


# SAR TEST REPORT

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1. Customer

- Name : POINTMOBILE CO., LTD.
- Address : Gasan-dong B-9F, Kabul Great Valley 32 Digital-ro 9-gil, Geumcheon-gu, Seoul, Korea 153-709

2. Use of Report : FCC Original Grant

3. Product Name (FCC ID): Mobile Computer (FCC ID : V2X-PM80W)

4. Date of Test :2015-11-03 ~ 2015-11-06

5. Test Method Used: CFR §2.1093

6. Testing Environment :See appended test report

7. Test Result :  Pass  Fail

The results shown in this test report refer only to the sample(s) tested unless otherwise stated. This Test Report cannot be reproduced, except in full.

Affirmation	Tested by Name : ChangWon, Lee (Signature)	Technical Manager Name : Harvey Sung (Signature)
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2015. 12. 22.

DT&C Co., Ltd.



## Test Report Version

Test Report No.	Date	Description
DRRFCC1512-0117	Dec. 22, 2015	Initial issue



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## 1. DESCRIPTION OF DEVICE

Environmental evaluation measurements of specific absorption rate (SAR) distributions in emulated human head and 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	Mobile Computer			
FCC ID	V2X-PM80W			
Equipment model name	PM80-W			
Equipment add model name	N/A			
Equipment serial no.	Identical prototype			
Mode(s) of Operation	2.4 GHz W-LAN(802.11b/g/n HT20), 5 G W-LAN (802.11a/n HT20)			
TX Frequency Range	<b>Band</b>	<b>Mode</b>	<b>Bandwidth</b>	<b>Frequency</b>
	DTS	802.11b/g/n HT20	HT20	2412 ~ 2462 MHz
	U-NII-1	802.11a/n HT20	HT20	5180 ~ 5240 MHz
	U-NII-2A	802.11a/n HT20	HT20	5260 ~ 5320 MHz
	U-NII-2C	802.11a/n HT20	HT20	5500 ~ 5700 MHz
RX Frequency Range	DTS	802.11b/g/n HT20	HT20	2412 ~ 2462 MHz
	U-NII-1	802.11a/n HT20	HT20	5180 ~ 5240 MHz
	U-NII-2A	802.11a/n HT20	HT20	5260 ~ 5320 MHz
	U-NII-2C	802.11a/n HT20	HT20	5500 ~ 5700 MHz
	U-NII-3	802.11a/n HT20	HT20	5745 ~ 5825 MHz
<b>Band</b>	<b>Mode</b>	<b>Reported SAR</b>		
		<b>1g SAR (W/kg)</b>		<b>10g SAR (W/kg)</b>
		<b>Head</b>	<b>Body-worn</b>	<b>Hand</b>
DTS	2.4 GHz W-LAN	0.14	<0.10	0.24
U-NII-2A	5.3 GHz W-LAN	0.14	N/A	N/A
U-NII-2C	5.6 GHz W-LAN	0.17	N/A	N/A
U-NII-3	5.8 GHz W-LAN	0.16	N/A	N/A
DSS	Bluetooth	N/A	N/A	N/A
FCC Equipment Class	Part 15 Spread Spectrum Transmitter (DSS) Digital Transmission System (DTS) Unlicensed National Information Infrastructure (UNII)			
Date(s) of Tests	2015-11-03 ~ 2015-11-06			
Antenna Type	Internal Type Antenna			
Functions	<ul style="list-style-type: none"> <li>● BT(2.4GHz) / W-LAN(2.4GHz 802.11b/g/n(HT20)) supported W-LAN(5GHz 802.11a/n(HT20)) supported</li> <li>* No simultaneous transmission between BT &amp; WLAN</li> <li>● W-LAN VoIP supported.</li> <li>● WiFi Mobile Hotspot not supported.</li> </ul>			

## 1.1 Guidance Applied

- IEEE 1528-2013
- FCC KDB Publication 248227 D01v02r02 (802.11 Wi-Fi SAR)
- FCC KDB Publication 447498 D01v06 (General RF Exposure Guidance)
- FCC KDB Publication 648474 D04 Handset SAR v01r03
- FCC KDB Publication 690783 D01 SAR Listings on Grants v01r03
- FCC KDB Publication 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04
- FCC KDB Publication 865664 D02 RF Exposure Reporting v01r02

## 1.2 Device Overview

Band	Mode	Operating Modes	Tx Frequency
DTS	2.4 GHz WLAN	Data	2412 ~ 2462 MHz
U-NII-1	5.2 GHz WLAN	Data	5180 ~ 5240 MHz
U-NII-2A	5.3 GHz WLAN	Data	5260 ~ 5320 MHz
U-NII-2C	5.6 GHz WLAN	Data	5500 ~ 5700 MHz
U-NII-3	5.8 GHz WLAN	Data	5745 ~ 5825 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 D01v06.

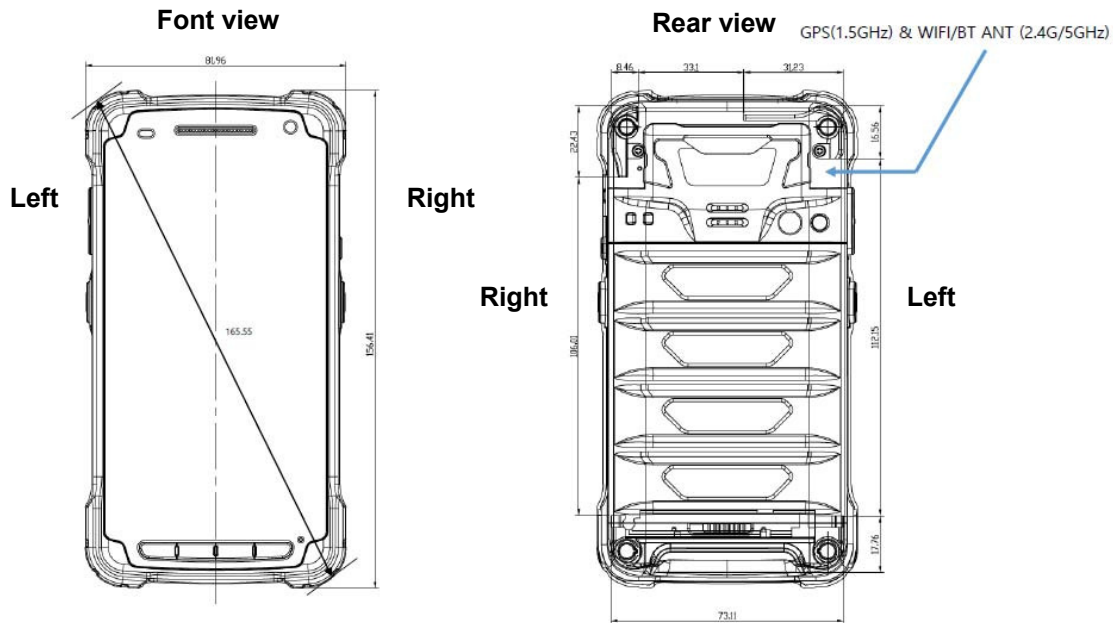
Band & Mode			Modulated Average[dBm]		
			Ch Low	Ch Mid	Ch High
DTS	IEEE 802.11b (2.4 GHz)	Maximum	15.3	14.7	15.1
		Nominal	14.3	13.7	14.1
	IEEE 802.11g (2.4 GHz)	Maximum	12.6	14.9	10.5
		Nominal	11.6	13.9	9.5
	IEEE 802.11n HT20 (2.4 GHz)	Maximum	11.6	15.0	10.0
		Nominal	10.6	14.0	9.0

Band & Mode		Modulated Average[dBm]	
U-NII-1	IEEE 802.11a/n HT20 (5.2 GHz)	Maximum	10.7
		Nominal	9.7
U-NII-2A	IEEE 802.11a/n HT20 (5.3 GHz)	Maximum	10.8
		Nominal	9.8
U-NII-2C	IEEE 802.11a/n HT20 (5.6 GHz)	Maximum	10.9
		Nominal	9.9
U-NII-3	IEEE 802.11a/n HT20 (5.8 GHz)	Maximum	10.4
		Nominal	9.4



Band & Mode			Modulated Average[dBm]		
			Ch Low	Ch Mid	Ch High
DSS	Bluetooth 1 Mbps	Maximum	8.5	8.0	8.5
		Nominal	7.5	7.0	7.5
	Bluetooth 2 Mbps	Maximum	6.0	5.5	6.0
		Nominal	5.0	4.5	5.0
	Bluetooth 3 Mbps	Maximum	6.0	5.5	6.0
		Nominal	5.0	4.5	5.0
DTS	Bluetooth LE	Maximum	-0.5	-1.0	-1.0
		Nominal	-1.5	-2.0	-2.0

### 1.4 DUT Antenna Locations



Note 1: Exact antenna dimensions and separation distances are shown in the "Antenna Location\_V2X-PM80W" in the FCC Filing.  
 Note 2: Since the diagonal dimension of this device is > 160 mm and < 200 mm, it is considered a "phablet".

Mode	Mobile Body Sides for SAR Testing					
	Top	Bottom	Front	Rear	Right	Left
2.4G W-LAN(802.11b)	O	X	O	O	X	O
5G W-LAN(802.11a)	O	X	O	O	X	O

Note: Particular DUT edges were not required to be evaluated for Phablet SAR if the edges were greater than 2.5 cm from the transmitting antenna according to FCC KDB Publication 648474 D04v01r03. The antenna document shows the distances between the transmit antennas and the edges of the device.



## 1.5 Near Field Communications (NFC) Antenna

This DUT has NFC operations. The NFC antenna is integrated into the back cover. The SAR tests were performed with the back cover with NFC antenna already incorporated.



## 1.6 SAR Test Exclusions Applied

### (A) WIFI & BT

Per FCC KDB 447498 D01v06, 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 Body** (rounded to the nearest mW) and the antenna to user separation distance, **Bluetooth Body SAR was not required**;  $[(7/10) * \sqrt{2.480}] = \mathbf{1.1} < 3.0$ .

Based on the maximum conducted power of **Bluetooth LE Body** (rounded to the nearest mW) and the antenna to user separation distance, **Bluetooth LE Body SAR was not required**;  $[(1/10) * \sqrt{2.480}] = \mathbf{0.1} < 3.0$ .

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**;  $[(34/10) * \sqrt{2.412}] = \mathbf{5.3} > 3.0$ .

Based on the maximum conducted power of **5.2 GHz WIFI Head** (rounded to the nearest mW) and the antenna to user separation distance, **5.2 GHz WIFI Head SAR was required**;  $[(12/5) * \sqrt{5.240}] = \mathbf{5.4} > 3.0$ .

Based on the maximum conducted power of **5.3 GHz WIFI Head** (rounded to the nearest mW) and the antenna to user separation distance, **5.3 GHz WIFI Head SAR was required**;  $[(12/5) * \sqrt{5.320}] = \mathbf{5.5} > 3.0$ .

Based on the maximum conducted power of **5.6 GHz WIFI Head** (rounded to the nearest mW) and the antenna to user separation distance, **5.6 GHz WIFI Head SAR was required**;  $[(12/5) * \sqrt{5.700}] = \mathbf{5.9} > 3.0$ .

Based on the maximum conducted power of **5.8 GHz WIFI Head** (rounded to the nearest mW) and the antenna to user separation distance, **5.8 GHz WIFI Head SAR was required**;  $[(11/5) * \sqrt{5.825}] = \mathbf{5.3} > 3.0$ .

Based on the maximum conducted power of **5.2 GHz WIFI Body** (rounded to the nearest mW) and the antenna to user separation distance, **5.2 GHz WIFI Body SAR was not required**;  $[(12/10)^* \sqrt{5.240}] = \underline{2.7} < 3.0$ .

Based on the maximum conducted power of **5.3 GHz WIFI Body** (rounded to the nearest mW) and the antenna to user separation distance, **5.3 GHz WIFI Body SAR was not required**;  $[(12/10)^* \sqrt{5.320}] = \underline{2.8} < 3.0$ .

Based on the maximum conducted power of **5.6 GHz WIFI Body** (rounded to the nearest mW) and the antenna to user separation distance, **5.6 GHz WIFI Body SAR was not required**;  $[(12/10)^* \sqrt{5.700}] = \underline{2.9} < 3.0$ .

Based on the maximum conducted power of **5.8 GHz WIFI Body** (rounded to the nearest mW) and the antenna to user separation distance, **5.8 GHz WIFI Body SAR was not required**;  $[(11/10)^* \sqrt{5.825}] = \underline{2.6} < 3.0$ .

Per FCC KDB 447498 D01v06, 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 Hand** (rounded to the nearest mW) and the antenna to user separation distance, **Bluetooth Hand SAR was not required**;  $[(7/5)^* \sqrt{2.480}] = \underline{2.2} < 7.5$ .

Based on the maximum conducted power of **Bluetooth LE Hand** (rounded to the nearest mW) and the antenna to user separation distance, **Bluetooth LE Hand SAR was not required**;  $[(1/5)^* \sqrt{2.480}] = \underline{0.3} < 7.5$ .

Based on the maximum conducted power of **2.4 GHz WIFI Hand** (rounded to the nearest mW) and the antenna to user separation distance, **2.4 GHz WIFI Hand SAR was required**;  $[(34/5)^* \sqrt{2.412}] = \underline{10.5} > 7.5$ .

Based on the maximum conducted power of **5.2 GHz WIFI Hand** (rounded to the nearest mW) and the antenna to user separation distance, **5.2 GHz WIFI Hand SAR was not required**;  $[(12/5)^* \sqrt{5.240}] = \underline{5.4} < 7.5$ .

Based on the maximum conducted power of **5.3 GHz WIFI Hand** (rounded to the nearest mW) and the antenna to user separation distance, **5.3 GHz WIFI Hand SAR was not required**;  $[(12/5)^* \sqrt{5.320}] = \underline{5.5} < 7.5$ .

Based on the maximum conducted power of **5.6 GHz WIFI Hand** (rounded to the nearest mW) and the antenna to user separation distance, **5.6 GHz WIFI Hand SAR was not required**;  $[(12/5)^* \sqrt{5.700}] = \underline{5.9} < 7.5$ .

Based on the maximum conducted power of **5.8 GHz WIFI Hand** (rounded to the nearest mW) and the antenna to user separation distance, **5.8 GHz WIFI Hand SAR was not required**;  $[(11/5)^* \sqrt{5.825}] = \underline{5.3} < 7.5$ .

Per FCC KDB Publication 648474 D04v01r03, this device is considered a "Phablet" since the diagonal dimension is greater than 160 mm and less than 200 mm. Extremity SAR tests are required when wireless router mode does not apply or if wireless router 1 g SAR > 1.2 W/Kg. Because wireless router mode does not supported, extremity SAR tests were required.

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



### 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	Head Serial Number	Body Serial Number	Hand Serial Number
2.4 GHz WLAN	FCC #1	FCC #1	FCC #1
5 GHz WLAN	FCC #1	FCC #1	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 (kg/m<sup>3</sup>)
- E = Total RMS electric field strength (V/m)

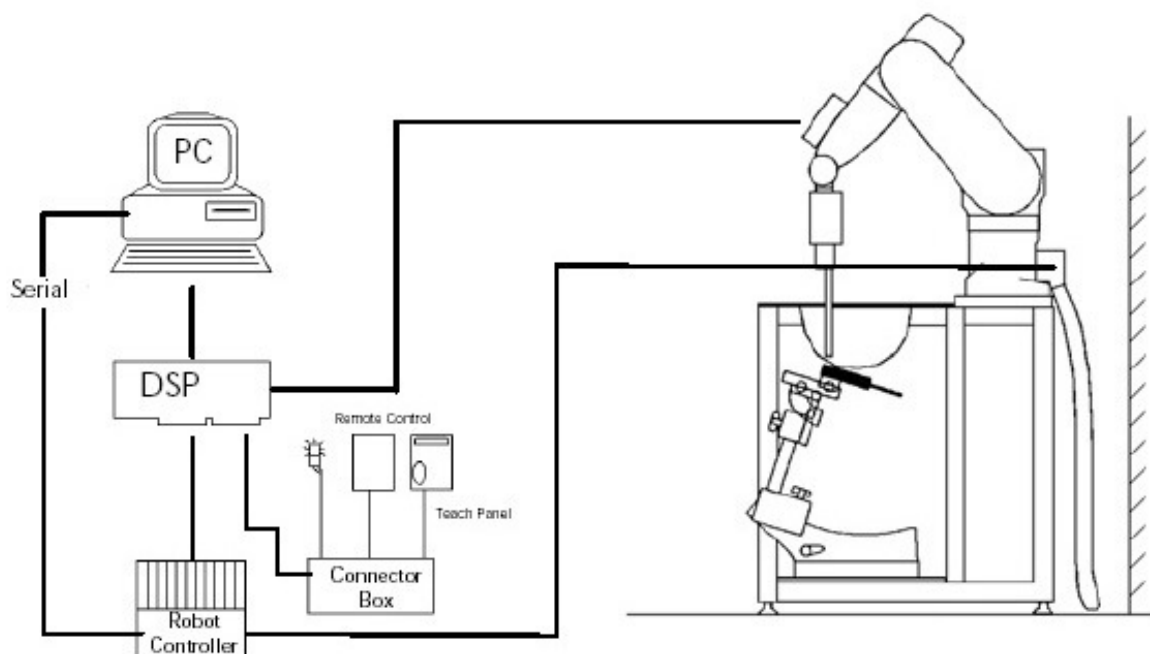
NOTE: The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relations to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces,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

### 3. DESCRIPTION OF TEST EQUIPMENT

#### 3.1 SAR MEASUREMENT SETUP

Measurements are performed using the DASY5 automated dosimetric assessment system. The DASY5 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, desktop computer, near-field probe, probe alignment sensor, and the generic twin phantom containing the brain equivalent material. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF) (see Fig. 3.1).

A cell controller system contains the power supply, robot controller each pendant (Joystick), and a remote control used to drive the robot motors. The PC consists of the Intel Core i7-3770 3.40 GHz desktop computer with Windows 7 system and SAR Measurement Software DASY5, A/D interface card, monitor, mouse, and keyboard. The Staubli Robot is connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.



**Figure 3.1 SAR Measurement System Setup**

The DAE4 consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer. The system is described in detail.

### 3.2 EX3DV4Probe Specification

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

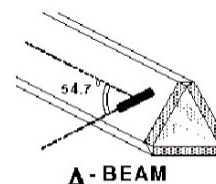


Figure 3.2 Triangular Probe Configurations



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 multilayer 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 (Norm X, Norm Y, Norm Z), the diode compression parameter (DCP) and the conversion factor (Conv F) 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;

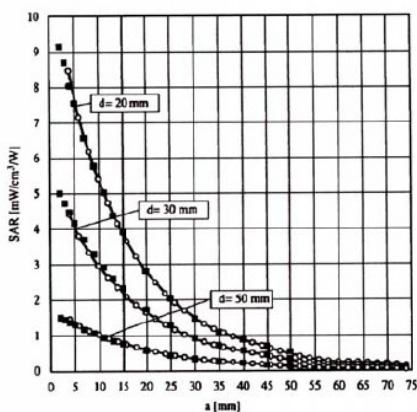


Figure 3.4 E-Field and Temperature Measurements at 900MHz

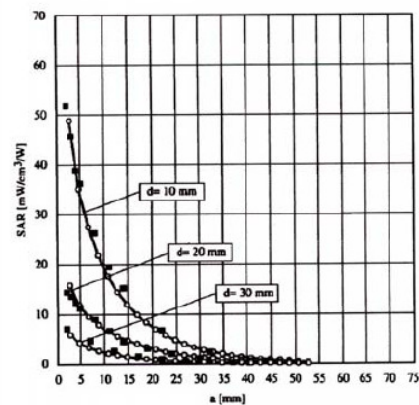


Figure 3.5 E-Field and Temperature Measurements at 1800MHz

### 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: 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

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

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  $g/cm^3$

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

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

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



### 3.5 SAM Twin PHANTOM

The SAM Twin Phantom V5.0 is constructed of a fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents the evaporation of the liquid.

Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. (see Fig. 3.6)



Figure 3.6 SAM Twin Phantom

#### SAM Twin Phantom Specification:

<b>Construction</b>	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.
	Twin SAM V5.0 has the same shell geometry and is manufactured from the same material as Twin SAM V4.0, but has reinforced top structure.
<b>Shell Thickness</b>	$2 \pm 0.2$ mm
<b>Filling Volume</b>	Approx. 25 liters
<b>Dimensions</b>	Length: 1000 mm Width: 500 mm Height: adjustable feet

#### Specific Anthropomorphic Mannequin (SAM) Specifications:

The phantom for handset SAR assessment testing is a low-loss dielectric shell, with shape and dimensions derived from the anthropometric data of the 90th percentile adult male head dimensions as tabulated by the US Army. The SAM Twin Phantom shell is bisected along the mid-sagittal plane into right and left halves (see Fig. 3.7). The perimeter sidewalls of each phantom halves are extended to allow filling with liquid to a depth that is sufficient to minimized reflections from the upper surface. The liquid depth is maintained at a minimum depth of 15cm to minimize reflections from the upper surface.



Figure 3.7 Sam Twin Phantom shell

### 3.6 Device Holder for Transmitters

In combination with the Twin SAM Phantom V4.0/V4.0c, V5.0 or ELI4, the Mounting Device enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to IEC, IEEE, FCC or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).

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 3.8 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 3.9 Simulated Tissue

Table3.1 Composition of the Tissue Equivalent Matter

Ingredients (% by weight)	Frequency (MHz)							
	835		1900		2450		5200 ~ 5800	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body
Water	40.19	50.75	55.24	70.23	71.88	73.40	65.52	80.00
Salt (NaCl)	1.480	0.940	0.310	0.290	0.160	0.060	-	-
Sugar	57.90	48.21	-	-	-	-	-	-
HEC	0.250	-	-	-	-	-	-	-
Bactericide	0.180	0.100	-	-	-	-	-	-
Triton X-100	-	-	-	-	19.97	-	17.24	-
DGBE	-	-	44.45	29.48	7.990	26.54	-	-
Diethylene glycol hexyl ether	-	-	-	-	-	-	17.24	-
Polysorbate (Tween) 80	-	-	-	-	-	-	-	20.00
Target for Dielectric Constant	41.5	55.2	40.0	53.3	39.2	52.7	-	-
Target for Conductivity (S/m)	0.90	0.97	1.40	1.52	1.80	1.95	-	-

- Salt: 99 % Pure Sodium Chloride
- Water: De-ionized, 16M resistivity
- 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
- Sugar: 98 % Pure Sucrose
- HEC: Hydroxyethyl Cellulose

### 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	TX60L	N/A	N/A	F12/5LP5A1/A/01
<input checked="" type="checkbox"/>	Robot Controller	SCHMID	CS8C	N/A	N/A	F12/5LP5A1/C/01
<input checked="" type="checkbox"/>	Joystick	SCHMID	N/A	N/A	N/A	S-12030401
<input checked="" type="checkbox"/>	IntelCorei7-3770 3.40 GHz 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"/>	Twin SAM Phantom	SCHMID	QD000P40CD	N/A	N/A	1679
<input checked="" type="checkbox"/>	Data Acquisition Electronics	SCHMID	DAE4V1	2015-08-13	2016-08-13	1335
<input checked="" type="checkbox"/>	Dosimetric E-Field Probe	SCHMID	ES3DV3	2015-05-27	2016-05-27	3866
<input type="checkbox"/>	Dummy Probe	N/A	N/A	N/A	N/A	N/A
<input checked="" type="checkbox"/>	2450 MHz SAR Dipole	SCHMID	D2450V2	2015-09-28	2017-09-28	726
<input checked="" 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	ESG-3000A	2015-06-26	2016-06-26	US37230529
<input checked="" type="checkbox"/>	Signal Generator	Agilent	E4438C	2015-09-09	2016-09-09	US41461520
<input checked="" type="checkbox"/>	Amplifier	EMPOWER	BBS3Q7ELU	2015-09-09	2016-09-09	1020
<input checked="" type="checkbox"/>	Amplifier	RFBAY	MPA-40-40	2015-05-08	2016-05-08	21151801
<input checked="" type="checkbox"/>	Amplifier	EMPOWER	BBS3Q8CCJ	2015-10-20	2016-10-20	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	2015-09-23	2016-09-23	1435003
<input checked="" type="checkbox"/>	Wide Bandwidth Power Sensor	Anritsu	MA2490A	2015-09-23	2016-09-23	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	772D	2015-07-27	2016-07-27	2889A01064
<input checked="" type="checkbox"/>	Low Pass Filter 3.0 GHz	Micro LAB	LA-30N	2015-09-09	2016-09-09	N/A
<input checked="" type="checkbox"/>	Low Pass Filter 6.0 GHz	Micro LAB	LA-60N	2015-02-25	2016-02-25	N/A
<input checked="" type="checkbox"/>	Attenuators (3 dB)	Agilent	8491B	2015-06-26	2016-06-26	MY39260700
<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	2015-09-10	2016-09-10	3308A33341
<input checked="" type="checkbox"/>	Dielectric Probe kit	SCHMID	DAK-3.5	2014-12-09	2015-12-09	1092
<input checked="" type="checkbox"/>	Power Splitter	Anritsu	K241B	2015-02-25	2016-02-25	1301184
<input checked="" type="checkbox"/>	Bluetooth Tester	TESCOM	TC-3000B	2015-01-06	2016-01-06	3000B770243

**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

<b>Robot</b>	Stäubli Unimation Corp. Robot Model: TX60L
<b>Repeatability</b>	0.02 mm
<b>No. of axis</b>	6

#### Data Acquisition Electronic (DAE) System

##### Cell Controller

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

##### Data Converter

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

##### PC Interface Card

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

##### E-Field Probes

<b>Model</b>	EX3DV4 S/N: 3866
<b>Construction</b>	Triangular core fiber optic detection system
<b>Frequency</b>	10 MHz to 6 GHz
<b>Linearity</b>	$\pm 0.2$ dB (30 MHz to 6 GHz)

##### Phantom

<b>Phantom</b>	SAM Twin Phantom (V5.0)
<b>Shell Material</b>	Composite
<b>Thickness</b>	$2.0 \pm 0.2$ mm

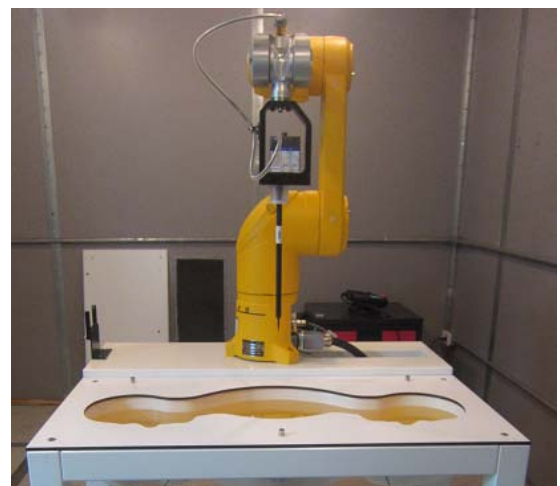
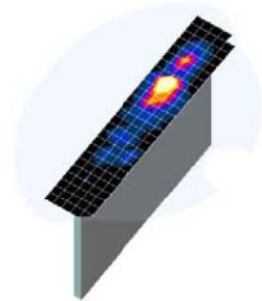


Figure 2.2 DASY5 Test System

## 5. SAR MEASUREMENT PROCEDURE

### 5.1 Measurement Procedure

The evaluation was performed using the following procedure compliant to FCC KDB Publication 865664 D01v01r04 and IEEE 1528-2013:



**Figure 5.1**  
Sample SAR Area Scan

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 D01v01r04 (See Table 5-1) and IEEE1528-2013.
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 D01v01r04 (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.

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

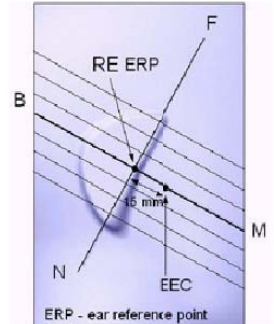
**Table 5.1 Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01v01r04\***

\*Also compliant to IEEE 1528-2013 Table 6

## 6. DEFINITION OF REFERENCE POINTS

### 6.1 Ear Reference Point

Figure 6.1 shows the front, back and side views of the SAM Twin Phantom. The point “M” is the reference point for the center of the mouth, “LE” is the left ear reference point(ERP), and “RE” is the right ERP. The ERPs are 15mm posterior to the entrance to the Ear canal (EEC) along the B-M line (Back-Mouth), as shown in Figure 6.5. The plane Passing, through the two ear canals and M is defined as the Reference Plane. The line N-F (Neck- Front) is perpendicular to the reference plane and passing through the RE (or LE) is called the Reference Pivoting Line (see Figure 6.1). Line B-M is perpendicular to the N-F line. Both N-F and B-M lines are marked on the external phantom shell to facilitate handset positioning.



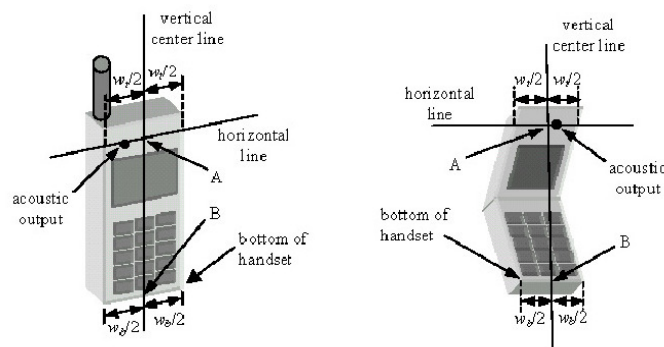
**Figure 6.1**  
Close-up side view of ERP

### 6.2 Handset Reference Points

Two imaginary lines on the handset were established: the vertical centerline and the horizontal line. The test device was placed in a normal operating position with the “test device reference point” located along the “vertical centerline” on the front of the device aligned to the “ear reference point” (See Fig. 6.3). The “test device reference point” was then located at the same level as the center of the ear reference point. The test device was positioned so that the “vertical centerline” was bisecting the front surface of the handset at it’s top and bottom edges, positioning the “ear reference point” on the outer surface of the both the left and right head phantoms on the ear reference point.



**Figure 6.2** Front, back and side view SAM Twin Phantom



**Figure 6.3** Handset Vertical Center & Horizontal Line Reference Points

## 7. TEST CONFIGURATION POSITIONS FOR HANDSETS

### 7.1 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  $\delta = 0.02$ .

### 7.2 Positioning for Cheek/Touch

1. The test device was positioned with the handset close to the surface of the phantom such that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Figure 7.1), such that the plane defined by the vertical center line and the horizontal line of the phone is approximately parallel to the sagittal plane of the phantom.

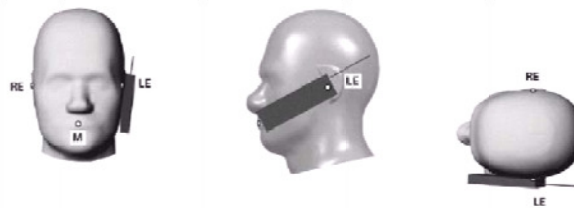


Figure 7.1 Front, Side and Top View of Cheek/Touch Position

2. The handset was translated towards the phantom along the line passing through RE & LE until the handset touches the ear.
3. While maintaining the handset in this plane, the handset was rotated around the LE-RE line until the vertical centerline was in the plane normal to MB-NF including the line MB (reference plane).
4. The phone was then rotated around the vertical centerline until the phone (horizontal line) was symmetrical with respect to the line NF.
5. While maintaining the vertical centerline in the reference plane, keeping point A on the line passing through RE and LE, and maintaining the phone contact with the ear, the handset was rotated about the line NF until any point on the handset made contact with a phantom point below the ear (cheek). (See Figure 7.2)

### 7.3 Positioning for Ear / 15 ° Tilt

With the test device aligned in the “Cheek/Touch Position”:

1. While maintaining the orientation of the phone, the phone was retracted parallel to the reference plane far enough to enable a rotation of the phone by 15 degree.
2. The phone was then rotated around the horizontal line by 15 degree.
3. While maintaining the orientation of the phone, the phone was moved parallel to the reference plane until any part of the phone touches the head. (In this position, point A was located on the line RE-LE). The tilted position is obtained when the contact is on the pinna. If the contact was at any location other than the pinna, the angle of the phone would then be reduced. The tilted position was obtained when any part of the phone was in contact of the ear as well as a second part of the phone was in contact with the head (see Figure 7.3).

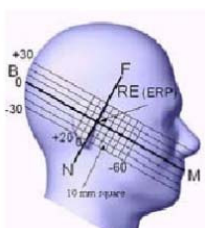


Figure 7.2 Side view w/relevant markings

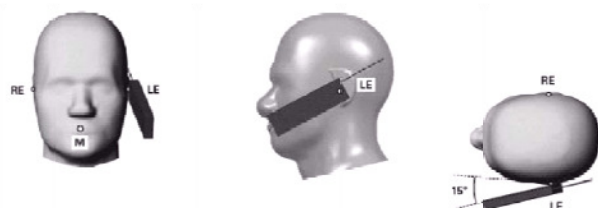
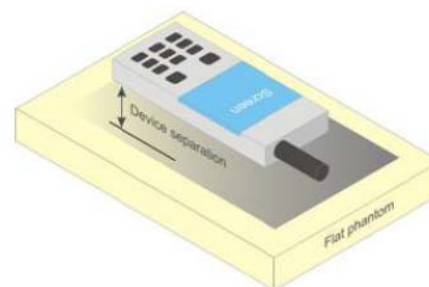


Figure 7.3 Front, Side and Top View of Ear/15° Position

## 7.4 Body-Worn Accessory Configurations

Body-worn operating configurations are tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in a normal use configuration (see Figure 6.7). Per FCC KDB Publication 648474 D04v01r03, Body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories. The body-worn accessory procedures in FCC KDB Publication 447498 D01v06 should be used to test for body-worn accessory SAR compliance, without a headset connected to it. This enables the test results for such configuration to be compatible with that required for hotspot mode when the body-worn accessory test separation distance is greater than or equal to that required for hotspot mode, when applicable. When the reported SAR for a body-worn accessory, measured without a headset connected to the handset, is  $> 1.2$  W/kg, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for that body-worn accessory with a headset attached to the handset.



**Figure 6.7 Sample Body-Worn Diagram**

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

Body-worn accessories may not always be supplied or available as options for some devices intended to be authorized for body-worn use. In this case, a test configuration with a separation distance between the back of the device and the flat phantom is used. Test position spacing was documented.

Transmitters that are designed to operate in front of a person's face, as in push-to-talk configurations, are tested for SAR compliance with the front of the device positioned to face the flat phantom in head fluid. For devices that are carried next to the body such as a shoulder, waist or chest-worn transmitters, SAR compliance is tested with the accessories, including headsets and microphones, attached to the device and positioned against a flat phantom in a normal use configuration.



## 7.5 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 D01v06 should be applied to determine SAR test requirements.

For smart phones with a display diagonal dimension > 15.0 cm or an overall diagonal dimension > 16.0 cm that provide similar mobile web access and multimedia support found in mini-tablets or UMPC mini-tablets that support voice calls next to the ear, unless it is confirmed otherwise through KDB inquiries, the following phablet procedures should be applied to evaluate SAR compliance for each applicable wireless modes and frequency band. Devices marketed as phablets, regardless of form factors and operating characteristics must be tested as a phablet to determine SAR compliance.

1. The normally required head and body-worn accessory SAR test procedures for handsets, including hotspot mode, must be applied.
2. The UMPC mini-tablet procedures must also be applied to test the SAR of all surfaces and edges with an antenna located at  $\leq 25$  mm from that surface or edge, in direct contact with a flat phantom, for 10-g extremity SAR according to the body-equivalent tissue dielectric parameters in KDB 865664 to address interactive hand use exposure conditions. The UMPC mini-tablet 1-g SAR at 5 mm is not required. When hotspot mode applies, 10-g extremity SAR is required only for the surfaces and edges with hotspot mode 1-g reported SAR > 1.2 W/kg; however, when power reduction applies to hotspot mode the measured SAR must be scaled to the maximum output power, including tolerance, allowed for phablet modes to compare with the 1.2 W/kg SAR test reduction threshold. The normal tablet procedures in KDB 616217 are required when the over diagonal dimension of the device is > 20.0 cm. Hotspot mode SAR is not required when normal tablet procedures are applied. Extremity 10-g SAR is also not required for the front (top) surface of large form factor full size tablets. The more conservative tablet SAR results can be used to support the 10-g extremity SAR for phablet mode.
3. The simultaneous transmission operating configurations applicable to voice and data transmissions for both phone and mini-tablet modes must be taken into consideration separately for 1-g and 10-g SAR to determine the simultaneous transmission SAR test exclusion and measurement requirements for the relevant wireless modes and exposure conditions.

## 8. 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 8.1.SAR Human Exposure Specified in ANSI/IEEE C95.1-2005**

	HUMAN EXPOSURE LIMITS	
	General Public Exposure (W/kg) or (mW/g)	Occupational Exposure (W/kg) or (mW/g)
SPATIAL PEAK SAR * (Brain)	1.60	8.00
SPATIAL AVERAGE SAR ** (Whole Body)	0.08	0.40
SPATIAL PEAK SAR *** (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).

## 9. FCC MEASUREMENT PROCEDURES

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

### 9.1 Measured and Reported SAR

Per FCC KDB Publication 447498 D01v06, 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.

### 9.2 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 D01v02r02 for more details.

#### 9.2.1 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.

#### 9.2.2 U-NII and U-NII-2A

For devices that operate in only one of the U-NII-1 and U-NII-2A bands, the normally required SAR procedures for OFDM configurations are applied. For devices that operate in both U-NII bands using the same transmitter and antenna(s), SAR test reduction is determined according to the following, with respect to the highest reported SAR and maximum output power specified for production units. The procedures are applied independently to each exposure configuration; for example, head, body, hotspot mode etc.

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

### 9.2.3 U-NII-2C and U-NII-3

The frequency range covered by U-NII-2C and U-NII-3 is 380 MHz (5.47 – 5.85 GHz), which requires a minimum of at least two SAR probe calibration frequency points to support SAR measurements.

When Terminal Doppler Weather Rader (TDWR) restriction applies, the channels at 5.60 – 5.65 GHz in U-NII-2C band must be disabled with acceptable mechanisms and documented in the equipment certification.

Unless band gap channels are permanently disabled, SAR must be considered for these channels. When band gap channels are disabled, each band is tested independently according to the normally required OFDM SAR measurements and probe calibration frequency points requirements.

### 9.2.4 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.

### 9.2.5 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.

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

For the 2.4 GHz and 5 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, 802.11a and 802.11n or 802.11g and 802.11n with the same channel bandwidth, modulation and data rate etc., the lower order 802.11 mode i.e., 802.11a, then 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.

### 9.2.7 Initial Test Configuration Procedure

For OFDM, in both 2.4 and 5 GHz 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.

### 9.2.8 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.

## 10. RF CONDUCTED POWERS

### 10.1 WLAN Conducted Powers

Mode	Freq. (MHz)	Channel	802.11b (2.4 GHz) Conducted Power (dBm)			
			Data Rate (Mbps)			
	1	2	5.5	11		
802.11b	2412	1	<u>15.28</u>	15.23	15.21	15.20
	2437	6	14.63	14.62	14.61	14.61
	2462	11	15.07	15.02	14.97	14.98

Table 10.1.1 IEEE 802.11b Average RF Power

Mode	Freq. (MHz)	Channel	802.11g (2.4 GHz) Conducted Power (dBm)							
			Data Rate (Mbps)							
	6	9	12	18	24	36	48	54		
802.11g	2412	1	12.55	12.54	12.53	12.53	12.54	12.52	12.50	12.48
	2437	6	14.84	14.81	14.77	14.75	14.72	14.78	14.74	14.80
	2462	11	10.41	10.40	10.39	10.39	10.40	10.39	10.38	10.36

Table 10.1.2 IEEE 802.11g Average RF Power

Mode	Freq. (MHz)	Channel	802.11n HT20 (2.4 GHz) Conducted Power (dBm)							
			Data Rate (Mbps)							
	6.5	13	19.5	26	39	52	58.5	65		
802.11n (HT-20)	2412	1	11.56	11.55	11.53	11.53	11.54	11.52	11.51	11.49
	2437	6	14.93	14.93	14.85	14.95	14.87	14.91	14.86	14.90
	2462	11	9.91	9.90	9.88	9.88	9.89	9.87	9.86	9.85

Table 10.1.3 IEEE 802.11n HT20 Average RF Power

Mode	Freq. (MHz)	Channel	802.11a (5 GHz) Conducted Power (dBm)							
			Data Rate (Mbps)							
	6	9	12	18	24	36	48	54		
802.11a	5180	36	10.63	10.62	10.60	10.59	10.59	10.56	10.54	10.58
	5200	40	10.41	10.41	10.38	10.41	10.41	10.37	10.37	10.36
	5220	44	10.43	10.35	10.38	10.28	10.31	10.33	10.35	10.32
	5240	48	10.46	10.45	10.42	10.41	10.38	10.38	10.28	10.38
	5260	52	10.66	10.55	10.58	10.61	10.56	10.60	10.59	10.63
	5280	56	10.64	10.59	10.61	10.44	10.52	10.56	10.57	10.58
	5300	60	<u>10.77</u>	10.75	10.77	10.75	10.72	10.67	10.69	10.69
	5320	64	10.63	10.60	10.61	10.54	10.58	10.52	10.51	10.51
	5500	100	<u>10.88</u>	10.86	10.87	10.83	10.82	10.83	10.80	10.78
	5580	116	10.85	10.81	10.78	10.74	10.75	10.72	10.78	10.69
	5660	132	10.45	10.38	10.41	10.40	10.38	10.39	10.42	10.32
	5720	144	10.38	10.37	10.29	10.30	10.25	10.31	10.29	10.30
	5745	149	<u>10.38</u>	10.37	10.38	10.32	10.38	10.31	10.34	10.36
	5785	157	10.25	10.22	10.20	10.12	10.19	10.17	10.13	10.17
5825	165	10.27	10.26	10.22	10.18	10.16	10.13	10.12	10.15	

Table 10.1.4 IEEE 802.11a Average RF Power

Mode	Freq. (MHz)	Channel	802.11n HT20 (5 GHz) Conducted Power (dBm)							
			Data Rate (Mbps)							
			6.5	13	19.5	26	39	52	58.5	65
802.11n (HT-20)	5180	36	10.49	10.48	10.47	10.45	10.42	10.40	10.40	10.39
	5200	40	10.38	10.36	10.37	10.31	10.30	10.26	10.32	10.25
	5220	44	10.35	10.33	10.28	10.22	10.31	10.29	10.27	10.24
	5240	48	10.34	10.33	10.32	10.34	10.30	10.31	10.27	10.32
	5260	52	10.43	10.35	10.35	10.38	10.33	10.37	10.36	10.33
	5280	56	10.58	10.55	10.49	10.42	10.38	10.41	10.47	10.53
	5300	60	10.66	10.64	10.63	10.62	10.60	10.57	10.60	10.63
	5320	64	10.53	10.51	10.45	10.45	10.44	10.45	10.39	10.45
	5500	100	10.88	10.87	10.87	10.84	10.86	10.83	10.83	10.85
	5580	116	10.79	10.78	10.77	10.72	10.77	10.75	10.73	10.74
	5660	132	10.41	10.35	10.33	10.22	10.28	10.19	10.27	10.36
	5720	144	10.29	10.26	10.29	10.29	10.27	10.28	10.26	10.25
	5745	149	10.34	10.35	10.33	10.33	10.31	10.27	10.26	10.24
	5785	157	10.22	10.21	10.17	10.20	10.16	10.09	10.15	10.15
5825	165	10.25	10.24	10.21	10.17	10.15	10.16	10.18	10.19	

Table 10.1.5 IEEE 802.11n HT20 Average RF Power

Justification for reduced test configurations for WIFI channels per KDB Publication 248227 D01v02r02 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, duo 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.

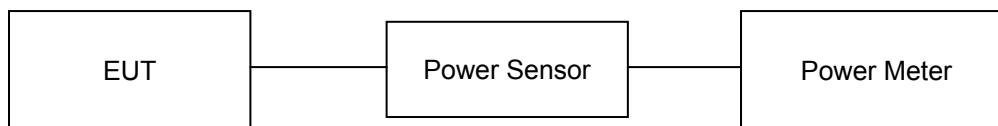


Figure 10.1 Power Measurement Setup

## 10.2 Bluetooth Conducted Powers

Channel	Frequency (MHz)	Frame AVG Output Power (1Mbps)		Frame AVG Output Power (2Mbps)		Frame AVG Output Power (3Mbps)	
		(dBm)	(mW)	(dBm)	(mW)	(dBm)	(mW)
Low	2402	8.07	6.412	5.74	3.750	5.76	3.767
Mid	2441	7.61	5.768	5.38	3.451	5.41	3.475
High	2480	8.17	6.561	5.78	3.784	5.70	3.715

Table 10.2.1 Bluetooth Frame Average RF Power

Channel	Frequency (MHz)	Frame AVG Output Power (LE)	
		(dBm)	(mW)
Low	2402	-0.84	0.824
Mid	2440	-1.26	0.748
High	2480	-1.19	0.760

Table 10.2.2 Bluetooth LE Frame Average RF Power

### ● Bluetooth Conducted Powers procedures

#### 1. Bluetooth (BDR, EDR)

1) Enter DUT mode in EUT and operate it.

When it operating, The EUT is transmitting at maximum power level and duty cycle fixed.

2) Instruments and EUT were connected like Figure 10.4(A).

3) The maximum output powers of BDR(1 Mbps), EDR(2, 3 Mbps) and each frequency were set by a Bluetooth Tester.

4) Power levels were measured by a Power Meter.

#### 2. Bluetooth (LE)

1) Enter LE mode in EUT and operate it.

When it operating, The EUT is transmitting at maximum power level and duty cycle fixed.

2) Instruments and EUT were connected like Figure 10.4(B).

3) The average conducted output powers of LE and each frequency can measurement according to setting program in EUT.

4) Power levels were measured by a Power Meter.

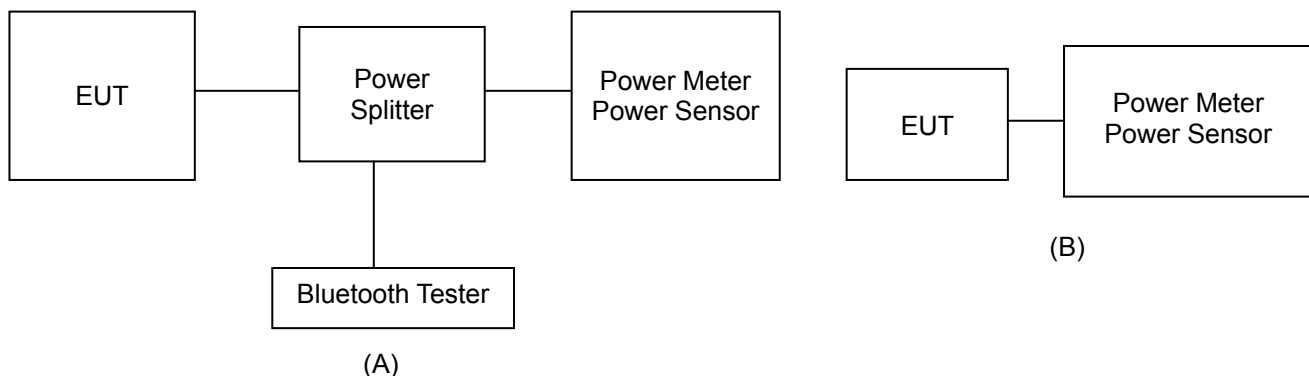


Figure 10.2 Average Power Measurement Setup

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





# 11. SYSTEM VERIFICATION

## 11.1 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 [%]
Nov. 03. 2015	2450 Head	21.2	21.6	2412.0	39.270	1.766	39.460	1.748	0.48	-1.02
				2437.0	39.220	1.788	39.408	1.776	0.48	-0.67
				2450.0	39.200	1.800	39.373	1.790	0.44	-0.56
				2462.0	39.180	1.813	39.348	1.803	0.43	-0.55
Nov. 03. 2015	2450 Body	21.2	21.6	2412.0	52.750	1.914	52.199	1.944	-1.04	1.57
				2437.0	52.720	1.938	52.141	1.974	-1.10	1.86
				2450.0	52.700	1.950	52.105	1.990	-1.13	2.05
				2462.0	52.680	1.967	52.081	2.004	-1.14	1.88
Nov. 04. 2015	5300 Head	21.5	21.9	5260.0	35.940	4.720	36.656	4.763	1.99	0.91
				5280.0	35.920	4.740	36.629	4.790	1.97	1.05
				5300.0	35.900	4.760	36.606	4.807	1.97	0.99
				5320.0	35.880	4.780	36.561	4.832	1.90	1.09
Nov. 05. 2015	5600 Head	21.3	21.7	5500.0	35.650	4.965	34.629	4.856	-2.86	-2.20
				5580.0	35.530	5.049	34.496	4.936	-2.91	-2.24
				5600.0	35.500	5.070	34.459	4.963	-2.93	-2.11
				5660.0	35.440	5.130	34.378	5.025	-3.00	-2.05
				5700.0	35.400	5.170	34.299	5.070	-3.11	-1.93
Nov. 06. 2015	5800 Head	21.4	21.8	5745.0	35.360	5.215	34.772	5.214	-1.66	-0.02
				5785.0	35.320	5.255	34.713	5.260	-1.72	0.10
				5800.0	35.300	5.270	34.683	5.279	-1.75	0.17
				5825.0	35.280	5.296	34.650	5.313	-1.79	0.32

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  $\epsilon_r$ , 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  $j = \sqrt{-1}$ .

## 11.2 Test System Verification

Prior to assessment, the system is verified to the  $\pm 10\%$  of the specifications at 835 MHz, 1800MHz, 1900 MHz, 2450 MHz and 5 GHz by using the SAR Dipole kit(s). (Graphic Plots Attached)

**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)	1 W Target SAR <sub>1g</sub> (W/kg)	Measured SAR <sub>1g</sub> (W/kg)	1 W Normalized SAR <sub>1g</sub> (W/kg)	Deviation [%]
A	2450	D2450V2, SN: 726	Nov. 03. 2015	Head	21.2	21.6	3866	250	51.2	13.1	52.40	2.34
A	2450	D2450V2, SN: 726	Nov. 03. 2015	Body	21.2	21.6	3866	250	49.5	12.4	49.60	0.20
A	5300	D5GHzV2, SN: 1103	Nov. 04. 2015	Head	21.5	21.9	3866	100	82.4	8.00	80.00	-2.91
A	5500	D5GHzV2, SN: 1103	Nov. 05. 2015	Head	21.3	21.7	3866	100	82.9	8.85	88.50	6.76
A	5600	D5GHzV2, SN: 1103	Nov. 05. 2015	Head	21.3	21.7	3866	100	82.2	8.46	84.60	2.92
A	5800	D5GHzV2, SN: 1103	Nov. 06. 2015	Head	21.4	21.8	3866	100	78.4	7.65	76.50	-2.42

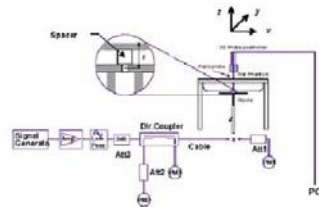
**SYSTEM DIPOLE VERIFICATION TARGET & MEASURED**

SAR System #	Freq. [MHz]	SAR Dipole kits	Date(s)	Tissue Type	Ambient Temp.[°C]	Liquid Temp.[°C]	Probe S/N	Input Power (mW)	1 W Target SAR <sub>10g</sub> (W/kg)	Measured SAR <sub>10g</sub> (W/kg)	1 W Normalized SAR <sub>10g</sub> (W/kg)	Deviation [%]
A	2450	D2450V2, SN: 726	Nov. 03. 2015	Body	21.2	21.6	3866	250	23.2	5.97	23.88	2.93

Note1 : System Verification was measured with input 250 mW , 100 mW(5200-5800 MHz) 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**



## 12. SAR TEST RESULTS

### 12.1 Head SAR Results

Table 12.1 DTS Head SAR

MEASUREMENT RESULTS															
FREQUENCY		Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Phantom Position	Device Serial Number	Peak SAR of Area Scan	Data Rate [Mbps]	Duty Cycle	1g SAR (W/kg)	Scaling Factor	Scaling Factor (Duty Cycle)	1g Scaled SAR (W/kg)	Plots #
MHz	Ch														
2412	1	802.11b	15.3	15.28	-	Left Touch	FCC #1	0.0706	1	97.7	-	1.005	1.024	-	
2412	1	802.11b	15.3	15.28	0.140	Right Touch	FCC #1	0.131	1	97.7	0.139	1.005	1.024	0.143	A1
2412	1	802.11b	15.3	15.28	-	Left Tilt	FCC #1	0.0679	1	97.7	-	1.005	1.024	-	
2412	1	802.11b	15.3	15.28	-	Right Tilt	FCC #1	0.0671	1	97.7	-	1.005	1.024	-	
2412	1	802.11b	15.3	15.28	0.190	Right Touch	FCC #1	0.125	1	97.7	0.122	1.005	1.024	0.126 <sup>Note</sup>	
ANSI / IEEE C95.1-2005– SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure								Head 1.6 W/kg (mW/g) averaged over 1 gram							

Note(s):

- Highest reported SAR is ≤ 0.4 W/kg. Therefore, further SAR measurements within this exposure condition are not required.
- Indicates a repeat measurement of the extended battery

Adjusted SAR results for OFDM SAR												
FREQUENCY		Mode/ Antenna	Service	Maximum Allowed Power [dBm]	1g Scaled SAR (W/kg)	FREQUENCY [MHz]	Mode	Service	Maximum Allowed Power [dBm]	Ratio of OFDM to DSSS	1g Adjusted SAR (W/kg)	Determine OFDM SAR
MHz	Ch											
2412	1	802.11b	DSSS	15.3	0.143	2412	802.11g	OFDM	14.9	0.912	0.130	X
2412	1	802.11b	DSSS	15.3	0.143	2412	802.11n HT20	OFDM	15.0	0.933	0.133	X
ANSI / IEEE C95.1-2005– SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure						Head 1.6 W/kg (mW/g) averaged over 1 gram						



Table 12.2 U-NII Head SAR

MEASUREMENT RESULTS

FREQUENCY		Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Phantom Position	Device Serial Number	Peak SAR of Area Scan	Data Rate [Mbps]	Duty Cycle	1g SAR (W/kg)	Scaling Factor	Scaling Factor (Duty Cycle)	1g Scaled SAR (W/kg)	Plots #
MHz	Ch														
5300	60	802.11a	10.8	10.77	-	Left Touch	FCC #1	0.0664	13.5	87.2	-	1.007	1.147	-	
5300	60	802.11a	10.8	10.77	-0.010	Right Touch	FCC #1	0.138	13.5	87.2	0.117	1.007	1.147	0.135	A2
5300	60	802.11a	10.8	10.77	-	Left Tilt	FCC #1	0.0231	13.5	87.2	-	1.007	1.147	-	
5300	60	802.11a	10.8	10.77	-	Right Tilt	FCC #1	0.094	13.5	87.2	-	1.007	1.147	-	
5300	60	802.11a	10.8	10.77	0.140	Right Touch	FCC #1	0.112	13.5	87.2	0.106	1.007	1.147	0.122	
5500	100	802.11a	10.9	10.88	-	Left Touch	FCC #1	0.0689	13.5	87.2	-	1.005	1.147	-	
5500	100	802.11a	10.9	10.88	-0.040	Right Touch	FCC #1	0.143	13.5	87.2	0.144	1.005	1.147	0.166	A3
5500	100	802.11a	10.9	10.88	-	Left Tilt	FCC #1	0.0304	13.5	87.2	-	1.005	1.147	-	
5500	100	802.11a	10.9	10.88	-	Right Tilt	FCC #1	0.0875	13.5	87.2	-	1.005	1.147	-	
5500	100	802.11a	10.9	10.88	-0.020	Right Touch	FCC #1	0.141	13.5	87.2	0.139	1.005	1.147	0.160	
5745	149	802.11a	10.4	10.38	-	Left Touch	FCC #1	0.0382	13.5	87.2	-	1.005	1.147	-	
5745	149	802.11a	10.4	10.38	0.030	Right Touch	FCC #1	0.133	13.5	87.2	0.136	1.005	1.147	0.157	A4
5745	149	802.11a	10.4	10.38	-	Left Tilt	FCC #1	0.032	13.5	87.2	-	1.005	1.147	-	
5745	149	802.11a	10.4	10.38	-	Right Tilt	FCC #1	0.0992	13.5	87.2	-	1.005	1.147	-	
5745	149	802.11a	10.4	10.38	0.100	Right Touch	FCC #1	0.131	13.5	87.2	0.132	1.005	1.147	0.152	
<b>ANSI / IEEE C95.1-2005- SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure</b>								<b>Head 1.6 W/kg (mW/g) averaged over 1 gram</b>							

Note: Highest reported SAR is ≤ 0.4 W/kg. Therefore, further SAR measurements within this exposure condition are not required.

Adjusted SAR results for UNII-1 and UNII-2A SAR

FREQUENCY		Model/ Antenna	Service	Maximum Allowed Power [dBm]	1g Scaled SAR (W/kg)	FREQUENCY [MHz]	Mode	Service	Maximum Allowed Power [dBm]	Adjusted Factor	1g Adjusted SAR (W/kg)	SAR for the band with lower maximum output power
MHz	Ch											
5300	60	802.11a	OFDM	10.8	0.135	5180	802.11a	OFDM	10.7	0.977	0.132	X
<b>ANSI / IEEE C95.1-2005- SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure</b>						<b>Head 1.6 W/kg (mW/g) averaged over 1 gram</b>						

Note(s):

- U-NII-1 and U-NII-2A Bands: When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest reported SAR for the tested configuration is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power in that test configuration.



## 12.2 Standalone Body-Worn SAR Worn SAR Results

Table 12.3 DTS Body-Worn SAR

MEASUREMENT RESULTS															
FREQUENCY		Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Phantom Position	Device Serial Number	Peak SAR of Area Scan	Data Rate [Mbps]	Duty Cycle	1g SAR (W/kg)	Scaling Factor	Scaling Factor (Duty Cycle)	SAR (W/kg)	Plots #
MHz	Ch														
2412	1	802.11b	15.3	15.28	0.020	10 mm [Rear]	FCC #1	0.0344	1	97.7	0.033	1.005	1.024	0.034	A5
2412	1	802.11b	15.3	15.28	0.030	10 mm [Rear]	FCC #1	0.0316	1	97.7	0.032	1.005	1.024	0.033 <sup>Note</sup>	
ANSI / IEEE C95.1-2005– SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure								Body 1.6 W/kg (mW/g) averaged over 1 gram							

Note(s):

- Highest reported SAR is  $\leq 0.4$  W/kg. Therefore, further SAR measurements within this exposure condition are not required.
- Indicates a repeat measurement of the extended battery

Adjusted SAR results for OFDM SAR												
FREQUENCY		Mode/ Antenna	Service	Maximum Allowed Power [dBm]	1g Scaled SAR (W/kg)	FREQUENCY [MHz]	Mode	Service	Maximum Allowed Power [dBm]	Ratio of OFDM to DSSS	1g Adjusted SAR (W/kg)	Determine OFDM SAR
MHz	Ch											
2412	1	802.11b	DSSS	15.3	0.034	2412	802.11g	OFDM	14.9	0.912	0.031	X
2412	1	802.11b	DSSS	15.3	0.034	2412	802.11n HT20	OFDM	15.0	0.933	0.032	X
ANSI / IEEE C95.1-2005– SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure						Body 1.6 W/kg (mW/g) averaged over 1 gram						



### 12.3 Standalone Hand SAR Results

Table 12.4 DTS Hand SAR

MEASUREMENT RESULTS															
FREQUENCY		Mode	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Drift Power [dB]	Phantom Position	Device Serial Number	Peak SAR of Area Scan	Data Rate [Mbps]	Duty Cycle	10g SAR (W/kg)	Scaling Factor	Scaling Factor (Duty Cycle)	SAR (W/kg)	Plots #
MHz	Ch														
2412	1	802.11b	15.3	15.28	-	0 mm [Top]	FCC #1	0.0891	1	97.7	-	1.005	1.024	-	
2412	1	802.11b	15.3	15.28	-	0 mm [Front]	FCC #1	0.163	1	97.7	-	1.005	1.024	-	
2412	1	802.11b	15.3	15.28	-	0 mm [Rear]	FCC #1	0.0639	1	97.7	-	1.005	1.024	-	
2412	1	802.11b	15.3	15.28	-0.060	0 mm [Left]	FCC #1	0.220	1	97.7	0.236	1.005	1.024	0.243	A6
2412	1	802.11b	15.3	15.28	-0.010	0 mm [Left]	FCC #1	0.220	1	97.7	0.235	1.005	1.024	0.242 <sup>Note</sup>	
ANSI / IEEE C95.1-2005– SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure								Hand 4.0 W/kg (mW/g) averaged over 10 gram							

Note(s):

1. Highest reported SAR is ≤ 0.4 W/kg. Therefore, further SAR measurements within this exposure condition are not required.
2. Indicates a repeat measurement of the extended battery

Adjusted SAR results for OFDM SAR												
FREQUENCY		Mode/ Antenna	Service	Maximum Allowed Power [dBm]	10g Scaled SAR (W/kg)	FREQUENCY [MHz]	Mode	Service	Maximum Allowed Power [dBm]	Ratio of OFDM to DSSS	10g Adjusted SAR (W/kg)	Determine OFDM SAR
MHz	Ch											
2412	1	802.11b	DSSS	15.3	0.243	2412	802.11g	OFDM	14.9	0.912	0.222	X
2412	1	802.11b	DSSS	15.3	0.243	2412	802.11n HT20	OFDM	15.0	0.933	0.227	X
ANSI / IEEE C95.1-2005– SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population Exposure						Hand 4.0 W/kg (mW/g) averaged over 10 gram						

## 12.4 SAR Test Notes

### General Notes:

1. The test data reported are the worst-case SAR values according to test procedures specified in IEEE 1528-2013, and FCC KDB Publication 447498 D01v06.
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 D01v06.
6. Device was tested using a fixed spacing for body-worn accessory testing. A separation distance of 10 mm was considered because the manufacturer has determined that there will be body-worn accessories available in the marketplace for users to support this separation distance.
7. Per FCC KDB Publication 648474 D04v01r03, 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.
8. Per FCC KDB 865664 D01v01r04, 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.

### 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 D01v02r02 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 adjusted SAR is  $\leq 1.2$  W/kg.
3. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02 for 5 GHz WIFI single transmission chain operations, the initial test configuration was selected according to the transmission mode with the highest maximum allowed powers. Other transmission modes were not investigated since the highest reported SAR for initial test configuration adjusted by the ratio of maximum output powers is less than 1.2 W/kg.
4. 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.
5. 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.

## 13. SAR MEASUREMENT VARIABILITY

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### 13.1 Measurement Variability

Per FCC KDB Publication 865664 D01v01r04, 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  $> 1.20$  or when the original or repeated measurement was  $\geq 1.45$  W/kg (~ 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  $> 1.20$ .
4. Repeated measurements are not required when the original highest measured SAR is  $< 0.80$  W/kg

### 13.2 Measurement Uncertainty

The measured SAR was  $< 1.5$  W/kg for all frequency bands. Therefore, per KDB Publication 865664D01v01r04, the standard measurement uncertainty analysis per IEEE 1528-2013 was not required.



## 14. IEEE P1528 –MEASUREMENT UNCERTAINTIES

### 2450 MHz Head

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.)	$\pm 4.4$	Normal	1	0.64	$\pm 4.4 \%$	$\infty$
Liquid permittivity (Target)	$\pm 5.0$	Rectangular	$\sqrt{3}$	0.6	$\pm 2.887 \%$	$\infty$
Liquid permittivity (Meas.)	$\pm 4.6$	Normal	1	0.6	$\pm 4.6 \%$	$\infty$
<b>Combined Standard Uncertainty</b>					<b><math>\pm 12.2 \%</math></b>	330
<b>Expanded Uncertainty (k=2)</b>					<b><math>\pm 24.4 \%</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	$\pm 0.145 \%$	$\infty$
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.)	$\pm 4.5$	Normal	1	0.6	$\pm 4.5 \%$	$\infty$
<b>Combined Standard Uncertainty</b>					<b><math>\pm 12.1 \%</math></b>	<b>330</b>
<b>Expanded Uncertainty (k=2)</b>					<b><math>\pm 24.2 \%</math></b>	

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

**5300 MHz Head**

Error Description	Uncertainty value $\pm\%$	Probability Distribution	Divisor	(Ci) 1g	Standard (1g)	vi 2 or Veff
<b>Measurement System</b>						
Probe calibration	$\pm 6.55$	Normal	1	1	$\pm 6.55 \%$	$\infty$
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.)	$\pm 3.7$	Normal	1	0.64	$\pm 3.7 \%$	$\infty$
Liquid permittivity (Target)	$\pm 5.0$	Rectangular	$\sqrt{3}$	0.6	$\pm 2.887 \%$	$\infty$
Liquid permittivity (Meas.)	$\pm 4.6$	Normal	1	0.6	$\pm 4.6 \%$	$\infty$
<b>Combined Standard Uncertainty</b>					<b><math>\pm 12.4 \%</math></b>	<b>330</b>
<b>Expanded Uncertainty (k=2)</b>					<b><math>\pm 24.8 \%</math></b>	

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

**5500 MHz Head**

Error Description	Uncertainty value $\pm\%$	Probability Distribution	Divisor	(Ci) 1g	Standard (1g)	vi 2 or Veff
<b>Measurement System</b>						
Probe calibration	$\pm 6.55$	Normal	1	1	$\pm 6.55 \%$	$\infty$
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.)	$\pm 3.8$	Normal	1	0.64	$\pm 3.8 \%$	$\infty$
Liquid permittivity (Target)	$\pm 5.0$	Rectangular	$\sqrt{3}$	0.6	$\pm 2.887 \%$	$\infty$
Liquid permittivity (Meas.)	$\pm 4.4$	Normal	1	0.6	$\pm 4.4 \%$	$\infty$
<b>Combined Standard Uncertainty</b>					<b><math>\pm 12.4 \%</math></b>	<b>330</b>
<b>Expanded Uncertainty (k=2)</b>					<b><math>\pm 24.8 \%</math></b>	

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

**5600 MHz Head**

Error Description	Uncertainty value $\pm\%$	Probability Distribution	Divisor	(Ci) 1g	Standard (1g)	vi 2 or Veff
<b>Measurement System</b>						
Probe calibration	$\pm 6.55$	Normal	1	1	$\pm 6.55 \%$	$\infty$
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.)	$\pm 3.9$	Normal	1	0.64	$\pm 3.9 \%$	$\infty$
Liquid permittivity (Target)	$\pm 5.0$	Rectangular	$\sqrt{3}$	0.6	$\pm 2.887 \%$	$\infty$
Liquid permittivity (Meas.)	$\pm 4.5$	Normal	1	0.6	$\pm 4.5 \%$	$\infty$
<b>Combined Standard Uncertainty</b>					<b><math>\pm 12.4 \%</math></b>	<b>330</b>
<b>Expanded Uncertainty (k=2)</b>					<b><math>\pm 24.8 \%</math></b>	

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

**5800 MHz Head**

Error Description	Uncertainty value $\pm\%$	Probability Distribution	Divisor	(Ci) 1g	Standard (1g)	vi 2 or Veff
<b>Measurement System</b>						
Probe calibration	$\pm 6.55$	Normal	1	1	$\pm 6.55 \%$	$\infty$
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.)	$\pm 4.4$	Normal	1	0.64	$\pm 4.4 \%$	$\infty$
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>					<b><math>\pm 12.4 \%</math></b>	<b>330</b>
<b>Expanded Uncertainty (k=2)</b>					<b><math>\pm 24.8 \%</math></b>	

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

## 15. 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 every 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.

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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  
**S** Swiss Calibration Service

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

Accreditation No.: **SCS 0108**

Client: **DT&C (Dymstec)**

Certificate No.: **EX3-3866\_May15**

### CALIBRATION CERTIFICATE

Object: **EX3DV4 - SN:3866**

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

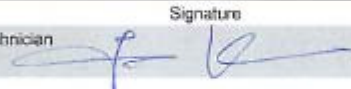

Calibration date: **May 27, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

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

Calibrated by:	Name <b>Jeton Kastrati</b>	Function <b>Laboratory Technician</b>	Signature 
Approved by:	Name <b>Katja Pokovic</b>	Function <b>Technical Manager</b>	Signature 

Issued: May 28, 2015

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

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



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

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

Accreditation No.: SCS 0108

### Glossary:

TSL	tissue simulating liquid
NORM <sub>x,y,z</sub>	sensitivity in free space
ConvF	sensitivity in TSL / NORM <sub>x,y,z</sub>
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization $\varphi$	$\varphi$ rotation around probe axis
Polarization $\vartheta$	$\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

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

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

EX3DV4 – SN:3866

May 27, 2015

# Probe EX3DV4

## SN:3866

Manufactured: February 2, 2012  
Calibrated: May 27, 2015

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

EX3DV4- SN:3866

May 27, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3866

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	0.42	0.46	0.40	$\pm 10.1 \%$
DCP (mV) <sup>B</sup>	101.2	101.7	102.6	

### Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc <sup>E</sup> (k=2)
0	CW	X	0.0	0.0	1.0	0.00	145.9	$\pm 3.8 \%$
		Y	0.0	0.0	1.0		130.9	
		Z	0.0	0.0	1.0		136.9	

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  $E^2$ -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.

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## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3866

### 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 (mm) <sup>G</sup>	Unct. (k=2)
300	45.3	0.87	10.94	10.94	10.94	0.10	1.15	± 13.3 %
450	43.5	0.87	11.20	11.20	11.20	0.18	1.20	± 13.3 %
600	42.7	0.88	9.99	9.99	9.99	0.08	1.15	± 13.3 %
750	41.9	0.89	9.54	9.54	9.54	0.25	1.20	± 12.0 %
835	41.5	0.90	9.09	9.09	9.09	0.18	1.68	± 12.0 %
900	41.5	0.97	8.93	8.93	8.93	0.24	1.37	± 12.0 %
1750	40.1	1.37	7.84	7.84	7.84	0.39	0.81	± 12.0 %
1900	40.0	1.40	7.58	7.58	7.58	0.26	0.98	± 12.0 %
2300	39.5	1.67	7.20	7.20	7.20	0.34	0.80	± 12.0 %
2450	39.2	1.80	6.85	6.85	6.85	0.25	1.09	± 12.0 %
2600	39.0	1.96	6.73	6.73	6.73	0.23	1.17	± 12.0 %
3500	37.9	2.91	6.58	6.58	6.58	0.21	1.79	± 13.1 %
5200	36.0	4.66	5.24	5.24	5.24	0.35	1.80	± 13.1 %
5300	35.9	4.76	5.02	5.02	5.02	0.35	1.80	± 13.1 %
5500	35.6	4.96	4.50	4.50	4.50	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.33	4.33	4.33	0.40	1.80	± 13.1 %
5800	35.3	5.27	4.57	4.57	4.57	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.

EX3DV4- SN:3866

May 27, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3866

### 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 (mm) <sup>G</sup>	Unct. (k=2)
300	58.2	0.92	10.73	10.73	10.73	0.06	1.15	± 13.3 %
450	56.7	0.94	10.60	10.60	10.60	0.10	1.15	± 13.3 %
600	56.1	0.95	10.02	10.02	10.02	0.05	1.15	± 13.3 %
750	55.5	0.96	9.39	9.39	9.39	0.43	0.80	± 12.0 %
835	55.2	0.97	9.25	9.25	9.25	0.51	0.84	± 12.0 %
900	55.0	1.05	9.12	9.12	9.12	0.33	1.06	± 12.0 %
1750	53.4	1.49	7.64	7.64	7.64	0.44	0.80	± 12.0 %
1900	53.3	1.52	7.31	7.31	7.31	0.42	0.80	± 12.0 %
2300	52.9	1.81	7.15	7.15	7.15	0.38	0.80	± 12.0 %
2450	52.7	1.95	7.00	7.00	7.00	0.36	0.80	± 12.0 %
2600	52.5	2.16	6.84	6.84	6.84	0.29	0.80	± 12.0 %
3500	51.3	3.31	6.18	6.18	6.18	0.22	2.07	± 13.1 %
5200	49.0	5.30	4.28	4.28	4.28	0.40	1.90	± 13.1 %
5300	48.9	5.42	4.21	4.21	4.21	0.40	1.90	± 13.1 %
5500	48.6	5.65	3.90	3.90	3.90	0.45	1.90	± 13.1 %
5600	48.5	5.77	3.83	3.83	3.83	0.45	1.90	± 13.1 %
5800	48.2	6.00	4.02	4.02	4.02	0.45	1.90	± 13.1 %

<sup>C</sup> Frequency validity above 300 MHz of  $\pm 100$  MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to  $\pm 50$  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  $\pm 10, 25, 40, 50$  and  $70$  MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to  $\pm 110$  MHz.

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to  $\pm 10\%$  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  $\pm 5\%$ . The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

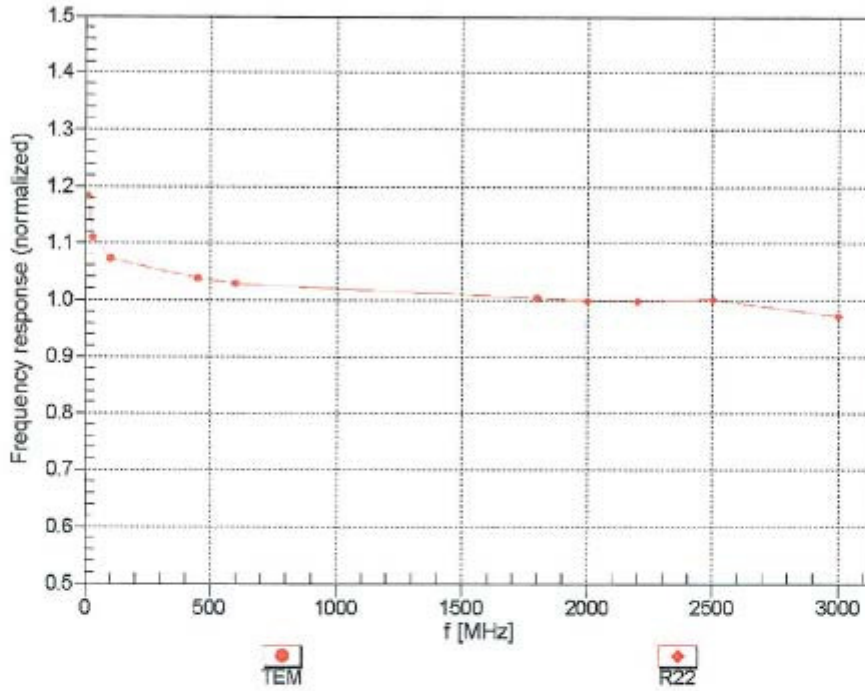
<sup>G</sup> Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than  $\pm 1\%$  for frequencies below 3 GHz and below  $\pm 2\%$  for frequencies between 3-6 GHz at any distance larger than half the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



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

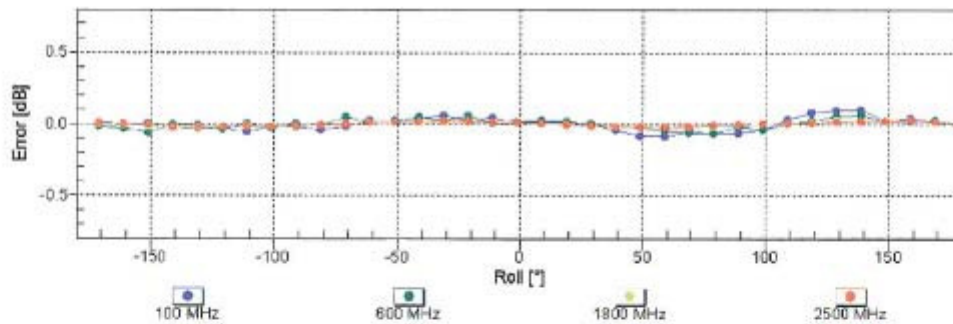
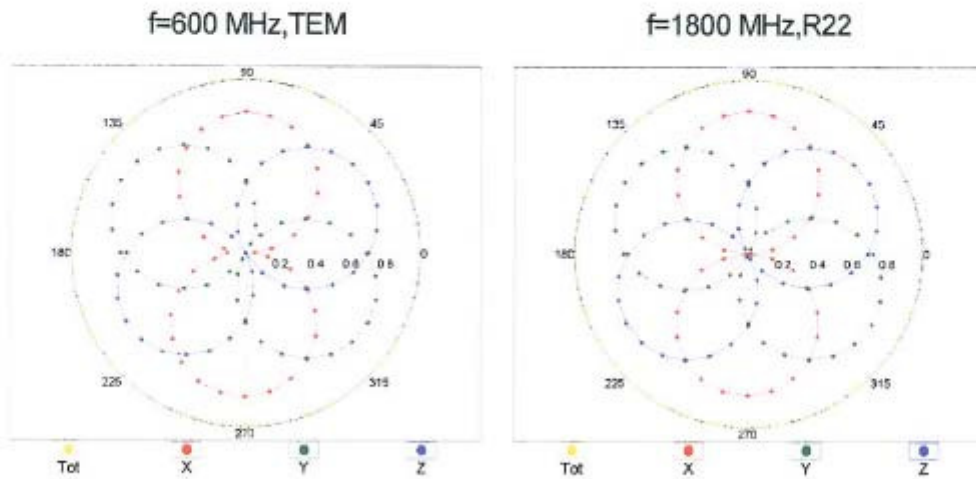


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

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May 27, 2015

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

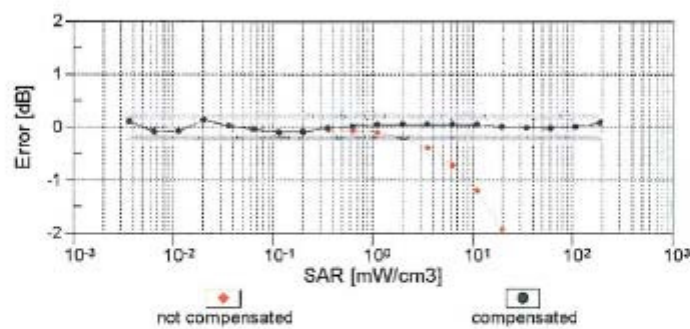
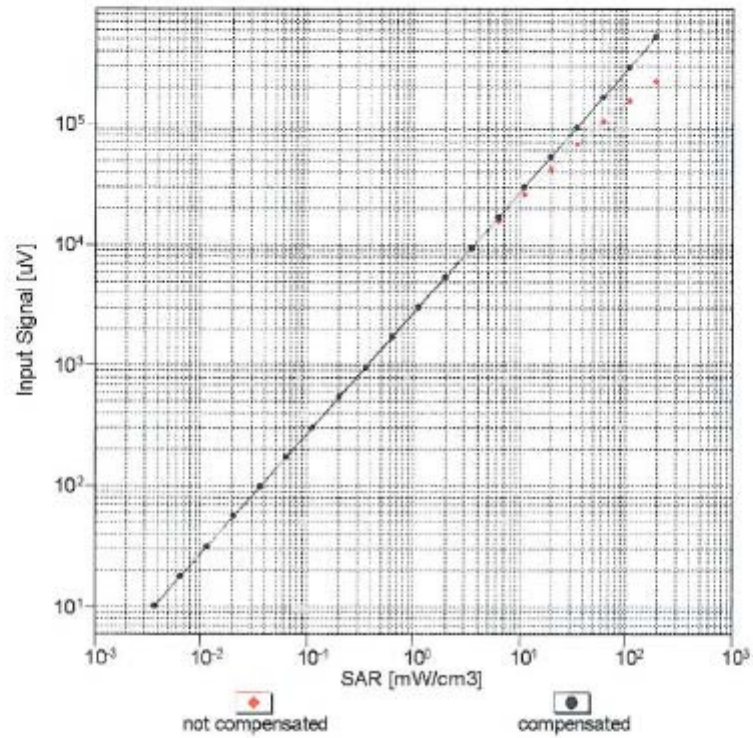


Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

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May 27, 2015

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

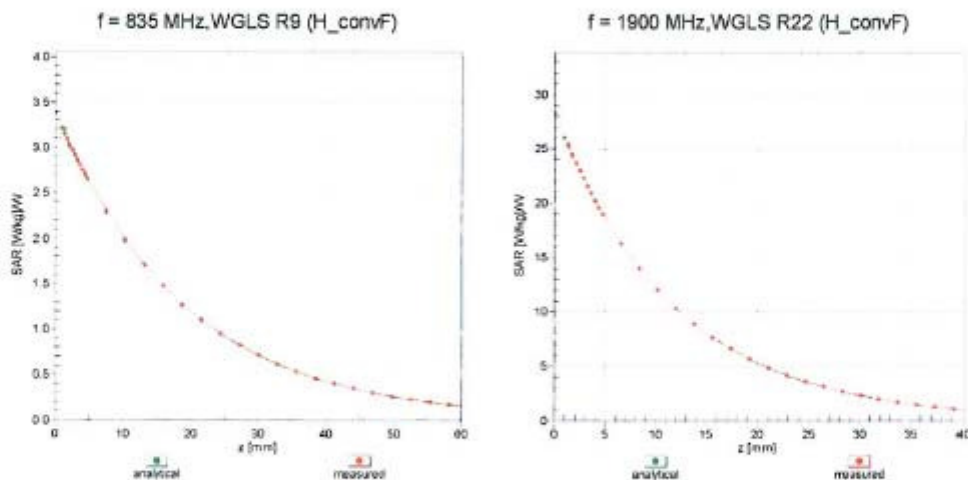


Uncertainty of Linearity Assessment:  $\pm 0.6\%$  (k=2)

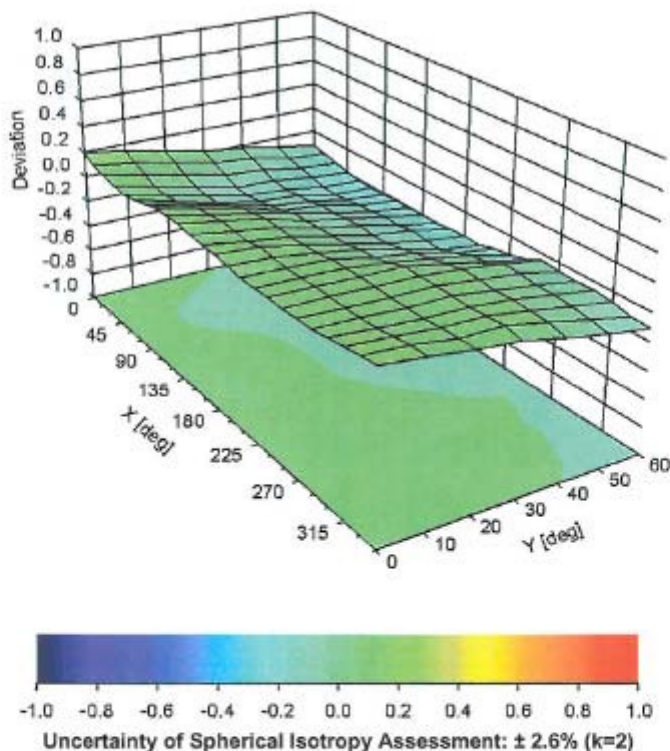
EX3DV4- SN:3866

May 27, 2015

### Conversion Factor Assessment



### Deviation from Isotropy in Liquid Error ( $\phi, \theta$ ), f = 900 MHz





EX3DV4- SN:3866

May 27, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3866

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	68.9
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

---

## Attachment 2. – Dipole Calibration Data

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



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **DT&C (Dymstec)**

Certificate No: D2450V2-726\_Sep15

### CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 726**

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

Calibration date: **September 28, 2015**

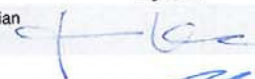

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe EX3DV4	SN: 7349	30-Dec-14 (No. EX3-7349_Dec14)	Dec-15
DAE4	SN: 601	17-Aug-15 (No. DAE4-601_Aug15)	Aug-16

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100972	15-Jun-15 (in house check Jun-15)	In house check: Jun-18
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: September 28, 2015

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Accreditation No.: SCS 0108

#### Glossary:

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

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

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

#### Additional Documentation:

- DASY4/5 System Handbook

#### Methods Applied and Interpretation of Parameters:

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

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



### Measurement Conditions

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

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

### Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	39.2 $\pm$ 6 %	1.86 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.0 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	51.2 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.01 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.8 W/kg $\pm$ 16.5 % (k=2)

### Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	53.2 $\pm$ 6 %	2.00 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.5 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	49.5 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.84 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.2 W/kg $\pm$ 16.5 % (k=2)

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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	$53.5 \Omega + 5.0 j\Omega$
Return Loss	- 24.6 dB

#### Antenna Parameters with Body TSL

Impedance, transformed to feed point	$49.3 \Omega + 6.1 j\Omega$
Return Loss	- 24.2 dB

#### General Antenna Parameters and Design

Electrical Delay (one direction)	1.160 ns
----------------------------------	----------

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

#### Additional EUT Data

Manufactured by	SPEAG
Manufactured on	January 09, 2003

## DASY5 Validation Report for Head TSL

Date: 28.09.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz ; Type: D2450V2; Serial: D2450V2 - SN: 726**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.86$  S/m;  $\epsilon_r = 39.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.67, 7.67, 7.67); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

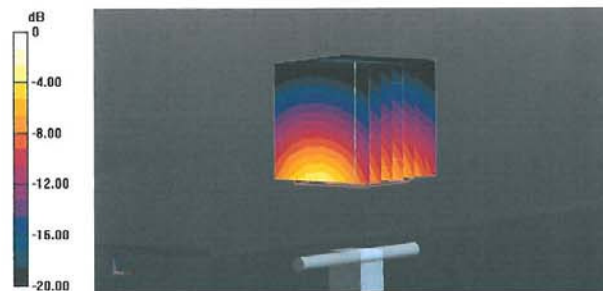
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 112.1 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 26.7 W/kg

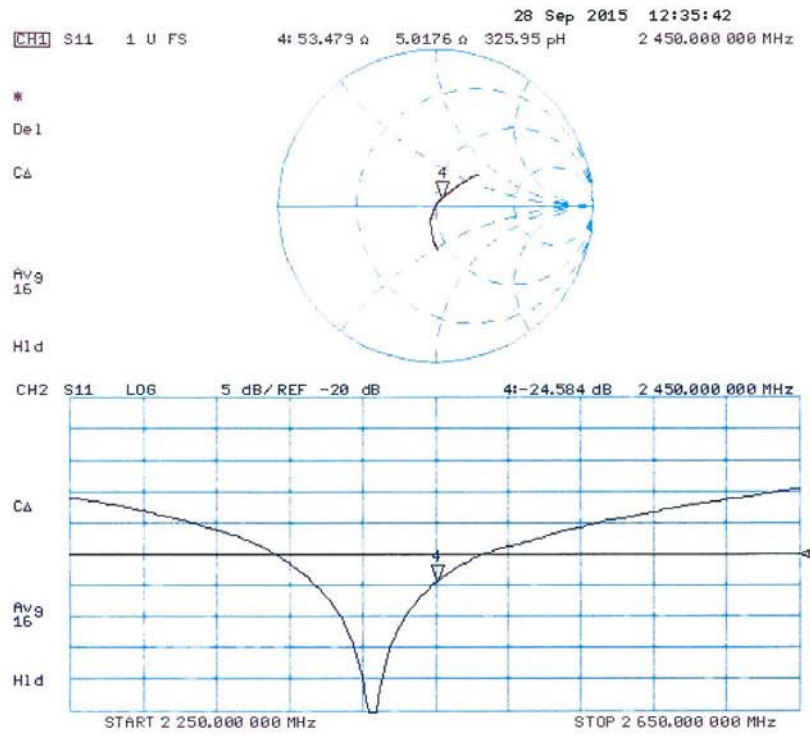
**SAR(1 g) = 13 W/kg; SAR(10 g) = 6.01 W/kg**

Maximum value of SAR (measured) = 21.5 W/kg



0 dB = 21.5 W/kg = 13.32 dBW/kg

### Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 28.09.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz ; Type: D2450V2; Serial: D2450V2 - SN: 726**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2$  S/m;  $\epsilon_r = 53.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.53, 7.53, 7.53); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

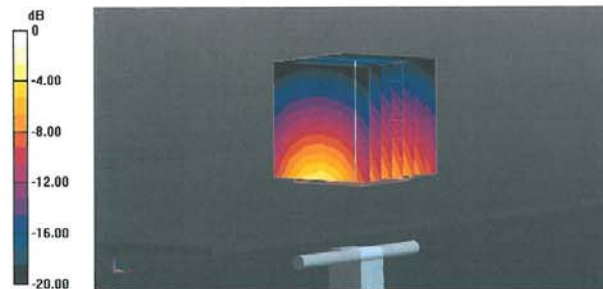
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 105.5 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 24.7 W/kg

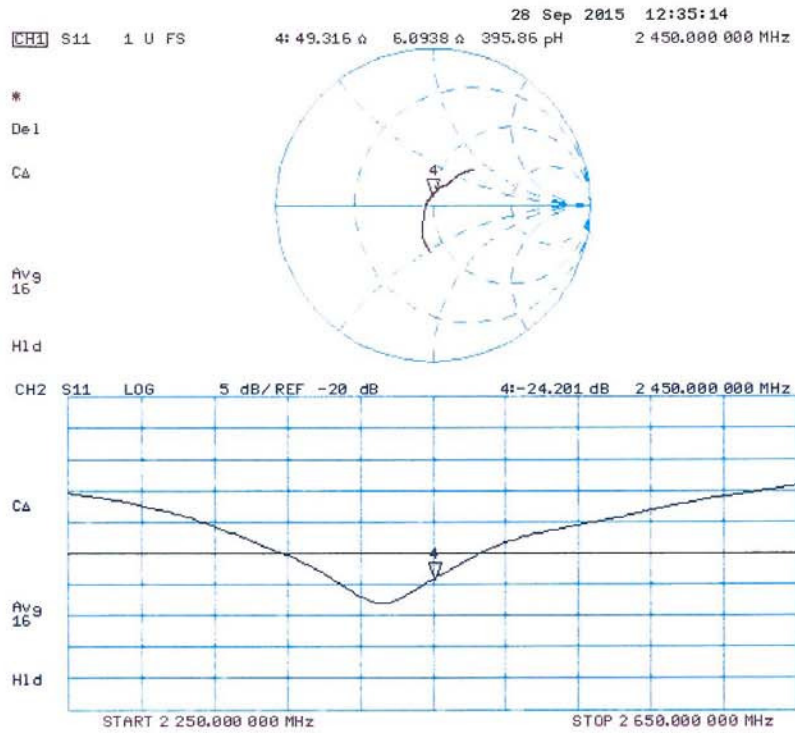
**SAR(1 g) = 12.5 W/kg; SAR(10 g) = 5.84 W/kg**

Maximum value of SAR (measured) = 20.3 W/kg



0 dB = 20.3 W/kg = 13.07 dBW/kg

### Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client **DT&C (Dymstec)**

Certificate No: **D5GHzV2-1103\_Mar15**

### CALIBRATION CERTIFICATE

Object: **D5GHzV2 - SN: 1103**

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



Calibration date: **March 23, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	03-Apr-14 (No. 217-01918)	Apr-15
Type-N mismatch combination	SN: 5047.2 / 06327	03-Apr-14 (No. 217-01921)	Apr-15
Reference Probe EX3DV4	SN: 3503	30-Dec-14 (No. EX3-3503_Dec14)	Dec-15
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by:	Name Michael Weber	Function Laboratory Technician	Signature 
Approved by:	Katja Pokovic	Technical Manager	

Issued: March 23, 2015

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Accreditation No.: **SCS 0108**

#### Glossary:

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

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

- IEC 62209-2, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures"; Part 2: "Procedure to determine the Specific Absorption Rate (SAR) for including accessories and multiple transmitters", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"
- 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

#### Additional Documentation:

- DASY4/5 System Handbook

#### Methods Applied and Interpretation of Parameters:

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

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



**Measurement Conditions**

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

<b>DASY Version</b>	DASY5	V52.8.8
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom V5.0	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
<b>Frequency</b>	5200 MHz ± 1 MHz 5250 MHz ± 1 MHz 5300 MHz ± 1 MHz 5500 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz 5800 MHz ± 1 MHz	

**Head TSL parameters at 5200 MHz**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	36.0	4.66 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	34.7 ± 6 %	4.53 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

**SAR result with Head TSL at 5200 MHz**

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.94 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>78.7 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>22.5 W/kg ± 19.5 % (k=2)</b>

### Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.6 ± 6 %	4.58 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	---	---

### SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.12 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>80.5 W / kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.1 W/kg ± 19.5 % (k=2)</b>

### Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.6 ± 6 %	4.63 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	---	---

### SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>82.4 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.40 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.7 W/kg ± 19.5 % (k=2)</b>