

# FCC SAR Test Report

APPLICANT : VeriFone, Inc.  
EQUIPMENT : Point of Sale Terminal  
BRAND NAME : VeriFone  
MODEL NAME : VX600  
FCC ID : B32VX600  
STANDARD : FCC 47 CFR Part 2 (2.1093)  
IEEE C95.1-1991  
IEEE 1528-2003  
FCC OET Bulletin 65 Supplement C (Edition 01-01)

The product was attached to Apple iPhone 3G (FCC ID: BCGA1241), 3GS Type A (FCC ID: BCGA1303A), and 3GS Type B (FCC ID: BCGA1303B) during SAR test in this report.

The product was received on Dec. 16, 2010 and completely tested on Dec. 21, 2010. We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample has been evaluated in accordance with the procedures and shown the compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL INC., the test report shall not be reproduced except in full.

Reviewed by:



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Roy Wu / Manager



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FCC ID : B32VX600

Page Number : 1 of 38

Report Issued Date : Dec. 23, 2010

Report Version : Rev. 01



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**Appendix B. Plots of SAR Measurement**

**Appendix C. DASY Calibration Certificate**

**Appendix D. Product Photos**

**Appendix E. Test Setup Photos**



## **Revision History**

<b>REPORT NO.</b>	<b>VERSION</b>	<b>DESCRIPTION</b>	<b>ISSUED DATE</b>
FA092829-01B	Rev. 01	Initial issue of report	Dec. 23, 2010

## 1. Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for **VeriFone, Inc. Point of Sale Terminal VeriFone VX600** are as follows (with expanded uncertainty 21.4 % for 300 MHz to 3 GHz, and 25.6% for 3 GHz to 6 GHz).

DUT Configuration	Band	Position	SAR <sub>1g</sub> (W/kg)
DUT with iPhone 3G (FCC ID: BCGA1241)	WLAN	Head	0.478
		Body (1cm Gap)	0.092
	Bluetooth	Head	N/A
		Body (1cm Gap)	N/A
DUT with iPhone 3GS Type A (FCC ID: BCGA1303A)	WLAN	Head	0.246
		Body (1cm Gap)	0.058
	Bluetooth	Head	N/A
		Body (1cm Gap)	N/A
DUT with iPhone 3GS Type B (FCC ID: BCGA1303B)	WLAN	Head	0.202
		Body (1cm Gap)	0.038
	Bluetooth	Head	N/A
		Body (1cm Gap)	N/A

This device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (1.6 W/kg) specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1991, and had been tested in accordance with the measurement methods and procedures specified in IEEE 1528-2003 and FCC OET Bulletin 65 Supplement C (Edition 01-01).

## **2. Administration Data**

### **2.1 Testing Laboratory**

Test Site	SPORTON INTERNATIONAL INC.
Test Site Location	No. 52, Hwa Ya 1 <sup>st</sup> Rd., Hwa Ya Technology Park, Kwei-Shan Hsiang, Tao Yuan Hsien, Taiwan, R.O.C. TEL: +886-3-327-3456 FAX: +886-3-328-4978

### **2.2 Applicant**

Company Name	VeriFone, Inc.
Address	1400 West Stanford Ranch Road Suit 200 Rocklin CA 95765 USA

### **2.3 Manufacturer**

Company Name	Inventec Appliances (Pudong) Co., Ltd.
Address	No. 789, Pu Xing Road, Shanghai, P.R.C.

### **2.4 Application Details**

Date of Receipt of Application	Dec. 16, 2010
Date of Start during the Test	Dec. 17, 2010
Date of End during the Test	Dec. 21, 2010

### 3. General Information

#### 3.1 Description of Device Under Test (DUT)

Product Feature & Specification	
DUT Type	Point of Sale Terminal
Brand Name	VeriFone
Model Name	VX600
FCC ID	B32VX600
Tx Frequency	13.553 MHz ~ 13.567 MHz
Rx Frequency	13.553 MHz ~ 13.567 MHz
Antenna Type	Fixed Internal Antenna
HW Version	DVT
SW Version	QT6000F
Type of Modulation	ASK
DUT Stage	Identical Prototype
DUT Configuration for SAR Testing	Sample 1 : VX600 with iPhone 3G Sample 2 : VX600 with iPhone 3GS Type A Sample 3 : VX600 with iPhone 3GS Type B
iPhone Feature & Specification	
Tx Frequency	2400 MHz ~ 2483.5 MHz
Rx Frequency	2400 MHz ~ 2483.5 MHz
Maximum Output Power to Antenna	<b>&lt;iPhone 3G&gt;</b> 802.11b : 16.82 dBm 802.11g : 16.37 dBm Bluetooth : 6.3 dBm <b>&lt;iPhone 3GS Type A&gt;</b> 802.11b : 16.80 dBm 802.11g : 16.70 dBm Bluetooth : 10 dBm <b>&lt;iPhone 3GS Type B&gt;</b> 802.11b : 16.70 dBm 802.11g : 16.70 dBm Bluetooth : 10 dBm
Type of Modulation	802.11b : DSSS (BPSK / QPSK / CCK) 802.11g : OFDM (BPSK / QPSK / 16QAM / 64QAM) Bluetooth (1Mbps) : GFSK Bluetooth EDR (2Mbps) : $\pi/4$ -DQPSK Bluetooth EDR (3Mbps) : 8-DPSK

**Note:** The difference between iPhone 3GS Type A and iPhone 3GS Type B is vendors of the WiFi/Bluetooth module (Type A: Murata, 339S0072 / Type B: Mitsumi, 339S0077).

**List of Accessory:**

Specification of Accessory		
Battery	Brand Name	VeriFone
	Model Name	BPK087-200
RFID Module	Brand Name	NXP
	Model Name	PN512

**Remark:** The above DUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

**3.2 Product Photos**

Please refer to Appendix D.

**3.3 Applied Standards**

The Specific Absorption Rate (SAR) testing specification, method and procedure for this device is in accordance with the following standards:

- FCC 47 CFR Part 2 (2.1093)
- IEEE C95.1-1991
- IEEE 1528-2003
- FCC OET Bulletin 65 Supplement C (Edition 01-01)
- FCC KDB 248227 D01 v01r02
- FCC KDB 648474 D01 v01r05

**3.4 Device Category and SAR Limits**

This device belongs to portable device category because its radiating structure is allowed to be used within 20 centimeters of the body of the user. Limit for General Population/Uncontrolled exposure should be applied for this device, it is 1.6 W/kg as averaged over any 1 gram of tissue.

**3.5 Test Conditions****3.5.1 Ambient Condition**

Ambient Temperature	20 to 24 °C
Humidity	< 60 %

**3.5.2 Test Configuration**

Because the Apple iPhone cannot install and execute the WiFi RF Utility SW for continuous transmission, we test the iPhone WiFi SAR by transferring a large file from WiFi notebook through a WiFi Access Point (AP). The details are described in the following 3 steps.

**Step 1:**

We test the iPhone standalone WiFi SAR in the worst position based on the original SAR original SAR reports. During the testing, the iPhone and one WiFi notebook link with one WiFi AP, and then transfer one large file from iPhone to AP to WiFi notebook. The step is to get the scaling factor between continuous transmission SW and transferring file method. The worst position is referred to the following reports:

For iPhone 3 WiFi SAR, we refer to the following report/page:

FCC ID: BCGA1241

REPORT NUMBER: 08U11814-4

ISSUE DATE: JUNE 3, 2008

Page 22: Left touch SAR 0.779 W/kg

For iPhone 3GS (Type A) WiFi SAR, we refer to the following report/page:

FCC ID: BCGA1303A

REPORT NUMBER: 09U12393-5

ISSUE DATE: April 10, 2009

Page 30: Left Touch SAR 0.520 W/kg

For iPhone 3GS (Type B) WiFi SAR, we refer to the following report/page:

FCC ID: BCGA1303A

REPORT NUMBER: 09U12393-5

ISSUE DATE: April 10, 2009

Page 31: Right Tilt SAR 0.254 W/kg

**Step 2:**

Comparing the SAR we got and the SAR in the original iPhone SAR reports to get the scaling factor.

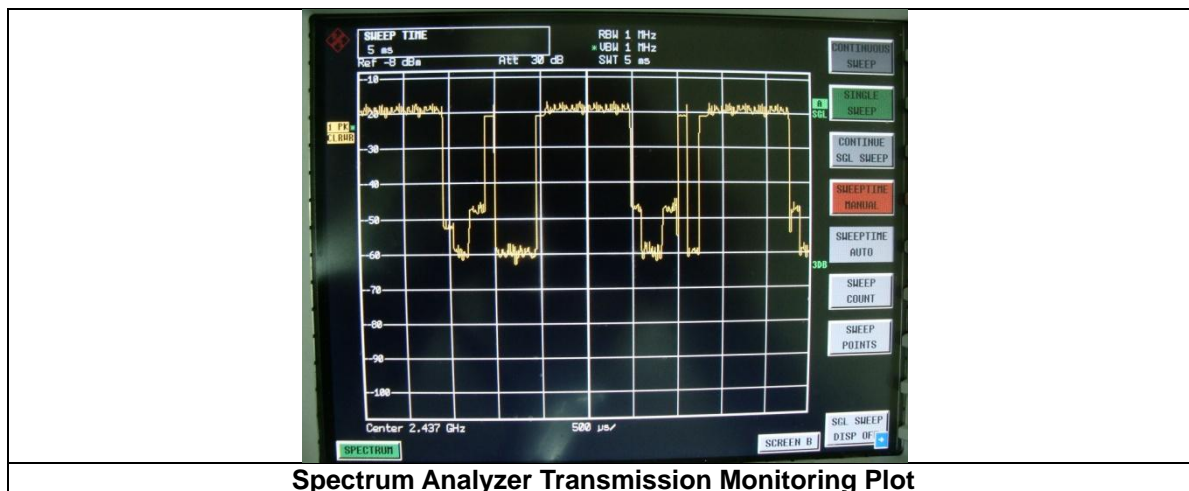
**Step 3:**

The iPhone was mounted to VX600 to test WiFi head SAR and body SAR of VX600+ iPhone. We take VX600+iPhone as a combined device during the testing. The testing method is the same as the step 1. The final SAR of VX600+iPhone is the measured SAR times the scaling factor.



The setup steps for large-file-transfer from iPhone to Laptop PC are as below.

1. Install FTP application software into both iPhone and laptop PC.
2. Set the Access Point to use 802.11b mode channel 6 only.
3. Make both iPhone and laptop PC linking with Access Point.
4. Execute FTP software of iPhone to transfer one large file (file name: 01.rar, file size: 2.11GB) to laptop PC through Access Point.
5. Use a Spectrum Analyzer to monitor and make sure the WLAN continuous transmission during SAR testing.



#### <Scaling Up Factor>

Apple iPhone Version	Apple Report	iPhone Big-File-Transfer	Scaling Up Factor
iPhone 3G SAR <sub>1g</sub>	0.779	0.43	<b>1.81</b>
iPhone 3GS Type A SAR <sub>1g</sub>	0.520	0.315	<b>1.65</b>
iPhone 3GS Type B SAR <sub>1g</sub>	0.254	0.227	<b>1.11</b>

#### Note:

1. The test condition for iPhone WLAN SAR testing is Left Cheek (for iPhone 3G and iPhone 3GS Type A) and Right Tilted (for iPhone 3GS Type B), and channel 6 of 802.11b mode.
2. Scaling Up Factor = SAR of Apple Report / SAR of iPhone Big-File-Transfer
3. Calculated Worst SAR = SAR of iPhone Big-File-Transfer \* Scaling Up Factor

**<VX600 + iPhone Head SAR Results>**

Plot No.	Band	Test Position	Ch	Sample	SAR <sub>1g</sub> (W/kg)	Scaling Factor	Scaled SAR <sub>1g</sub>
#117	802.11b	Right Cheek	6	1	0.196	1.81	0.355
#118	802.11b	Right Tilted	6	1	0.166	1.81	0.300
<b>#119</b>	<b>802.11b</b>	<b>Left Cheek</b>	<b>6</b>	<b>1</b>	<b>0.264</b>	<b>1.81</b>	<b>0.478</b>
#120	802.11b	Left Tilted	6	1	0.208	1.81	0.376
#85	802.11b	Right Cheek	6	2	0.1	1.65	0.165
#86	802.11b	Right Tilted	6	2	0.111	1.65	0.183
<b>#87</b>	<b>802.11b</b>	<b>Left Cheek</b>	<b>6</b>	<b>2</b>	<b>0.149</b>	<b>1.65</b>	<b>0.246</b>
#88	802.11b	Left Tilted	6	2	0.137	1.65	0.226
#95	802.11b	Right Cheek	6	3	0.101	1.11	0.112
#96	802.11b	Right Tilted	6	3	0.11	1.11	0.122
#97	802.11b	Left Cheek	6	3	0.161	1.11	0.179
<b>#98</b>	<b>802.11b</b>	<b>Left Tilted</b>	<b>6</b>	<b>3</b>	<b>0.182</b>	<b>1.11</b>	<b>0.202</b>

**<VX600 + iPhone Body SAR Results>**

Plot No.	Band	Test Position	Separation Distance (cm)	Ch	Sample	Ear-phone	SAR <sub>1g</sub> (W/kg)	Scaling Factor	Scaled SAR <sub>1g</sub>
<b>#111</b>	<b>802.11b</b>	<b>Front Face</b>	<b>1</b>	<b>6</b>	<b>1</b>	<b>Without</b>	<b>0.051</b>	<b>1.81</b>	<b>0.092</b>
#112	802.11b	Rear Face	1	6	1	Without	0.00817	1.81	0.015
#113	802.11b	Top Side	1	6	1	Without	0.014	1.81	0.025
#114	802.11b	Left Side	1	6	1	Without	0.03	1.81	0.054
#115	802.11b	Right Side	1	6	1	Without	0.018	1.81	0.033
#116	802.11b	Front Face	1	6	1	With	0.039	1.81	0.071
<b>#99</b>	<b>802.11b</b>	<b>Front Face</b>	<b>1</b>	<b>6</b>	<b>2</b>	<b>Without</b>	<b>0.035</b>	<b>1.65</b>	<b>0.058</b>
#100	802.11b	Rear Face	1	6	2	Without	0.00359	1.65	0.006
#101	802.11b	Top Side	1	6	2	Without	0.012	1.65	0.020
#102	802.11b	Left Side	1	6	2	Without	0.015	1.65	0.025
#103	802.11b	Right Side	1	6	2	Without	0.00965	1.65	0.016
#104	802.11b	Front Face	1	6	2	With	0.00225	1.65	0.004
<b>#105</b>	<b>802.11b</b>	<b>Front Face</b>	<b>1</b>	<b>6</b>	<b>3</b>	<b>Without</b>	<b>0.034</b>	<b>1.11</b>	<b>0.038</b>
#106	802.11b	Rear Face	1	6	3	Without	0.00436	1.11	0.005
#107	802.11b	Top Side	1	6	3	Without	0.013	1.11	0.014
#108	802.11b	Left Side	1	6	3	Without	0.019	1.11	0.021
#109	802.11b	Right Side	1	6	3	Without	0.00916	1.11	0.010
#110	802.11b	Front Face	1	6	3	With	0.012	1.11	0.013

**<Maximum SAR list for each band and position>**
**VX600 + iPhone 3G**

	<b>GSM 850</b>	<b>GSM 1900</b>	<b>WCDMA Band V</b>	<b>WCDMA Band II</b>	<b>802.11b/g</b>	<b>Max. SAR Summation</b>
<b>Right Cheek</b>	0.169	0.649	0.263	<b>0.817</b>	<b>0.355</b>	<b>1.172</b>
<b>Right Tilted</b>	0.104	0.345	0.162	<b>0.403</b>	<b>0.300</b>	<b>0.703</b>
<b>Left Cheek</b>	0.141	0.568	0.226	<b>0.668</b>	<b>0.478</b>	<b>1.146</b>
<b>Left Tilted</b>	0.092	0.304	0.16	<b>0.374</b>	<b>0.376</b>	<b>0.75</b>
<b>Front Face</b>	0.244	<b>0.567</b>	0.259	0.414	<b>0.092</b>	<b>0.659</b>
<b>Rear Face</b>	0.032	<b>0.12</b>	0.032	0.077	<b>0.015</b>	<b>0.135</b>
<b>Bottom Side</b>	0.057	0.034	0.04	<b>0.062</b>	<b>0</b>	<b>0.062</b>
<b>Left Side</b>	<b>0.126</b>	0.108	0.069	0.075	<b>0.054</b>	<b>0.18</b>
<b>Right Side</b>	<b>0.211</b>	0.067	0.189	0.057	<b>0.033</b>	<b>0.244</b>
<b>Top Side</b>	0	0	0	0	<b>0.025</b>	<b>0.025</b>

**VX600 + iPhone 3GS Type A**

	<b>GSM 850</b>	<b>GSM 1900</b>	<b>WCDMA Band V</b>	<b>WCDMA Band II</b>	<b>802.11b/g</b>	<b>Max. SAR Summation</b>
<b>Right Cheek</b>	0.114	<b>0.304</b>	0.216	0.297	<b>0.165</b>	<b>0.469</b>
<b>Right Tilted</b>	0.044	0.411	0.092	<b>0.431</b>	<b>0.183</b>	<b>0.614</b>
<b>Left Cheek</b>	0.063	<b>0.401</b>	0.127	0.379	<b>0.246</b>	<b>0.647</b>
<b>Left Tilted</b>	0.042	<b>0.382</b>	0.082	0.355	<b>0.226</b>	<b>0.608</b>
<b>Front Face</b>	0.097	<b>0.218</b>	0.139	0.214	<b>0.058</b>	<b>0.276</b>
<b>Rear Face</b>	0.022	<b>0.054</b>	0.026	0.05	<b>0.006</b>	<b>0.06</b>
<b>Bottom Side</b>	0.038	0.038	0.042	<b>0.044</b>	<b>0</b>	<b>0.044</b>
<b>Left Side</b>	0.057	<b>0.076</b>	0.067	0.073	<b>0.025</b>	<b>0.101</b>
<b>Right Side</b>	0.092	0.053	<b>0.119</b>	0.046	<b>0.016</b>	<b>0.135</b>
<b>Top Side</b>	0	0	0	0	<b>0.020</b>	<b>0.02</b>

**VX600 + iPhone 3GS Type B**

	<b>GSM 850</b>	<b>GSM 1900</b>	<b>WCDMA Band V</b>	<b>WCDMA Band II</b>	<b>802.11b/g</b>	<b>Max. SAR Summation</b>
<b>Right Cheek</b>	0.114	<b>0.304</b>	0.216	0.297	<b>0.112</b>	<b>0.416</b>
<b>Right Tilted</b>	0.044	0.411	0.092	<b>0.431</b>	<b>0.122</b>	<b>0.553</b>
<b>Left Cheek</b>	0.063	<b>0.401</b>	0.127	0.379	<b>0.179</b>	<b>0.58</b>
<b>Left Tilted</b>	0.042	<b>0.382</b>	0.082	0.355	<b>0.202</b>	<b>0.584</b>
<b>Front Face</b>	0.097	<b>0.218</b>	0.139	0.214	<b>0.038</b>	<b>0.256</b>
<b>Rear Face</b>	0.022	<b>0.054</b>	0.026	0.05	<b>0.005</b>	<b>0.059</b>
<b>Bottom Side</b>	0.038	0.038	0.042	<b>0.044</b>	<b>0</b>	<b>0.044</b>
<b>Left Side</b>	0.057	<b>0.076</b>	0.067	0.073	<b>0.021</b>	<b>0.097</b>
<b>Right Side</b>	0.092	0.053	<b>0.119</b>	0.046	<b>0.010</b>	<b>0.129</b>
<b>Top Side</b>	0	0	0	0	<b>0.014</b>	<b>0.014</b>

**Note:** The maximum SAR summation is calculated based on the same configuration and test position.

According to KDB 648474, the simultaneous transmission SAR for WWAN and WLAN was not required, because all the SAR summations are less than 1.6 W/kg.

BT standalone SAR and simultaneous transmission SAR for WWAN and BT were not required, because BT power is less than Pref. WLAN and BT cannot transmit simultaneously.

## **4. Specific Absorption Rate (SAR)**

### **4.1 Introduction**

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

### **4.2 SAR Definition**

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

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

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

SAR measurement can be either related to the temperature elevation in tissue by

$$SAR = C \left( \frac{\delta T}{\delta t} \right)$$

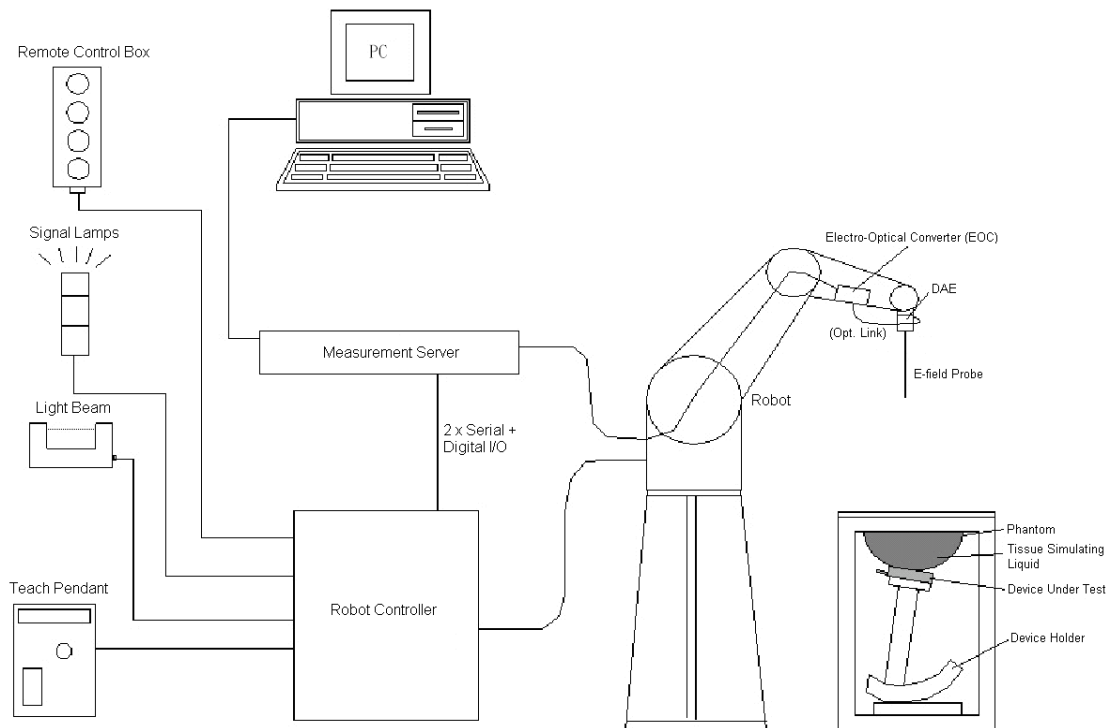
Where: C is the specific heat capacity,  $\delta T$  is the temperature rise and  $\delta t$  is the exposure duration, or related to the electrical field in the tissue by

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

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

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

## 5. SAR Measurement System



**Fig 5.1 SPEAG DASY4 or DASY5 System Configurations**

The DASY4 or DASY5 system for performance compliance tests is illustrated above graphically. This system consists of the following items:

- A standard high precision 6-axis robot with controller, a teach pendant and software
- A data acquisition electronic (DAE) attached to the robot arm extension
- A dosimetric probe equipped with an optical surface detector system
- The electro-optical converter (ECO) performs the conversion between optical and electrical signals
- A measurement server performs the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the accuracy of the probe positioning
- A computer operating Windows XP
- DASY4 or DASY5 software
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom
- A device holder
- Tissue simulating liquid
- Dipole for evaluating the proper functioning of the system

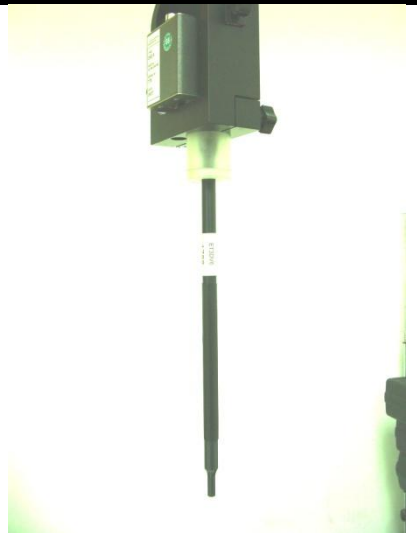
Some of the components are described in details in the following sub-sections.

## 5.1 E-Field Probe

The SAR measurement is conducted with the dosimetric probe (manufactured by SPEAG). The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency. This probe has a built in optical surface detection system to prevent from collision with phantom.


### 5.1.1 E-Field Probe Specification

#### <ET3DV6>

<b>Construction</b>	Symmetrical design with triangular core Built-in optical fiber for surface detection system. Built-in shielding against static charges. PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
<b>Frequency</b>	10 MHz to 3 GHz; Linearity: $\pm 0.2$ dB	
<b>Directivity</b>	$\pm 0.2$ dB in HSL (rotation around probe axis) $\pm 0.4$ dB in HSL (rotation normal to probe axis)	
<b>Dynamic Range</b>	5 $\mu$ W/g to 100 mW/g; Linearity: $\pm 0.2$ dB	
<b>Dimensions</b>	Overall length: 330 mm (Tip: 16 mm) Tip diameter: 6.8 mm (Body: 12 mm) Distance from probe tip to dipole centers: 2.7 mm	

**Fig 5.2 Photo of ET3DV6**

#### <EX3DV4 Probe>

<b>Construction</b>	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
<b>Frequency</b>	10 MHz to 6 GHz; Linearity: $\pm 0.2$ dB	
<b>Directivity</b>	$\pm 0.3$ dB in HSL (rotation around probe axis) $\pm 0.5$ dB in tissue material (rotation normal to probe axis)	
<b>Dynamic Range</b>	10 $\mu$ W/g to 100 mW/g; Linearity: $\pm 0.2$ dB (noise: typically $< 1$ $\mu$ W/g)	
<b>Dimensions</b>	Overall length: 330 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm	

**Fig 5.3 Photo of EX3DV4**



### 5.1.2 E-Field Probe Calibration

Each probe needs to be calibrated according to a dosimetric assessment procedure with accuracy better than  $\pm 10\%$ . The spherical isotropy shall be evaluated and within  $\pm 0.25$  dB. The sensitivity parameters (NormX, NormY, and NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe are tested. The calibration data can be referred to appendix C of this report.

### 5.2 Data Acquisition Electronics (DAE)

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

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



**Fig 5.4 Photo of DAE**

### 5.3 Robot

The SPEAG DASY system uses the high precision robots (DASY4: RX90BL; DASY5: TX90XL) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version (DASY4: CS7MB; DASY5: CS8c) from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability  $\pm 0.035$  mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)



**Fig 5.5 Photo of DASY4**



**Fig 5.6 Photo of DASY5**

### **5.4 Measurement Server**

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

The measurement server performs all the real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operations.



**Fig 5.7 Photo of Server for DASY4**




**Fig 5.8 Photo of Server for DASY5**



## 5.5 Phantom

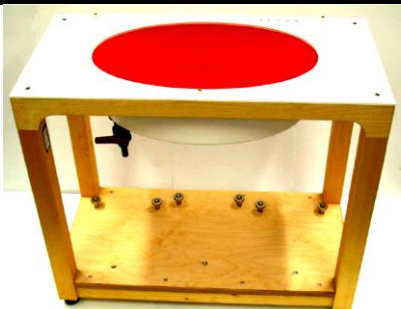
### <SAM Twin Phantom>

<b>Shell Thickness</b>	2 ± 0.2 mm; Center ear point: 6 ± 0.2 mm	
<b>Filling Volume</b>	Approx. 25 liters	
<b>Dimensions</b>	Length: 1000 mm; Width: 500 mm; Height: adjustable feet	
<b>Measurement Areas</b>	Left Hand, Right Hand, Flat Phantom	

**Fig 5.9 Photo of SAM Phantom**

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

### <ELI4 Phantom>

<b>Shell Thickness</b>	2 ± 0.2 mm (sagging: <1%)	
<b>Filling Volume</b>	Approx. 30 liters	
<b>Dimensions</b>	Major ellipse axis: 600 mm Minor axis: 400 mm	

**Fig 5.10 Photo of ELI4 Phantom**

The ELI4 phantom is intended for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI4 is fully compatible with standard and all known tissue simulating liquids.

## 5.6 Device Holder

### <Device Holder for SAM Twin Phantom>

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

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

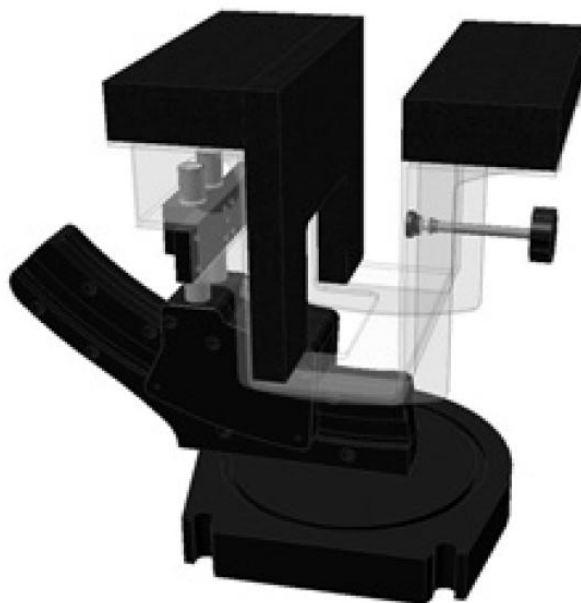
The DASY device holder is constructed of low-loss POM material having the following dielectric parameters: relative permittivity  $\epsilon = 3$  and loss tangent  $\delta = 0.02$ . The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.



Fig 5.11 Device Holder

**<Laptop Extension Kit>**

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



**Fig 5.12      Laptop Extension Kit**

## 5.7 Data Storage and Evaluation

### 5.7.1 Data Storage

The DASY software stores the assessed data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all the necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files. The post-processing software evaluates the desired unit and format for output each time the data is visualized or exported. This allows verification of the complete software setup even after the measurement and allows correction of erroneous parameter settings. For example, if a measurement has been performed with an incorrect crest factor parameter in the device setup, the parameter can be corrected afterwards and the data can be reevaluated.

The measured data can be visualized or exported in different units or formats, depending on the selected probe type (e.g., [V/m], [A/m], [mW/g]). Some of these units are not available in certain situations or give meaningless results, e.g., a SAR-output in a non-lose media, will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

### 5.7.2 Data Evaluation

The DASY post-processing software (SEMCAD) automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The parameters used in the evaluation are stored in the configuration modules of the software :

<b>Probe parameters :</b>	- Sensitivity	Norm <sub>i</sub> , a <sub>i0</sub> , a <sub>i1</sub> , a <sub>i2</sub>
	- Conversion factor	ConvF <sub>i</sub>
	- Diode compression point	dcp <sub>i</sub>
<b>Device parameters :</b>	- Frequency	f
	- Crest factor	cf
<b>Media parameters :</b>	- Conductivity	$\sigma$
	- Density	$\rho$

These parameters must be set correctly in the software. They can be found in the component documents or they can be imported into the software from the configuration files issued for the DASY components. In the direct measuring mode of the multi-meter option, the parameters of the actual system setup are used. In the scan visualization and export modes, the parameters stored in the corresponding document files are used.

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 as :

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

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 :

$$\text{E-field Probes : } E_i = \sqrt{\frac{V_i}{\text{Norm}_i \cdot \text{ConvF}}}$$

$$\text{H-field Probes : } H_i = \sqrt{V_i} \cdot \frac{a_{i0} + a_{i1}f + a_{i2}f^2}{f}$$

with  $V_i$  = compensated signal of channel i, (i = x, y, z)  
 $\text{Norm}_i$  = sensor sensitivity of channel i, (i = x, y, z),  $\mu\text{V}/(\text{V/m})^2$  for E-field Probes  
 $\text{ConvF}$  = sensitivity enhancement in solution  
 $a_{ij}$  = sensor sensitivity factors for H-field probes  
 $f$  = carrier frequency [GHz]  
 $E_i$  = electric field strength of channel i in V/m  
 $H_i$  = magnetic field strength of channel i in A/m

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

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

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

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

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

Note that the density is set to 1, to account for actual head tissue density rather than the density of the tissue simulating liquid.

### 5.8 Test Equipment List

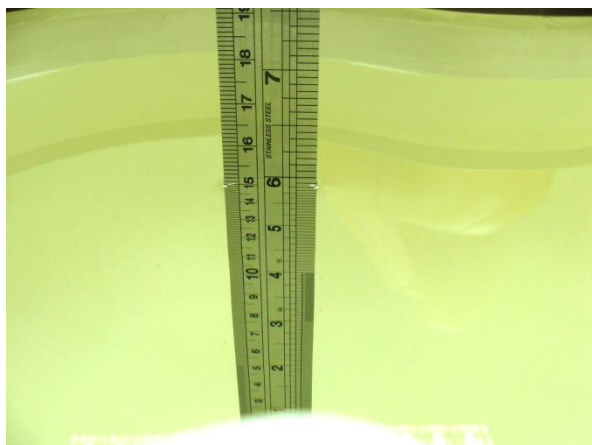
Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	Dosimetric E-Field Probe	ET3DV6	1787	May 18, 2010	May 17, 2011
SPEAG	Dosimetric E-Field Probe	ET3DV6	1788	Sep. 21, 2010	Sep. 20, 2011
SPEAG	Dosimetric E-Field Probe	EX3DV4	3731	Jul. 16, 2010	Jul. 15, 2011
SPEAG	835MHz System Validation Kit	D835V2	499	Mar. 22, 2010	Mar. 21, 2012
SPEAG	900MHz System Validation Kit	D900V2	190	Jul. 21, 2009	Jul. 20, 2011
SPEAG	1800MHz System Validation Kit	D1800V2	2d076	Jul. 20, 2009	Jul. 19, 2011
SPEAG	1900MHz System Validation Kit	D1900V2	5d041	Mar. 23, 2010	Mar. 22, 2012
SPEAG	2000MHz System Validation Kit	D2000V2	1010	Sep. 22, 2010	Sep. 21, 2012
SPEAG	2300MHz System Validation Kit	D2300V2	1006	Sep. 24, 2009	Sep. 23, 2011
SPEAG	2450MHz System Validation Kit	D2450V2	736	Jul. 20, 2009	Jul. 19, 2011
SPEAG	2600MHz System Validation Kit	D2600V2	1008	Sep. 24, 2009	Sep. 23, 2011
SPEAG	3500MHz System Validation Kit	D3500V2	1014	Sep. 17, 2009	Sep. 16, 2011
SPEAG	5GHz System Validation Kit	D5GHzV2	1006	Jan. 21, 2010	Jan. 20, 2012
SPEAG	Data Acquisition Electronics	DAE3	577	Aug. 18, 2010	Aug. 17, 2011
SPEAG	Data Acquisition Electronics	DAE4	778	Oct. 22, 2010	Oct. 21, 2011
SPEAG	Device Holder	N/A	N/A	NCR	NCR
SPEAG	SAM Phantom	QD 000 P40 C	TP-1303	NCR	NCR
SPEAG	SAM Phantom	QD 000 P40 C	TP-1383	NCR	NCR
SPEAG	SAM Phantom	QD 000 P40 C	TP-1446	NCR	NCR
SPEAG	SAM Phantom	QD 000 P40 C	TP-1478	NCR	NCR
SPEAG	ELI4 Phantom	QD 0VA 001 BB	1026	NCR	NCR
SPEAG	ELI4 Phantom	QD 0VA 001 BA	1029	NCR	NCR
Agilent	PNA Series Network Analyzer	E8358A	US40260131	May 06, 2010	May 05, 2011
Agilent	Wireless Communication Test Set	E5515C	MY48360820	Jan. 12, 2010	Jan. 11, 2012
Agilent	Wireless Communication Test Set	E5515C	GB46311322	Feb. 16, 2009	Feb. 15, 2011
R&S	Universal Radio Communication Tester	CMU200	117995	Mar. 19, 2009	Mar. 18, 2011
Agilent	Dielectric Probe Kit	85070D	US01440205	NCR	NCR
Agilent	Dual Directional Coupler	778D	50422	NCR	NCR
AR	Power Amplifier	5S1G4M2	0328767	NCR	NCR
R&S	Spectrum Analyzer	FSP7	101131	Mar. 05, 2010	Mar. 04, 2011

**Table 5.1 Test Equipment List**

**Note:** The calibration certificate of DASY can be referred to appendix C of this report.

## 6. Tissue Simulating Liquids

For the measurement of the field distribution inside the SAM phantom with DASY, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. For head SAR testing, the liquid height from the ear reference point (ERP) of the phantom to the liquid top surface is larger than 15 cm, which is shown in Fig. 6.1. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm, which is shown in Fig. 6.2.



**Fig 6.1 Photo of Liquid Height for Head SAR**



**Fig 6.2 Photo of Liquid Height for Body SAR**

The following table gives the recipes for tissue simulating liquid.

Frequency (MHz)	Water (%)	Sugar (%)	Cellulose (%)	Salt (%)	Preventol (%)	DGBE (%)	Conductivity ( $\sigma$ )	Permittivity ( $\epsilon_r$ )
<b>For Head</b>								
835	40.3	57.9	0.2	1.4	0.2	0	0.90	41.5
900	40.3	57.9	0.2	1.4	0.2	0	0.97	41.5
1800, 1900, 2000	55.2	0	0	0.3	0	44.5	1.40	40.0
2450	55.0	0	0	0	0	45.0	1.80	39.2
<b>For Body</b>								
835	50.8	48.2	0	0.9	0.1	0	0.97	55.2
900	50.8	48.2	0	0.9	0.1	0	1.05	55.0
1800, 1900, 2000	70.2	0	0	0.4	0	29.4	1.52	53.3
2450	68.6	0	0	0	0	31.4	1.95	52.7

**Table 6.1 Recipes of Tissue Simulating Liquid**

The following table gives the targets for tissue simulating liquid.

Frequency (MHz)	Liquid Type	Conductivity ( $\sigma$ )	$\pm 5\%$ Range	Permittivity ( $\epsilon_r$ )	$\pm 5\%$ Range
2450	Head	1.80	1.71 ~ 1.89	39.2	37.2 ~ 41.2
5200	Head	4.66	4.43 ~ 4.89	36.0	34.2 ~ 37.8
5500	Head	4.96	4.71 ~ 5.21	35.6	33.8 ~ 37.4
5800	Head	5.27	5.01 ~ 5.53	35.3	33.5 ~ 37.1
2450	Body	1.95	1.85 ~ 2.05	52.7	50.1 ~ 55.3
5200	Body	5.30	5.04 ~ 5.57	49.0	46.6 ~ 51.5
5500	Body	5.65	5.37 ~ 5.93	48.6	46.2 ~ 51.0
5800	Body	6.00	5.70 ~ 6.30	48.2	45.8 ~ 50.6

**Table 6.2 Targets of Tissue Simulating Liquid**

The dielectric parameters of the liquids were verified prior to the SAR evaluation using an Agilent 85070D Dielectric Probe Kit and an Agilent Network Analyzer.

The following table shows the measuring results for simulating liquid.

Frequency (MHz)	Liquid Type	Temperature ( $^{\circ}\text{C}$ )	Conductivity ( $\sigma$ )	Permittivity ( $\epsilon_r$ )	Measurement Date
2450	Head	21.3	1.85	39.3	Dec. 17, 2010
2450	Head	21.6	1.84	38.2	Dec. 21, 2010
2450	Body	21.4	1.97	52.8	Dec. 17, 2010
2450	Body	21.5	1.96	52.9	Dec. 21, 2010

**Table 6.3 Measuring Results for Simulating Liquid**



## 7. Uncertainty Assessment

The component of uncertainty may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainty by the statistical analysis of a series of observations is termed a Type A evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience and knowledge of the behavior and properties of relevant materials and instruments, manufacture's specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in Table 7.1

Uncertainty Distributions	Normal	Rectangular	Triangular	U-Shape
Multi-plying Factor <sup>(a)</sup>	1/k <sup>(b)</sup>	1/√3	1/√6	1/√2

(a) standard uncertainty is determined as the product of the multiplying factor and the estimated range of variations in the measured quantity

(b)  $k$  is the coverage factor

**Table 7.1 Standard Uncertainty for Assumed Distribution**

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual "root-sum-squares" (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is showed in Table 7.2 and Table 7.3.

Error Description	Uncertainty Value (±%)	Probability Distribution	Divisor	Ci (1g)	Standard Uncertainty (1g)
<b>Measurement System</b>					
Probe Calibration	5.5	Normal	1	1	± 5.5 %
Axial Isotropy	4.7	Rectangular	√3	0.7	± 1.9 %
Hemispherical Isotropy	9.6	Rectangular	√3	0.7	± 3.9 %
Boundary Effects	1.0	Rectangular	√3	1	± 0.6 %
Linearity	4.7	Rectangular	√3	1	± 2.7 %
System Detection Limits	1.0	Rectangular	√3	1	± 0.6 %
Readout Electronics	0.3	Normal	1	1	± 0.3 %
Response Time	0.8	Rectangular	√3	1	± 0.5 %
Integration Time	2.6	Rectangular	√3	1	± 1.5 %
RF Ambient Noise	3.0	Rectangular	√3	1	± 1.7 %
RF Ambient Reflections	3.0	Rectangular	√3	1	± 1.7 %
Probe Positioner	0.4	Rectangular	√3	1	± 0.2 %
Probe Positioning	2.9	Rectangular	√3	1	± 1.7 %
Max. SAR Eval.	1.0	Rectangular	√3	1	± 0.6 %
<b>Test Sample Related</b>					
Device Positioning	2.9	Normal	1	1	± 2.9 %
Device Holder	3.6	Normal	1	1	± 3.6 %
Power Drift	5.0	Rectangular	√3	1	± 2.9 %
<b>Phantom and Setup</b>					
Phantom Uncertainty	4.0	Rectangular	√3	1	± 2.3 %
Liquid Conductivity (Target)	5.0	Rectangular	√3	0.64	± 1.8 %
Liquid Conductivity (Meas.)	2.5	Normal	1	0.64	± 1.6 %
Liquid Permittivity (Target)	5.0	Rectangular	√3	0.6	± 1.7 %
Liquid Permittivity (Meas.)	2.5	Normal	1	0.6	± 1.5 %
<b>Combined Standard Uncertainty</b>					± 10.7 %
<b>Coverage Factor for 95 %</b>					K = 2
<b>Expanded Uncertainty</b>					± 21.4 %

**Table 7.2 Uncertainty Budget of DASY for frequency range 300 MHz to 3 GHz**

Error Description	Uncertainty Value (±%)	Probability Distribution	Divisor	Ci (1g)	Standard Uncertainty (1g)
<b>Measurement System</b>					
Probe Calibration	6.55	Normal	1	1	± 6.55 %
Axial Isotropy	4.7	Rectangular	√3	0.7	± 1.9 %
Hemispherical Isotropy	9.6	Rectangular	√3	0.7	± 3.9 %
Boundary Effects	2.0	Rectangular	√3	1	± 1.2 %
Linearity	4.7	Rectangular	√3	1	± 2.7 %
System Detection Limits	1.0	Rectangular	√3	1	± 0.6 %
Readout Electronics	0.3	Normal	1	1	± 0.3 %
Response Time	0.8	Rectangular	√3	1	± 0.5 %
Integration Time	2.6	Rectangular	√3	1	± 1.5 %
RF Ambient Noise	3.0	Rectangular	√3	1	± 1.7 %
RF Ambient Reflections	3.0	Rectangular	√3	1	± 1.7 %
Probe Positioner	0.8	Rectangular	√3	1	± 0.5 %
Probe Positioning	9.9	Rectangular	√3	1	± 5.7 %
Max. SAR Eval.	4.0	Rectangular	√3	1	± 2.3 %
<b>Test Sample Related</b>					
Device Positioning	2.9	Normal	1	1	± 2.9 %
Device Holder	3.6	Normal	1	1	± 3.6 %
Power Drift	5.0	Rectangular	√3	1	± 2.9 %
<b>Phantom and Setup</b>					
Phantom Uncertainty	4.0	Rectangular	√3	1	± 2.3 %
Liquid Conductivity (Target)	5.0	Rectangular	√3	0.43	± 1.8 %
Liquid Conductivity (Meas.)	2.5	Normal	1	0.43	± 1.6 %
Liquid Permittivity (Target)	5.0	Rectangular	√3	0.49	± 1.7 %
Liquid Permittivity (Meas.)	2.5	Normal	1	0.49	± 1.5 %
<b>Combined Standard Uncertainty</b>					± 12.8 %
<b>Coverage Factor for 95 %</b>					K = 2
<b>Expanded Uncertainty</b>					± 25.6 %

**Table 7.3 Uncertainty Budget of DASY for frequency range 3 GHz to 6 GHz**

## **8. SAR Measurement Evaluation**

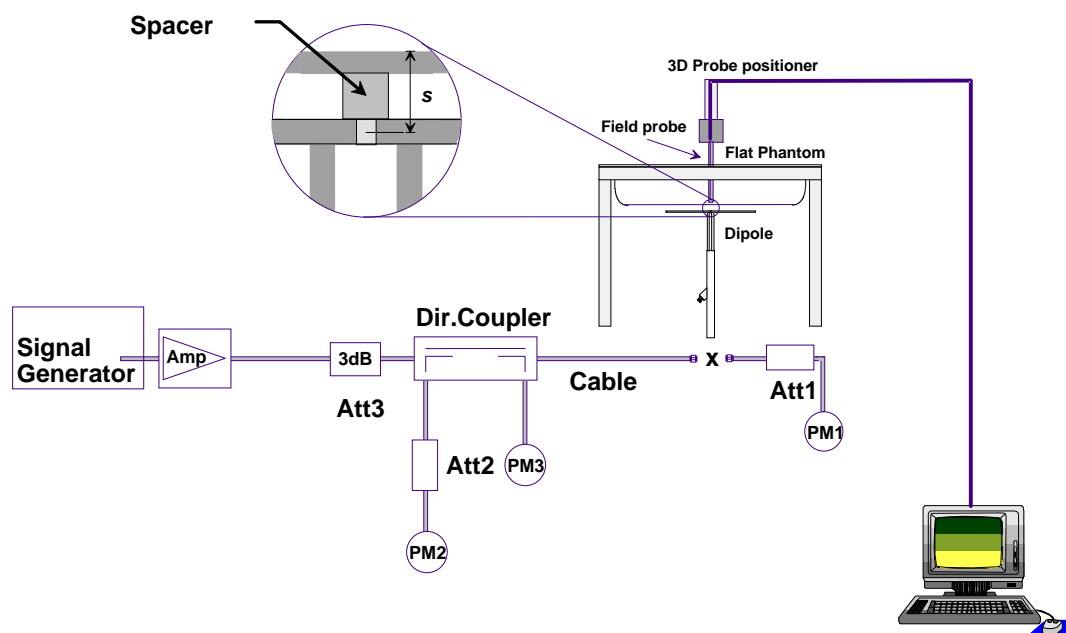
Each DASY system is equipped with one or more system validation kits. These units, together with the predefined measurement procedures within the DASY software, enable the user to conduct the system performance check and system validation. System validation kit includes a dipole, tripod holder to fix it underneath the flat phantom and a corresponding distance holder.

### **8.1 Purpose of System Performance check**

The system performance check verifies that the system operates within its specifications. System and operator errors can be detected and corrected. It is recommended that the system performance check be performed prior to any usage of the system in order to guarantee reproducible results. The system performance check uses normal SAR measurements in a simplified setup with a well characterized source. This setup was selected to give a high sensitivity to all parameters that might fail or vary over time. The system check does not intend to replace the calibration of the components, but indicates situations where the system uncertainty is exceeded due to drift or failure.

### **8.2 System Setup**

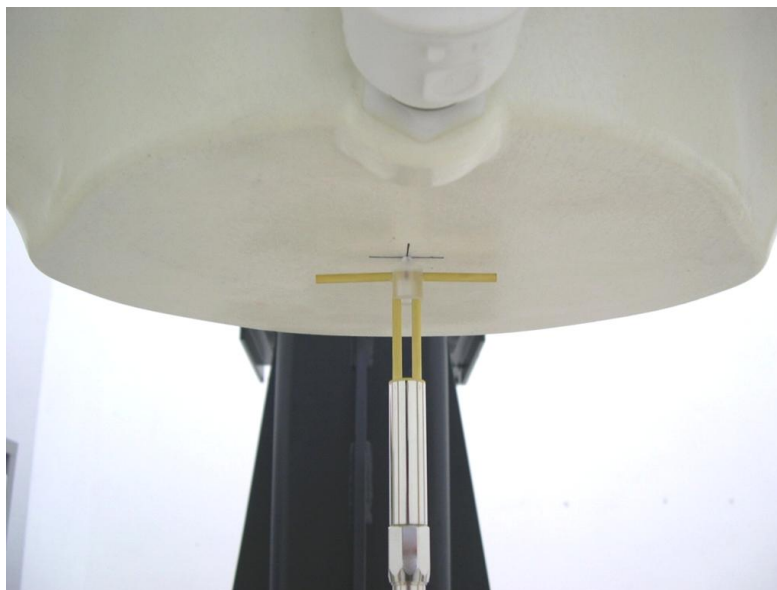
In the simplified setup for system evaluation, the DUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave that comes from a signal generator. The calibrated dipole must be placed beneath the flat phantom section of the SAM twin phantom with the correct distance holder.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



**Fig 8.1 System Setup for System Evaluation**

1. Signal Generator
2. Amplifier
3. Directional Coupler
4. Power Meter
5. Calibrated Dipole

The output power on dipole port must be calibrated to 20 dBm (100 mW) before dipole is connected.



**Fig 8.2 Photo of Dipole Setup**

### **8.3 Validation Results**

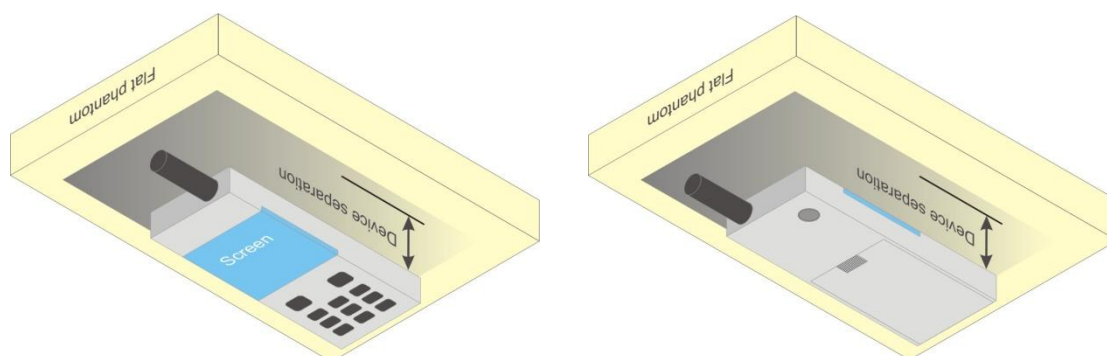
Comparing to the original SAR value provided by SPEAG, the validation data should be within its specification of 10 %. Table 8.1 shows the target SAR and measured SAR after normalized to 1W input power. The table below indicates the system performance check can meet the variation criterion and the plots can be referred to Appendix A of this report.

Measurement Date	Frequency (MHz)	Targeted SAR <sub>1g</sub> (W/kg)	Measured SAR <sub>1g</sub> (W/kg)	Deviation (%)
Dec. 17, 2010	2450	54.20	49.10	-9.41
Dec. 21, 2010	2450	54.20	50.80	-6.27
Dec. 17, 2010	2450	53.00	56.20	6.04
Dec. 21, 2010	2450	53.00	55.90	5.47

**Table 8.1 Target and Measurement SAR after Normalized**

## 9. DUT Testing Position

This DUT was tested in nine different positions. They are right cheek, right tilted, left cheek, left tilted, front face of the DUT with phantom 1 cm gap, rear face of the DUT with phantom 1 cm gap, top side of the DUT with phantom 1 cm gap, left side of the DUT with phantom 1 cm gap, and right side of the DUT with phantom 1 cm gap. Please refer to Appendix E for the test setup photos.



**Fig 9.1 Illustration for Body Worn Position**

## **10. Measurement Procedures**

The measurement procedures are as follows:

- (a) Use engineering software to transmit RF power continuously (continuous Tx) in the highest power channel
- (b) Measure output power through RF cable and power meter
- (c) Place the DUT in the positions described in the last section
- (d) Set scan area, grid size and other setting on the DASY software
- (e) Taking data for the middle channel on each testing position
- (f) Find out the largest SAR result on these testing positions of each band
- (g) Measure SAR results for other channels in worst SAR testing position if the SAR of highest power channel is larger than 0.8 W/kg

According to the test standard, the recommended procedure for assessing the peak spatial-average SAR value consists of the following steps:

- (a) Power reference measurement
- (b) Area scan
- (c) Zoom scan
- (d) Power drift measurement

### **10.1 Spatial Peak SAR Evaluation**

The procedure for spatial peak SAR evaluation has been implemented according to the test standard. It can be conducted for 1g and 10g, as well as for user-specific masses. The DASY software includes all numerical procedures necessary to evaluate the spatial peak SAR value.

The base for the evaluation is a "cube" measurement. The measured volume must include the 1g and 10g cubes with the highest averaged SAR values. For that purpose, the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan.

The entire evaluation of the spatial peak values is performed within the post-processing engine (SEMCAD). The system always gives the maximum values for the 1g and 10g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

- (a) Extraction of the measured data (grid and values) from the Zoom Scan
- (b) Calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
- (c) Generation of a high-resolution mesh within the measured volume
- (d) Interpolation of all measured values from the measurement grid to the high-resolution grid
- (e) Extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
- (f) Calculation of the averaged SAR within masses of 1g and 10g

## **10.2 Area & Zoom Scan Procedures**

First Area Scan is used to locate the approximate location(s) of the local peak SAR value(s). The measurement grid within an Area Scan is defined by the grid extent, grid step size and grid offset. Next, in order to determine the EM field distribution in a three-dimensional spatial extension, Zoom Scan is required. The Zoom Scan measures 5x5x7 points with step size 8, 8 and 5 mm for 300 MHz to 3 GHz, and 8x8x8 points with step size 4, 4 and 2.5 mm for 3 GHz to 6 GHz. The Zoom Scan is performed around the highest E-field value to determine the averaged SAR-distribution over 10 g.

## **10.3 Volume Scan Procedures**

The volume scan is used for assess overlapping SAR distributions for antennas transmitting in different frequency bands. It is equivalent to an oversized zoom scan used in standalone measurements. The measurement volume will be used to enclose all the simultaneous transmitting antennas. For antennas transmitting simultaneously in different frequency bands, the volume scan is measured separately in each frequency band. In order to sum correctly to compute the 1g aggregate SAR, the DUT remain in the same test position for all measurements and all volume scan use the same spatial resolution and grid spacing (step-size is 4, 4 and 2.5 mm). When all volume scan were completed, the software, SEMCAD postprocessor can combine and subsequently superpose these measurement data to calculating the multiband SAR.

## **10.4 SAR Averaged Methods**

In DASY, the interpolation and extrapolation are both based on the modified Quadratic Shepard's method. The interpolation scheme combines a least-square fitted function method and a weighted average method which are the two basic types of computational interpolation and approximation.

Extrapolation routines are used to obtain SAR values between the lowest measurement points and the inner phantom surface. The extrapolation distance is determined by the surface detection distance and the probe sensor offset. The uncertainty increases with the extrapolation distance. To keep the uncertainty within 1% for the 1 g and 10 g cubes, the extrapolation distance should not be larger than 5 mm.

## **10.5 Power Drift Monitoring**

All SAR testing is under the DUT install full charged battery and transmit maximum output power. In DASY measurement software, the power reference measurement and power drift measurement procedures are used for monitoring the power drift of DUT during SAR test. Both these procedures measure the field at a specified reference position before and after the SAR testing. The software will calculate the field difference in dB. If the power drift more than 5%, the SAR will be retested.



## **11. SAR Test Results**

### **11.1 Conducted Power (Unit: dBm)**

#### **<CCS iPhone 3G (Sample 1) Power Data>**

Band	802.11b			802.11g		
Channel	1	6	11	1	6	11
Frequency (MHz)	2412	2437	2462	2412	2437	2462
Power	16.42	16.82	16.55	16.25	16.37	16.31

**Note:** The above power value is not measured by Sporton which are not applicable for VX600 compliance demonstration, but are summarized from CCS report (FCC ID: BCGA1241, Report No. 08U11814-4 page 20 of 27, Issue Date: June 3, 2008) to confirm consistent device setup in support of SAR results tested by Sporton.

#### **<CCS iPhone 3GS Type A (Sample 2) Power Data>**

Band	802.11b			802.11g		
Channel	1	6	11	1	6	11
Frequency (MHz)	2412	2437	2462	2412	2437	2462
Power	16.50	16.80	16.60	16.50	16.70	16.50

**Note:** The above power value is not measured by Sporton which are not applicable for VX600 compliance demonstration, but are summarized from CCS report (FCC ID: BCGA1303A, Report No. 09U12393-5 page 25 of 49, Issue Date: April 10, 2009) to confirm consistent device setup in support of SAR results tested by Sporton.

#### **<CCS iPhone 3GS Type B (Sample 3) Power Data>**

Band	802.11b			802.11g		
Channel	1	6	11	1	6	11
Frequency (MHz)	2412	2437	2462	2412	2437	2462
Power	16.50	16.70	16.60	16.50	16.70	16.50

**Note:** The above power value is not measured by Sporton which are not applicable for VX600 compliance demonstration, but are summarized from CCS report (FCC ID: BCGA1303A, Report No. 09U12393-5 page 25 of 49, Issue Date: April 10, 2009) to confirm consistent device setup in support of SAR results tested by Sporton.

**11.2 Test Records for Head SAR Test**
**<CCS iPhone Standalone SAR Data>**

iPhone	Posi.	802.11b			802.11g		
		1	6	11	1	6	11
		2412	2437	2462	2412	2437	2462
3G	LC		0.779				
	LT		0.755				
	RC		0.613				
	RT		0.634				
3GS Type A	LC		0.520				
	LT		0.451				
	RC		0.480				
	RT		0.480				
3GS Type B	LC		0.187				
	LT		0.226				
	RC		0.249				
	RT		0.254				

**Note:** The above data is not measured by Sporton.

**<Sporton VX600 + iPhone SAR Results>**

iPhone	Posi.	802.11b			802.11g		
		1	6	11	1	6	11
		2412	2437	2462	2412	2437	2462
3G	LC		<b>0.478</b>				
	LT		0.376				
	RC		0.355				
	RT		0.300				
3GS Type A	LC		<b>0.246</b>				
	LT		0.226				
	RC		0.165				
	RT		0.183				
3GS Type B	LC		0.179				
	LT		<b>0.202</b>				
	RC		0.112				
	RT		0.122				

### 11.3 Test Records for Body SAR Test

#### <CCS iPhone Standalone SAR Data>

iPhone	Posi. / SP (cm)	802.11b			802.11g		
		1	6	1	6	1	6
		2412	2437	2412	2437	2412	2437
3G w/o Earphone	Front / 1.5		0.064				
	Rear / 1.5		0.088				
3G w/ Earphone	Front / 1.5						
	Rear / 1.5						
3GS Type A w/o Earphone	Front / 1.5						
	Rear / 1.5						
3GS Type A w/ Earphone	Front / 1.5		0.060				
	Rear / 1.5		0.061				
3GS Type B w/o Earphone	Front / 1.5						
	Rear / 1.5						
3GS Type B w/ Earphone	Front / 1.5		0.016				
	Rear / 1.5		0.009				

**Note:** The above data is not measured by Sporton.

**<Sporton VX600 + iPhone SAR Results>**

iPhone	Posi. / SP (cm)	802.11b			802.11g		
		1	6	1	6	1	6
		2412	2437	2412	2437	2412	2437
3G w/o Earphone	Front / 1.0		0.092				
	Rear / 1.0		0.015				
	Top / 1.0		0.025				
	Left / 1.0		0.054				
	Right / 1.0		0.033				
3G w/ Earphone	Front / 1.0		0.071				
	Rear / 1.0						
	Bottom / 1.0						
	Left / 1.0						
	Right / 1.0						
3GS Type A w/o Earphone	Front / 1.0		0.058				
	Rear / 1.0		0.006				
	Top / 1.0		0.020				
	Left / 1.0		0.025				
	Right / 1.0		0.016				
3GS Type A w/ Earphone	Front / 1.0		0.004				
	Rear / 1.0						
	Bottom / 1.0						
	Left / 1.0						
	Right / 1.0						

iPhone	Posi. / SP (cm)	802.11b			802.11g		
		1	6	1	6	1	6
		2412	2437	2412	2437	2412	2437
3GS Type B w/o Earphone	Front / 1.0		0.038				
	Rear / 1.0		0.005				
	Top / 1.0		0.014				
	Left / 1.0		0.021				
	Right / 1.0		0.010				
3GS Type B w/ Earphone	Front / 1.0		0.013				
	Rear / 1.0						
	Bottom / 1.0						
	Left / 1.0						
	Right / 1.0						

Test Engineer : A-Rod Chen and Andy He

## **12. References**

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## ***Appendix A. Plots of System Performance Check***

The plots are shown as follows.



## ***Appendix B. Plots of SAR Measurement***

The plots are shown as follows.





## ***Appendix C. DASY Calibration Certificate***

The DASY calibration certificates are shown as follows.