# SAR TEST REPORT

# No. I18Z60895-SEM02

**For**

**Lenovo PC HK Limited**

**Portable Tablet Computer**

**Model Name: Lenovo TB-7104F**

**With**

**Hardware Version: Lenovo Tablet TB-7104F**

**Software Version: TB-7104F_RF01_180623**

**FCC ID: O57TB7104F**

**Issued Date: 2018-6-13**

TESTING
NVLAP LAB CODE 600118-0

**Note:**

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## REPORT HISTORY

| Report Number | Revision | Issue Date | Description |
|---|---|---|---|
| I18Z60895-SEM02 | Rev.0 | 2018-6-13 | Initial creation of test report |

# TABLE OF CONTENT

# 1  Test Laboratory

## 1.1  Testing Location

| Company Name: | CTTL(Shouxiang) |
|---|---|
| Address: | No. 51 Shouxiang Science Building, Xueyuan Road, Haidian District, Beijing, P. R. China100191 |

## 1.2  Testing Environment

| Temperature: | 18°C~25°C, |
|---|---|
| Relative humidity: | 30%~ 70% |
| Ground system resistance: | < 0.5 Ω |
| Ambient noise & Reflection: | < 0.012 W/kg |

## 1.3  Project Data

| Project Leader: | Qi Dianyuan |
|---|---|
| Test Engineer: | Lin Xiaojun |
| Testing Start Date: | May 31, 2018 |
| Testing End Date: | May 31, 2018 |

## 1.4  Signature

**Lin Xiaojun**

**(Prepared this test report)**
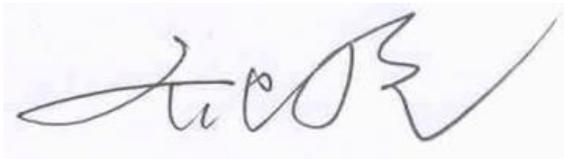
**Qi Dianyuan**

**(Reviewed this test report)**
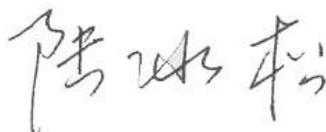
**Lu Bingsong**

**Deputy Director of the laboratory**

**(Approved this test report)**

## 2 Statement of Compliance

The maximum results of SAR found during testing for Lenovo PC HK Limited Portable Tablet Computer  Lenovo TB-7104F  is as follows:

**Table 2.1: Highest Reported SAR (1g)**

| Exposure Configuration | Technology Band | Highest Reported SAR 1g(W/Kg) | Equipment Class |
|---|---|---|---|
| Body (Separation Distance 0mm) | WLAN 2.4 GHz | 1.19 | DTS |

The SAR values found for the Mobile Phone are below the maximum recommended levels of 1.6 W/Kg as averaged over any 1g tissue according to the ANSI C95.1-1992.

For body operation, this device has been tested and meets FCC RF exposure guidelines when used with any accessory that contains no metal and which provides a minimum separation distance of 0 mm between this device and the body of the user. Use of other accessories may not ensure compliance with FCC RF exposure guidelines.

The EUT battery must be fully charged and checked periodically during the test to ascertain uniform power output.

The measurement together with the test system set-up is described in annex C of this test report. A detailed description of the equipment under test can be found in chapter 4 of this test report.

The highest reported SAR value is obtained at the case of **(Table 2.1),** and the values are**: 1.19 W/kg(1g).**

# 3 Client Information

## 3.1 3.1 Applicant Information

| | |
|---|---|
| Company Name: | Lenovo(Shanghai) Electronics Technology Co., Ltd. |
| Address/Post: | NO.68 BUILDING, 199 FENJU RD, Pilot Free Trade Zone, 200131, China |
| City: | Shang Hai |
| Postal Code: | 200131 |
| Country: | China |
| Contact Person: | Spring Zhou |
| E-mail: | zhoucb1@lenovo.com |
| Telephone: | +86-21-50504500-8281 |
| Fax: | +86-21-50807240 |

## 3.2 3.2 Manufacturer Information

| | |
|---|---|
| Company Name: | Lenovo PC HK Limited |
| Address/Post: | 23/F, Lincoln House, Taikoo Place 979 King's Road, Quarry Bay, Hong Kong |
| City: | Hong Kong |
| Postal Code: | / |
| Country: | China |
| Contact Person: | Spring Zhou |
| E-mail: | zhoucb1@lenovo.com |
| Telephone: | +86-21-50504500-8281 |
| Fax: | +86-21-50807240 |

# 4 Equipment Under Test (EUT) and Ancillary Equipment (AE)

## 4.1 About EUT

| | |
|---|---|
| Description: | Portable Tablet Computer |
| Model name: | Lenovo TB-7104F |
| Operating mode(s): | BT, WLAN |
| Tx Frequency: | 2402 – 2480 MHz (Bluetooth) |
| | 2412 – 2462 MHz (Wi-Fi 2.4G) |
| Test device Production information: | Production unit |
| Device type: | Portable device |
| Antenna type: | Integrated antenna |

## 4.2 Internal Identification of EUT used during the test

| EUT ID | IMEI | HW Version | SW Version |
|---|---|---|---|
| 1 | HAOWL9HZ(11) | Lenovo Tablet TB-7104F | TB-7104F_RF01_180623 |
| 2 | HAOWNCQ8(10) | Lenovo Tablet TB-7104F | TB-7104F_RF01_180623 |
| 3 | HAOWN6AK(10) | Lenovo Tablet TB-7104F | TB-7104F_RF01_180623 |
| 4 | HAOWL49S(11) | Lenovo Tablet TB-7104F | TB-7104F_RF01_180623 |

*EUT ID: is used to identify the test sample in the lab internally.

**Note:** It is performed to test SAR with the EUT1&2&3 and conducted power with the EUT4.

## 4.3 Internal Identification of AE used during the test

| AE ID* | Description | Model | SN | Manufacturer |
|---|---|---|---|---|
| AE1 | Battery | LI-LON | SB18C31688 | ATL |
| AE2 | Battery | LI-LON | SB18C31689 | SCUD |

There are three kinds of combination modes to be tested and the detail information is as follows:

| No. | sku1 | sku2 | sku3 |
|---|---|---|---|
| wingtech model | P98995AA1 | P98995AA1 | P98995BA1 |
| Memory | 1+8G | 1+8G | 1+16G |
| CPU | MT8167 A/D | MT8167 A/D | MT8167 A/D |
| Band | WIFI only | WIFI only | WIFI only |
| Card configuration | TF only | TF only | TF only |
| PMU | MT6392 | MT6392 | MT6392 |
| OS | Android8.1 | Android8.1 | Android8.1 |
| TLCD | 7inch HD TN 1024 x 600 Dots/ oncell | 7inch HD TN 1024 x 600 Dots/ oncell | 7inch HD TN 1024 x 600 Dots/ oncell |
| front camera | 0.3M FF | 0.3M FF | 0.3M FF |
| back camera | 2M FF | 2M FF | 2M FF |
| battery | 2750mAH | 2750mAH | 2750mAH |
| REC\SPK | two-in-one, 1115 3.0; the big magnet steel (nonsupport REC) | two-in-one, 1115 3.0; the big magnet steel (nonsupport REC) | two-in-one, 1115 3.0; the big magnet steel (nonsupport REC) |
| Mic | 4015 lead type | 4015 lead type | 4015 lead type |
| Audio PA | AW87317CSR | AW87317CSR | AW87317CSR |
| RF PA | NA | NA | NA |
| GPS\WIFI\BT | nonsupport GPS, support WIF/BT | nonsupport GPS, support WIF/BT | nonsupport GPS, support WIF/BT |
| FM | NA | NA | NA |
| G sensor | support | support | support |
| P-Sensor | NA | NA | NA |
| SAR sensor IC | NA | NA | NA |
| OVP | NA | NA | NA |
| indicator light | monochrome LED | monochrome LED | monochrome LED |
| charger | 5.0V/1A | 5.0V/1A | 5.0V/1A |
| motor | NA | NA | NA |
| subpanel | NA | NA | NA |
| blendent | Slate Black | Slate Black | Slate Black |

NOTE: For sku1 & sku2, the corresponding model name is the same,but some materials are different.

We'll perform the SAR measurement with SKU3 and retest on highest value point with SKU1&2.

# 5   TEST METHODOLOGY

## 5.1   Applicable Limit Regulations

**ANSI C95.1–1992** IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

It specifies the maximum exposure limit of **1.6 W/kg** as averaged over any 1 gram of tissue for portable devices being used within 20 cm of the user in the uncontrolled environment.

## 5.2   Applicable Measurement Standards

**IEEE 1528–2013** Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques.

**KDB447498 D01 General RF Exposure Guidance v06** Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies.

**KDB616217 D04 SAR for laptop and tablets v01r02** SAR Evaluation Considerations for Laptop, Notebook, Notebook and Tablet Computers.

**KDB248227 D01 802.11 Wi-Fi SAR v02r02:** SAR GUIDANCE FOR IEEE 802.11 (Wi-Fi) TRANSMITTERS

**KDB865664 D01SAR measurement 100 MHz to 6 GHz v01r04** SAR Measurement Requirements for 100 MHz to 6 GHz.

**KDB865664 D02RF Exposure Reporting v01r02** RF Exposure Compliance Reporting and Documentation Considerations

# 6 Specific Absorption Rate (SAR)

## 6.1 Introduction

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

## 6.2 SAR Definition

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

$$SAR = \frac{d}{dt}(\frac{dW}{dm}) = \frac{d}{dt}(\frac{dW}{\rho dv})$$

SAR is expressed in units of Watts per kilogram (W/kg)
SAR measurement can be either related to the temperature elevation in tissue by

$$SAR = c(\frac{\delta T}{\delta t})$$

Where: C is the specific head capacity, $\delta T$ is the temperature rise and $\delta t$ is the exposure duration, or related to the electrical field in the tissue by

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

Where: $\sigma$ is the conductivity of the tissue, $\rho$ is the mass density of tissue and $E$ is the RMS electrical field strength.

However for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

# 7   Tissue Simulating Liquids

## 7.1   Targets for tissue simulating liquid

**Table 7.1: Targets for tissue simulating liquid**

| Frequency(MHz) | Liquid Type | Conductivity(σ) | ± 5% Range | Permittivity(ε) | ± 5% Range |
|---|---|---|---|---|---|
| 2450 | Body | 1.95 | 1.85～2.05 | 52.7 | 50.1～55.3 |

## 7.2   Dielectric Performance

**Table 7.2: Dielectric Performance of Tissue Simulating Liquid**

| Measurement Date yyyy-mm-dd | Frequency | Type | Permittivity ε | Drift (%) | Conductivity σ (S/m) | Drift (%) |
|---|---|---|---|---|---|---|
| 2018-5-31 | 2450 MHz | Body | 52.18 | -0.99 | 1.962 | 0.62 |

Note: The liquid temperature is 22.0 ℃
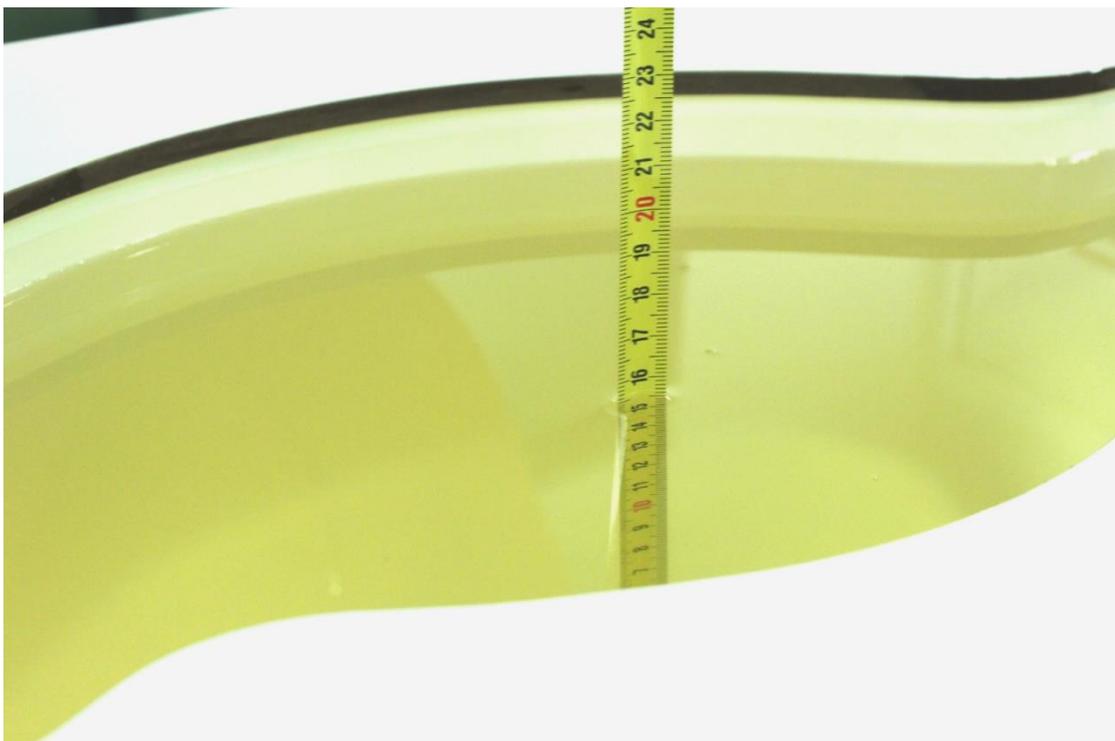


**Picture 7-1 Liquid depth in the Flat Phantom (2450MHz)**

# 8   System verification

## 8.1   System Setup

In the simplified setup for system evaluation, the DUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave that comes from a signal generator. The calibrated dipole must be placed beneath the flat phantom section of the SAM twin phantom with the correct distance holder. The distance holder should touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The equipment setup is shown below:
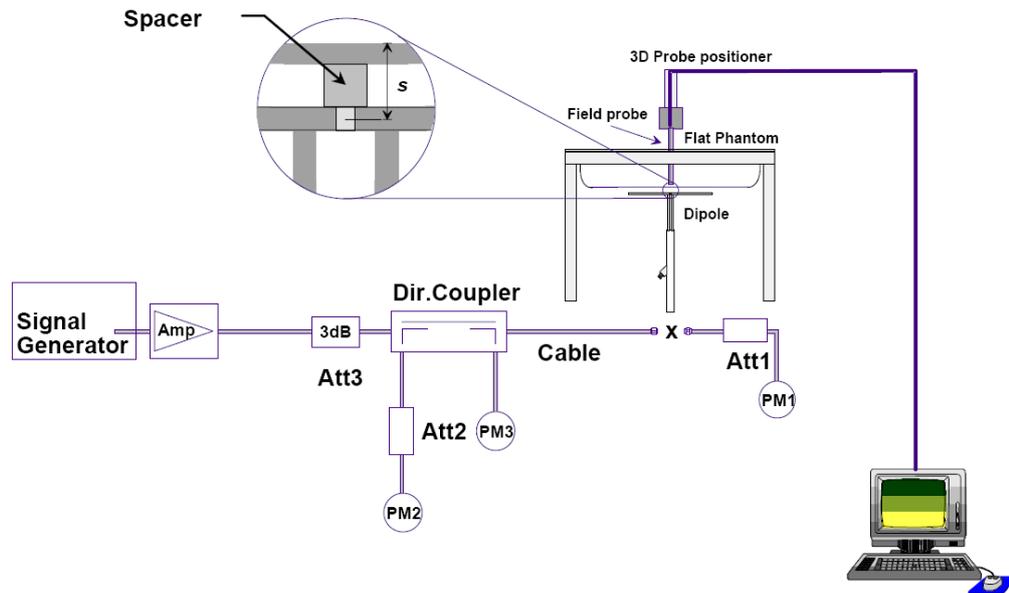


**Picture 8.1 System Setup for System Evaluation**
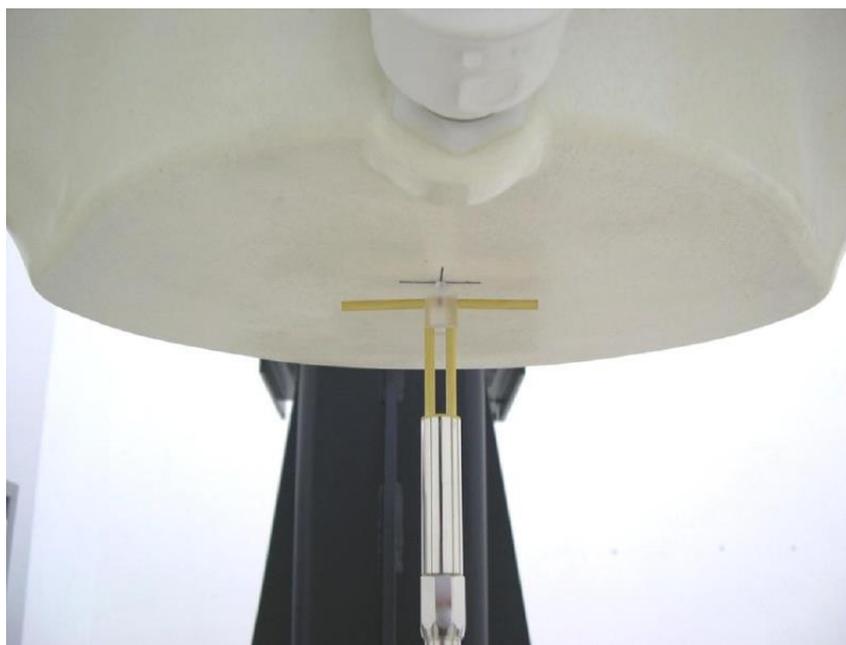


**Picture 8.2 Photo of Dipole Setup**

## 8.2   System Verification

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media, probe calibration points and other system operating parameters required for measuring the SAR of a test device. The system verification must be performed for each frequency band and within the valid range of each probe calibration point required for testing the device.

**Table 8.1: System Verification of Body**

| Measurement Date (yyyy-mm-dd) | Frequency | Target value (W/kg) | | Measured value (W/kg) | | Deviation | |
|---|---|---|---|---|---|---|---|
| | | 10 g Average | 1 g Average | 10 g Average | 1 g Average | 10 g Average | 1 g Average |
| 2018-5-31 | 2450 MHz | 23.8 | 50.4 | 23.96 | 51.20 | 0.67% | 1.59% |

# 9 Measurement Procedures

## 9.1 Tests to be performed

In order to determine the highest value of the peak spatial-average SAR of a handset, all device positions, configurations and operational modes shall be tested for each frequency band according to steps 1 to 3 below. A flowchart of the test process is shown in picture 9.1.

**Step 1**: The tests described in 9.2 shall be performed at the channel that is closest to the center of

the transmit frequency band ( $f_c$ ) for:

a) all device positions (cheek and tilt, for both left and right sides of the SAM phantom, as described in annex D),
b) all configurations for each device position in a), e.g., antenna extended and retracted, and
c) all operational modes, e.g., analogue and digital, for each device position in a) and configuration in b) in each frequency band.

If more than three frequencies need to be tested according to 11.1 (i.e., $N_c > 3$), then all

frequencies, configurations and modes shall be tested for all of the above test conditions.

**Step 2**: For the condition providing highest peak spatial-average SAR determined in Step 1, perform all tests described in 9.2 at all other test frequencies, i.e., lowest and highest frequencies. In addition, for all other conditions (device position, configuration and operational mode) where the peak spatial-average SAR value determined in Step 1 is within 3 dB of the applicable SAR limit, it is recommended that all other test frequencies shall be tested as well.

**Step 3**: Examine all data to determine the highest value of the peak spatial-average SAR found in Steps 1 to 2.

**Picture a – Tests to be performed**

**Picture b – General procedure**
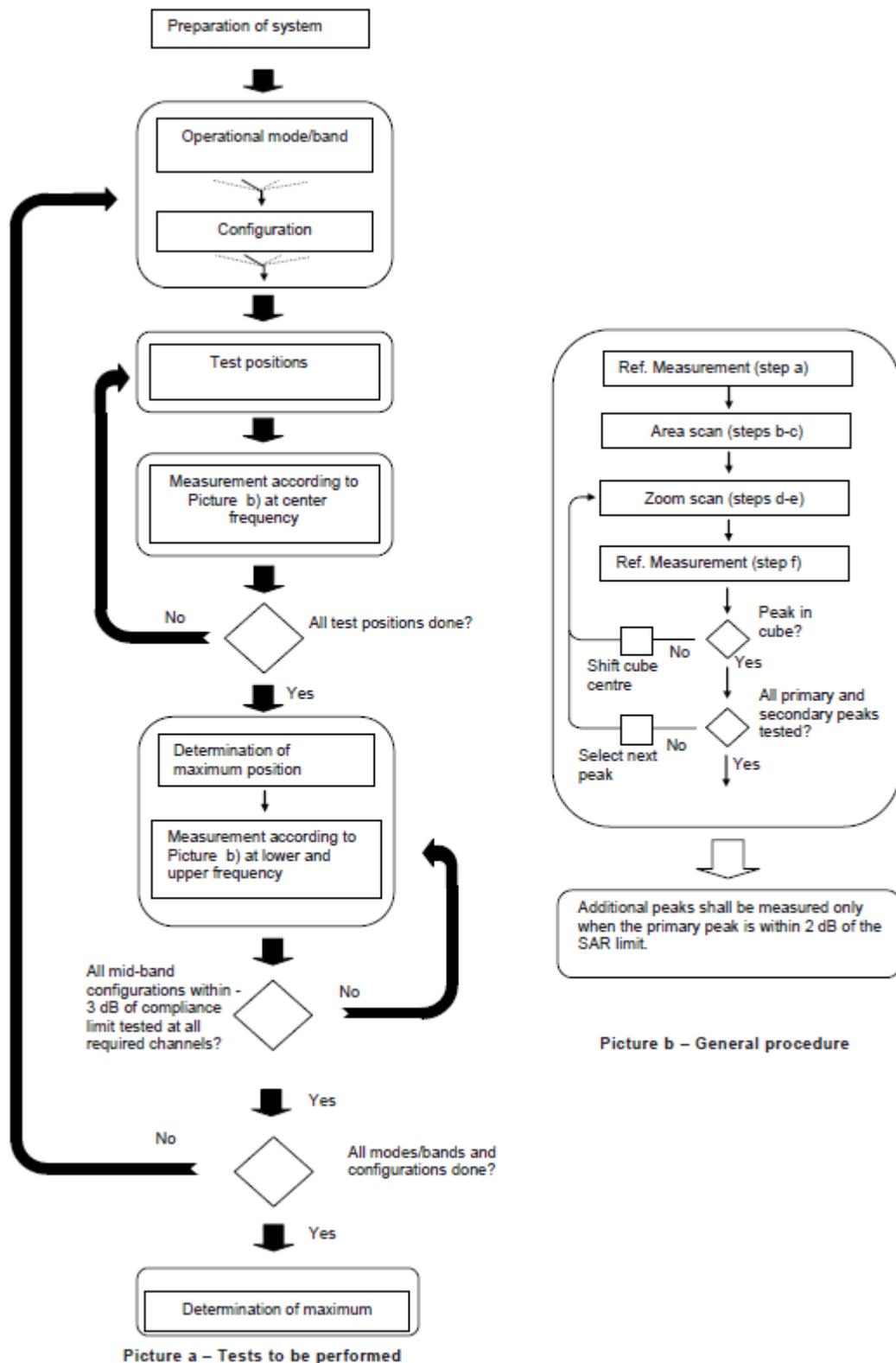
**Picture 9.1 Block diagram of the tests to be performed**

## 9.2   General Measurement Procedure

The area and zoom scan resolutions specified in the table below must be applied to the SAR measurements and fully documented in SAR reports to qualify for TCB approval. Probe boundary effect error compensation is required for measurements with the probe tip closer than half a probe tip diameter to the phantom surface. Both the probe tip diameter and sensor offset distance must satisfy measurement protocols; to ensure probe boundary effect errors are minimized and the higher fields closest to the phantom surface can be correctly measured and extrapolated to the phantom surface for computing 1-g SAR. Tolerances of the post-processing algorithms must be verified by the test laboratory for the scan resolutions used in the SAR measurements, according to the reference distribution functions specified in IEEE Std 1528-2003. The results should be documented as part of the system validation records and may be requested to support test results when all the measurement parameters in the following table are not satisfied.

| | | | $\leq$ 3 GHz | > 3 GHz |
|---|---|---|---|---|
| Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface | | | 5 ± 1 mm | ½·$\delta$·ln(2) ± 0.5 mm |
| Maximum probe angle from probe axis to phantom surface normal at the measurement location | | | 30° ± 1° | 20° ± 1° |
| Maximum area scan spatial resolution: $\Delta x_{Area}$, $\Delta y_{Area}$ | | | $\leq$ 2 GHz: $\leq$ 15 mm<br>2 – 3 GHz: $\leq$ 12 mm | 3 – 4 GHz: $\leq$ 12 mm<br>4 – 6 GHz: $\leq$ 10 mm |
| | | | When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device. | |
| Maximum zoom scan spatial resolution: $\Delta x_{Zoom}$, $\Delta y_{Zoom}$ | | | $\leq$ 2 GHz: $\leq$ 8 mm<br>2 – 3 GHz: $\leq$ 5 mm* | 3 – 4 GHz: $\leq$ 5 mm*<br>4 – 6 GHz: $\leq$ 4 mm* |
| Maximum zoom scan spatial resolution, normal to phantom surface | uniform grid: $\Delta z_{Zoom}(n)$ | | $\leq$ 5 mm | 3 – 4 GHz: $\leq$ 4 mm<br>4 – 5 GHz: $\leq$ 3 mm<br>5 – 6 GHz: $\leq$ 2 mm |
| | graded grid | $\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface | $\leq$ 4 mm | 3 – 4 GHz: $\leq$ 3 mm<br>4 – 5 GHz: $\leq$ 2.5 mm<br>5 – 6 GHz: $\leq$ 2 mm |
| | | $\Delta z_{Zoom}(n>1)$: between subsequent points | $\leq$ 1.5·$\Delta z_{Zoom}(n-1)$ | |
| Minimum zoom scan volume | x, y, z | | $\geq$ 30 mm | 3 – 4 GHz: $\geq$ 28 mm<br>4 – 5 GHz: $\geq$ 25 mm<br>5 – 6 GHz: $\geq$ 22 mm |

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

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

## 9.3   Bluetooth & Wi-Fi Measurement Procedures for SAR

Normal network operating configurations are not suitable for measuring the SAR of 802.11 transmitters in general. Unpredictable fluctuations in network traffic and antenna diversity conditions can introduce undesirable variations in SAR results. The SAR for these devices should be measured using chipset based test mode software to ensure that the results are consistent and reliable.

Chipset based test mode software is hardware dependent and generally varies among manufacturers. The device operating parameters established in a test mode for SAR measurements must be identical to those programmed in production units, including output power levels, amplifier gain settings and other RF performance tuning parameters. The test frequencies should correspond to actual channel frequencies defined for domestic use. SAR for devices with switched diversity should be measured with only one antenna transmitting at a time during each SAR measurement, according to a fixed modulation and data rate. The same data pattern should be used for all measurements.

## 9.4   Power Drift

To control the output power stability during the SAR test, DASY4 system calculates the power drift by measuring the E-field at the same location at the beginning and at the end of the measurement for each test position. These drift values can be found in section12 labeled as: (Power Drift [dB]). This ensures that the power drift during one measurement is within 5%.

# 10 Conducted Output Power

The output power of BT antenna is as following:

| Mode | Conducted Power (dBm) | | | Tune up |
|---|---|---|---|---|
| | Channel 0 (2402MHz) | Channel 39 (2441MHz) | Channel 78(2480MHz) | |
| GFSK | 5.57 | 6.16 | 5.81 | **6.5** |
| EDR2M-4_DQPSK | 4.75 | 5.24 | 4.93 | **6.5** |
| EDR3M-8DPSK | 4.79 | 5.28 | 4.97 | **6.5** |

The average conducted power for Wi-Fi is as following:

802.11b (dBm)

| Channel\data rate | 1Mbps | 2Mbps | 5.5Mbps | 11Mbps |
|---|---|---|---|---|
| 11 | 15.95 | / | 16.27 | / |
| 6 | 16.10 | 16.07 | 16.42 | 16.16 |
| 1 | 15.67 | / | 16.38 | / |
| **Tune up** | **16.5** | **16.5** | **16.5** | **16.5** |

802.11g (dBm)

| Channel\data rate | 6Mbps | 9Mbps | 12Mbps | 18Mbps | 24Mbps | 36Mbps | 48Mbps | 54Mbps |
|---|---|---|---|---|---|---|---|---|
| 11 | 15.81 | / | / | / | / | / | / | / |
| 6 | 15.84 | / | / | / | / | / | / | / |
| 1 | 16.02 | 15.61 | 15.82 | 15.76 | 15.51 | 15.54 | 15.66 | 15.72 |
| **Tune up** | **16.5** | **16.5** | **16.5** | **16.5** | **16.5** | **16.5** | **16.5** | **16.5** |

802.11n (dBm) - HT20 (2.4G)

| Channel\data rate | MCS0 | MCS1 | MCS2 | MCS3 | MCS4 | MCS5 | MCS6 | MCS7 |
|---|---|---|---|---|---|---|---|---|
| 11 | 15.51 | / | / | / | / | / | / | / |
| 6 | 15.69 | / | / | / | / | / | / | / |
| 1 | 15.71 | 15.46 | 15.64 | 15.62 | 15.60 | 15.57 | 15.45 | 15.03 |
| **Tune up** | **16.5** | **16.5** | **16.5** | **16.5** | **16.5** | **16.5** | **16.5** | **16.5** |

# 11 Standalone SAR Considerations

## 11.1 Transmit Antenna Separation Distances
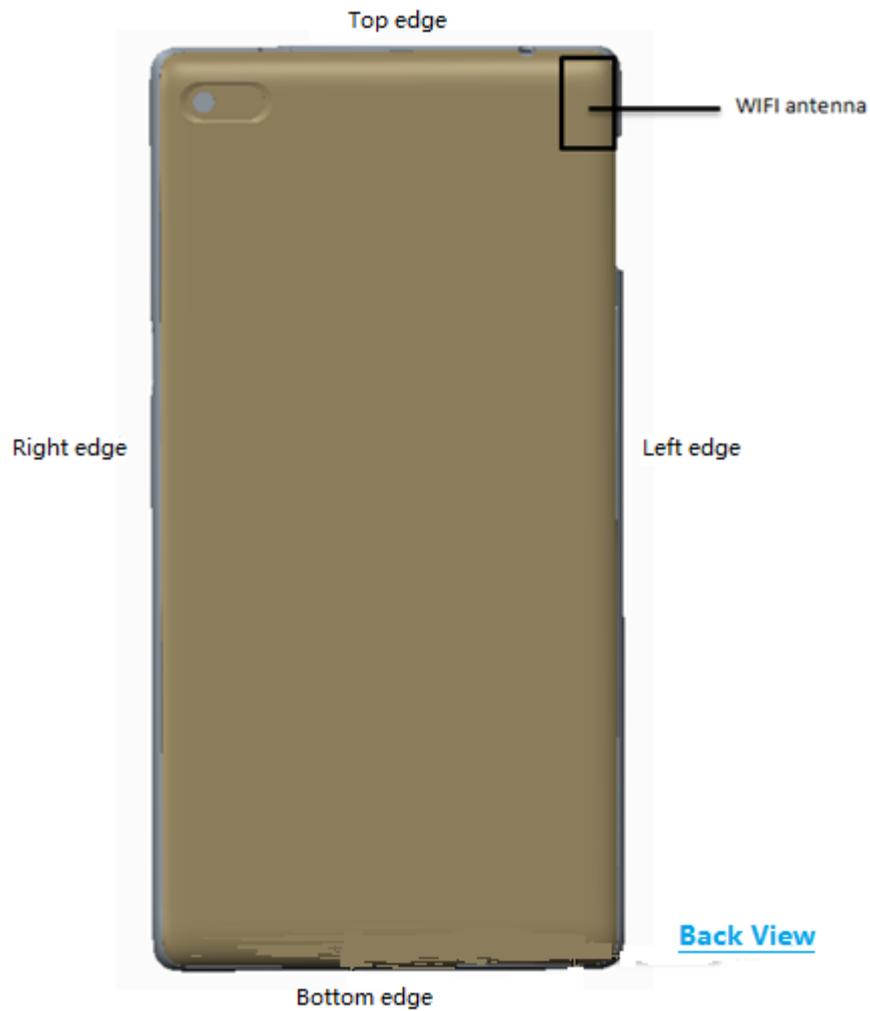


**Picture 11.1 Antenna Locations**

## 11.2 SAR Measurement Positions

| SAR measurement positions | | | | | | |
|---|---|---|---|---|---|---|
| Mode | Front | Rear | Left edge | Right edge | Top edge | Bottom edge |
| WLAN | No | Yes | Yes | No | Yes | No |

## 11.3 Standalone SAR Test Exclusion Considerations

Standalone 1-g head or body SAR evaluation by measurement or numerical simulation is not required when the corresponding SAR Exclusion Threshold condition, listed below, is satisfied. The 1-g SAR test exclusion threshold 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, 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

**Table 11.1: Standalone SAR test exclusion considerations**

| Band/Mode | F(GHz) | Position | SAR test exclusion threshold (mW) | RF output power | | SAR test exclusion |
|---|---|---|---|---|---|---|
| | | | | dBm | mW | |
| Bluetooth | 2.441 | Body | 19.2 | 6.5 | 4.47 | Yes |
| WLAN 802.11 b | 2.45 | Body | 19.17 | 16.5 | 44.67 | No |

## 12 SAR Test Result

It is determined by user manual for the distance between the EUT and the phantom bottom.

The distance is 0 mm and just applied to the condition of body worn accessory.

The calculated SAR is obtained by the following formula:

$$\text{Reported SAR} = \text{Measured SAR} \times 10^{(P_{Target} - P_{Measured})/10}$$

Where $P_{Target}$ is the power of manufacturing upper limit;

$P_{Measured}$ is the measured power in chapter 10.

We'll perform the SAR measurement with SKU3 and retest on highest value point with SKU1&2.

**Table 12-1: SAR Values (WLAN - Body) – 802.11b 5.5Mbps**

| Frequency | | Test Position | Distance (mm) | Figure No. | Note | Conducted Power (dBm) | Max. tune-up Power (dBm) | Measured SAR(10g) (W/kg) | Reported SAR(10g) (W/kg) | Measured SAR(1g) (W/kg) | Reported SAR(1g) (W/kg) | Power Drift (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | | | | | | | | | | |
| 2462 | 11 | Rear | 0 | / | SKU3 | 16.27 | 16.5 | 0.420 | **0.44** | 1.12 | **1.18** | 0.05 |
| 2437 | 6 | Rear | 0 | / | SKU3 | 16.42 | 16.5 | 0.411 | **0.42** | 1.08 | **1.10** | 0.03 |
| 2412 | 1 | Rear | 0 | Fig.1 | SKU3 | 16.38 | 16.5 | 0.437 | **0.45** | 1.16 | **1.19** | -0.06 |
| 2437 | 6 | Left | 0 | / | SKU3 | 16.42 | 16.5 | 0.137 | **0.14** | 0.283 | **0.29** | 0.08 |
| 2437 | 6 | Top | 0 | / | SKU3 | 16.42 | 16.5 | 0.199 | **0.20** | 0.491 | **0.50** | -0.03 |
| 2412 | 1 | Rear | 0 | / | SKU1 | 16.38 | 16.5 | 0.389 | **0.40** | 1.06 | **1.09** | -0.07 |
| 2412 | 1 | Rear | 0 | / | SKU2 | 16.38 | 16.5 | 0.428 | **0.44** | 1.15 | **1.18** | 0.16 |

Ambient Temperature: 22.9 ℃　　Liquid Temperature: 22.5 ℃

According to the KDB248227 D01, The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit. The scaled reported SAR is presented as below.

**Table 12-2: SAR Values (WLAN - Body) – 802.11b 5.5Mbps (Scaled Reported SAR)**

| Frequency | | Test Position | Actual duty factor | maximum duty factor | Reported SAR (1g)(W/kg) | Scaled reported SAR (1g)(W/kg) |
|---|---|---|---|---|---|---|
| MHz | Ch. | | | | | |
| 2412 | 1 | Rear | 100% | 100% | **1.19** | **1.19** |

Ambient Temperature: 22.5 ℃　　Liquid Temperature: 22.0 ℃

Att 40 dB

Ref 20.00 dBm

* RBW 1 MHz
* VBW 3 MHz
* SWT 10ms

1AP
Clrw

-20 dBm

-30 dBm

SGL   -40 dBm

-50 dBm

-60 dBm

-70 dBm

CF 2.412 GHz          1.0 ms/
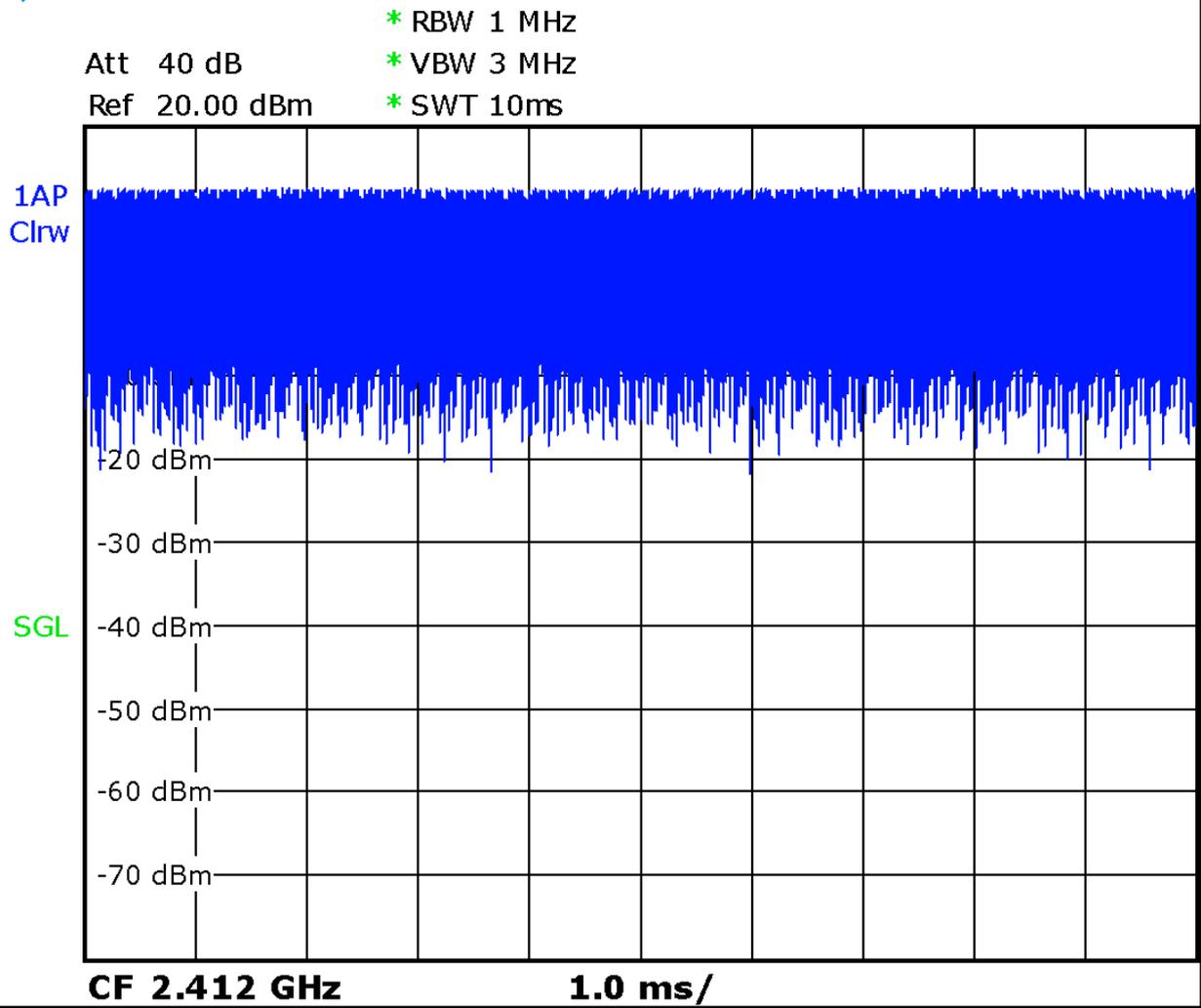
**Picture 12.1 Duty factor plot**

# 13 SAR Measurement Variability

SAR measurement variability must be assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media are required for SAR measurements in a frequency band, the variability measurement procedures should be applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium.

The following procedures are applied to determine if repeated measurements are required.

1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps2) through 4) do not apply.

2) When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.

3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45W/kg (~ 10% from the 1-g SAR limit).

4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

**Table 13.1: SAR Measurement Variability for Body WLAN (1g)**

| Frequency | | Test Position | Spacing (mm) | Original SAR (W/kg) | First Repeated SAR (W/kg) | The Ratio | Second Repeated SAR (W/kg) | The Ratio |
|---|---|---|---|---|---|---|---|---|
| Ch. | MHz | | | | | | | |
| 1 | 2412 | Rear | 0 | 1.16 | 1.14 | 1.02 | / | / |

## 14 Measurement Uncertainty

| No. | Error Description | Type | Uncertainty value | Probably Distribution | Div. | (Ci) 1g | (Ci) 10g | Std. Unc. (1g) | Std. Unc. (10g) | Degree of freedom |
|---|---|---|---|---|---|---|---|---|---|---|
| **Measurement system** | | | | | | | | | | |
| 1 | Probe calibration | B | 6.0 | N | 1 | 1 | 1 | 6.0 | 6.0 | ∞ |
| 2 | Isotropy | B | 4.7 | R | $\sqrt{3}$ | 0.7 | 0.7 | 1.9 | 1.9 | ∞ |
| 3 | Boundary effect | B | 1.0 | R | $\sqrt{3}$ | 1 | 1 | 0.6 | 0.6 | ∞ |
| 4 | Linearity | B | 4.7 | R | $\sqrt{3}$ | 1 | 1 | 2.7 | 2.7 | ∞ |
| 5 | Detection limit | B | 1.0 | N | 1 | 1 | 1 | 0.6 | 0.6 | ∞ |
| 6 | Readout electronics | B | 0.3 | R | $\sqrt{3}$ | 1 | 1 | 0.3 | 0.3 | ∞ |
| 7 | Response time | B | 0.8 | R | $\sqrt{3}$ | 1 | 1 | 0.5 | 0.5 | ∞ |
| 8 | Integration time | B | 2.6 | R | $\sqrt{3}$ | 1 | 1 | 1.5 | 1.5 | ∞ |
| 9 | RF ambient conditions-noise | B | 0 | R | $\sqrt{3}$ | 1 | 1 | 0 | 0 | ∞ |
| 10 | RFambient conditions-reflection | B | 0 | R | $\sqrt{3}$ | 1 | 1 | 0 | 0 | ∞ |
| 11 | Probe positioned mech. restrictions | B | 0.4 | R | $\sqrt{3}$ | 1 | 1 | 0.2 | 0.2 | ∞ |
| 12 | Probe positioning with respect to phantom shell | B | 2.9 | R | $\sqrt{3}$ | 1 | 1 | 1.7 | 1.7 | ∞ |
| 13 | Post-processing | B | 1.0 | R | $\sqrt{3}$ | 1 | 1 | 0.6 | 0.6 | ∞ |
| **Test sample related** | | | | | | | | | | |
| 14 | Test sample positioning | A | 3.3 | N | 1 | 1 | 1 | 3.3 | 3.3 | 71 |
| 15 | Device holder uncertainty | A | 3.4 | N | 1 | 1 | 1 | 3.4 | 3.4 | 5 |
| 16 | Drift of output power | B | 5.0 | R | $\sqrt{3}$ | 1 | 1 | 2.9 | 2.9 | ∞ |
| **Phantom and set-up** | | | | | | | | | | |
| 17 | Phantom uncertainty | B | 4.0 | R | $\sqrt{3}$ | 1 | 1 | 2.3 | 2.3 | ∞ |
| 18 | Liquid conductivity (target) | B | 5.0 | R | $\sqrt{3}$ | 0.64 | 0.43 | 1.8 | 1.2 | ∞ |
| 19 | Liquid conductivity (meas.) | A | 2.06 | N | 1 | 0.64 | 0.43 | 1.32 | 0.89 | 43 |
| 20 | Liquid permittivity (target) | B | 5.0 | R | $\sqrt{3}$ | 0.6 | 0.49 | 1.7 | 1.4 | ∞ |
| 21 | Liquid permittivity (meas.) | A | 1.6 | N | 1 | 0.6 | 0.49 | 1.0 | 0.8 | 521 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Combined standard uncertainty | $u_c^{'} = \sqrt{\sum_{i=1}^{21} c_i^2 u_i^2}$ | | | | | 9.55 | 9.43 | 257 |
| Expanded uncertainty (confidence interval of 95 %) | $u_e = 2u_c$ | | | | | 19.1 | 18.9 | |

## 15 MAIN TEST INSTRUMENTS

**Table 15.1: List of Main Instruments**

| No. | Name | Type | Serial Number | Calibration Date | Valid Period |
|---|---|---|---|---|---|
| 01 | Network analyzer | E5071C | MY46110673 | January 24, 2018 | One year |
| 02 | Dielectric Probe Kit | 85070E | Agilent | No Calibration Requested | |
| 03 | Power meter | NRVD | 102083 | November 01, 2017 | One year |
| 04 | Power sensor | NRV-Z5 | 100542 | | |
| 05 | Signal Generator | E4438C | MY49071430 | January 2,2018 | One Year |
| 06 | Amplifier | 60S1G4 | 0331848 | No Calibration Requested | |
| 07 | Directional Coupler | 778D | MY48220584 | No Calibration Requested | |
| 08 | E-field Probe | SPEAG EX3DV4 | 7464 | September 12,2017 | One year |
| 09 | DAE | SPEAG DAE4 | 1525 | October 2, 2017 | One year |
| 10 | Dipole Validation Kit | SPEAG D2450V2 | 853 | July 21, 2017 | One year |

***END OF REPORT BODY***

## ANNEX A   Graph Results

**WLAN_CH1 Rear**

Date: 2018-5-31

Electronics: DAE4 Sn1525

Medium: Body 2450 MHz

Medium parameters used (interpolated): f = 2412 MHz; σ = 1.929 mho/m; εr = 52.251; ρ = 1000 kg/m$^3$

Ambient Temperature: 22.9ºC,     Liquid Temperature: 22.5ºC

Communication System: WLAN    Duty Cycle: 1:1

Probe: EX3DV4 – SN7464 ConvF(8.09, 8.09, 8.09)


**Area Scan (151x111x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 1.86 W/kg


**Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 5.416 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 3.34 W/kg

**SAR(1 g) = 1.16 W/kg; SAR(10 g) = 0.437 W/kg**

Maximum value of SAR (measured) = 1.63 W/kg
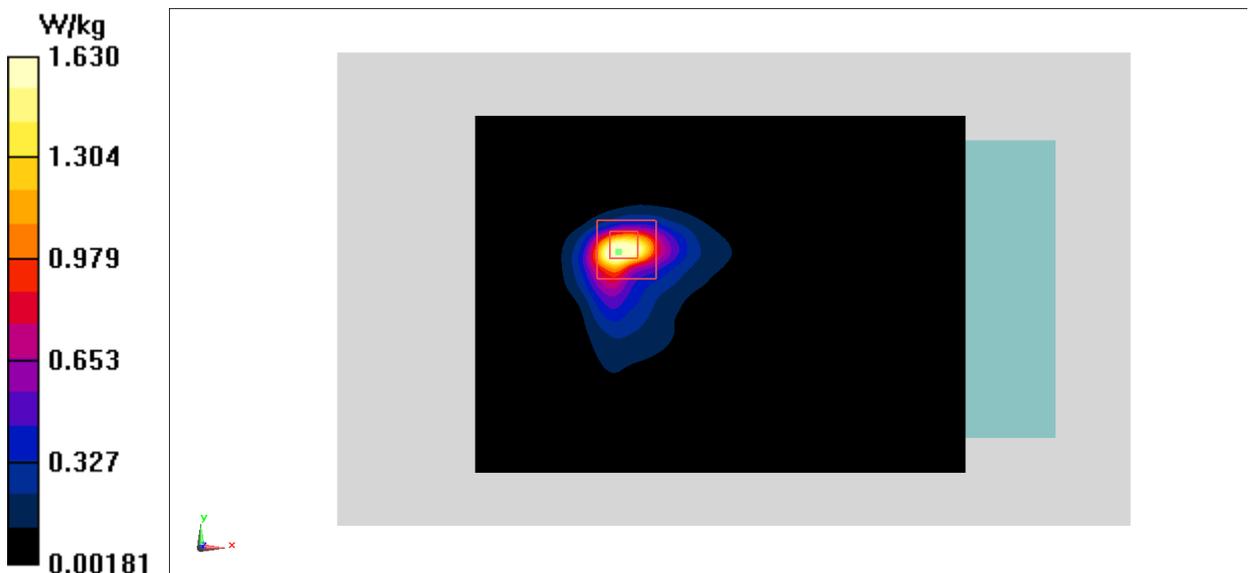


**Figure 1**
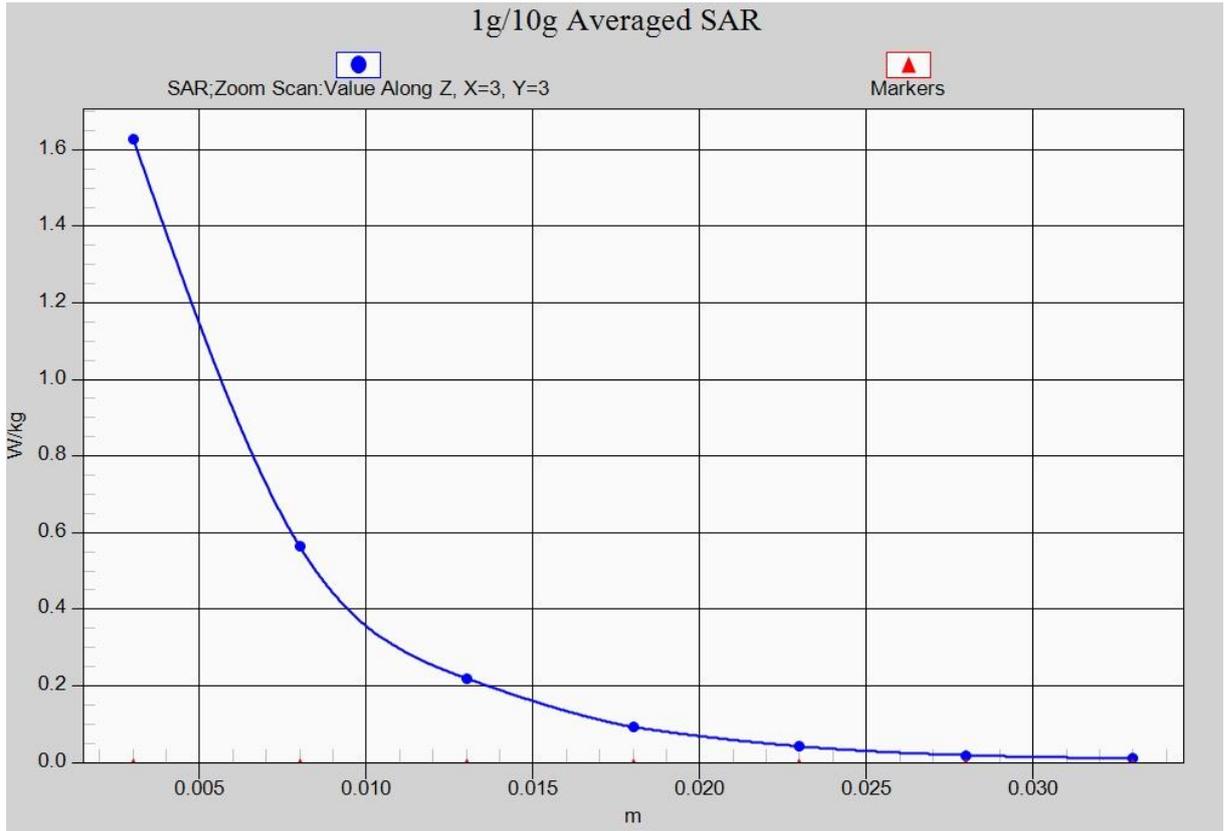
**Figure 1-1**

## ANNEX B   SystemVerification Results

### 2450MHz

Date: 2018-5-31
Electronics: DAE4 Sn1525
Medium: Body 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.962 S/m; ε$_r$ = 52.18; ρ = 1000 kg/m$^3$
Ambient Temperature: 22.9ºC          Liquid Temperature: 22.5ºC
Communication System: CW Frequency: 2450 MHz Duty Cycle: 1:1
Probe: EX3DV4 – SN7464 ConvF(8.09, 8.09, 8.09)

**System Validation/Area Scan (81x101x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm
Reference Value = 88.35 V/m; Power Drift = 0.02 dB
**SAR(1 g) = 12.6 W/kg; SAR(10 g) = 5.81 W/kg**
Maximum value of SAR (interpolated) = 14.2 W/kg

**System Validation/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 88.35 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 24.41 W/kg
**SAR(1 g) = 12.8 W/kg; SAR(10 g) = 5.99 W/kg**
Maximum value of SAR (measured) = 14.4 W/kg
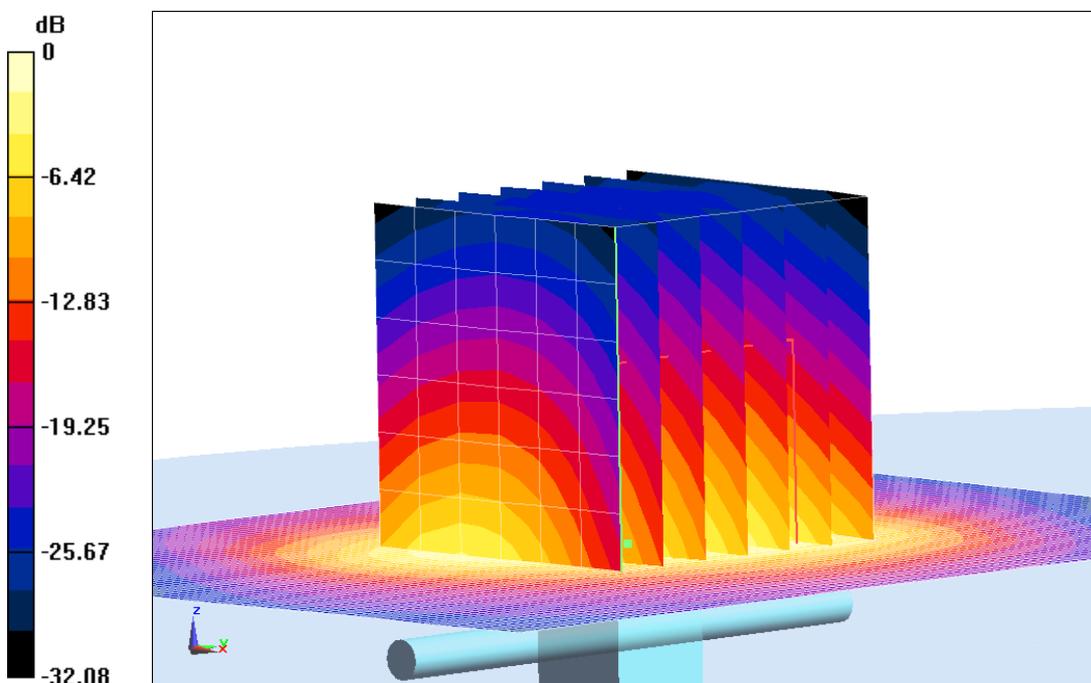


0 dB = 14.4 W/kg = 11.58 dB W/kg

**Fig.B.1 validation 2450MHz 250mW**

# ANNEX C   SAR Measurement Setup

## C.1 Measurement Set-up

The Dasy4 or DASY5 system for performing compliance tests is illustrated above graphically. This system consists of the following items:
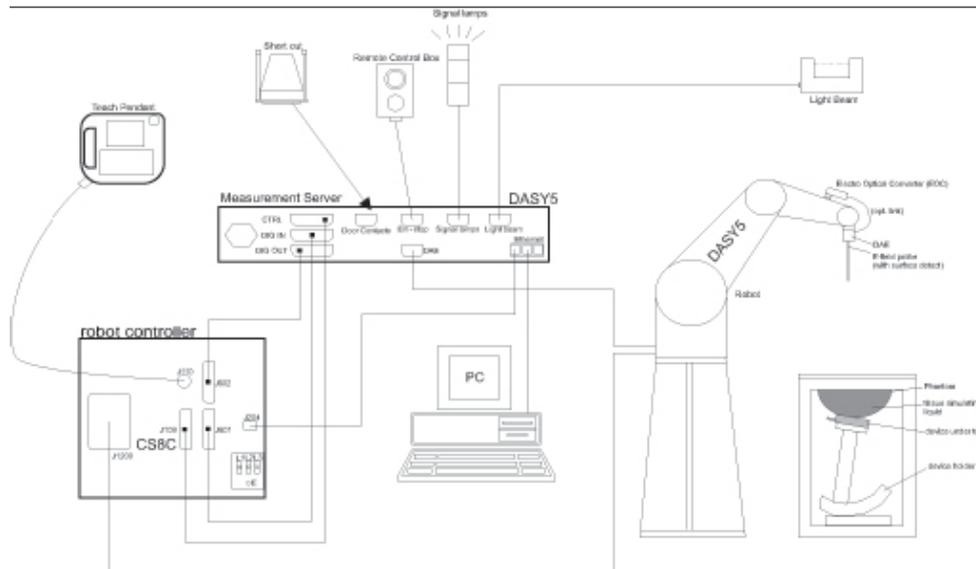


**Picture C.1 SAR Lab Test Measurement Set-up**

- A standard high precision 6-axis robot (StäubliTX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP and the DASY4 or DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as
- warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

## C.2 Dasy4 or DASY5 E-field Probe System

The SAR measurements were conducted with the dosimetric probe designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multifiber line ending at the front of the probe tip. It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY4 or DASY5 software reads the reflection durning a software approach and looks for the maximum using 2$^{nd}$ ord curve fitting. The approach is stopped at reaching the maximum.

### Probe Specifications:



**Picture C.2 Near-field Probe**

| | |
|---|---|
| **Model:** | **ES3DV3, EX3DV4** |
| **Frequency** | **10MHz — 6.0GHz(EX3DV4)** |
| **Range:** | **10MHz — 4GHz(ES3DV3)** |
| **Calibration:** | **In head and body simulating tissue at Frequencies from 835 up to 5800MHz** |
| **Linearity:** | **± 0.2 dB(30 MHz to 6 GHz) for EX3DV4 ± 0.2 dB(30 MHz to 4 GHz) for ES3DV3** |
| **Dynamic Range:** | **10 mW/kg — 100W/kg** |
| **Probe Length:** | **330 mm** |
| **Probe Tip Length:** | **20 mm** |
| **Body Diameter:** | **12 mm** |
| **Tip Diameter:** | **2.5 mm (3.9 mm for ES3DV3)** |
| **Tip-Center:** | **1 mm (2.0mm for ES3DV3)** |
| **Application:** | **SAR Dosimetry Testing Compliance tests of mobile phones Dosimetry in strong gradient fields** |



**Picture C.3 E-field Probe**

## C.3 E-field Probe Calibration

Each E-Probe/Probe Amplifier combination has unique calibration parameters. A TEM cell calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the probe to a known E-field density (1 mW/cm$^2$) using an RF Signal generator, TEM cell, and RF Power Meter.

The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and inn a waveguide or other methodologies above 1 GHz for free space. For the free space calibration, the probe is placed

in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees until the three channels show the maximum reading. The power density readings equates to 1 mW/ cm$^2$.

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The E-field in the medium correlates with the temperature rise in the dielectric medium. For temperature correlation calibration a RF transparent thermistor-based temperature probe is used in conjunction with the E-field probe.

$$SAR = C\frac{\Delta T}{\Delta t}$$

Where:

$\Delta t$ = Exposure time (30 seconds),

C = Heat capacity of tissue (brain or muscle),

$\Delta T$ = Temperature increase due to RF exposure.

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

Where:

σ = Simulated tissue conductivity,

ρ = Tissue density (kg/m$^3$).


## C.4 Other Test Equipment

## C.4.1 Data Acquisition Electronics(DAE)

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

The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection.

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



**PictureC.4: DAE**

## C.4.2 Robot

The SPEAG DASY system uses the high precision robots (DASY4: RX90XL; DASY5: RX160L) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version from Stäubli is used. The Stäubli robot series have many features that are important for our application:

➢ High precision (repeatability 0.02mm)
➢ High reliability (industrial design)
➢ Low maintenance costs (virtually maintenance free due to direct drive gears; no belt drives)
➢ Jerk-free straight movements (brushless synchron motors; no stepper motors)
➢ Low ELF interference (motor control fields shielded via the closed metallic construction shields)



**Picture C.5 DASY 4**



**Picture C.6 DASY 5**

## C.4.3 Measurement Server

The Measurement server is based on a PC/104 CPU broad with CPU (dasy4: 166 MHz, Intel Pentium; DASY5: 400 MHz, Intel Celeron), chip disk (DASY4: 32 MB; DASY5: 128MB), RAM (DASY4: 64 MB, DASY5: 128MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bit AD converter system for optical detection and digital I/O interface are contained on the DASY I/O broad, which is directly connected to the PC/104 bus of the CPU broad.

The measurement server performs all real-time data evaluation of field measurements and surface detection, controls robot movements and handles safety operation. The PC operating system cannot interfere with these time critical processes. All connections are supervised by a watchdog, and disconnection of any of the cables to the measurement server will automatically disarm the robot and disable all program-controlled robot movements. Furthermore, the measurement server is equipped with an expansion port which is reserved for future applications. Please note that this expansion port does not have a standardized pinout, and therefore only devices provided by SPEAG can be connected. Devices from any other supplier could seriously damage the measurement server.

**Picture C.7 Server for DASY 4**



**Picture C.8 Server for DASY 5**

## C.4.4 Device Holder for Phantom

The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source at 5mm distance, a positioning uncertainty of ±0.5mm would produce a SAR uncertainty of ±20%. Accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions in which the devices must be measured are defined by the standards.

The DASY device holder is designed to cope with the different positions given in the standard. It has two scales for device rotation (with respect to the body axis) and device inclination (with respect to the line between the ear reference points). The rotation centers for both scales is the ear reference point (ERP). Thus the device needs no repositioning when changing the angles.

The DASY device holder is constructed of low-loss

POM material having the following dielectric

parameters: relative permittivity $\varepsilon$ =3 and loss tangent $\delta$ =0.02. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.

<Laptop Extension Kit>

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



**Picture C.9-1: Device Holder**
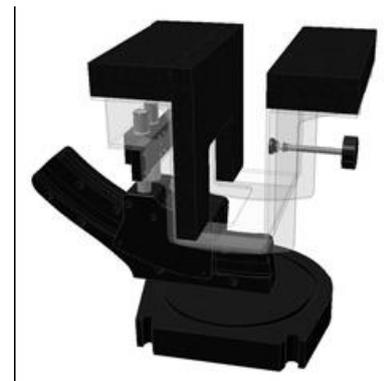


**Picture C.9-2: Laptop Extension Kit**

## C.4.5 Phantom

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a table. The shape of the shell is based on data from an anatomical study designed to

Represent the 90th percentile of the population. The phantom enables the dissymmetric evaluation of SAR for both left and right handed handset usage, as well as body-worn usage using the flat phantom region. Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. The shell phantom has a 2mm shell thickness (except the ear region where shell thickness increases to 6 mm).

Shell Thickness:    2 ± 0. 2 mm

Filling Volume:    Approx. 25 liters

Dimensions:    810 x l000 x 500 mm (H x L x W)

Available:    Special



**Picture C.10: SAM Twin Phantom**

## ANNEX D   Position of the wireless device in relation to the phantom

### D.1 Body-supported device

Other devices that fall into this category include tablet type portable computers and credit card transaction authorisation terminals, point-of-sale and/or inventory terminals. Where these devices may be torso or limb-supported, the same principles for body-supported devices are applied.
The example in Picture D.1 shows a tablet form factor portable computer for which SAR should be separately assessed with
a) each surface and
b) the separation distances
positioned against the flat phantom that correspond to the intended use as specified by the manufacturer. If the intended use is not specified in the user instructions, the device shall be tested directly against the flat phantom in all usable orientations.
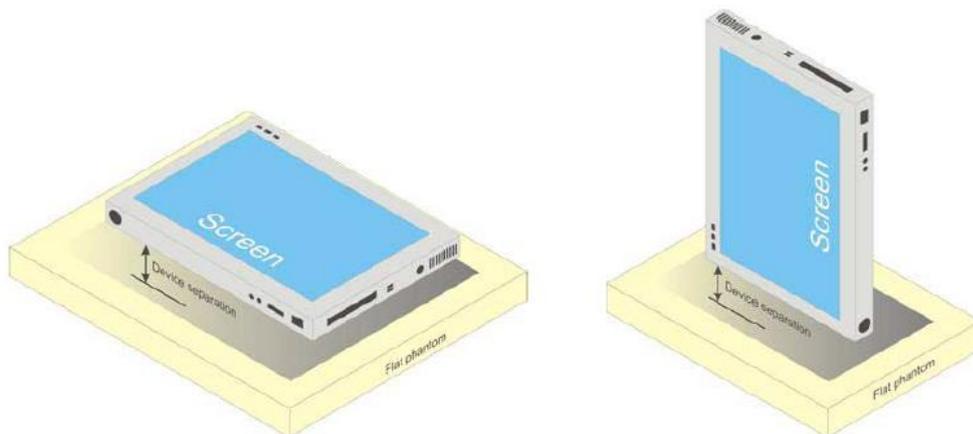


**Picture D.1 Tablet form factor portable computer**

### D.2 DUT Setup Photos



**Picture D.2**

## ANNEX E  Equivalent Media Recipes

The liquid used for the frequency range of 800-3000 MHz consisted of water, sugar, salt, preventol, glycol monobutyl and Cellulose. The liquid has been previously proven to be suited for worst-case. The Table E.1 shows the detail solution. It's satisfying the latest tissue dielectric parameters requirements proposed by the IEEE 1528 and IEC 62209.

**TableE.1: Composition of the Tissue Equivalent Matter**

| Frequency (MHz) | 835Head | 835Body | 1900 Head | 1900 Body | 2450 Head | 2450 Body | 5800 Head | 5800 Body |
|---|---|---|---|---|---|---|---|---|
| Ingredients (% by weight) | | | | | | | | |
| Water | 41.45 | 52.5 | 55.242 | 69.91 | 58.79 | 72.60 | 65.53 | 65.53 |
| Sugar | 56.0 | 45.0 | \ | \ | \ | \ | \ | \ |
| Salt | 1.45 | 1.4 | 0.306 | 0.13 | 0.06 | 0.18 | \ | \ |
| Preventol | 0.1 | 0.1 | \ | \ | \ | \ | \ | \ |
| Cellulose | 1.0 | 1.0 | \ | \ | \ | \ | \ | \ |
| Glycol Monobutyl | \ | \ | 44.452 | 29.96 | 41.15 | 27.22 | \ | \ |
| Diethylenglycol monohexylether | \ | \ | \ | \ | \ | \ | 17.24 | 17.24 |
| Triton X-100 | \ | \ | \ | \ | \ | \ | 17.24 | 17.24 |
| Dielectric Parameters Target Value | $\varepsilon$=41.5 $\sigma$=0.90 | $\varepsilon$=55.2 $\sigma$=0.97 | $\varepsilon$=40.0 $\sigma$=1.40 | $\varepsilon$=53.3 $\sigma$=1.52 | $\varepsilon$=39.2 $\sigma$=1.80 | $\varepsilon$=52.7 $\sigma$=1.95 | $\varepsilon$=35.3 $\sigma$=5.27 | $\varepsilon$=48.2 $\sigma$=6.00 |

**Note: There are a little adjustment respectively for 750, 1750, 2600, 5200, 5300 and 5600 based on the recipe of closest frequency in table E.1.**

## ANNEX F   System Validation

The SAR system must be validated against its performance specifications before it is deployed. When SAR probes, system components or software are changed, upgraded or recalibrated, these must be validated with the SAR system(s) that operates with such components.

**Table F.1: System Validation for 7464**

| Probe SN. | Liquid name | Validation date | Frequency point | Status (OK or Not) |
|---|---|---|---|---|
| 7464 | Head 750MHz | Sep.26,2017 | 750 MHz | OK |
| 7464 | Head 850MHz | Sep.26,2017 | 850 MHz | OK |
| 7464 | Head 900MHz | Sep.26,2017 | 900 MHz | OK |
| 7464 | Head 1750MHz | Sep.26,2017 | 1750 MHz | OK |
| 7464 | Head 1810MHz | Sep.26,2017 | 1810 MHz | OK |
| 7464 | Head 1900MHz | Sep.27,2017 | 1900 MHz | OK |
| 7464 | Head 1950MHz | Sep.27,2017 | 1950 MHz | OK |
| 7464 | Head 2000MHz | Sep.27,2017 | 2000 MHz | OK |
| 7464 | Head 2100MHz | Sep.27,2017 | 2100 MHz | OK |
| 7464 | Head 2300MHz | Sep.27,2017 | 2300 MHz | OK |
| 7464 | Head 2450MHz | Sep.27,2017 | 2450 MHz | OK |
| 7464 | Head 2550MHz | Sep.28,2017 | 2550 MHz | OK |
| 7464 | Head 2600MHz | Sep.28,2017 | 2600 MHz | OK |
| 7464 | Head 3500MHz | Sep.28,2017 | 3500 MHz | OK |
| 7464 | Head 3700MHz | Sep.28,2017 | 3700 MHz | OK |
| 7464 | Head 5200MHz | Sep.28,2017 | 5200 MHz | OK |
| 7464 | Head 5500MHz | Sep.28,2017 | 5500 MHz | OK |
| 7464 | Head 5800MHz | Sep.28,2017 | 5800 MHz | OK |
| 7464 | Body 750MHz | Sep.28,2017 | 750 MHz | OK |
| 7464 | Body 850MHz | Sep.25,2017 | 850 MHz | OK |
| 7464 | Body 900MHz | Sep.25,2017 | 900 MHz | OK |
| 7464 | Body 1750MHz | Sep.25,2017 | 1750 MHz | OK |
| 7464 | Body 1810MHz | Sep.25,2017 | 1810 MHz | OK |
| 7464 | Body 1900MHz | Sep.25,2017 | 1900 MHz | OK |
| 7464 | Body 1950MHz | Sep.25,2017 | 1950 MHz | OK |
| 7464 | Body 2000MHz | Sep.29,2017 | 2000 MHz | OK |
| 7464 | Body 2100MHz | Sep.29,2017 | 2100 MHz | OK |
| 7464 | Body 2300MHz | Sep.29,2017 | 2300 MHz | OK |
| 7464 | Body 2450MHz | Sep.29,2017 | 2450 MHz | OK |
| 7464 | Body 2550MHz | Sep.29,2017 | 2550 MHz | OK |
| 7464 | Body 2600MHz | Sep.29,2017 | 2600 MHz | OK |
| 7464 | Body 3500MHz | Sep.24,2017 | 3500 MHz | OK |
| 7464 | Body 3700MHz | Sep.24,2017 | 3700 MHz | OK |
| 7464 | Body 5200MHz | Sep.24,2017 | 5200 MHz | OK |
| 7464 | Body 5500MHz | Sep.24,2017 | 5500 MHz | OK |
| 7464 | Body 5800MHz | Sep.24,2017 | 5800 MHz | OK |

# ANNEX G   Probe Calibration Certificate

## Probe 7464 Calibration Certificate

**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 | **CTTL-BJ (Auden)** | Certificate No: **EX3-7464_Sep17** |
|---|---|---|

## CALIBRATION CERTIFICATE

| Object | EX3DV4 - SN:7464 |
|---|---|
| Calibration procedure(s) | QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6<br>Calibration procedure for dosimetric E-field probes |
| Calibration date: | September 12, 2017 |

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter NRP | SN: 104778 | 04-Apr-17 (No. 217-02521/02522) | Apr-18 |
| Power sensor NRP-Z91 | SN: 103244 | 04-Apr-17 (No. 217-02521) | Apr-18 |
| Power sensor NRP-Z91 | SN: 103245 | 04-Apr-17 (No. 217-02525) | Apr-18 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 07-Apr-17 (No. 217-02528) | Apr-18 |
| Reference Probe ES3DV2 | SN: 3013 | 31-Dec-16 (No. ES3-3013_Dec16) | Dec-17 |
| DAE4 | SN: 660 | 7-Dec-16 (No. DAE4-660_Dec16) | Dec-17 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB41293874 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| Power sensor E4412A | SN: MY41498087 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| Power sensor E4412A | SN: 000110210 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| RF generator HP 8648C | SN: US3642U01700 | 04-Aug-99 (in house check Jun-16) | In house check: Jun-18 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-16) | In house check: Oct-17 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |
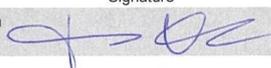
Issued: September 12, 2017

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## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization $\varphi$ | $\varphi$ rotation around probe axis |
| Polarization $\vartheta$ | $\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta$ = 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, ", "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization $\vartheta$ = 0 (f $\leq$ 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 $\leq$ 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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EX3DV4 – SN:7464

September 12, 2017

# Probe  EX3DV4

# SN:7464

Manufactured:    September 6, 2016
Calibrated:        September 12, 2017

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7464

### Basic Calibration Parameters

|  | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (μV/(V/m)$^2$)$^A$ | 0.45 | 0.43 | 0.45 | ± 10.1 % |
| DCP (mV)$^B$ | 101.6 | 99.3 | 99.7 | |

### 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 | 150.5 | ±3.3 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 144.7 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 147.0 | |

Note: For details on UID parameters see Appendix.

### Sensor Model Parameters

|  | C1 fF | C2 fF | α V$^{-1}$ | T1 ms.V$^{-2}$ | T2 ms.V$^{-1}$ | T3 ms | T4 V$^{-2}$ | T5 V$^{-1}$ | T6 |
|---|---|---|---|---|---|---|---|---|---|
| X | 57.86 | 441.1 | 37.02 | 12.02 | 0.826 | 5.039 | 0.00 | 0.727 | 1.006 |
| Y | 59.82 | 453.4 | 36.65 | 14.84 | 0.468 | 5.100 | 0.25 | 0.626 | 1.007 |
| Z | 65.01 | 497.8 | 37.35 | 15.97 | 1.043 | 5.073 | 0.00 | 0.801 | 1.008 |

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

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