan (71x121x1):** Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.535 W/kg

**Ch20525/Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 23.43 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 0.587 W/kg
**SAR(1 g) = 0.464 W/kg; SAR(10 g) = 0.361 W/kg**
Maximum value of SAR (measured) = 0.532 W/kg




0 dB = 0.532 W/kg = -2.74 dBW/kg

# 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 0108**

**Client** **Sporton-CN (Auden)**

**Certificate No: D835V2-4d151_Mar16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D835V2 - SN:4d151 |
| Calibration procedure(s) | QA CAL-05.v9<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | March 16, 2016 |

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 | 07-Oct-15 (No. 217-02222) | Oct-16 |
| Power sensor HP 8481A | US37292783 | 07-Oct-15 (No. 217-02222) | Oct-16 |
| Power sensor HP 8481A | MY41092317 | 07-Oct-15 (No. 217-02223) | Oct-16 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 01-Apr-15 (No. 217-02131) | Mar-16 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134) | Mar-16 |
| Reference Probe EX3DV4 | SN: 7349 | 31-Dec-15 (No. EX3-7349_Dec15) | Dec-16 |
| DAE4 | SN: 601 | 30-Dec-15 (No. DAE4-601_Dec15) | Dec-16 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| RF generator R&S SMT-06 | 100972 | 15-Jun-15 (in house check Jun-15) | In house check: Jun-18 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

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

Issued: March 16, 2016

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 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
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) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Additional Documentation:

e) 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 | V52.8.8 |
| **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 | 41.7 ± 6 % | 0.93 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 | 2.37 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **9.26 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.54 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **6.05 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 | 55.2 | 0.97 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 54.5 ± 6 % | 1.01 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 | 2.46 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **9.52 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.61 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **6.28 W/kg ± 16.5 % (k=2)** |

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 52.2 Ω - 3.3 jΩ |
| Return Loss | - 28.3 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 47.9 Ω - 4.5 jΩ |
| Return Loss | - 25.9 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.390 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 | March 27, 2012 |

## DASY5 Validation Report for Head TSL

Date: 16.03.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d151**

Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; $\sigma$ = 0.93 S/m; $\varepsilon_r$ = 41.7; $\rho$ = 1000 kg/m$^3$
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

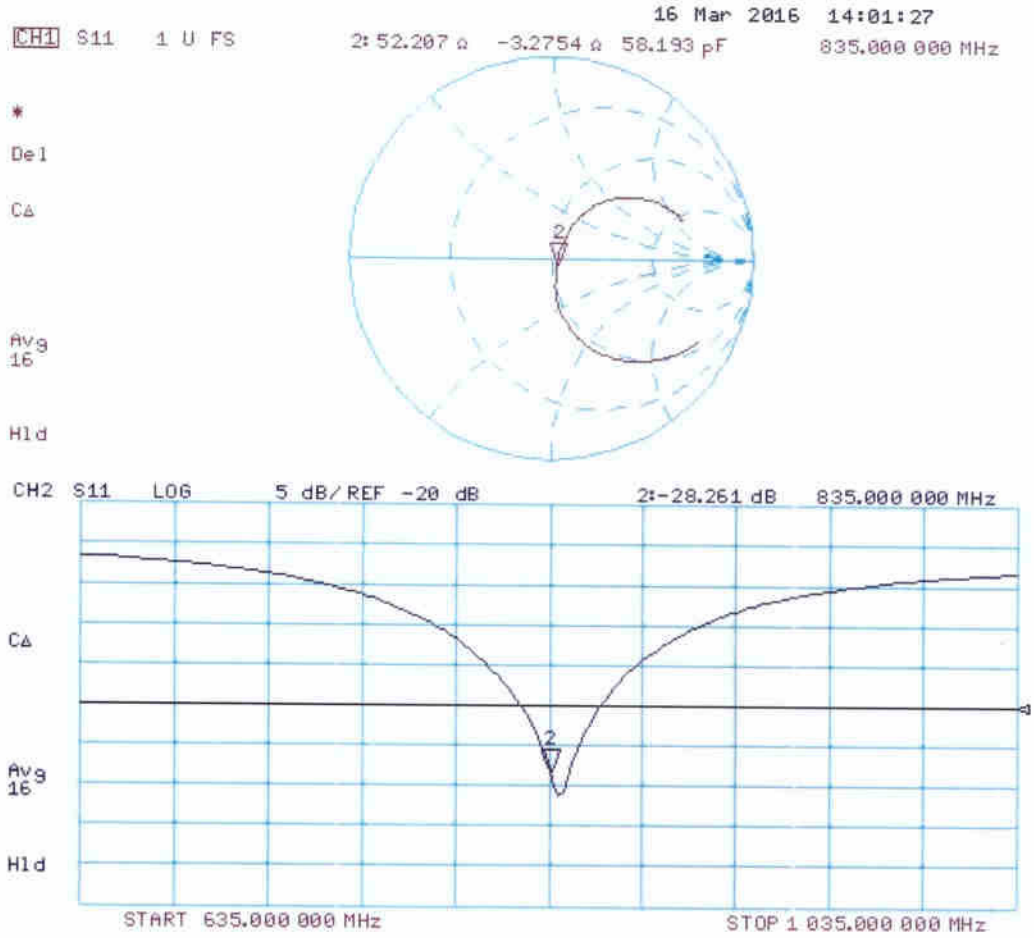
DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.83, 9.83, 9.83); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom Type: QD000P49AA
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Head Tissue EX-Probe/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 61.40 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 3.57 W/kg
**SAR(1 g) = 2.37 W/kg; SAR(10 g) = 1.54 W/kg**
Maximum value of SAR (measured) = 3.18 W/kg

0 dB = 3.18 W/kg = 5.02 dBW/kg

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 16.03.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d151**

Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; $\sigma$ = 1.01 S/m; $\varepsilon_r$ = 54.5; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

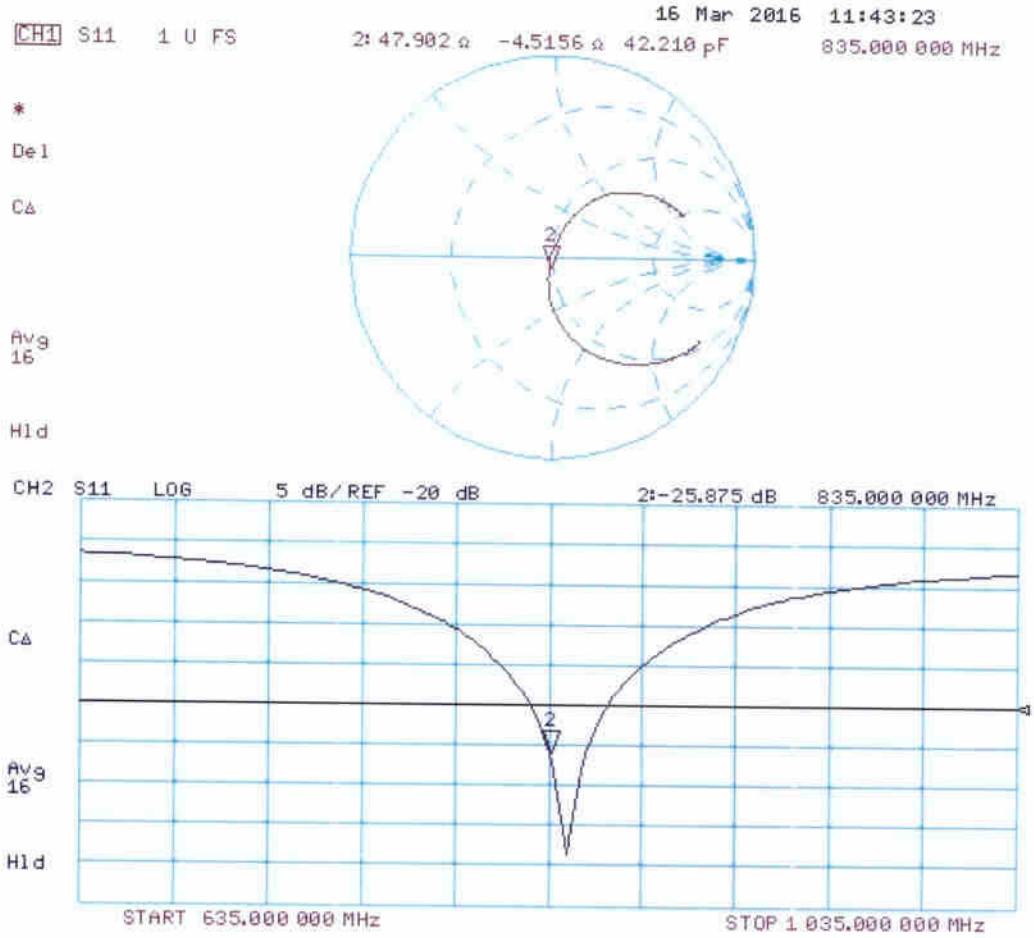
DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.73, 9.73, 9.73); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Body Tissue EX-Probe/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 60.04 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 3.65 W/kg
**SAR(1 g) = 2.46 W/kg; SAR(10 g) = 1.61 W/kg**
Maximum value of SAR (measured) = 3.26 W/kg

0 dB = 3.26 W/kg = 5.13 dBW/kg

## Impedance Measurement Plot for Body TSL



Schmid & Partner Engineering AG

s p e a g

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1279

# IMPORTANT NOTICE

## USAGE OF THE DAE 4

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

**Battery Exchange**: The battery cover of the DAE4 unit is closed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

**Shipping of the DAE**: Before shipping the DAE to SPEAG for calibration, remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts during transportation. The package shall be marked to indicate that a fragile instrument is inside.

**E-Stop Failures**: Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, the customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

**Repair**: Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

**DASY Configuration Files:** Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 MOhm is given in the corresponding configuration file.

**Important Note:**
**Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.**

**Important Note:**
**Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.**

**Important Note:**
**To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.**

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

**Accreditation No.: SCS 0108**

**Client** **Sporton-TW (Auden)**

**Certificate No: DAE4-1279_Apr16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | DAE4 - SD 000 D04 BM - SN: 1279 |
| Calibration procedure(s) | QA CAL-06.v29<br>Calibration procedure for the data acquisition electronics (DAE) |
| Calibration date: | April 04, 2016 |

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 | 09-Sep-15 (No:17153) | Sep-16 |
| **Secondary Standards** | **ID #** | **Check Date (in house)** | **Scheduled Check** |
| Auto DAE Calibration Unit | SE UWS 053 AA 1001 | 05-Jan-16 (in house check) | In house check: Jan-17 |
| Calibrator Box V2.1 | SE UMS 006 AA 1002 | 05-Jan-16 (in house check) | In house check: Jan-17 |

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

Issued: April 4, 2016

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** | 403.905 ± 0.02% (k=2) | 403.857 ± 0.02% (k=2) | 404.596 ± 0.02% (k=2) |
| **Low Range** | 3.94769 ± 1.50% (k=2) | 3.98798 ± 1.50% (k=2) | 3.98844 ± 1.50% (k=2) |

## Connector Angle

| | |
|---|---|
| **Connector Angle** to be used in DASY system | 353.0 ° ± 1 ° |

## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

| High Range | | Reading (µV) | Difference (µV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 200034.21 | 0.64 | 0.00 |
| Channel X | + Input | 20007.04 | 2.71 | 0.01 |
| Channel X | - Input | -20003.94 | 1.81 | -0.01 |
| Channel Y | + Input | 200033.55 | 0.14 | 0.00 |
| Channel Y | + Input | 20003.53 | -0.81 | -0.00 |
| Channel Y | - Input | -20006.93 | -1.15 | 0.01 |
| Channel Z | + Input | 200035.84 | 2.29 | 0.00 |
| Channel Z | + Input | 20004.20 | -0.11 | -0.00 |
| Channel Z | - Input | -20007.71 | -1.89 | 0.01 |

| Low Range | | Reading (µV) | Difference (µV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 2000.35 | -0.21 | -0.01 |
| Channel X | + Input | 201.21 | 0.64 | 0.32 |
| Channel X | - Input | -198.81 | 0.54 | -0.27 |
| Channel Y | + Input | 2000.44 | -0.15 | -0.01 |
| Channel Y | + Input | 200.00 | -0.41 | -0.21 |
| Channel Y | - Input | -199.44 | -0.00 | 0.00 |
| Channel Z | + Input | 1999.73 | -0.78 | -0.04 |
| Channel Z | + Input | 199.17 | -1.28 | -0.64 |
| Channel Z | - Input | -200.05 | -0.52 | 0.26 |

### 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 | -18.84 | -20.08 |
| | - 200 | 22.54 | 20.58 |
| Channel Y | 200 | 4.56 | 4.07 |
| | - 200 | -5.40 | -5.53 |
| Channel Z | 200 | 5.77 | 5.39 |
| | - 200 | -7.62 | -7.90 |

### 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 | - | 3.57 | -3.56 |
| Channel Y | 200 | 8.26 | - | 4.72 |
| Channel Z | 200 | 10.27 | 5.83 | - |

## 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** | 15947 | 15498 |
| **Channel Y** | 15956 | 16142 |
| **Channel Z** | 15706 | 15616 |

## 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** | -0.29 | -1.03 | 1.13 | 0.38 |
| **Channel Y** | 0.16 | -0.88 | 1.41 | 0.42 |
| **Channel Z** | -1.95 | -3.80 | -0.11 | 0.58 |

## 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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**S** Swiss Calibration Service

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**Accreditation No.: SCS 0108**

**Client** **Sporton-KS (Auden)**

**Certificate No: EX3-3954_Nov16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | EX3DV4 - SN:3954 |
| Calibration procedure(s) | QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6<br>Calibration procedure for dosimetric E-field probes |
| Calibration date: | November 28, 2016 |

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 NRP | SN: 104778 | 06-Apr-16 (No. 217-02288/02289) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103244 | 06-Apr-16 (No. 217-02288) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103245 | 06-Apr-16 (No. 217-02289) | Apr-17 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 05-Apr-16 (No. 217-02293) | Apr-17 |
| Reference Probe ES3DV2 | SN: 3013 | 31-Dec-15 (No. ES3-3013_Dec15) | Dec-16 |
| DAE4 | SN: 660 | 23-Dec-15 (No. DAE4-660_Dec15) | Dec-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB41293874 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| Power sensor E4412A | SN: MY41498087 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| Power sensor E4412A | SN: 000110210 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| RF generator HP 8648C | SN: US3642U01700 | 04-Aug-99 (in house check Jun-16) | In house check: Jun-18 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-16) | In house check: Oct-17 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Leif Klysner | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: November 28, 2016

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## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
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) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe EX3DV4

## SN:3954

| | |
|---|---|
| Manufactured: | August 6, 2013 |
| Repaired: | November 21, 2016 |
| Calibrated: | November 28, 2016 |

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3954

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 0.54 | 0.43 | 0.52 | ± 10.1 % |
| DCP (mV)[B] | 99.5 | 101.4 | 97.0 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB$\sqrt{\mu V}$ | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 148.0 | ±3.3 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 149.5 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 139.8 | |

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

[A] The uncertainties of Norm X,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 5 and 6).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.