

## SAR Compliance Test Report

**APPLICANT NAME & ADDRESS :**

Woosim Systems Inc.  
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of Korea

**DATA & LOCATION OF TESTING**

Dates of testing : 2016-10-11  
Test Site : ESTECH Co., Ltd.  
140-16, Eongmali-ro, Majang-myeon,  
Icheon-si, Gyeonggi-do, Korea

**Test Device :**

FCC ID (Printer) : QDDWSP-I450X  
FCC ID (Module) : RYYWYSAVKXY  
MODEL : WSP-i450  
APPLICANT : Woosim Systems Inc.

**Test Report No. :**

ESTRSFC1610-001

**FCC Rule Part(s) :**

CFR §2.1093

**Applicant Type :**

Certification

**Number of page :**

22

**Test results :**

The Tested device complies with the requirements in respect of all parameters subject to the test. The test results and statements relate only to the items tested. The test report shall not be reproduced receipt in full, without written approval of the laboratory.

Date and Signatures : 2016-10-12  
Report Prepared By : Engineer/ In-Ki Hong  
(Signature)

Engineering Manager/ Keum Bum Lee  
(Signature)

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## 1. SUMMARY FOR TEST REPORT

|                          |                    |
|--------------------------|--------------------|
| FCC ID (Printer)         | QDDWSP-I450X       |
| FCC ID (module)          | RYYWYSAAVKXY       |
| Date of test             | 2016-10-11         |
| Measurement performed by | In-Ki Hong         |
| Technical Reviewer       | Keum Bum Lee       |
| EUT Type                 | Mobile Printer     |
| Frequency                | 2412 – 2462 MHz    |
| Duty Cycle               | >98%               |
| Battery Type             | DC 7.4 V (Battery) |

### 1.1 Body Worn Configuration (WLAN)

Max. SAR Measurement

| Mode    | Body Position | EUT Position | Frequency (MHz) | Channel | Power (dBm) | Scaled SAR(mW/g) |
|---------|---------------|--------------|-----------------|---------|-------------|------------------|
| 802.11g | Flat          | Bottom       | 2437            | 6       | 23.37       | 0.0052           |

### 1.2 Measurement Uncertainty

|                               |                                             |
|-------------------------------|---------------------------------------------|
| Combine Standard Uncertainty  | $\pm 11.00$ ( $k=1$ )                       |
| Extended Standard Uncertainty | $\pm 22.00$ ( $k=2$ , 95% CONFIDENCE LEVEL) |

### 1.3 Conducted power table for 802.11b/g/n

| Mode    | Ch      | 802.11b/g/n (2.4GHz)<br>Peak Conducted Power |        |
|---------|---------|----------------------------------------------|--------|
|         |         | dBm                                          | mW     |
| 802.11b | ch 1-11 | 21.75                                        | 149.62 |
| 802.11g | ch 1-11 | 23.37                                        | 217.77 |
| 802.11n | ch 1-11 | 22.71                                        | 186.64 |

\*Note : The RF Power was referred to the FCC Report RF140117C02

## 2. INTRODUCTION

The FCC has adopted the guidelines for evaluating the environmental effects of radio frequency radiation in ET Docket 93-62 on Aug. 6, 1996 to protect the public and workers from the potential hazards of RF emissions due to FCC-regulated portable device.

The safety limits used for the environmental evaluation measurements are the criteria published by the based on American National Standards Institute (ANSI) For localized specific absorption rate (SAR) in IEEE/ANSI C95.1-1992 Standard for safety Levels with Respect to Human Exposure to Radio Frequency Electronic Fields, 3 kHz to 300 GHz. 1992 by the institute of Electrical and Electronics Engineers, Inc., New York, New York 10017. The measurement procedure described in IEEE/ANSI C95.3-1992 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave is used for guidance in measuring SAR due to the RF radiation exposure from the Equipment Under Test (EUT). These criteria for SAR evaluation are similar to those recommended by the National Council on Radiation Protection and Measurements (IC NRP) in Biological Effects and Exposure Criteria for Radio Frequency Electromagnetic Fields,” IC NRP Report No. 86 IC NRP, 1986, Bethesda, MD 20814. SAR is a measure of the rate of energy absorption due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potential biological hazards.

### SAR Definition

Specific Absorption Rate (SAR) is defined as the time derivative (rate) of the incremental energy (dU) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given density (ρ). it is also defined as the rate of rf energy absorption per unit mass at a point in an absorbing body (see Fig. 2.1.).

$$SAR = \frac{d}{dt} \left( \frac{dU}{dm} \right) = \frac{d}{dt} \left( \frac{dU}{\rho dV} \right)$$

Figure 2.1 SAR Mathematical Equation

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

$$SAR = \sigma E^2 / \rho$$

Where:

- σ = conductivity of the tissue-simulant material (S/m)
- ρ = mass density of the tissue-simulant material (kg/m³)
- E = Total RMS electric field strength (V/m)

### 3. DESCRIPTION OF THE DEVICE UNDER TEST

The FCC rules for evaluating portable devices for RF exposure compliance are contained in 47 CFR §2.1093. For purposes of RF exposure evaluation, a portable device is defined as a transmitting device designed to be used with any part of its radiating structure in direct contact with the user's body or within 20 cm of the body of a user or bystanders under normal operating conditions. This category of devices would include hand-held that incorporate the radiating antenna into the hand-piece and wireless transmitters that are carried next to the body. Portable devices are evaluated with respect to SAR limits for RF exposure. The applicable SAR limit for portable transmitters used by consumers is 1.6 W/kg, which is averaged over any one gram of tissue defined as a tissue volume in the shape of a cube.

#### 3.1 Antenna Description

|          |                                   |
|----------|-----------------------------------|
| Type     | Chip Antenna                      |
| Location | the top of the device(Appendix E) |

#### 3.2 Device Description

|                      |                                                                                                        |
|----------------------|--------------------------------------------------------------------------------------------------------|
| Serial numbers       | NONE                                                                                                   |
| Exposure environment | Uncontrolled exposure                                                                                  |
| Device category      | Portable device                                                                                        |
| Mode(s) of Operation | 802.11b/g/n                                                                                            |
| Modulation Mode(s)   | DSSS, OFDM                                                                                             |
| Duty Cycle           | >98%                                                                                                   |
| 2.4GHz WLAN          | 2412 – 2462 MHz                                                                                        |
| test signal method   | <input type="checkbox"/> Base station simulator <input checked="" type="checkbox"/> Internal test code |

#### 3.3 Battery Options

☒ Standard ☐ Extended

Standard Capacity: Li-ion 7.4V/1800mAh

## 4. TEST CONDITIONS

### 4.1 Ambient Conditions

|                                           |    |
|-------------------------------------------|----|
| Ambient Temperature (°C)                  | 23 |
| Tissue simulating liquid temperature (°C) | 23 |
| Humidity (% R.H.)                         | 44 |

### 4.2 RF Characteristics of The Test Site

This measurement were performed in a fully enclosed RF Shielded environment

### 4.3 Test Signal, Frequencies, And Output Power

The Mobile Computer was placed into simulated call mode

In all operation bands the measurements were performed on lowest, middle and highest channels.

The Mobile Computer was placed into simulated call mode was set to maximum power level during the all tests and at the beginning of the each test the battery was fully

DASY4 system measures power drift during SAR testing by comparing e-field in the same location at the beginning and at the end of measurement. These records were used to monitor stability of power output.



Fig. 4.1 SAR Measurement System

## 5. DESCRIPTION OF THE TEST EQUIPMENT

An SAR measurement system usually consists of a small diameter isotropic electric field probe, a multiple axis probe positioning system, a test device holder, one or more phantom models, the field probe instrumentation, a computer and other electronic equipment for controlling the probe and making the measurements. Other supporting equipment, such as a network analyzer, power meters and RF signal generators, are also required to measure the dielectric parameters of the simulated tissue media and to verify the measurement accuracy of the SAR system.

### 5.1 Test System Specifications

| Test Equipment           | Model      | Serial Number | Cal. Date  |
|--------------------------|------------|---------------|------------|
| DAE                      | DAE4       | 479           | 2016-01-25 |
| E-Field Probe            | EX3DV4     | 3882          | 2015-11-24 |
| Dipole validation kit    | D2450V2    | 741           | 2016-02-18 |
| Network analyzer         | 8753ES     | US39173718    | 2016-09-28 |
| Signal generator         | SMBV100A   | 256663        | 2016-01-11 |
| RF Power meter           | EPM-442A   | GB37170412    | 2016-01-12 |
| Power Sensor             | 8481A      | 3318A96476    | 2016-01-12 |
| Power Sensor             | 8481A      | 3318A87063    | 2016-01-12 |
| Dielectric Probe         | 85070D     | US01440154    | -          |
| Power Amplifier          | BBS3Q7ECK  | NONE          | 2016-01-12 |
| LP Filter                | LA-30N     | NONE          | 2016-09-22 |
| Attenuator               | 8491B      | 21828         | 2016-01-11 |
| Attenuator               | 50FH-010-5 | 74868         | 2016-01-11 |
| Dual Directional Coupler | 772D       | 3736A22424    | 2016-01-11 |

### 5.2 SAR Measurement Setup

Measurement are performed using the DASY4 dosimetric assessment system. The DASY4 is made by Schmid & Partner Engineering AG(SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, Pentium IV computer, near-field probe, probe alignment sensor, and the SAM twin phantom containing the brain equivalent material. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field(EMF) (see Fig. 5.1) A cell controller system contains the power supply, robot controller, teach pendant(Joystick), and a remote control used to drive the robot motors. The pc consists of the Intel Pentium IV 2.4 GHz computer with WindowsXP system and SAR measurement Software DASY4, A/D interface card, monitor, mouse, and keyboard. The Staubli Robot data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc.

## 5. DESCRIPTION OF THE TEST EQUIPMENT(continued)

Is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.

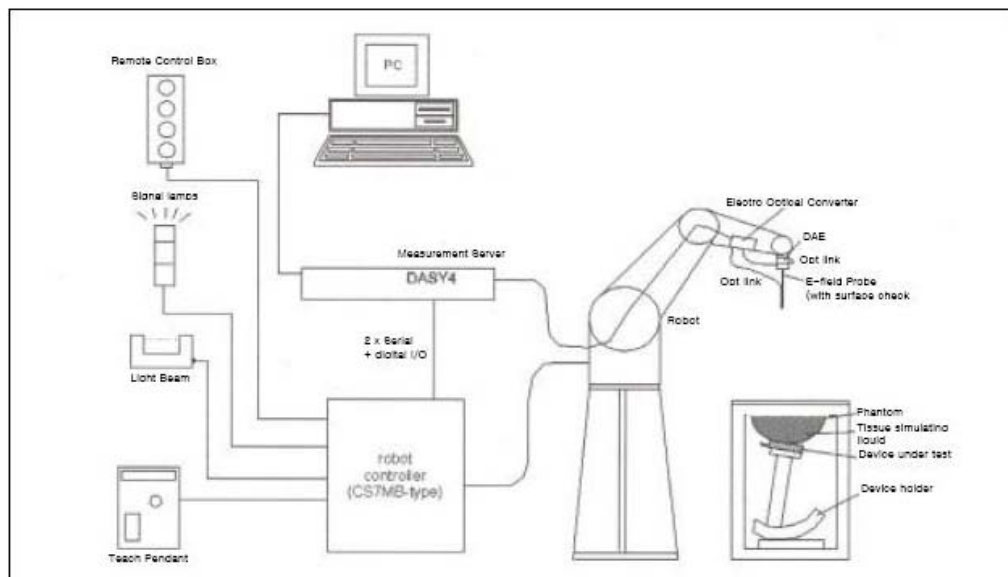


Fig. 5.1 SAR Measurement System Setup

The DAE4 consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gainswitching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the Ethernet Card is accomplished through an optical downlink for data and status

information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer. The system is described in detail in.

### 5.3 DASY4 E-Field Probe System

The SAR measurements were conducted with the dosimetric probe ET3DV6, designed in the classical triangular configuration (see Fig.5.2) 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 in the robot arm and provides an automatic detection transmitter, the other half to a synchronized receiver.

## 5. DESCRIPTION OF THE TEST EQUIPMENT(continued)

As the probe approach 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 coupling is zero. The distance of the coupling maximum to the surface is probe angle. The DASY4 software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting (see Fig. 5.2). The approach is stopped at reaching the maximum.

|                                                                                                                          |                                                            |                                                                                                                                                                                                         |
|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p><b>Isotropic E-Field Probe</b></p> | <b>Isotropic E-Field Probe for Dosimetric Measurements</b> |                                                                                                                                                                                                         |
|                                                                                                                          | <b>Construction</b>                                        | Symmetrical design with triangular core<br>Interleafed sensors<br>Built-in shielding against static charges<br>PEEK enclosure material (resistant to organic solvents, e.g., glycol)                    |
|                                                                                                                          | <b>Calibration</b>                                         | In air from 10 MHz to 3 GHz<br>In brain and muscle simulating tissue at frequencies of 450 MHz, 900 MHz and 1.8 GHz (accuracy $\pm 8\%$ )<br>Calibration for other liquids and frequencies upon request |
|                                                                                                                          | <b>Frequency</b>                                           | 10 MHz to $> 6$ GHz; Linearity: $\pm 0.2$ dB (30 MHz to 3 GHz)                                                                                                                                          |
|                                                                                                                          | <b>Directivity</b>                                         | $\pm 0.2$ dB in brain tissue (rotation around probe axis)<br>$\pm 0.3$ dB in brain tissue (rotation normal to probe axis)                                                                               |
|                                                                                                                          | <b>Dynamic Range</b>                                       | 5 $\mu$ W/g to $> 100$ mW/g; Linearity: $\pm 0.2$ dB                                                                                                                                                    |
|                                                                                                                          | <b>Dimensions</b>                                          | Overall length: 330 mm<br>Tip length: 20 mm<br>Body diameter: 12 mm<br>Tip diameter: 3.9 mm<br>Distance from probe tip to dipole centers: 2.7 mm                                                        |

Fig. 5.2 Probe Specifications

## 5. DESCRIPTION OF THE TEST EQUIPMENT(continued)

### 5.4 Phantom & Equivalent Tissues

#### SAM Phantom

The SAM Twin Phantom V4.0 is constructed of the fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users. 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 the evaporation of the liquid. 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.

#### Head & Muscle simulation Mixture Characterization

The brain and muscle mixtures consist of a viscous gel using hydroxethylcellulose(HEC) gelling agent and saline solution (see Fig 5.3). Preservation with a bactericide is added and visual inspection is made to make sure air bubbles are not trapped during the mixing process. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 have been specified in IEEE1528(2003) are derived from the issue dielectric parameters computed from the 4-Cole-Cole equations The mixture characterizations used for the brain and muscle tissue simulation liquids are according to the data by C. Gabriel and G. Hartagrove. (see Fig. 5.3)

| Frequency | Head         |                | Body         |                |
|-----------|--------------|----------------|--------------|----------------|
| (MHz)     | $\epsilon_r$ | $\sigma$ (S/m) | $\epsilon_r$ | $\sigma$ (S/m) |
| 150       | 52.3         | 0.76           | 61.9         | 0.8            |
| 300       | 45.3         | 0.87           | 58.2         | 0.92           |
| 450       | 43.5         | 0.87           | 56.7         | 0.94           |
| 835       | 41.5         | 0.9            | 55.2         | 0.97           |
| 900       | 41.5         | 0.97           | 55           | 1.05           |
| 915       | 41.5         | 0.98           | 55           | 1.06           |
| 1450      | 40.5         | 1.2            | 54           | 1.3            |
| 1610      | 40.3         | 1.29           | 53.8         | 1.4            |
| 1800-2000 | 40           | 1.4            | 53.3         | 1.52           |
| 2450      | 39.2         | 1.8            | 52.7         | 1.95           |
| 3000      | 38.5         | 2.4            | 52           | 2.73           |
| 5800      | 35.3         | 5.27           | 48.2         | 6              |

Fig.5.3 Head and body tissue parameters by the IEEE SCC-34/SC-2 in P1528

## 5. DESCRIPTION OF THE TEST EQUIPMENT(continued)

| Ingredients<br>(% by weight) | Frequency(MHz) |       |      |      |       |      |       |       |       |      |       |      |
|------------------------------|----------------|-------|------|------|-------|------|-------|-------|-------|------|-------|------|
|                              | 450            |       | 750  |      | 835   |      | 915   |       | 1 900 |      | 2 450 |      |
| Tissue Type                  | Head           | Body  | Head | Body | Head  | Body | Head  | Body  | Head  | Body | Head  | Body |
| Water                        | 38.56          | 51.16 | 41.2 | 51.7 | 41.45 | 52.4 | 41.05 | 56.0  | 54.9  | 40.4 | 62.7  | 73.2 |
| Salt(NaCl)                   | 3.95           | 1.49  | 1.4  | 1.0  | 1.45  | 1.4  | 1.35  | 0.76  | 0.18  | 0.5  | 0.5   | 0.04 |
| Sugar                        | 56.32          | 46.78 | 57   | 47.2 | 56.0  | 45.0 | 56.5  | 41.76 | 0.0   | 58.0 | 0.0   | 0.0  |
| HEC                          | 0.98           | 0.52  | 0.2  | 0.0  | 1.0   | 1.0  | 1.0   | 1.21  | 0.0   | 1.0  | 0.0   | 0.0  |
| Bactericide                  | 0.19           | 0.05  | 0.2  | 0.1  | 0.1   | 0.1  | 0.1   | 0.27  | 0.0   | 0.1  | 0.0   | 0.0  |
| Triton X-100                 | 0.0            | 0.0   | 0.0  | 0.0  | 0.0   | 0.0  | 0.0   | 0.0   | 0.0   | 0.0  | 36.8  | 0.0  |
| DGBE                         | 0.0            | 0.0   | 0.0  | 0.0  | 0.0   | 0.0  | 0.0   | 0.0   | 44.92 | 0.0  | 0.0   | 26.7 |

Salt: 99 % Pure Sodium Chloride      Sugar: 98 % Pure Sucrose  
 Water: De-ionized, 16 M resistivity      HEC: Hydroxyethyl Cellulose  
 DGBE: 99 % Di(ethylene glycol) butyl ether, [2-(2-butoxyethoxy) ethanol]  
 Triton X-100(ultra pure): Polyethylene glycol mono [4-(1,1,3,3-tetramethylbutyl)phenyl] ether

**Fig. 5.4 Composition of the Tissue Equivalent Matter**

### Device Holder for Transmitters

In combination with the SAM Twin Phantom V4.0, the Mounting Device enables the rotation of the accurately, and repeatably be positioned according to the FCC specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).

Note : A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produce infinite number of configurations [12]. To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

## 6. DESCRIPTION OF THE TEST PROCEDURE

### 6.1 Definition of Reference Point

#### EAR Reference point

The point “M” is the reference point for the center of the mouth, “ERP” is the ear reference point. The ERP are 15mm posterior to the entrance to the ear canal (EEC) along the B-M line (Back-Mouth), as shown is figure 6.1. The plane passing through the two ear canals and M is defined as the Reference Plane. The line N-F (Neck-Front) is perpendicular to the reference plane and passing through the ERP is called the Reference Pivoting Line (see Figure 6.1) B-M is perpendicular to the N-F line. Both N-F and B-M lines are marked on the external phantom shell to facilitate handset positioning [5].

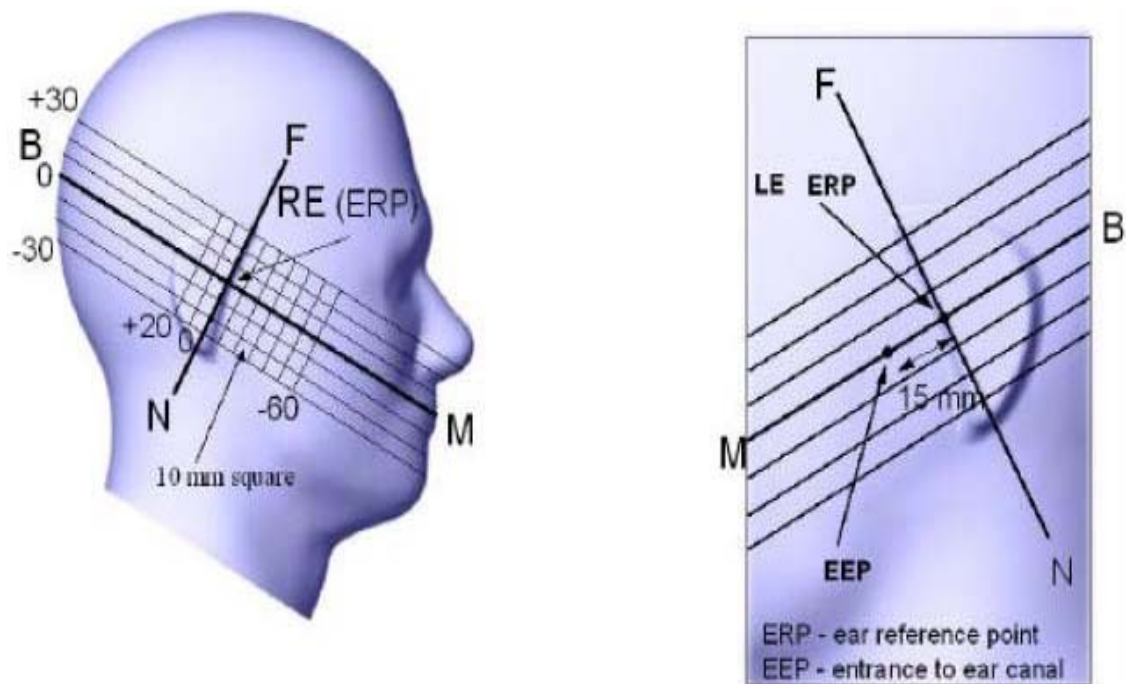


Figure 6.1 Close-up side view of ERP

#### Handset Reference Points

Two imaginary lines on the handset were established: the vertical centerline and the horizontal line. The test device was placed in a normal operating position with the “test device reference point” located along the “vertical centerline” on the front of the device aligned to the “ear reference point” (see Fig. 6.2). The “test device reference point” was then located at the same level as the center of the ear reference point. The test device was positioned so that the “vertical centerline” was bisecting the front surface of the handset at it’s top and bottom edges, positioning the “ear reference point” on the outer surface of the both the left and right head phantoms on the ear reference point” on the outer surface of the both the left and right head phantoms on the ear reference point.

## 6. DESCRIPTION OF THE TEST PROCEDURE(continued)

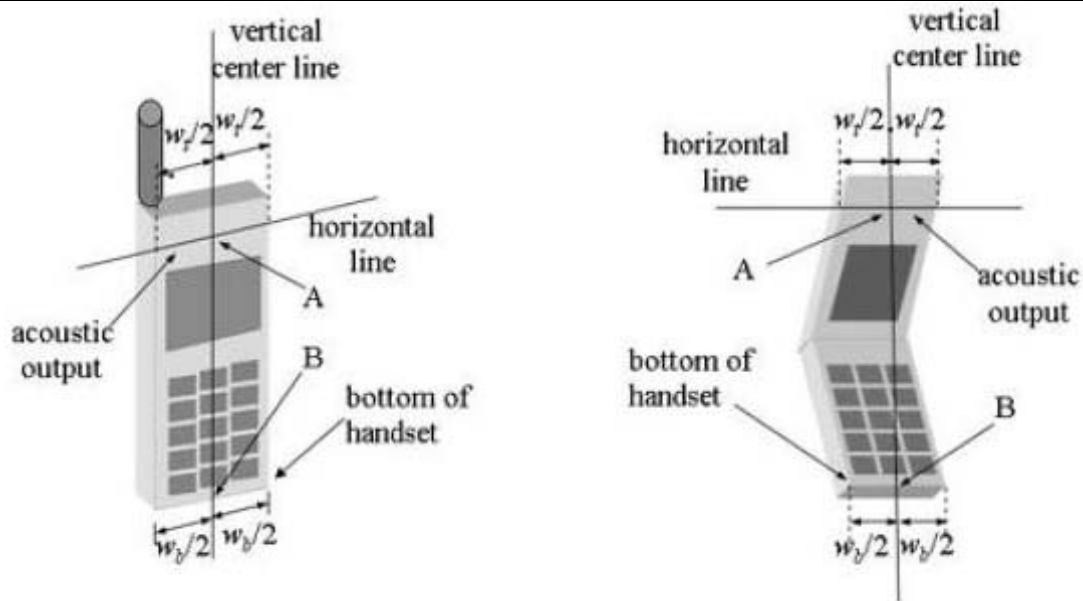


Figure 6.2 Handset Vertical Center & Horizontal Line Reference Points

### 6.2 Test Configuration Positions

#### Positioning for Cheek/Touch

- 1) Ready the handset for talk operation, if necessary. For example, for handsets with a cover piece, open the cover . (If the phone can also be used with the cover closed ,both configurations must be tested.)
- 2) Define two imaginary lines on the handset: the vertical centerline and the horizontal line. The vertical centerline passes through two points on the front side of the handset: the midpoint of the width  $w_t$  of the handset at the level of the acoustic output (point A on Figures 6.2), and the midpoint of the width  $w_b$  of the bottom of the handset (point B). The horizontal line is perpendicular to the vertical centerline and passes through the center of the acoustic output (see Figure 6.2). The two lines intersect at point A. Note that for many handsets, point A coincides with the center of the acoustic output. However, the acoustic output may be located elsewhere on the horizontal line. Also note that the vertical centerline is not necessarily parallel to the front face of the handset (see Figure 6.2), especially for clamshell handsets, handsets with lip pieces, and other irregularly-shaped handsets.
- 3) Position the handset close to the surface of the phantom touch that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Figure 6.3), such that the plane defined by the vertical center line and the horizontal line of the phone is approximately parallel to the sagittal plane of the phantom.

## 6. DESCRIPTION OF THE TEST PROCEDURE(continued)

- 4) Translate the handset towards the phantom along the line passing through RE and LE until the handset touches the ear.
- 5) While maintaining the handset in this plane, rotate it around the LE-RE line until the vertical centerline is in the plane normal to MB-NF including the line MB (called the reference plane).
- 6) Rotate the phone around the vertical centerline until the phone (horizontal line) is symmetrical with respect to the line NF.
- 7) While maintaining the vertical centerline in the reference plane, keeping point A on the line passing through RE and LE, and maintaining the phone contact with the ear, rotate the handset about the line NF until any point on the handset is in contact with a phantom point

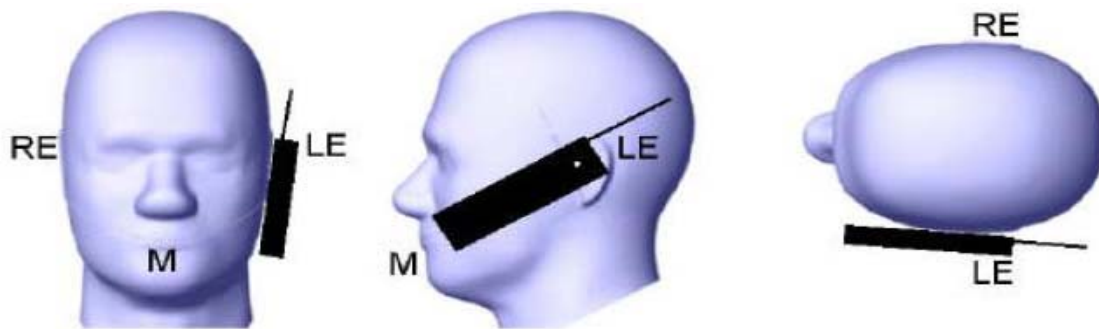


Figure 6.3 “Cheek” or “Touch” Position.

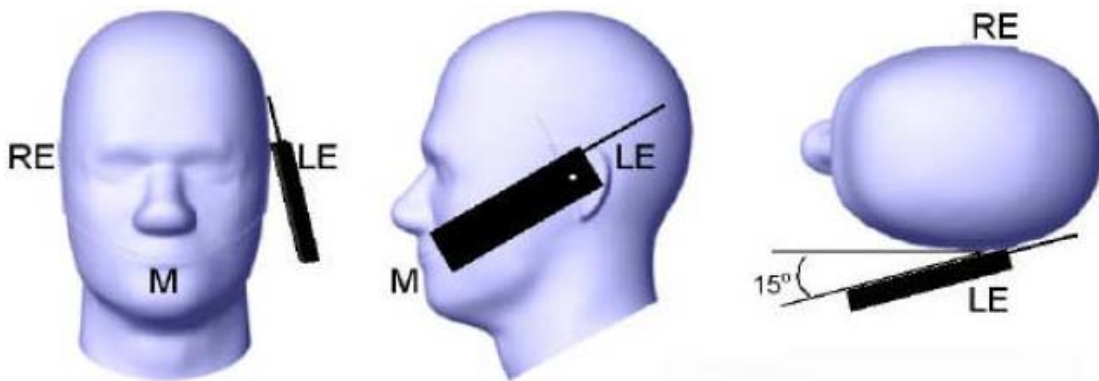


Figure 6.4 “Tilted” Position.

## 6. DESCRIPTION OF THE TEST PROCEDURE(continued)

### Positioning for Ear / 15° Tilted

- 1) Repeat steps 1 to 7 of 6.2(Positioning for Cheek/Touch) to place the device in the “cheek position.”
- 2) While maintaining the orientation of the phone retract the phone parallel to the reference plane far enough to enable a rotation of the phone by 15 degree.
- 3) Rotate the phone around the horizontal line by 15 degree.
- 4) While maintaining the orientation of the phone, move the phone parallel to the reference plane until any part of the phone touches the head. (In this position, point A will be located on the line RE–LE). The tilted position is obtained when the contact is on the pinna. If the contact is at any location other than the pinna, the angle of the phone shall be reduced. The tilted position is obtained if any part of the phone is in contact of the ear as well as a second part of the phone is contact with the head.

### Body Holder / Belt Clip Configurations

Body-worn operation configurations are tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in a normal use configuration. A device with a headset output is tested with a headset connected to the device. Body dielectric parameters are used.

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

Body-worn accessories may not always be supplied or available as options for some devices intended to be authorized for body-worn use. In this case, a test configuration where a separation distance between the back of the device and the flat phantom is used. All test position spacings are documented. Transmitters that are designed to operate in front of a person's face, as in push-to-talk configurations, are tested for SAR compliance is tested with the accessory(ies), including headsets and microphones, attached to the device and positioned against a flat phantom in a normal use configuration. In all case SAR measurements are performed to investigate the worst case positioning. Worst-case positioning is then documented and used to perform Body SAR testing.

In order for users to be aware of the body-worn operation requirements for meeting RF exposure compliance, operation instructing instructions and cautions statements are included in the user's manual.

## 6. DESCRIPTION OF THE TEST PROCEDURE(continued)

### 6.3 Scan Procedures

First coarse scans are used for quick determination of the field distribution. Nest cube scan, 5x5x7 points; spacing between each point 5x5x5 mm, is performed around the highest E-field value to determine the averaged SAR-distribution over 1g.

### 6.4 SAR Averaging Methods

The maximum SAR value is averaged over its volume using interpolation and extrapolation.

The interpolation of the points is done with a 3d-Spline. The 3d-Spline is composed of three one-dimensional splines with the “Not a Knot” condition [W.Gander, Computermathematik, p. 141–150](x, y and z directions) [Numerical Recipes in C, Second Edition, p 123].

The extrapolation is based on least square algorithm [W.Gander, Computermathematik, p. 168–180]. Through the points in the first 30 mm in all z-axis, polynomials of order four are calculated. This polynomial is then used to evaluate the points between the surface and the probe tip. The points calculated from the surface, have a distance of 1 mm from one another.

## 7. MEASUREMENT UNCERTAINTY

According to CENELEC [17], typical worst-case uncertainty of field measurements is 5 dB.  
 For well-defined modulation characteristics the uncertainty can be reduced to 3 dB.

| ERROR Description                                                               | Uncertainty | Probability  | Divisor | ci 1                   | Standard unc. | vi or |
|---------------------------------------------------------------------------------|-------------|--------------|---------|------------------------|---------------|-------|
|                                                                                 | value ±%    | Distribution |         | 1g                     | (1g)          | Veff  |
| MEASUREMENT SYSTEM                                                              |             |              |         |                        |               |       |
| Probe Calibration                                                               | ± 11.7 %    | normal       | 1       | 1                      | ± 4.8 %       | ∞     |
| Axial Isotropy                                                                  | ± 4.7       | rectangular  | √ 3     | (1-cp ) <sup>1/2</sup> | ± 1.9%        | ∞     |
| Hemispherical Isotropy                                                          | ± 9.6       | rectangular  | √ 3     | (cp ) <sup>1/2</sup>   | ± 3.9%        | ∞     |
| Boundary Effects                                                                | ± 1.0       | rectangular  | √ 3     | 1                      | ± 0.6%        | ∞     |
| Linearity                                                                       | ± 4.7       | rectangular  | √ 3     | 1                      | ± 2.7%        | ∞     |
| Modulation Response                                                             | ± 3.5       | rectangular  | √ 3     | 1                      | ± 2.0%        | ∞     |
| System Detection Limits                                                         | ± 1.0       | rectangular  | √ 3     | 1                      | ± 0.6%        | ∞     |
| Readout Electronics                                                             | ± 1.0       | normal       | 1       | 1                      | ± 1.0%        | ∞     |
| Response time                                                                   | ± 0.8       | rectangular  | √ 3     | 1                      | ± 0.5%        | ∞     |
| Integration time                                                                | ± 2.6       | rectangular  | √ 3     | 1                      | ± 1.5%        | ∞     |
| RF Amnient Conditions                                                           | ± 3.0       | rectangular  | √ 3     | 1                      | ± 1.7%        | ∞     |
| Probe Positioner Mechanical Tolerance                                           | ± 0.4       | rectangular  | √ 3     | 1                      | ± 0.2%        | ∞     |
| Probe Positioning with respect to Phantom Shell                                 | ± 2.9       | rectangular  | √ 3     | 1                      | ± 1.7%        | ∞     |
| Extrapolation, Interpolation and Integration Algorithms for Max. SAR Evaluation | ± 1.0       | rectangular  | √ 3     | 1                      | ± 0.6%        | ∞     |
| Test Sample Related                                                             |             |              |         |                        |               |       |
| Test Sample Positioning                                                         | ± 2.9       | normal       | 1       | 1                      | ± 2.97%       | 145   |
| Device Holder Uncertainty                                                       | ± 3.6       | normal       | 0.84    | 1                      | ± 3.69%       | 5     |
| Output Power Validation – SAR drift measurement                                 | ± 5.0       | rectangular  | √ 3     | 1                      | ± 2.9%        | ∞     |
| Phantom and Tissue                                                              |             |              |         |                        |               |       |
| Phantom Uncertainty (shape and thickness tolerances)                            | ± 4.0       | rectangular  | √ 3     | 1                      | ± 2.3%        | ∞     |
| SAR Correction                                                                  | ± 5.0       | normal       | 1       | 1                      | ± 5.0%        | ∞     |
| Liquid Conductivity – measurement uncertainty                                   | ± 5.0       | normal       | 1       | 0.78                   | ± 3.9%        | ∞     |
| Liquid Conductivity – temperature uncertainty                                   | ± 1.7       | rectangular  | √ 3     | 0.78                   | ± 0.77%       | ∞     |
| Liquid Permittivity – measurement uncertainty                                   | ± 5.0       | normal       | 1       | 0.23                   | ± 1.15%       | ∞     |
| Liquid Permittivity – temperature uncertainty                                   | ± 0.3       | rectangular  | √ 3     | 0.23                   | ± 0.04%       | ∞     |
| Combined Standard Uncertainty                                                   |             |              |         |                        | ± 11.91 %     | 330   |
| Coverage Factor for 95%                                                         |             |              |         | K = 2                  |               |       |
| Expanded Standard Uncertainty                                                   |             |              |         |                        | ± 23.82 %     |       |

## 8. SYSTEM VERIFICATION

### Tissue Verification

Table 8.1 Simulated Tissue Verification [5]

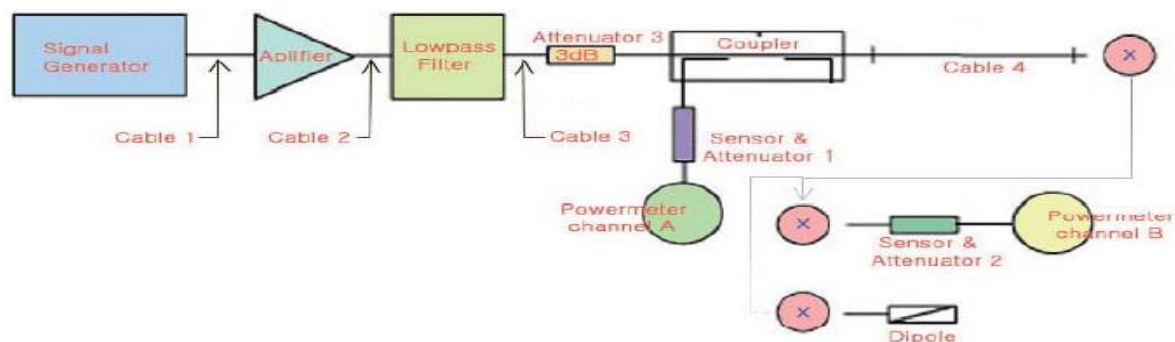
| MEASURED TISSUE PARAMETERS      |                                          |    |                  |     |  |
|---------------------------------|------------------------------------------|----|------------------|-----|--|
| Liquid Temperature (°C)         |                                          | 23 | Liquid Depth(mm) | 150 |  |
| Date                            | 2016-10-11                               |    |                  |     |  |
| Tissue                          | 2450MHz Body                             |    |                  |     |  |
|                                 | Target                                   |    | Measured         |     |  |
| Dielectric Constant: $\epsilon$ | 52.70                                    |    | 52.20            |     |  |
| Conductivity: $\sigma$          | 1.95                                     |    | 1.89             |     |  |
| Deviation (%)                   | $\epsilon$ : -0.95%<br>$\sigma$ : -3.08% |    |                  |     |  |

### Test System Validation

- Prior to assessment, the system is verified to the  $\pm 10\%$  of the specifications at 2450MHz and 5GHz (Graphic Plots Attached)
- The results are nominalized to 1W input power

Table 8.2 System Validation [5]

| SYSTEM DIPOLE VALIDATION TARGET & MEASURED |                        |                   |                       |                       |               |            |
|--------------------------------------------|------------------------|-------------------|-----------------------|-----------------------|---------------|------------|
| Tissue                                     | System Validation Kit: | Forward Power (W) | Targeted SAR1g (mW/g) | Measured SAR1g (mW/g) | Deviation (%) | Test Date  |
| 2450MHz Body                               | D2450V2(S/N :741)      | 1.0               | 51.2                  | 49.6                  | -3.13%        | 2016-10-11 |



## 9. RESULTS

Ambient TEMPERATURE (C) : 23.0

Relative HUMIDITY (%) : 44

Mixture Type : 2.4GHz Body

Model Name : WSP-i450

### Measurement Results (802.11g Body SAR)

|                                                                                                   |                                         |
|---------------------------------------------------------------------------------------------------|-----------------------------------------|
| ANSI / IEEE C95.1 1992 – SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | 1.6 W/kg (W/kg)<br>averaged over 1 gram |
|---------------------------------------------------------------------------------------------------|-----------------------------------------|

### MEASUREMENT RESULTS (802.11g Body SAR)

| Mode    | Body/EUT Position | Frequency (MHz) | Channel | Power (dBm) | Power Drift (dBm) | 1g SAR (W/Kg) | scaling Factor | Scaled SAR(mW/g) |
|---------|-------------------|-----------------|---------|-------------|-------------------|---------------|----------------|------------------|
| 802.11g | Flat/Front        | 2437            | 6       | 23.37       | -0.28             | 0.0048        | 1.005          | 0.0048           |
| 802.11g | Flat/Rear         | 2437            | 6       | 23.37       | -0.54             | 0.0043        | 1.005          | 0.0043           |
| 802.11g | Flat/Right        | 2437            | 6       | 23.37       | 0.43              | 0.0049        | 1.005          | 0.0049           |
| 802.11g | Flat/Left         | 2437            | 6       | 23.37       | 0.68              | 0.0052        | 1.005          | 0.0052           |
| 802.11g | Flat/Top          | 2437            | 6       | 23.37       | 0.28              | 0.0033        | 1.005          | 0.0033           |
| 802.11g | Flat/Bottom       | 2437            | 6       | 23.37       | -0.82             | 0.0031        | 1.005          | 0.0032           |
| 802.11g | Flat/Front        | 2412            | 1       | 23.37       | 0.68              | 0.0034        | 1.005          | 0.0034           |
| 802.11g | Flat/Front        | 2462            | 11      | 23.37       | 0.96              | 0.0038        | 1.005          | 0.0038           |

## 10. REFERENCE

- [1] Federal Communications Commission, ET Docket 93–62, Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation, Aug. 1996.
- [2] ANSI/IEEE C95.1–2005, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, 2006.
- [3] ANSI/IEEE C95.1–1992, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, Sept. 1992.
- [4] ANSI/IEEE C95.3–2002, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave, New York: IEEE, December 2002.
- [5] IEEE Standards Coordinating Committee 39 –Standards Coordinating Committee 34 – IEEE Std. 1528–2013, Recommended Practice for Determining the Peak Spatial–Average Specific Absorption Rate (SAR) in the Human Head Due to Wireless Communications Devices: Measurement Techniques.
- [6] NCRP, National Council on Radiation Protection and Measurements, Biological Effects and Exposure Criteria for RadioFrequency Electromagnetic Fields, NCRP Report No. 86, 1986. Reprinted Feb. 1995.
- [7] T. Schmid, O. Egger, N. Kuster, Automated E–field scanning system for dosimetric assessments, IEEE Transaction on Microwave Theory and Techniques, vol. 44, Jan. 1996, pp. 105–113.
- [8] K. Pokovic, T. Schmid, N. Kuster, Robust setup for precise calibration of E–field probes in tissue simulating liquids at mobile communications frequencies, ICECOM97, Oct. 1997, pp. 1 –124.
- [9] K. Pokovic, T. Schmid, and N. Kuster, E–field Probe with improved isotropy in brain simulating liquids, Proceedings of the ELMAR, Zadar, Croatia, June 23–25, 1996, pp. 172–175.
- [10] Schmid & Partner Engineering AG, Application Note: Data Storage and Evaluation, June 1998, p2.
- [11] V. Hombach, K. Meier, M. Burkhardt, E. Kuhn, N. Kuster, The Dependence of EM Energy Absorption upon Human Modeling at 900 MHz, IEEE Transaction on Microwave Theory and Techniques, vol. 44 no. 10, Oct. 1996, pp. 1865–1873.
- [12] N. Kuster and Q. Balzano, Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300MHz, IEEE Transaction on Vehicular Technology, vol. 41, no. 1, Feb. 1992, pp. 17–23.
- [13] G. Hartsgrrove, A. Kraszewski, A. Surowiec, Simulated Biological Materials for Electromagnetic Radiation Absorption Studies, University of Ottawa, Bioelectromagnetics, Canada: 1987, pp. 29–36.
- [14] Q. Balzano, O. Garay, T. Manning Jr., Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones, IEEE Transactions on Vehicular Technology, vol. 44, no.3, Aug. 1995.
- [15] W. Gander, Computermathematik, Birkhaeuser, Basel, 1992.
- [16] W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Numerical Recipes in C, The Art of Scientific Computing, Second edition, Cambridge University Press, 1992.
- [17] N. Kuster, R. Kastle, T. Schmid, Dosimetric evaluation of mobile communications equipment with known precision, IEEE Transaction on Communications, vol. E80–B, no. 5, May 1997, pp. 645–652.
- [18] CENELEC CLC/SC111B, European Prestandard (prENV 50166–2), Human Exposure to Electromagnetic Fields High–frequency: 10kHz–300GHz, Jan. 1995.
- [19] Prof. Dr. Niels Kuster, ETH, Eidgenössische Technische Hochschule Zürich, Dosimetric Evaluation of the Cellular Phone.
- [20] IEC 62209–1, Human exposure to radio frequency fields from hand–held and body–mounted wireless communication devices – Human models, instrumentation, and procedures – Part 1: Procedure to determine the specific absorption rate (SAR) for hand–held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz), Feb. 2005.
- [21] Industry Canada RSS–102 Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands) Issue 4, March 2010.

[22] Health Canada Safety Code 6 Limits of Human Exposure to Radio Frequency Electromagnetic Fields in the Frequency Range from 3 kHz – 300 GHz, 2009

[23] FCC SAR Test Procedures for 2G–3G Devices, Mobile Hotspot and UMPC Devices KDB Publications 941225, D01–D07

[24] SAR Measurement Guidance for IEEE 802.11 Transmitters, KDB Publication 248227 D01v02r02

[25] FCC SAR Considerations for Handsets with Multiple Transmitters and Antennas, KDB Publications 648474 D03–D04

[26] FCC SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers, FCC KDB Publication 616217 D04

[27] FCC SAR Measurement and Reporting Requirements for 100MHz – 6 GHz, KDB Publications 865664 D01–D02

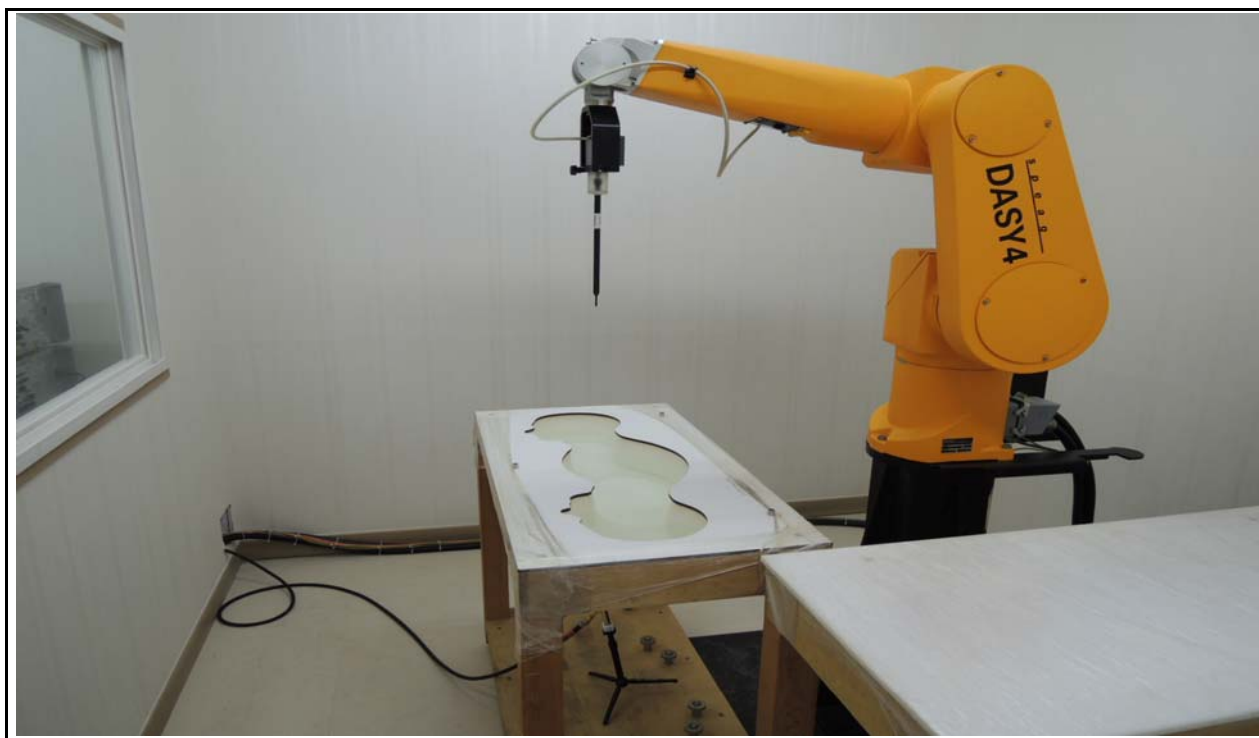
[28] FCC General RF Exposure Guidance and SAR Procedures for Dongles, KDB Publication 447498, D01–D02

[29] Anexo à Resolução No. 533, de 10 de Setembro de 2009.

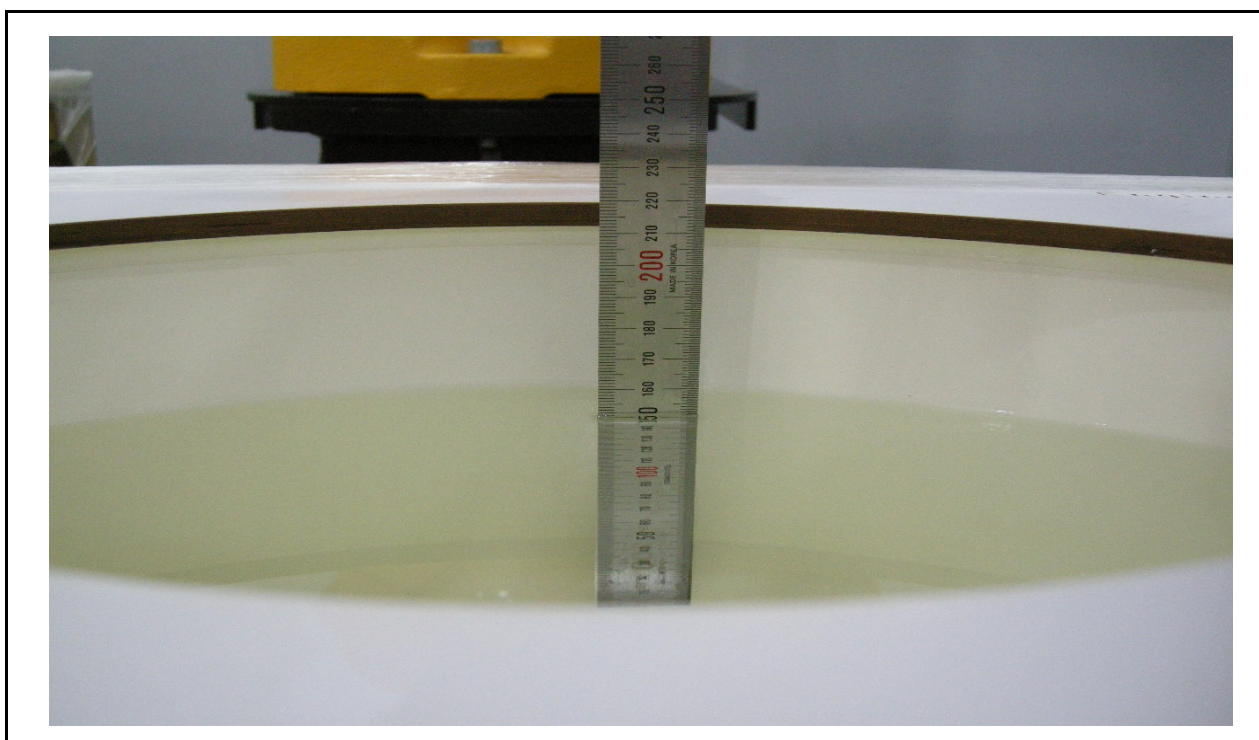
[30] IEC 62209–2, Human exposure to radio frequency fields from hand–held and body–mounted wireless communication devices – Human models, instrumentation, and procedures – Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz), Mar. 2010.

## APPENDIX A : Validation Test Data

### Dipole Validation



### Liquid depth



Date: 2016-10-11

Test Laboratory: ESTECH

## VALIDATION

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: 741**

Communication System: CW; Frequency: 2450 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.89$  mho/m;  $\epsilon_r = 52.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 – SN3882; ConvF(7.02, 7.02, 7.02); Calibrated: 2015-11-24
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn551; Calibrated: 2016-01-25
- Phantom: HSL1800\_12\_03\_23; Type: TP-1263;
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

**Area Scan (41x61x1):** Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (interpolated) = 14.6 mW/g

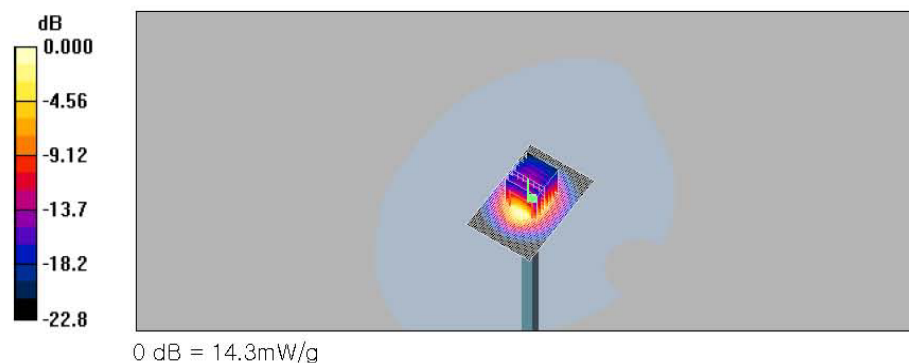
**Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 88.0 V/m; Power Drift = -0.053 dB

Peak SAR (extrapolated) = 25.9 W/kg

**SAR(1 g) = 12.4 mW/g**

Maximum value of SAR (measured) = 14.3 mW/g



## APPENDIX B : SAR Test Data

Date: 2016-10-11

Test Laboratory: ESTECH

**WSP-i450\_802.11g FRONT**

**DUT: WSP-i450: Type**

Communication System: Wireless 2.4GHz; Frequency: 2442 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 2442$  MHz;  $\sigma = 1.87$  mho/m;  $\epsilon_r = 52.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 – SN3882; ConvF(7.02, 7.02, 7.02); Calibrated: 2015-11-24
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn551; Calibrated: 2016-01-25
- Phantom: HSL1800\_12\_03\_23; Type: TP-1263;
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

**Area Scan (91x101x1):** Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (interpolated) = 0.006 mW/g

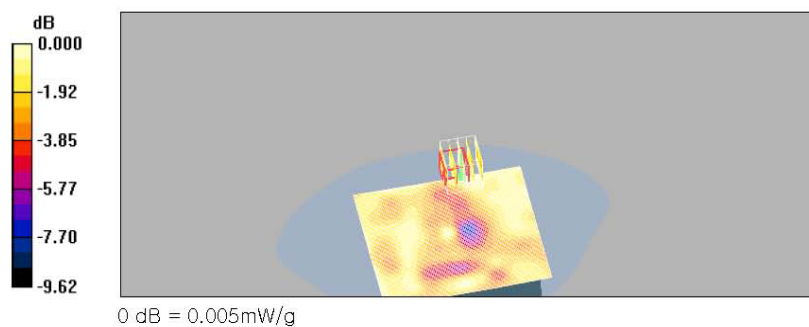
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 1.39 V/m; Power Drift = -0.284 dB

Peak SAR (extrapolated) = 0.007 W/kg

**SAR(1 g) = 0.00479 mW/g**

Maximum value of SAR (measured) = 0.005 mW/g



Date: 2016-10-11

Test Laboratory: ESTECH

**WSP-i350\_802.11g REAR**

**DUT: WSP-i450: Type**

Communication System: Wireless 2.4GHz; Frequency: 2437 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated):  $f = 2437$  MHz;  $\sigma = 1.87$  mho/m;  $\epsilon_r = 52.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 – SN3882; ConvF(7.02, 7.02, 7.02); Calibrated: 2015-11-24
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn551; Calibrated: 2016-01-25
- Phantom: HSL1800\_12\_03\_23; Type: TP-1263;
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

**Area Scan (91x101x1):** Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (interpolated) = 0.005 mW/g

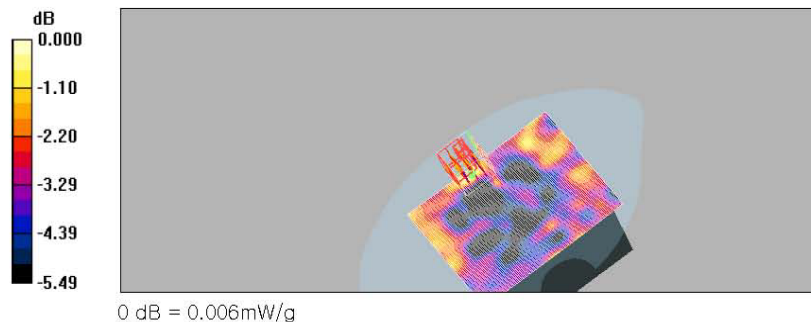
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 1.56 V/m; Power Drift = -0.539 dB

Peak SAR (extrapolated) = 0.007 W/kg

**SAR(1 g) = 0.00425 mW/g**

Maximum value of SAR (measured) = 0.006 mW/g



Date: 2016-10-11

Test Laboratory: ESTECH

**WSP-i350\_802.11g RIGHT**

**DUT: WSP-i450: Type**

Communication System: Wireless 2.4GHz; Frequency: 2437 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated):  $f = 2437$  MHz;  $\sigma = 1.87$  mho/m;  $\epsilon_r = 52.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 – SN3882; ConvF(7.02, 7.02, 7.02); Calibrated: 2015-11-24
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn551; Calibrated: 2016-01-25
- Phantom: HSL1800\_12\_03\_23; Type: TP-1263;
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

**Area Scan (101x61x1):** Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (interpolated) = 0.004 mW/g

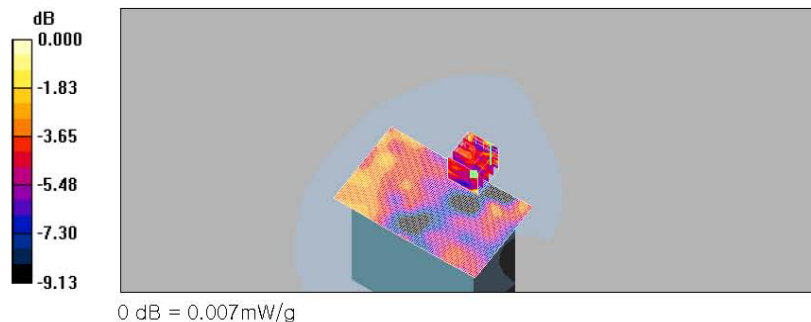
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 0.924 V/m; Power Drift = 0.280 dB

Peak SAR (extrapolated) = 0.007 W/kg

**SAR(1 g) = 0.00325 mW/g**

Maximum value of SAR (measured) = 0.007 mW/g



Date: 2016-10-11

Test Laboratory: ESTECH

**WSP-i350\_802.11g LEFT**

**DUT: WSP-i450: Type**

Communication System: Wireless 2.4GHz; Frequency: 2437 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated):  $f = 2437$  MHz;  $\sigma = 1.87$  mho/m;  $\epsilon_r = 52.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 – SN3882; ConvF(7.02, 7.02, 7.02); Calibrated: 2015-11-24
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn551; Calibrated: 2016-01-25
- Phantom: HSL1800\_12\_03\_23; Type: TP-1263;
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

**Area Scan (101x61x1):** Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (interpolated) = 0.005 mW/g

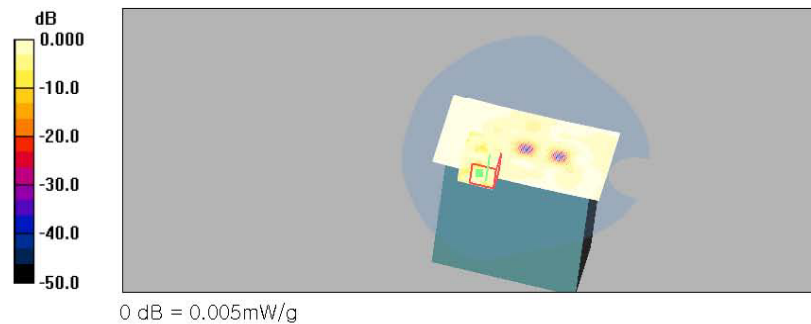
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 1.03 V/m; Power Drift = -0.818 dB

Peak SAR (extrapolated) = 0.005 W/kg

**SAR(1 g) = 0.00314 mW/g**

Maximum value of SAR (measured) = 0.005 mW/g



Date: 2016-10-11

Test Laboratory: ESTECH

**WSP-i350\_802.11g TOP**

**DUT: WSP-i450: Type**

Communication System: Wireless 2.4GHz; Frequency: 2437 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated):  $f = 2437$  MHz;  $\sigma = 1.87$  mho/m;  $\epsilon_r = 52.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 – SN3882; ConvF(7.02, 7.02, 7.02); Calibrated: 2015-11-24
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn551; Calibrated: 2016-01-25
- Phantom: HSL1800\_12\_03\_23; Type: TP-1263;
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

**Area Scan (91x61x1):** Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (interpolated) = 0.005 mW/g

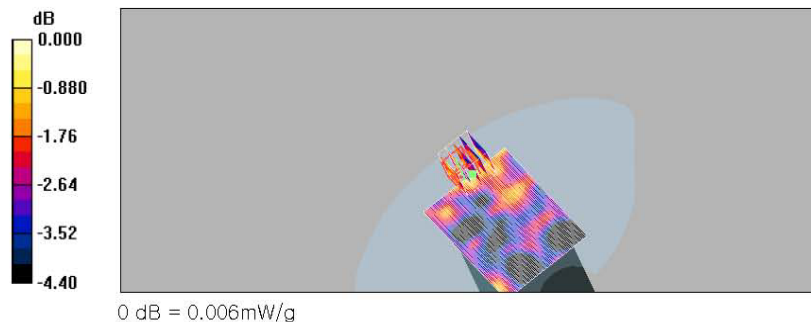
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 1.13 V/m; Power Drift = 0.433 dB

Peak SAR (extrapolated) = 0.006 W/kg

**SAR(1 g) = 0.00486 mW/g**

Maximum value of SAR (measured) = 0.006 mW/g



Date: 2016-10-11

Test Laboratory: ESTECH

**WSP-i350\_802.11g BOTTOM**

**DUT: WSP-i450: Type**

Communication System: Wireless 2.4GHz; Frequency: 2437 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated):  $f = 2437$  MHz;  $\sigma = 1.87$  mho/m;  $\epsilon_r = 52.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 – SN3882; ConvF(7.02, 7.02, 7.02); Calibrated: 2015-11-24
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn551; Calibrated: 2016-01-25
- Phantom: HSL1800\_12\_03\_23; Type: TP-1263;
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

**Area Scan (91x61x1):** Measurement grid: dx=15mm, dy=15mm.

Maximum value of SAR (interpolated) = 0.005 mW/g

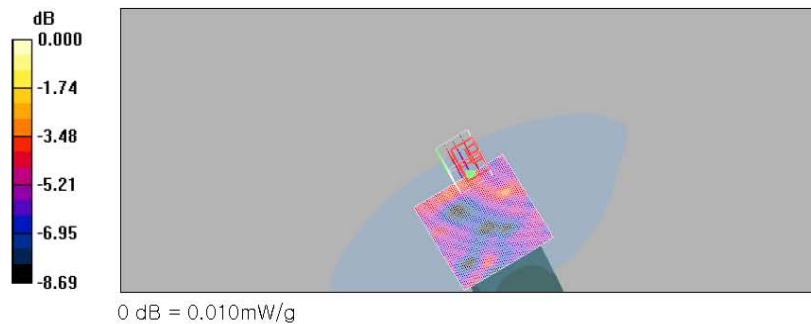
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 1.14 V/m; Power Drift = 0.675 dB

Peak SAR (extrapolated) = 0.010 W/kg

**SAR(1 g) = 0.00521 mW/g**

Maximum value of SAR (measured) = 0.010 mW/g



Date: 2016-10-11

Test Laboratory: ESTECH

**WSP-i350\_802.11g BOTTOM LOW**

**DUT: WSP-i450: Type**

Communication System: Wireless 2.4GHz; Frequency: 2412 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 2412$  MHz;  $\sigma = 1.87$  mho/m;  $\epsilon_r = 52.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 – SN3882; ConvF(7.02, 7.02, 7.02); Calibrated: 2015-11-24
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn551; Calibrated: 2016-01-25
- Phantom: HSL1800\_12\_03\_23; Type: TP-1263;
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

**Area Scan (91x61x1):** Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (interpolated) = 0.004 mW/g

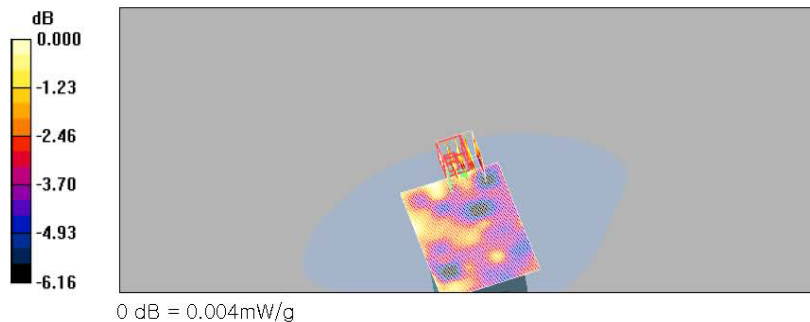
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 0.937 V/m; Power Drift = 0.680 dB

Peak SAR (extrapolated) = 0.004 W/kg

**SAR(1 g) = 0.00338 mW/g**

Maximum value of SAR (measured) = 0.004 mW/g



Date: 2016-10-11

Test Laboratory: ESTECH

**WSP-i350\_802.11g BOTTOM HI**

**DUT: WSP-i450: Type**

Communication System: Wireless 2.4GHz; Frequency: 2462 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 2462 \text{ MHz}$ ;  $\sigma = 1.91 \text{ mho/m}$ ;  $\epsilon_r = 52.2$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 – SN3882; ConvF(7.02, 7.02, 7.02); Calibrated: 2015-11-24
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn551; Calibrated: 2016-01-25
- Phantom: HSL1800\_12\_03\_23; Type: TP-1263;
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

**Area Scan (91x61x1):** Measurement grid:  $dx=15\text{mm}$ ,  $dy=15\text{mm}$

Maximum value of SAR (interpolated) =  $0.004 \text{ mW/g}$

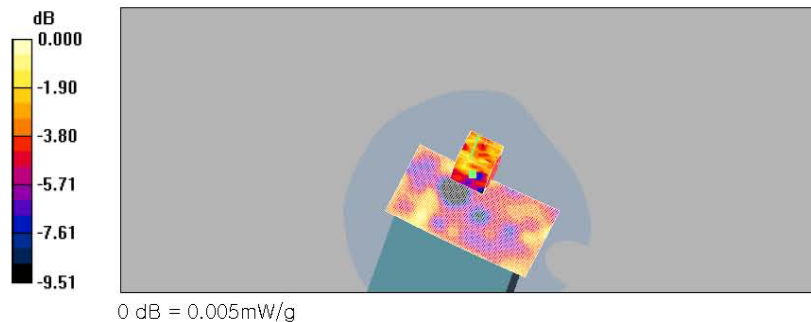
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid:  $dx=8\text{mm}$ ,  $dy=8\text{mm}$ ,  $dz=5\text{mm}$

Reference Value =  $0.874 \text{ V/m}$ ; Power Drift =  $0.834 \text{ dB}$

Peak SAR (extrapolated) =  $0.007 \text{ W/kg}$

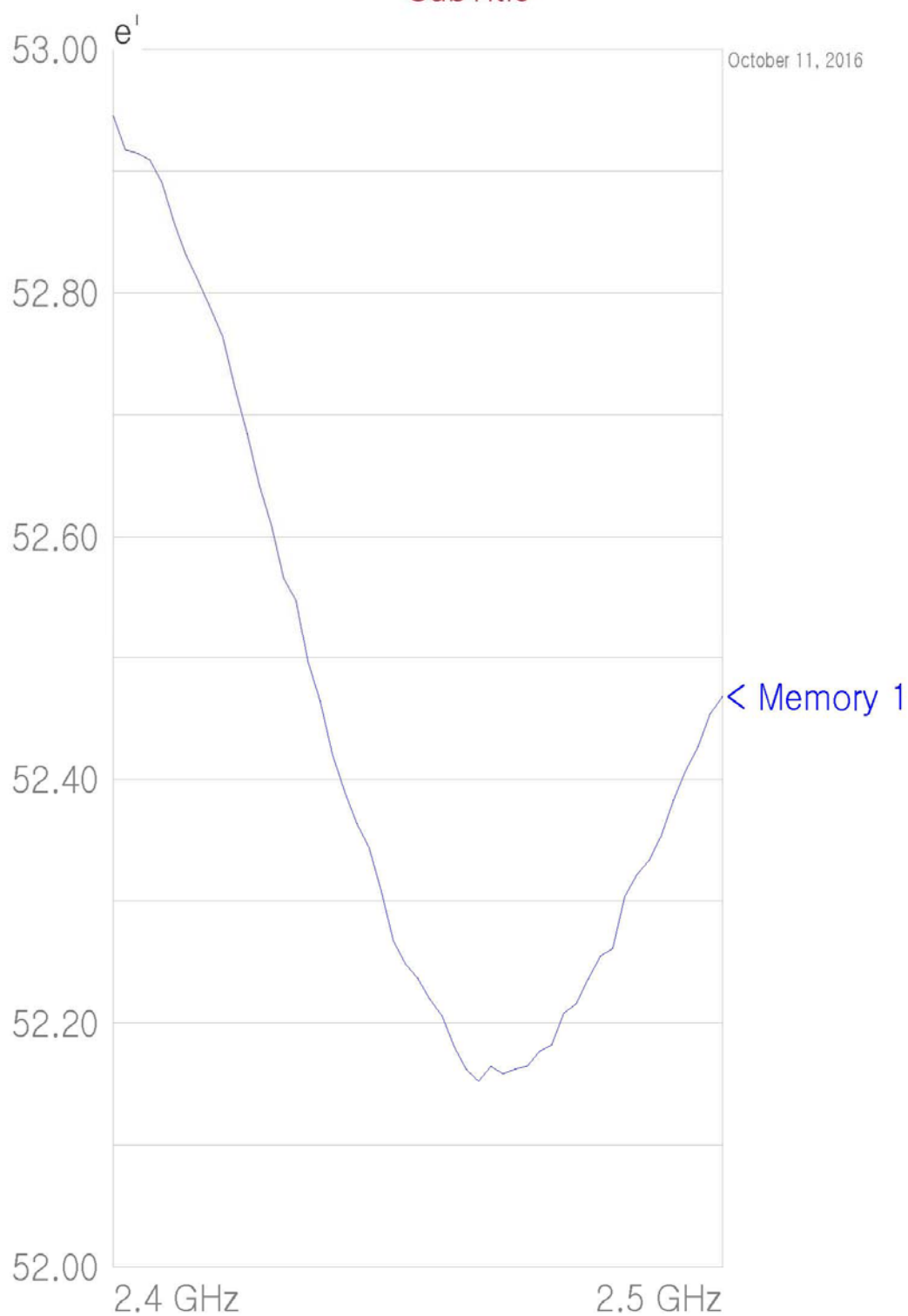
**SAR(1 g) =  $0.00376 \text{ mW/g}$**

Maximum value of SAR (measured) =  $0.005 \text{ mW/g}$



## APPENDIX C : SAR Tissue Data

Title  
SubTitle



Title  
 SubTitle  
 October 11, 2016

| Frequency       | e <sup>I</sup> | e <sup>II</sup> |
|-----------------|----------------|-----------------|
| 2.40000000 GHz  | 52.9457        | 13.9877         |
| 2.401963461 GHz | 52.9176        | 13.9764         |
| 2.403926921 GHz | 52.9148        | 13.9788         |
| 2.405890382 GHz | 52.9095        | 13.9614         |
| 2.407853843 GHz | 52.8909        | 13.9306         |
| 2.409817303 GHz | 52.8579        | 13.9184         |
| 2.411788795 GHz | 52.8306        | 13.9104         |
| 2.413760288 GHz | 52.8096        | 13.8867         |
| 2.415731780 GHz | 52.7874        | 13.8798         |
| 2.417703272 GHz | 52.7641        | 13.8631         |
| 2.419674764 GHz | 52.7221        | 13.8438         |
| 2.421654321 GHz | 52.6849        | 13.8222         |
| 2.423633878 GHz | 52.6425        | 13.8114         |
| 2.425613435 GHz | 52.6093        | 13.8076         |
| 2.427592991 GHz | 52.5660        | 13.8019         |
| 2.429572548 GHz | 52.5483        | 13.8011         |
| 2.431560202 GHz | 52.4966        | 13.7684         |
| 2.433547856 GHz | 52.4640        | 13.7795         |
| 2.435535511 GHz | 52.4205        | 13.7706         |
| 2.437523165 GHz | 52.3902        | 13.7864         |
| 2.439510819 GHz | 52.3640        | 13.7819         |
| 2.441506604 GHz | 52.3443        | 13.7765         |
| 2.443502388 GHz | 52.3088        | 13.7765         |
| 2.445498173 GHz | 52.2677        | 13.7838         |
| 2.447493958 GHz | 52.2487        | 13.8081         |
| 2.449489743 GHz | 52.2370        | 13.8380         |
| 2.451493691 GHz | 52.2196        | 13.8489         |
| 2.453497640 GHz | 52.2061        | 13.8510         |
| 2.455501589 GHz | 52.1808        | 13.8760         |
| 2.457505537 GHz | 52.1620        | 13.9002         |
| 2.459509486 GHz | 52.1525        | 13.9314         |
| 2.461521632 GHz | 52.1646        | 13.9647         |
| 2.463533778 GHz | 52.1585        | 13.9839         |
| 2.465545923 GHz | 52.1622        | 14.0018         |
| 2.467558069 GHz | 52.1649        | 14.0363         |
| 2.469570215 GHz | 52.1769        | 14.0662         |
| 2.471590592 GHz | 52.1824        | 14.0970         |
| 2.473610968 GHz | 52.2084        | 14.1316         |
| 2.475631345 GHz | 52.2158        | 14.1752         |
| 2.477651722 GHz | 52.2364        | 14.1940         |
| 2.479672098 GHz | 52.2552        | 14.2228         |
| 2.481700739 GHz | 52.2611        | 14.2534         |
| 2.483729380 GHz | 52.3040        | 14.2887         |
| 2.485758021 GHz | 52.3221        | 14.3110         |
| 2.487786662 GHz | 52.3337        | 14.3340         |
| 2.489815303 GHz | 52.3542        | 14.3608         |
| 2.491852243 GHz | 52.3831        | 14.3879         |
| 2.493889182 GHz | 52.4074        | 14.3942         |
| 2.495926121 GHz | 52.4267        | 14.4110         |
| 2.497963061 GHz | 52.4539        | 14.4366         |
| 2.500000000 GHz | 52.4677        | 14.4492         |

Title  
SubTitle



Title  
 SubTitle  
 October 11, 2016

| Frequency       | e <sup>i</sup> | e <sup>ii</sup> |
|-----------------|----------------|-----------------|
| 2.40000000 GHz  | 52.9457        | 13.9877         |
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| 2.471590592 GHz | 52.1824        | 14.0970         |
| 2.473610968 GHz | 52.2084        | 14.1316         |
| 2.475631345 GHz | 52.2158        | 14.1752         |
| 2.477651722 GHz | 52.2364        | 14.1940         |
| 2.479672098 GHz | 52.2552        | 14.2228         |
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| 2.487786662 GHz | 52.3337        | 14.3340         |
| 2.489815303 GHz | 52.3542        | 14.3608         |
| 2.491852243 GHz | 52.3831        | 14.3879         |
| 2.493889182 GHz | 52.4074        | 14.3942         |
| 2.495926121 GHz | 52.4267        | 14.4110         |
| 2.497963061 GHz | 52.4539        | 14.4366         |
| 2.500000000 GHz | 52.4677        | 14.4492         |

## APPENDIX D : Calibration Certificates

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  
 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 **Estech (Dymstec)**

Certificate No: **EX3-3882\_Nov15**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3882**

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: **November 24, 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-15) | In house check: Oct-16 |

|                |                         |                                   |                                                                                                   |
|----------------|-------------------------|-----------------------------------|---------------------------------------------------------------------------------------------------|
| Calibrated by: | Name<br>Claudio Leubler | Function<br>Laboratory Technician | Signature<br> |
| Approved by:   | Katja Pokovic           | Technical Manager                 |               |

Issued: November 24, 2015

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

**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  
**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**

#### Glossary:

|                       |                                                                                                                                                   |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| TSL                   | tissue simulating liquid                                                                                                                          |
| NORM <sub>x,y,z</sub> | sensitivity in free space                                                                                                                         |
| ConvF                 | sensitivity in TSL / NORM <sub>x,y,z</sub>                                                                                                        |
| DCP                   | diode compression point                                                                                                                           |
| CF                    | crest factor (1/duty_cycle) of the RF signal                                                                                                      |
| A, B, C, D            | modulation dependent linearization parameters                                                                                                     |
| Polarization $\phi$   | $\phi$ rotation around probe axis                                                                                                                 |
| Polarization $\theta$ | $\theta$ rotation around an axis that is in the plane normal to probe axis (at measurement center),<br>i.e., $\theta = 0$ 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:

- 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
- 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
- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>: Assessed for E-field polarization  $\theta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not affect the  $E^2$ -field uncertainty inside TSL (see below ConvF).
- NORM( $f$ )<sub>x,y,z</sub> = NORM<sub>x,y,z</sub> \* 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
- A<sub>x,y,z</sub>; B<sub>x,y,z</sub>; C<sub>x,y,z</sub>; D<sub>x,y,z</sub>; VR<sub>x,y,z</sub>: 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 NORM<sub>x,y,z</sub> \* 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  $\pm 50$  MHz to  $\pm 100$  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 NORM<sub>x</sub> (no uncertainty required).

# Probe EX3DV4

SN:3882

Manufactured: April 30, 2012  
Calibrated: November 24, 2015

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3882

### Basic Calibration Parameters

|                                       | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---------------------------------------|----------|----------|----------|-----------|
| Norm ( $\mu V/(V/m)^2$ ) <sup>A</sup> | 0.44     | 0.48     | 0.40     | ± 10.1 %  |
| DCP (mV) <sup>B</sup>                 | 102.3    | 100.7    | 103.8    |           |

### Modulation Calibration Parameters

| UID | Communication System Name |   | A<br>dB | B<br>dB $\sqrt{\mu V}$ | C   | D<br>dB | VR<br>mV | Unc <sup>E</sup><br>(k=2) |
|-----|---------------------------|---|---------|------------------------|-----|---------|----------|---------------------------|
| 0   | CW                        | X | 0.0     | 0.0                    | 1.0 | 0.00    | 169.6    | ±3.3 %                    |
|     |                           | Y | 0.0     | 0.0                    | 1.0 |         | 157.6    |                           |
|     |                           | Z | 0.0     | 0.0                    | 1.0 |         | 164.5    |                           |

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%.

<sup>A</sup> The uncertainties of Norm X,Y,Z do not affect the E<sup>2</sup>-field uncertainty inside TSL (see Pages 5 and 6).

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

<sup>E</sup> Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3882

### Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) <sup>c</sup> | Relative Permittivity <sup>f</sup> | Conductivity (S/m) <sup>f</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>g</sup> | Depth <sup>g</sup> (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 2450                 | 39.2                               | 1.80                            | 7.00    | 7.00    | 7.00    | 0.37               | 0.87                    | ± 12.0 %  |
| 5200                 | 36.0                               | 4.66                            | 4.80    | 4.80    | 4.80    | 0.35               | 1.80                    | ± 13.1 %  |
| 5300                 | 35.9                               | 4.76                            | 4.66    | 4.66    | 4.66    | 0.35               | 1.80                    | ± 13.1 %  |
| 5500                 | 35.6                               | 4.96                            | 4.52    | 4.52    | 4.52    | 0.40               | 1.80                    | ± 13.1 %  |
| 5600                 | 35.5                               | 5.07                            | 4.16    | 4.16    | 4.16    | 0.45               | 1.80                    | ± 13.1 %  |
| 5800                 | 35.3                               | 5.27                            | 4.22    | 4.22    | 4.22    | 0.45               | 1.80                    | ± 13.1 %  |

<sup>c</sup> 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.

<sup>f</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  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 ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

<sup>g</sup> 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.

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3882

### Calibration Parameter Determined in Body Tissue Simulating Media

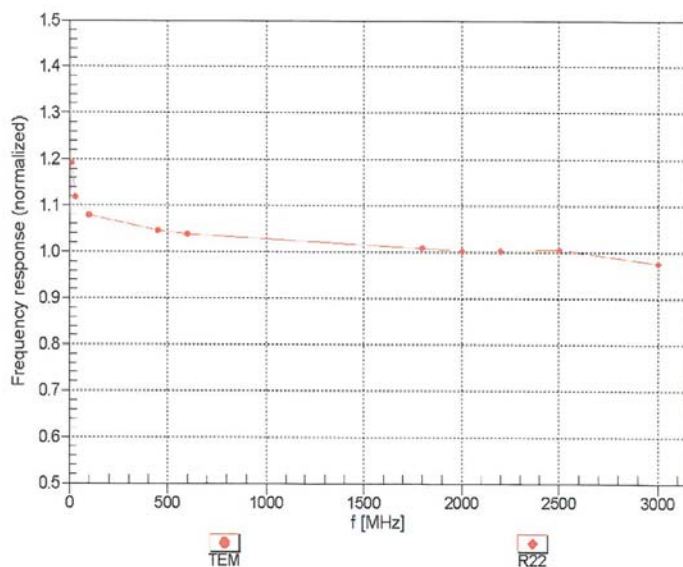
| f (MHz) <sup>C</sup> | Relative Permittivity <sup>F</sup> | Conductivity (S/m) <sup>F</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>G</sup> | Depth <sup>G</sup> (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 2450                 | 52.7                               | 1.95                            | 7.02    | 7.02    | 7.02    | 0.29               | 0.95                    | ± 12.0 %  |
| 5200                 | 49.0                               | 5.30                            | 4.17    | 4.17    | 4.17    | 0.50               | 1.90                    | ± 13.1 %  |
| 5300                 | 48.9                               | 5.42                            | 3.97    | 3.97    | 3.97    | 0.50               | 1.90                    | ± 13.1 %  |
| 5500                 | 48.6                               | 5.65                            | 3.66    | 3.66    | 3.66    | 0.55               | 1.90                    | ± 13.1 %  |
| 5600                 | 48.5                               | 5.77                            | 3.49    | 3.49    | 3.49    | 0.60               | 1.90                    | ± 13.1 %  |
| 5800                 | 48.2                               | 6.00                            | 3.73    | 3.73    | 3.73    | 0.60               | 1.90                    | ± 13.1 %  |

<sup>C</sup> 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.

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  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 ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

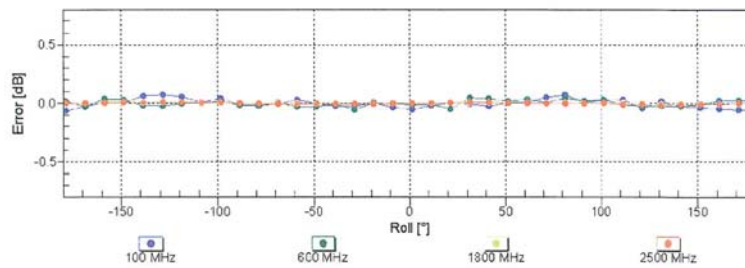
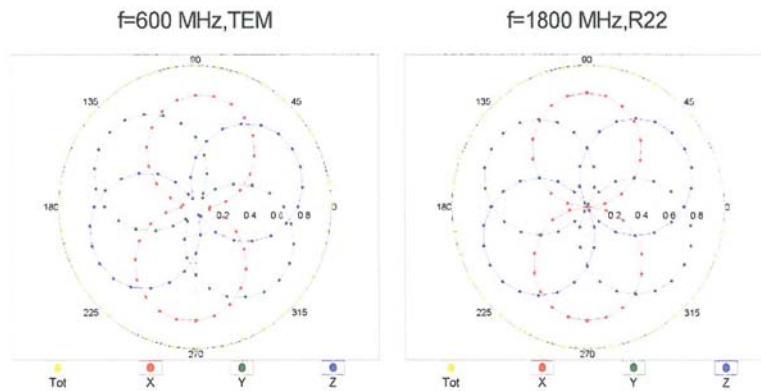
<sup>G</sup> Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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



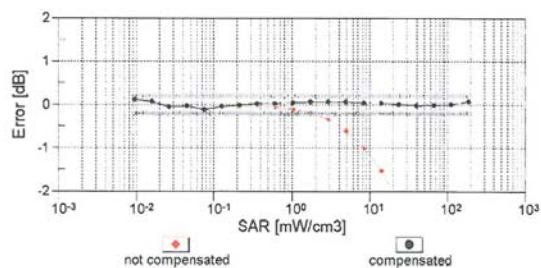
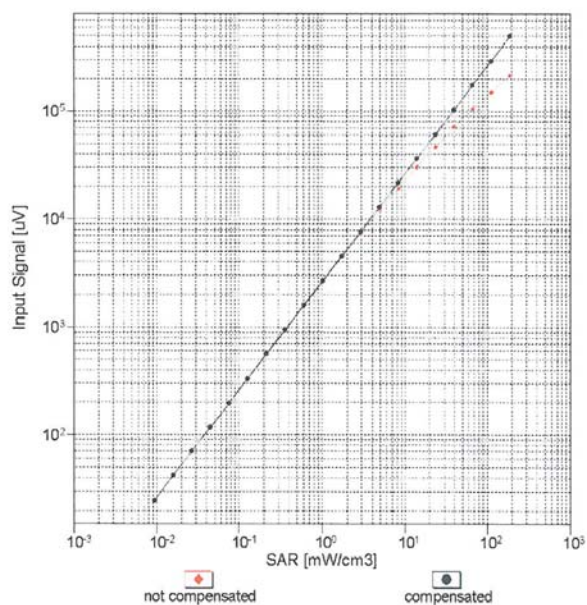
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

### Receiving Pattern ( $\phi$ ), $\theta = 0^\circ$



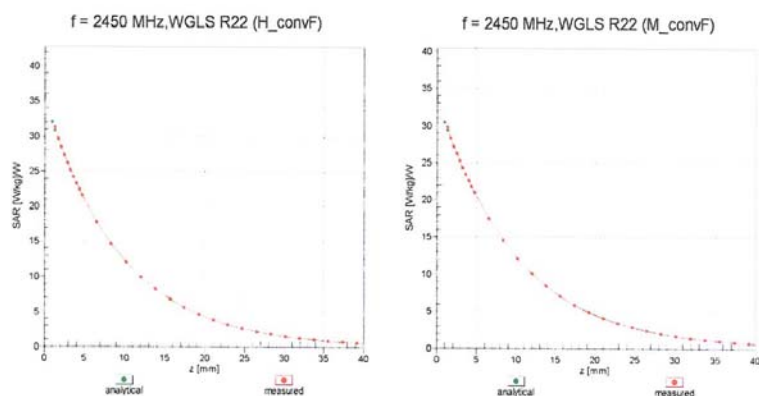
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

### Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell , $f_{\text{eval}} = 1900 \text{ MHz}$ )



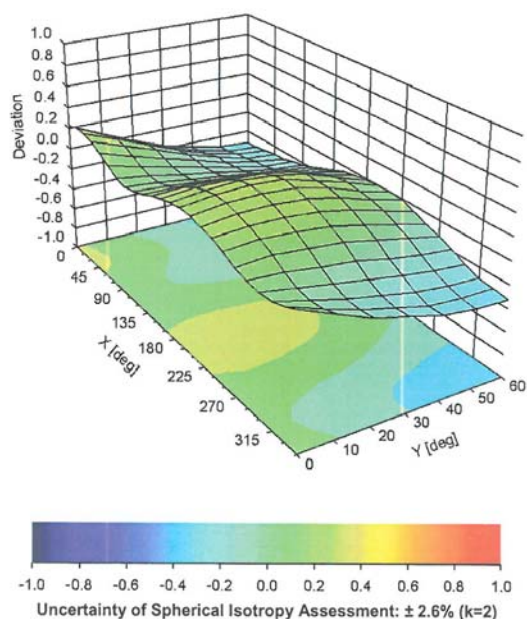
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

Error ( $\phi$ ,  $\theta$ ), f = 900 MHz



**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3882****Other Probe Parameters**

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 31.4       |
| 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     |

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



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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **Estech (Dymstec)**

Certificate No: D2450V2-741\_Feb16

## CALIBRATION CERTIFICATE

Object D2450V2 - SN: 741

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

Calibration date: February 18, 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 ( $22 \pm 3$ )°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards           | ID #               | Cal Date (Certificate No.)        | Scheduled Calibration  |
|-----------------------------|--------------------|-----------------------------------|------------------------|
| Power meter EPM-442A        | GB37480704         | 07-Oct-15 (No. 217-02222)         | Oct-16                 |
| Power sensor HP 8481A       | US37292783         | 07-Oct-15 (No. 217-02222)         | Oct-16                 |
| Power sensor HP 8481A       | MY41092317         | 07-Oct-15 (No. 217-02223)         | Oct-16                 |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 01-Apr-15 (No. 217-02131)         | Mar-16                 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134)         | Mar-16                 |
| Reference Probe EX3DV4      | SN: 7349           | 31-Dec-15 (No. EX3-7349_Dec15)    | Dec-16                 |
| DAE4                        | SN: 601            | 30-Dec-15 (No. DAE4-601_Dec15)    | Dec-16                 |
| Secondary Standards         | ID #               | Check Date (in house)             | Scheduled Check        |
| RF generator R&S SMT-06     | 100972             | 15-Jun-15 (in house check Jun-15) | In house check: Jun-18 |
| Network Analyzer HP 8753E   | US37390585 S4206   | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

Calibrated by: Name Claudio Leubler Function Laboratory Technician Signature 

Approved by: Katja Pokovic Technical Manager Signature 

Issued: February 19, 2016

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

**Calibration Laboratory of**  
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**Glossary:**

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

**Calibration is Performed According to the Following Standards:**

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

- e) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

### Measurement Conditions

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

|                              |                        |             |
|------------------------------|------------------------|-------------|
| DASY Version                 | DASY5                  | V52.8.8     |
| Extrapolation                | Advanced Extrapolation |             |
| Phantom                      | Modular Flat Phantom   |             |
| Distance Dipole Center - TSL | 10 mm                  | with Spacer |
| Zoom Scan Resolution         | dx, dy, dz = 5 mm      |             |
| Frequency                    | 2450 MHz $\pm$ 1 MHz   |             |

### Head TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Head TSL parameters             | 22.0 °C             | 39.2           | 1.80 mho/m           |
| Measured Head TSL parameters            | (22.0 $\pm$ 0.2) °C | 38.7 $\pm$ 6 % | 1.84 mho/m $\pm$ 6 % |
| Head TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

### SAR result with Head TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 12.9 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 50.9 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 6.01 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 23.9 W/kg $\pm$ 16.5 % (k=2) |

### Body TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Body TSL parameters             | 22.0 °C             | 52.7           | 1.95 mho/m           |
| Measured Body TSL parameters            | (22.0 $\pm$ 0.2) °C | 52.9 $\pm$ 6 % | 2.00 mho/m $\pm$ 6 % |
| Body TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

### SAR result with Body TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 12.5 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 49.4 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 5.86 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 23.3 W/kg $\pm$ 16.5 % (k=2) |

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

### Antenna Parameters with Head TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 53.5 $\Omega$ + 5.4 j $\Omega$ |
| Return Loss                          | - 24.1 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 52.4 $\Omega$ + 7.1 j $\Omega$ |
| Return Loss                          | - 22.8 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.160 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 | December 01, 2003 |

## DASY5 Validation Report for Head TSL

Date: 18.02.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 741**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.84$  S/m;  $\epsilon_r = 38.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.76, 7.76, 7.76); 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/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

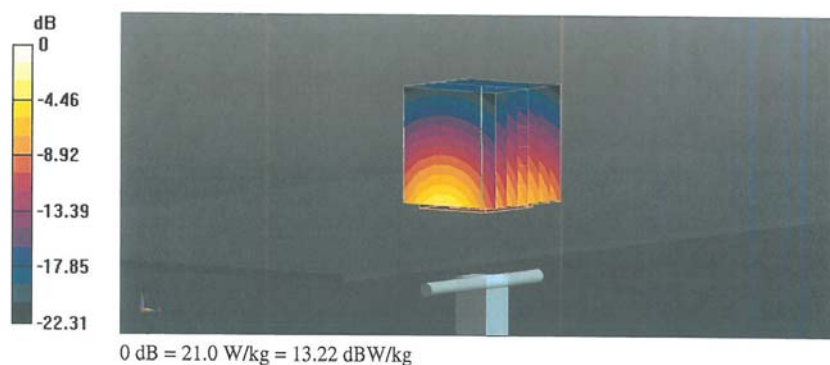
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 112.2 V/m; Power Drift = 0.05 dB

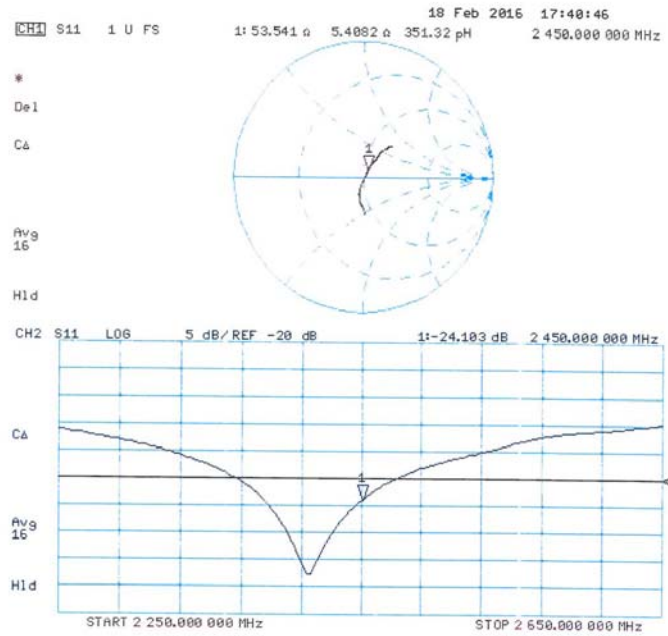
Peak SAR (extrapolated) = 25.9 W/kg

**SAR(1 g) = 12.9 W/kg; SAR(10 g) = 6.01 W/kg**

Maximum value of SAR (measured) = 21.0 W/kg



# Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 18.02.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 741**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2$  S/m;  $\epsilon_r = 52.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); 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=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

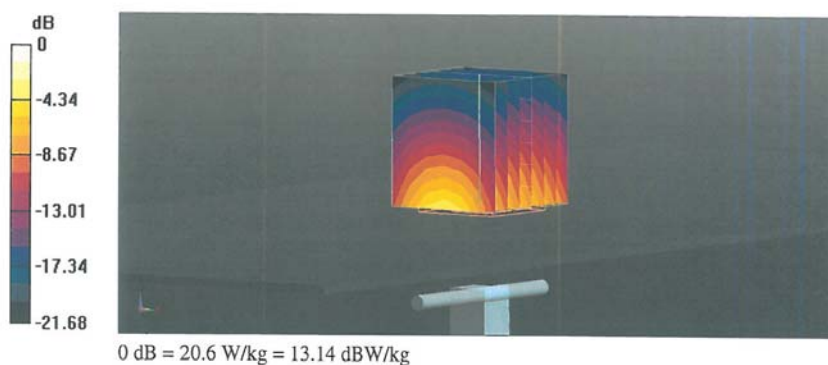
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 105.6 V/m; Power Drift = -0.02 dB

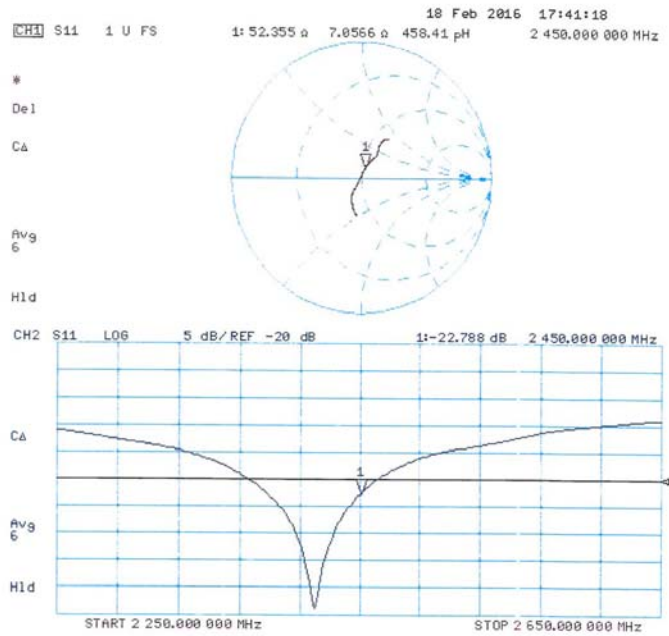
Peak SAR (extrapolated) = 24.9 W/kg

**SAR(1 g) = 12.5 W/kg; SAR(10 g) = 5.86 W/kg**

Maximum value of SAR (measured) = 20.6 W/kg



Impedance Measurement Plot for Body TSL



## APPENDIX E : Test Setup Photo

Front



Back



Top



Bottom



Right



Left



## APPENDIX F : EUT Photo

Front



Back



Top



Bottom



Right



Left

