



# FCC SAR Report

**Report No.** : SESF1508132  
**Client/Manufacturer** : ELITEGROUP COMPUTER SYSTEMS CO., LTD  
**Address** : No.239, Sec. 2, Tiding Blvd., Neihu Dist, Taipei City 14, Taiwan (R.O.C)  
**Product** : Tablet PC  
**Brand** : ECS ELITEGROUP  
**Model** : TC80RA6, TC80XXX(X=0~9,A~Z or blank)  
**FCC ID** : 2AEKR-TC80RA6  
**Standards** : FCC 47 CFR Part 2 (2.1093) / IEEE C95.1:1992 / IEEE 1528-2013 / KDB 865664 D01 v01r03 / KDB 248227 D01 v02r01 / KDB 447498 D01 v05r02 / KDB 616217 D04 v01r01 /KDB 648474 D04 v01r02  
**Test Date** : August 14<sup>th</sup>, 2015

**Statement of Compliance:**

The SAR values measured for the test sample are below the maximum recommended level of 1.6W/kg averaged over any 1g tissue according to FCC Acknowledge Data Base/ FCC 47CFR Part 2 (2.1093) / IEEE Std.1528-2013.

**The test result only corresponds to the tested sample. It is not permitted to copy this report, in part or in full, without the permission of the test laboratory.**

The testing described in this report has been carried out to the best of our knowledge and ability, and our responsibility is limited to the exercise of reasonable care. This certification is not intended to relieve the sellers from their legal and/or contractual obligations.

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## Release Version

| Report No.  | Issue Date | Description     |
|-------------|------------|-----------------|
| SESF1507176 | 2015-08-18 | Initial release |
|             |            |                 |
|             |            |                 |



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## 1. Summary of Maximum SAR Value

| Equipment Class          | Highest Reported SAR <sub>1-g</sub> (W/kg) |
|--------------------------|--|
| DTS                      | 1.34                                       |
| DSS                      | 0.4  |
| Highest Simultaneous SAR |  |
| DTS+DSS                  | 1.58                                       |



## 2. Description of Equipment under Test

|                                |  |
|--------------------------------|--|
| <b>Product Name</b>            | Tablet PC  |
| <b>Model No.</b>               | TC80RA6, TC80XXX(X=0~9,A~Z or blank)   |
| <b>Brand Name</b>              | ECS ELITEGROUP   |
| <b>Product Type</b>            | WLAN 1TX   |
| <b>Antenna Type</b>            | Internal   |
| <b>Device Category</b>         | Portable   |
| <b>RF Exposure Environment</b> | Uncontrolled   |
| <b>Bluetooth</b>               |  |
| <b>Bluetooth Frequency</b>     | 2402~2480MHz   |
| <b>Data Rate</b>               | 1 Mbps, 2Mbps and Up to 3Mbps  |
| <b>Channel Separation</b>      | 1MHz for BT3.0, 2MHz for BLE   |
| <b>Modulation technology</b>   | BLE4.0 (GFSK), V3.0+EDR(GFSK), V3.0+EDR(8-DPSK)  |
| <b>Wi-Fi</b>                   |  |
| <b>Modulation Techniques:</b>  | <b>802.11b:</b><br>CCK, DQPSK, DBPSK<br><b>802.11g:</b><br>64QAM, 16QAM, QPSK, BPSK<br><b>802.11n:</b><br>BPSK, QPSK, 16QAM, 64QAM   |
| <b>Data Rate</b>               | 802.11b: 11, 5.5, 2, 1 Mbps<br>802.11g: 54, 48, 36, 24, 18, 12, 9, 6 Mbps<br>802.11n: MCS 0 to 7 for HT20MHz, MCS 0 to 7 for HT40MHz |
| <b>Wi-Fi Frequency</b>         | <b>For 15.247:</b> 2.4GHz: 2.412 ~ 2.462GHz  |
| <b>Modulation Technology</b>   | <b>For 15.247(2.4GHz):</b><br>802.11b, 802.11g, 802.11n  |



### **3. General Information**

Our Lab,

|                    |  |
|--------------------|--|
| Test Site          | Cerpass Technology (Suzhou) Co.,Ltd                                  |
| Test Site Location | No.66,Tangzhuang Road, Suzhou Industrial Park, Jiangsu 215006, China |



## 4. Basic restrictions and Standards

### 4.1. Test Standards

1. IEEE 1528-2013
2. FCC KDB Publication 447498 D01 General RF Exposure Guidance v05r02
3. FCC KDB Publication 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r03
4. FCC KDB Publication 616217 D04 SAR for laptop and tablets v01r01
5. FCC KDB Publication 248227 D01 802.11 Wi-Fi SAR v02r01
6. FCC KDB Publication 648474 D04, Handset SAR v01r02

### 4.2. Environment Condition

| Item                        | Target | Measured |
|-----------------------------|--------|----------|
| Ambient Temperature(°C)     | 18~25  | 21.5±2   |
| Temperature of Simulant(°C) | 20~22  | 21±2     |
| Relative Humidity(%RH)      | 30~70  | 52       |

### 4.3. RF Exposure Limits

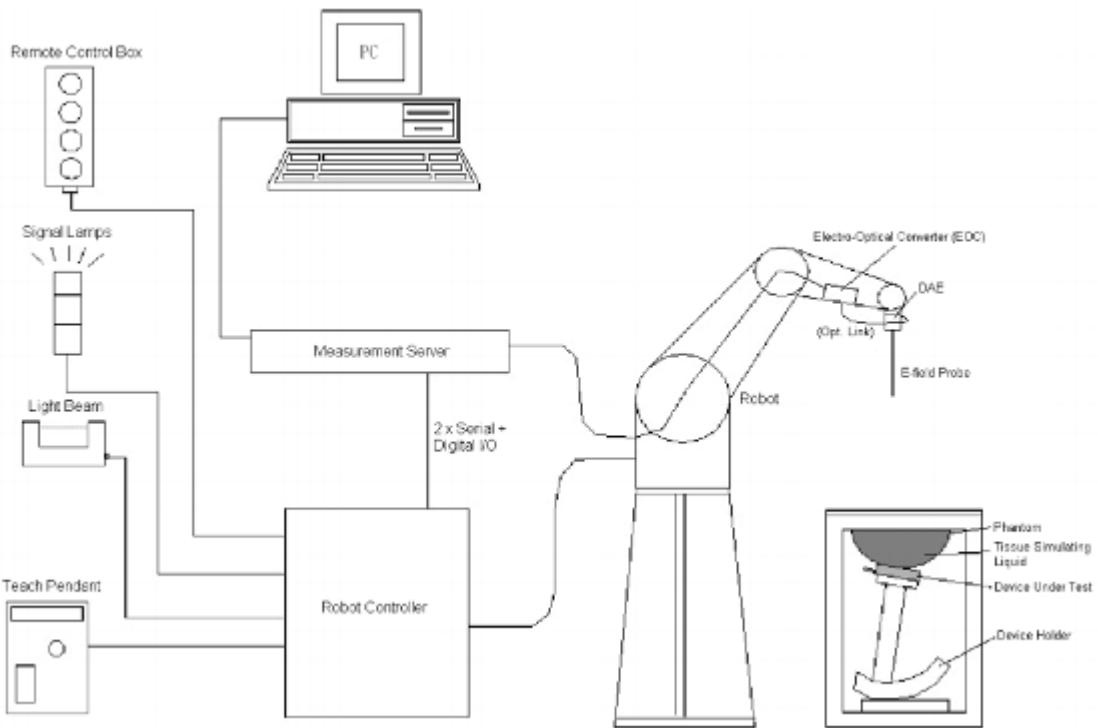
| Human Exposure                                | Basic restrictions for electric, magnetic and electromagnetic fields. (Unit in mW/g or W/kg) |
|---|--|
| Spatial Peak SAR <sup>1</sup> (Head and Body) | 1.60   |
| Spatial Average SAR <sup>2</sup> (Whole Body) | 0.08   |
| Spatial Peak SAR <sup>3</sup> (Arms and Legs) | 4.00   |

#### Notes:

1. The Spatial Peak value of the SAR averaged over any 1gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.
2. The Spatial Average value of the SAR averaged over the whole body.
3. The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over appropriate averaging time.

## 5. DASY5 Measurement System

### DASY5 Measurement System



**Figure 2.1 SPEAG DASY5 System Configurations**

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

- A standard high precision 6-axis robot with controller, a teach pendant and software
- A data acquisition electronic(DAE)attached to the robot arm extension
- A dosimetric probe equipped with an optical surface detector system
- The electro-optical converter(ECO)performs the conversion between optical and electrical signals
- A measurement server performs the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the accuracy of the probe positioning
- A computer operating Windows 7
- DASY5 software
- Remove control with teach pendant additional circuitry for robot safety such as warming lamps, etc.
- The SAM twin phantom
- A device holder
- Tissue simulating liquid
- Dipole for evaluating the proper functioning of the system



### 5.1. Uncertainty of Inter-/Extrapolation and Averaging

In order to evaluate the uncertainty of the interpolation, extrapolation and averaged SAR calculation algorithms of the Postprocessor, DASY5 allows the generation of measurement grids which are artificially predefined by analytically based test functions. Therefore, the grids of area scans and zoom scans can be filled with uncertainty test data, according to the SAR benchmark functions of IEEE 1528. The three analytical functions shown in equations as below are used to describe the possible range of the expected SAR distributions for the tested handsets. The field gradients are covered by the spatially flat distribution  $f_1$ , the spatially steep distribution  $f_3$  and  $f_2$  accounts for H-field cancellation on the phantom/tissue surface.

$$f_1(x, y, z) = Ae^{-\frac{z}{2a}} \cos^2 \left( \frac{\pi}{2} \frac{\sqrt{x'^2 + y'^2}}{5a} \right)$$
$$f_2(x, y, z) = Ae^{-\frac{z}{a}} \frac{a^2}{a^2 + x'^2} \left( 3 - e^{-\frac{2z}{a}} \right) \cos^2 \left( \frac{\pi}{2} \frac{y'}{3a} \right)$$
$$f_3(x, y, z) = A \frac{a^2}{\frac{a^2}{4} + x'^2 + y'^2} \left( e^{-\frac{2z}{a}} + \frac{a^2}{2(a + 2z)^2} \right)$$

### 5.2. DASY5 E-Field Probe

The SAR measurement is conducted with the dosimetric probe manufactured by SPEAG. The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency.

SPEAG conducts the probe calibration in compliance with international and national standards (e.g. IEEE 1528, EN 62209-1, IEC 62209, etc.) under ISO 17025. The calibration data are in Appendix D.

|                      |  |
|----------------------|--|
| <b>Model</b>         | EX3DV4   |
| <b>Construction</b>  | Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)  |
| <b>Frequency</b>     | 10 MHz to 6 GHz<br>Linearity: $\pm 0.2$ dB (30 MHz to 6 GHz)   |
| <b>Directivity</b>   | $\pm 0.3$ dB in HSL (rotation around probe axis)<br>$\pm 0.5$ dB in tissue material (rotation normal to probe axis)  |
| <b>Dynamic Range</b> | 10 $\mu$ W/g to 100 mW/g<br>Linearity: $\pm 0.2$ dB (noise: typically $< 1 \mu$ W/g)   |
| <b>Dimensions</b>    | Overall length: 330 mm (Tip: 20 mm)<br>Tip diameter: 2.5 mm (Body: 12 mm)<br>Typical distance from probe tip to dipole centers: 1 mm   |
| <b>Application</b>   | High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%. |

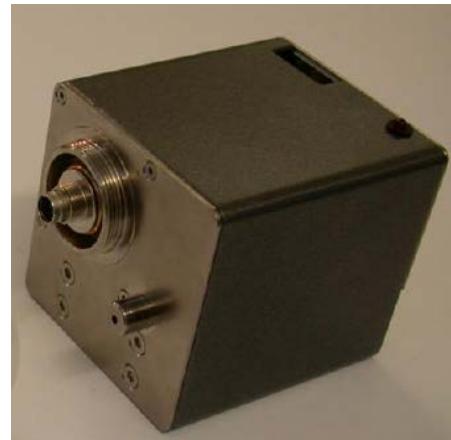


### 5.3. Data Acquisition Electronics (DAE)

The data acquisition electronics (DAE) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit.

Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock.

The input impedance of the DAE4 is 200M Ohm; the inputs are symmetrical and floating. Common mode rejection is above 80dB.



### 5.4. Robot

The DASY5 system uses the high precision robots TX90 XL type out of the newer series from Stäubli SA (France). For the 6-axis controller DASY5 system, the CS8C robot controller version from Stäubli is used.

The XL robot series have many features that are important for our application:

- High precision (repeatability 0.02 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)
- 6-axis controller



### 5.5. Light Beam Unit

The light beam switch allows automatic "tooling" of the probe. During the process, the actual position of the probe tip with respect to the robot arm is measured, as well as the probe length and the horizontal probe offset. The software then corrects all movements, such that the robot coordinates are valid for the probe tip.

The repeatability of this process is better than 0.1 mm. If a position has been taught with an aligned probe, the same position will be reached with another aligned probe within 0.1 mm, even if the other probe has different dimensions. During probe rotations, the probe tip will keep its actual position.





## 5.6. Measurement Server

The DASY5 measurement server is based on a PC/104 CPU board with a 400MHz intel ULV Celeron, 128MB chipdisk and 128MB RAM. The necessary circuits for communication with the DAE electronics box, as well as the 16 bit AD converter system for optical detection and digital I/O interface are contained on the DASY5 I/O board, which is directly connected to the PC/104 bus of the CPU board.



## 5.7. SAM Phantom

The SAM twin phantom is a fiberglass shell phantom with 2mm shell thickness (except the ear region where shell thickness increases to 6mm). It has three measurement areas:

- Left head
- Right head
- Flat phantom



The ELI4 Phantom also is a fiberglass shell phantom with 2mm shell thickness. It has 30 liters filling volume, and with a dimension of 600mm for major ellipse axis, 400mm for minor axis. It is intended for compliance testing of handheld and body-mounted wireless devices in frequency range of 30 MHz to 6GHz. ELI4 is fully compatible with standard and all known tissue simulating liquids.



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

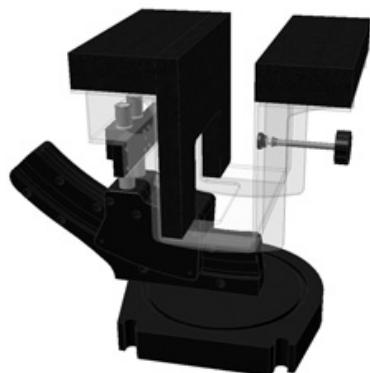


## 5.8. Device Holder

The DASY5 device holder is designed to cope with different positions given in the standard. It has two scales for the device rotation (with respect to the body axis) and the device inclination (with respect to the line between the ear reference points). The rotation center for both scales is the ear reference point (EPR). Thus the device needs no repositioning when changing the angles. The DASY5 device holder has been made out of low-loss POM material having the following dielectric parameters: relative permittivity  $\epsilon_r = 3$  and loss tangent  $\delta = 0.02$ . The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.



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





### 5.9. Test Equipment List

| Instrument                  | Manufacturer | Model No.            | Serial No.     | Cali. Due Date |
|-----------------------------|--------------|----------------------|----------------|----------------|
| Stäubli Robot TX60L         | Stäubli      | TX60L                | 5P6VA1/A/01    | only once      |
| Robot Controller            | Stäubli      | CS8C                 | 5P6VA1/C/01    | only once      |
| Dipole Validation Kits      | Speag        | D2450V2              | 914            | 2017.05.18     |
| SAM ELI Phantom             | Speag        | SAM                  | 1211           | N/A            |
| Laptop Holder               | Speag        | SM LH1 001CD         | N/A            | N/A            |
| Data Acquisition Electronic | Speag        | DAE4                 | 1379           | 2016.05.19     |
| E-Field Probe               | Speag        | EX3DV4               | 3927           | 2016.05.26     |
| SAR Software                | Speag        | DASY5                | V5.2 Build 162 | N/A            |
| Power Amplifier             | Mini-Circuit | ZVA-183W-S+          | MN136701248    | 2016.09.02     |
| Directional Coupler         | Agilent      | 772D                 | MY52180104     | 2016.09.02     |
| Spectrum Analyzer           | R&S          | FSP40                | 100324         | 2016.03.22     |
| Vector Network              | Agilent      | E5071C               | MY4631693      | 2016.01.14     |
| Signal Generator            | R&S          | SML                  | 103287         | 2016.03.08     |
| Power Meter                 | BONN         | BLWA0830-160/100/40D | 76659          | 2015.11.10     |
| AUG Power Sensor            | R&S          | NRP-Z91              | 100384         | 2016.03.08     |



## 6. The SAR Measurement Procedure

### 6.1. System Performance Check

#### 6.1.1 Purpose

1. To verify the simulating liquids are valid for testing.
2. To verify the performance of testing system is valid for testing.

#### 6.1.2 Tissue Dielectric Parameters for Head and Body Phantoms

| Target Frequency<br>(MHz) | Head         |                | Body         |                |
|---------------------------|--------------|----------------|--------------|----------------|
|                           | $\epsilon_r$ | $\sigma$ (S/m) | $\epsilon_r$ | $\sigma$ (S/m) |
| 150                       | 52.3         | 0.76           | 61.9         | 0.80           |
| 300                       | 45.3         | 0.87           | 58.2         | 0.92           |
| 450                       | 43.5         | 0.87           | 56.7         | 0.94           |
| 835                       | 41.5         | 0.90           | 55.2         | 0.97           |
| 850                       | 41.5         | 0.92           | 55.2         | 0.99           |
| 900                       | 41.5         | 0.97           | 55.0         | 1.05           |
| 915                       | 41.5         | 0.98           | 55.0         | 1.06           |
| 1450                      | 40.5         | 1.20           | 54.0         | 1.30           |
| 1610                      | 40.3         | 1.29           | 53.8         | 1.40           |
| 1800 – 2000               | 40.0         | 1.40           | 53.3         | 1.52           |
| <b>2450</b>               | <b>39.2</b>  | <b>1.80</b>    | <b>52.7</b>  | <b>1.95</b>    |
| 3000                      | 38.5         | 2.40           | 52.0         | 2.73           |
| 5200                      | 36.0         | 4.66           | 49.0         | 5.30           |
| 5300                      | 35.87        | 4.76           | 48.88        | 5.42           |
| 5600                      | 35.5         | 5.07           | 48.5         | 5.77           |
| 5800                      | 35.3         | 5.27           | 48.2         | 6.00           |

( $\epsilon_r$  = relative permittivity,  $\sigma$  = conductivity and  $\rho = 1000 \text{ kg/m}^3$ )



### 6.1.3 Tissue Calibration Result

- The dielectric parameters of the liquids were verified prior to the SAR evaluation using DASY5 Dielectric Assessment Kit and Agilent Vector Network Analyzer E5071C.

| Tissue parameter for body |              |              |                     |                     |                     |                      |                       |
|---------------------------|--------------|--------------|---------------------|---------------------|---------------------|----------------------|-----------------------|
| Fre. <MHz>                | Permittivity | Conductivity | Target Permittivity | Target Conductivity | Delta Permittivity% | Delta Conductivity % | Tissue Temperature °C |
| 14-08-2015                |              |              |                     |                     |                     |                      |                       |
| 2450                      | 52.47        | 1.96         | 52.70               | 1.95                | 0.00                | 0.01                 | 21.0                  |
| 2412                      | 52.57        | 1.93         | 52.70               | 1.90                | 0.00                | 0.02                 | 21.0                  |
| 2437                      | 52.51        | 1.95         | 52.70               | 1.93                | 0.00                | 0.01                 | 21.0                  |
| 2462                      | 52.43        | 1.97         | 52.70               | 1.97                | -0.01               | 0.00                 | 21.0                  |

- Refer to KDB 865664 D01 v01r03, The depth of body tissue-equivalent liquid in a phantom must be  $\geq 15.0$  cm with  $\leq \pm 0.5$  cm variation for SAR measurements  $\leq 3$  GHz and  $\geq 10.0$  cm with  $\leq \pm 0.5$  cm variation for measurements  $> 3$  GHz.

### 6.1.4 System Performance Check Procedure

The DASY5 installation includes predefined files with recommended procedures for measurements and the system performance check. They are read-only document files and destined as fully defined but unmeasured masks, so the finished system performance check must be saved under a different name. The system performance check document requires the SAM Twin Phantom or ELI4 Phantom, so the phantom must be properly installed in your system. (User defined measurement procedures can be created by opening a new document or editing an existing document file). Before you start the system performance check, you need only to tell the system with which components (probe, medium, and device) you are performing the system performance check; the system will take care of all parameters.

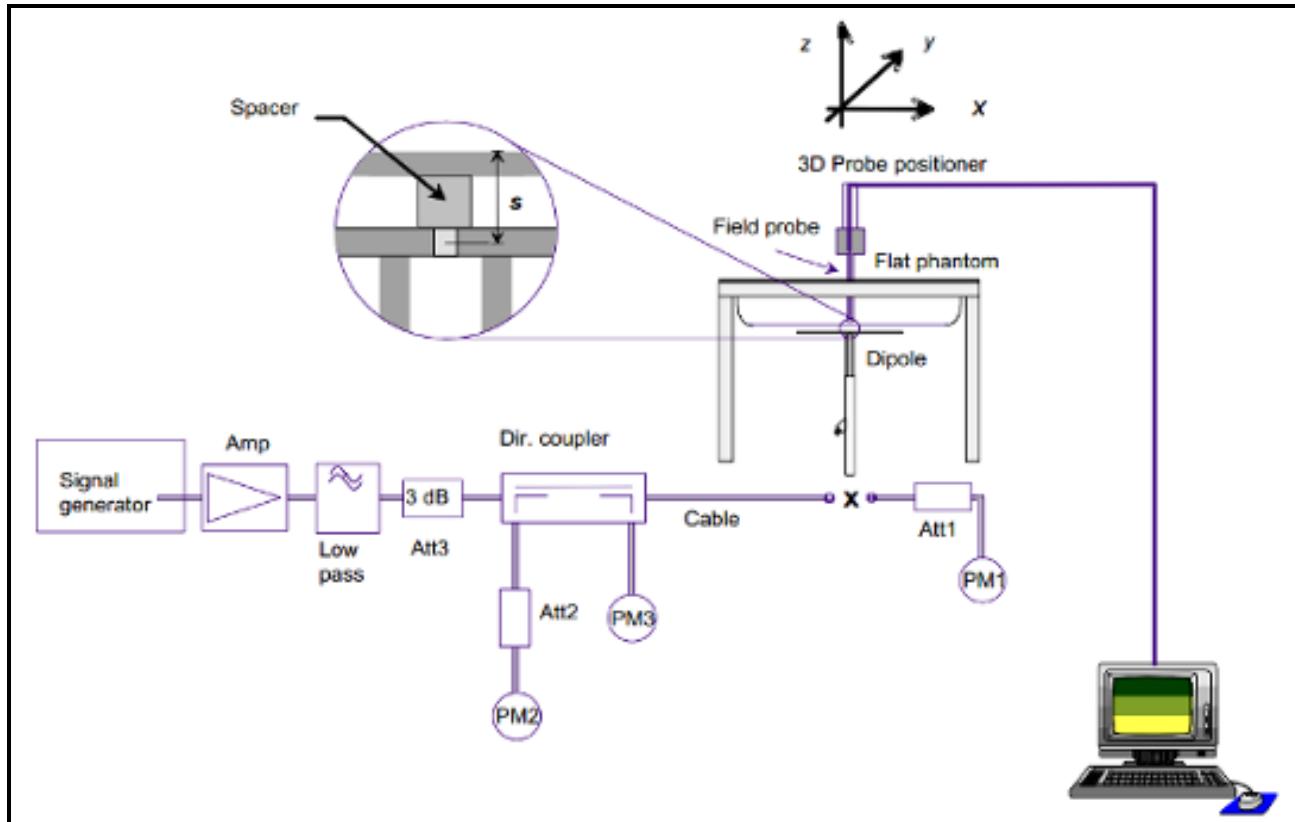
■ **The Power Reference Measurement and Power Drift Measurement** jobs are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure. The indicated drift is mainly the variation of the Dipole output power. If it is too high (above  $\pm 0.2$  dB), the system performance check should be repeated;

■ **The Surface Check** job tests the optical surface detection system of the DASY5 system by repeatedly detecting the surface with the optical and mechanical surface detector and comparing the results. The output gives the detecting heights of both systems, the difference between the two systems and the standard deviation of the detection repeatability. Air bubbles or refraction in the liquid due to separation of the sugar-water mixture gives poor repeatability (above  $\pm 0.1$ mm). In that case it is better to abort the system performance check and stir the liquid;

■ **The Area Scan** job measures the SAR above the dipole on a plane parallel to the surface. It is used to locate the approximate location of the peak SAR. The proposed scan uses large grid spacing for faster measurement; due to the symmetric field, the peak detection is reliable;

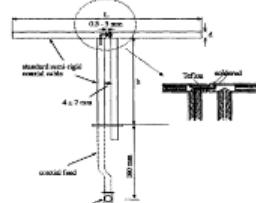
■ **The Zoom Scan** job measures the field in a volume around the peak SAR value assessed in the previous Area Scan job (for more information see the application note on SAR evaluation). If the system performance check gives reasonable results. The dipole input power(forward power) was 250mW, 1 g and 10 g spatial average SAR values normalized to 1W dipole input power give reference data for comparisons and it's equal to 10x(dipole forward power). The next sections analyze the expected uncertainties of these values, as well as additional checks for further information or troubleshooting.

### 6.1.5 System Performance Check Setup



### 6.1.6 Validation Dipoles

The dipoles use is based on the IEEE Std.1528-2013 and FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r03standard, and is complied with mechanical and electrical specifications in line with the requirements of both EN62209-1 and EN62209-2. The table below provides details for the mechanical and electrical specifications for the dipoles.





### **6.1.7 Result of System Performance Check: Valid Result**

#### **System Performance Check at 2450MHz for Body.**

##### **Validation Dipole: D2450V2-SN 914**

| Frequency [MHz] | Description                      | SAR [w/kg]<br>1g       | SAR [w/kg]<br>10g      | Tissue Temp. [°C] |
|-----------------|----------------------------------|------------------------|------------------------|-------------------|
| 2450 MHz        | Reference result<br>± 10% window | 52.5<br>47.25 to 57.75 | 24.6<br>22.14 to 27.06 | 21.0              |
|                 | 14-08-2015                       | 53.6                   | 24.24                  |                   |

Note: All SAR values are normalized to 1W forward power.

## **6.2. Test Requirements**

### **6.2.1 Test Procedures**

#### **Step 1 Setup a Connection**

First, engineer should record the conducted power before the test. Then establish a call in handset at the maximum power level with a base station simulator via air interface, or make the EUT estimate by itself in testing band. Place the EUT to the specific test location. After the testing, must export SAR test data by SEMCAD. Then writing down the conducted power of the EUT into the report, also the SAR values tested.

#### **Step 2 Power Reference Measurements**

To measure the local E-field value at a fixed location which value will be taken as a reference value for calculating a possible power drift.

#### **Step 3 Area Scan**

The Area Scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maximal found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE Standard 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan). If only one Zoom Scan follows the Area Scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of Zoom Scans has to be increased accordingly.

**Area Scan Parameters extracted from KDB 865664 D01v01r01**

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

**Step 4 Zoom Scan**

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

**Zoom Scan Parameters extracted from KDB 865664 D01 v01r03**

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

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

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



## Step 5 Power Drift Measurements

Repetition of the E-field measurement at the fixed location mentioned in Step 1 to make sure the two results differ by less than  $\pm 0.2$  dB.

### 6.2.2 Test Channel

Per KDB248227 D01 v02r01, channel selection procedures below apply to both the initial test configuration and subsequent test configuration(s):

- 1) 802.11a is chosen over 802.11n then 802.11ac or 802.11g is chosen over 802.11n.
- 2) The largest channel bandwidth configuration is selected among the multiple configurations in a frequency band with the same specified maximum output power.
- 3) If multiple configurations have the same specified maximum output power and largest channel bandwidth, the lowest order modulation among the largest channel bandwidth configurations is selected.
- 4) If multiple configurations have the same specified maximum output power, largest channel bandwidth and lowest order modulation, the lowest data rate configuration among these configurations is selected.
- 5) The same procedures also apply to subsequent highest output power channel(s) selection.
  - a> The channel closest to mid-band frequency is selected for SAR measurement.
  - b> For channels with equal separation from mid-band frequency; for example, high and low channels or two mid-band channels, the higher frequency (number) channel is selected for SAR measurement.



## 7. Wi-Fi/Bluetooth SAR Exclusion and Results

### 7.1. Maximum Tune-up Conducted Average Power

#### Wi-Fi <Unite: dBm>

| Configurations                         | Mode                      |        |         |
|--|---------------------------|--------|---------|
|  | Channel / Frequency (MHz) |        |         |
| 2.4GHz WLAN<br>Average Power<br>(Main) | 802.11b                   |        |         |
|  | 1/2412                    | 6/2437 | 11/2462 |
|  | 15.0                      | 17.0   | 14.0    |
|  | 802.11g                   |        |         |
|  | 1/2412                    | 6/2437 | 11/2462 |
|  | 16.0                      | 16.5   | 15.5    |
|  | 802.11n(HT20)             |        |         |
|  | 1/2412                    | 6/2437 | 11/2462 |
|  | 16.0                      | 16.0   | 15.5    |
|  | 802.11n(HT40)             |        |         |
| Bluetooth <Unite: dBm>                 | 3/2422                    | 6/2437 | 9/2452  |
|  | 16.0                      | 16.5   | 15.0    |

#### Bluetooth <Unite: dBm>

| Max. Bluetooth Power |       |
|----------------------|-------|
| 2480MHz GFSK         | 6.356 |

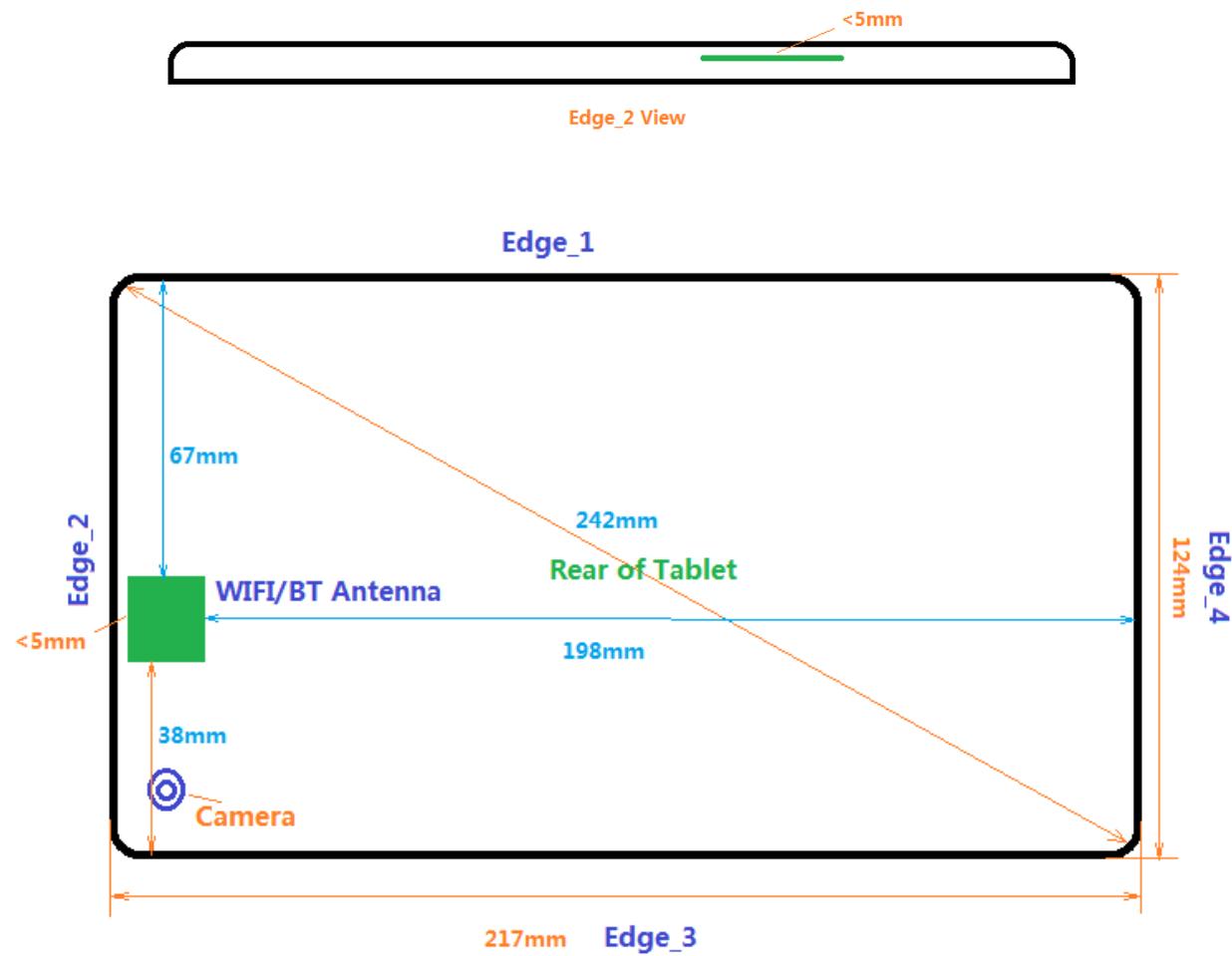
### 7.2. Measured Conducted Average Power

#### Wi-Fi <Unite: dBm>

| Configurations               | Mode                      |        |         |
|------------------------------|---------------------------|--------|---------|
|                              | Channel / Frequency (MHz) |        |         |
| 2.4GHz WLAN<br>Average Power | 802.11b                   |        |         |
|                              | 1/2412                    | 6/2437 | 11/2462 |
|                              | 14.86                     | 16.92  | 13.73   |
|                              | 802.11g                   |        |         |
|                              | 1/2412                    | 6/2437 | 11/2462 |
|                              | 15.91                     | 16.04  | 15.19   |
|                              | 802.11n(HT20)             |        |         |
|                              | 1/2412                    | 6/2437 | 11/2462 |
|                              | 15.73                     | 15.87  | 15.17   |
|                              | 802.11n(HT40)             |        |         |
| Bluetooth <Unite: dBm>       | 3/2422                    | 6/2437 | 9/2452  |
|                              | 15.84                     | 16.06  | 14.72   |



### 7.3. Antenna Location



| Antenna | Antenna Distance to Edges(mm) |        |        |        |        |
|---------|-------------------------------|--------|--------|--------|--------|
|         | Back                          | Edge_1 | Edge_2 | Edge_3 | Edge_4 |
| WIFI/BT | <5                            | 67     | <5     | 38     | 198    |



#### 7.4. SAR exclusion

Per FCC KDB 447498 D01v05r02 for 100MHz~6GHz:

1) The 1g-SAR exclusion threshold for distances<50mm is defined by the following equation:

$$\frac{\text{Max Power of Channel}(mW)}{\text{Test Separation Distance}(mm)} \times \sqrt{\text{Frequency}(GHz)} \leq 3.0$$

##### 5mm Test Separation

| Test Mode     | Frq.(MHz) | Test Separations | Thresholds (mW) | Max. Tune-up Power(dBm) | Max. Tune-up Power(mW) | SAR Test(Y/N) |
|---------------|-----------|------------------|-----------------|-------------------------|------------------------|---------------|
| Bluetooth     | 2480      | 5                | 10              | 6.356                   | 4                      | N             |
| 802.11b       | 2437      | 5                | 10              | 17                      | 50                     | Y             |
| 802.11g       | 2437      | 5                | 10              | 16.5                    | 45                     | Y             |
| 802.11n(HT20) | 2437      | 5                | 10              | 16                      | 40                     | Y             |
| 802.11n(HT40) | 2437      | 5                | 10              | 16.5                    | 45                     | Y             |

##### 38mm Test Separation

| Test Mode     | Frq.(MHz) | Test Separations | Thresholds (mW) | Max. Tune-up Power(dBm) | Max. Tune-up Power(mW) | SAR Test(Y/N) |
|---------------|-----------|------------------|-----------------|-------------------------|------------------------|---------------|
| Bluetooth     | 2480      | 38               | 72              | 6.356                   | 4                      | N             |
| 802.11b       | 2437      | 38               | 73              | 17                      | 50                     | N             |
| 802.11g       | 2437      | 38               | 73              | 16.5                    | 45                     | N             |
| 802.11n(HT20) | 2437      | 38               | 73              | 16                      | 40                     | N             |
| 802.11n(HT40) | 2437      | 38               | 73              | 16.5                    | 45                     | N             |

2) At test separation distances > 50 mm, the SAR test exclusion threshold is determined according to the following:

- [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50mm)·(f (MHz)/150)] mW, at 100 MHz to 1500 MHz
- [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm)·10] mW at > 1500 MHz and ≤ 6 GHz

##### 67mm Test Separation

| Test Mode     | Frq.(MHz) | Test Separations | Thresholds (mW) | Max. Tune-up Power(dBm) | Max. Tune-up Power(mW) | SAR Test(Y/N) |
|---------------|-----------|------------------|-----------------|-------------------------|------------------------|---------------|
| Bluetooth     | 2480      | 67               | 265             | 6.356                   | 4                      | N             |
| 802.11b       | 2437      | 67               | 266             | 17                      | 50                     | N             |
| 802.11g       | 2437      | 67               | 266             | 16.5                    | 45                     | N             |
| 802.11n(HT20) | 2437      | 67               | 266             | 16                      | 40                     | N             |
| 802.11n(HT40) | 2437      | 67               | 266             | 16.5                    | 45                     | N             |

##### 198mm Test Separation

| Test Mode     | Frq.(MHz) | Test Separations | Thresholds (mW) | Max. Tune-up Power(dBm) | Max. Tune-up Power(mW) | SAR Test(Y/N) |
|---------------|-----------|------------------|-----------------|-------------------------|------------------------|---------------|
| Bluetooth     | 2480      | 198              | 1575            | 6.356                   | 4                      | N             |
| 802.11b       | 2437      | 198              | 1576            | 17                      | 50                     | N             |
| 802.11g       | 2437      | 198              | 1576            | 16.5                    | 45                     | N             |
| 802.11n(HT20) | 2437      | 198              | 1576            | 16                      | 40                     | N             |
| 802.11n(HT40) | 2437      | 198              | 1576            | 16.5                    | 45                     | N             |



## 7.5. Required Edges for SAR Testing

| Mode          | Back | Edge_1 | Edge_2 | Edge_3 | Edge_4 |
|---------------|------|--------|--------|--------|--------|
| BT(GFSK)      | NO   | NO     | NO     | NO     | NO     |
| 802.11b       | YES  | NO     | YES    | NO     | NO     |
| 802.11g       | YES  | NO     | YES    | NO     | NO     |
| 802.11n(HT20) | YES  | NO     | YES    | NO     | NO     |
| 802.11n(HT40) | YES  | NO     | YES    | NO     | NO     |

Note: According to KDB 248227 D01 v02r01, SAR configuration may be reduced.

## 7.6. Estimated SAR

This device contains transmitters that may operate simultaneously. Therefore simultaneous transmission analysis is required. Per FCC KDB 447498 D01v05r02, simultaneous transmission SAR test exclusion may be applied when the sum of the 1-g SAR for all the simultaneous transmitting antennas in a specific physical test configuration is  $\leq 1.6\text{W/kg}$ . When standalone SAR is not required to be measured, per FCC KDB 447498 D01v05r02 4.3.2 2, the following equation must be used to estimate the standalone 1g SAR for simultaneous transmission assessment involving that transmitter.

$$\text{Estimated SAR} = \frac{\sqrt{f(\text{GHz})} * (\text{Max Power of channel, mW})}{7.5 \text{ Min. Separation, mm}}$$

### WIFI/ Bluetooth

| Test Position | Test Mode | Frq.(MHz) | Test Separations | Max. Tune-up Power(dBm) | Max. Tune-up Power(mW) | Estimated SAR(W/kg) |
|---------------|-----------|-----------|------------------|-------------------------|------------------------|---------------------|
| Back/Edge_2   | Bluetooth | 2480      | 5                | 5.636                   | 4                      | 0.24                |
| Edge_3        | Bluetooth | 2480      | 38               | 5.636                   | 4                      | 0.03                |
| Edge_1        | Bluetooth | 2480      | 67               | 5.636                   | 4                      | 0.02                |
| Edge_4        | Bluetooth | 2480      | 198              | 5.636                   | 4                      | 0.01                |
| Edge_3        | 802.11b   | 2437      | 38               | 17                      | 50                     | 0.09                |
| Edge_1        | 802.11b   | 2437      | 67               | 17                      | 50                     | 0.05                |
| Edge_4        | 802.11b   | 2437      | 198              | 17                      | 50                     | 0.02                |
| Edge_3        | 802.11g/n | 2437      | 38               | 16.5                    | 45                     | 0.09                |
| Edge_1        | 802.11g/n | 2437      | 67               | 16.5                    | 45                     | 0.05                |
| Edge_4        | 802.11g/n | 2437      | 198              | 16.5                    | 45                     | 0.02                |



## 7.7. SAR Test Results Summary

### ■ DTS\_WLAN 2.4GHz

| Plot No. | Band    | Mode | Test Position | Dist. mm | Ch. | Fre. | Max. Tune-up Power(dBm) | Measured Conducted Power (dBm) | Scaling Factor | Power Drift(dB) | Measured SAR-1g (W/kg) | Scaled SAR-1g (W/kg) |
|----------|---------|------|---------------|----------|-----|------|-------------------------|--------------------------------|----------------|-----------------|------------------------|----------------------|
| 01       | 802.11b | CCK  | Back          | 0        | 1   | 2412 | 15.0                    | 14.86                          | 1.01           | -0.11           | 0.761                  | 0.768                |
|          | 802.11b | CCK  | Back          | 0        | 6   | 2437 | 17.0                    | 16.92                          | 1.00           | 0.02            | 1.33                   | <b>1.34</b>          |
|          | 802.11b | CCK  | Back*         | 0        | 6   | 2437 | 17.0                    | 16.92                          | 1.00           | 0.07            | 1.31                   | 1.32                 |
|          | 802.11b | CCK  | Back          | 0        | 11  | 2462 | 14.0                    | 13.73                          | 1.02           | -0.11           | 0.536                  | 0.547                |
|          | 802.11b | CCK  | Edge_2        | 0        | 6   | 2437 | 17.0                    | 16.92                          | 1.00           | -0.03           | 0.871                  | 0.875                |

**Note:**

1. Per KDB248227 D01 v02r01 section 5.2.1 2), when the reported SAR is > 0.8 W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.
2. When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, 802.11ssg/n OFDM SAR is not required, per KDB248227 D01 v02r01 section 5.2.2 2).
3. “\*\*”, Repeated SAR is required only when the measured SAR is ≥ 0.80 W/kg. If the measured SAR value of the initial repeated measurement is <1.45 W/kg with ≤20% variation, only one repeated measurement is required per KDB865664 D01 r01v03.



## 8. Simultaneous Transmission Analysis

### 8.1. Max. Simultaneous SAR

#### ■WLAN+ Bluetooth

| No. | Configurations            | Test Position | WLAN SAR(W/kg) | BT SAR(W/kg) | $\Sigma$ SAR(W/kg) |
|-----|---------------------------|---------------|----------------|--------------|--------------------|
| 1   | WLAN(DTS)<br>+<br>BT(DSS) | Body-Back     | 1.34           | 0.24         | 1.58               |
|     |                           | Body-Edge_1   | 0.4            | 0.4          | 0.8                |
|     |                           | Body-Edge_2   | 0.875          | 0.24         | 1.115              |
|     |                           | Body-Edge_3   | 0.09           | 0.03         | 0.12               |
|     |                           | Body-Edge_4   | 0.4            | 0.4          | 0.8                |

Note: An estimated SAR of 0.4 W/kg was used to determine simultaneous transmission SAR for test separate -on distances >50mm per 447498 D01v05r02.

### 8.2. Simultaneous Transmission Conclusion

The above numerical summed SAR results for all the worst-case simultaneous transmission conditions were below the SAR limit. Therefore, the above analysis is sufficient to determine that simultaneous transmission cases will not exceed the SAR limit and therefore no measured volumetric simultaneous SAR summation is required per FCC KDB Publication 447498 D01v05r02.



## 9. Measurement Uncertainty

| Error Description                    | Uncert. value | Prob. Dist. | Div.       | (ci) 1g | (ci) 10g | Std.Unc. (1g) | Std. nc. (10g) | (vi) veff |
|--------------------------------------|---------------|-------------|------------|---------|----------|---------------|----------------|-----------|
| <b>Measurement System</b>            |               |             |            |         |          |               |                |           |
| Probe Calibration                    | ±6.0%         | N           | 1          | 1       | 1        | ±6.0%         | ±6.0%          | ∞         |
| Axial Isotropy                       | ±4.7%         | R           | $\sqrt{3}$ | 0.7     | 0.7      | ±1.9%         | ±1.9%          | ∞         |
| Hemispherical Isotropy               | ±9.6%         | R           | $\sqrt{3}$ | 0.7     | 0.7      | ±3.9%         | ±3.9%          | ∞         |
| Boundary Effects                     | ±1.0%         | R           | $\sqrt{3}$ | 1       | 1        | ±0.6%         | ±0.6%          | ∞         |
| Linearity                            | ±4.7%         | R           | $\sqrt{3}$ | 1       | 1        | ±2.7%         | ±2.7%          | ∞         |
| System Detection Limits              | ±1.0%         | R           | $\sqrt{3}$ | 1       | 1        | ±0.6%         | ±0.6%          | ∞         |
| Modulation Response                  | ±2.4%         | R           | $\sqrt{3}$ | 1       | 1        | ±1.4%         | ±1.4%          | ∞         |
| Readout Electronics                  | ±0.3%         | N           | 1          | 1       | 1        | ±0.3%         | ±0.3%          | ∞         |
| Response Time                        | ±0.8%         | R           | $\sqrt{3}$ | 1       | 1        | ±0.5%         | ±0.5%          | ∞         |
| Integration Time                     | ±2.6%         | R           | $\sqrt{3}$ | 1       | 1        | ±1.5%         | ±1.5%          | ∞         |
| RF Ambient Noise                     | ±3.0%         | R           | $\sqrt{3}$ | 1       | 1        | ±1.7%         | ±1.7%          | ∞         |
| RF Ambient Reflections               | ±3.0%         | R           | $\sqrt{3}$ | 1       | 1        | ±1.7%         | ±1.7%          | ∞         |
| Probe Positioner                     | ±0.4%         | R           | $\sqrt{3}$ | 1       | 1        | ±0.2%         | ±0.2%          | ∞         |
| Probe Positioning                    | ±2.9%         | R           | $\sqrt{3}$ | 1       | 1        | ±1.7%         | ±1.7%          | ∞         |
| Max.SAR Eval.                        | ±2.0%         | R           | $\sqrt{3}$ | 1       | 1        | ±1.2%         | ±1.2%          | ∞         |
| <b>Test Sample Related</b>           |               |             |            |         |          |               |                |           |
| Device Positioning                   | ±2.9%         | N           | 1          | 1       | 1        | ±2.9%         | ±2.9%          | 145       |
| Device Holder                        | ±3.6%         | N           | 1          | 1       | 1        | ±3.6%         | ±3.6%          | 5         |
| Power Drift                          | ±5.0%         | R           | $\sqrt{3}$ | 1       | 1        | ±2.9%         | ±2.9%          | ∞         |
| Power Scalingp                       | ±0%           | R           | $\sqrt{3}$ | 0       | 0        | ±0%           | ±0%            | ∞         |
| <b>Phantom and Setup</b>             |               |             |            |         |          |               |                |           |
| Phantom Uncertainty                  | ±6.1%         | R           | $\sqrt{3}$ | 1       | 1        | ±3.5%         | ±3.5%          | ∞         |
| SAR correction                       | ±1.9%         | R           | $\sqrt{3}$ | 1       | 0.84     | ±1.1%         | ±0.9%          | ∞         |
| Liquid Conductivity (mea.)DAK        | ±2.5%         | R           | $\sqrt{3}$ | 0.78    | 0.71     | ±1.1%         | ±1.0%          | ∞         |
| Liquid Permittivity (mea.)DAK        | ±2.5%         | R           | $\sqrt{3}$ | 0.26    | 0.26     | ±0.3%         | ±0.4%          | ∞         |
| Temp. unc. – ConductivityBB          | ±3.4%         | R           | $\sqrt{3}$ | 0.78    | 0.71     | ±1.5%         | ±1.4%          | ∞         |
| Temp. unc. – PermittivityBB          | ±0.4%         | R           | $\sqrt{3}$ | 0.23    | 0.26     | ±0.1%         | ±0.1%          | ∞         |
| <b>Combined Std. Uncertainty</b>     |               |             |            |         |          | ±11.2%        | ±11.1%         | 361       |
| <b>Expanded STD Uncertainty(k=2)</b> |               |             |            |         |          | ±22.3%        | ±22.2%         |           |

DASY5 Uncertainty Budget, according to IEEE 1528/2011 and IEC 62209-1/2011(0.3-3GHz)

--END--

## **APPENDIX A. SAR System Verification Data**

The plots for system verification with largest deviation for each SAR system combination are shown as follows.

Date/Time: 14/08/2015

Test Laboratory: Cerpass Lab

SystemPerformanceCheck-D2450 Body

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

Communication System: CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.96$  S/m;  $\epsilon_r = 52.47$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section; Meas. Ambient Temp (celsius) -21°C; Input power-250mW

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

DASY Configuration:

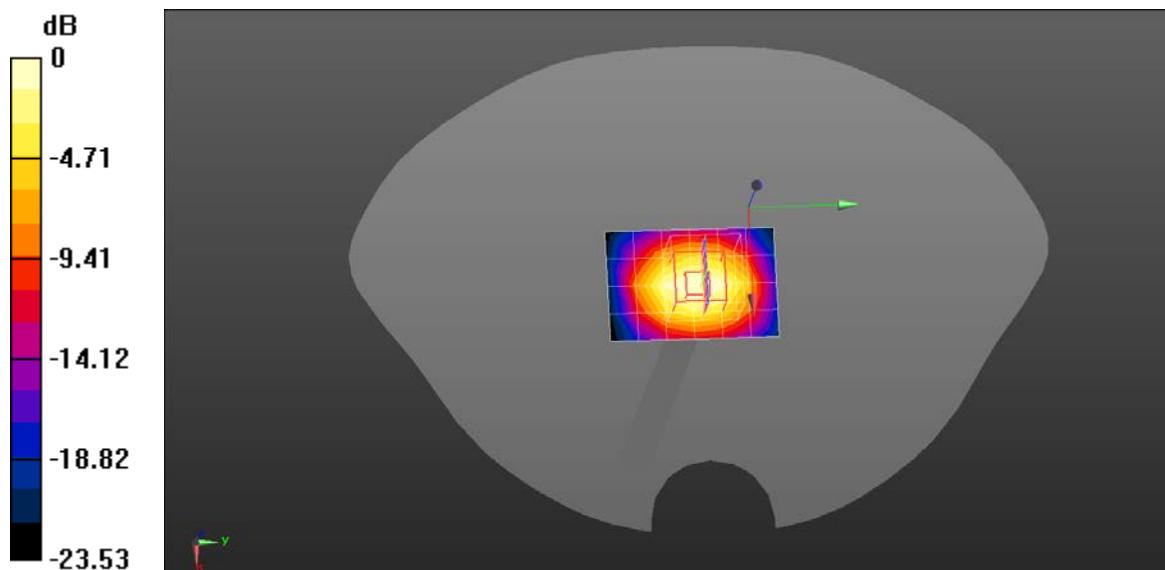
- Probe: EX3DV4 - SN3927; ConvF(7.54, 7.54, 7.54); Calibrated: 2015/5/27;
- Sensor-Surface: 3mm (Mechanical Surface Detection), Sensor-Surface: 4mm (Mechanical Surface Detection),  $z = 1.0, 31.0$
- Electronics: DAE4 Sn1379; Calibrated: 2015/5/20
- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Configuration/SystemPerformanceCheck-D2450 Body/Area Scan (5x7x1):** Measurement grid:  $dx=12$  mm,  $dy=12$  mm, Maximum value of SAR (measured) = 17.7 W/kg

**Configuration/SystemPerformanceCheck-D2450 Body/Zoom Scan (7x7x7)/Cube 0:**

Measurement grid:  $dx=5$  mm,  $dy=5$  mm,  $dz=5$  mm, Reference Value = 91.33 V/m; Power Drift = -0.02 dB, Peak SAR (extrapolated) = 29.3 W/kg

**SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.06 W/kg** Maximum value of SAR (measured) = 15.1 W/kg



0 dB = 15.1 W/kg = 11.79 dBW/kg

## **APPENDIX B. SAR measurement Data**

The SAR plots for highest measured SAR in each exposure configuration, wireless mode and frequency band combination, and measured SAR > 1.5 W/kg are shown as follows.

Date/Time: 14/08/2015

Test Laboratory: Cerpass Lab

DUT: Tablet PC; Type: TC80RA6

**Procedure Name: 802.11b 2437MHz Mid Body-Back**

Communication System Band: 802.11b; Frequency: 2437 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 2437$  MHz;  $\sigma = 1.95$  S/m;  $\epsilon_r = 52.51$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section; Tissue Temp (celsius) - 21°C

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

DASY5 Configuration:

- Probe: EX3DV4 - SN3927; ConvF(7.54, 7.54, 7.54); Calibrated: 2015/5/27;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1379; Calibrated: 2015/5/20
- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD
- Measurement SW: DASY52, Version 52.8 (8);

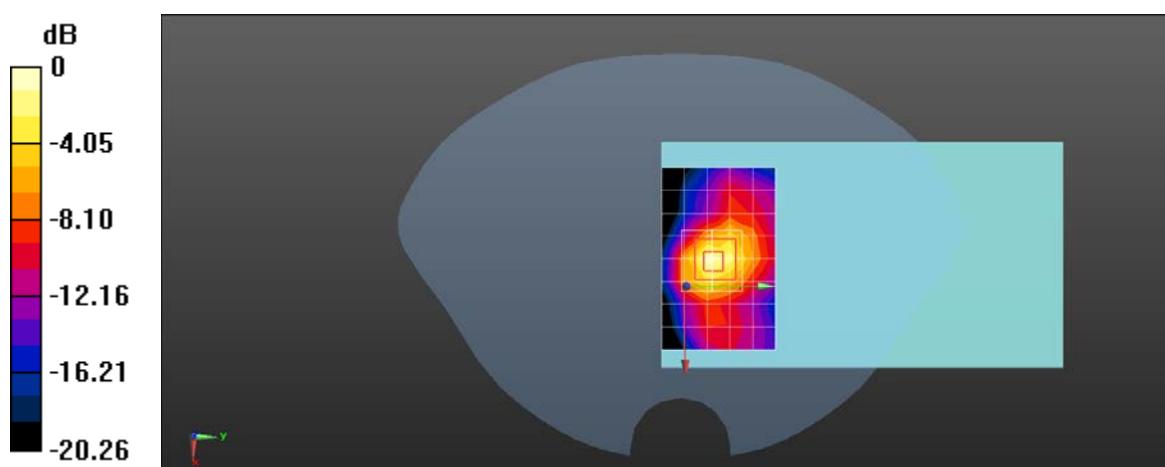
**Configuration/802.11b 2437MHz Mid Body-Back/Area Scan (9x6x1):** Measurement grid:

$dx=12$  mm,  $dy=12$  mm, Maximum value of SAR (measured) = 1.46 W/kg

**Configuration/802.11b 2437MHz Mid Body-Back/Zoom Scan (5x5x7)/Cube**

**0:** Measurement grid:  $dx=8$  mm,  $dy=8$  mm,  $dz=5$  mm, Reference Value = 10.48 V/m; Power Drift = 0.02 dB, Peak SAR (extrapolated) = 3.03 W/kg

**SAR(1 g) = 1.33 W/kg; SAR(10 g) = 0.606 W/kg** Maximum value of SAR (measured) = 1.62 W/kg



## **APPENDIX C. Calibration Data for Probe, Dipole and DAE**

Please refer to attached files.

## **APPENDIX D. Photographs of EUT and Setup**

Please refer to attached files.

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)

Accreditation No.: SCS 0108

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

Client Cerpass (Auden)

Certificate No: EX3-3927\_May15

## CALIBRATION CERTIFICATE

Object EX3DV4 - SN:3927

Calibration procedure(s) QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v4, QA CAL-23.v5,  
QA CAL-25.v6  
Calibration procedure for dosimetric E-field probes

Calibration date: May 27, 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  $(22 \pm 3)^\circ\text{C}$  and humidity  $< 70\%$ .

Calibration Equipment used (M&TE critical for calibration)

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

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

Issued: June 1, 2015

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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 $\varphi$ | $\varphi$ rotation around probe axis  |
| Polarization $\beta$   | $\beta$ rotation around an axis that is in the plane normal to probe axis (at measurement center),<br>i.e., $\beta = 0$ 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

#### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>: Assessed for E-field polarization  $\beta = 0$  ( $f \leq 900$  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<sup>2</sup>-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.
- DCP<sub>x,y,z</sub>: 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:3927

Manufactured: March 8, 2013  
Calibrated: May 27, 2015

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3927

### Basic Calibration Parameters

|   | Sensor X | Sensor Y | Sensor Z | Unc (k=2)    |
|---|----------|----------|----------|--------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 0.57     | 0.33     | 0.62     | $\pm 10.1\%$ |
| DCP (mV) <sup>B</sup>                                     | 100.4    | 94.7     | 89.6     |              |

### Modulation Calibration Parameters

| UID | Communication System Name |   | A<br>dB | B<br>dB/ $\mu\text{V}$ | C   | D<br>dB | VR<br>mV | Unc <sup>C</sup><br>(k=2) |
|-----|---------------------------|---|---------|------------------------|-----|---------|----------|---------------------------|
| 0   | CW                        | X | 0.0     | 0.0                    | 1.0 | 0.00    | 148.2    | $\pm 3.3\%$               |
|     |                           | Y | 0.0     | 0.0                    | 1.0 |         | 140.7    |                           |
|     |                           | Z | 0.0     | 0.0                    | 1.0 |         | 129.7    |                           |

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 NormX,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>C</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:3927

### 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) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 450                  | 43.5                               | 0.87                            | 10.78   | 10.78   | 10.78   | 0.16               | 1.30                    | ± 13.3 %    |
| 850                  | 41.5                               | 0.92                            | 9.78    | 9.78    | 9.78    | 0.44               | 0.88                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 8.49    | 8.49    | 8.49    | 0.30               | 0.85                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 8.24    | 8.24    | 8.24    | 0.33               | 0.80                    | ± 12.0 %    |
| 2100                 | 39.8                               | 1.49                            | 8.36    | 8.36    | 8.36    | 0.31               | 0.85                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 7.51    | 7.51    | 7.51    | 0.39               | 0.80                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 7.23    | 7.23    | 7.23    | 0.26               | 1.08                    | ± 12.0 %    |
| 5200                 | 36.0                               | 4.66                            | 5.27    | 5.27    | 5.27    | 0.35               | 1.80                    | ± 13.1 %    |
| 5300                 | 35.9                               | 4.76                            | 5.18    | 5.18    | 5.18    | 0.35               | 1.80                    | ± 13.1 %    |
| 5600                 | 35.5                               | 5.07                            | 4.81    | 4.81    | 4.81    | 0.40               | 1.80                    | ± 13.1 %    |
| 5800                 | 35.3                               | 5.27                            | 4.72    | 4.72    | 4.72    | 0.40               | 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:3927

### 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) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 450                  | 56.7                               | 0.94                            | 11.37   | 11.37   | 11.37   | 0.10               | 1.25                    | ± 13.3 %    |
| 850                  | 55.2                               | 0.99                            | 9.74    | 9.74    | 9.74    | 0.28               | 1.16                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 8.19    | 8.19    | 8.19    | 0.42               | 0.80                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 7.93    | 7.93    | 7.93    | 0.35               | 0.91                    | ± 12.0 %    |
| 2100                 | 53.2                               | 1.62                            | 8.24    | 8.24    | 8.24    | 0.41               | 0.80                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 7.54    | 7.54    | 7.54    | 0.30               | 0.85                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 7.36    | 7.36    | 7.36    | 0.27               | 0.90                    | ± 12.0 %    |
| 5200                 | 49.0                               | 5.30                            | 4.60    | 4.60    | 4.60    | 0.45               | 1.90                    | ± 13.1 %    |
| 5300                 | 48.9                               | 5.42                            | 4.37    | 4.37    | 4.37    | 0.45               | 1.90                    | ± 13.1 %    |
| 5600                 | 48.5                               | 5.77                            | 4.03    | 4.03    | 4.03    | 0.50               | 1.90                    | ± 13.1 %    |
| 5800                 | 48.2                               | 6.00                            | 4.16    | 4.16    | 4.16    | 0.50               | 1.90                    | ± 13.1 %    |

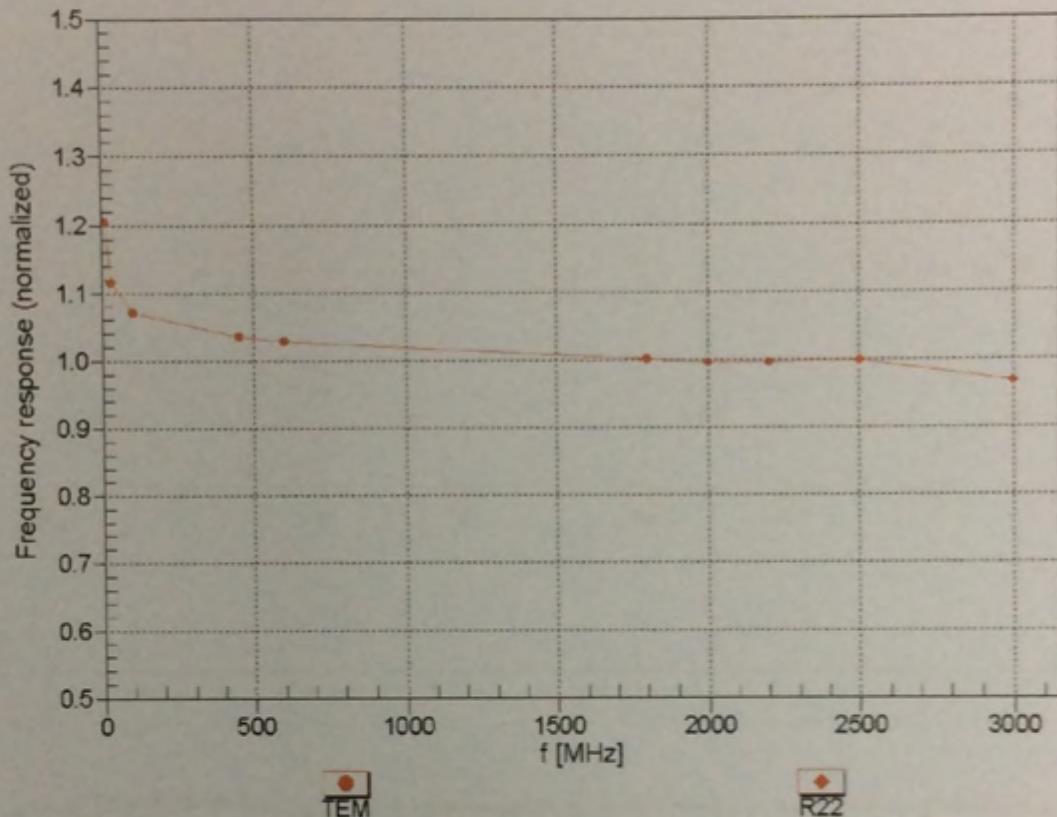
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 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 (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

<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

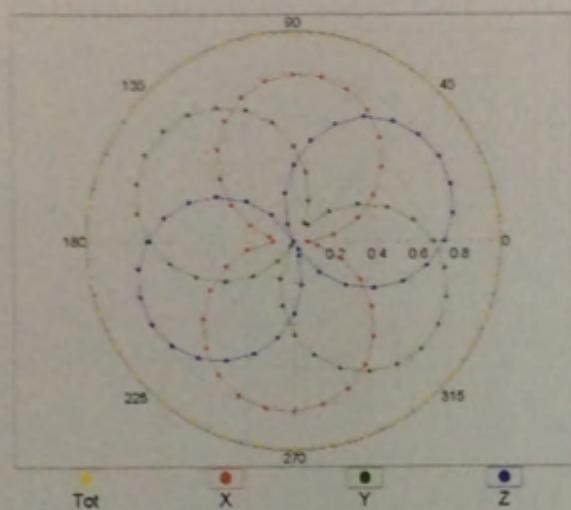
(TEM-Cell:ifi110 EXX, Waveguide: R22)



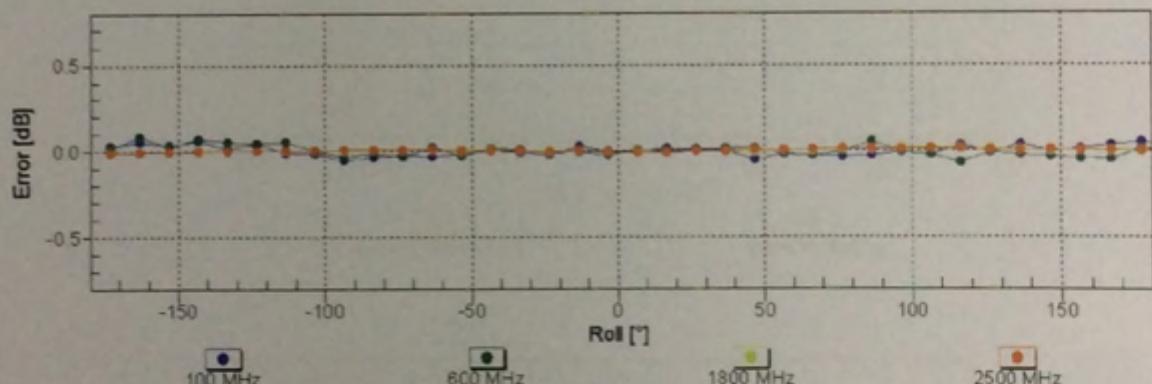
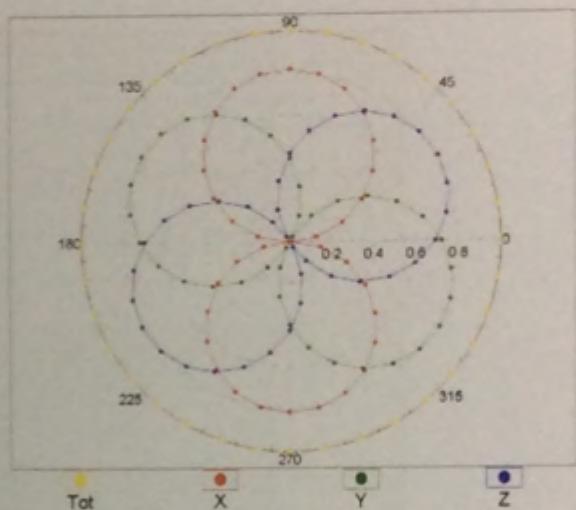
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

$f=600$  MHz, TEM

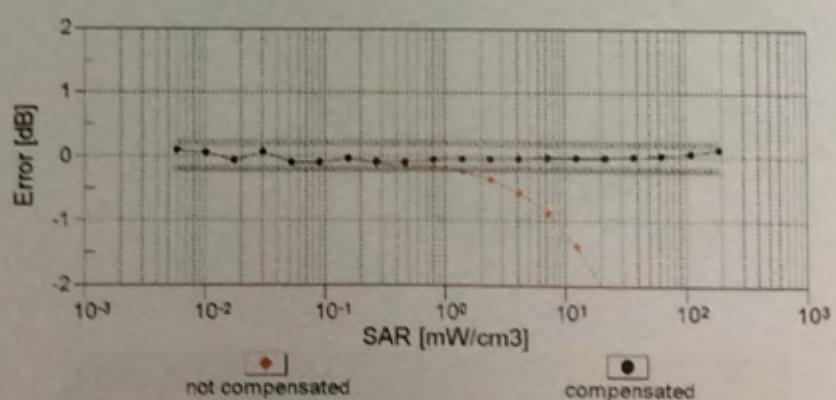
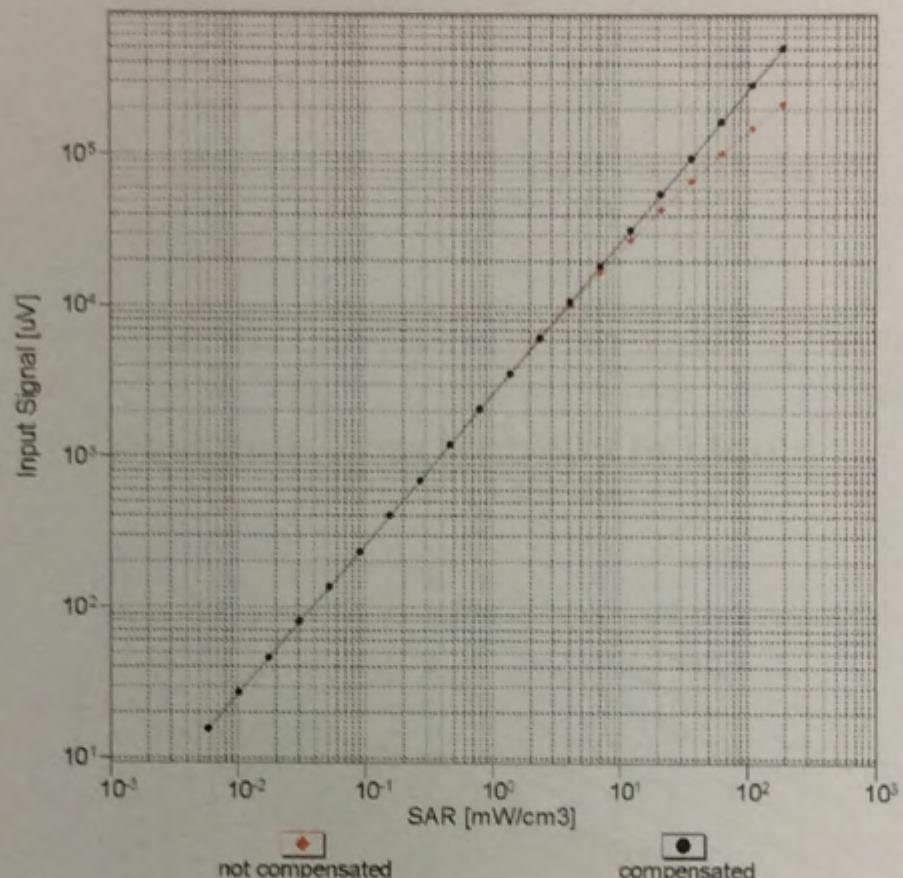


$f=1800$  MHz, R22



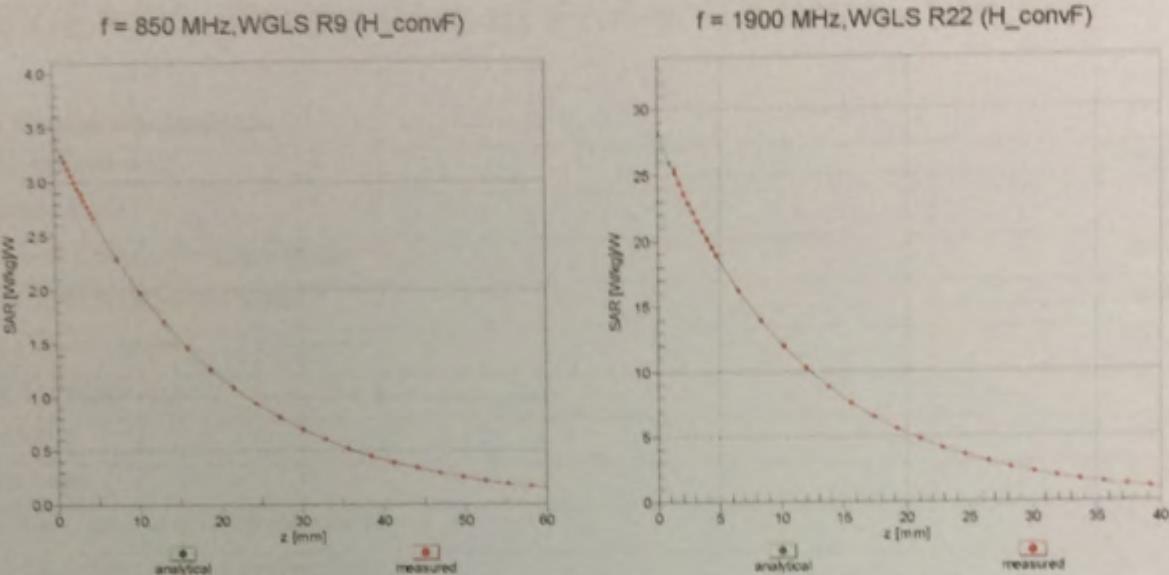
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

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



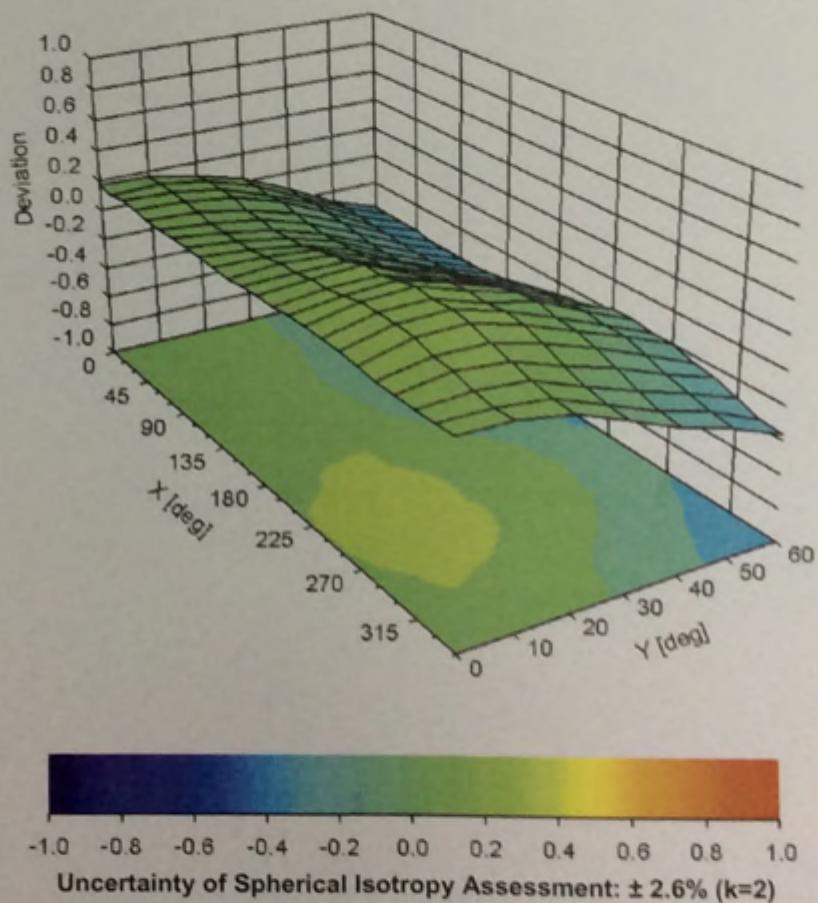
Uncertainty of Linearity Assessment:  $\pm 0.6\% (k=2)$

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3927****Other Probe Parameters**

|   |            |
|---|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 26.6       |
| Mechanical Surface Detection Mode             | enabled    |
| Optical Surface Detection Mode                | disabled   |
| Probe Overall Length                          | 337 mm     |
| Probe Body Diameter                           | 10 mm      |
| Tip Length                                    | 9 mm       |
| Tip Diameter                                  | 2.5 mm     |
| Probe Tip to Sensor X Calibration Point       | 1 mm       |
| Probe Tip to Sensor Y Calibration Point       | 1 mm       |
| Probe Tip to Sensor Z Calibration Point       | 1 mm       |
| Recommended Measurement Distance from Surface | 1.4 mm     |

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## IMPORTANT NOTICE

### USAGE OF THE DAE 4

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

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

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

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

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

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

**Important Note:**

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

**Important Note:**

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

**Important Note:**

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



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Client Cerpass (Auden)

Certificate No: DAE4-1379\_May15

## CALIBRATION CERTIFICATE

Object DAE4 - SD 000 D04 BM - SN: 1379

Calibration procedure(s) QA CAL-06.v29  
Calibration procedure for the data acquisition electronics (DAE)

Calibration date: May 20, 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  $(22 \pm 3)^\circ\text{C}$  and humidity  $< 70\%$ .

### Calibration Equipment used (M&TE critical for calibration)

| Primary Standards             | ID #               | Cal Date (Certificate No.) | Scheduled Calibration  |
|-------------------------------|--------------------|----------------------------|------------------------|
| Keithley Multimeter Type 2001 | SN: 0810278        | 03-Oct-14 (No:15573)       | Oct-15                 |
| Secondary Standards           | ID #               | Check Date (in house)      | Scheduled Check        |
| Auto DAE Calibration Unit     | SE UWS 053 AA 1001 | 06-Jan-15 (in house check) | In house check: Jan-16 |
| Calibrator Box V2.1           | SE UMS 006 AA 1002 | 06-Jan-15 (in house check) | In house check: Jan-16 |

| Calibrated by: | Name              | Function                 | Signature |
|----------------|-------------------|--------------------------|-----------|
|                | Dominique Steffen | Technician               |           |
| Approved by:   | Fin Bornholt      | Deputy Technical Manager |           |

Issued: May 20, 2015

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Accreditation No.: SCS 0108

## Glossary

|                 |   |
|-----------------|---|
| DAE             | data acquisition electronics  |
| Connector angle | information used in DASY system to align probe sensor X to the robot coordinate system. |

## Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement*: Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity*: Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity*: Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation*: Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted*: Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current*: Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance*: Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage*: Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption*: Typical value for information. Supply currents in various operating modes.

## DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB =  $6.1\mu\text{V}$ , full range =  $-100...+300\text{ mV}$

Low Range: 1LSB =  $61\text{nV}$ , full range =  $-1.....+3\text{mV}$

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X                                 | Y                                 | Z                                 |
|---------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| High Range          | $403.794 \pm 0.02\% (\text{k}=2)$ | $404.061 \pm 0.02\% (\text{k}=2)$ | $403.997 \pm 0.02\% (\text{k}=2)$ |
| Low Range           | $4.00602 \pm 1.50\% (\text{k}=2)$ | $3.97643 \pm 1.50\% (\text{k}=2)$ | $3.99886 \pm 1.50\% (\text{k}=2)$ |

## Connector Angle

|   |                           |
|---|---------------------------|
| Connector Angle to be used in DASY system | $149.0^\circ \pm 1^\circ$ |
|---|---------------------------|

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

### 1. DC Voltage Linearity

| High Range |         | Reading (µV) | Difference (µV) | Error (%) |
|------------|---------|--------------|-----------------|-----------|
| Channel X  | + Input | 199991.98    | -2.41           | -0.00     |
| Channel X  | + Input | 20000.84     | 0.17            | 0.00      |
| Channel X  | - Input | -19998.26    | 2.72            | -0.01     |
| Channel Y  | + Input | 199994.23    | -0.26           | -0.00     |
| Channel Y  | + Input | 19996.94     | -3.80           | -0.02     |
| Channel Y  | - Input | -20001.70    | -0.82           | 0.00      |
| Channel Z  | + Input | 199992.74    | -1.87           | -0.00     |
| Channel Z  | + Input | 19997.90     | -2.73           | -0.01     |
| Channel Z  | - Input | -20001.62    | -0.73           | 0.00      |

| Low Range |         | Reading (µV) | Difference (µV) | Error (%) |
|-----------|---------|--------------|-----------------|-----------|
| Channel X | + Input | 2000.59      | -0.04           | -0.00     |
| Channel X | + Input | 201.24       | 0.15            | 0.08      |
| Channel X | - Input | -198.45      | 0.40            | -0.20     |
| Channel Y | + Input | 2001.24      | 0.50            | 0.03      |
| Channel Y | + Input | 200.74       | -0.46           | -0.23     |
| Channel Y | - Input | -199.18      | -0.48           | 0.24      |
| Channel Z | + Input | 2000.74      | 0.06            | 0.00      |
| Channel Z | + Input | 200.67       | -0.37           | -0.18     |
| Channel Z | - Input | -199.95      | -1.13           | 0.57      |

### 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

|           | Common mode<br>Input Voltage (mV) | High Range<br>Average Reading (µV) | Low Range<br>Average Reading (µV) |
|-----------|-----------------------------------|------------------------------------|-----------------------------------|
| Channel X | 200                               | -17.81                             | -19.64                            |
|           | -200                              | 20.38                              | 18.43                             |
| Channel Y | 200                               | -4.03                              | -4.78                             |
|           | -200                              | 3.81                               | 3.62                              |
| Channel Z | 200                               | -10.83                             | -10.51                            |
|           | -200                              | 8.36                               | 8.62                              |

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

|           | Input Voltage (mV) | Channel X (µV) | Channel Y (µV) | Channel Z (µV) |
|-----------|--------------------|----------------|----------------|----------------|
| Channel X | 200                | -              | -0.93          | -5.30          |
| Channel Y | 200                | 7.21           | -              | 0.59           |
| Channel Z | 200                | 9.42           | 5.21           | -              |

#### 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

|           | High Range (LSB) | Low Range (LSB) |
|-----------|------------------|-----------------|
| Channel X | 16033            | 16067           |
| Channel Y | 16249            | 16166           |
| Channel Z | 15828            | 15613           |

#### 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Input 10MΩ

|           | Average (µV) | min. Offset (µV) | max. Offset (µV) | Std. Deviation (µV) |
|-----------|--------------|------------------|------------------|---------------------|
| Channel X | -1.03        | -1.89            | -0.05            | 0.40                |
| Channel Y | 0.06         | -1.84            | 1.45             | 0.58                |
| Channel Z | -0.37        | -1.37            | 1.45             | 0.56                |

#### 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

#### 7. Input Resistance (Typical values for information)

|           | Zeroing (kOhm) | Measuring (MOhm) |
|-----------|----------------|------------------|
| Channel X | 200            | 200              |
| Channel Y | 200            | 200              |
| Channel Z | 200            | 200              |

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

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

#### 9. Power Consumption (Typical values for information)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|----------------|-------------------|---------------|-------------------|
| Supply (+ Vcc) | +0.01             | +6            | +14               |
| Supply (- Vcc) | -0.01             | -8            | -9                |



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: SCS 0108

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

Client Cerpass (Auden)

Certificate No: D2450V2-914\_May15

## CALIBRATION CERTIFICATE

Object D2450V2 - SN: 914

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

Calibration date: May 19, 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  $(22 \pm 3)^\circ\text{C}$  and humidity  $< 70\%$ .

### Calibration Equipment used (M&TE critical for calibration)

| Primary Standards           | ID #               | Cal Date (Certificate No.)        | Scheduled Calibration  |
|-----------------------------|--------------------|-----------------------------------|------------------------|
| Power meter EPM-442A        | GB37480704         | 07-Oct-14 (No. 217-02020)         | Oct-15                 |
| Power sensor HP 8481A       | US37292783         | 07-Oct-14 (No. 217-02020)         | Oct-15                 |
| Power sensor HP 8481A       | MY41092317         | 07-Oct-14 (No. 217-02021)         | Oct-15                 |
| 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 ES3DV3      | SN: 3205           | 30-Dec-14 (No. ES3-3205_Dec14)    | Dec-15                 |
| DAE4                        | SN: 601            | 18-Aug-14 (No. DAE4-601_Aug14)    | Aug-15                 |
| Secondary Standards         | ID #               | Check Date (in house)             | Scheduled Check        |
| RF generator R&S SMT-06     | 100005             | 04-Aug-99 (in house check Oct-13) | In house check: Oct-16 |
| Network Analyzer HP 8753E   | US37390585 S4206   | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

Calibrated by: Name Michael Weber Function Laboratory Technician

Signature

Approved by: Katja Pokovic Technical Manager

Issued: May 20, 2015

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



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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:

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

#### Additional Documentation:

- DASY4/5 System Handbook

#### Methods Applied and Interpretation of Parameters:

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

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 | 37.9 $\pm$ 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 | 13.7 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 53.8 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 | 6.38 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 25.2 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 | 50.7 $\pm$ 6 % | 2.03 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 | 13.5 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 52.5 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 | 6.26 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 24.6 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 | $55.7 \Omega + 1.8 \text{ j} \Omega$ |
| Return Loss                          | - 24.9 dB                            |

### Antenna Parameters with Body TSL

|                                      |                                      |
|--------------------------------------|--------------------------------------|
| Impedance, transformed to feed point | $53.0 \Omega + 3.7 \text{ j} \Omega$ |
| Return Loss                          | - 26.6 dB                            |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.158 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 19, 2012 |

# DASY5 Validation Report for Head TSL

Date: 19.05.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 914**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.84$  S/m;  $\epsilon_r = 37.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.54, 4.54, 4.54); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

## 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 = 103.0 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 28.2 W/kg

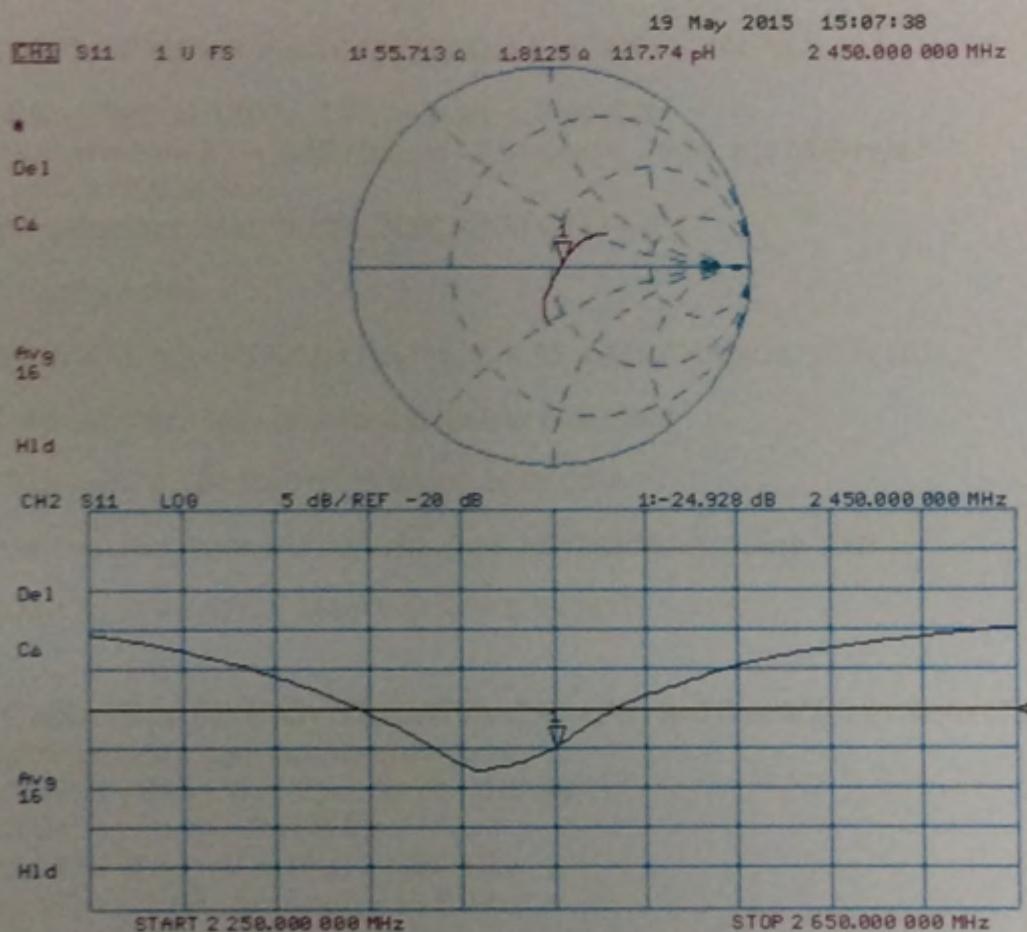
**SAR(1 g) = 13.7 W/kg; SAR(10 g) = 6.38 W/kg**

Maximum value of SAR (measured) = 18.1 W/kg



0 dB = 18.1 W/kg = 12.58 dBW/kg

# Impedance Measurement Plot for Head TSL



# DASY5 Validation Report for Body TSL

Date: 19.05.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 914

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.03$  S/m;  $\epsilon_r = 50.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.32, 4.32, 4.32); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

## Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

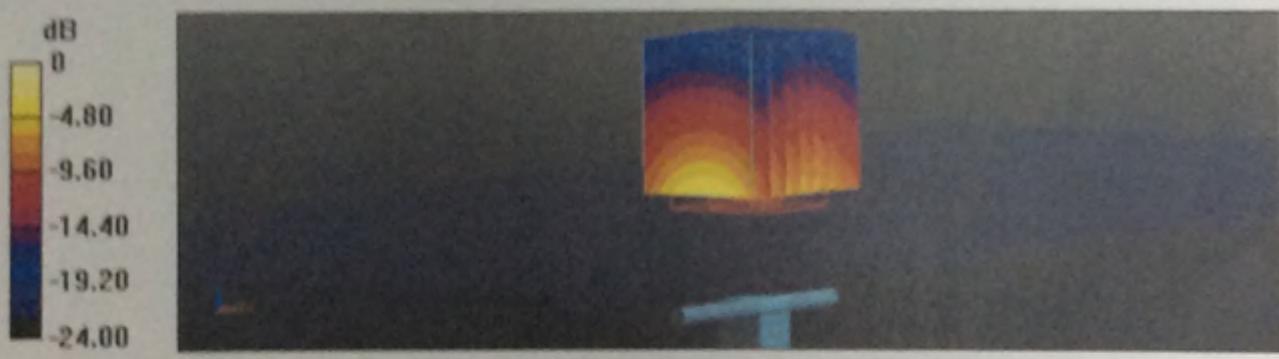
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 96.84 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 28.1 W/kg

SAR(1 g) = 13.5 W/kg; SAR(10 g) = 6.26 W/kg

Maximum value of SAR (measured) = 17.9 W/kg



## Impedance Measurement Plot for Body TSL

