

# SAR TEST REPORT

Test item : GNSS Data Collector  
Model No. : Zeno 20  
Order No. : DTNC1503-00989  
Date of receipt : 2015-03-04  
Test duration : 2015-04-15 ~ 2015-08-24  
Date of issue : 2015-08-25  
Use of report : FCC Original Grant

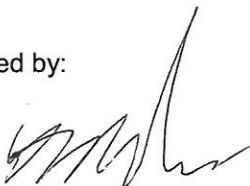
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Test rule part : CFR §2.1093  
Test environment : See appended test report  
Test result : ☒ Pass ☐ Fail

The test results presented in this test report are limited only to the sample supplied by applicant and the use of this test report is inhibited other than its purpose. This test report shall not be reproduced except in full, without the written approval of DT&C Co., Ltd.

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## Test Report Version

| Test Report No.    | Date          | Description                      |
|--------------------|---------------|----------------------------------|
| DRRFCC1505-0039    | May. 12, 2015 | Final version for approval       |
| DRRFCC1505-0039(1) | Jun. 18, 2015 | Changed for KDB 248227 D01v02r01 |
| DRRFCC1505-0039(2) | Aug. 25, 2015 | Add of Head SAR Test             |
|                    |               |                                  |
|                    |               |                                  |
|                    |               |                                  |
|                    |               |                                  |
|                    |               |                                  |
|                    |               |                                  |

## 1. DESCRIPTION OF DEVICE

Environmental evaluation measurements of specific absorption rate (SAR) distributions in emulated human body tissues exposed to radio frequency (RF) radiation from wireless portable devices for compliance with the rules and regulations of the U.S. Federal Communications Commission (FCC).

### General Information:

| EUT type             | GNSS Data Collector   |                                |                          |                                |               |
|----------------------|---|--------------------------------|--------------------------|--------------------------------|---------------|
| FCC ID               | RFD-ZENO20C   |                                |                          |                                |               |
| Equipment model name | Zeno 20   |                                |                          |                                |               |
| Equipment serial no. | Identical prototype   |                                |                          |                                |               |
| Mode(s) of Operation | CDMA 850, CDMA 1900, 2.4 GHz W-LAN (802.11b/g/n HT20)   |                                |                          |                                |               |
| TX Frequency Range   | 824.7 ~ 848.31 MHz (Cellular Band) / 1851.25 ~ 1908.75 MHz (PCS Band)<br>2412 ~ 2462 MHz (802.11b/g/n HT20)   |                                |                          |                                |               |
| RX Frequency Range   | 869.7 ~ 893.31 MHz (Cellular Band) / 1931.25 ~ 1988.75 MHz (PCS Band)<br>2412 ~ 2462 MHz (802.11b/g/n HT20)   |                                |                          |                                |               |
| Equipment Class      | Band  | Measured Conducted Power [dBm] | Reported SAR             | Measured Conducted Power [dBm] | Reported SAR  |
|                      |   |                                | 10g Extremity SAR (W/kg) |                                | 1g SAR (W/kg) |
|                      |   |                                | Hand                     |                                | Head          |
| PCB                  | CDMA 850  | 24.81                          | 0.43                     | 24.81                          | 0.20          |
| PCB                  | CDMA 1900   | 23.95                          | 1.55                     | 23.95                          | 0.11          |
| DTS                  | 2.4 GHz W-LAN   | 15.68                          | 0.17                     | 15.68                          | 0.07          |
| DSS                  | Bluetooth   | 2.72                           | N/A                      |                                |               |
| FCC Equipment Class  | PCS Licensed Transmitter (PCB)<br>Part 15 Spread Spectrum Transmitter(DSS)<br>Digital Transmission System(DTS)  |                                |                          |                                |               |
| Date(s) of Tests     | 2015-04-15 ~ 2015-08-24   |                                |                          |                                |               |
| Antenna Type         | Internal Type Antenna   |                                |                          |                                |               |
| Functions            | <ul style="list-style-type: none"><li>● BT (2.4 GHz) / W-LAN (2.4 GHz 802.11b/g/n(HT20)) supported<br/>* No simultaneous transmission between BT &amp; WLAN</li><li>● VoIP supported. (Speaker phone only)</li><li>● Mobile Hotspot not supported.</li><li>● This industrial PDA OS doesn't support any simultaneous transmission between transmitters.</li></ul> |                                |                          |                                |               |

## 1.1 Guidance Applied

- IEEE 1528-2003
- FCC KDB Publication 941225 D01 3G SAR Procedures v03
- FCC KDB Publication 248227 D01v02r01 (802.11 Wi-Fi SAR)
- FCC KDB Publication 447498 D01v05r02 (General SAR Guidance)
- FCC KDB Publication 648474 D04 Handset SAR v01r02
- FCC KDB Publication 690783 D01 SAR Listings on Grants v01r03
- FCC KDB Publication 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r03
- FCC KDB Publication 865664 D02 RF Exposure Reporting v01r01
- October 2013 TCB Workshop Notes (GPRS testing criteria)

## 1.2 Device Overview

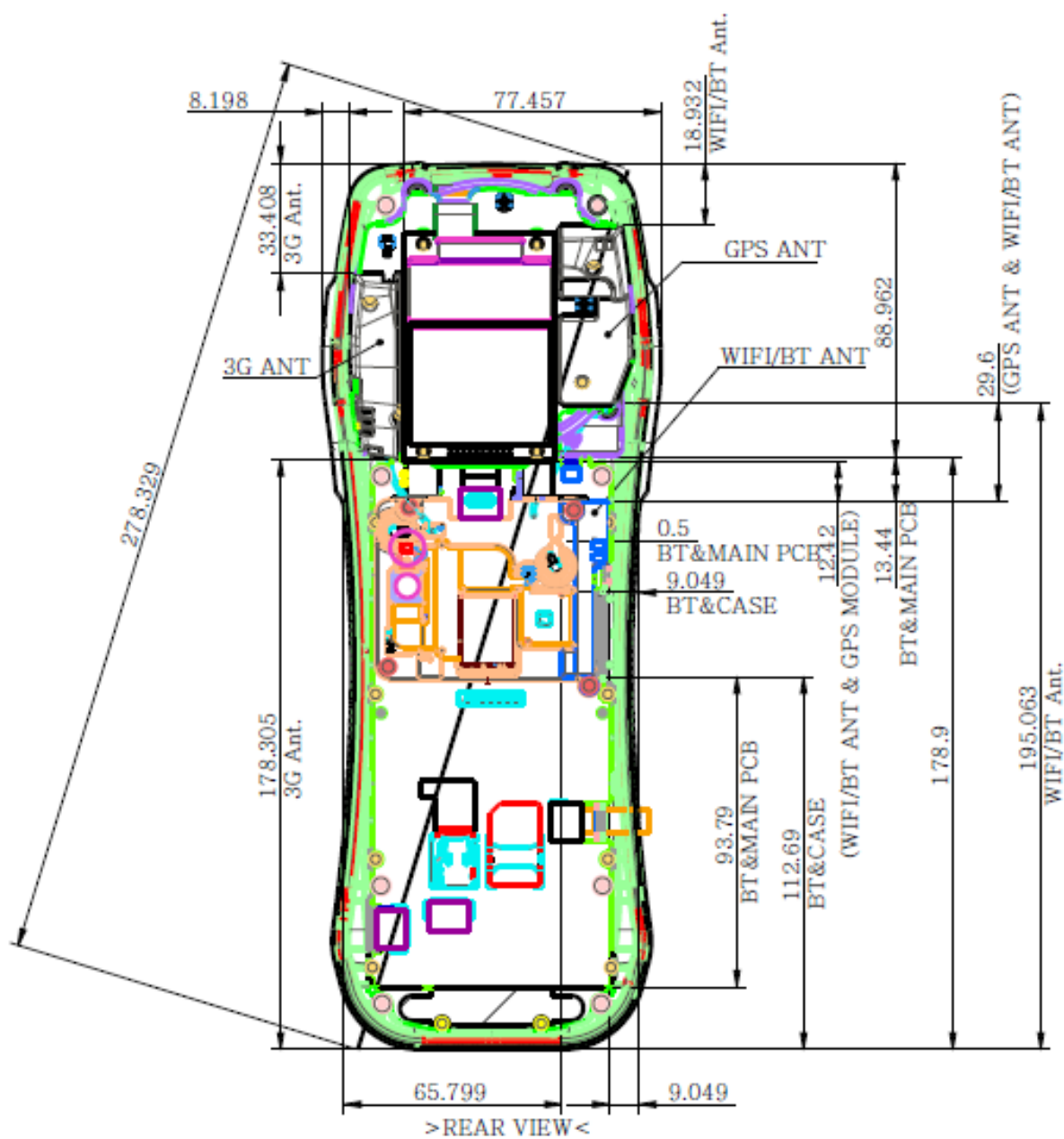
| Band | Mode         | Operating Modes | Tx Frequency          |
|------|--------------|-----------------|-----------------------|
| PCB  | CDMA 850     | Data            | 824.7 ~ 848.31 MHz    |
|      | CDMA 1900    | Data            | 1851.25 ~ 1908.75 MHz |
| DTS  | 2.4 GHz WLAN | Data            | 2412 ~ 2462 MHz       |
| DSS  | Bluetooth    | Data            | 2402 ~ 2480 MHz       |

## 1.3 Nominal and Maximum Output Power Specifications

This device operates using the following maximum and nominal output power specifications. SAR values were scaled to the maximum allowed power to determine compliance per KDB Publication 447498 D01v05r02.

| Band & Mode |                        |         | Modulated Average [dBm] |
|-------------|------------------------|---------|-------------------------|
| PCB         | CDMA 850               | Maximum | 25.0                    |
|             |                        | Nominal | 24.5                    |
|             | CDMA 1900              | Maximum | 24.1                    |
|             |                        | Nominal | 23.6                    |
| DTS         | IEEE 802.11b (2.4 GHz) | Maximum | 15.7                    |
|             |                        | Nominal | 14.7                    |
|             | IEEE 802.11g (2.4 GHz) | Maximum | 15.5                    |
|             |                        | Nominal | 14.5                    |
|             | IEEE 802.11n (2.4 GHz) | Maximum | 15.5                    |
|             |                        | Nominal | 14.5                    |
| DSS         | Bluetooth 1 Mbps       | Maximum | 3.0                     |
|             |                        | Nominal | 2.0                     |
|             | Bluetooth 2 Mbps       | Maximum | -1.5                    |
|             |                        | Nominal | -2.5                    |
|             | Bluetooth 3 Mbps       | Maximum | -1.5                    |
|             |                        | Nominal | -2.5                    |

## 1.4 DUT Antenna Locations



Note: Exact antenna dimensions and separation distances are shown in the "Antenna Location\_RFD-ZENO20C" in the FCC Filing.

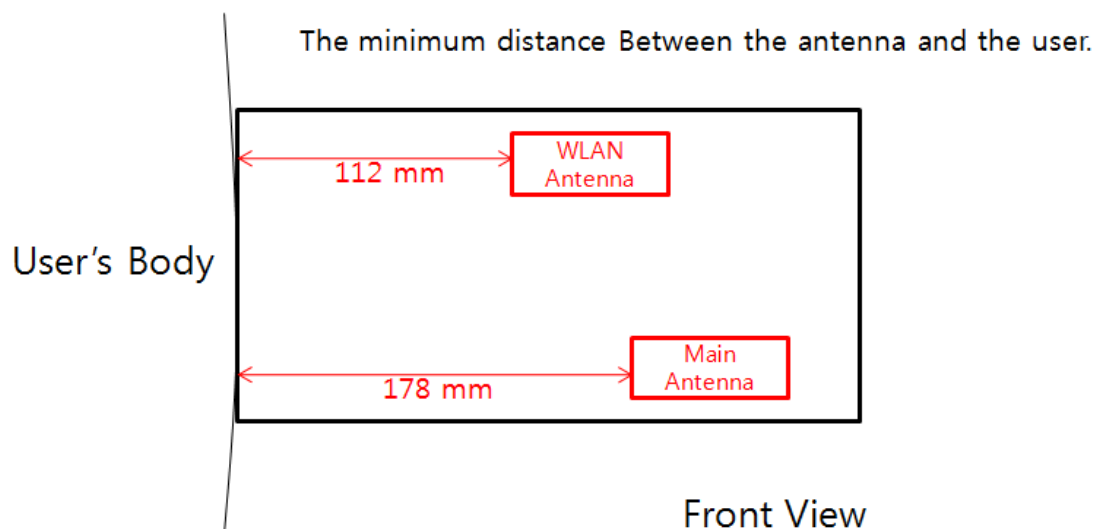
## 1.5 Determination of the SAR Test Configuration

According to the applicant's description, this device can be used only in hand (Hand-held Device) or pole mount or vehicle mount and does not support voice call.

Also the body SAR tests are excluded according to the KDB 447498 as below.

When the user uses this device in hand, the bottom side can only be touched to user's body.

In this situation, the user's body shall be separated from the closest edges of the antennas as below picture.



Per FCC KDB 447498 D01v05r02, the SAR exclusion threshold for distances > 50 mm is defined by the following equation:  
(The SAR test exclusion threshold is determined according to the following, and as illustrated in KDB 447498 Appendix B.)

**Table 1.1 Determination of the Body SAR**

| FREQUENCY |      | Mode/<br>Band | Service             | Equation                            | Threshold<br>Power<br>[mW] | Tune up<br>Max<br>Power<br>[mW] | Determine<br>Body SAR |
|-----------|------|---------------|---------------------|-------------------------------------|----------------------------|---------------------------------|-----------------------|
| MHz       | Ch   |               |                     |                                     |                            |                                 |                       |
| 848.31    | 777  | CDMA 850      | TDSO<br>SO32<br>FCH | $[163 + (178 - 50) * (848.31/150)]$ | <b>886.9</b>               | <b>&gt; 316</b>                 | <b>X</b>              |
| 1908.75   | 1175 | CDMA 1900     | TDSO<br>SO32<br>FCH | $[109 + (178 - 50) * 10]$           | <b>1389</b>                | <b>&gt; 257</b>                 | <b>X</b>              |
| 2462      | 11   | 802.11b       | DSSS                | $[96 + (112 - 50) * 10]$            | <b>716</b>                 | <b>&gt; 37</b>                  | <b>X</b>              |

Therefore the body SAR tests were excluded as above table 1.1 and only hands SAR tests were conducted.



## 1.6 SAR Test Exclusions Applied

### (A) WIFI & BT for head and hands SAR configuration

Per FCC KDB 447498 D01v05r02, the **1g SAR exclusion threshold for distances < 50 mm** is defined by the following equation:

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

Based on the maximum conducted power of **Bluetooth** (rounded to the nearest mW) and the antenna to user separation distance, **Bluetooth SAR was not required**;  $[(2/5) * \sqrt{2.480}] = \underline{0.6} < 3.0$ .

Based on the maximum conducted power of **2.4 GHz WIFI** (rounded to the nearest mW) and the antenna to user separation distance, **2.4 GHz WIFI SAR was required**;  $[(37/5) * \sqrt{2.462}] = \underline{11.7} > 3.0$ .

Per FCC KDB 447498 D01v05r02, the **10g SAR exclusion threshold for distances < 50 mm** is defined by the following equation:

$$\frac{\text{Max Power of Channel (mW)}}{\text{Test Separation Dist (mm)}} * \sqrt{\text{Frequency (GHz)}} \leq 7.5$$

Based on the maximum conducted power of **Bluetooth** (rounded to the nearest mW) and the antenna to user separation distance, **Bluetooth SAR was not required**;  $[(2/5) * \sqrt{2.480}] = \underline{0.6} < 7.5$ .

Based on the maximum conducted power of **2.4 GHz WIFI** (rounded to the nearest mW) and the antenna to user separation distance, **2.4 GHz WIFI SAR was required**;  $[(37/5) * \sqrt{2.462}] = \underline{11.7} > 7.5$ .

Per KDB Publication 447498 D01v05r02, the maximum power of the channel was rounded to the nearest mW before calculation.

### (B) Tested sides for Hands SAR configuration

- 1) Per FCC KDB 447498 D01v05r02, the **10g SAR exclusion threshold for distances < 50 mm** is defined by the following equation:

$$\frac{\text{Max Power of Channel (mW)}}{\text{Test Separation Dist (mm)}} * \sqrt{\text{Frequency (GHz)}} \leq 7.5$$

**Table 1.2 SAR Test Exclusion for Edges (Antennas < 50 mm)**

| FREQUENCY |      | Mode/<br>Band | Service             | Tune up<br>Max<br>Power<br>[mW] | Separation Distance [mm] |        |       |      | Calculated Threshold Power [mW] |                      |                      |                      |
|-----------|------|---------------|---------------------|---------------------------------|--------------------------|--------|-------|------|---------------------------------|----------------------|----------------------|----------------------|
| MHz       | Ch   |               |                     |                                 | Top                      | Bottom | Right | Left | Top                             | Bottom               | Right                | Left                 |
| 848.31    | 777  | CDMA 850      | TDSO<br>SO32<br>FCH | 316                             | 33                       | 178    | 8     | 77   | <u>8.8 (O)</u>                  | > 50mm <sup>2)</sup> | <u>36.4 (O)</u>      | > 50mm <sup>2)</sup> |
| 1908.75   | 1175 | CDMA 1900     | TDSO<br>SO32<br>FCH | 257                             | 33                       | 178    | 8     | 77   | <u>10.8 (O)</u>                 | > 50mm <sup>2)</sup> | <u>44.4 (O)</u>      | > 50mm <sup>2)</sup> |
| 2462      | 11   | 802.11b       | DSSS                | 37                              | 102                      | 112    | 65    | 9    | > 50mm <sup>2)</sup>            | > 50mm <sup>2)</sup> | > 50mm <sup>2)</sup> | 6.5 (X)              |

**Note 1:** See Table 1.3

Per FCC KDB 447498 D01v05r02, the **SAR exclusion threshold for distances > 50 mm** is defined by the following equation: (the SAR test exclusion threshold is determined according to the following, and as illustrated in KDB 447498 Appendix B.)

- [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm) · ( $f_{\text{MHz}}/150$ )] 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

Table 1.3 SAR Test Exclusion for Edges (Antennas &gt; 50 mm)

| FREQUENCY |      | Mode/<br>Band | Service             | Maximum<br>Allowed<br>Power<br>[mW] | Separation Distance [mm] |        |       |      | Calculated Threshold Power [mW] |           |                      |                      |
|-----------|------|---------------|---------------------|-------------------------------------|--------------------------|--------|-------|------|---------------------------------|-----------|----------------------|----------------------|
| MHz       | Ch   |               |                     |                                     | Top                      | Bottom | Right | Left | Top                             | Bottom    | Right                | Left                 |
| 848.31    | 777  | CDMA 850      | TDSO<br>SO32<br>FCH | 316                                 | 33                       | 178    | 8     | 77   | < 50mm <sup>2)</sup>            | 886.9 (X) | < 50mm <sup>2)</sup> | 315.7 (O)            |
| 1908.75   | 1175 | CDMA 1900     | TDSO<br>SO32<br>FCH | 257                                 | 33                       | 178    | 8     | 77   | < 50mm <sup>2)</sup>            | 1389 (X)  | < 50mm <sup>2)</sup> | 379 (X)              |
| 2462      | 11   | 802.11b       | DSSS                | 37                                  | 102                      | 112    | 65    | 9    | 616 (X)                         | 716 (X)   | 246 (X)              | < 50mm <sup>2)</sup> |

Note 1: See Table 1.2

| Mode                        | EUT Sides for SAR Testing |        |       |      |       |      |
|-----------------------------|---------------------------|--------|-------|------|-------|------|
|                             | Top                       | Bottom | Front | Rear | Right | Left |
| CDMA 850                    | O                         | X      | O     | O    | O     | O    |
| CDMA 1900                   | O                         | X      | O     | O    | O     | X    |
| 2.4 GHz W-LAN (802.11b/g/n) | X                         | X      | O     | O    | X     | X    |

Table 1.4 Determined EUT sides for SAR Testing

Note: Particular DUT edges were not required to be evaluated for SAR based on the SAR exclusion threshold in KDB 447498 D01v05r02.

### 1.7 Power Reduction for SAR

There is no power reduction used for any band/mode implemented in this device for SAR purposes.

### 1.8 Device Serial Numbers

| Band & Mode  | Serial Number |
|--------------|---------------|
| CDMA 850     | FCC #1        |
| CDMA 1900    | FCC #1        |
| 2.4 GHz WLAN | FCC #1        |

## 2. INTROCUCTION

The FCC and Industry Canada have adopted the guidelines for evaluating the environmental effects of radio frequency (RF) radiation in ET Docket 93-62 on Aug. 6, 1996 and Health Canada Safety Code 6 to protect the public and workers from the potential hazards of RF emissions due to FCC-regulated portable devices.

The FCC has adopted the guidelines for evaluating the environmental effects of radio frequency radiation in ET Docket 93-62 on Aug. 6, 1996 to protect the public and workers from the potential hazards of RF emissions due to FCC-regulated portable devices. The safety limits used for the environmental evaluation measurements are based on the criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate (SAR) in IEEE/ANSI C95\*.1-2005 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz. 1992 by the Institute of Electrical and Electronics Engineers, Inc., New York, New York 10017. The measurement procedure described in IEEE/ANSI C95.3-1992 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave is used for guidance in measuring SAR due to the RF radiation exposure from the Equipment Under Test (EUT). These criteria for SAR evaluation are similar to those recommended by the National Council on Radiation Protection and Measurements (NCRP) in Biological Effects and Exposure Criteria for Radio frequency Electromagnetic Fields," NCRP Report No. 86 NCRP, 1986, Bethesda, MD 20814. SAR is a measure of the rate of energy absorption due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potential biological hazards.

### SAR Definition

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

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

Fig. 2.1 SAR Mathematical Equation

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

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

where:

- $\sigma$  = conductivity of the tissue-simulating material (S/m)
- $\rho$  = mass density of the tissue-simulating material ( $\text{kg/m}^3$ )
- E = Total RMS electric field strength (V/m)

NOTE: The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relations to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane.



3.2 EX3DV4 Probe Specification

|  |  |          |  |
|--|--|----------|--|
| Calibration                              | In air from 10 MHz to 6 GHz<br>In brain and muscle simulating tissue at Frequencies of<br>300 MHz, 450 MHz, 600 MHz, 750 MHz, 835 MHz, 900 MHz, 1750 MHz, 1900 MHz,<br>2300 MHz, 2450 MHz, 2600 MHz, 3500 MHz, 5200 MHz, 5300 MHz, 5500 MHz, 5600 MHz,<br>5800 MHz |          |  |
| Frequency                                | 10 MHz to 6 GHz  |          |  |
| Linearity                                | ± 0.2 dB (30 MHz to 6 GHz)   |          |  |
| Dynamic                                  | 10 μW/g to > 100 mW/g  |          |  |
| Range                                    | Linearity :  | ± 0.2 dB |  |
| Dimensions                               | Overall length :   | 337 mm   |  |
| Tip length                               | 20 mm  |          |  |
| Body diameter                            | 12 mm  |          |  |
| Tip diameter                             | 2.5 mm   |          |  |
| Distance from probe tip to sensor center | 1.0 mm   |          |  |
| Application                              | SAR Dosimetry Testing<br>Compliance tests of mobile phones   |          |  |

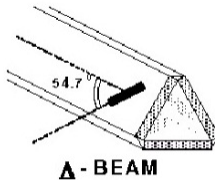



Figure 3.2 Triangular Probe Configurations



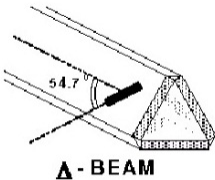
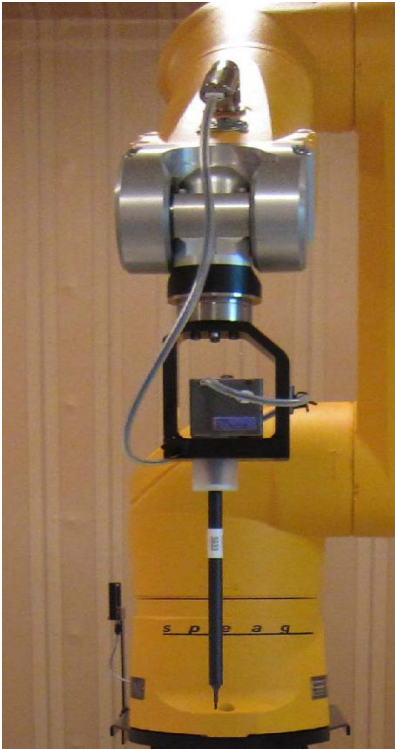


Figure 3.2 Triangular Probe Configurations



Figure 3.3 Probe Thick-Film Technique



DAE System

The SAR measurements were conducted with the dosimetric probe EX3DV4, designed in the classical triangular configuration(see Fig. 3.2) and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multitier line ending at the front of the probe tip. It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY5 software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting. The approach is stopped at reaching the maximum.

### 3.3 Probe Calibration Process

#### 3.3.1 E-Probe Calibration

##### Dosimetric Assessment Procedure

Each probe is calibrated according to a dosimetric assessment procedure with accuracy better than +/- 10%. The spherical isotropy was evaluated with the procedure and found to be better than +/-0.25dB. The sensitivity parameters (NormX, NormY, NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe is tested.

##### Free Space Assessment

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies below 1 GHz, and in a waveguide above 1GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity at the proper orientation with the field. The probe is then rotated 360 degrees.

##### Temperature Assessment \*

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

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

where:

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

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

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

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

where:

$\sigma$  = simulated tissue conductivity,

$\rho$  = Tissue density (1.25 g/cm<sup>3</sup> for brain tissue)

SAR is proportional to  $\Delta T / \Delta t$ , the initial rate of tissue heating, before thermal diffusion takes place. Now it's possible to quantify the electric field in the simulated tissue by equating the thermally derived SAR to the E- field;

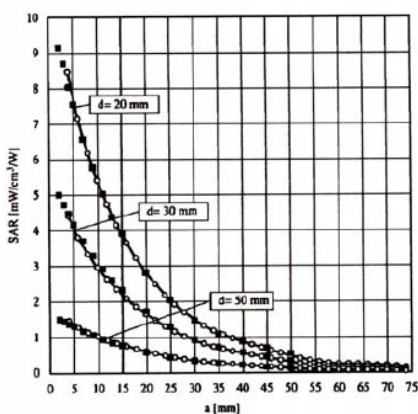


Figure 3.4 E-Field and Temperature Measurements at 900MHz

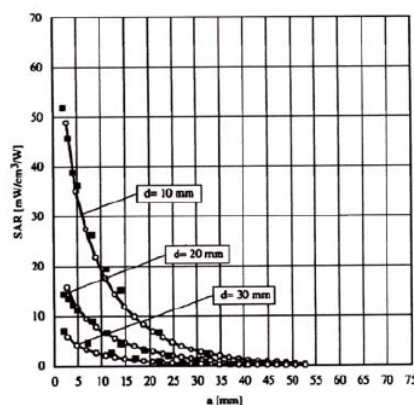


Figure 3.5 E-Field and Temperature Measurements at 1800MHz



### 3.4 Data Extrapolation

The DASY5 software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given like below;

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

with  $V_i$  = compensated signal of channel i (i=x,y,z)  
 $U_i$  = input signal of channel i (i=x,y,z)  
 $cf$  = crest factor of exciting field (DASY parameter)  
 $dcp_i$  = diode compression point (DASY parameter)

From the compensated input signals the primary field data for each channel can be evaluated:

E-field probes:

$$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

with  $V_i$  = compensated signal of channel i (i = x,y,z)  
 $Norm_i$  = sensor sensitivity of channel i (i = x,y,z)  
 $\mu V/(V/m)^2$  for E-field probes  
 $ConvF$  = sensitivity of enhancement in solution  
 $E_i$  = electric field strength of channel i in V/m

The RSS value of the field components gives the total field strength (Hermetian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

with  $SAR$  = local specific absorption rate in W/g  
 $E_{tot}$  = total field strength in V/m  
 $\sigma$  = conductivity in [mho/m] or [Siemens/m]  
 $\rho$  = equivalent tissue density in g/cm<sup>3</sup>

The power flow density is calculated assuming the excitation field to be a free space field.

$$P_{free} = \frac{E_{tot}^2}{3770}$$

with  $P_{pwe}$  = equivalent power density of a plane wave in W/cm<sup>2</sup>  
 $E_{tot}$  = total electric field strength in V/m

### 3.5 ELI PHANTOM

Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is compatible with all SPEAG dosimetric probes and dipoles.

ELI V5.0 has the same shell geometry and is manufactured from the same material as ELI4, but has reinforced top structure. (see fig. 3.6)



Figure 3.6 ELI Phantom

#### ELI Phantom Specification:

|                 |  |
|-----------------|--|
| Shell Thickness | $2 \pm 0.2$ mm (bottom plate)            |
| Dimensions      | Major axis: 600 mm<br>Minor axis: 400 mm |
| Filling Volume  | Approx. 30 liters                        |

### 3.6 Device Holder for Transmitters

In combination with the Twin SAM Phantom V4.0/V4.0c, V5.0 or ELI the Mounting Device (See Fig. 3.7) enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to IEC, IEEE, FCC or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).

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



Figure 3.7 Mounting Device



### 3.7 Brain & Muscle Simulation Mixture Characterization

The brain and muscle mixtures consist of a viscous gel using hydrox-ethylcellulose (HEC) gelling agent and saline solution (see Table 3.1). Preservation with a bactericide is added and visual inspection is made to make sure air bubbles are not trapped during the mixing process. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. The mixture characterizations used for the brain and muscle tissue simulating liquids are according to the data by C. Gabriel and G. Harts grove.



Figure 3.8 Simulated Tissue

Table 3.1 Composition of the Tissue Equivalent Matter

| Ingredients<br>(% by weight)   | Frequency (MHz) |       |       |             |
|--------------------------------|-----------------|-------|-------|-------------|
|                                | 835             | 1900  | 2450  | 5200 ~ 5800 |
| Tissue Type                    | Body            | Body  | Body  | Body        |
| Water                          | 50.75           | 70.23 | 73.40 | 80.00       |
| Salt (NaCl)                    | 0.940           | 0.290 | 0.060 | -           |
| Sugar                          | 48.21           | -     | -     | -           |
| HEC                            | -               | -     | -     | -           |
| Bactericide                    | 0.100           | -     | -     | -           |
| Triton X-100                   | -               | -     | -     | -           |
| DGBE                           | -               | 29.48 | 26.54 | -           |
| Diethylene glycol hexyl ether  | -               | -     | -     | -           |
| Polysorbate (Tween) 80         | -               | -     | -     | 20.00       |
| Target for Dielectric Constant | 55.2            | 53.3  | 52.7  | -           |
| Target for Conductivity (S/m)  | 0.97            | 1.52  | 1.95  | -           |

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

### 3.8 SAR TEST EQUIPMENT

Table 3.2 Test Equipment Calibration

|                                     | Type  | Manufacturer | Model      | Cal.Date   | Next.Cal.Date | S/N             |
|-------------------------------------|---|--------------|------------|------------|---------------|-----------------|
| <input checked="" type="checkbox"/> | SEMITEC Engineering                                   | SEMITEC      | N/A        | N/A        | N/A           | Shield Room     |
| <input checked="" type="checkbox"/> | Robot   | SCHMID       | TX90XL     | N/A        | N/A           | F13/5P9GA1/A/01 |
| <input checked="" type="checkbox"/> | Robot Controller                                      | SCHMID       | C58C       | N/A        | N/A           | F13/5P9GA1/C/01 |
| <input checked="" type="checkbox"/> | Joystick  | SCHMID       | N/A        | N/A        | N/A           | S-12450905      |
| <input checked="" type="checkbox"/> | Intel Core i7-3770 3.40 GHz<br>Windows 7 Professional | N/A          | N/A        | N/A        | N/A           | N/A             |
| <input checked="" type="checkbox"/> | Probe Alignment Unit LB                               | N/A          | N/A        | N/A        | N/A           | SE UKS 030 AA   |
| <input checked="" type="checkbox"/> | Mounting Device                                       | SCHMID       | Holder     | N/A        | N/A           | SD000H01KA      |
| <input checked="" type="checkbox"/> | Laptop Holder   | SCHMID       | SMLH1001CD | N/A        | N/A           | N/A             |
| <input type="checkbox"/>            | Twin SAM Phantom                                      | SCHMID       | QD000P40CD | N/A        | N/A           | 1785            |
| <input type="checkbox"/>            | Twin SAM Phantom                                      | SCHMID       | QD000P40CD | N/A        | N/A           | 1786            |
| <input checked="" type="checkbox"/> | 2mm Oval Phantom ELI5                                 | SCHMID       | QDIVA001BB | N/A        | N/A           | 1223            |
| <input checked="" type="checkbox"/> | Data Acquisition Electronics                          | SCHMID       | DAE4V1     | 2014-11-05 | 2015-11-05    | 1453            |
| <input checked="" type="checkbox"/> | Dosimetric E-Field Probe                              | SCHMID       | EX3DV4     | 2014-09-22 | 2015-09-22    | 3933            |
| <input checked="" type="checkbox"/> | 835 MHz SAR Dipole                                    | SCHMID       | D835V2     | 2014-11-19 | 2016-11-19    | 4d159           |
| <input checked="" type="checkbox"/> | 1900 MHz SAR Dipole                                   | SCHMID       | D1900V2    | 2014-11-14 | 2016-11-14    | 5d176           |
| <input checked="" type="checkbox"/> | 2450 MHz SAR Dipole                                   | SCHMID       | D2450V2    | 2014-11-19 | 2016-11-19    | 920             |
| <input type="checkbox"/>            | 5 GHz SAR Dipole                                      | SCHMID       | D5GHZV2    | 2015-03-23 | 2017-03-23    | 1103            |
| <input checked="" type="checkbox"/> | Network Analyzer                                      | Agilent      | E5071C     | 2014-12-19 | 2015-12-19    | MY46111534      |
| <input checked="" type="checkbox"/> | Signal Generator                                      | Agilent      | E4438C     | 2014-09-12 | 2015-09-12    | US41461520      |
| <input checked="" type="checkbox"/> | Amplifier   | EMPOWER      | BBS3Q7ELU  | 2014-09-12 | 2015-09-12    | 1020            |
| <input type="checkbox"/>            | High Power RF Amplifier                               | EMPOWER      | BBS3Q8CCJ  | 2014-10-20 | 2015-10-20    | 1005            |
| <input checked="" type="checkbox"/> | Power Meter   | HP           | EPM-442A   | 2015-02-26 | 2016-02-26    | GB37170267      |
| <input checked="" type="checkbox"/> | Power Meter   | Anritsu      | ML2495A    | 2014-10-07 | 2015-10-07    | 1435003         |
| <input checked="" type="checkbox"/> | Wide Bandwidth Power Sensor                           | Anritsu      | MA2490A    | 2014-10-07 | 2015-10-07    | 1409034         |
| <input checked="" type="checkbox"/> | Power Sensor  | HP           | 8481A      | 2015-02-26 | 2016-02-26    | 3318A96566      |
| <input checked="" type="checkbox"/> | Power Sensor  | HP           | 8481A      | 2015-02-06 | 2016-02-06    | 2702A65976      |
| <input checked="" type="checkbox"/> | Dual Directional Coupler                              | Agilent      | 778D-012   | 2015-01-06 | 2016-01-06    | 50228           |
| <input checked="" type="checkbox"/> | Directional Coupler                                   | HP           | 773D       | 2014-06-27 | 2015-06-27    | 2389A00640      |
|                                     |   |              |            | 2015-06-26 | 2016-06-26    |                 |
| <input checked="" type="checkbox"/> | Low Pass Filter 1.5 GHz                               | Micro LAB    | LA-15N     | 2014-09-11 | 2015-09-11    | N/A             |
| <input checked="" type="checkbox"/> | Low Pass Filter 3.0 GHz                               | Micro LAB    | LA-30N     | 2014-09-11 | 2015-09-11    | N/A             |
| <input type="checkbox"/>            | Low Pass Filter 6.0 GHz                               | Micro LAB    | LA-60N     | 2015-02-25 | 2016-02-25    | 03942           |
| <input checked="" type="checkbox"/> | Attenuators (3 dB)                                    | Agilent      | 8491B      | 2014-06-27 | 2015-06-27    | MY39260700      |
|                                     |   |              |            | 2015-06-26 | 2016-06-26    |                 |
| <input checked="" type="checkbox"/> | Attenuators (10 dB)                                   | WEINSCHEL    | 23-10-34   | 2015-01-06 | 2016-01-06    | BP4387          |
| <input type="checkbox"/>            | Step Attenuator                                       | HP           | 8494A      | 2014-09-11 | 2015-09-11    | 3308A33341      |
| <input checked="" type="checkbox"/> | Dielectric Probe kit                                  | SCHMID       | DAK-3.5    | 2014-12-09 | 2015-12-09    | 1092            |
| <input checked="" type="checkbox"/> | 8960 Series 10<br>Wireless Comms. Test Set            | Agilent      | E5515C     | 2014-09-12 | 2015-09-12    | GB41321164      |
| <input checked="" type="checkbox"/> | Power Splitter  | Anritsu      | K241B      | 2014-10-21 | 2015-10-21    | 1701102         |
| <input checked="" type="checkbox"/> | Bluetooth Tester                                      | TESCOM       | TC-3000B   | 2014-06-26 | 2015-06-26    | 3000B640046     |
|                                     |   |              |            | 2015-06-26 | 2016-06-26    |                 |

**NOTE:** The E-field probe was calibrated by SPEAG, by temperature measurement procedure. Dipole Verification measurement is performed by DT&C before each test. The brain and muscle simulating material are calibrated by DT&C using the dielectric probe system and network analyzer to determine the conductivity and permittivity (dielectric constant) of the brain-equivalent material. Each equipment item was used solely within its respective calibration period.

## 4. TEST SYSTEM SPECIFICATIONS

### Automated TEST SYSTEM SPECIFICATIONS:

#### Positioner

|               |   |
|---------------|---|
| Robot         | Stäubli Unimation Corp. Robot Model: TX90XL |
| Repeatability | 0.02 mm                                     |
| No. of axis   | 6   |

#### Data Acquisition Electronic (DAE) System

##### Cell Controller

|                  |                        |
|------------------|------------------------|
| Processor        | Intel Core i7-3770     |
| Clock Speed      | 3.40 GHz               |
| Operating System | Windows 7 Professional |
| Data Card        | DASY5 PC-Board         |

##### Data Converter

|                  |  |
|------------------|--|
| Features         | Signal, multiplexer, A/D converter. & control logic                                |
| Software         | DASY5  |
| Connecting Lines | Optical downlink for data and status info<br>Optical uplink for commands and clock |

##### PC Interface Card

|          |  |
|----------|--|
| Function | 24 bit (64 MHz) DSP for real time processing<br>Link to DAE 4<br>16 bit A/D converter for surface detection system<br>serial link to robot<br>direct emergency stop output for robot |
|----------|--|

##### E-Field Probes

|              |  |
|--------------|--|
| Model        | EX3DV4 S/N: 3933                             |
| Construction | Triangular core fiber optic detection system |
| Frequency    | 10 MHz to 6 GHz                              |
| Linearity    | $\pm 0.2$ dB (30 MHz to 6 GHz)               |

##### Phantom

|                |                               |
|----------------|-------------------------------|
| Phantom        | ELI Phantom (V5.0)            |
| Shell Material | Composite                     |
| Thickness      | $2 \pm 0.2$ mm (bottom plate) |



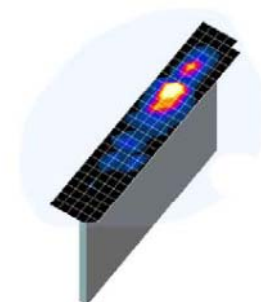
Figure 2.2 DASY5 Test System

## 5. SAR MEASUREMENT PROCEDURE

### 5.1 Measurement Procedure

The evaluation was performed using the following procedure compliant to FCC KDB Publication 865664 D01v01r03 and IEEE 1528-2013:

1. The SAR distribution at the exposed side of the head or body was measured at a distance no greater than 5.0 mm from the inner surface of the shell. The area covered the entire dimension of the device-head and body interface and the horizontal grid resolution was determined per FCC KDB Publication 865664 D01v01r03 (See Table 5-1) and IEEE 1528-2013.
2. The point SAR measurement was taken at the maximum SAR region determined from Step 1 to enable the monitoring of SAR fluctuations/drifts during the 1g/10g cube evaluation. SAR at this fixed point was measured and used as a reference value.
3. Based on the area scan data, the peak of the region with maximum SAR was determined by spline interpolation. Around this point, a volume was assessed according to the measurement resolution and volume size requirements of FCC KDB Publication 865664 D01v01r03 (See Table 5-1) and IEEE 1528-2013. On the basis of this data set, the spatial peak SAR value was evaluated with the following procedure (see references or the DASY manual online for more details):
  - a. SAR values at the inner surface of the phantom are extrapolated from the measured values along the line away from the surface with spacing no greater than that in Table 3-1. The extrapolation was based on a least-squares algorithm. A polynomial of the fourth order was calculated through the points in the z-axis (normal to the phantom shell).
  - b. After the maximum interpolated values were calculated between the points in the cube, the SAR was averaged over the spatial volume (1g or 10g) using a 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines with the “Not a knot” condition (in x, y, and z directions). The volume was then integrated with the trapezoidal algorithm. One thousand points (10 x 10 x 10) were obtained through interpolation, in order to calculate the averaged SAR.
  - c. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.
4. The SAR reference value, at the same location as step 2, was re-measured after the zoom scan was complete to calculate the SAR drift. If the drift deviated by more than 5%, the SAR test and drift measurements were repeated.



**Figure 5.1**  
Sample SAR Area Scan

| Frequency    | Maximum Area Scan Resolution (mm)<br>( $\Delta x_{\text{area}}, \Delta y_{\text{area}}$ ) | Maximum Zoom Scan Resolution (mm)<br>( $\Delta x_{\text{zoom}}, \Delta y_{\text{zoom}}$ ) | Maximum Zoom Scan Spatial Resolution (mm) |                               |  | Minimum Zoom Scan Volume (mm)<br>(x,y,z) |
|--------------|---|---|---|-------------------------------|--|--|
|              |   |   | Uniform Grid                              | Graded Grid                   |  |  |
|              |   |   | $\Delta z_{\text{zoom}}(n)$               | $\Delta z_{\text{zoom}}(1)^*$ | $\Delta z_{\text{zoom}}(n>1)^*$          |  |
| $\leq 2$ GHz | $\leq 15$   | $\leq 8$  | $\leq 5$                                  | $\leq 4$                      | $\leq 1.5^* \Delta z_{\text{zoom}}(n-1)$ | $\geq 30$                                |
| 2-3 GHz      | $\leq 12$   | $\leq 5$  | $\leq 5$                                  | $\leq 4$                      | $\leq 1.5^* \Delta z_{\text{zoom}}(n-1)$ | $\geq 30$                                |
| 3-4 GHz      | $\leq 12$   | $\leq 5$  | $\leq 4$                                  | $\leq 3$                      | $\leq 1.5^* \Delta z_{\text{zoom}}(n-1)$ | $\geq 28$                                |
| 4-5 GHz      | $\leq 10$   | $\leq 4$  | $\leq 3$                                  | $\leq 2.5$                    | $\leq 1.5^* \Delta z_{\text{zoom}}(n-1)$ | $\geq 25$                                |
| 5-6 GHz      | $\leq 10$   | $\leq 4$  | $\leq 2$                                  | $\leq 2$                      | $\leq 1.5^* \Delta z_{\text{zoom}}(n-1)$ | $\geq 22$                                |

**Table 5.1 Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01v01r03\***

\*Also compliant to IEEE 1528-2013 Table 6

## 6. TEST CONFIGURATION POSITIONS FOR HANDSETS

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### 6.1 Device Holder

The device holder is made out of low-loss POM material having the following dielectric parameters: relative permittivity  $\epsilon = 3$  and loss tangent  $\delta = 0.02$ .

### 6.2 Head Exposure Configurations

Transmitters that are built-in within a wrist watch or similar wrist-worn devices typically operate in speaker mode for voice communication, with the device worn on the wrist and positioned next to the mouth. Next to the mouth exposure requires 1-g SAR, and the wrist-worn condition requires 10-g extremity SAR. The 10-g extremity and 1-g SAR test exclusions may be applied to the wrist and face exposure conditions. When SAR evaluation is required, next to the mouth use is evaluated with the front of the device positioned at 10 mm from a flat phantom filled with head tissue-equivalent medium. The face exposure condition procedures in FCC KDB Publication 447498 D01v05r02 should be used to test for face exposure condition SAR compliance.

### 6.3 Extremity Exposure Configurations

Devices that are designed or intended for use on extremities or mainly operated in extremity only exposure conditions; i.e., hands, wrists, feet and ankles, may require extremity SAR evaluation. When the device also operates in close proximity to the user's body, SAR compliance for the body is also required. The 1-g body and 10-g extremity SAR Exclusion Thresholds found in KDB Publication 447498 D01v05r02 should be applied to determine SAR test requirements.

## 7. RF EXPOSURE LIMITS

### Uncontrolled Environment:

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

### Controlled Environment:

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

**Table 7.1.SAR Human Exposure Specified in ANSI/IEEE C95.1-2005**

|  | HUMAN EXPOSURE LIMITS                       |   |
|--|---|---|
|  | General Public Exposure<br>(W/kg) or (mW/g) | Occupational Exposure<br>(W/kg) or (mW/g) |
| SPATIAL PEAK SAR *<br>(Brain)                          | 1.60  | 8.00                                      |
| SPATIAL AVERAGE SAR **<br>(Whole Body)                 | 0.08  | 0.40                                      |
| SPATIAL PEAK SAR ***<br>(Hands / Feet / Ankle / Wrist) | 4.00  | 20.0                                      |

1. 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 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 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

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

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

## 8. FCC MEASUREMENT PROCEDURES

Power measurements were performed using a base station simulator under digital average power.

### 8.1 Measured and Reported SAR

Per FCC KDB Publication 447498 D01v05r02, When SAR is not measured at the maximum power level allowed for production units, the results must be scaled to the maximum tune-up tolerance limit according to the power applied to the individual channels tested to determine compliance. For simultaneous transmission, the measured aggregate SAR must be scaled according to the sum of the differences between the maximum tune-up tolerance and actual power used to test each transmitter. When SAR is measured at or scaled to the maximum tune-up tolerance limit, the results are referred to as reported SAR. The highest reported SAR results are identified on the grant of equipment authorization according to procedures in KDB 690783 D01v01r03.

### 8.2 Procedures Used to Establish RF Signal for SAR

The following procedures are according to FCC KDB Publication 941225 D01 "3G SAR Procedures" v03, October 16, 2014.

The device was placed into a simulated call using a base station simulator in a RF shielded chamber. Establishing connections in this manner ensure a consistent means for testing SAR and are recommended for evaluating SAR [4]. Devices under test were evaluated prior to testing, with a fully charged battery and were configured to operate at maximum output power. In order to verify that the device was tested throughout the SAR test at maximum output power, the SAR measurement system measures a "point SAR" at an arbitrary reference point at the start and end of the 1 gram SAR evaluation, to assess for any power drifts during the evaluation. If the power drift deviated by more than 5%, the SAR test and drift measurements were repeated.

### 8.3 SAR Measurement Conditions for CDMA2000

The following procedures were performed according to FCC KDB Publication 941225 D01 "3G SAR Procedures" v03, October 16, 2014.

#### 8.3.1 Output Power Verification

See 3GPP2 C.S0011/TIA-98-E as recommended by "SAR Measurement Procedures for 3G Devices" v02, October 2007. Maximum output power is verified on the High, Middle and Low channels according to procedures in section 4.4.5.2 of 3GPP2 C.S0011/TIA-98-E. SO55 tests were measured with power control bits in the "All Up" condition.

1. If the mobile station (MS) supports Reverse TCH RC 1 and Forward TCH RC 1, set up a call using Fundamental Channel Test Mode 1 (RC=1/1) with 9600 bps data rate only.
2. Under RC1, C.S0011 Table 4.4.5.2-1, Table 11-1 parameters were applied.
3. If the MS supports the RC 3 Reverse FCH, RC3 Reverse SCH0 and demodulation of RC 3, 4, or 5, set up a call using Supplemental Channel Test Mode 3 (RC 3/3) with 9600 bps Fundamental Channel and 9600 bps SCH0 data rate.
4. Under RC3, C.S0011 Table 4.4.5.2-2, Table 11-2 was applied.

**Parameters for Max. Power for RC1**

| Parameter                    | Units        | Value |
|------------------------------|--------------|-------|
| $I_{or}$                     | dBm/1.23 MHz | -104  |
| $\frac{Pilot E_c}{I_{or}}$   | dB           | -7    |
| $\frac{Traffic E_c}{I_{or}}$ | dB           | -7.4  |

**Table 11-1**

**Parameters for Max. Power for RC3**

| Parameter                    | Units        | Value |
|------------------------------|--------------|-------|
| $I_{or}$                     | dBm/1.23 MHz | -86   |
| $\frac{Pilot E_c}{I_{or}}$   | dB           | -7    |
| $\frac{Traffic E_c}{I_{or}}$ | dB           | -7.4  |

**Table 11-2**

5. FCHs were configured at full rate for maximum SAR with "All Up" power control bits.



### 8.3.2 CDMA 2000 1x Advanced

This device additionally supports 1x Advanced. Conducted powers were measured using SO75 with RC8 on the uplink and RC11 on the downlink per Oct 2012 TCB Workshop notes. Smart blanking was disabled for all measurements. The EUT was configured with forward power control Mode 000 and reverse power control at 400 bps. Conducted powers were measured on an Agilent 8960 Series 10 Wireless Communications Test Set, Model E5515C using the CDMA2000 1x Advanced application, Option E1962B-410.

Based on the maximum output power measured for 1x Advanced, SAR is required for 1x advanced when if the maximum output for 1x Advanced is more than 0.25 dB higher than the maximum measured for 1x. Also, if the measured SAR in any 1x mode exposure conditions (head, body etc.) is larger than 1.2 W/kg, the highest of those configurations above 1.2 W/kg for each exposure condition in 1x Advanced has to be repeated. All measured SAR in 1x mode higher than 1.5 W/kg must be repeated for 1x Advanced.

## 8.4 SAR Testing with 802.11 Transmitters

Normal network operating configurations are not suitable for measuring the SAR of 802.11 b/g/n transmitters. Unpredictable fluctuations in network traffic and antenna diversity conditions can introduce undesirable variations in SAR results. The SAR for these devices should be measured using chipset based test mode software to ensure the results are consistent and reliable. See KDB Publication 248227 D01v02r01 for more details.

### 8.4.1 General Device Setup

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

A periodic duty factor is required for current generation SAR systems to measure SAR. When 802.11 frame gaps are accounted for in the transmission, a maximum transmission duty factor of 92 - 96 % is typically achievable in most test mode configurations. A minimum transmission duty factor of 85% is required to avoid certain hardware and device implementation issues related to wide range SAR scaling. The reported SAR is scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

### 8.4.2 Initial Test Position Procedure

For exposure conditions with multiple test positions, such as handset operating next to the ear, devices with hotspot mode or UMPC mini-tablet, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all position in an exposure condition. The test position with the highest extrapolated (peak) SAR is used as the initial test position. When reported SAR for the initial test position is  $\leq 0.4$  W/kg, no additional testing for the remaining test positions is required. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is  $\leq 0.8$  W/kg or all test position are measured.



### 8.4.3 2.4 GHz SAR Test Requirements

SAR is measured for 2.4 GHz 802.11b DSSS using either a fixed test position or, when applicable, the initial test position procedure. SAR test reduction is determined according to the following:

- 1) When the reported SAR of the highest measured maximum output power channel for the exposure configuration is  $\leq 0.8$  W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.
- 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.

2.4 GHz 802.11 g/n OFDM are additionally evaluated for SAR if the highest reported SAR for 802.11b, adjusted by the ratio of the OFDM to DSSS specified maximum output power is  $> 1.2$  W/kg. When SAR is required for OFDM modes in 2.4 GHz band, the Initial Test Configuration Procedures should be followed.

### 8.4.4 OFDM Transmission Mode and SAR Test Channel Selection

For the 2.4 GHz bands, when the same maximum output power was specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration with the largest channel bandwidth, lowest order modulation and lowest data rate. When the maximum output power of a channel is the same for equivalent OFDM configurations; for example, 802.11n with the same channel bandwidth, modulation and data rate etc., the lower order 802.11 mode i.e., 802.11g then 802.11n is used for SAR measurement. When the maximum output power were the same for multiple test channels, either according to the default or additional power measurement requirements, SAR is measured using the channel closest to the middle of the frequency band or aggregated band. When there are multiple channels with the same maximum output power, SAR is measured using the higher number channel.

### 8.4.5 Initial Test Configuration Procedure

For OFDM, in both 2.4 bands, an initial test configuration is determined for each frequency band and aggregated band, according to the transmission mode with the highest maximum output power specified for SAR measurements. When the same maximum output is specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration(s) with the largest channel bandwidth, lowest order modulation, and lowest data rate. The channel of the transmission mode with the highest average RF output conducted power will be the initial test configuration.

### 8.4.6 Subsequent Test Configuration Procedures

For OFDM configurations, in each frequency band and aggregated band, SAR is evaluated for initial test configuration using the fixed test position or the initial test position procedure, when applicable. When the highest reported SAR for the initial test configuration, adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power is  $\leq 1.2$  W/kg, no additional SAR testing for the subsequent test configurations is required.

## 9. RF CONDUCTED POWERS

### 9.1 CDMA Conducted Powers

| Band     | Channel | TDSO<br>SO32<br>FCH | TDSO<br>SO32<br>FCH+SCHn | 1xEVDO<br>Rev.0 | 1xEVDO<br>Rev.0 | 1xEVDO<br>Rev. A | 1xEVDO<br>Rev. A |
|----------|---------|---------------------|--------------------------|-----------------|-----------------|------------------|------------------|
|          |         | RC3                 | RC3                      | (FTAP)          | (RTAP)          | (FETAP)          | (RETAP)          |
| Cellular | 1013    | 24.29               | 24.25                    | 24.28           | 24.22           | 24.20            | 24.19            |
|          | 384     | 24.81               | 24.79                    | 24.63           | 24.57           | 24.55            | 24.55            |
|          | 777     | 24.28               | 24.21                    | 24.25           | 24.31           | 24.29            | 24.28            |
| PCS      | 20      | 23.97               | 23.90                    | 23.76           | 23.72           | 23.71            | 23.70            |
|          | 600     | 23.95               | 23.89                    | 23.87           | 23.81           | 23.79            | 23.78            |
|          | 1175    | 23.89               | 23.81                    | 23.93           | 23.88           | 23.86            | 23.86            |

Table 9.1 The power was measured by E5515C

Per KDB Publication 941225 D01v03:

1. Head and Hand SAR was tested with 1x RTT with TDSO / SO32 FCH Only. Ev-Do and TDSO / SO32 FCH+SCH SAR tests were not required since the average output power was not more than 0.25 dB higher than the TDSO / SO32 FCH only powers.



Figure 9.1 Power Measurement Setup

## 9.2 WLAN Conducted Powers

| Mode    | Freq. | Channel | 802.11b (2.4 GHz) Conducted Power (dBm) |       |       |       |
|---------|-------|---------|---|-------|-------|-------|
|         |       |         | Data Rate (Mbps)                        |       |       |       |
|         | (MHz) |         | 1                                       | 2     | 5.5   | 11    |
| 802.11b | 2412  | 1       | 15.45                                   | 15.40 | 15.31 | 15.29 |
|         | 2437  | 6       | 15.54                                   | 15.47 | 15.42 | 15.37 |
|         | 2462  | 11      | <u>15.68</u>                            | 15.60 | 15.56 | 15.62 |

Table 9.2 IEEE 802.11b Average RF Power

| Mode    | Freq. | Channel | 802.11g (2.4 GHz) Conducted Power (dBm) |       |       |       |       |       |       |       |
|---------|-------|---------|---|-------|-------|-------|-------|-------|-------|-------|
|         |       |         | Data Rate (Mbps)                        |       |       |       |       |       |       |       |
|         | (MHz) |         | 6                                       | 9     | 12    | 18    | 24    | 36    | 48    | 54    |
| 802.11g | 2412  | 1       | 15.19                                   | 15.05 | 15.11 | 15.01 | 14.94 | 15.06 | 14.97 | 15.12 |
|         | 2437  | 6       | 15.23                                   | 15.10 | 14.97 | 15.09 | 15.19 | 15.08 | 15.04 | 15.18 |
|         | 2462  | 11      | 15.36                                   | 15.21 | 15.20 | 15.32 | 15.28 | 15.18 | 15.11 | 15.24 |

Table 9.3 IEEE 802.11g Average RF Power

| Mode               | Freq. | Channel | 802.11n HT20 (2.4 GHz) Conducted Power (dBm) |       |       |       |       |       |       |       |
|--------------------|-------|---------|--|-------|-------|-------|-------|-------|-------|-------|
|                    |       |         | Data Rate (Mbps)                             |       |       |       |       |       |       |       |
|                    | (MHz) |         | 6.5  | 13    | 19.5  | 26    | 39    | 52    | 58.5  | 65    |
| 802.11n<br>(HT-20) | 2412  | 1       | 15.04  | 14.92 | 14.97 | 14.90 | 14.80 | 14.91 | 15.01 | 14.89 |
|                    | 2437  | 6       | 15.22  | 15.10 | 15.14 | 15.06 | 15.08 | 15.11 | 15.20 | 14.96 |
|                    | 2462  | 11      | 15.30  | 15.22 | 15.28 | 15.16 | 15.04 | 15.18 | 15.24 | 15.17 |

Table 9.4 IEEE 802.11n HT20 Average RF Power

Justification for reduced test configurations for WIFI channels per KDB Publication 248227 D01v02r01 and October 2012 / April 2013 FCC/TCB Meeting Notes:

- Power measurements were performed for the transmission mode configuration with the highest maximum output power specified for production units.
- For transmission modes with the same maximum output power specification, powers were measured for the largest channel bandwidth, lowest order modulation and lowest data rate.
- For transmission modes with identical maximum specified output power, channel bandwidth, modulation and data rates, power measurements were required for all identical configurations.
- For each transmission mode configuration, powers were measured for the highest and lowest channels; and at the mid-band channel(s) when there were at least 3 channels supported. For configurations with multiple mid-band channels, due to an even number of channels, both channels were measured.
- Output Power and SAR is not required for 802.11 g/n HT20 channels when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjust SAR is  $\leq 1.2$  W/kg.
- The underlined data rate and channel above were tested for SAR.

The average output powers of this device were tested by below configuration.

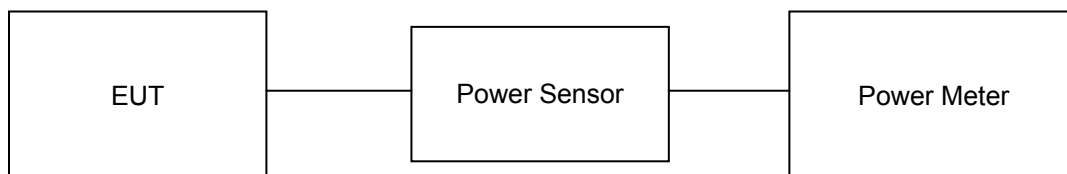


Figure 9.2 Power Measurement Setup

### 9.3 Bluetooth Conducted Powers

| Channel | Frequency | Frame AVG Output Power (1Mbps) |             | Frame AVG Output Power (2Mbps) |      | Frame AVG Output Power (3Mbps) |      |
|---------|-----------|--------------------------------|-------------|--------------------------------|------|--------------------------------|------|
|         | (MHz)     | (dBm)                          | (mW)        | (dBm)                          | (mW) | (dBm)                          | (mW) |
| Low     | 2402      | 2.46                           | 1.76        | -2.15                          | 0.61 | -2.08                          | 0.62 |
| Mid     | 2441      | <b>2.72</b>                    | <b>1.87</b> | -1.94                          | 0.64 | -1.87                          | 0.65 |
| High    | 2480      | 2.58                           | 1.81        | -2.08                          | 0.62 | -2.01                          | 0.63 |

Table 9.5 Bluetooth Frame Average RF Power

**Note:**

The average conducted output powers of Bluetooth were measured using following test setup and a wideband gated RF power meter when the EUT is transmitting at its maximum power level.

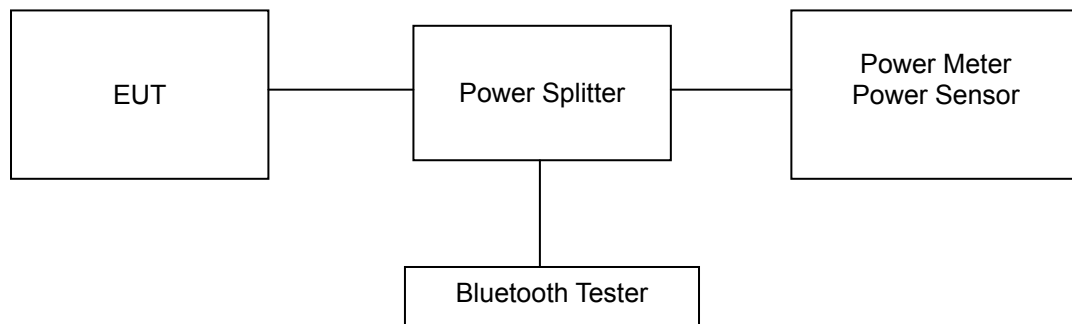


Figure 9.3 Power Measurement Setup

## 10. SYSTEM VERIFICATION

### 10.1 Tissue Verification

| MEASURED TISSUE PARAMETERS |             |                   |                  |                          |  |                                     |  |                                       |                  |                        |
|----------------------------|-------------|-------------------|------------------|--------------------------|--|-------------------------------------|--|---------------------------------------|------------------|------------------------|
| Date(s)                    | Tissue Type | Ambient Temp.[°C] | Liquid Temp.[°C] | Measured Frequency [MHz] | Target Dielectric Constant, $\epsilon_r$ | Target Conductivity, $\sigma$ (S/m) | Measured Dielectric Constant, $\epsilon_r$ | Measured Conductivity, $\sigma$ (S/m) | Er Deviation [%] | $\sigma$ Deviation [%] |
| Apr. 15. 2015              | 835 Body    | 21.1              | 21.6             | 824.7                    | 55.230                                   | 0.969                               | 55.573                                     | 0.993                                 | 0.62             | 2.48                   |
|                            |             |                   |                  | 835.0                    | 55.200                                   | 0.970                               | 55.554                                     | 1.001                                 | 0.64             | 3.20                   |
|                            |             |                   |                  | 836.5                    | 55.195                                   | 0.972                               | 55.550                                     | 1.003                                 | 0.64             | 3.19                   |
|                            |             |                   |                  | 848.3                    | 55.160                                   | 0.984                               | 55.532                                     | 1.013                                 | 0.67             | 2.95                   |
| Apr. 20. 2015              | 1900 Body   | 21.2              | 21.8             | 1851.3                   | 53.300                                   | 1.520                               | 51.877                                     | 1.475                                 | -2.67            | -2.96                  |
|                            |             |                   |                  | 1880.0                   | 53.300                                   | 1.520                               | 51.849                                     | 1.501                                 | -2.72            | -1.25                  |
|                            |             |                   |                  | 1900.0                   | 53.300                                   | 1.520                               | 51.835                                     | 1.520                                 | -2.75            | 0.00                   |
|                            |             |                   |                  | 1908.8                   | 53.300                                   | 1.520                               | 51.825                                     | 1.528                                 | -2.77            | 0.53                   |
| Apr. 21. 2015              | 2450 Body   | 20.8              | 21.4             | 2412                     | 52.751                                   | 1.914                               | 52.359                                     | 1.900                                 | -0.74            | -0.73                  |
|                            |             |                   |                  | 2437                     | 52.717                                   | 1.938                               | 52.302                                     | 1.930                                 | -0.79            | -0.41                  |
|                            |             |                   |                  | 2450                     | 52.700                                   | 1.950                               | 52.272                                     | 1.946                                 | -0.81            | -0.21                  |
|                            |             |                   |                  | 2462                     | 52.685                                   | 1.967                               | 52.250                                     | 1.960                                 | -0.83            | -0.36                  |
| Aug.24. 2015               | 835 Head    | 21.2              | 21.6             | 824.7                    | 41.540                                   | 0.899                               | 41.245                                     | 0.877                                 | -0.71            | -2.45                  |
|                            |             |                   |                  | 835.0                    | 41.500                                   | 0.900                               | 41.198                                     | 0.887                                 | -0.73            | -1.44                  |
|                            |             |                   |                  | 836.5                    | 41.500                                   | 0.902                               | 41.184                                     | 0.889                                 | -0.76            | -1.44                  |
|                            |             |                   |                  | 848.3                    | 41.500                                   | 0.912                               | 41.108                                     | 0.900                                 | -0.94            | -1.32                  |
| Aug.24. 2015               | 1900 Head   | 21.2              | 21.8             | 1851.3                   | 40.000                                   | 1.400                               | 38.922                                     | 1.356                                 | -2.70            | -3.14                  |
|                            |             |                   |                  | 1880.0                   | 40.000                                   | 1.400                               | 38.780                                     | 1.385                                 | -3.05            | -1.07                  |
|                            |             |                   |                  | 1900.0                   | 40.000                                   | 1.400                               | 38.712                                     | 1.406                                 | -3.22            | 0.43                   |
|                            |             |                   |                  | 1908.8                   | 40.000                                   | 1.400                               | 38.674                                     | 1.415                                 | -3.32            | 1.07                   |
| Aug.24. 2015               | 2450 Head   | 21.2              | 21.7             | 2412                     | 39.265                                   | 1.766                               | 38.583                                     | 1.787                                 | -1.74            | 1.19                   |
|                            |             |                   |                  | 2437                     | 39.222                                   | 1.788                               | 38.520                                     | 1.813                                 | -1.79            | 1.40                   |
|                            |             |                   |                  | 2450                     | 39.200                                   | 1.800                               | 38.480                                     | 1.828                                 | -1.84            | 1.56                   |
|                            |             |                   |                  | 2462                     | 39.184                                   | 1.813                               | 38.454                                     | 1.841                                 | -1.86            | 1.54                   |

The above measured tissue parameters were used in the DASY software. The DASY software was used to perform interpolation to determine the dielectric parameters at the SAR test device frequencies (per KDB 865664 and IEEE 1528-2013 6.6.1.2). The tissue parameters listed in the SAR test plots may slightly differ from the table above due to significant digit rounding in the software.

#### Measurement Procedure for Tissue verification:

- 1) The network analyzer and probe system was configured and calibrated.
- 2) The probe was immersed in the sample which was placed in a nonmetallic container. Trapped air bubbles beneath the flange were minimized by placing the probe at a slight angle.
- 3) The complex admittance with respect to the probe aperture was measured
- 4) The complex relative permittivity, for example from the below equation (Pournaropoulos and Misra):

$$Y = \frac{j2\omega\epsilon_r\epsilon_0}{[\ln(b/a)]^2} \int_a^b \int_a^b \int_0^\pi \cos\phi' \frac{\exp[-j\omega r(\mu_0\epsilon_r'\epsilon_0)^{1/2}]}{r} d\phi' d\rho' d\rho$$

where Y is the admittance of the probe in contact with the sample, the primed and unprimed coordinates refer to source and observation points, respectively,  $r^2 = \rho^2 + \rho'^2 - 2\rho\rho'\cos\phi'$ ,  $\omega$  is the angular frequency, and  $j = \sqrt{-1}$ .

## 10.2 Test System Verification

Prior to assessment, the system is verified to the  $\pm 10\%$  of the specifications at 835 MHz, 1900 MHz and 2450 MHz by using the SAR Dipole kit(s). (Graphic Plots Attached)

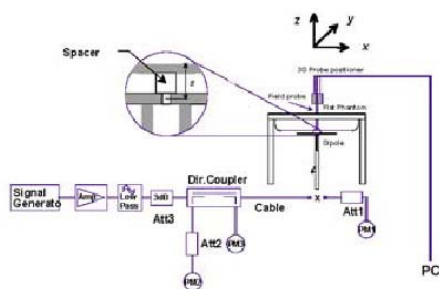
**Table 10.2 System Verification Results**

| SYSTEM DIPOLE VERIFICATION TARGET & MEASURED |             |                    |               |             |                    |                   |           |                  |                      |                     |                           |               |
|--|-------------|--------------------|---------------|-------------|--------------------|-------------------|-----------|------------------|----------------------|---------------------|---------------------------|---------------|
| SAR System #                                 | Freq. [MHz] | SAR Dipole kits    | Date(s)       | Tissue Type | Ambient Temp. [°C] | Liquid Temp. [°C] | Probe S/N | Input Power (mW) | 1W Target SAR (W/kg) | Measured SAR (W/kg) | 1 W Normalized SAR (W/kg) | Deviation [%] |
| D  | 835         | D835V2, SN: 4d159  | Apr. 15. 2015 | Body        | 21.1               | 21.6              | 3933      | 250              | 6.35                 | 1.53                | 6.12                      | -3.62         |
| D  | 1900        | D1900V2, SN: 5d176 | Apr. 20. 2015 | Body        | 21.2               | 21.8              | 3933      | 250              | 21.2                 | 5.55                | 22.20                     | 4.72          |
| D  | 2450        | D2450V2, SN: 920   | Apr. 21. 2015 | Body        | 20.8               | 21.4              | 3933      | 250              | 23.9                 | 5.75                | 23.00                     | -3.77         |
| D  | 835         | D835V2, SN:4d159   | Aug.24.2015   | Head        | 21.2               | 21.6              | 3933      | 250              | 9.19                 | 2.33                | 9.32                      | 1.41          |
| D  | 1900        | D1900V2, SN: 5d176 | Aug.24.2015   | Head        | 21.2               | 21.8              | 3933      | 250              | 40.1                 | 9.56                | 38.24                     | -4.64         |
| D  | 2450        | D2450V2, SN:920    | Aug.24.2015   | Head        | 21.2               | 21.7              | 3933      | 250              | 52.7                 | 13.60               | 54.40                     | 3.23          |

Note1 : System Verification was measured with input 250 mW and normalized to 1W.

Note2 : To confirm the proper SAR liquid depth, the z-axis plots from the system verifications were included since the system verifications were performed using the same liquid, probe and DAE as the SAR tests in the same time period.

Note3: Full system validation status and results can be found in Attachment 3.



**Figure 11.1 Dipole Verification Test Setup Diagram & Photo**

## 11. SAR TEST RESULTS

### 11.1 Hand SAR Results

Table 11.1 CDMA Hand SAR

| MEASUREMENT RESULTS   |     |               |                     |                                      |                             |                        |                    |   |                       |               |                      |                   |                                |            |
|---|-----|---------------|---------------------|--------------------------------------|-----------------------------|------------------------|--------------------|---|-----------------------|---------------|----------------------|-------------------|--------------------------------|------------|
| FREQUENCY   |     | Mode/<br>Band | Service             | Maximum<br>Allowed<br>Power<br>[dBm] | Conducted<br>Power<br>[dBm] | Drift<br>Power<br>[dB] | Spacing<br>[Side]  | Device<br>Serial<br>Number                            | # of<br>Time<br>Slots | Duty<br>Cycle | 10g<br>SAR<br>(W/kg) | Scaling<br>Factor | 10g<br>Scaled<br>SAR<br>(W/kg) | Plots<br># |
| MHz   | Ch  |               |                     |                                      |                             |                        |                    |   |                       |               |                      |                   |                                |            |
| 836.5   | 384 | CDMA 850      | TDSO<br>SO32<br>FCH | 25.0                                 | 24.81                       | -0.040                 | 0 mm<br>[Top #1]   | FCC #1  | N/A                   | 1:1           | 0.119                | 1.045             | 0.124                          |            |
| 836.5   | 384 | CDMA 850      | TDSO<br>SO32<br>FCH | 25.0                                 | 24.81                       | 0.060                  | 0 mm<br>[Top #2]   | FCC #1  | N/A                   | 1:1           | 0.099                | 1.045             | 0.103                          |            |
| 836.5   | 384 | CDMA 850      | TDSO<br>SO32<br>FCH | 25.0                                 | 24.81                       | -0.040                 | 0 mm<br>[Front #1] | FCC #1  | N/A                   | 1:1           | 0.262                | 1.045             | 0.274                          |            |
| 836.5   | 384 | CDMA 850      | TDSO<br>SO32<br>FCH | 25.0                                 | 24.81                       | -0.030                 | 0 mm<br>[Front #2] | FCC #1  | N/A                   | 1:1           | 0.189                | 1.045             | 0.198                          |            |
| 836.5   | 384 | CDMA 850      | TDSO<br>SO32<br>FCH | 25.0                                 | 24.81                       | -0.010                 | 0 mm<br>[Rear]     | FCC #1  | N/A                   | 1:1           | 0.393                | 1.045             | 0.411                          |            |
| 836.5   | 384 | CDMA 850      | TDSO<br>SO32<br>FCH | 25.0                                 | 24.81                       | 0.060                  | 0 mm<br>[Right #1] | FCC #1  | N/A                   | 1:1           | 0.408                | 1.045             | 0.426                          | A1         |
| 836.5   | 384 | CDMA 850      | TDSO<br>SO32<br>FCH | 25.0                                 | 24.81                       | 0.090                  | 0 mm<br>[Right #2] | FCC #1  | N/A                   | 1:1           | 0.367                | 1.045             | 0.384                          |            |
| 836.5   | 384 | CDMA 850      | TDSO<br>SO32<br>FCH | 25.0                                 | 24.81                       | 0.040                  | 0 mm<br>[Left #1]  | FCC #1  | N/A                   | 1:1           | 0.024                | 1.045             | 0.025                          |            |
| 836.5   | 384 | CDMA 850      | TDSO<br>SO32<br>FCH | 25.0                                 | 24.81                       | 0.040                  | 0 mm<br>[Left #2]  | FCC #1  | N/A                   | 1:1           | 0.021                | 1.045             | 0.022                          |            |
| 1880.0  | 600 | CDMA 1900     | TDSO<br>SO32<br>FCH | 24.1                                 | 23.95                       | 0.040                  | 0 mm<br>[Top #1]   | FCC #1  | N/A                   | 1:1           | 0.183                | 1.035             | 0.189                          |            |
| 1880.0  | 600 | CDMA 1900     | TDSO<br>SO32<br>FCH | 24.1                                 | 23.95                       | -0.010                 | 0 mm<br>[Top #2]   | FCC #1  | N/A                   | 1:1           | 0.116                | 1.035             | 0.120                          |            |
| 1880.0  | 600 | CDMA 1900     | TDSO<br>SO32<br>FCH | 24.1                                 | 23.95                       | 0.050                  | 0 mm<br>[Front #1] | FCC #1  | N/A                   | 1:1           | 0.104                | 1.035             | 0.108                          |            |
| 1880.0  | 600 | CDMA 1900     | TDSO<br>SO32<br>FCH | 24.1                                 | 23.95                       | -0.140                 | 0 mm<br>[Front #2] | FCC #1  | N/A                   | 1:1           | 0.117                | 1.035             | 0.121                          |            |
| 1880.0  | 600 | CDMA 1900     | TDSO<br>SO32<br>FCH | 24.1                                 | 23.95                       | -0.050                 | 0 mm<br>[Rear]     | FCC #1  | N/A                   | 1:1           | 0.449                | 1.035             | 0.465                          |            |
| 1880.0  | 600 | CDMA 1900     | TDSO<br>SO32<br>FCH | 24.1                                 | 23.95                       | -0.180                 | 0 mm<br>[Right #1] | FCC #1  | N/A                   | 1:1           | 1.500                | 1.035             | 1.553                          | A2         |
| 1880.0  | 600 | CDMA 1900     | TDSO<br>SO32<br>FCH | 24.1                                 | 23.95                       | 0.090                  | 0 mm<br>[Right #2] | FCC #1  | N/A                   | 1:1           | 1.400                | 1.035             | 1.449                          |            |
| ANSI / IEEE C95.1-2005- SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population Exposure |     |               |                     |                                      |                             |                        |                    | Extremity<br>4.0 W/kg (mW/g)<br>averaged over 10 gram |                       |               |                      |                   |                                |            |

Note: Top, Front, Right, Left configuration tested twice. Refer to Test photo (SAR).

Table 11.2 DTS (2.4G) Hand SAR

## MEASUREMENT RESULTS

| FREQUENCY   |    | Mode/<br>Antenna | Service | Maximum<br>Allowed<br>Power<br>[dBm] | Conducted<br>Power<br>[dBm] | Drift Power<br>[dB] | Phantom<br>Position | Device<br>Serial<br>Number | Data<br>Rate<br>[Mbps]                                | Duty<br>Cycle | Area<br>SAR<br>(W/kg) | 10g<br>SAR<br>(W/kg) | Scaling<br>Factor<br>(Power) | Scaling<br>Factor<br>(Duty<br>Cycle) | 10g<br>Scaled<br>SAR<br>(W/kg) | Plots<br># |
|---|----|------------------|---------|--------------------------------------|-----------------------------|---------------------|---------------------|----------------------------|---|---------------|-----------------------|----------------------|------------------------------|--------------------------------------|--------------------------------|------------|
| MHz   | Ch |                  |         |                                      |                             |                     |                     |                            |   |               |                       |                      |                              |                                      |                                |            |
| 2462  | 11 | 802.11b          | DSSS    | 15.70                                | 15.68                       | -0.150              | 0 mm<br>[Front #1]  | FCC #1                     | 1   | 89.3          | 0.146                 | 0.152                | 1.005                        | 1.120                                | 0.171                          | A3         |
| 2462  | 11 | 802.11b          | DSSS    | 15.70                                | 15.68                       | -0.040              | 0 mm<br>[Front #2]  | FCC #1                     | 1   | 89.3          | 0.0475                | -                    | 1.005                        | 1.120                                | -                              |            |
| 2462  | 11 | 802.11b          | DSSS    | 15.70                                | 15.68                       | 0.060               | 0 mm<br>[Rear]      | FCC #1                     | 1   | 89.3          | 0.0191                | -                    | 1.005                        | 1.120                                | -                              |            |
| ANSI / IEEE C95.1-2005– SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population Exposure |    |                  |         |                                      |                             |                     |                     |                            | Extremity<br>4.0 W/kg (mW/g)<br>averaged over 10 gram |               |                       |                      |                              |                                      |                                |            |

Note(s):

- Highest reported SAR is  $\leq 0.4$  W/kg. Therefore, further SAR measurements within this exposure condition are not required.
- Front configuration tested twice. Refer to Test photo (SAR).

## Adjusted SAR results for OFDM SAR

| FREQUENCY   |    | Mode/ Antenna | Service | Maximum<br>Allowed<br>Power<br>[dBm] | 1g<br>Scaled<br>SAR<br>(W/kg) | FREQUENCY<br>[MHz] | Mode  | Service | Maximum<br>Allowed<br>Power<br>[dBm] | Ratio of<br>OFDM to<br>DSSS | 1g<br>Adjusted<br>SAR<br>(W/kg) | Determine OFDM<br>SAR |
|---|----|---------------|---------|--------------------------------------|-------------------------------|--------------------|---|---------|--------------------------------------|-----------------------------|---------------------------------|-----------------------|
| MHz   | Ch |               |         |                                      |                               |                    |   |         |                                      |                             |                                 |                       |
| 2462  | 11 | 802.11b       | DSSS    | 15.70                                | 0.171                         | 2462               | 802.11g   | OFDM    | 15.50                                | 0.955                       | 0.163                           | X                     |
| 2462  | 11 | 802.11b       | DSSS    | 15.70                                | 0.171                         | 2462               | 802.11n<br>HT20                                       | OFDM    | 15.50                                | 0.955                       | 0.163                           | X                     |
| ANSI / IEEE C95.1-2005– SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population Exposure |    |               |         |                                      |                               |                    | Extremity<br>4.0 W/kg (mW/g)<br>averaged over 10 gram |         |                                      |                             |                                 |                       |



## 11.2 Head SAR Results

Table 11.3 CDMA Head SAR

| MEASUREMENT RESULTS   |     |               |                     |                                      |                             |                        |                     |   |                       |               |                     |                   |                               |            |
|---|-----|---------------|---------------------|--------------------------------------|-----------------------------|------------------------|---------------------|---|-----------------------|---------------|---------------------|-------------------|-------------------------------|------------|
| FREQUENCY   |     | Mode/<br>Band | Service             | Maximum<br>Allowed<br>Power<br>[dBm] | Conducted<br>Power<br>[dBm] | Drift<br>Power<br>[dB] | Spacing<br>[Side]   | Device<br>Serial<br>Number                      | # of<br>Time<br>Slots | Duty<br>Cycle | 1g<br>SAR<br>(W/kg) | Scaling<br>Factor | 1g<br>Scaled<br>SAR<br>(W/kg) | Plots<br># |
| MHz   | Ch  |               |                     |                                      |                             |                        |                     |   |                       |               |                     |                   |                               |            |
| 836.5   | 384 | CDMA 850      | TDSO<br>SO32<br>FCH | 25.0                                 | 24.81                       | -0.090                 | 10 mm<br>[Front #1] | FCC #1  | N/A                   | 1:1           | 0.187               | 1.045             | 0.195                         | A4         |
| 1880.0  | 600 | CDMA 1900     | TDSO<br>SO32<br>FCH | 24.1                                 | 23.95                       | -0.190                 | 10 mm<br>[Front #1] | FCC #1  | N/A                   | 1:1           | 0.107               | 1.035             | 0.111                         | A5         |
| ANSI / IEEE C95.1-2005– SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population Exposure |     |               |                     |                                      |                             |                        |                     | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram |                       |               |                     |                   |                               |            |

Note: The front #1 with 10 mm spacing configuration was tested since only the front #1 is 10 mm spacing to human head in normal operation of this device.

Table 11.4 DTS (2.4G) Head SAR

| MEASUREMENT RESULTS   |    |                  |         |                                      |                             |                     |                     |                            |   |               |                     |                              |                                      |                               |            |
|---|----|------------------|---------|--------------------------------------|-----------------------------|---------------------|---------------------|----------------------------|---|---------------|---------------------|------------------------------|--------------------------------------|-------------------------------|------------|
| FREQUENCY   |    | Mode/<br>Antenna | Service | Maximum<br>Allowed<br>Power<br>[dBm] | Conducted<br>Power<br>[dBm] | Drift Power<br>[dB] | Phantom<br>Position | Device<br>Serial<br>Number | Data<br>Rate<br>[Mbps]                          | Duty<br>Cycle | 1g<br>SAR<br>(W/kg) | Scaling<br>Factor<br>(Power) | Scaling<br>Factor<br>(Duty<br>Cycle) | 1g<br>Scaled<br>SAR<br>(W/kg) | Plots<br># |
| MHz   | Ch |                  |         |                                      |                             |                     |                     |                            |   |               |                     |                              |                                      |                               |            |
| 2462  | 11 | 802.11b          | DSSS    | 15.70                                | 15.68                       | 0.090               | 10 mm<br>[Front #1] | FCC #1                     | 1   | 89.3          | 0.065               | 1.005                        | 1.120                                | 0.073                         | A6         |
| ANSI / IEEE C95.1-2005– SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population Exposure |    |                  |         |                                      |                             |                     |                     |                            | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram |               |                     |                              |                                      |                               |            |

Note(s):

- The front #1 with 10 mm spacing configuration was tested since only the front #1 is 10 mm spacing to human head in normal operation of this device.
- Highest reported SAR is  $\leq 0.4$  W/kg. Therefore, further SAR measurements within this exposure condition are not required.

Adjusted SAR results for OFDM SAR

| Adjusted SAR results for OFDM SAR   |    |               |         |                                      |                               |                    |                 |   |                                      |                             |                                 |                       |
|---|----|---------------|---------|--------------------------------------|-------------------------------|--------------------|-----------------|---|--------------------------------------|-----------------------------|---------------------------------|-----------------------|
| FREQUENCY   |    | Mode/ Antenna | Service | Maximum<br>Allowed<br>Power<br>[dBm] | 1g<br>Scaled<br>SAR<br>(W/kg) | FREQUENCY<br>[MHz] | Mode            | Service   | Maximum<br>Allowed<br>Power<br>[dBm] | Ratio of<br>OFDM to<br>DSSS | 1g<br>Adjusted<br>SAR<br>(W/kg) | Determine OFDM<br>SAR |
| MHz   | Ch |               |         |                                      |                               |                    |                 |   |                                      |                             |                                 |                       |
| 2462  | 11 | 802.11b       | DSSS    | 15.70                                | 0.073                         | 2462               | 802.11g         | OFDM  | 15.50                                | 0.955                       | 0.070                           | X                     |
| 2462  | 11 | 802.11b       | DSSS    | 15.70                                | 0.073                         | 2462               | 802.11n<br>HT20 | OFDM  | 15.50                                | 0.955                       | 0.070                           | X                     |
| ANSI / IEEE C95.1-2005– SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population Exposure |    |               |         |                                      |                               |                    |                 | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram |                                      |                             |                                 |                       |

## 11.3 SAR Test Notes

### General Notes:

1. The test data reported are the worst-case SAR values according to test procedures specified in IEEE 1528-2003, and FCC KDB Publication 447498 D01v05r02.
2. Batteries are fully charged at the beginning of the SAR measurements. A standard battery was used for all SAR measurements.
3. Liquid tissue depth was at least 15.0 cm for all frequencies.
4. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units
5. SAR results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D01v05r02.
6. Per FCC KDB Publication 648474 D04v01r02, SAR was evaluated without a headset connected to the device. Since the standalone reported SAR was not > 1.2 W/kg, no additional SAR evaluations using a headset cable were performed.
7. Per FCC KDB 865664 D01v01r03, variability SAR tests were performed when the measured SAR results for a frequency band were greater than 0.8 W/kg. Repeated SAR measurements are highlighted in the tables above for clarity. Please see Section 14 for variability analysis.

### CDMA Notes:

1. Hand SAR was tested with 1x RTT with TDSO / SO32 FCH Only. EVDO and TDSO / SO32 FCH+SCH SAR tests were not required since the average output power was not more than 0.25 dB higher than the TDSO / SO32 FCH only powers, per FCC KDB Publication 941225 D01v03.
2. Per FCC KDB Publication 447498 D01v05, if the reported (scaled) SAR measured at the middle channel or highest output power channel for each test configuration is  $\leq 0.8$  W/kg then testing at the other channels is not required for such test configuration(s). When the maximum output power variation across the required test channels is  $> \frac{1}{2}$  dB, instead of the middle channel, the highest output power channel must be used.

### WLAN Notes:

1. The initial test position procedures were applied. The test position with the highest extrapolated peak SAR will be used as the initial test position. When reported SAR for the initial test position is  $\leq 0.4$  W/kg, no additional testing for the remaining test positions was required. Otherwise, SAR is evaluated at the subsequent highest peak SAR positions until the reported SAR result is  $\leq 0.8$  W/kg or all test positions are measured.
2. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r01 for 2.4 GHz WIFI single transmission chain operations, the highest measured maximum output power channel for DSSS was selected for SAR measurement. SAR for OFDM modes (2.4 GHz 802.11g/n) was not required due to the maximum allowed powers and the highest reported DSSS SAR when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output and the adjust SAR is  $\leq 1.2$  W/kg.
3. When the maximum reported 1g averaged SAR  $\leq 0.8$  W/kg, SAR testing on additional channels was not required. Otherwise, SAR for the next highest output power channel was required until the reported SAR result was  $\leq 1.20$  W/kg or all test channels were measured.
4. The device was configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor to determine compliance.

## 12. SAR MEASUREMENT VARIABILITY

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### 12.1 Measurement Variability

Per FCC KDB Publication 865664 D01v01r03, SAR measurement variability was assessed for each frequency band, which was determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media were required for SAR measurements in a frequency band, the variability measurement procedures were applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium. These additional measurements were repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device was returned to ambient conditions (normal room temperature) with the battery fully charged before it was re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

*SAR Measurement Variability was assessed using the following procedures for each frequency band:*

1. When the original highest measured SAR is  $\geq 0.80$  W/kg, the measurement was repeated once.
2. A second repeated measurement was performed only if the ratio of largest to smallest SAR for the original and first repeated measurements was  $> 1.2$  or when the original or repeated measurement was  $\geq 1.45$  W/kg ( $\sim 10\%$  from the 1-g SAR limit).
3. A third repeated measurement was performed only if the original, first or second repeated measurement was  $\geq 1.5$  W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is  $> 1.2$ .
4. Repeated measurements are not required when the original highest measured SAR is  $< 0.80$  W/kg

### 12.2 Measurement Uncertainty

The measured SAR was  $< 1.5$  W/kg for all frequency bands. Therefore, per KDB Publication 865664 D01v01r03, the standard measurement uncertainty analysis per IEEE 1528-2003 was not required.

### 13. IEEE P1528 –MEASUREMENT UNCERTAINTIES

#### 835 MHz Body

| Error Description                    | Uncertainty value $\pm\%$ | Probability Distribution | Divisor    | (Ci) 1g | Standard (1g)                   | vi 2 or Veff |
|--------------------------------------|---------------------------|--------------------------|------------|---------|---------------------------------|--------------|
| <b>Measurement System</b>            |                           |                          |            |         |                                 |              |
| Probe calibration                    | $\pm 6.0$                 | Normal                   | 1          | 1       | $\pm 6.0 \%$                    | $\infty$     |
| Axial isotropy                       | $\pm 4.7$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 2.714 \%$                  | $\infty$     |
| Hemispherical isotropy               | $\pm 9.6$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 5.543 \%$                  | $\infty$     |
| Boundary Effects                     | $\pm 0.8$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.462 \%$                  | $\infty$     |
| Probe Linearity                      | $\pm 4.7$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 2.714 \%$                  | $\infty$     |
| Detection limits                     | $\pm 0.25$                | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.144 \%$                  | $\infty$     |
| Readout Electronics                  | $\pm 1.0$                 | Normal                   | 1          | 1       | $\pm 1.0 \%$                    | $\infty$     |
| Response time                        | $\pm 0.8$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.462 \%$                  | $\infty$     |
| Integration time                     | $\pm 2.6$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 1.501 \%$                  | $\infty$     |
| RF Ambient Conditions                | $\pm 3.0$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 1.732 \%$                  | $\infty$     |
| Probe Positioner                     | $\pm 0.4$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.231 \%$                  | $\infty$     |
| Probe Positioning                    | $\pm 2.9$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 1.674 \%$                  | $\infty$     |
| Algorithms for Max. SAR Eval.        | $\pm 1.0$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.577 \%$                  | $\infty$     |
| <b>Test Sample Related</b>           |                           |                          |            |         |                                 |              |
| Device Positioning                   | $\pm 2.9$                 | Normal                   | 1          | 1       | $\pm 2.9 \%$                    | 145          |
| Device Holder                        | $\pm 3.6$                 | Normal                   | 1          | 1       | $\pm 3.6 \%$                    | 5            |
| Power Drift                          | $\pm 5.0$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 2.887 \%$                  | $\infty$     |
| <b>Physical Parameters</b>           |                           |                          |            |         |                                 |              |
| Phantom Shell                        | $\pm 4.0$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 2.31 \%$                   | $\infty$     |
| Liquid conductivity (Target)         | $\pm 5.0$                 | Rectangular              | $\sqrt{3}$ | 0.64    | $\pm 2.887 \%$                  | $\infty$     |
| Liquid conductivity (Meas.)          | $\pm 4.5$                 | Normal                   | 1          | 0.64    | $\pm 4.5 \%$                    | $\infty$     |
| Liquid permittivity (Target)         | $\pm 5.0$                 | Rectangular              | $\sqrt{3}$ | 0.6     | $\pm 2.887 \%$                  | $\infty$     |
| Liquid permittivity (Meas.)          | $\pm 4.2$                 | Normal                   | 1          | 0.6     | $\pm 4.2 \%$                    | $\infty$     |
| <b>Combined Standard Uncertainty</b> |                           | RSS                      |            |         | <b><math>\pm 12.1 \%</math></b> | 330          |
| <b>Expanded Uncertainty (k=2)</b>    |                           |                          |            |         | <b><math>\pm 24.2 \%</math></b> |              |

The above measurement uncertainties are according to IEEE P1528 (2003)

**1900 MHz Body**

| Error Description                    | Uncertainty value $\pm\%$ | Probability Distribution | Divisor    | (Ci) 1g | Standard (1g)                   | vi 2 or Veff |
|--------------------------------------|---------------------------|--------------------------|------------|---------|---------------------------------|--------------|
| <b>Measurement System</b>            |                           |                          |            |         |                                 |              |
| Probe calibration                    | $\pm 6.0$                 | Normal                   | 1          | 1       | $\pm 6.0 \%$                    | $\infty$     |
| Axial isotropy                       | $\pm 4.7$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 2.714 \%$                  | $\infty$     |
| Hemispherical isotropy               | $\pm 9.6$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 5.543 \%$                  | $\infty$     |
| Boundary Effects                     | $\pm 0.8$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.462 \%$                  | $\infty$     |
| Probe Linearity                      | $\pm 4.7$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 2.714 \%$                  | $\infty$     |
| Detection limits                     | $\pm 0.25$                | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.145 \%$                  | $\infty$     |
| Readout Electronics                  | $\pm 1.0$                 | Normal                   | 1          | 1       | $\pm 1.0 \%$                    | $\infty$     |
| Response time                        | $\pm 0.8$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.462 \%$                  | $\infty$     |
| Integration time                     | $\pm 2.6$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 1.501 \%$                  | $\infty$     |
| RF Ambient Conditions                | $\pm 3.0$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 1.732 \%$                  | $\infty$     |
| Probe Positioner                     | $\pm 0.4$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.231 \%$                  | $\infty$     |
| Probe Positioning                    | $\pm 2.9$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 1.674 \%$                  | $\infty$     |
| Algorithms for Max. SAR Eval.        | $\pm 1.0$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.577 \%$                  | $\infty$     |
| <b>Test Sample Related</b>           |                           |                          |            |         |                                 |              |
| Device Positioning                   | $\pm 2.9$                 | Normal                   | 1          | 1       | $\pm 2.9 \%$                    | 145          |
| Device Holder                        | $\pm 3.6$                 | Normal                   | 1          | 1       | $\pm 3.6 \%$                    | 5            |
| Power Drift                          | $\pm 5.0$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 2.887 \%$                  | $\infty$     |
| <b>Physical Parameters</b>           |                           |                          |            |         |                                 |              |
| Phantom Shell                        | $\pm 4.0$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 2.31 \%$                   | $\infty$     |
| Liquid conductivity (Target)         | $\pm 5.0$                 | Rectangular              | $\sqrt{3}$ | 0.64    | $\pm 2.887 \%$                  | $\infty$     |
| Liquid conductivity (Meas.)          | $\pm 4.1$                 | Normal                   | 1          | 0.64    | $\pm 4.1 \%$                    | $\infty$     |
| Liquid permittivity (Target)         | $\pm 5.0$                 | Rectangular              | $\sqrt{3}$ | 0.6     | $\pm 2.887 \%$                  | $\infty$     |
| Liquid permittivity (Meas.)          | $\pm 3.9$                 | Normal                   | 1          | 0.6     | $\pm 3.9 \%$                    | $\infty$     |
| <b>Combined Standard Uncertainty</b> |                           | RSS                      |            |         | <b><math>\pm 12.0 \%</math></b> | 330          |
| <b>Expanded Uncertainty (k=2)</b>    |                           |                          |            |         | <b><math>\pm 24.0 \%</math></b> |              |

The above measurement uncertainties are according to IEEE P1528 (2003)

**2450 MHz Body**

| Error Description                    | Uncertainty value $\pm\%$ | Probability Distribution | Divisor    | (Ci) 1g | Standard (1g)                   | vi 2 or Veff |
|--------------------------------------|---------------------------|--------------------------|------------|---------|---------------------------------|--------------|
| <b>Measurement System</b>            |                           |                          |            |         |                                 |              |
| Probe calibration                    | $\pm 6.0$                 | Normal                   | 1          | 1       | $\pm 6.0 \%$                    | $\infty$     |
| Axial isotropy                       | $\pm 4.7$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 2.714 \%$                  | $\infty$     |
| Hemispherical isotropy               | $\pm 9.6$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 5.543 \%$                  | $\infty$     |
| Boundary Effects                     | $\pm 0.8$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.462 \%$                  | $\infty$     |
| Probe Linearity                      | $\pm 4.7$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 2.714 \%$                  | $\infty$     |
| Detection limits                     | $\pm 0.25$                | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.144 \%$                  | $\infty$     |
| Readout Electronics                  | $\pm 1.0$                 | Normal                   | 1          | 1       | $\pm 1.0 \%$                    | $\infty$     |
| Response time                        | $\pm 0.8$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.462 \%$                  | $\infty$     |
| Integration time                     | $\pm 2.6$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 1.501 \%$                  | $\infty$     |
| RF Ambient Conditions                | $\pm 3.0$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 1.732 \%$                  | $\infty$     |
| Probe Positioner                     | $\pm 0.4$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.231 \%$                  | $\infty$     |
| Probe Positioning                    | $\pm 2.9$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 1.674 \%$                  | $\infty$     |
| Algorithms for Max. SAR Eval.        | $\pm 1.0$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 0.577 \%$                  | $\infty$     |
| <b>Test Sample Related</b>           |                           |                          |            |         |                                 |              |
| Device Positioning                   | $\pm 2.9$                 | Normal                   | 1          | 1       | $\pm 2.9 \%$                    | 145          |
| Device Holder                        | $\pm 3.6$                 | Normal                   | 1          | 1       | $\pm 3.6 \%$                    | 5            |
| Power Drift                          | $\pm 5.0$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 2.887 \%$                  | $\infty$     |
| <b>Physical Parameters</b>           |                           |                          |            |         |                                 |              |
| Phantom Shell                        | $\pm 4.0$                 | Rectangular              | $\sqrt{3}$ | 1       | $\pm 2.31 \%$                   | $\infty$     |
| Liquid conductivity (Target)         | $\pm 5.0$                 | Rectangular              | $\sqrt{3}$ | 0.64    | $\pm 2.887 \%$                  | $\infty$     |
| Liquid conductivity (Meas.)          | $\pm 4.2$                 | Normal                   | 1          | 0.64    | $\pm 4.2 \%$                    | $\infty$     |
| Liquid permittivity (Target)         | $\pm 5.0$                 | Rectangular              | $\sqrt{3}$ | 0.6     | $\pm 2.887 \%$                  | $\infty$     |
| Liquid permittivity (Meas.)          | $\pm 4.0$                 | Normal                   | 1          | 0.6     | $\pm 4.0 \%$                    | $\infty$     |
| <b>Combined Standard Uncertainty</b> |                           | RSS                      |            |         | <b><math>\pm 12.1 \%</math></b> | 330          |
| <b>Expanded Uncertainty (k=2)</b>    |                           |                          |            |         | <b><math>\pm 24.2 \%</math></b> |              |

The above measurement uncertainties are according to IEEE P1528 (2003)

## 14. CONCLUSION

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### Measurement Conclusion

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the FCC. These measurements are taken to simulate the RF effects exposure under the worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters subject to the test. The test results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body are very complex phenomena that depend on the mass, shape, and size of the body, the orientation of the body with respect to the field vectors, and the electrical properties of both the body and the environment. Other variables that may play a substantial role impossible biological effect are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease).

Because innumerable factors may interact to determine the specific biological outcome of an exposure to electromagnetic fields, any protection guide shall consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables.

## 15. REFERENCES

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## Attachment 1. – Probe Calibration Data

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



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

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

Accreditation No.: **SCS 108**

Client **DT&C (Dymstec)**

Certificate No: **EX3-3933\_Sep14**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3933**

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: **September 22, 2014**

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      | 03-Apr-14 (No. 217-01911)         | Apr-15                 |
| Power sensor E4412A        | MY41498087      | 03-Apr-14 (No. 217-01911)         | Apr-15                 |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 03-Apr-14 (No. 217-01915)         | Apr-15                 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 03-Apr-14 (No. 217-01919)         | Apr-15                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 03-Apr-14 (No. 217-01920)         | Apr-15                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-13 (No. ES3-3013_Dec13)    | Dec-14                 |
| DAE4                       | SN: 660         | 13-Dec-13 (No. DAE4-660_Dec13)    | Dec-14                 |
| 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-13) | In house check: Oct-14 |

|                            | Name           | Function              | Signature |
|----------------------------|----------------|-----------------------|-----------|
| Calibrated by:             | Jeton Kastrati | Laboratory Technician |           |
| Approved by:               | Katja Pokovic  | Technical Manager     |           |
| Issued: September 23, 2014 |                |                       |           |

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

Certificate No: EX3-3933\_Sep14

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**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  
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 Multilateral Agreement for the recognition of calibration certificates

#### 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 $\vartheta$ | $\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center),<br>i.e., $\vartheta = 0$ is normal to probe axis |
| Connector Angle          | information used in DASY system to align probe sensor X to the robot coordinate system  |

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

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

EX3DV4 – SN:3933

September 22, 2014

# Probe EX3DV4

## SN:3933

Manufactured: July 24, 2013  
Calibrated: September 22, 2014

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

EX3DV4- SN:3933

September 22, 2014

**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3933****Basic Calibration Parameters**

|  | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|--|----------|----------|----------|-----------|
| Norm ( $\mu\text{V}/(\text{V/m})^2$ ) <sup>A</sup> | 0.49     | 0.53     | 0.19     | ± 10.1 %  |
| DCP (mV) <sup>B</sup>                              | 102.0    | 99.5     | 90.2     |           |

**Modulation Calibration Parameters**

| UID | Communication System Name |   | A<br>dB | B<br>dB√μV | C   | D<br>dB | VR<br>mV | Unc <sup>E</sup><br>(k=2) |
|-----|---------------------------|---|---------|------------|-----|---------|----------|---------------------------|
| 0   | CW                        | X | 0.0     | 0.0        | 1.0 | 0.00    | 139.3    | ±3.8 %                    |
|     |                           | Y | 0.0     | 0.0        | 1.0 |         | 141.1    |                           |
|     |                           | Z | 0.0     | 0.0        | 1.0 |         | 149.8    |                           |

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

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

EX3DV4-- SN:3933

September 22, 2014

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3933

### 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) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 300                  | 45.3                               | 0.87                            | 13.04   | 13.04   | 13.04   | 0.08               | 1.50                    | ± 13.3 %    |
| 450                  | 43.5                               | 0.87                            | 12.65   | 12.65   | 12.65   | 0.15               | 1.80                    | ± 13.3 %    |
| 600                  | 42.7                               | 0.88                            | 11.04   | 11.04   | 11.04   | 0.08               | 1.20                    | ± 13.3 %    |
| 750                  | 41.9                               | 0.89                            | 10.90   | 10.90   | 10.90   | 0.42               | 0.80                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 10.48   | 10.48   | 10.48   | 0.60               | 0.65                    | ± 12.0 %    |
| 900                  | 41.5                               | 0.97                            | 10.36   | 10.36   | 10.36   | 0.50               | 0.70                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 8.76    | 8.76    | 8.76    | 0.24               | 1.00                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 8.46    | 8.46    | 8.46    | 0.28               | 0.91                    | ± 12.0 %    |
| 2300                 | 39.5                               | 1.67                            | 8.39    | 8.39    | 8.39    | 0.22               | 1.04                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 7.99    | 7.99    | 7.99    | 0.30               | 0.85                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 7.40    | 7.40    | 7.40    | 0.32               | 0.91                    | ± 12.0 %    |
| 3500                 | 37.9                               | 2.91                            | 7.35    | 7.35    | 7.35    | 0.17               | 1.92                    | ± 13.1 %    |
| 5200                 | 36.0                               | 4.66                            | 5.38    | 5.38    | 5.38    | 0.35               | 1.80                    | ± 13.1 %    |
| 5300                 | 35.9                               | 4.76                            | 5.15    | 5.15    | 5.15    | 0.35               | 1.80                    | ± 13.1 %    |
| 5500                 | 35.6                               | 4.96                            | 5.01    | 5.01    | 5.01    | 0.40               | 1.80                    | ± 13.1 %    |
| 5600                 | 35.5                               | 5.07                            | 4.90    | 4.90    | 4.90    | 0.40               | 1.80                    | ± 13.1 %    |
| 5800                 | 35.3                               | 5.27                            | 4.78    | 4.78    | 4.78    | 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.

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September 22, 2014

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3933

### 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) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 300                  | 58.2                               | 0.92                            | 12.23   | 12.23   | 12.23   | 0.05               | 1.10                    | ± 13.3 %    |
| 450                  | 56.7                               | 0.94                            | 12.93   | 12.93   | 12.93   | 0.05               | 1.10                    | ± 13.3 %    |
| 600                  | 56.1                               | 0.95                            | 11.28   | 11.28   | 11.28   | 0.10               | 1.20                    | ± 13.3 %    |
| 750                  | 55.5                               | 0.96                            | 10.58   | 10.58   | 10.58   | 0.25               | 0.95                    | ± 12.0 %    |
| 835                  | 55.2                               | 0.97                            | 10.38   | 10.38   | 10.38   | 0.55               | 0.75                    | ± 12.0 %    |
| 900                  | 55.0                               | 1.05                            | 10.27   | 10.27   | 10.27   | 0.32               | 0.80                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 8.91    | 8.91    | 8.91    | 0.38               | 0.83                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 8.14    | 8.14    | 8.14    | 0.38               | 0.82                    | ± 12.0 %    |
| 2300                 | 52.9                               | 1.81                            | 7.96    | 7.96    | 7.96    | 0.26               | 1.02                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 7.78    | 7.78    | 7.78    | 0.64               | 0.59                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 7.58    | 7.58    | 7.58    | 0.64               | 0.59                    | ± 12.0 %    |
| 3500                 | 51.3                               | 3.31                            | 6.96    | 6.96    | 6.96    | 0.19               | 2.26                    | ± 13.1 %    |
| 5200                 | 49.0                               | 5.30                            | 4.91    | 4.91    | 4.91    | 0.40               | 1.90                    | ± 13.1 %    |
| 5300                 | 48.9                               | 5.42                            | 4.72    | 4.72    | 4.72    | 0.40               | 1.90                    | ± 13.1 %    |
| 5500                 | 48.6                               | 5.65                            | 4.18    | 4.18    | 4.18    | 0.50               | 1.90                    | ± 13.1 %    |
| 5600                 | 48.5                               | 5.77                            | 4.01    | 4.01    | 4.01    | 0.50               | 1.90                    | ± 13.1 %    |
| 5800                 | 48.2                               | 6.00                            | 4.24    | 4.24    | 4.24    | 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 ( $\epsilon$  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.

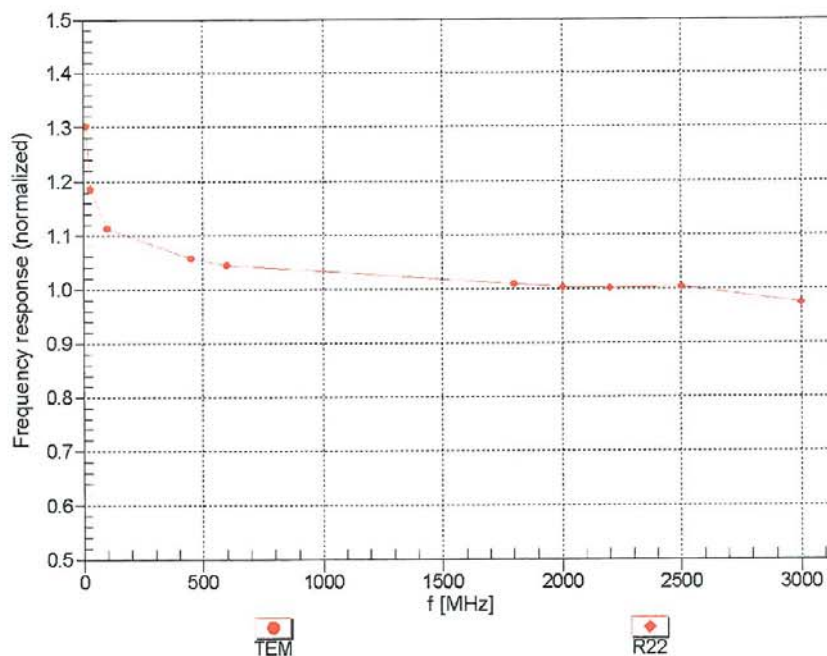
<sup>G</sup> Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter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



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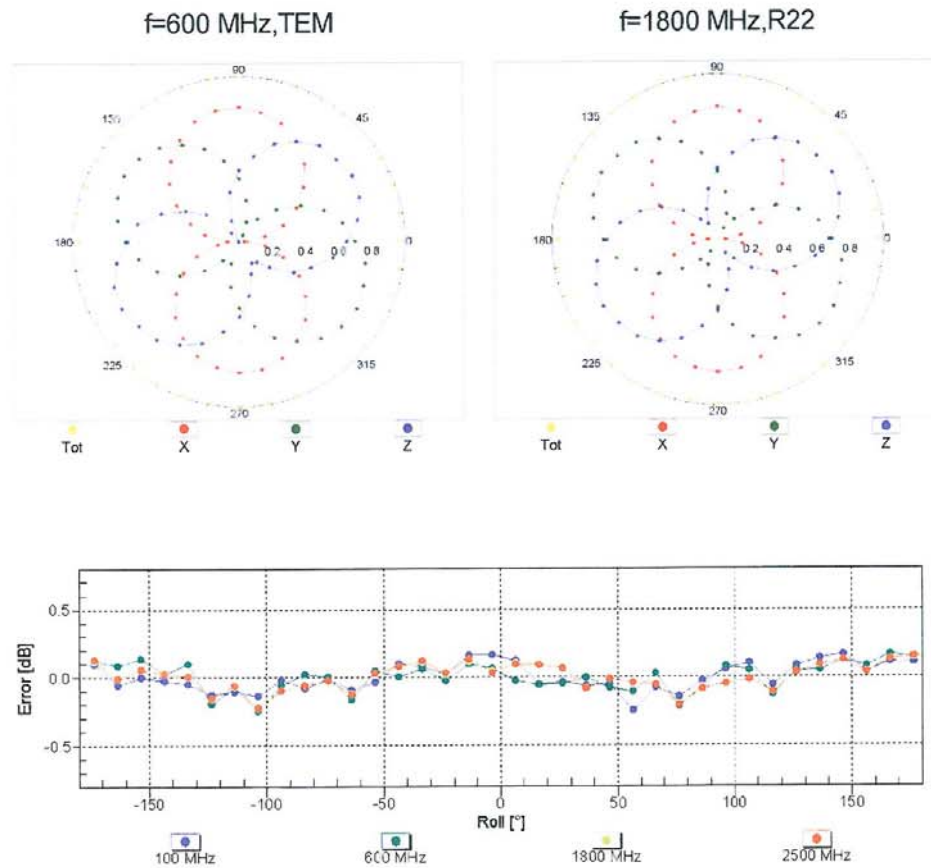
September 22, 2014

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

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

EX3DV4- SN:3933

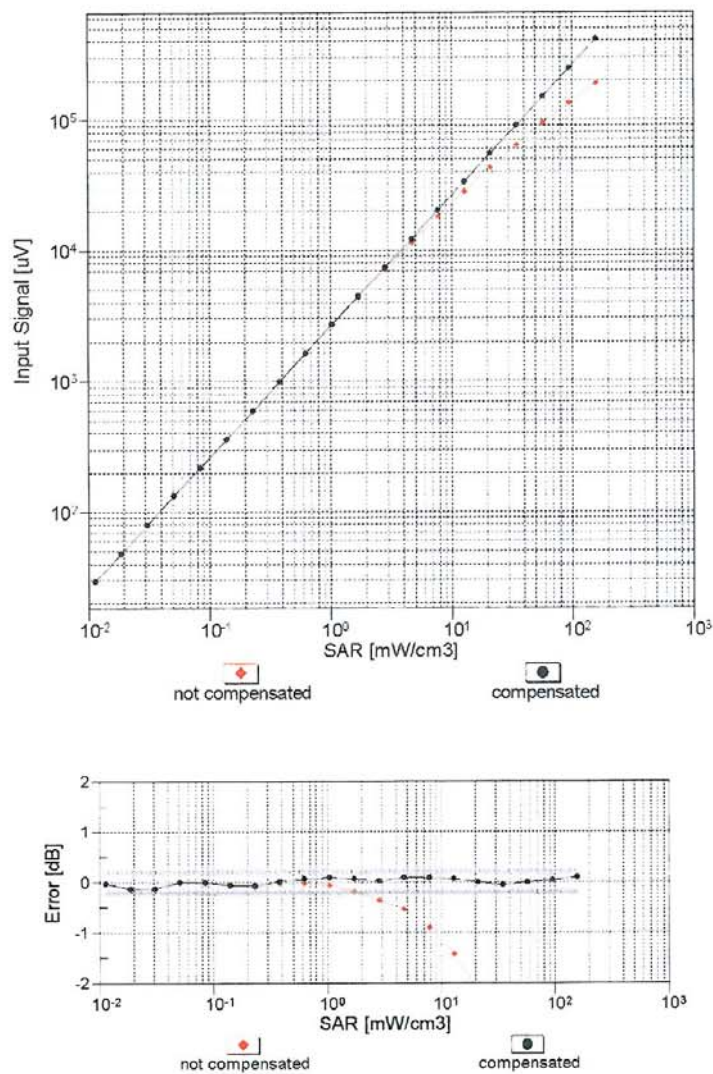
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**Receiving Pattern ( $\phi$ ),  $\theta = 0^\circ$** 

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September 22, 2014

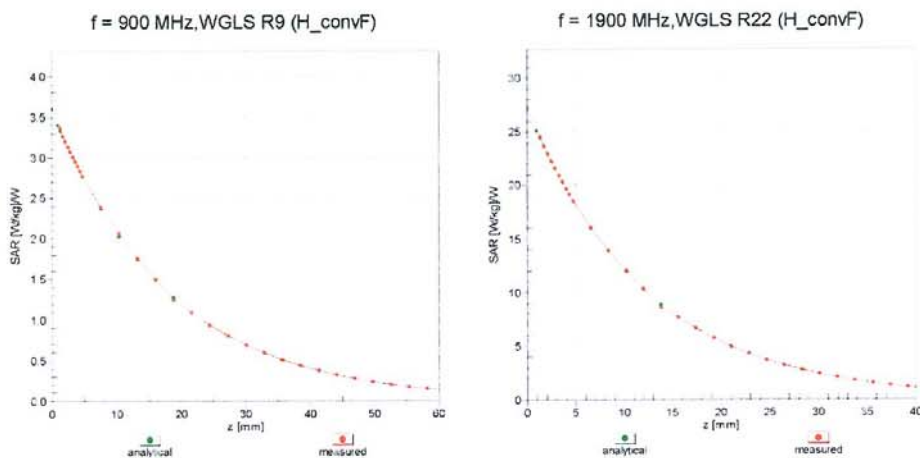
### Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$ )

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

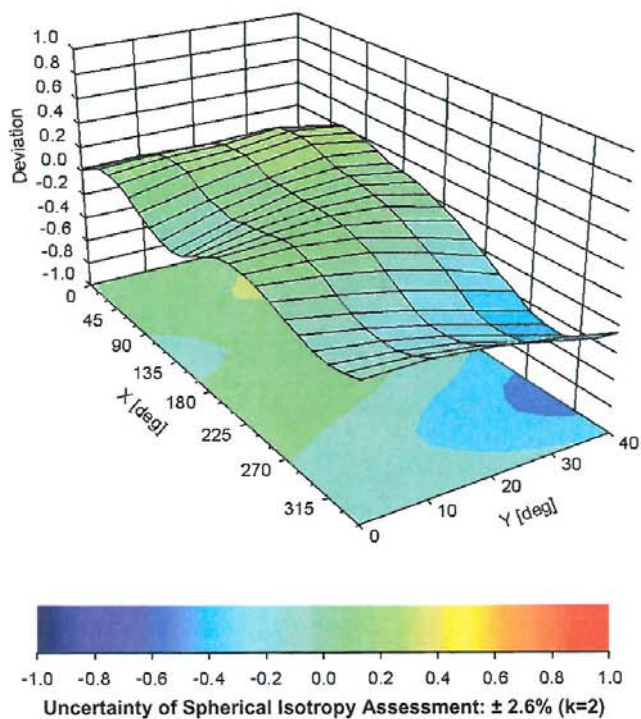
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## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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

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September 22, 2014

**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3933****Other Probe Parameters**

|   |            |
|---|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | -103.6     |
| 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     |