# SAR TEST REPORT

## Test Report No. : 11231232H-A-R1

| | | |
|---|---|---|
| **Applicant** | : | **silex technology, Inc.** |
| **Type of Equipment** | : | **SDIO Wireless Module** |
| **Model No.** | : | **SX-SDMAN** |
| **FCC ID** | : | **N6C-SDMAN** |
| **Test regulation** | : | **FCC47CFR 2.1093**<br>***Class II permissive change** |
| **Test Result** | : | **Complied** |
| **Reported SAR(1g) Value** | | **The highest reported SAR(1g)**<br>UNII: 5500-5700MHz band: 0.07 W/kg |

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2. The results in this report apply only to the sample tested.
3. This sample tested is in compliance with the limits of the above regulation.
4. The test results in this report are traceable to the national or international standards.
5. This test report must not be used by the customer to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.
6. This test report covers SAR technical requirements. It does not cover administrative issues such as Manual or non-SAR test related Requirements. (if applicable)

**Date of test:** June 9, 2016

**Representative test engineer:**
Keisuke Kawamura
Engineer
Consumer Technology Division

**Approved by :**
Takahiro Hatakeda
Leader
Consumer Technology Division

NVLAP TESTING
NVLAP LAB CODE: 200572-0

This laboratory is accredited by the NVLAP LAB CODE 200572-0, U.S.A. The tests reported herein have been performed in accordance with its terms of accreditation.
*As for the range of Accreditation in NVLAP, you may refer to the WEB address,
http://japan.ul.com/resources/emc_accredited/

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# REVISION HISTORY

## Original Test Report No.: 11231232H-A

| Revision | Test report No. | Date | Page revised | Contents |
|---|---|---|---|---|
| - (Original) | 11231232H-A | June 24, 2016 | - | - |
| 1 | 11231232H-A-R1 | September 14, 2016 | P.11 | Correction of chart and Note(s) of SECTION 6.1 |
| 1 | 11231232H-A-R1 | September 14, 2016 | P.23 | Correction of note *5 of APPENDIX 2.1 (2) |
| 1 | 11231232H-A-R1 | September 14, 2016 | P.63 | Correction of Top view figure of APPENDIX4.2 |
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## CONTENTS PAGE

## SECTION 1: Customer information

| | | |
|---|---|---|
| Company Name | : | silex technology, Inc. |
| Address | : | 2-3-1 Hikaridai, Seika-cho, Kyoto 619-0237, Japan |
| Telephone Number | : | +81-774-98-3878 |
| Facsimile Number | : | +81-774-98-3758 |
| Contact Person | : | Toshiro Kometani |

## SECTION 2: Equipment under test (E.U.T.)

### 2.1 Identification of E.U.T.

| | | |
|---|---|---|
| Type of Equipment | : | SDIO Wireless Module |
| Model No. | : | SX-SDMAN |
| Serial No. | : | 001 |
| Rating | : | DC 3.3 V |
| Receipt Date of Sample | : | April 12, 2016 |
| Country of Mass-production | : | Japan |
| Condition of EUT | : | Production model |
| Modification of EUT | : | No Modification by the test lab |

[Identification of Host]

| | | |
|---|---|---|
| Type of Equipment | : | WIRELESS TEACH PENDANT |
| Model No. | : | FDWLTPDSJN-2 |
| Serial No. | : | 00-1L22660YZ55092005 |
| Rating | : | 230 V AC 50 / 60 Hz |
| Option battery | : | None |

### 2.2 Product Description

Model: SX-SDMAN (referred to as the EUT in this report) is a SDIO Wireless Module.

## General Specification

Clock frequency(ies) in the system : 26MHz

## Radio Specification

Radio Type : Transceiver
Method of Frequency Generation : Synthesizer
Power Supply (inner) : DC1.2V

**Specification of Wireless LAN (IEEE802.11b/g/a/n-20/n-40)**

| Type of radio | IEEE802.11b | IEEE802.11g | IEEE802.11a | IEEE802.11n (20 M band) | IEEE802.11n (40 M band) |
|---|---|---|---|---|---|
| Frequency of operation | 2412-2462MHz | 2412-2462MHz | 5180-5320MHz<br>5500-5580MHz<br>5660-5700MHz<br>5745-5825MHz | 2412-2462MHz<br>5180-5320MHz<br>5500-5580MHz<br>5660-5700MHz<br>5745-5825MHz | 5190-5310MHz<br>5510-5550MHz<br>5670MHz<br>5755-5795MHz |
| Type of modulation | DSSS (CCK, DQPSK, DBPSK) | OFDM-CCK (64QAM, 16QAM, QPSK, BPSK) | OFDM (64QAM, 16QAM, QPSK, BPSK) | | |
| Channel spacing | 5MHz | | 20MHz | 2.4GHz band<br>5MHz<br>5GHz band<br>20MHz | 40MHz |
| Antenna type | Sleeve antenna: Sansei | | | | |
| Antenna Gain | 1.0dBi (2.4GHz including cableloss 0.5dB), 1.1dBi (5GHz including cableloss 1.0dB) | | | | |
| Antenna Connector type | U.FL connector | | | | |

**Specification of Bluetooth (Ver.4.0 + EDR)**

| Type of radio | Bluetooth |
|---|---|
| Frequency of Operation | 2402-2480MHz |
| Type of Modulation | FHSS |
| Channel spacing | 1MHz |
| Antenna type | Embedded antenna: Ethertronics |
| Antenna Gain | 2.0dBi (2.4GHz including cableloss 0.5dB), 2.5dBi (5GHz including cableloss 1.0dB) |
| Antenna Connector Type | U.FL Alternative connector |

**Specification of Low Energy (Ver.4.0 + EDR/LE Dual mode)**

| Type of radio | Low Energy |
|---|---|
| Frequency of Operation | 2402-2480MHz |
| Type of Modulation | DSSS |
| Channel spacing | 2MHz |
| Antenna type | Embedded antenna: Ethertronics |
| Antenna Gain | 2.0dBi (2.4GHz including cableloss 0.5dB), 2.5dBi (5GHz including cableloss 1.0dB) |
| Antenna Connector Type | U.FL Alternative connector |

*This test report applies for Wireless LAN (IEEE802.11a/n-20/n-40:5500-5700 MHz band).
Wireless LAN and Bluetooth do not transmit simultaneously.
Bluetooth doesn't function in this host. Therefore Bluetooth isn't evaluated.

## SECTION 3 : Test standard information

### 3.1 Test Specification

Title : **FCC47CFR 2.1093**
Radiofrequency radiation exposure evaluation: portable devices.
: **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.

: **Published RF exposure KDB procedures**

| | |
|---|---|
| ☑ **KDB447498D01(v06)** | Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies |
| ☐ **KDB447498D02(v02r01)** | SAR Measurement Procedures for USB Dongle Transmitters |
| ☐ **KDB648474D04(v01r03)** | SAR Evaluation Considerations for Wireless Handsets |
| ☐ **KDB941225D01(v03r01)** | SAR Measurement Procedures for 3G Devices |
| ☐ **KDB941225D05(v02r05)** | SAR for LTE Devices |
| ☐ **KDB941225D06(v02r01)** | SAR test procedures for devices incorporating SAR Evaluation Procedures for Portable Devices with Wireless Router Capabilities (Hot Spot SAR) |
| ☐ **KDB941225D07(v01r02)** | SAR Evaluation Procedures for UMPC Mini-Tablet Devices |
| ☐ **KDB616217D04(v01r02)** | SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers |
| ☑ **KDB865664D01(v01r04)** | SAR Measurement Requirements for 100MHz to 6 GHz |
| ☑ **KDB248227D01(v02r02)** | SAR Measurement Procedures for 802.11a//b/g Transmitters |

**Reference**
[1]SPEAG uncertainty document (AN 15-7/AN19-17) for DASY 5 System from SPEAG (Schmid & Partner Engineering AG).

### 3.2 Procedure

| **Transmitter** | **WLAN** |
|---|---|
| **Test Procedure** | Published RF exposure KDB procedures |
| | SAR |
| **Category** | FCC47CFR 2.1093 |
| Note: UL Japan, Inc. 's SAR Work Procedures 13-EM-W0429 and 13-EM-W0430 | |

## 3.3 Exposure limit

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

| Spatial Average (averaged over the whole body) | Spatial Peak (averaged over any 1g of tissue) | Spatial Peak (hands/wrists/feet/ankles averaged over 10g) |
|---|---|---|
| 0.4 | 8.0 | 20.0 |

(B) Limits for General population/Uncontrolled Exposure (W/kg)

| Spatial Average (averaged over the whole body | Spatial Peak (averaged over any 1g of tissue) | Spatial Peak (hands/wrists/feet/ankles averaged over 10g) |
|---|---|---|
| 0.08 | 1.6 | 4.0 |

**Occupational/Controlled Environments:** are defined as locations where there is exposure that may be incurred by people who are aware of the potential for exposure, (i.e. as a result of employment or occupation).

**General Population/Uncontrolled Environments:** are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure.

**NOTE:GENERAL POPULATION/UNCONTROLLED EXPOSURE**
**SPATIAL PEAK(averaged over any 1g of tissue) LIMIT**
**1.6 W/kg**

## 3.4 Test Location

*Shielded room for SAR testings
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## SECTION 4 : Test result

### 4.1 Stand-alone SAR result

**Reported SAR**
Measured SAR is scaled to the maximum tune-up tolerance limit by the following formulas.
Reported SAR= Measured SAR [W/kg] · Scaled factor *1
Maximum tune-up tolerance limit is by the specification from a customer.

**Body SAR**

| Mode | Frequency | Measured power [dBm]*2 | Measured power [mW] | Maximum tune-up tolerance limit [dBm]*3 | Maximum tune-up tolerance limit [mW]*3 | Measured SAR [W/kg] | Scaled factor | **Reported SAR [W/kg]** |
|---|---|---|---|---|---|---|---|---|
| WLAN 11n-40 (UNII : 5500 - 5700MHz band) | 5670MHz | 12.98 | 19.86 | 14.00 | 25.12 | 0.056 | 1.265 | **0.07** |

**Note**
*1 Scaled factor = Maximum tune-up tolerance limit [mW] / Measured power [mW]
*2 The sample used by the SAR test is within the tune-up tolerance but not more than 2 dB lower than the maximum tune-up tolerance limit. That is, measured power is included the tune-up tolerance range.
*3 Maximum tune-up tolerance limit is defined as maximum timed-average value. (Considering to maximum duty cycle of WLAN.)

## SECTION 5 SAR test exclusion considerations according to KDB447498 D01

.
The following is based on KDB447498D01.
1) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:
*[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)]* ·[√f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where
f(GHz) is the RF channel transmit frequency in GHz
Power and distance are rounded to the nearest mW and mm before calculation
The result is rounded to one decimal place for comparison
The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

WLAN 5.6GHz OFDM mode

| Band | Standalone SAR tested | Positiom | Mode | Upper frequency of band *1 | Maximum tune-up tolerance limit *4 | Min distance *2 | Calculation of exclusion *3 |
|---|---|---|---|---|---|---|---|
| WLAN (5.6GHz band) | ☑ | Front | 11a, 11n20 | 5700 [MHz] (140ch) | 14 [dBm] 25.12 [mW] 25 [mW]*5 | 13 [mm] | 4.6 |
| WLAN (5.6GHz band) | ☑ | Rear | 11a, 11n20 | 5700 [MHz] (140ch) | 14 [dBm] 25.12 [mW] 25 [mW]*5 | 12 [mm] | 5.0 |
| WLAN (5.6GHz band) | ☑ | Bottom | 11a, 11n20 | 5700 [MHz] (140ch) | 14 [dBm] 25.12 [mW] 25 [mW]*5 | 10 [mm] | 6.0 |
| WLAN (5.6GHz band) | ☑ | Left | 11a, 11n20 | 5700 [MHz] (140ch) | 14 [dBm] 25.12 [mW] 25 [mW]*5 | 17 [mm] | 3.5 |

WLAN 5.6GHz OFDM mode

| Band | Standalone SAR tested | Position | Mode | Upper frequency of band *1 | Maximum tune-up tolerance limit *4 | Min distance *2 | Calculation of exclusion *3 |
|---|---|---|---|---|---|---|---|
| WLAN (5.6GHz band) | ☑ | Front | 11n40 | 5670 [MHz] (134ch) | 14 [dBm] 25.12 [mW] 25 [mW]*5 | 13 [mm] | 4.6 |
| WLAN (5.6GHz band) | ☑ | Rear | 11n40 | 5670 [MHz] (134ch) | 14 [dBm] 25.12 [mW] 25 [mW]*5 | 12 [mm] | 5.0 |
| WLAN (5.6GHz band) | ☑ | Bottom | 11n40 | 5670 [MHz] (134ch) | 14 [dBm] 25.12 [mW] 25 [mW]*5 | 10 [mm] | 6.0 |
| WLAN (5.6GHz band) | ☑ | Left | 11n40 | 5670 [MHz] (134ch) | 14 [dBm] 25.12 [mW] 25 [mW]*5 | 17 [mm] | 3.5 |

2) At 100 MHz to 6 GHz and for *test separation distances* > 50 mm, the SAR test exclusion threshold is determined according to the following.
a) [Threshold at 50 mm in step 1) + (test separation distance - 50 mm)·( f(MHz)/150)] mW, at 100MHz to 1500 MHz
b) [Threshold at 50 mm in step 1) + (test separation distance - 50 mm)·10] mW at > 1500 MHz and≤ 6 GHz

WLAN 5.6GHz OFDM mode

| Band | Standalone SAR tested | Positiom | Mode | Upper frequency of band *1 | Maximum tune-up tolerance limit *4 | Min distance | Calculation of threshold*6 |
|---|---|---|---|---|---|---|---|
| WLAN (5.6GHz band) | ☐ | Top | 11a, 11n20 | 5700 [MHz] (140ch) | 14 [dBm] 25.12 [mW] 25 [mW]*5 | 177 [mm] | 1333 [mW] |
| WLAN (5.6GHz band) | ☐ | Right | 11a, 11n20 | 5700 [MHz] (140ch) | 14 [dBm] 25.12 [mW] 25 [mW]*5 | 117 [mm] | 733 [mW] |

WLAN 5.6GHz OFDM mode

| Band | Standalone SAR tested | Positiom | Mode | Upper frequency of band *1 | Maximum tune-up tolerance limit *4 | Min distance | Calculation of threshold*6 |
|---|---|---|---|---|---|---|---|
| WLAN (5.6GHz band) | ☐ | Top | 11n40 | 5670 [MHz] (134ch) | 14 [dBm] 25.12 [mW] 25 [mW]*5 | 177 [mm] | 1333 [mW] |
| WLAN (5.6GHz band) | ☐ | Right | 11n40 | 5670 [MHz] (134ch) | 14 [dBm] 25.12 [mW] 25 [mW]*5 | 117 [mm] | 733 [mW] |

*1 The upper frequency of the frequency band was used in order to calculate standalone SAR test exclusion considerations.
*2 Based on KDB447498D01, min distance is 5mm. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion. Refer to Appendix 4.
*3 [(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] ·[√f(GHz)] ≤ 3.0
If it is Calculation of exclusion ≤ 3.0 standalone SAR test is excluded.
*4 Maximum tune-up tolerance limit is by the specification from a customer.
*5 Maximum tune-up tolerance limit(mW) is rounded to one decimal place.
*6 $[(3\cdot 50)/(\sqrt{f_{(GHz)}})]$ + (test separation distance - 50 mm)·(f(MHz)/150)] mW at > 100 MHz and ≤ 1500 MHz
$[(3\cdot 50)/(\sqrt{f_{(GHz)}})]$ + (test separation distance - 50 mm)·10] mW at > 1500 MHz and ≤ 6 GHz

## SECTION 6 : SAR test opearting mode

### 6.1 Output Power and SAR test required

The initial test configuration for 2.4 GHz and 5 GHz OFDM transmission modes is determined by the 802.11 configuration with the highest maximum output power specified for production units, including tune-up tolerance, in each standalone and aggregated frequency band. SAR for the initial test configuration is measured using the highest maximum output power channel determined by the default power measurement procedures (section 4). When multiple configurations in a frequency band have the same specified maximum output power, the initial test configuration is determined according to the following steps applied sequentially.

1) The largest channel bandwidth configuration is selected among the multiple configurations with the same specified maximum output power.
2) If multiple configurations have the same specified maximum output power and largest channel bandwidth, the lowest order modulation among the largest channel bandwidth configurations is selected.
3) If multiple configurations have the same specified maximum output power, largest channel bandwidth and lowest order modulation, the lowest data rate configuration among these configurations is selected.
4) When multiple transmission modes (802.11a/g/n/ac) have the same specified maximum output power, largest channel bandwidth, lowest order modulation and lowest data rate, the lowest order 802.11 mode is selected; i.e., 802.11a is chosen over 802.11n then 802.11ac or 802.11g is chosen over 802.11n.

### Wi-Fi 5GHz (U-NII Bands)

| Band (GHz) | Mode | Data Rate | Ch # | Freq. (MHz) | Measured average Power (dBm) | Tune-up upper Power (dBm) | SAR Test (Yes/No) | Note(s) |
|---|---|---|---|---|---|---|---|---|
| 5.6 (U-NII-2C) | 802.11a | 6 Mbps | 100 | 5500 | 12.42 | 14.0 | No | 1 |
| | | | 104 | 5520 | 12.25 | | | |
| | | | 108 | 5540 | 12.22 | | | |
| | | | 112 | 5560 | 12.26 | | | |
| | | | 116 | 5580 | 12.24 | | | |
| | | | 132 | 5660 | 12.98 | | | |
| | | | 136 | 5680 | 12.82 | | | |
| | | | 140 | 5700 | 12.70 | | | |
| 5.6 (U-NII-2C) | 802.11n20 | 6.5 Mbps | 100 | 5500 | 12.53 | 14.0 | No | 1 |
| | | | 104 | 5520 | 12.38 | | | |
| | | | 108 | 5540 | 12.15 | | | |
| | | | 112 | 5560 | 12.55 | | | |
| | | | 116 | 5580 | 12.31 | | | |
| | | | 132 | 5660 | 12.73 | | | |
| | | | 136 | 5680 | 12.87 | | | |
| | | | 140 | 5700 | 12.74 | | | |
| 5.6 (U-NII-2C) | 802.11n (HT40) | 13.5 Mbps | 102 | 5510 | 12.37 | 14.0 | No | 2 |
| | | | 110 | 5550 | 12.26 | | | |
| | | | 134 | 5670 | 12.98 | | Yes | |

**Note(s):**

1. According to KDB248227D01, SAR measurement is not required for 802.11a and 802.11n HT20 channels because the specified tune-up tolerances for 802.11a and 802.11n HT20 are equal or lower than 802.11n HT40 and the measured SAR is ≤ 1.2 W/Kg.
2. According to KDB248227D01, When the reported SAR of the initial test position is ≤ 0.4 W/kg, further SAR measurement is not required.

**Software information**

*The power value of the EUT was set for testing as follows (setting value might be different from product specification value);

Power Setting: Refer to the following table.
Software: Atheros Test Command (Athtestcmd)
- v3.1.1 Build 563

*This setting of software is the worst case.
Any conditions under the normal use do not exceed the condition of setting.
In addition, end users cannot change the settings of the output power of the product.

**[Power Settings]**

| 20MHz Band W56 | ch100 | Ch104 | Ch108 | Ch112 | Ch116 |
|---|---|---|---|---|---|
| 11a (6Mbps) | 11.5 dBm | 11.5 dBm | 11 dBm | 11.5 dBm | 11.5 dBm |
| 11n-20 (MCS0) | 12 dBm | 11.5 dBm | 11 dBm | 12 dBm | 11 dBm |

| 20MHz Band W56 | Ch132 | Ch136 | Ch140 |
|---|---|---|---|
| 11a (6Mbps) | 12.5 dBm | 12.5 dBm | 12.5 dBm |
| 11n-20 (MCS0) | 12 dBm | 12.5 dBm | 12.5 dBm |

| 40MHz Band W56 | Ch102 | Ch110 | Ch134 |
|---|---|---|---|
| 11n-40 (MCS0) | 12 dBm | 11.5 dBm | 13 dBm |

## SECTION 7: Description of the Body setup

### 7.1 Test position for Body setup

**i) Procedure for SAR testing**

-The tested procedure was performed according to the KDB447498 D01 (Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies)

**ii) Test mode**

| | |
|---|---|
| **WLAN 5GHz** | **11n-40** |

**iii) Test position**

| No. | Position | Test distance | WLAN 5GHz |
|---|---|---|---|
| | | | Tested |
| 1 | Front | 0mm | ☑ |
| 2 | Rear | 0mm | ☑ |
| 3 | Left | 0mm | ☑ |
| 4 | Right | 0mm | ☐ |
| 5 | Top | 0mm | ☐ |
| 6 | Bottom | 0mm | ☑ |

## SECTION 8 : Test surrounding

### 8.1 Measurement uncertainty

This measurement uncertainty budget is suggested by IEEE Std 1528(2013) and IEC62209-2:2010, and determined by Schmid & Partner Engineering AG (DASY5 Uncertainty Budget). Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r01 Section 2.8.1., when the highest measured SAR(1g) within a frequency band is < 1.5W/kg, the extensive SAR measurement uncertainty analysis described in IEEE Std.1528 (2013) is not required in SAR reports submitted for equipment approval.

<3 – 6GHz range Body>

| Error Description | Uncertai value ± | | Probability distribution | divisor | (ci) 1g | Standard (1g) | |
|---|---|---|---|---|---|---|---|
| **Measurement System** | | | | | | | |
| Probe calibration | ± | 6.55 | Normal | 1 | 1 | ± | 6.55 |
| Axial isotropy of the probe | ± | 4.7 | Rectangular | √3 | 0.7 | ± | 1.9 |
| Spherical isotropy of the probe | ± | 9.6 | Rectangular | √3 | 0.7 | ± | 3.9 |
| Boundary effects | ± | 2.0 | Rectangular | √3 | 1 | ± | 1.2 |
| Probe linearity | ± | 4.7 | Rectangular | √3 | 1 | ± | 2.7 |
| Detection limit | ± | 1.0 | Rectangular | √3 | 1 | ± | 0.6 |
| Modulation response | ± | 2.4 | Rectangular | √3 | 1 | ± | 1.4 |
| Readout electronics | ± | 0.3 | Normal | 1 | 1 | ± | 0.3 |
| Response time | ± | 0.8 | Rectangular | √3 | 1 | ± | 0.5 |
| Integration time | ± | 2.6 | Rectangular | √3 | 1 | ± | 1.5 |
| RF ambient Noise | ± | 3.0 | Rectangular | √3 | 1 | ± | 1.7 |
| RF ambient Reflections | ± | 3.0 | Rectangular | √3 | 1 | ± | 1.7 |
| Probe Positioner | ± | 0.8 | Rectangular | √3 | 1 | ± | 0.5 |
| Probe positioning | ± | 6.7 | Rectangular | √3 | 1 | ± | 3.9 |
| Max.SAR Eval. | ± | 4.0 | Rectangular | √3 | 1 | ± | 2.3 |
| **Test Sample Related** | | | | | | | |
| Device positioning | ± | 2.9 | Normal | 1 | 1 | ± | 2.9 |
| Device holder uncertainty | ± | 3.6 | Normal | 1 | 1 | ± | 3.6 |
| Power drift | ± | 5.0 | Rectangular | √3 | 1 | ± | 2.9 |
| Power Scaling | + | 0.0 | Rectangular | √3 | 1 | ± | 0.0 |
| **Phantom and Setup** | | | | | | | |
| Phantom uncertainty | ± | 6.6 | Rectangular | √3 | 1 | ± | 3.8 |
| Algorithm for correcting SAR for deviations in permittivity and conductivity | ± | 1.9 | Normal | 1 | 1 | ± | 1.9 |
| Liquid conductivity (meas.) | + | 4.8 | Rectangular | 1 | 0.78 | + | 3.7 |
| Liquid permittivity (meas.) | – | 4.2 | Rectangular | 1 | 0.23 | - | 1.0 |
| Liquid conductivity - temp.unc (below 2deg.C.) | ± | 2.4 | Rectangular | √3 | 0.78 | ± | 1.1 |
| Liquid permittivity - temp.unc (below 2deg.C.) | ± | 0.8 | Rectangular | √3 | 0.23 | ± | 0.1 |
| | | | | | | | |
| **Combined Standard Uncertainty** | | | | | | ± | **12.799** |
| **Expanded Uncertainty (k=2)** | | | | | | ± | **25.6** |

*. Table of uncertainties are listed for ISO/IEC 17025.

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## SECTION 9 : Measurement results

### 9.1 Body SAR of 5.6GHz

**(1)Method of measurement**

Step.1 The searching for the worst position

The test was performed at the highest power channel of 5.6GHz band 11n40 MCS0. *1 *2

Note:

*1 According to KDB248227D01

1) The largest channel bandwidth configuration is selected among the multiple configurations in a frequency band with the same specified maximum output power.
2) If multiple configurations have the same specified maximum output power and largest channel bandwidth, the lowest order modulation among the largest channel bandwidth configurations is selected.
3) If multiple configurations have the same specified maximum output power, largest channel bandwidth and lowest order modulation, the lowest data rate configuration among these configurations is selected.
4) When multiple transmission modes (802.11a/g/n/ac) have the same specified maximum output power, largest channel bandwidth, lowest order modulation and lowest data rate, the lowest order 802.11 mode is selected.

*2 SAR is not required for the following OFDM U-NII-1(5.2 GHz band) conditions according to KDB248227D01.
1) When the same maximum output power is specified for both bands, begin SAR measurement in U-NII-2A(5.3GHz band) band by applying the OFDM SAR requirements. If the highest *reported* SAR for a test configuration is ≤ 1.2 W/kg, SAR is not required for U-NII-1(5.2GHz band) band for that configuration (802.11 mode and exposure condition); otherwise, each band is tested independently for SAR.
2) When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest *reported* SAR for the tested configuration is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power in that test configuration; otherwise, each band is tested independently for SAR.

**(2)Simulated Tissue Liquid Parameter confirmation**

The dielectric parameters were checked prior to assessment using the DAKS dielectric probe kit.
The dielectric parameters measurement is reported in each correspondent section.

**DIELECTRIC PARAMETERS MEASUREMENT RESULTS**

| Date | Ambient Temp. [deg.c] | Relative Humidity [%] | Liquid type | Liquid Temp. [deg.c] | Measured Frequency [MHz] | Parameters | Target Value | Measured | Deviation [%] | Limit [%] | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| - | - | - | - | - | 3000 | εr | 52.0 | - | - | - | *1 |
| | | | | | | σ [mho/m] | 2.73 | - | - | - | |
| 9-Jun | 24.0 | 50 | MBBL 3.5-5.8 | 23.5 | 5670 | εr | 48.4 | 46.4 | -4.2 | +/-5 | *2 |
| | | | | | | σ [mho/m] | 5.85 | 6.13 | 4.8 | +/-5 | |
| - | - | - | MBBL 3.5-5.8 | - | 5800 | εr | 48.2 | - | - | +/-5 | *1 |
| | | | | | | σ [mho/m] | 6.00 | - | - | +/-5 | |

εr: Relative Permittivity / σ : Coductivity
*1 The Target value is a parameter defined in KDB 865664D01.
*2 The dielectric parameters should be linearly interpolated between the closest pair of target frequencies to determine the applicable dielectric parameters corresponding to the device test frequency.

## (3)Result of Body SAR

| SAR MEASUREMENT RESULTS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency | | Modulation | Measured power | | Maximum tune-up tolerance limit | | Phantom Section | EUT Set-up Conditions | | | Measured SAR(1g) [W/kg] | Scaled factor *1 | Reported SAR(1g) [W/kg] *2 | Remark |
| Channel | [MHz] | | [dBm] | [mW] | [dBm] | [mW] | | Antenna | Position | Separation [mm] | | | | |
| **Step.1 The searching for the worst position** | | | | | | | | | | | | | | |
| 134 | 5670 | 11n40 MCS0 | 12.98 | 19.86 | 14.00 | 25.12 | Flat | Fixed | Front | 0 | **0.056** | **1.265** | **0.07** | |
| 134 | 5670 | 11n40 MCS0 | 12.98 | 19.86 | 14.00 | 25.12 | Flat | Fixed | Rear | 0 | **0.016** | **1.265** | **0.02** | |
| 134 | 5670 | 11n40 MCS0 | 12.98 | 19.86 | 14.00 | 25.12 | Flat | Fixed | Bottom | 0 | **0.009** | **1.265** | **0.01** | |
| 134 | 5670 | 11n40 MCS0 | 12.98 | 19.86 | 14.00 | 25.12 | Flat | Fixed | Left | 0 | **0.050** | **1.265** | **0.06** | |

*1 Scaled factor = Maximum tune-up tolerance limit [mW] / Measured power [mW]
*2 Reported SAR= Measured SAR [W/kg] · Scaled factor

## SECTION 10 Test instruments

| Control No. | Instrument | Manufacturer | Model No | Serial No | Test Item | Calibration Date * Interval(month) |
|---|---|---|---|---|---|---|
| MNA-03 | Vector Reflectometer | Copper Mountain Technologies | PLANAR R140 | 0030913 | SAR | 2016/04/22 * 12 |
| MDPK-03 | Dielectric assessment kit | Schmid&Partner Engineering AG | DAK-3.5 | 0008 | SAR | 2016/04/12 * 12 |
| MOS-37 | Digital thermometer | LKM electronic | DTM3000 | - | SAR | 2015/07/07 * 12 |
| COTS-MSAR-04 | Dielectric assessment software | Schmid&Partner Engineering AG | DAK | | SAR | - |
| MPM-11 | Dual Power Meter | Agilent | E4419B | MY45102060 | SAR | 2015/08/04 * 12 |
| MPSE-15 | Power sensor | Agilent | E9301A | MY41498311 | SAR | 2015/08/04 * 12 |
| MPSE-16 | Power sensor | Agilent | E9301A | MY41498313 | SAR | 2015/08/04 * 12 |
| MRFA-24 | Pre Amplifier | R&K | R&K CGA020M602-2633R | B30550 | SAR | 2015/06/15 * 12 |
| MSG-10 | Signal Generator | Agilent | N5181A | MY47421098 | SAR | 2015/11/16 * 12 |
| MAT-78 | Attenuator | Telegrartner | J01156A0011 | 0042294119 | SAR | Pre Check |
| MPM-15 | Power Meter | Agilent | N1914A | MY53060017 | SAR | 2015/06/15 * 12 |
| MPSE-21 | Power sensor | Agilent | N8482H | MY52460010 | SAR | 2015/06/15 * 12 |
| MHDC-12 | Dual Directional Coupler | Hewlett Packard | 772D | 2839A0016 | SAR(2-18GHz) | Pre Check |
| MDA-08 | Dipole Antenna | Schmid&Partner Engineering AG | D5GHzV2 | 1020 | SAR(D5G) | 2016/01/20 * 12 |
| MDAE-03 | Data Acquisition Electronics | Schmid&Partner Engineering AG | DAE4 | 1372 | SAR | 2015/06/15 * 12 |
| MPB-09 | Dosimetric E-Field Probe | Schmid&Partner Engineering AG | EX3DV4 | 3922 | SAR | 2015/06/17 * 12 |
| MPSAM-03 | SAM Phantom | Schmid&Partner Engineering AG | QD000P40CD | 1764 | SAR | 2016/05/07 * 12 |
| MPF-04 | 2mm Oval Flat Phantom | Schmid&Partner Engineering AG | QDOVA001BB | 1207 | SAR | 2016/05/07 * 12 |
| MDH-03 | Device holder | Schmid&Partner Engineering AG | Mounting device for transmitter | - | SAR | Pre Check |
| MOS-35 | Digital thermometer | HANNA | Checktemp 4 | - | SAR | 2015/07/07 * 12 |
| COTS-MSAR-03 | Dasy5 | Schmid&Partner Engineering AG | DASY5 | - | SAR | - |
| MRBT-04 | SAR robot | Schmid&Partner Engineering AG | TX60 Lspeag | F13/5PPLA1/A/01 | SAR | 2015/06/23 * 12 |
| MBBL3.5-5.8 | | | | | Daily check | Target value ± 5% |
| SAR Room | | | | | Daily check Ambient Noise<0.012W/kg | |

**The expiration date of the calibration is the end of the expired month.**
**All equipment is calibrated with valid calibrations. Each measurement data is traceable to the national or international standards.**
**As for some calibrations performed after the tested dates, those test equipment have been controlled by means of an unbroken chains of calibrations.**

## APPENDIX 1 : SAR Measurement data

### 1. Evaluation procedure

**The evaluation was performed with the following procedure:**

**Step 1:** Measurement of the E-field at a fixed location above the ear point or central position of flat phantom was used as a reference value for assessing the power drop.

**Step 2:** The SAR distribution at the exposed side of head or body position was measured at a distance of each device from the inner surface of the shell. The area covered the entire dimension of the antenna of EUT and the horizontal grid spacing was 15 mm x 15 mm, 12 mm x 12 mm or 10mm x 10mm. Based on these data, the area of the maximum absorption was determined by spline interpolation.

**Step 3:** Around this point found in the Step 2 (area scan), a volume of 30mm x 30mm x 30mm or more was assessed by measuring 7 x 7 x 7 points at least for below 3GHz and a volume of 28 mm x 28mm x 22.5mm or more was assessed by measuring 8 x 8 x 6(ratio step method (*1)) points at least for 5GHz band.

And for any secondary peaks found in the Step2 which are within 2dB of maximum peak and not with this Step3 (Zoom scan) is repeated. On the basis of this data set, the spatial peak SAR value was evaluated under the following procedure:

(1). The data at the surface were extrapolated, since the center of the dipoles is 1mm(EX3DV4) away from the tip of the probe and the distance between the surface and the lowest measuring point is 1.3 mm. The extrapolation was based on a least square algorithm [4]. A polynomial of the fourth order was calculated through the points in z-axes.
This polynomial was then used to evaluate the points between the surface and the probe tip.

(2). The maximum interpolated value was searched with a straightforward algorithm. Around this maximum the SAR values averaged over the spatial volumes (1 g or 10 g) were computed by the 3D-Spline interpolation algorithm. The 3D-Spline is composed of three one-dimensional splines with the “Not a knot"-condition (in x, y and z-directions) [4], [5]. The volume was integrated with the trapezoidal-algorithm. One thousand points (10 x 10 x 10) were interpolated to calculate the average.

(3). All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.

**Step 4**: Re-measurement of the E-field at the same location as in Step 1.
It was checked that the power drift [W] is within +/-5%.The verification of power drift during the SAR test is that DASY5 system calculates the power drift by measuring the e-filed at the same location at beginning and the end of the scan measurement for each test position.
DASY5 system calculation Power drift value[dB] =20log(Ea)/(Eb)
Before SAR testing : Eb[V/m]
After SAR testing : Ea[V/m]
Limit of power drift[W] =+/-5%
X[dB]=10log[P]=10log(1.05/1)=10log(1.05)-10log(1)=0.212dB
from E-filed relations with power.
p=E^2/η=E^2/
Therefore, The correlation of power and the E-filed
XdB=10log(P)=10log(E)^2=20log(E)
Therefore,
The calculated power drift of DASY5 System must be the less than +/-0.212dB.

***1. Ratio step method parameters used;**
**The first measurement point: 2mm from the phantom surface, the initial grid separation: 2mm, subsequent graded grid ratio: 1.5**
**These parameters comply with the requirement of the KDB 865664D01.**

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## 2. Measurement data(5.6GHz)

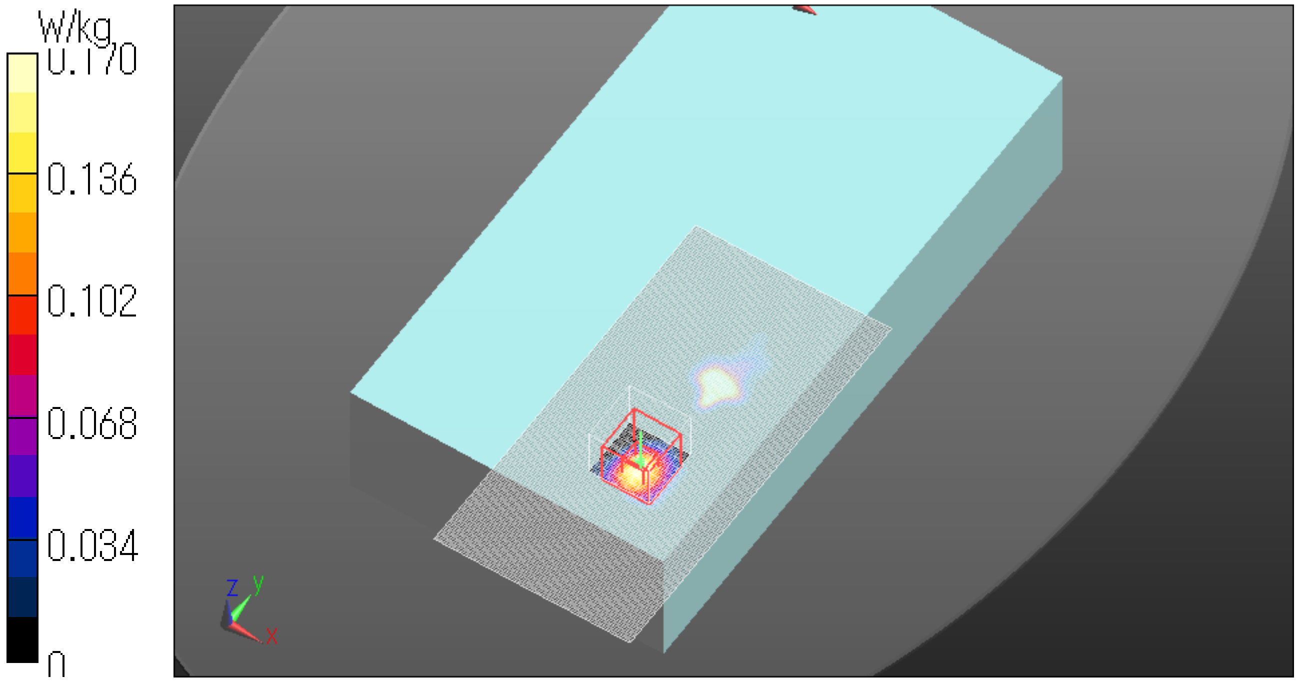
**WLAN 5G 11n40 MCS0 5670MHz Front 0mm**

Communication System: UID 0, WLAN (0); Communication System Band: 11n40/ac40; Frequency: 5670 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5670 MHz; $\sigma$ = 6.133 S/m; $\varepsilon_r$ = 46.365; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)
DASY5 Configuration
Probe: EX3DV4 - SN3825; ConvF(3.61, 3.61, 3.61); Calibrated: 2015/12/11;
Sensor-Surface: 1.4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn509; Calibrated: 2015/07/07
Phantom: ELI v5.0 TP1207 (30deg probe tilt); Type: QDOVA002AA; Serial: TP:1207
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Area Scan 2 (91x181x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.358 W/kg

**Zoom Scan (4x4x1.4mm, graded), dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 5.110 V/m; Power Drift = -0.18 dB
Peak SAR (extrapolated) = 0.626 W/kg
**SAR(1 g) = 0.056 W/kg; SAR(10 g) = 0.016 W/kg**

Maximum value of SAR (measured) = 0.170 W/kg
Date: 2016/06/09
Ambient Temp. : 24.0 degree.C.     Liquid Temp.; 23.5 degree.C.

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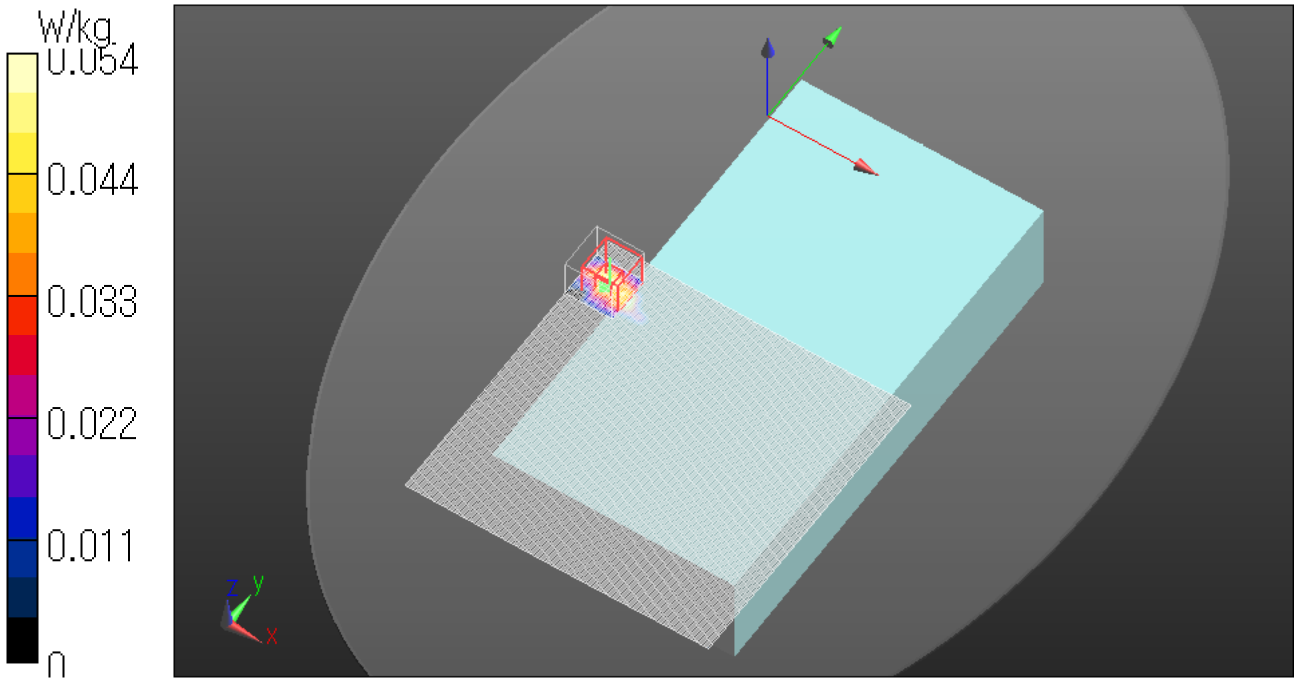
**WLAN 5G 11n40 MCS0 5670MHz Rear 0mm**

Communication System: UID 0, WLAN (0); Communication System Band: 11n40/ac40; Frequency: 5670 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5670 MHz; σ = 6.133 S/m; $\varepsilon_r$ = 46.365; ρ = 1000 kg/$m^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)
DASY5 Configuration
Probe: EX3DV4 - SN3825; ConvF(3.61, 3.61, 3.61); Calibrated: 2015/12/11;
Sensor-Surface: 1.4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn509; Calibrated: 2015/07/07
Phantom: ELI v5.0 TP1207 (30deg probe tilt); Type: QDOVA002AA; Serial: TP:1207
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Area Scan 2 2 (181x181x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.0927 W/kg

**Zoom Scan (4x4x1.4mm, graded), dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 2.655 V/m; Power Drift = -0.10 dB
Peak SAR (extrapolated) = 0.213 W/kg
**SAR(1 g) = 0.016 W/kg; SAR(10 g) = 0.00573 W/kg**

Maximum value of SAR (measured) = 0.0544 W/kg
Date: 2016/06/09
Ambient Temp. : 24.0 degree.C.     Liquid Temp.; 23.5 degree.C.

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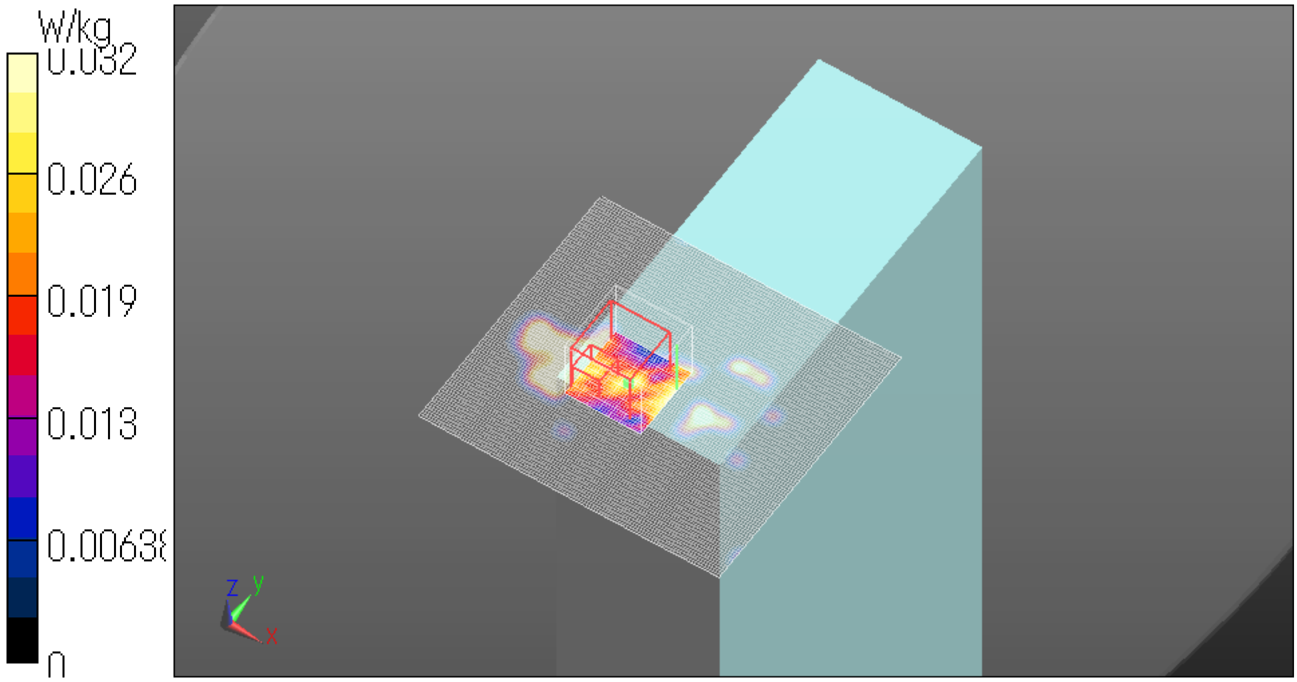
**WLAN 5G 11n40 MCS0 5670MHz Bottom 0mm**

Communication System: UID 0, WLAN (0); Communication System Band: 11n40/ac40; Frequency: 5670 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5670 MHz; σ = 6.133 S/m; $\varepsilon_r$ = 46.365; ρ = 1000 kg/$m^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)
DASY5 Configuration
Probe: EX3DV4 - SN3825; ConvF(3.61, 3.61, 3.61); Calibrated: 2015/12/11;
Sensor-Surface: 1.4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn509; Calibrated: 2015/07/07
Phantom: ELI v5.0 TP1207 (30deg probe tilt); Type: QDOVA002AA; Serial: TP:1207
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Area Scan 2 (111x101x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.0728 W/kg

**Zoom Scan (4x4x1.4mm, graded), dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 1.693 V/m; Power Drift = -0.12 dB
Peak SAR (extrapolated) = 0.152 W/kg
**SAR(1 g) = 0.00885 W/kg; SAR(10 g) = 0.00193 W/kg**

Maximum value of SAR (measured) = 0.0319 W/kg
Date: 2016/06/09
Ambient Temp. : 24.0 degree.C.     Liquid Temp.; 23.5 degree.C.

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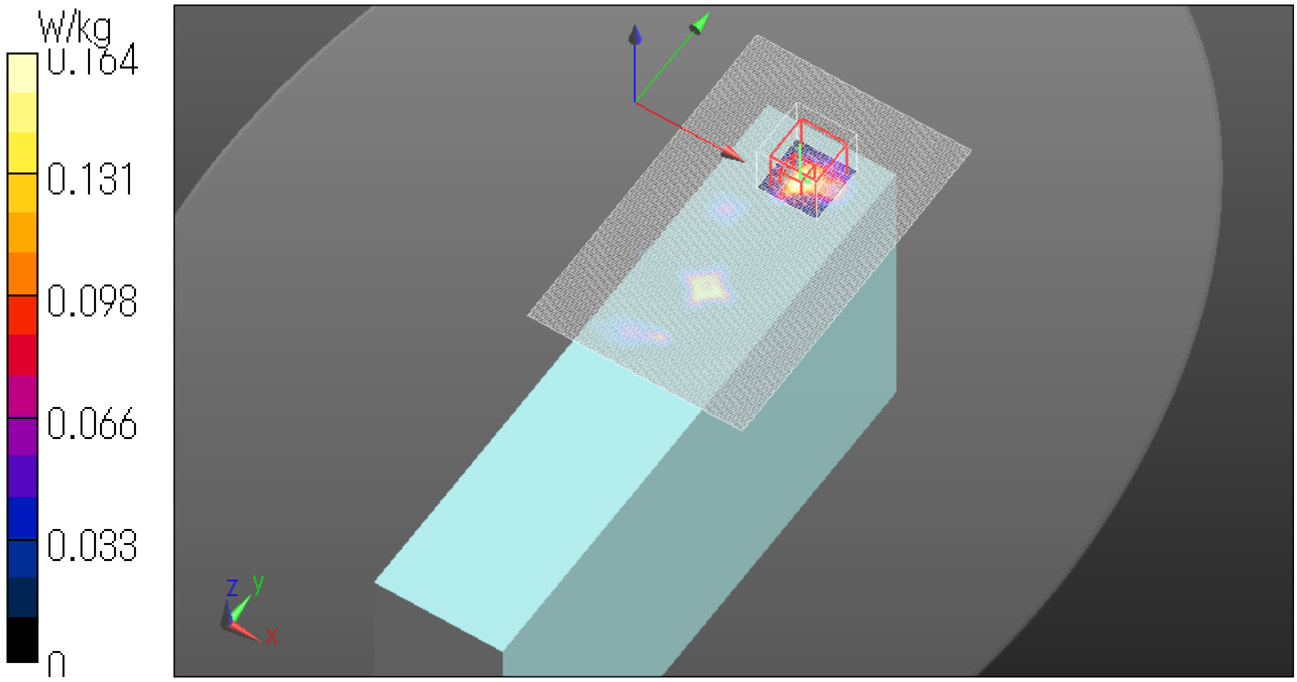
**WLAN 5G 11n40 MCS0 5670MHz Left 0mm**

Communication System: UID 0, WLAN (0); Communication System Band: 11n40/ac40; Frequency: 5670 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5670 MHz; σ = 6.133 S/m; $\varepsilon_r$ = 46.365; ρ = 1000 kg/$m^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)
DASY5 Configuration
Probe: EX3DV4 - SN3825; ConvF(3.61, 3.61, 3.61); Calibrated: 2015/12/11;
Sensor-Surface: 1.4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn509; Calibrated: 2015/07/07
Phantom: ELI v5.0 TP1207 (30deg probe tilt); Type: QDOVA002AA; Serial: TP:1207
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Area Scan 2 (101x161x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.389 W/kg

**Zoom Scan (4x4x1.4mm, graded), dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 4.710 V/m; Power Drift = 0.13 dB
Peak SAR (extrapolated) = 0.476 W/kg
**SAR(1 g) = 0.050 W/kg; SAR(10 g) = 0.016 W/kg**
Maximum value of SAR (measured) = 0.164 W/kg
Date: 2016/06/09
Ambient Temp. : 24.0 degree.C.     Liquid Temp.; 23.5 degree.C.

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## APPENDIX2 : System Check

### 1. System check result Body 5600MHz

### (1) Simulated Tissue Liquid Parameter confirmation

DIELECTRIC PARAMETERS MEASUREMENT RESULTS

| Date | Ambient Temp. [deg.c] | Relative Humidity [%] | Liquid type | Liquid Temp. [deg.c] | Measured Frequency [MHz] | Parameters | Target Value | Measured | Deviation [%] | Limit [%] | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| - | - | - | - | - | 3000 | εr | 52.0 | - | - | - | *1 |
| | | | | | | σ [mho/m] | 2.73 | - | - | - | |
| 9-Jun | 24.0 | 50 | MBBL 3.5-5.8 | 23.5 | 5600 | εr | 48.5 | 46.5 | -4.1 | +/-5 | *2 |
| | | | | | | σ [mho/m] | 5.77 | 6.01 | 4.1 | +/-5 | |
| - | - | - | - | - | 5800 | εr | 48.2 | - | - | - | *1 |
| | | | | | | σ [mho/m] | 6.00 | - | - | - | |

εr: Relative Permittivity / σ : Coductivity
*1 The Target value is a parameter defined in KDB 865664D01.
*2 The dielectric parameters should be linearly interpolated between the closest pair of target frequencies to determine the applicable dielectric parameters corresponding to the device test frequency.

DIELECTRIC PARAMETERS MEASUREMENT RESULTS

| Date | Ambient Temp. [deg.c] | Relative Humidity [%] | Liquid type | Liquid Temp. [deg.c] | Measured Frequency [MHz] | Parameters | Target Value | Measured | Deviation [%] | Limit [%] | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9-Jun | 24.0 | 50 | MBBL 3.5-5.8 | 23.5 | 5600 | εr | 48.5 | 46.5 | -4.2 | +/-6 | *3*4 |
| | | | | | | σ [mho/m] | 5.77 | 6.01 | 4.1 | +/-6 | |

εr: Relative Permittivity / σ : Coductivity
*3 The target value is the calibrated dipole Body TSL parameters. (D5GHzV2 SN:1020, Measured Body TSL parameters)
*4 The limit is for deviation provided by manufacture.

### (2) System check result (for calibration by manufacture)

SYSTEM CHECK

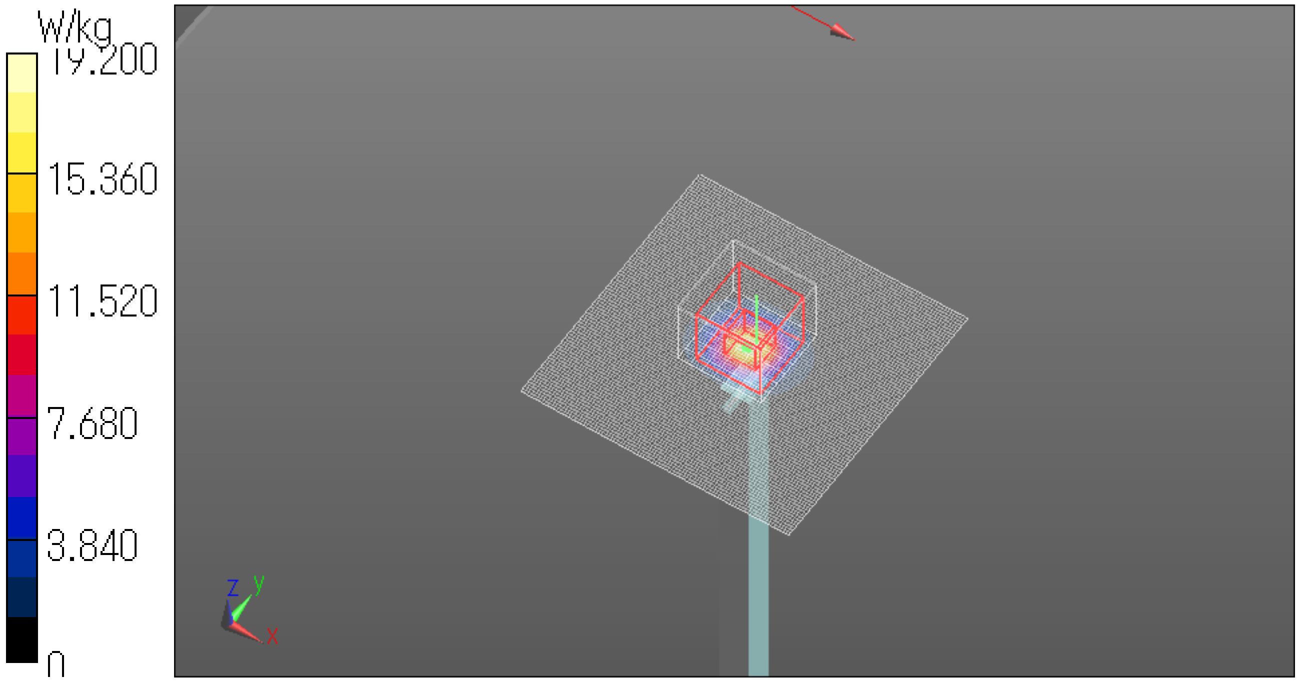
| Date | Frequency [MHz] | SAR 1g [W/kg] Forward Power Measured | SAR 1g [W/kg] Conversion 1W Calculation | Target Value(1W) | Deviation [%] | Limit [%] | Remark |
|---|---|---|---|---|---|---|---|
| 9-Jun | 5600.00 | 7.95 | 79.50 | 78.20 | 1.7 | +/-10 | *5 |

*5 The taget value is the parameter defined in SAR measured x 10( 7.82 x 10 = 78.2) in manufacturer calibrated dipole (D5GHzV2 SN:1020)
Please refer to " SAR result with Body TSL of Appendix 2 System Check Dipole (D5GHzV2 SN:1020)".

**Body 5600MHz System Check Data / D5GHzV2 / Forward Conducted Power: 100mW**
Communication System: UID 0, CW (0); Communication System Band: D5GHz (5000.0 - 6000.0 MHz); Frequency: 5600 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5600 MHz; $\sigma$ = 6.006 S/m; $\varepsilon_r$ = 46.482; $\rho$ = 1000 kg/$m^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)
DASY5 Configuration
Probe: EX3DV4 - SN3825; ConvF(3.61, 3.61, 3.61); Calibrated: 2015/12/11;
Sensor-Surface: 1.4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn509; Calibrated: 2015/07/07
Phantom: ELI v5.0 TP1207 (30deg probe tilt); Type: QDOVA002AA; Serial: TP:1207
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Area Scan (91x91x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 18.6 W/kg

**Zoom Scan (4x4x1.4mm, graded), dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.10 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 31.5 W/kg
**SAR(1 g) = 7.95 W/kg; SAR(10 g) = 2.19 W/kg**
Maximum value of SAR (measured) = 19.2 W/kg
Date: 2016/06/09
Ambient Temp. : 24.0 degree.C.     Liquid Temp.; 23.5 degree.C.

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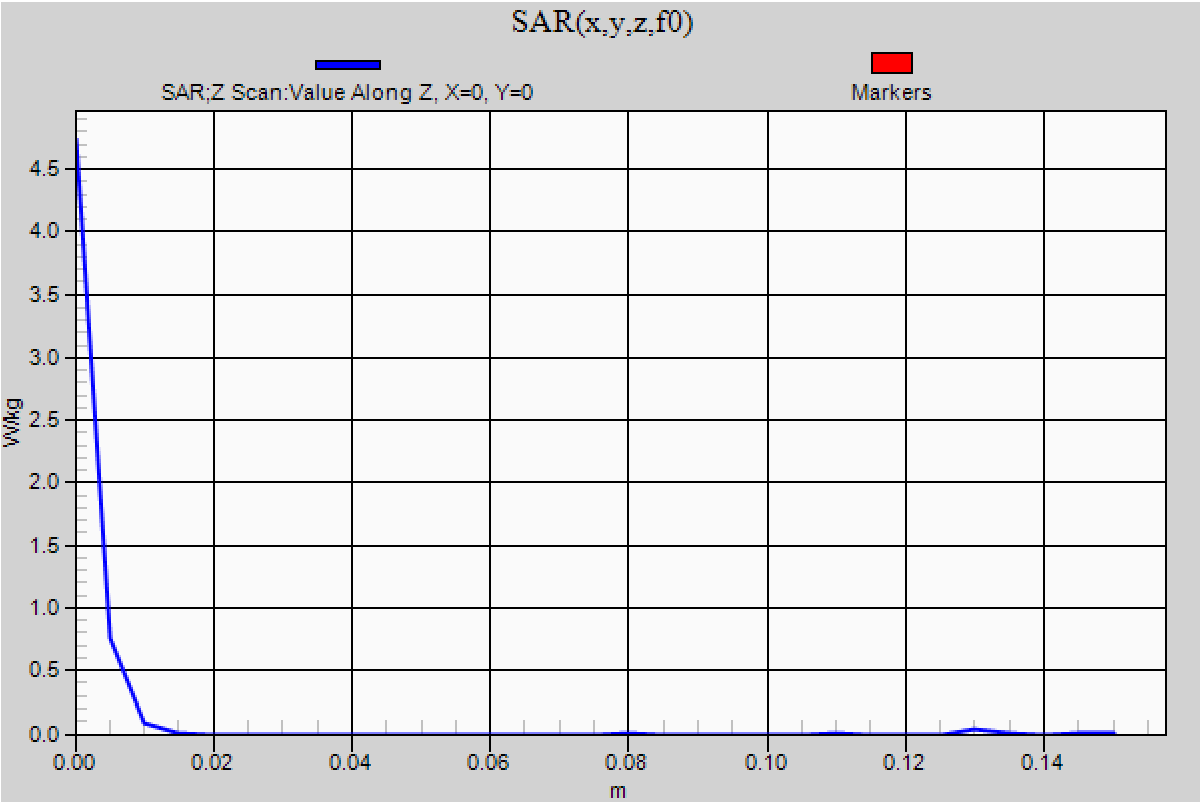
**Body 5600MHz System Check Data / D5GHzV2 / Forward Conducted Power: 100mW**
Communication System: UID 0, CW (0); Communication System Band: D5GHz (5000.0 - 6000.0 MHz); Frequency: 5600 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5600 MHz; σ = 6.006 S/m; $\varepsilon_r$ = 46.482; ρ = 1000 kg/$m^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)
DASY5 Configuration
Probe: EX3DV4 - SN3825; ConvF(3.61, 3.61, 3.61); Calibrated: 2015/12/11;
Sensor-Surface: 0mm (Fix Surface)
Electronics: DAE4 Sn509; Calibrated: 2015/07/07
Phantom: ELI v5.0 TP1207 (30deg probe tilt); Type: QDOVA002AA; Serial: TP:1207
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Z Scan (1x1x31):** Measurement grid: dx=20mm, dy=20mm, dz=5mm
Maximum value of SAR (measured) = 4.74 W/kg
Date: 2016/06/09
Ambient Temp. : 24.0 degree.C.  Liquid Temp.; 23.5 degree.C.



## 2. System Check Dipole (D5GHzV2,S/N:1020)

**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 UL Japan HQ (Vitec)

Certificate No: D5GHzV2-1020_Jan16

# CALIBRATION CERTIFICATE

Object D5GHzV2 - SN: 1020

Calibration procedure(s) QA CAL-22.v2
Calibration procedure for dipole validation kits between 3-6 GHz

Calibration date: January 20, 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: 3503 | 31-Dec-15 (No. EX3-3503_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: January 20, 2016

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

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

S Schweizerischer Kalibrierdienst
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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**

**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 62209-2, "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
c) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

d) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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%.



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## 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 V5.0 | |
| **Distance Dipole Center - TSL** | 10 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy = 4.0 mm, dz = 1.4 mm | Graded Ratio = 1.4 (Z direction) |
| **Frequency** | 5200 MHz ± 1 MHz<br>5250 MHz ± 1 MHz<br>5300 MHz ± 1 MHz<br>5500 MHz ± 1 MHz<br>5600 MHz ± 1 MHz<br>5750 MHz ± 1 MHz<br>5800 MHz ± 1 MHz | |

## Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 36.0 | 4.66 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 35.2 ± 6 % | 4.51 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5200 MHz

| **SAR averaged over 1 cm³ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 7.79 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **77.5 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.25 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **22.3 W/kg ± 19.5 % (k=2)** |



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## Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| Nominal Head TSL parameters | 22.0 °C | 35.9 | 4.71 mho/m |
| Measured Head TSL parameters | (22.0 ± 0.2) °C | 35.2 ± 6 % | 4.55 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5250 MHz

| SAR averaged over 1 $cm^3$ (1 g) of Head TSL | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 8.00 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **79.6 W/kg ± 19.9 % (k=2)** |

| SAR averaged over 10 $cm^3$ (10 g) of Head TSL | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.31 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **22.9 W/kg ± 19.5 % (k=2)** |

## Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| Nominal Head TSL parameters | 22.0 °C | 35.9 | 4.76 mho/m |
| Measured Head TSL parameters | (22.0 ± 0.2) °C | 35.1 ± 6 % | 4.60 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5300 MHz

| SAR averaged over 1 $cm^3$ (1 g) of Head TSL | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 8.28 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **82.3 W/kg ± 19.9 % (k=2)** |

| SAR averaged over 10 $cm^3$ (10 g) of Head TSL | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.39 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **23.7 W/kg ± 19.5 % (k=2)** |



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## Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 35.6 | 4.96 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 34.8 ± 6 % | 4.79 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5500 MHz

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 8.10 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **80.5 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.32 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **23.0 W/kg ± 19.5 % (k=2)** |

## Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 35.5 | 5.07 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 34.7 ± 6 % | 4.90 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5600 MHz

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 8.42 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **83.7 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.43 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **24.1 W/kg ± 19.5 % (k=2)** |



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## Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 35.4 | 5.22 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 34.5 ± 6 % | 5.05 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5750 MHz

| **SAR averaged over 1 cm³ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 7.96 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **79.1 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.28 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **22.6 W/kg ± 19.5 % (k=2)** |

## Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 35.3 | 5.27 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 34.4 ± 6 % | 5.10 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5800 MHz

| **SAR averaged over 1 cm³ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 7.99 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **79.4 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.29 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **22.7 W/kg ± 19.5 % (k=2)** |



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**Body TSL parameters at 5250 MHz**

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| Nominal Body TSL parameters | 22.0 °C | 48.9 | 5.36 mho/m |
| Measured Body TSL parameters | (22.0 ± 0.2) °C | 47.0 ± 6 % | 5.44 mho/m ± 6 % |
| Body TSL temperature change during test | < 0.5 °C | ---- | ---- |

**SAR result with Body TSL at 5250 MHz**

| SAR averaged over 1 cm³ (1 g) of Body TSL | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 7.36 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **73.0 W/kg ± 19.9 % (k=2)** |

| SAR averaged over 10 cm³ (10 g) of Body TSL | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.09 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **20.7 W/kg ± 19.5 % (k=2)** |

**Body TSL parameters at 5600 MHz**

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| Nominal Body TSL parameters | 22.0 °C | 48.5 | 5.77 mho/m |
| Measured Body TSL parameters | (22.0 ± 0.2) °C | 46.4 ± 6 % | 5.91 mho/m ± 6 % |
| Body TSL temperature change during test | < 0.5 °C | ---- | ---- |

**SAR result with Body TSL at 5600 MHz**

| SAR averaged over 1 cm³ (1 g) of Body TSL | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 7.82 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **77.6 W/kg ± 19.9 % (k=2)** |

| SAR averaged over 10 cm³ (10 g) of Body TSL | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.21 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **21.9 W/kg ± 19.5 % (k=2)** |



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### Body TSL parameters at 5750 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 48.3 | 5.94 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 46.1 ± 6 % | 6.12 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

### SAR result with Body TSL at 5750 MHz

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 7.39 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **73.3 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.07 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **20.5 W/kg ± 19.5 % (k=2)** |



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

### Antenna Parameters with Head TSL at 5200 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 49.4 Ω - 9.7 jΩ |
| Return Loss | - 20.2 dB |

### Antenna Parameters with Head TSL at 5250 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 49.4 Ω - 5.7 jΩ |
| Return Loss | - 24.7 dB |

### Antenna Parameters with Head TSL at 5300 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 51.7 Ω - 3.6 jΩ |
| Return Loss | - 28.3 dB |

### Antenna Parameters with Head TSL at 5500 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 49.2 Ω - 1.5 jΩ |
| Return Loss | - 35.0 dB |

### Antenna Parameters with Head TSL at 5600 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 54.8 Ω - 3.3 jΩ |
| Return Loss | - 25.1 dB |

### Antenna Parameters with Head TSL at 5750 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 57.5 Ω + 0.3 jΩ |
| Return Loss | - 23.1 dB |

### Antenna Parameters with Head TSL at 5800 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 56.0 Ω + 0.1 jΩ |
| Return Loss | - 25.0 dB |



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## Antenna Parameters with Body TSL at 5250 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 51.8 Ω - 5.2 jΩ |
| Return Loss | - 25.4 dB |

## Antenna Parameters with Body TSL at 5600 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 54.4 Ω - 1.6 jΩ |
| Return Loss | - 26.9 dB |

## Antenna Parameters with Body TSL at 5750 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 58.8 Ω + 0.9 jΩ |
| Return Loss | - 21.8 dB |

## General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.199 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 | February 05, 2004 |



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## DASY5 Validation Report for Head TSL

Date: 20.01.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1020**

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5250 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; $\sigma$ = 4.51 S/m; $\varepsilon_r$ = 35.2; $\rho$ = 1000 kg/m$^3$ , Medium parameters used: f = 5250 MHz; $\sigma$ = 4.55 S/m; $\varepsilon_r$ = 35.2; $\rho$ = 1000 kg/m$^3$ , Medium parameters used: f = 5300 MHz; $\sigma$ = 4.6 S/m; $\varepsilon_r$ = 35.1; $\rho$ = 1000 kg/m$^3$ , Medium parameters used: f = 5500 MHz; $\sigma$ = 4.79 S/m; $\varepsilon_r$ = 34.8; $\rho$ = 1000 kg/m$^3$ , Medium parameters used: f = 5600 MHz; $\sigma$ = 4.9 S/m; $\varepsilon_r$ = 34.7; $\rho$ = 1000 kg/m$^3$ , Medium parameters used: f = 5750 MHz; $\sigma$ = 5.05 S/m; $\varepsilon_r$ = 34.5; $\rho$ = 1000 kg/m$^3$ , Medium parameters used: f = 5800 MHz; $\sigma$ = 5.1 S/m; $\varepsilon_r$ = 34.4; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.59, 5.59, 5.59); Calibrated: 31.12.2015, ConvF(5.53, 5.53, 5.53); Calibrated: 31.12.2015, ConvF(5.25, 5.25, 5.25); Calibrated: 31.12.2015, ConvF(5.18, 5.18, 5.18); Calibrated: 31.12.2015, ConvF(4.99, 4.99, 4.99); Calibrated: 31.12.2015, ConvF(4.95, 4.95, 4.95); Calibrated: 31.12.2015; ConvF(4.95, 4.95, 4.95); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Head Tissue 2/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 72.07 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 28.1 W/kg
**SAR(1 g) = 7.79 W/kg; SAR(10 g) = 2.25 W/kg**
Maximum value of SAR (measured) = 18.2 W/kg

**Dipole Calibration for Head Tissue 2/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 72.72 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 29.2 W/kg
**SAR(1 g) = 8 W/kg; SAR(10 g) = 2.31 W/kg**
Maximum value of SAR (measured) = 18.7 W/kg

**Dipole Calibration for Head Tissue 2/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 73.60 V/m; Power Drift = 0.09 dB
Peak SAR (extrapolated) = 31.2 W/kg
**SAR(1 g) = 8.28 W/kg; SAR(10 g) = 2.39 W/kg**
Maximum value of SAR (measured) = 19.6 W/kg



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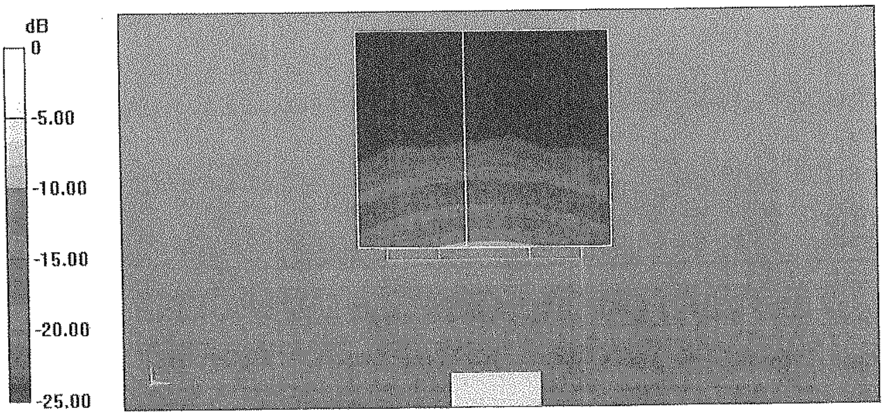
**Dipole Calibration for Head Tissue 2/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 72.02 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 32.0 W/kg
**SAR(1 g) = 8.1 W/kg; SAR(10 g) = 2.32 W/kg**
Maximum value of SAR (measured) = 19.7 W/kg

**Dipole Calibration for Head Tissue 2/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 72.66 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 32.9 W/kg
**SAR(1 g) = 8.42 W/kg; SAR(10 g) = 2.43 W/kg**
Maximum value of SAR (measured) = 20.5 W/kg

**Dipole Calibration for Head Tissue 2/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 70.61 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 32.4 W/kg
**SAR(1 g) = 7.96 W/kg; SAR(10 g) = 2.28 W/kg**
Maximum value of SAR (measured) = 19.5 W/kg

**Dipole Calibration for Head Tissue 2/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 70.21 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 32.7 W/kg
**SAR(1 g) = 7.99 W/kg; SAR(10 g) = 2.29 W/kg**
Maximum value of SAR (measured) = 19.8 W/kg



0 dB = 18.2 W/kg = 12.60 dBW/kg

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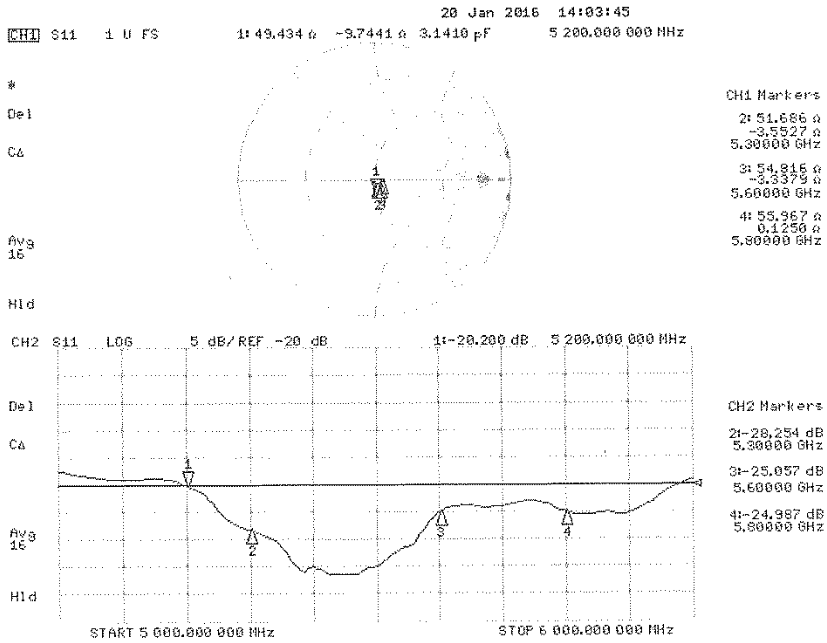
Impedance Measurement Plot for Head TSL (5200, 5300, 5600, 5800)

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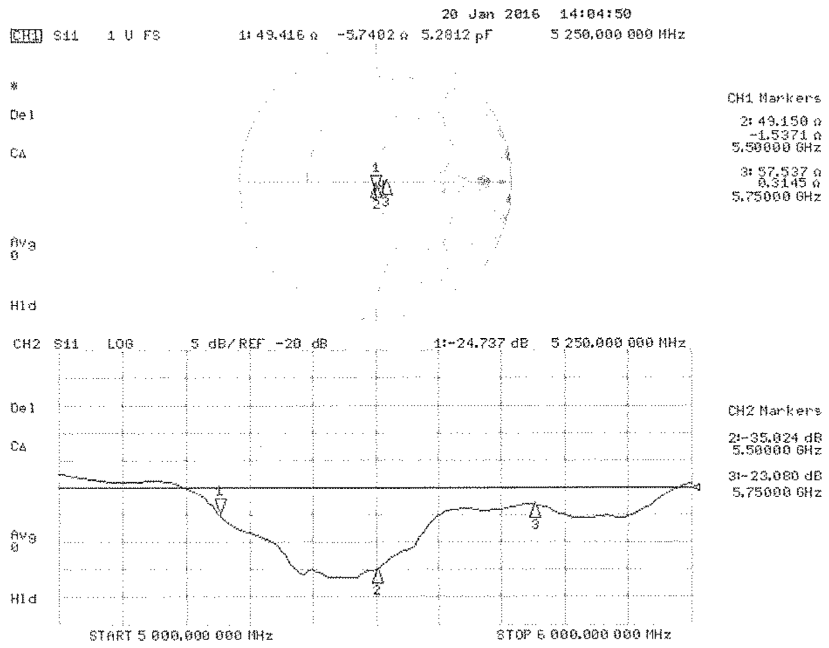
Impedance Measurement Plot for Head TSL (5250, 5500, 5750)




Certificate No: D5GHzV2-1020_Jan16 Page 14 of 17

## DASY5 Validation Report for Body TSL

Date: 13.01.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1020**

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz
Medium parameters used: f = 5250 MHz; σ = 5.44 S/m; $\varepsilon_r$ = 47; ρ = 1000 kg/m$^3$ , Medium parameters used: f = 5600 MHz; σ = 5.91 S/m; $\varepsilon_r$ = 46.4; ρ = 1000 kg/m$^3$ , Medium parameters used: f = 5750 MHz; σ = 6.12 S/m; $\varepsilon_r$ = 46.1; ρ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(4.85, 4.85, 4.85); Calibrated: 31.12.2015, ConvF(4.35, 4.35, 4.35); Calibrated: 31.12.2015, ConvF(4.3, 4.3, 4.3); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 66.83 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 27.5 W/kg
**SAR(1 g) = 7.36 W/kg; SAR(10 g) = 2.09 W/kg**
Maximum value of SAR (measured) = 17.4 W/kg

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 67.07 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 31.9 W/kg
**SAR(1 g) = 7.82 W/kg; SAR(10 g) = 2.21 W/kg**
Maximum value of SAR (measured) = 19.1 W/kg

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.16 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 31.5 W/kg
**SAR(1 g) = 7.39 W/kg; SAR(10 g) = 2.07 W/kg**
Maximum value of SAR (measured) = 18.3 W/kg



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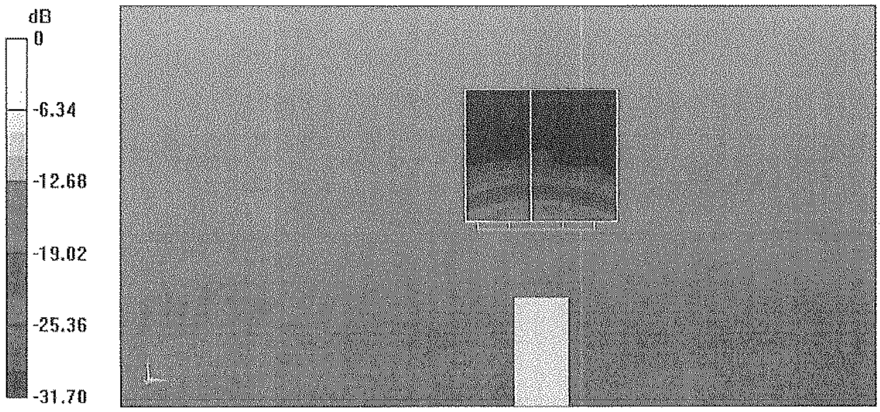


0 dB = 17.4 W/kg = 12.41 dBW/kg



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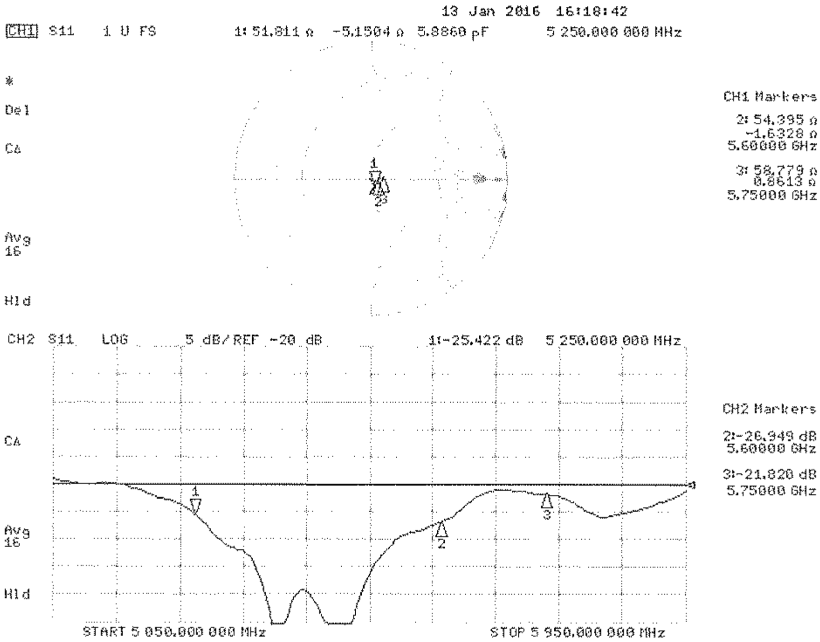
Impedance Measurement Plot for Body TSL

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## 3.System check uncertainty

The uncertainty budget has been determined for the DASY5 measurement system according to the SPEAG documents and is given in the following Table.

**Repeatability Budget for System Check**
<0.3 – 3GHz range Body>

| Error Description | Uncertainty value ± % | Probability distribution | divisor | (ci) 1g | Standard (1g) | vi or veff |
|---|---|---|---|---|---|---|
| **Measurement System** | | | | | | |
| Probe calibration | ± 1.8 | Normal | 1 | 1 | ± 1.8 | ∞ |
| Axial isotropy of the probe | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Spherical isotropy of the probe | ± 0.0 | Rectangular | √3 | 0 | ± 0.0 | ∞ |
| Boundary effects | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Probe linearity | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Detection limit | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Modulation response | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Readout electronics | ± 0.0 | Normal | 1 | 1 | ± 0.0 | ∞ |
| Response time | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Integration time | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| RF ambient Noise | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| RF ambient Reflections | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Probe Positioner | ± 0.4 | Rectangular | √3 | 1 | ± 0.2 | ∞ |
| Probe positioning | ± 2.9 | Rectangular | √3 | 1 | ± 1.7 | ∞ |
| Max.SAR Eval. | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| **Test Sample Related** | | | | | | |
| Deviation of wxp.dipole | ± 0.0 | Normal | √3 | 1 | ± 0.0 | ∞ |
| Dipole Axis to Liquid Distance | ± 2.0 | Normal | √3 | 1 | ± 1.2 | ∞ |
| Input power and SAR drift meas. | ± 3.4 | Rectangular | √3 | 1 | ± 2.0 | ∞ |
| **Phantom and Setup** | | | | | | |
| Phantom uncertainty | ± 4.0 | Rectangular | √3 | 1 | ± 2.3 | ∞ |
| Algorithm for correcting SAR for deviations in permittivity and conductivity | ± 1.9 | Normal | 1 | 1 | ± 1.9 | ∞ |
| Liquid conductivity (meas.) | ± 5.0 | Rectangular | 1 | 0.78 | + 3.9 | ∞ |
| Liquid permittivity (meas.) | ± 5.0 | Rectangular | 1 | 0.26 | - 1.3 | ∞ |
| Liquid conductivity - temp.unc (below 2deg.C.) | ± 1.7 | Rectangular | √3 | 0.78 | ± 0.8 | ∞ |
| Liquid permittivity - temp.unc (below 2deg.C.) | ± 0.3 | Rectangular | √3 | 0.23 | ± 0.0 | ∞ |
| | | | | | | |
| **Combined Standard Uncertainty** | | | | | ± **6.144** | |
| **Expanded Uncertainty (k=2)** | | | | | ± **12.3** | |

**Repeatability Budget for System Check**

<3 – 6GHz range Body>

| Error Description | Uncertainty value ± % | Probability distribution | divisor | (ci) 1g | Standard (1g) | vi or veff |
|---|---|---|---|---|---|---|
| **Measurement System** | | | | | | |
| Probe calibration | ± 1.8 | Normal | 1 | 1 | ± 1.8 | ∞ |
| Axial isotropy of the probe | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Spherical isotropy of the probe | ± 0.0 | Rectangular | √3 | 0 | ± 0.0 | ∞ |
| Boundary effects | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Probe linearity | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Detection limit | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Modulation response | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Readout electronics | ± 0.0 | Normal | 1 | 1 | ± 0.0 | ∞ |
| Response time | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Integration time | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| RF ambient Noise | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| RF ambient Reflections | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| Probe Positioner | ± 0.8 | Rectangular | √3 | 1 | ± 0.5 | ∞ |
| Probe positioning | ± 6.7 | Rectangular | √3 | 1 | ± 3.9 | ∞ |
| Max.SAR Eval. | ± 0.0 | Rectangular | √3 | 1 | ± 0.0 | ∞ |
| **Test Sample Related** | | | | | | |
| Deviation of wxp.dipole | ± 0.0 | Normal | √3 | 1 | ± 0.0 | ∞ |
| Dipole Axis to Liquid Distance | ± 2.0 | Normal | √3 | 1 | ± 1.2 | ∞ |
| Input power and SAR drift meas. | ± 3.4 | Rectangular | √3 | 1 | ± 2.0 | ∞ |
| **Phantom and Setup** | | | | | | |
| Phantom uncertainty | ± 4.0 | Rectangular | √3 | 1 | ± 2.3 | ∞ |
| Algorithm for correcting SAR for deviations in permittivity and conductivity | ± 1.9 | Normal | 1 | 1 | ± 1.9 | ∞ |
| Liquid conductivity (meas.) | ± 5.0 | Rectangular | 1 | 0.78 | + 3.9 | ∞ |
| Liquid permittivity (meas.) | ± 5.0 | Rectangular | 1 | 0.26 | - 1.3 | ∞ |
| Liquid conductivity - temp.unc (below 2deg.C.) | ± 1.7 | Rectangular | √3 | 0.78 | ± 0.8 | ∞ |
| Liquid permittivity - temp.unc (below 2deg.C.) | ± 0.3 | Rectangular | √3 | 0.23 | ± 0.0 | ∞ |
| | | | | | | |
| **Combined Standard Uncertainty** | | | | | ± **7.078** | |
| **Expanded Uncertainty (k=2)** | | | | | ± **14.2** | |

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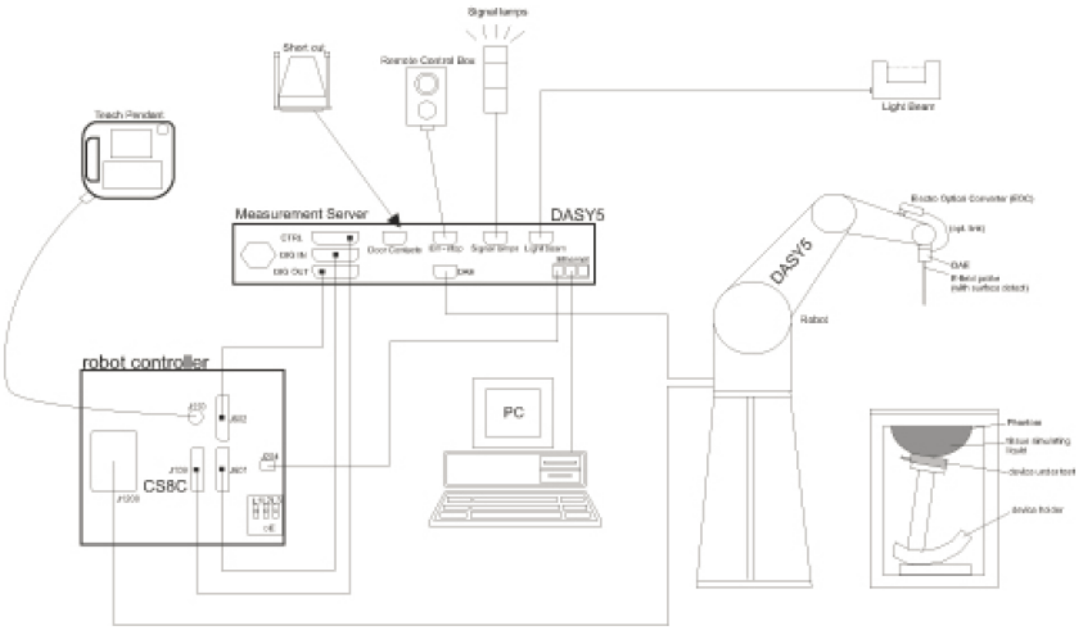
## APPENDIX 3 : System specifications

### 1. Configuration and peripherals




The DASY5 system for performing compliance tests consist of the following items:

a) A standard high precision 6-axis robot (Stäubli RX family) with controller and software.
An arm extension for accommodating the data acquisition electronics (DAE).

b) An isotropic field probe optimized and calibrated for the targeted measurement.

c) A data acquisition electronic (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.

d) The Electro-optical converter (EOC) performs the conversion between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection.
The EOC is connected to the measurement server.

e) 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.

f) The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.

g) A computer running WinXP and the DASY5 software.

h) Remote control with teaches pendant and additional circuitry for robot safety such as warning lamps, etc.

i) The phantom, the device holder and other accessories according to the targeted measurement.

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## 2. Specifications

**a)Robot TX60L**

| | | |
|---|---|---|
| **Number of Axes** | : | 6 |
| **Nominal Load** | : | 2 kg |
| **Maximum Load** | : | 5kg |
| **Reach** | : | 920mm |
| **Repeatability** | : | +/-0.03mm |
| **Control Unit** | : | CS8c |
| **Programming Language** | : | VAL3 |
| **Weight** | : | 52.2kg |
| **Manufacture** | : | Stäubli Robotics |

**b)E-Field Probe**

| | | |
|---|---|---|
| **Model** | : | EX3DV4 |
| **Serial No.** | : | 3922 |
| **Construction** | : | Symmetrical design with triangular core<br>Built-in shielding against static charges<br>PEEK enclosure material<br>(resistant to organic solvents, e.g., glycol ether) |
| **Frequency** | : | 10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz) |
| **Directivity** | : | +/-0.3 dB in HSL (rotation around probe axis)<br>+/-0.5 dB in tissue material (rotation normal probe axis) |
| **Dynamic Range** | : | 10uW/g to > 100 mW/g;Linearity<br>+/-0.2 dB(noise: typically < 1uW/g) |
| **Dimensions** | : | Overall length: 337 mm (Tip: 20 mm)<br>Tip diameter: 2.5mm (Body: 12 mm)<br>Typical distance from probe tip to dipole centers: 1 mm |
| **Application** | : | Highprecision dosimetric measurement in any exposure scenario<br>(e.g., very strong gradient fields).Only probe which enables compliance<br>testing for frequencies up to 6GHz with precision of better 30%. |
| **Manufacture** | : | Schmid & Partner Engineering AG |

**EX3DV4 E-field Probe**

## c)Data Acquisition Electronic (DAE4)

| | | |
|---|---|---|
| **Features** | : | Signal amplifier, multiplexer, A/D converter and control logic<br>Serial optical link for communication with DASY5 embedded system (fully remote controlled)<br>Two step probe touch detector for mechanical surface detection and emergency robot stop |
| **Measurement Range** | : | -100 to +300 mV (16 bit resolution and two range settings: 4mV, 400mV) |
| **Input Offset voltage** | : | < 5 μV (with auto zero) |
| **Input Resistance** | : | 200 MΩ |
| **Input Bias Current** | : | < 50 fA |
| **Battery Power** | : | > 10 h of operation (with two 9.6 V NiMH accus) |
| **Dimension** | : | 60 x 60 x 68 mm |
| **Manufacture** | : | Schmid & Partner Engineering AG |

## d)Electro-Optic Converter (EOC)

| | | |
|---|---|---|
| **Version** | : | EOC 61 |
| **Description** | : | for TX60 robot arm, including proximity sensor |
| **Manufacture** | : | Schmid & Partner Engineering AG |

## e)DASY5 Measurement server

| | | |
|---|---|---|
| **Features** | : | Intel ULV Celeron 400MHz<br>128MB chip disk and 128MB RAM<br>16 Bit A/D converter for surface detection system<br>Vacuum Fluorescent Display<br>Robot Interface<br>Serial link to DAE (with watchdog supervision)<br>Door contact port (Possibility to connect a light curtain)<br>Emergency stop port (to connect the remote control)<br>Signal lamps port<br>Light beam port<br>Three Ethernet connection ports<br>Two USB 2.0 Ports<br>Two serial links<br>Expansion port for future applications |
| **Dimensions (L x W x H)** | : | 440 x 241 x 89 mm |
| **Manufacture** | : | Schmid & Partner Engineering AG |

## f) Light Beam Switches

| | | |
|---|---|---|
| **Version** | : | LB5 |
| **Dimensions (L x H)** | : | 110 x 80 mm |
| **Thickness** | : | 12 mm |
| **Beam-length** | : | 80 mm |
| **Manufacture** | : | Schmid & Partner Engineering AG |

## g)Software

| | | |
|---|---|---|
| **Item** | : | Dosimetric Assessment System DASY5 |
| **Type No.** | : | SD 000 401A, SD 000 402A |
| **Software version No.** | : | DASY52, Version 52.6 (1) |
| **Manufacture / Origin** | : | Schmid & Partner Engineering AG |

## h)Robot Control Unit

| | | |
|---|---|---|
| **Weight** | : | 70 Kg |
| **AC Input Voltage** | : | selectable |
| **Manufacturer** | : | Stäubli Robotics |

## i)Phantom and Device Holder

### Phantom

**Type** : SAM Twin Phantom V4.0

**Description** : The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.

**Material** : Vinylester, glass fiber reinforced (VE-GF)

**Shell Material** : Fiberglass

**Thickness** : 2.0 +/-0.2 mm

**Dimensions** : Length: 1000 mm Width: 500 mm Height: adjustable feet

**Volume** : Approx. 25 liters

**Manufacture** : Schmid & Partner Engineering AG

**Type** : 2mm Flat phantom ERI4.0

**Description** : Phantom 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 the latest draft of the standard IEC 62209 Part II and all known tissue simulating liquids. ELI4 has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is supported by software version DASY4.5 and higher and is compatible with all SPEAG dosimetric probes and dipoles.

**Material** : Vinylester, glass fiber reinforced (VE-GF)

**Shell Thickness** : 2.0 ± 0.2 mm (sagging: <1%)

**Filling Volume** : approx. 30 liters

**Dimensions** : Major ellipse axis: 600 mm Minor axis: 400 mm

**Manufacture** : Schmid & Partner Engineering AG

### Device Holder

In combination with the Twin SAM Phantom V4.0/V4.0c or ELI4, the Mounting Device enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to IEC, IEEE, FCC or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).

**Material** : POM

### Laptio Extensions kit

Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices according to IEC 62209-2 (e.g., laptops, cameras, etc.). It is lightweight and fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin-SAM, ELI4 Phantoms.

**Material** : POM, Acrylic glass, Foam

### Urethane

For this measurement, the urethane foam was used as device holder.

## j)Simulated Tissues (Liquid)

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 required for routine SAR evaluation.

| Mixture (%) | Frequency (MHz) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 450 | | 900 | | 1800 | | 1950 | | 2450 | |
| **Tissue Type** | **Head** | **Body** | **Head** | **Body** | **Head** | **Body** | **Head** | **Body** | **Head** | **Body** |
| **Water** | 38.91 | 46.21 | 40.29 | 50.75 | 55.24 | 70.17 | 55.41 | 69.79 | 55.0 | 68.64 |
| **Sugar** | 56.93 | 51.17 | 57.90 | 48.21 | - | - | - | - | - | - |
| **Cellulose** | 0.25 | 0.18 | 0.24 | 0.00 | - | - | | - | - | - |
| **Salt (NaCl)** | 3.79 | 2.34 | 1.38 | 0.94 | 0.31 | 0.39 | 0.08 | 0.2 | - | - |
| **Preventol** | 0.12 | 0.08 | 0.18 | 0.10 | - | | | | - | - |
| **DGMBE** | - | - | - | - | 44.45 | 29.44 | 44.51 | 30.0 | 45.0 | 31.37 |
| **Dielectric Constant** | 43.42 | 58.0 | 42.54 | 56.1 | 42.0 | 56.8 | 39.9 | 54.0 | 39.8 | 52.5 |
| **Conductivity (S/m)** | 0.85 | 0.83 | 0.91 | 0.95 | 1.0 | 1.07 | 1.42 | 1.45 | 1.88 | 1.78 |

Note:DGMBE(Diethylenglycol-monobuthyl ether)

The simulated tissue (liquid) of 1800MHz was used for the test frequency of 1700MHz to 1800MHz.

| Mixture (%) | Frequency(MHz) | |
|---|---|---|
| | 650&750 | 1450 |
| **Tissue Type** | **Head and Body** | **Head and Body** |
| **Water** | 35-58% | 52-75% |
| **Sugar** | 40-60% | - |
| **Cellulose** | <0.3% | - |
| **Salt (NaCl)** | 0-6% | <1% |
| **Preventol** | 0.1-0.7% | - |
| **DGMBE** | - | 25-48% |

| Mixture (%) | Frequency(MHz) | |
|---|---|---|
| | 5800 | |
| **Tissue Type** | **Head** | **Body** |
| **Water** | 64.0 | 78.0 |
| **Mineral Oil** | 18.0 | 11.0 |
| **Emulsifiers** | 15.0 | 9.0 |
| **Additives and salt** | 3.0 | 2.0 |

## 3. Dosimetric E-Field Probe Calibration (EX3DV4, S/N: 3922)

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

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

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client UL Japan (Vitec)

Certificate No: EX3-3922_Jun15

# CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:3922

Calibration procedure(s): QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: June 17, 2015

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 E4419B | GB41293874 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Power sensor E4412A | MY41498087 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 01-Apr-15 (No. 217-02129) | Mar-16 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132) | Mar-16 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133) | Mar-16 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-14 (No. ES3-3013_Dec14) | Dec-15 |
| DAE4 | SN: 660 | 14-Jan-15 (No. DAE4-660_Jan15) | Jan-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-16 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Israe Elnaouq | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: June 18, 2015

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

Certificate No: EX3-3922_Jun15 Page 1 of 11

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Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

## 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

## 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).

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# Probe EX3DV4

## SN:3922

Manufactured: March 8, 2013
Calibrated: June 17, 2015

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



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# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3922

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 0.37 | 0.45 | 0.50 | ± 10.1 % |
| DCP (mV)[B] | 104.8 | 103.1 | 100.7 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√μV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 134.1 | ±3.3 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 131.4 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 141.4 | |

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 NormX,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.



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# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3922

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 2450 | 39.2 | 1.80 | 7.39 | 7.39 | 7.39 | 0.23 | 1.15 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 7.20 | 7.20 | 7.20 | 0.34 | 0.95 | ± 12.0 % |
| 5200 | 36.0 | 4.66 | 5.35 | 5.35 | 5.35 | 0.30 | 1.80 | ± 13.1 % |
| 5250 | 35.9 | 4.71 | 5.10 | 5.10 | 5.10 | 0.30 | 1.80 | ± 13.1 % |
| 5300 | 35.9 | 4.76 | 5.07 | 5.07 | 5.07 | 0.30 | 1.80 | ± 13.1 % |
| 5500 | 35.6 | 4.96 | 4.85 | 4.85 | 4.85 | 0.35 | 1.80 | ± 13.1 % |
| 5600 | 35.5 | 5.07 | 4.62 | 4.62 | 4.62 | 0.40 | 1.80 | ± 13.1 % |
| 5750 | 35.4 | 5.22 | 4.75 | 4.75 | 4.75 | 0.40 | 1.80 | ± 13.1 % |
| 5800 | 35.3 | 5.27 | 4.60 | 4.60 | 4.60 | 0.40 | 1.80 | ± 13.1 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.



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# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3922

**Calibration Parameter Determined in Body Tissue Simulating Media**

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 2450 | 52.7 | 1.95 | 7.49 | 7.49 | 7.49 | 0.30 | 0.80 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 7.28 | 7.28 | 7.28 | 0.30 | 0.80 | ± 12.0 % |
| 5250 | 48.9 | 5.36 | 4.46 | 4.46 | 4.46 | 0.40 | 1.90 | ± 13.1 % |
| 5600 | 48.5 | 5.77 | 3.87 | 3.87 | 3.87 | 0.50 | 1.90 | ± 13.1 % |
| 5750 | 48.3 | 5.94 | 4.08 | 4.08 | 4.08 | 0.50 | 1.90 | ± 13.1 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters ($\varepsilon$ and $\sigma$) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ($\varepsilon$ and $\sigma$) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.



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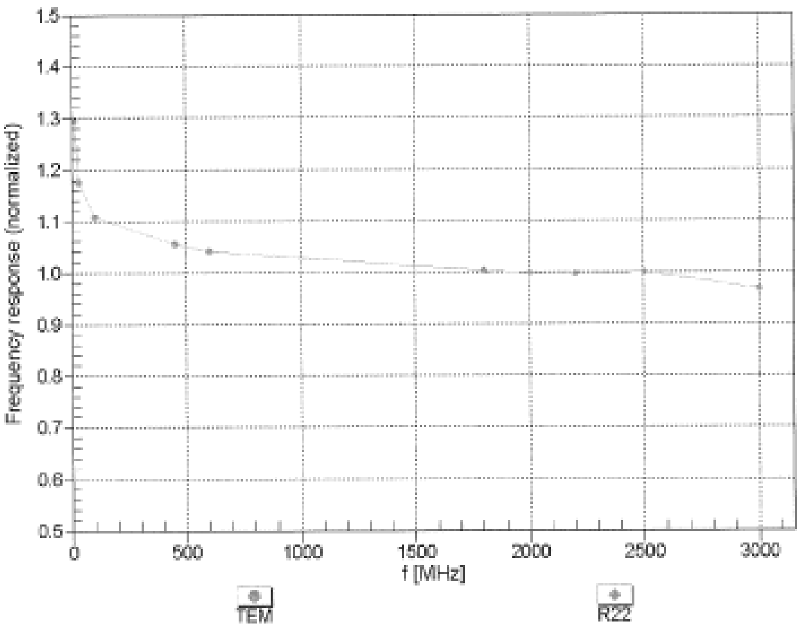
## Frequency Response of E-Field
**(TEM-Cell:ifi110 EXX, Waveguide: R22)**




**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

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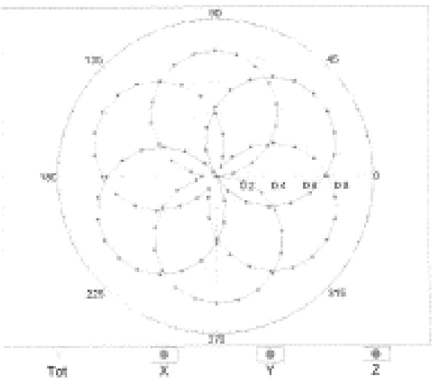
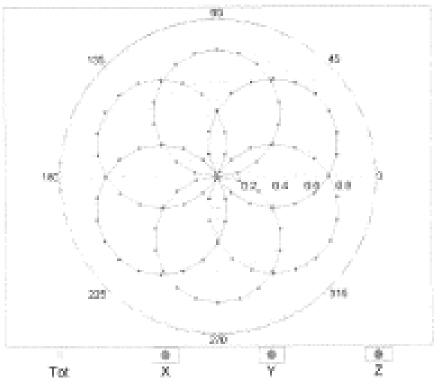
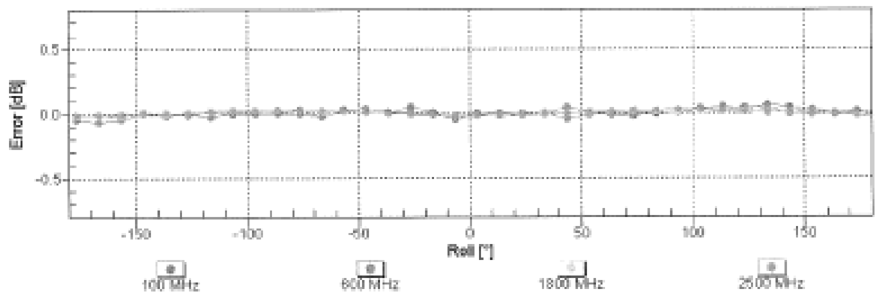
## Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM




f=1800 MHz,R22




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**



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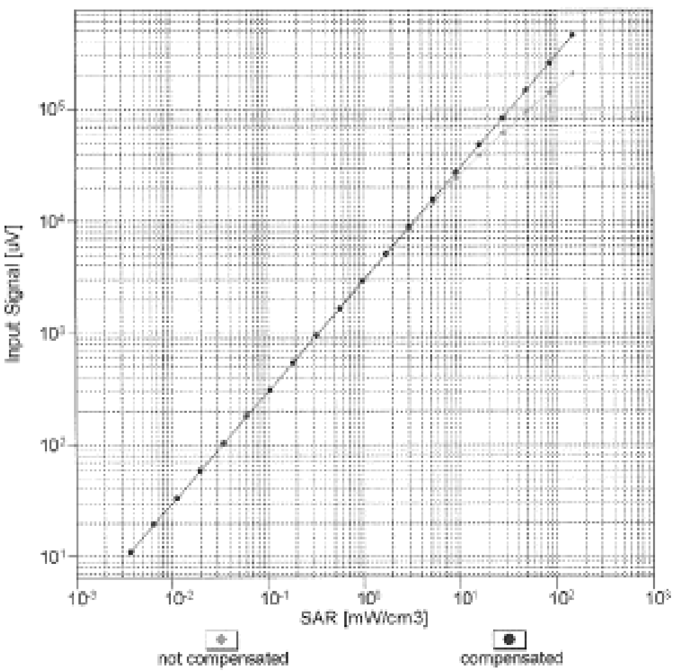
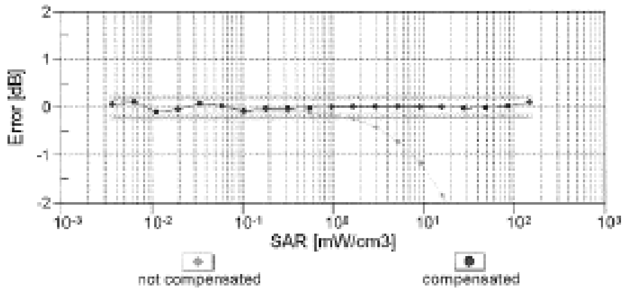
# Dynamic Range f($SAR_{head}$)

**(TEM cell , $f_{eval}$= 1900 MHz)**




**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**



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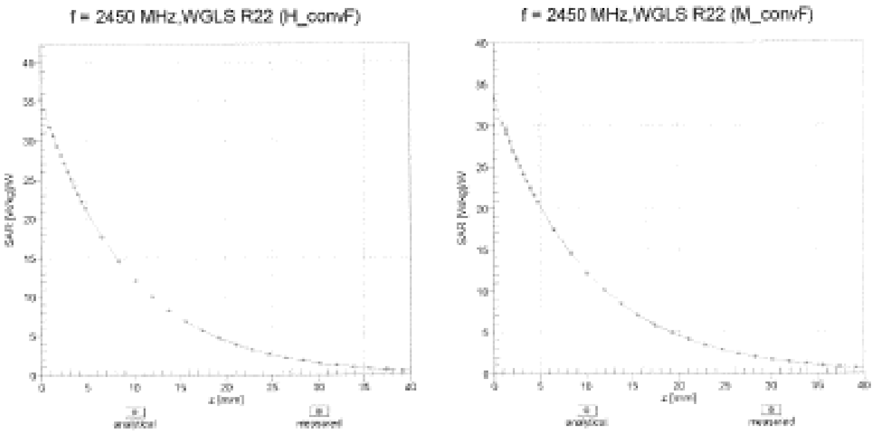
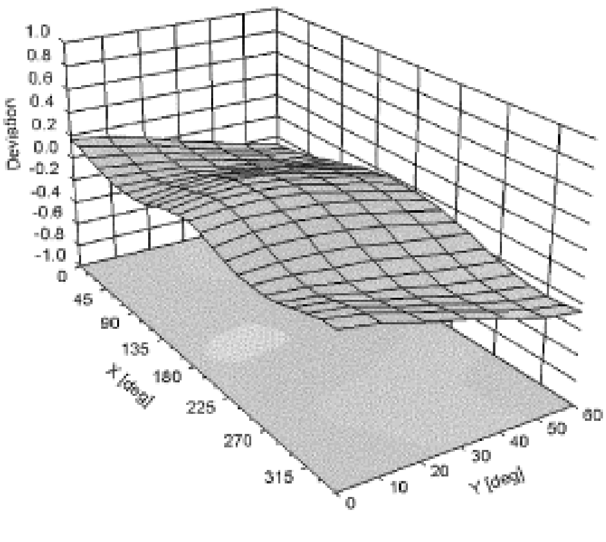
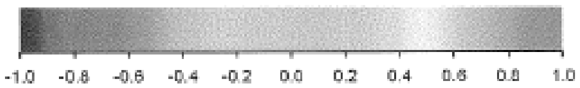
# Conversion Factor Assessment




# Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz




Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)



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# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3922

### Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 73.4 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 9 mm |
| Tip Diameter | 2.5 mm |
| Probe Tip to Sensor X Calibration Point | 1 mm |
| Probe Tip to Sensor Y Calibration Point | 1 mm |
| Probe Tip to Sensor Z Calibration Point | 1 mm |
| Recommended Measurement Distance from Surface | 1.4 mm |



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