



# TEST REPORT

No. I17D00262-SAR01

*For*

**Client: Shanghai Sunmi Technology Co.,Ltd.**

**Production: Wireless data POS System**

**Model Name: W5920**

**FCC ID: 2AH25V1SNFC**

**Hardware Version: 2.0**

**Software Version: 1.1.0**

**Issued date: 2018-4-4**

**Note:**

The test results in this test report relate only to the devices specified in this report. This report shall not be reproduced except in full without the written approval of ECIT Shanghai.

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**Revision Version**

<b>Report Number</b>	<b>Revision</b>	<b>Date</b>	<b>Memo</b>
I17D00262-SAR01	00	2018-3-29	Initial creation of test report
I17D00262-SAR01	01	2018-4-4	Second creation of test report

**CONTENTS**

<b>1.</b>	<b>TEST LABORATORY .....</b>	<b>6</b>
<b>1.1.</b>	<b>TESTING LOCATION .....</b>	<b>6</b>
<b>1.2.</b>	<b>TESTING ENVIRONMENT.....</b>	<b>6</b>
<b>1.3.</b>	<b>PROJECT DATA.....</b>	<b>6</b>
<b>1.4.</b>	<b>SIGNATURE .....</b>	<b>6</b>
<b>2.</b>	<b>STATEMENT OF COMPLIANCE .....</b>	<b>7</b>
<b>3.</b>	<b>CLIENT INFORMATION .....</b>	<b>8</b>
<b>3.1.</b>	<b>APPLICANT INFORMATION .....</b>	<b>8</b>
<b>3.2.</b>	<b>MANUFACTURER INFORMATION .....</b>	<b>8</b>
<b>4.</b>	<b>EQUIPMENT UNDER TEST (EUT) AND ANCILLARY EQUIPMENT (AE).....</b>	<b>9</b>
<b>4.1.</b>	<b>ABOUT EUT .....</b>	<b>9</b>
<b>4.2.</b>	<b>INTERNAL IDENTIFICATION OF EUT USED DURING THE TEST.....</b>	<b>10</b>
<b>4.3.</b>	<b>INTERNAL IDENTIFICATION OF AE USED DURING THE TEST .....</b>	<b>10</b>
<b>5.</b>	<b>TEST METHODOLOGY .....</b>	<b>11</b>
<b>5.1.</b>	<b>APPLICABLE LIMIT REGULATIONS .....</b>	<b>11</b>
<b>5.2.</b>	<b>APPLICABLE MEASUREMENT STANDARDS.....</b>	<b>11</b>
<b>6.</b>	<b>SPECIFIC ABSORPTION RATE (SAR).....</b>	<b>12</b>
<b>6.1.</b>	<b>INTRODUCTION .....</b>	<b>12</b>
<b>6.2.</b>	<b>SAR DEFINITION .....</b>	<b>12</b>
<b>7.</b>	<b>TISSUE SIMULATING LIQUIDS .....</b>	<b>13</b>
<b>7.1.</b>	<b>TARGETS FOR TISSUE SIMULATING LIQUID.....</b>	<b>13</b>
<b>7.2.</b>	<b>DIELECTRIC PERFORMANCE.....</b>	<b>13</b>
<b>8.</b>	<b>SYSTEM VERIFICATION .....</b>	<b>15</b>
<b>8.1.</b>	<b>SYSTEM SETUP .....</b>	<b>15</b>
<b>8.2.</b>	<b>SYSTEM VERIFICATION.....</b>	<b>16</b>
<b>9.</b>	<b>MEASUREMENT PROCEDURES .....</b>	<b>17</b>

9.1.	TESTS TO BE PERFORMED .....	17
9.2.	GENERAL MEASUREMENT PROCEDURE.....	18
9.3.	WCDMA MEASUREMENT PROCEDURES FOR SAR .....	20
9.4.	BLUETOOTH & WI-FI MEASUREMENT PROCEDURES FOR SAR.....	21
9.5.	POWER DRIFT .....	21
10.	AREA SCAN BASED 1-G SAR .....	22
11.	CONDUCTED OUTPUT POWER .....	23
11.1.	MANUFACTURING TOLERANCE.....	23
11.2.	GSM MEASUREMENT RESULT .....	26
11.3.	WCDMA MEASUREMENT RESULT .....	26
11.4.	WI-FI AND BT MEASUREMENT RESULT .....	27
12.	SIMULTANEOUS TX SAR CONSIDERATIONS.....	29
12.1.	INTRODUCTION .....	29
12.2.	TRANSMIT ANTENNA SEPARATION DISTANCES.....	29
12.3.	STANDALONE SAR TEST EXCLUSION CONSIDERATIONS .....	29
12.4.	SAR MEASUREMENT POSITIONS .....	30
13.	SAR TEST RESULT .....	31
14.	EVALUATION OF SIMULTANEOUS.....	38
15.	SAR MEASUREMENT VARIABILITY.....	40
16.	MEASUREMENT UNCERTAINTY .....	41
17.	MAIN TEST INSTRUMENT .....	43
ANNEX A.	GRAPH RESULTS .....	44
ANNEX B.	SYSTEM VALIDATION RESULTS.....	49
ANNEX C.	SAR MEASUREMENT SETUP.....	52
ANNEX D.	POSITION OF THE WIRELESS DEVICE IN RELATION TO THE PHANTOM.....	61
ANNEX E.	EQUIVALENT MEDIA RECIPES .....	63
ANNEX F.	SYSTEM VALIDATION .....	64



**ANNEX G. PROBE AND DAE CALIBRATION CERTIFICATE..... 65**

**ANNEX H. ACCREDITATION CERTIFICATE..... 112**

## 1. Test Laboratory

### 1.1. Testing Location

Company Name:	ECIT Shanghai, East China Institute of Telecommunications
Address:	7-8F, G Area, No. 668, Beijing East Road, Huangpu District, Shanghai, P. R. China
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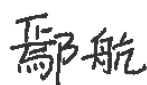
### 1.2. Testing Environment

Normal Temperature:	18-25°C
Relative Humidity:	25-75%
Ambient noise & Reflection:	< 0.012 W/kg

### 1.3. Project Data

Project Leader:	Zhou Yan
Testing Start Date:	2018-03-21
Testing End Date:	2018-03-25

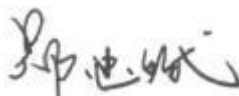
### 1.4. Signature



Yan Hang  
(Prepared this test report)



Fu Erliang  
(Reviewed this test report)



Zheng Zhongbin  
(Approved this test report)

## 2. Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for **W5920** are as follows

**Table 2.1: Max. Reported SAR (1g)**

Band	Position/Distance	SAR 1g (W/Kg)
GSM850	Body	1.163
GSM1900	Body	<b>1.270</b>
WCDMA Band2	Body	1.146
WCDMA Band5	Body	0.586
2.4G Wi-Fi	Body	0.384

The SAR values found for the Mobile Phone are below the maximum recommended levels of 1.6 W/Kg as averaged over any 1g tissue according to the ANSI C95.1-1999.

The sample has Two antennas. One is main antenna for GSM/WCDMA, and the other is for WiFi/BT. So simultaneous transmission is GSM/WCDMA and WiFi/BT.

**Table 2.2: Simultaneous SAR (1g)**

Transmission SAR(W/Kg)						
Test Position		2G	3G	2.4G WIFI	BT	SUM
Body	Phantom	1.163	0.902	0.072	0.133	1.296
	Ground	1.030	0.676	0.041	0.133	1.163
	Left Side	0.894	0.320	0.015	0.133	1.027
	Right Side	0.605	0.908	0.384	0.133	1.292
	Bottom Side	1.270	1.146	0.060	0.133	<b>1.403</b>
	Top Side	--	--	0.014	0.133	0.133

According to the above table, the maximum sum of reported SAR value between main antenna and WiFi is 1.33 W/Kg, maximum sum of reported SAR value between main antenna and Bluetooth (estimated) is 1.403 W/Kg

### **3. Client Information**

#### **3.1. Applicant Information**

Company Name: Shanghai Sunmi Technology Co.,Ltd.  
Address: Room 605, Block 7, KIC Plaza, No.388 Song Hu Road, Yang Pu District,  
Shanghai, China  
Tel: 18721763396

#### **3.2. Manufacturer Information**

Company Name: Shanghai Sunmi Technology Co.,Ltd.  
Address: Room 605, Block 7, KIC Plaza, No.388 Song Hu Road, Yang Pu District,  
Shanghai, China  
Tel: 18721763396



## 4. Equipment Under Test (EUT) and Ancillary Equipment (AE)

### 4.1. About EUT

Description:	Wireless data POS System
Model name:	W5920
Operation Model(s):	GSM850/1900,WCDMA Band II/V WIFI2450
Tx Frequency:	824.2-848.8MHz(GSM850) 1850.2-1909.8MHz (GSM1900) 1852.4-1907.6 MHz (WCDMA Band II) 826.4-846.6MHz (WCDMA Band V) 2412- 2462 MHz (Wi-Fi) 2400-2483.5 MHz (BT)
Test device Production information:	Production unit
GPRS Class Mode:	B
GPRS Multislot Class:	12
EDGE Multislot Class:	12(downlink only)
Device type:	Portable device
UE category:	3
Antenna type:	Inner antenna
Accessories/Body-worn configurations:	Battery
Dimensions:	21.2cm×8.3cm×5cm
Hotspot Mode:	N/A
FCC ID:	2AH25V1SNFC

**4.2. Internal Identification of EUT used during the test**

EUT ID*	SN or IMEI	HW Version	SW Version	Receive Date
N03	865150030317082	2.0	1.1.0	2017-11-23

\*EUT ID: is used to identify the test sample in the lab internally.

**4.3. Internal Identification of AE used during the test**

AE ID*	Description	Model	SN	Manufacturer
BA01	Battery	SMBP001	N/A	Shanghai Sunmi Technology Co.,Ltd.
BB01	Battery	SM-18650B4-1S2P	N/A	Shanghai Sunmi Technology Co.,Ltd.

\*AE ID: is used to identify the test sample in the lab internally.

## 5. TEST METHODOLOGY

### 5.1. Applicable Limit Regulations

**ANSI C95.1–1999:**IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

It specifies the maximum exposure limit of **1.6 W/kg** as averaged over any 1 gram of tissue for portable devices being used within 20 cm of the user in the uncontrolled environment.

### 5.2. Applicable Measurement Standards

**IEEE 1528–2013:** Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices:Experimental Techniques.

**KDB248227 D01 802 11 Wi-Fi SAR v02r02:** SAR measurement procedures for 802.112abg transmitters.

**KDB447498 D01 General RF Exposure Guidance v06:**Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies.

**KDB865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04:**SAR Measurement Requirements for 100 MHz to 6 GHz

**KDB865664 D02 RF Exposure Reporting v01r02:**provides general reporting requirements as well as certain specific information required to support MPE and SAR compliance.

**KDB941225 D01 3G SAR Procedures v03r01:** 3G SAR Measurement Procedures.

NOTE: KDB is not in A2LA Scope List.

## 6. Specific Absorption Rate (SAR)

### 6.1. 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.

### 6.2. 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 tissue and  $E$  is the RMS electrical field strength.

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

## 7. Tissue Simulating Liquids

### 7.1. Targets for tissue simulating liquid

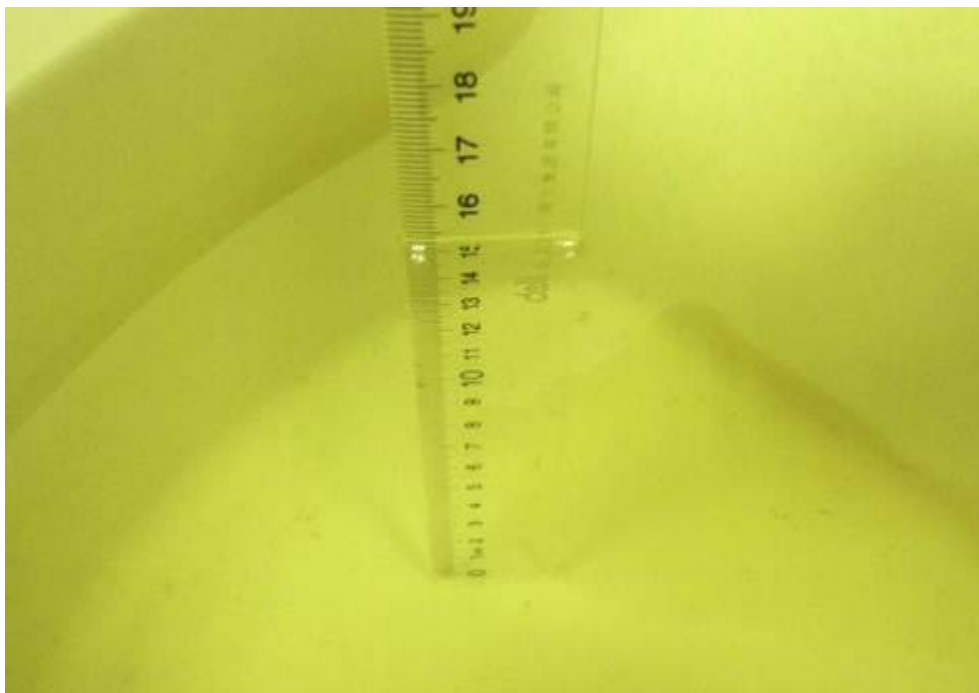
**Table 7.1: Targets for tissue simulating liquid**

Frequency (MHz)	Liquid Type	Conductivity ( $\sigma$ )	$\pm 5\%$ Range	Permittivity( $\epsilon$ )	$\pm 5\%$ Range
835	Body	0.97	0.92~1.02	55.2	52.4~58.0
1900	Body	1.52	1.44~1.60	53.3	50.6~56.0
2450	Body	1.95	1.85~2.05	52.7	50.1~55.3

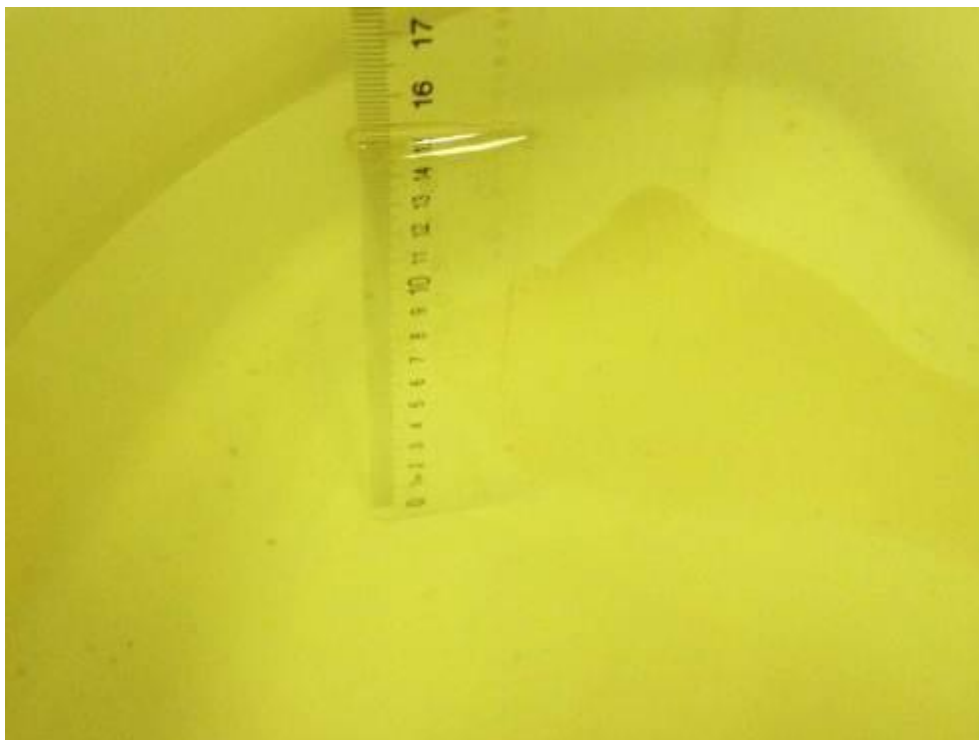
### 7.2. Dielectric Performance

**Table 7.2: Dielectric Performance of Tissue Simulating Liquid**

Measurement Value						
Liquid Temperature: 22 °C						
Type	Frequency	Permittivity $\epsilon$	Drift (%)	Conductivity $\sigma$	Drift (%)	Test Date
Body	835 MHz	56.727	2.77%	0.998	2.89%	2018-3-23
Body	1900 MHz	54.865	2.94%	1.554	2.24%	2018-3-21
Body	2450 MHz	52.97	0.51%	1.976	1.33%	2018-3-25



**Picture 7-1: Liquid depth in the Flat Phantom (835 MHz Body)**

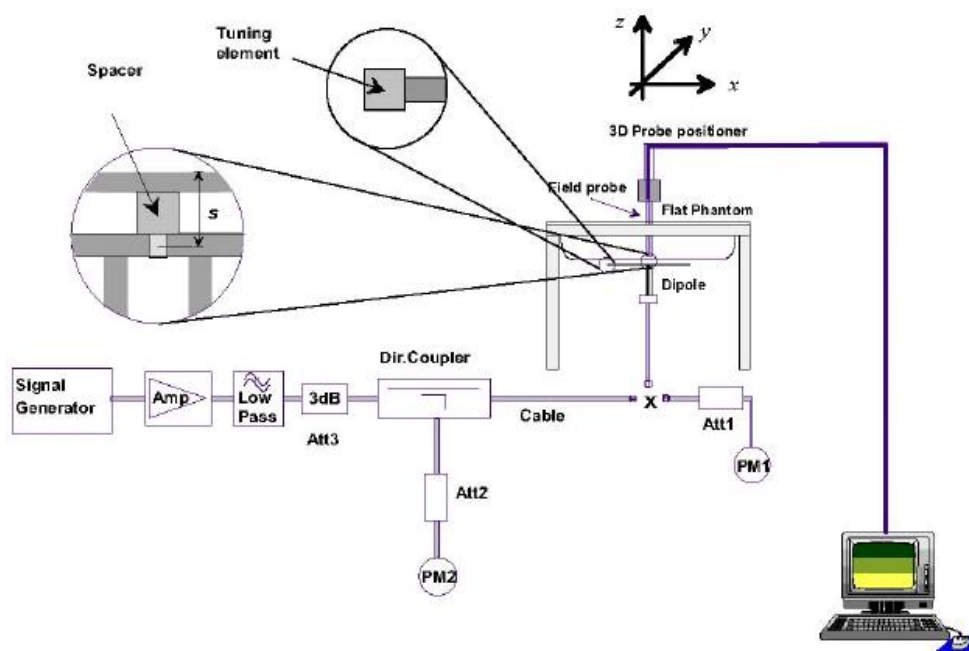


**Picture 7-2: Liquid depth in the Flat Phantom (2450 MHz Body)**

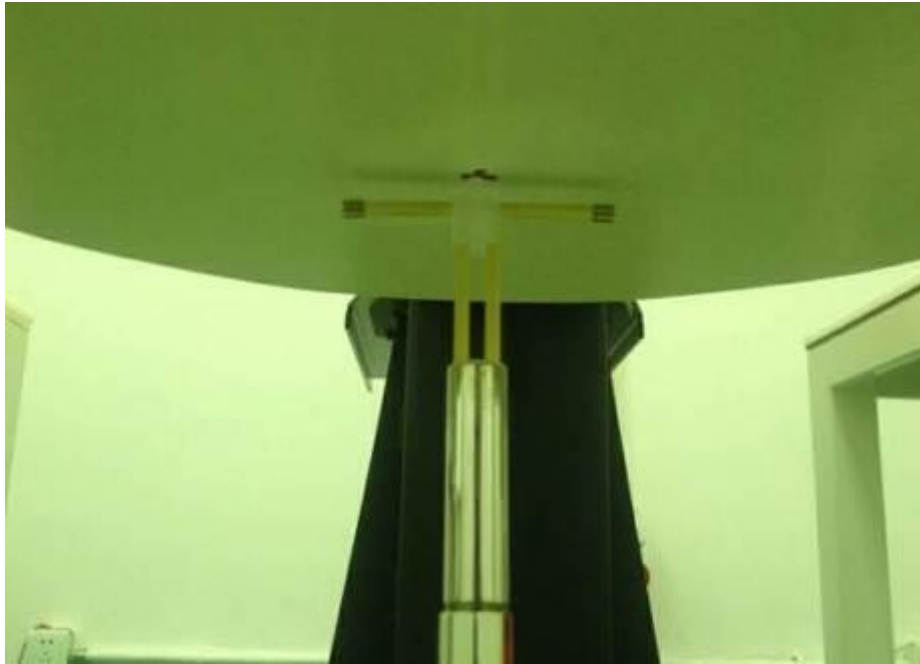
## 8. System verification

### 8.1. 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 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:



**Picture 8.1 System Setup for System Evaluation**



**Picture 8.2 Photo of Dipole Setup**

## 8.2. System Verification

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media, probe calibration points and other system operating parameters required for measuring the SAR of test device. The system verification must be performed for each frequency band and within the valid range of each probe calibration point required for testing the device.

**Table 8.1: System Verification of Body**

Verification Results							
Input power level: 1W							
Frequency	Target value (W/kg)		Measured value (W/kg)		Deviation		Test date
	10 g Average	1 g Average	10 g Average	1 g Average	10 g Average	1 g Average	
835 MHz	6.29	9.57	6.48	9.64	3.02%	0.73%	2018-3-23
1900 MHz	21.5	40.6	21.16	41.6	-1.58%	2.46%	2018-3-21
2450 MHz	24.7	53.1	23.48	50.4	-4.94%	-5.08%	2018-3-25



## 9. Measurement Procedures

### 9.1. Tests to be performed

In order to determine the highest value of the peak spatial-average SAR of a handset, all device positions, configurations and operational modes shall be tested for each frequency band according to steps 1 to 3 below. A flowchart of the test process is shown in Picture 11.1.

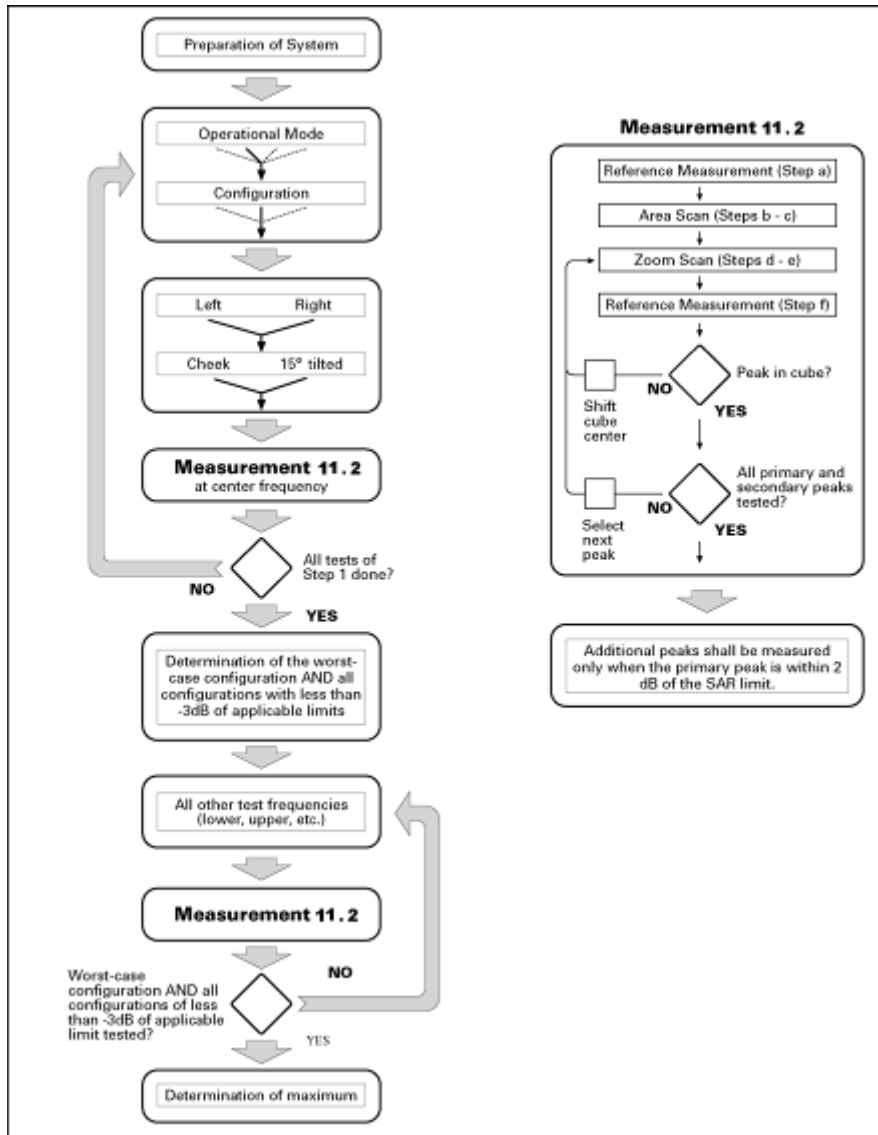
**Step 1:** The tests described in 11.2 shall be performed at the channel that is closest to the centre of the transmit frequency band ( $f_c$ ) for:

- a) all device positions (cheek and tilt, for both left and right sides of the SAM phantom, as described in Chapter 8),
- b) all configurations for each device position in a), e.g., antenna extended and retracted, and
- c) all operational modes, e.g., analogue and digital, for each device position in a) and configuration in b) in each frequency band.

If more than three frequencies need to be tested according to 11.1 (i.e.,  $N_c > 3$ ), then all frequencies, configurations and modes shall be tested for all of the above test conditions.

**Step 2:** For the condition providing highest peak spatial-average SAR determined in Step 1, perform all tests described in 11.2 at all other test frequencies, i.e., lowest and highest frequencies. In addition, for all other conditions (device position, configuration and operational mode) where the peak spatial-average SAR value determined in Step 1 is within 3 dB of the applicable SAR limit, it is recommended that all other test frequencies shall be tested as well.

**Step 3:** Examine all data to determine the highest value of the peak spatial-average SAR found in Steps 1 to 2.



**Picture 9.1**Block diagram of the tests to be performed

## 9.2. General Measurement Procedure

The following procedure shall be performed for each of the test conditions (see Picture 11.1) described in 11.1:

- a) Measure the local SAR at a test point within 8 mm or less in the normal direction from the inner surface of the phantom.
- b) Measure the two-dimensional SAR distribution within the phantom (area scan procedure). The boundary of the measurement area shall not be closer than 20 mm from the phantom side walls. The distance between the measurement points should enable the detection of the location of local maximum with an accuracy of better than half the linear dimension of the tissue cube after interpolation. A maximum grip spacing of 20 mm for

frequencies below 3 GHz and  $(60/f \text{ [GHz]})$  mm for frequencies of 3GHz and greater is recommended. The maximum distance between the geometrical centre of the probe detectors and the inner surface of the phantom shall be 5 mm for frequencies below 3 GHz and  $\delta \ln(2)/2$  mm for frequencies of 3 GHz and greater, where  $\delta$  is the plane wave skin depth and  $\ln(x)$  is the natural logarithm. The maximum variation of the sensor-phantom surface shall be  $\pm 1$  mm for frequencies below 3 GHz and  $\pm 0.5$  mm for frequencies of 3 GHz and greater. At all measurement points the angle of the probe with respect to the line normal to the surface should be less than  $5^\circ$ . If this cannot be achieved for a measurement distance to the phantom inner surface shorter than the probe diameter, additional uncertainty evaluation is needed.

c) From the scanned SAR distribution, identify the position of the maximum SAR value, in addition identify the positions of any local maxima with SAR values within 2 dB of the maximum value that are not within the zoom-scan volume; additional peaks shall be measured only when the primary peak is within 2 dB of the SAR limit. This is consistent with the 2 dB threshold already stated;

d) Measure the three-dimensional SAR distribution at the local maxima locations identified in step c). The horizontal grid step shall be  $(24/f[\text{GHz}])$  mm or less but not more than 8 mm. The minimum zoom size of 30 mm by 30 mm and 30 mm for frequencies below 3 GHz. For higher frequencies, the minimum zoom size of 22 mm by 22 mm and 22 mm. The grid step in the vertical direction shall be  $(8-f[\text{GHz}])$  mm or less but not more than 5 mm, if uniform spacing is used. If variable spacing is used in the vertical direction, the maximum spacing between the two closest measured points to the phantom shell shall be  $(12 / f[\text{GHz}])$  mm or less but not more than 4 mm, and the spacing between farther points shall increase by an incremental factor not exceeding 1.5. When variable spacing is used, extrapolation routines shall be tested with the same spacing as used in measurements.

The maximum distance between the geometrical centre of the probe detectors and the inner surface of the phantom shall be 5 mm for frequencies below 3 GHz and  $\delta \ln(2)/2$  mm for frequencies of 3 GHz and greater, where  $\delta$  is the plane wave skin depth and  $\ln(x)$  is the natural logarithm. Separate grids shall be centered on each of the local SAR maxima found in step c). Uncertainties due to field distortion between the media boundary and the dielectric enclosure of the probe should also be minimized, which is achieved is the distance between the phantom surface and physical tip of the probe is larger than probe tip diameter. Other methods may utilize correction procedures for these boundary effects that enable high precision measurements closer than half the probe diameter. For all measurement points, the angle of the probe with respect to the flat phantom surface shall

be less than  $5^\circ$ . If this cannot be achieved an additional uncertainty evaluation is needed.

e) Use post processing( e.g. interpolation and extrapolation ) procedures to determine the local SAR values at the spatial resolution needed for mass averaging.

### 9.3. WCDMA Measurement Procedures for SAR

The following procedures are applicable to WCDMA handsets operating under 3GPP Release99, Release 5 and Release 6. The default test configuration is to measure SAR with an established radio link between the DUT and a communication test set using a 12.2kbps RMC (reference measurement channel) configured in Test Loop Mode 1. SAR is selectively confirmed for other physical channel configurations (DPCCH &DPDCH<sub>n</sub>), HSDPA and HSPA (HSUPA/HSDPA) modes according to output power, exposure conditions and device operating capabilities. Both uplink and downlink should be configured with the same RMC or AMR, when required. SAR for Release 5 HSDPA and Release 6 HSPA are measured using the applicable FRC (fixed reference channel) and E-DCH reference channel configurations. Maximum output power is verified according to applicable versions of 3GPP TS 34.121 and SAR must be measured according to these maximum output conditions. When Maximum Power Reduction (MPR) is not implemented according to Cubic Metric (CM) requirements for Release 6 HSPA, the following procedures do not apply.

#### For Release 5 HSDPA Data Devices:

Sub-test	$\beta_c$	$\beta_d$	$\beta_d$ (SF)	$\beta_c / \beta_d$	$\beta_{hs}$	CM/dB	MPR (dB)
1	2/15	15/15	64	2/15	4/15	1.5	0
2	12/15	15/15	64	12/15	24/25	2.0	1
3	15/15	8/15	64	15/8	30/15	2.0	1
4	15/15	4/15	64	15/4	30/15	2.0	1

#### For Release 6 HSUPA Data Devices

Sub-test	$\beta_c$	$\beta_d$	$\beta_d$ (SF)	$\beta_c / \beta_d$	$\beta_{hs}$	$\beta_{ec}$	$\beta_{ed}$	$\beta_{ed}$ (SF)	$\beta_{ed}$ (codes)	CM (dB)	MPR (dB)	AG Index	E-TFCI
1	11/15	15/15	64	11/15	22/15	209/225	1039/225	4	1	2.0	1.0	20	75
2	6/15	15/15	64	6/15	12/15	12/15	12/15	4	1	3.0	1.0	12	67

3	15/15	9/15	64	15/9	30/15	30/15	$\beta_{ed1}:47/15$ $\beta_{ed2}:47/15$	4	2	3.0	1.0	15	92
4	2/15	15/15	64	2/15	4/15	4/15	56/75	4	1	2.0	1.0	17	71
5	15/15	15/15	64	15/15	24/15	30/15	134/15	4	1	2.0	1.0	21	81

## 9.4. Bluetooth & Wi-Fi Measurement Procedures for SAR

Normal network operating configurations are not suitable for measuring the SAR of 802.11 transmitters in general. 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 that the results are consistent and reliable.

Chipset based test mode software is hardware dependent and generally varies among manufacturers. The device operating parameters established in a 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.

## 9.5. Power Drift

To control the output power stability during the SAR test, DASY4 system calculates the power drift by measuring the E-field at the same location at the beginning and at the end of the measurement for each test position. These drift values can be found in Section 13 labeled as: (Power Drift [dB]). This ensures that the power drift during one measurement is within 5%.

## **10. Area Scan Based 1-g SAR**

### **10.1 Requirement of KDB**

According to the KDB447498 D01 v06, when the implementation is based the specific polynomial fit algorithm as presented at the 29th Bioelectromagnetics Society meeting (2007) and the estimated 1-g SAR is  $\leq 1.2$  W/kg, a zoom scan measurement is not required provided it is also not needed for any other purpose; for example, if the peak SAR location required for simultaneous transmission SAR test exclusion can be determined accurately by the SAR system or manually to discriminate between distinctive peaks and scattered noisy SAR distributions from area scans.

There must not be any warning or alert messages due to various measurement concerns identified by the SAR system; for example, noise in measurements, peaks too close to scan boundary, peaks are too sharp, spatial resolution and uncertainty issues etc. The SAR system verification must also demonstrate that the area scan estimated 1-g SAR is within 3% of the zoom scan 1-g SAR (See Annex B). When all the SAR results for each exposure condition in a frequency band and wireless mode are based on estimated 1-g SAR, the 1-g SAR for the highest SAR configuration must be determined by a zoom scan.

### **10.2 Fast SAR Algorithms**

The approach is based on the area scan measurement applying a frequency dependent attenuation parameter. This attenuation parameter was empirically determined by analyzing a large number of phones. The MOTOROLA FAST SAR was developed and validated by the MOTOROLA Research Group in Ft. Lauderdale.

In the initial study, an approximation algorithm based on Linear fit was developed. The accuracy of the algorithm has been demonstrated across a broad frequency range (136-2450 MHz) and for both 1- and 10-g averaged SAR using a sample of 264 SAR measurements from 55 wireless handsets. For the sample size studied, the root-mean-squared errors of the algorithm are 1.2% and 5.8% for 1- and 10-g averaged SAR, respectively. The paper describing the algorithm in detail is expected to be published in August 2004 within the Special Issue of Transactions on MTT.

In the second step, the same research group optimized the fitting algorithm to an Polynomial fit whereby the frequency validity was extended to cover the range 30-6000MHz. Details of this study can be found in the BEMS 2007 Proceedings.

Both algorithms are implemented in DASY software.

## 11. Conducted Output Power

### 11.1. Manufacturing tolerance

**Table 11.1: GPRS (GMSK Modulation)**

GSM 850 GPRS				
Channel		128	190	251
1 Txslots	Maximum Target Value (dBm)	33.0	33.0	33.0
2 Txslots	Maximum Target Value (dBm)	32.5	32.5	32.5
3 Txslots	Maximum Target Value (dBm)	31.0	31.0	31.0
4 Txslots	Maximum Target Value (dBm)	30.0	30.0	30.0
GSM 1900 GPRS				
Channel		512	661	810
1 Txslots	Maximum Target Value (dBm)	29.5	29.5	29.5
2 Txslots	Maximum Target Value (dBm)	26.5	26.5	26.5
3 Txslots	Maximum Target Value (dBm)	24.5	24.5	24.5
4 Txslots	Maximum Target Value (dBm)	23.5	23.5	23.5

**Table 11.2: WCDMA**

WCDMA Band II			
Channel	Channel 9262	Channel 9400	Channel 9538
Maximum Target Value (dBm)	21.5	21.5	21.5

WCDMA Band II HSDPA					MPR (dB)
Channel		9262	9400	9538	
1	Maximum Target Value (dBm)	21.5	21.5	21.5	0
2	Maximum Target Value (dBm)	21.5	21.5	21.5	1
3	Maximum Target Value (dBm)	21.5	21.5	21.5	1
4	Maximum Target Value (dBm)	21.5	21.5	21.5	1
WCDMA Band II HSUPA					MPR

Channel		9262	9400	9538	(dB)
1	Maximum Target Value (dBm)	21.5	21.5	21.5	1
2	Maximum Target Value (dBm)	21.5	21.5	21.5	1
3	Maximum Target Value (dBm)	21	21	21	1
4	Maximum Target Value (dBm)	21.5	21.5	21.5	1
5	Maximum Target Value (dBm)	21	21	21	1

**Table 11.3: WCDMA**

WCDMA Band V			
Channel	4233	4182	4132
Maximum Target Value (dBm)	23.5	23.5	23.5

WCDMA Band V HSDPA					MPR (dB)
Channel	4233	4182	4132		
1	Maximum Target Value (dBm)	23	23	23	0
2	Maximum Target Value (dBm)	23	23	23	1
3	Maximum Target Value (dBm)	22	22	22	1
4	Maximum Target Value (dBm)	22	22	22	1
WCDMA Band V HSUPA					MPR (dB)
Channel	4233	4182	4132		
1	Maximum Target Value (dBm)	22	22	22	1
2	Maximum Target Value (dBm)	22	22	22	1
3	Maximum Target Value (dBm)	22	22	22	1
4	Maximum Target Value (dBm)	22	22	22	1
5	Maximum Target Value (dBm)	22	22	22	1



**Table 11.4: WiFi**

WiFi 802.11b 2.4G			
Channel	Channel 1	Channel 6	Channel 11
Maximum Target Value (dBm)	14.5	14.5	14.5
WiFi 802.11g 2.4G			
Channel	Channel 1	Channel 6	Channel 11
Maximum Target Value (dBm)	12.0	14	14
WiFi 802.11n 20M 2.4G			
Channel	Channel 1	Channel 6	Channel 11
Maximum Target Value (dBm)	12.0	14	14

**Table 11.5: The Tune up power for Bluetooth**

	Bluetooth 2.1	Bluetooth BLE
Tune up power (dBm)	5	-3

**NOTE:** According to KDB447498 D01 BT standalone SAR are not required, because maximum average output power is less than 10mW.

When the standalone SAR test exclusion is applied to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to the following to determine simultaneous transmission SAR test exclusion:

(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm) • [ √ f(GHz)/x] W/kg for test separation distances ≤ 50 mm;  
 where x = 7.5 for 1-g SAR, and x = 18.75 for 10-g SAR.

SAR body value of BT is 0.133 W/Kg.

**11.2. GSM Measurement result**

During the process of testing, the EUT was controlled via Agilent Digital Radio Communication tester (E5515C) to ensure the maximum power transmission and proper modulation. This result contains conducted output power for the EUT. In all cases, the measured peak output power should be greater and within 5% than EMI measurement.

**Table 11.6: The conducted power measurement results for GPRS**

GSM 850 GMSK	Measured Power (dBm)			calculation	Averaged Power (dBm)		
	128	190	251		128	190	251
1 Txslot	32.54	32.59	32.49	-9.03dB	23.51	23.56	23.46
2 Txslots	31.79	31.77	31.72	-6.02dB	25.77	25.75	25.7
3 Txslots	29.95	29.93	29.93	-4.26dB	25.69	25.67	25.67
4 Txslots	29.44	29.46	29.43	-3.01dB	26.43	26.45	26.42
GSM 1900 GMSK	Measured Power (dBm)			calculation	Averaged Power (dBm)		
	512	661	810		512	661	810
1 Txslot	29.41	29.42	29.43	-9.03dB	20.38	20.39	20.4
2 Txslots	26.38	26.3	26.36	-6.02dB	20.36	20.28	20.34
3 Txslots	24.36	24.51	24.5	-4.26dB	20.1	20.25	20.24
4 Txslots	23.19	23.15	23.13	-3.01dB	20.18	20.14	20.12

**11.3. WCDMA Measurement result**

**Table 11.7: The conducted Power for WCDMA**

Item	band	WCDMA BAND II result(dBm)		
	ARFCN	2712 (1852.4MHz)	2788 (1880.0MHz)	2863 (1907.6MHz)
WCDMA	\	21.36	21.41	21.37
HSDPA	1	21.31	21.33	21.31
	2	20.11	20.15	20.11
	3	20.42	20.46	20.41
	4	20.04	20.07	20.02
HSUPA	1	20.80	20.80	20.85
	2	21.16	21.12	21.11
	3	20.60	20.52	20.62
	4	21.18	21.15	21.11
	5	20.46	20.42	20.42

Item	band	WCDMA BAND V result(dBm)		
	ARFCN	Channel 4132 (826.4MHz)	Channel 4183 (836.6MHz)	Channel 4233 (846.6MHz)

<b>WCDMA</b>	\	23.28	23.24	23.25
<b>HSDPA</b>	<b>1</b>	22.46	22.41	22.41
	<b>2</b>	22.24	22.21	22.23
	<b>3</b>	21.91	21.91	21.94
	<b>4</b>	21.83	21.81	21.81
<b>HSUPA</b>	<b>1</b>	21.81	21.81	21.8
	<b>2</b>	20.86	20.75	20.84
	<b>3</b>	20.85	20.89	20.77
	<b>4</b>	21.66	21.59	21.68
	<b>5</b>	21.46	21.49	21.57

### 11.4. Wi-Fi and BT Measurement result

**The default power measurement procedures are:**

a) Power must be measured at each transmit antenna port according to the DSSS and OFDM transmission configurations in each standalone and aggregated frequency band.

b) Power measurement is required for the transmission mode configuration with the highest maximum output power specified for production units.

1) When the same highest maximum output power specification applies to multiple transmission modes, the largest channel bandwidth configuration with the lowest order modulation and lowest data rate is measured.

2) When the same highest maximum output power is specified for multiple largest channel bandwidth configurations with the same lowest order modulation or lowest order modulation and lowest data rate, power measurement is required for all equivalent 802.11 configurations with the same maximum output power.

c) For each transmission mode configuration, power must be measured for the highest and lowest channels; and at the mid-band channel(s) when there are at least 3 channels. For configurations with multiple mid-band channels, due to an even number of channels, both channels should be measured.

During WLAN SAR testing EUT is configured with the WLAN continuous TX tool, and the transmission duty factor was monitored on the spectrum analyzer with zero-span setting, the duty cycle is 99%.

#### 2.4 GHz 802.11g/n OFDM SAR Test Exclusion Requirements

When SAR measurement is required for 2.4 GHz 802.11g/n OFDM configurations, the measurement and test reduction procedures for OFDM are applied. SAR is not required for the following 2.4 GHz OFDM conditions.

a) When KDB Publication 447498 D01 SAR test exclusion applies to the OFDM configuration.

b) When the highest *reported* SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is  $\leq 1.2$  W/kg.

**Table 11.8: The average conducted power for WiFi**

Mode	Channel	Frequency	Average power(dBm)
802.11 b	1	2412 MHZ	14.42
	6	2437 MHZ	14.26
	11	2462 MHZ	14.27
802.11 g	1	2412 MHZ	11.37
	6	2437 MHZ	13.23
	11	2462 MHZ	13.85
802.11 n 20M	1	2412 MHZ	11.27
	6	2437 MHZ	13.71
	11	2462 MHZ	13.34

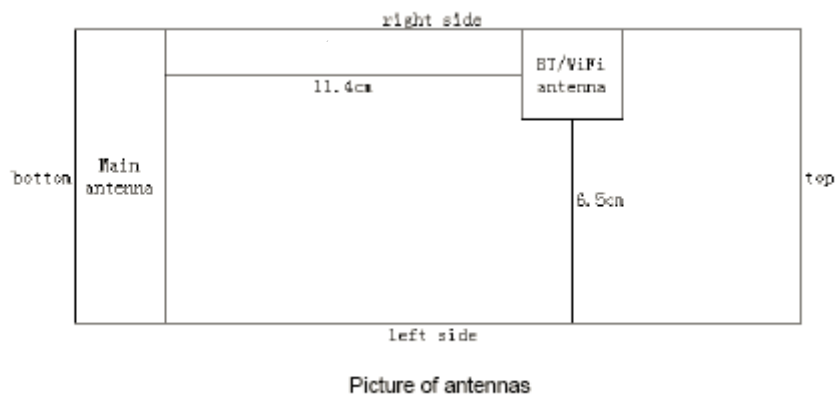
## 12. Simultaneous TX SAR Considerations

### 12.1. Introduction

The following procedures adopted from “FCC SAR Considerations for Cell Phones with Multiple Transmitters” are applicable to handsets with built-in unlicensed transmitters such as 802.11 a/b/g and Bluetooth devices which may simultaneously transmit with the licensed transmitter.

For this device, the BT and Wi-Fi can transmit simultaneous with other transmitters.

### 12.2. Transmit Antenna Separation Distances



**Picture 12.1 Antenna Locations**

**Note:**

**Main Antenna meaning is 2G/3G TX Antenna**

### 12.3. Standalone SAR Test Exclusion Considerations

Standalone 1-g head or body SAR evaluation by measurement or numerical simulation is not required when the corresponding SAR Exclusion Threshold condition, listed below, is satisfied.

The 1-g SAR test exclusion threshold for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

$$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot$$

$$[\sqrt{f(\text{GHz})}] \leq 3.0 \text{ for 1-g SAR, where}$$

- f(GHz) is the RF channel transmit frequency in GHz

- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

According to the KDB447498 appendix A, the SAR test exclusion threshold for 2450MHz at 5mm test separation distances is 10mW.

$$\frac{(\text{max. power of channel, including tune-up tolerance, mW})}{(\text{min. test separation distance, mm})} * \sqrt{\text{Frequency (GHz)}} \leq 3.0$$

Based on the above equation, Bluetooth SAR was not required:

Evaluation=0.99 < 3.0

Based on the above equation, WiFi SAR was required:

Evaluation=8.823 > 3.0

## 12.4. SAR Measurement Positions

According to the KDB941225 D06 Hot Spot SAR v01, the edges with less than 2.5 cm distance to the antennas need to be tested for SAR.

SAR Measurement Positions						
Antenna Mode	Phantom	Ground	Left	Right	Top	Bottom
WWAN	Yes	Yes	Yes	Yes	No	Yes
WLAN	Yes	Yes	Yes	Yes	Yes	No

### 13. SAR Test Result

#### 13.1. SAR results for Fast SAR

**Table 13.1: Duty Cycle**

Duty Cycle	
GSM850	1:2
GSM1900	1.8.3
WCDMA Band I/ Band V	1:1
wifi	1:0.99

**Table 13.2: SAR Values (GSM 850 MHz Band-Body)**

Frequency		Mode /Band	Test Position	Spacing (mm)	Figure No.	Measured average power (dBm)	Maximum allowed Power (dBm)	Scaling factor	1g SAR (W/kg)		Power Drift (dB)
MHz	Ch.								Measured SAR	Reported SAR	
Battery BA01											
836.6	190	GPRS 4TS	Phantom	0	/	29.46	30	1.132	0.870	0.985	0.10
			Ground	0	/	29.46	30	1.132	0.847	0.959	0.10
			Left	0	/	29.46	30	1.132	0.741	0.839	-0.06
			Right	0	/	29.46	30	1.132	0.534	0.605	-0.14
			Bottom	0	/	29.46	30	1.132	0.538	0.609	0.04
824.2	128	GPRS 4TS	Phantom	0	/	29.44	30	1.138	0.859	0.977	0.11
848.8	251			0	Fig.1	29.43	30	1.140	1.02	1.163	-0.05
824.2	128		Ground	0	/	29.44	30	1.138	0.789	0.898	-0.10
848.8	251			0	/	29.43	30	1.140	0.903	1.030	-0.15
824.2	128		Left	0	/	29.44	30	1.138	0.729	0.829	0.08
848.8	251			0	/	29.43	30	1.140	0.784	0.894	0.09
Repeated											
848.8	251	GPRS 4TS	Phantom	0	/	29.43	30	1.140	0.95	1.083	0.12

**Table 13.3: SAR Values (GSM 1900 MHz Band-Body)**

Frequency		Mode /Band	Test Position	Spacing (mm)	Figure No.	Measured average power (dBm)	Maximum allowed Power (dBm)	Scaling factor	1g SAR (W/kg)		Power Drift (dB)
MHz	Ch.								Measured SAR	Reported SAR	
Battery BA01											
1880	661	GPRS 1TS	Phantom	0	/	29.42	29.5	1.019	0.553	0.563	0.12
			Ground	0	/	29.42	29.5	1.019	0.437	0.445	-0.03
			Left	0	/	29.42	29.5	1.019	0.546	0.556	-0.14
			Right	0	/	29.42	29.5	1.019	0.110	0.112	0.00
			Bottom	0	/	29.42	29.5	1.019	0.971	0.989	0.03
1850.2	512	GPRS 1TS	Bottom	0	/	29.41	29.5	1.021	1.11	1.13	-0.16
1909.8	810			0	Fig.2	29.43	29.5	1.016	1.25	1.270	-0.17
Repeated(Battery BA01)											
1909.8	810	GPRS 1TS	Bottom	0	/	29.43	29.5	1.016	1.23	1.250	0.12
Battery BB01											
1880	661	GPRS 1TS	Bottom	0	/	29.42	29.5	1.019	0.807	0.822	-0.11
1850.2	512			0	/	29.41	29.5	1.021	1.16	1.184	-0.05
1909.8	810			0	/	29.43	29.5	1.016	0.806	0.819	-0.01
Repeated (Battery BB01)											
1850.2	512	GPRS 1TS	Bottom	0	/	29.41	29.5	1.021	1.15	1.174	0.09



**Table 13.4: SAR Values (WCDMA Band 2-Body)**

Frequency		Mode /Band	Test Position	Spacing (mm)	Figure No.	Measured average power (dBm)	Maximum allowed Power (dBm)	Scaling factor	1g SAR (W/kg)		Power Drift (dB)
MHz	Ch.								Measured SAR	Reported SAR	
Battery BA01											
1880	9800	12.2kbps RMC	Phantom	0	/	21.41	21.5	1.021	0.815	0.832	0.03
			Ground	0	/	21.41	21.5	1.021	0.662	0.676	-0.10
			Left	0	/	21.41	21.5	1.021	0.158	0.161	0.12
			Right	0	/	21.41	21.5	1.021	0.856	0.874	0.02
			Bottom	0	/	21.41	21.5	1.021	1.12	1.143	-0.03
1852.4	9662	12.2kbps RMC	Phantom	0	/	21.36	21.5	1.033	0.755	0.780	0.01
1907.6	9938			0	/	21.37	21.5	1.030	0.875	0.902	-0.02
1852.4	9662		Right	0	/	21.36	21.5	1.033	0.726	0.750	0.01
1907.6	9938			0	/	21.37	21.5	1.030	0.881	0.908	-0.09
1852.4	9662		Bottom	0	Fig.3	21.36	21.5	1.033	1.11	1.146	0.04
1907.6	9938			0	/	21.37	21.5	1.030	1.1	1.133	0.02
Repeated											
1880	9800	12.2kbps RMC	Bottom	0	/	21.41	21.5	1.021	1.11	1.123	0.16

**Table 13.5: SAR Values (WCDMA Band 5-Body)**

Frequency		Mode /Band	Test Position	Spacing (mm)	Figure No.	Measured average power (dBm)	Maximum allowed Power (dBm)	Scaling factor	1g SAR (W/kg)		Power Drift (dB)
MHz	Ch.								Measured SAR	Reported SAR	
Battery BA01											
836.6	4175	12.2kbps RMC	Phantom	0	Fig.4	23.24	23.5	1.062	0.552	0.586	0.03
			Ground	0	/	23.24	23.5	1.062	0.499	0.530	-0.02
			Left	0	/	23.24	23.5	1.062	0.301	0.320	0.01
			Right	0	/	23.24	23.5	1.062	0.434	0.461	-0.09
			Bottom	0	/	23.24	23.5	1.062	0.364	0.386	0.04
826.4	4133	12.2kbps RMC	Phantom	0	/	23.28	23.5	1.052	0.437	0.460	0.02
846.6	4232			0	/	23.25	23.5	1.059	0.365	0.387	-0.02

**Table 13.6: SAR Values (WIFI 2450-Body)**

Frequency		Mode /Band	Test Position	Spacing (mm)	Figure No.	Measured average power (dBm)	Maximum allowed Power (dBm)	Scaling factor	Duty cycle factor	1g SAR (W/kg)		Power Drift (dB)
MHz	Ch.									Measured SAR	Reported SAR	
Battery BA01												
2412	1	Wi-Fi 802.11b	Phantom	0	/	14.42	14.5	1.019	1.01	0.0698	0.072	0.12
			Ground	0	/	14.42	14.5	1.019	1.01	0.0395	0.041	0.02
			Left	0	/	14.42	14.5	1.019	1.01	0.0144	0.015	-0.11
			Right	0	/	14.42	14.5	1.019	1.01	0.265	0.273	0.01
			Top	0	/	14.42	14.5	1.019	1.01	0.0586	0.060	-0.02
			Bottom	0	/	14.42	14.5	1.019	1.01	0.014	0.014	0.01
2437	6	Wi-Fi 802.11b	Right	0	/	14.26	14.5	1.057	1.01	0.314	0.335	-0.09
2462	11			0	Fig.5	14.27	14.5	1.054	1.01	0.361	0.384	-0.08

## 13.2. SAR results for Full SAR

There is zoom scan measurement to be added for the highest measured SAR in each exposure configuration/band. Tune-up scaling Factor = tune-up limit power (mW) / EUT RF power (mW), where tune-up limit is the maximum rated power among all production units.

**Table 13.7: SAR Values (GSM 850 MHz Band-Body)**

Frequency		Mode /Band	Test Position	Spacing (mm)	Figure No.	Measured average power (dBm)	Maximum allowed Power (dBm)	Scaling factor	1g SAR (W/kg)		Power Drift (dB)
MHz	Ch.								Measured SAR	Reported SAR	
Battery BA01											
836.6	190	GPRS 4TS	Phantom	0	/	29.46	30	1.132	0.870	0.985	0.10
824.2	128			0	/	29.44	30	1.138	0.859	0.977	0.11
848.8	251			0	Fig.1	29.43	30	1.140	1.02	1.163	-0.05
836.6	190		Ground	0	/	29.46	30	1.132	0.847	0.959	0.10
824.2	128			0	/	29.44	30	1.138	0.789	0.898	-0.10
848.8	251			0	/	29.43	30	1.140	0.903	1.030	-0.15
Repeated(Battery BA01)											
848.8	251	GPRS 4TS	Phantom	0	/	29.43	30	1.140	0.95	1.083	0.12

**Table 13.8: SAR Values (GSM 1900 MHz Band-Body)**

Frequency		Mode /Band	Test Position	Spacing (mm)	Figure No.	Measured average power (dBm)	Maximum allowed Power (dBm)	Scaling factor	1g SAR (W/kg)		Power Drift (dB)
MHz	Ch.								Measured SAR	Reported SAR	
Battery BA01											
1880	661	GPRS 1TS	Bottom	0	/	29.42	29.5	1.019	0.971	0.989	0.03
1850.2	512			0	/	29.41	29.5	1.021	1.11	1.13	-0.16
1909.8	810			0	Fig.2	29.43	29.5	1.016	1.25	1.270	-0.17
Repeated(Battery BA01)											
1909.8	810	GPRS 1TS	Bottom	0	/	29.43	29.5	1.016	1.23	1.250	0.12
Battery BB01											
1880	661	GPRS	Bottom	0	/	29.42	29.5	1.019	0.807	0.822	-0.11

1850.2	512	1TS		0	/	29.41	29.5	1.021	1.16	1.184	-0.05
1909.8	810			0	/	29.43	29.5	1.016	0.806	0.819	-0.01
Repeated (Battery BB01)											
1850.2	512	GPRS 1TS	Bottom	0	/	29.41	29.5	1.021	1.15	1.174	0.09

**Table 13.9: SAR Values (WCDMA Band 2-Body)**

Frequency		Mode /Band	Test Position	Spacing (mm)	Figure No.	Measured average power (dBm)	Maximum allowed Power (dBm)	Scaling factor	1g SAR (W/kg)		Power Drift (dB)
MHz	Ch.								Measured SAR	Reported SAR	
Battery BA01											
1880	9800	12.2kbps RMC	Phantom	0	/	21.41	21.5	1.021	0.815	0.832	0.03
1852.4	9662			0	/	21.36	21.5	1.033	0.755	0.780	0.01
1907.6	9938			0	/	21.37	21.5	1.030	0.875	0.902	-0.02
1880	9800		Right	0	/	21.41	21.5	1.021	0.856	0.874	0.02
1852.4	9662			0	/	21.36	21.5	1.033	0.726	0.750	0.01
1907.6	9938			0	/	21.37	21.5	1.030	0.881	0.908	-0.09
1880	9800		Bottom	0	/	21.41	21.5	1.021	1.12	1.143	-0.03
1852.4	9662			0	Fig.3	21.36	21.5	1.033	1.11	1.146	0.04
1907.6	9938			0	/	21.37	21.5	1.030	1.1	1.133	0.02
Repeated											
1880	9800	12.2kbps RMC	Bottom	0	/	21.41	21.5	1.021	1.11	1.123	0.16

**Table 13.10: SAR Values (WCDMA Band 5-Body)**

Frequency		Mode /Band	Test Position	Spacing (mm)	Figure No.	Measured average power (dBm)	Maximum allowed Power (dBm)	Scaling factor	1g SAR (W/kg)		Power Drift (dB)
MHz	Ch.								Measured SAR	Reported SAR	
Battery BA01											
836.6	4175	12.2kbps RMC	Phantom	0	Fig.4	23.24	23.5	1.062	0.552	0.586	0.03
826.4	4133			0	/	23.28	23.5	1.052	0.437	0.460	0.02
846.6	4232			0	/	23.25	23.5	1.059	0.365	0.387	-0.02

**Table 13.11: SAR Values (WIFI 2450-Body)**

Frequency		Mode /Band	Test Position	Spacing (mm)	Figure No.	Measured average power (dBm)	Maximum allowed Power (dBm)	Scaling factor	Duty cycle factor	1g SAR (W/kg)		Power Drift (dB)
MHz	Ch.									Measured SAR	Reported SAR	
Battery BA01												
2412	1	Wi-Fi 802.11b	Right	0	/	14.42	14.5	1.019	1.01	0.265	0.273	0.01
2437	6			0	/	14.26	14.5	1.057	1.01	0.314	0.335	-0.09
2462	11			0	Fig.5	14.27	14.5	1.054	1.01	0.361	0.384	-0.08

## 14. Evaluation of Simultaneous

**Table 14.1: Summary of Transmitters**

Band/Mode	Frequency (GHz)	SAR test exclusion threshold(mW)	RF output power (mW)
Bluetooth	2.41	10	3.162
2.4GHz WLAN 802.11 b/g/n	2.45	10	28.18

**Table13.2 Simultaneous transmission SAR**

Standalone SAR for 2G(W/Kg)				
Test Position		GSM 850	GSM 1900	Highest SAR
Body	Phantom	1.163	0.563	1.163
	Ground	1.030	0.445	1.030
	Left Side	0.894	0.556	0.894
	Right Side	0.605	0.112	0.605
	Bottom Side	0.609	1.270	1.270
	Top Side	--	--	--

Standalone SAR for 3G (W/Kg)				
Test Position		WCDMA Band II	WCDMA Band V	Highest SAR
Body	Phantom	0.902	0.586	0.902
	Ground	0.676	0.530	0.676
	Left Side	0.161	0.320	0.320
	Right Side	0.908	0.461	0.908
	Bottom Side	1.146	0.386	1.146
	Top Side	--	--	--

Transmission SAR(W/Kg)						
Test Position		2G	3G	2.4G WIFI	BT	SUM
Body	Phantom	1.163	0.902	0.072	0.133	1.296
	Ground	1.030	0.676	0.041	0.133	1.163
	Left Side	0.894	0.320	0.015	0.133	1.027
	Right Side	0.605	0.908	0.384	0.133	1.292
	Bottom Side	1.270	1.146	0.060	0.133	1.403
	Top Side	--	--	0.014	0.133	0.133

According to the conducted power measurement result, we can draw the conclusion that: stand-alone SAR for WiFi should be performed. Then, simultaneous transmission SAR for WiFi/BT is considered with measurement results of GSM/WCDMA and WiFi/BT. According to the above table, the sum of reported SAR values for GSM/WCDMA and WiFi/BT < 1.6W/kg. So the simultaneous transmission SAR is not required for WiFi/BT transmitter.

## 15. SAR Measurement Variability

SAR measurement variability must be assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media are required for SAR measurements in a frequency band, the variability measurement procedures should be applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium.

The following procedures are applied to determine if repeated measurements are required.

- 1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.
- 2) When the original highest measured SAR is  $\geq 0.80$  W/kg, repeat that measurement once.
- 3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is  $\geq 1.45$  W/kg (~ 10% from the 1-g SAR limit).
- 4) Perform a third repeated measurement only if the original, first or second repeated measurement is  $\geq 1.5$  W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

**Table 15.1: SAR Measurement Variability for Body Value (1g)**

Frequency		Test Position	Original SAR (W/kg)	First Repeated SAR (W/kg)	The Ratio
MHz	Ch.				
848.8	251	Phantom	1.02	0.95	1.074
1909.8	810	Bottom	1.25	1.23	1.016
1850.2	512	Bottom	1.16	1.15	1.009
1880	9800	Bottom	1.12	1.11	1.009

**Note:** According to the KDB 865664 D01 repeated measurement is not required when the original highest measured SAR is < 0.8 W/kg.



## 16. Measurement Uncertainty

Error Description	Unc. value, ±%	Prob. Dist.	Div.	$c_i$ 1g	$c_i$ 10g	Std.Unc. ±%, 1g	Std.Unc. ±%, 10g	$V_i$ $V_{eff}$
<b>Measurement System</b>								
Probe Calibration	6.0	N	1	1	1	6.0	6.0	∞
Axial Isotropy	0.5	R	$\sqrt{3}$	0.7	0.7	0.2	0.2	∞
Hemispherical Isotropy	2.6	R	$\sqrt{3}$	0.7	0.7	1.1	1.1	∞
Boundary Effects	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
Linearity	0.6	R	$\sqrt{3}$	1	1	0.3	0.3	∞
System Detection Limits	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
Readout Electronics	0.7	N	1	1	1	0.7	0.7	∞
Response Time	0	R	$\sqrt{3}$	1	1	0	0	∞
Integration Time	2.6	R	$\sqrt{3}$	1	1	1.5	1.5	∞
RF Ambient Noise	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
RF Ambient Reflections	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
Probe Positioner	1.5	R	$\sqrt{3}$	1	1	0.9	0.9	∞
Probe Positioning	2.9	R	$\sqrt{3}$	1	1	1.7	1.7	∞
Max. SAR Eval.	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
<b>Test Sample Related</b>								
Device Positioning	2.9	N	1	1	1	2.9	2.9	145
Device Holder	3.6	N	1	1	1	3.6	3.6	5
<b>Dipole</b>								
Power Drift	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Dipole Positioning	2.0	N	1	1	1	2.0	2.0	∞
Dipole Input Power	5.0	N	1	1	1	5.0	5.0	∞
<b>Phantom and Setup</b>								
Phantom Uncertainty	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
Liquid Conductivity (target)	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
Liquid Conductivity (meas.)	2.5	N	1	0.64	0.43	1.6	1.1	∞
Liquid Permittivity (target)	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
Liquid Permittivity (meas.)	2.5	N	1	0.6	0.49	1.5	1.2	∞
<b>Combined Std Uncertainty</b>								
						±11.2 %	±10.9 %	387

<b>Expanded Std Uncertainty</b>						<b>±22.4 %</b>	<b>±21.8 %</b>	
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## 17. Main Test Instrument

**Table 17.1: List of Main Instruments**

No.	Name	Type	Serial Number	Calibration Date	Valid Period
01	Network analyzer	N5242A	MY51221755	Dec 25, 2017	1 year
				Dec. 25,2017	1 year
02	Power meter	NRVD	102257	May 11, 2017	1 year
03	Power sensor	NRV-Z5	100241		
			100644		
04	Signal Generator	E4438C	MY49072044	May 11, 2017	1 Year
05	Amplifier	NTWPA-0086010F	12023024	No Calibration Requested	
06	Coupler	778D	MY4825551	May 11, 2017	1 year
07	BTS	E5515C	MY50266468	Dec 25, 2017	1 year
08	E-field Probe	ES3DV3	3252	Aug 31, 2017	1 year
09	DAE	SPEAG DAE4	1244	Dec. 4,2017	1 year
10	Dipole Validation Kit	SPEAG D835V2	4d112	Oct 22,2015	3 year
		SPEAG D1900V2	5d018	June 28,017	1 year
		SPEAG D2450V2	858	Oct 30,2015	3 year

## ANNEX A. GRAPH RESULTS

### GSM850 Phantom 4TS Mode High 0mm

Date/Time: 2018/3/23

Electronics: DAE4 Sn1244

Medium parameters used:  $f = 849$  MHz;  $\sigma = 1.012$  S/m;  $\epsilon_r = 56.579$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature: 22 °C      Liquid Temperature: 22 °C

Communication System: GSM 835MHz GPRS 4TS (0);      Frequency: 848.8 MHz; Duty Cycle: 1:2

Probe: ES3DV3 - SN3252ConvF(6.14, 6.14, 6.14); Calibrated: 8/31/2017

#### GSM850 Phantom 4TS Mode High 0mm/Area Scan (71x141x1):

Measurement grid: dx=10 mm, dy=10 mm

Maximum value of SAR (Measurement) = 1.09 W/kg

#### GSM850 Phantom 4TS Mode High 0mm/Zoom Scan (7x7x7)/Cube 0:

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

Reference Value = 13.26 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 1.84 W/kg

SAR(1 g) = 1.02 W/kg; SAR(10 g) = 0.602 W/kg

Maximum value of SAR (measured) = 1.08 W/kg

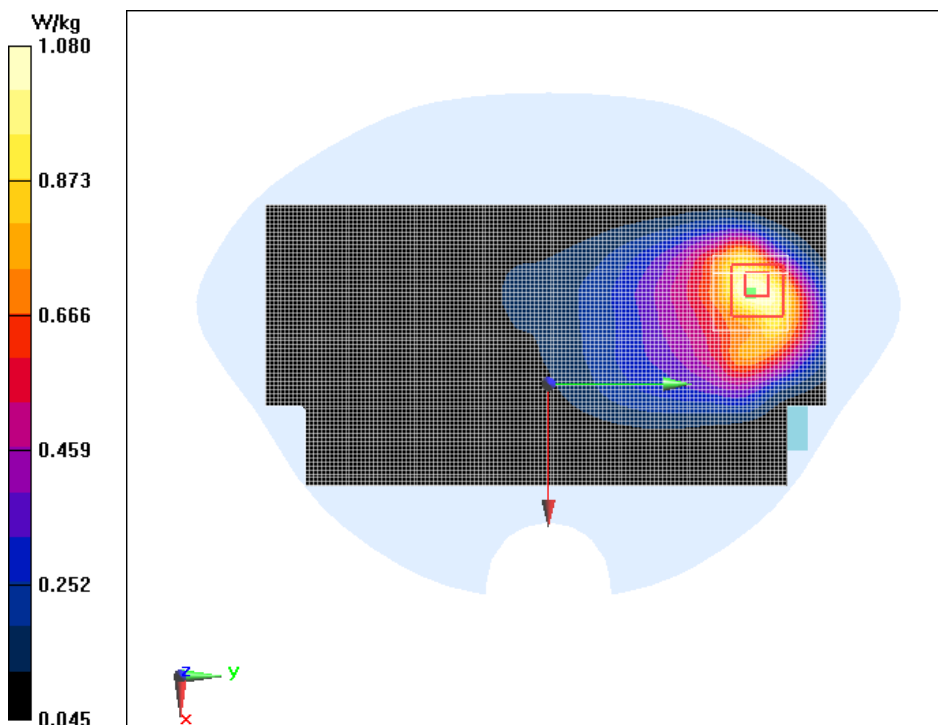


Fig.1 GSM850 Phantom 4TS Mode High 0mm

**GSM1900 Bottom 1TX High 0mm**

Date/Time: 2018/3/21

Electronics: DAE4 Sn1244

Medium parameters used:  $f = 1910 \text{ MHz}$ ;  $\sigma = 1.564 \text{ S/m}$ ;  $\epsilon_r = 54.861$ ;  $\rho = 1000 \text{ kg/m}^3$

Ambient Temperature: 22 °C      Liquid Temperature: 22 °C

Communication System: GSM Professional 1900MHz;    Frequency: 1909.8 MHz; Duty Cycle: 1:8.3

Probe: ES3DV3 - SN3252ConvF(4.69, 4.69, 4.69); Calibrated: 8/31/2017

**GSM1900 1TX High 0mm/Area Scan (71x71x1):**

Measurement grid:  $dx=10 \text{ mm}$ ,  $dy=10 \text{ mm}$

Maximum value of SAR (Measurement) = 1.31 W/kg

**GSM1900 1TX High 0mm/Zoom Scan (7x7x7)/Cube 0:**

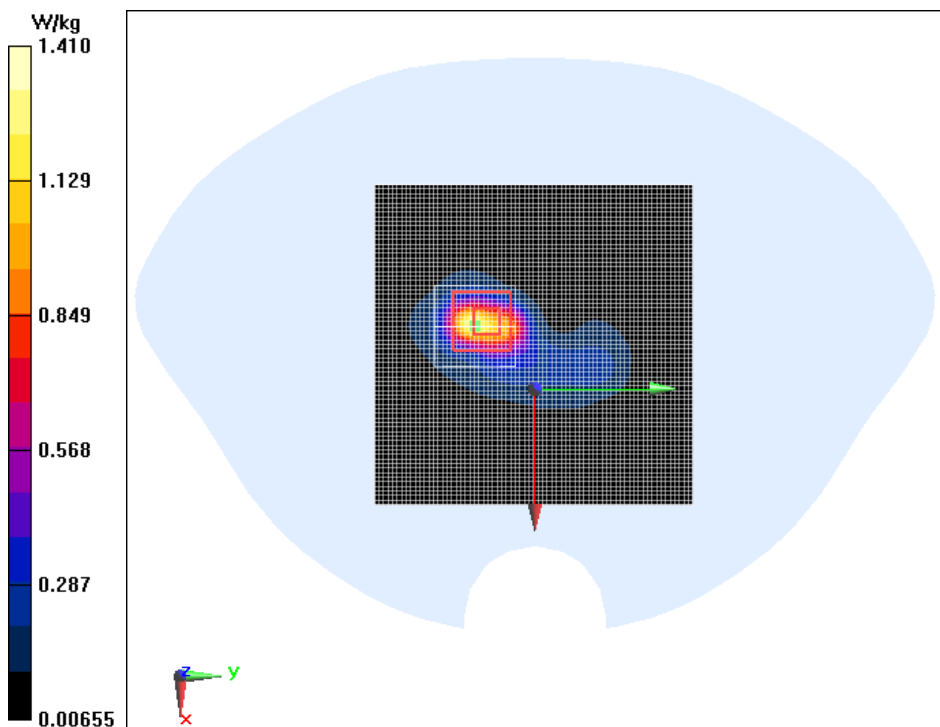
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 11.58 V/m; Power Drift = -0.17 dB

Peak SAR (extrapolated) = 2.74 W/kg

SAR(1 g) = 1.25 W/kg; SAR(10 g) = 0.544 W/kg

Maximum value of SAR (measured) = 1.41 W/kg



**Fig.2 GSM1900 Bottom 1TX High 0mm**

**WCDMA Band 2 Bottom RMC Mode Low 0mm**

Date/Time: 2018/3/21

Electronics: DAE4 Sn1244

Medium parameters used (interpolated):  $f = 1852.4$  MHz;  $\sigma = 1.505$  S/m;  $\epsilon_r = 55.034$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature: 22 °C      Liquid Temperature: 22 °C

Communication System: WCDMA Professional Band II ; Frequency: 1852.4 MHz; Duty Cycle: 1:1

Probe: ES3DV3 - SN3252ConvF(4.69, 4.69, 4.69); Calibrated: 8/31/2017

**WCDMA Band 2 Bottom RMC Mode Low 0mm/Area Scan (51x51x1):**

Measurement grid: dx=10 mm, dy=10 mm

Maximum value of SAR (Measurement) = 1.20 W/kg

**WCDMA Band 2 Bottom RMC Mode Low 0mm/Zoom Scan (7x7x7)/Cube 0:**

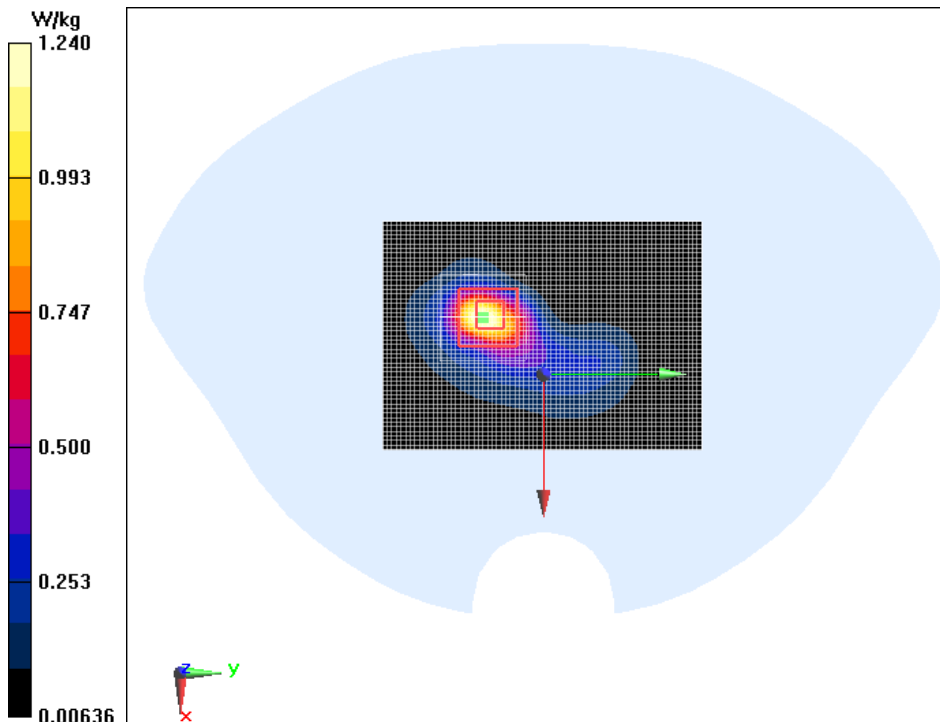
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 9.544 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 2.42 W/kg

SAR(1 g) = 1.11 W/kg; SAR(10 g) = 0.487 W/kg

Maximum value of SAR (measured) = 1.24 W/kg



**Fig.3 WCDMA Band 2 Bottom RMC Mode Low 0mm**

**WCDMA Band5 Phantom Mode Middle**

Date/Time: 2018/3/23

Electronics: DAE4 Sn1244

Medium parameters used:  $f = 837 \text{ MHz}$ ;  $\sigma = 1 \text{ S/m}$ ;  $\epsilon_r = 56.705$ ;  $\rho = 1000 \text{ kg/m}^3$

Ambient Temperature: 22 °C      Liquid Temperature: 22 °C

Communication System: WCDMA Professional 835MHz;    Frequency: 836.6 MHz; Duty Cycle: 1:1

Probe: ES3DV3 - SN3252ConvF(6.14, 6.14, 6.14); Calibrated: 8/31/2017

**WCDMA Band5 Phantom Mode Middle/Area Scan (71x141x1):**

Measurement grid:  $dx=10 \text{ mm}$ ,  $dy=10 \text{ mm}$

Maximum value of SAR (Measurement) = 0.640 W/kg

**WCDMA Band5 Phantom Mode Middle/Zoom Scan (7x7x7)/Cube 0:**

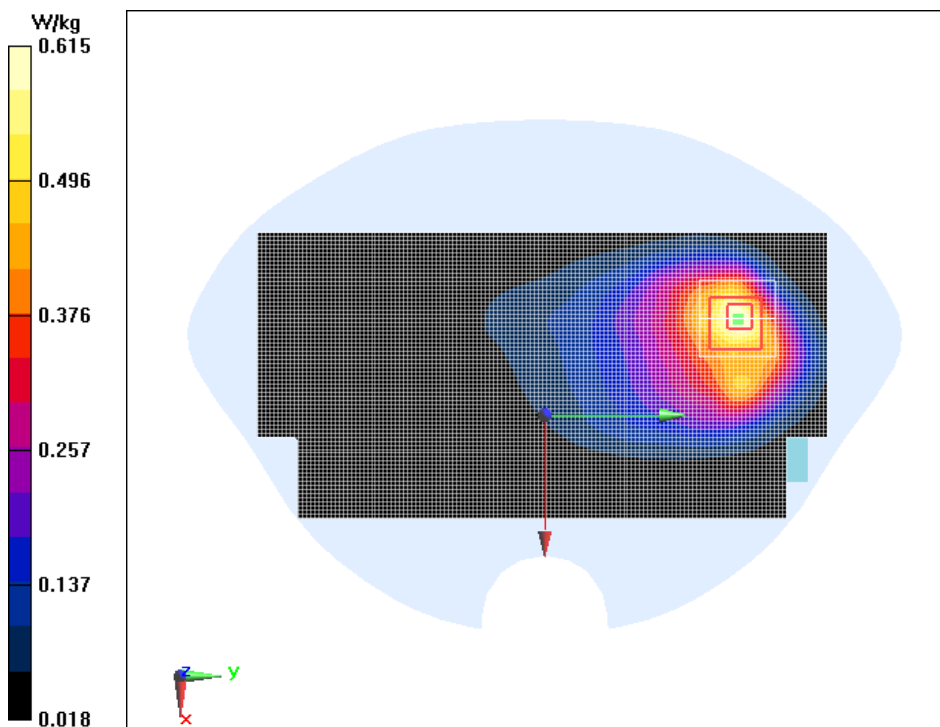
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 8.913 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 0.944 W/kg

SAR(1 g) = 0.552 W/kg; SAR(10 g) = 0.337 W/kg

Maximum value of SAR (measured) = 0.615 W/kg



**Fig.4 WCDMA Band5 Phantom Mode Middle**

**WIFI2450 Right Mode High 0mm**

Date/Time: 2018/3/25

Electronics: DAE4 Sn1244

Medium parameters used:  $f = 2462 \text{ MHz}$ ;  $\sigma = 1.99 \text{ S/m}$ ;  $\epsilon_r = 52.926$ ;  $\rho = 1000 \text{ kg/m}^3$

Ambient Temperature:  $22 \text{ }^\circ\text{C}$       Liquid Temperature:  $22 \text{ }^\circ\text{C}$

Communication System: Wifi 2450 2450MHz;    Frequency: 2462 MHz; Duty Cycle: 1:1

Probe: ES3DV3 - SN3252ConvF(4.42, 4.42, 4.42); Calibrated: 8/31/2017

**WIFI2450 Right Mode High 0mm/Area Scan (41x141x1):**

Measurement grid:  $dx=10 \text{ mm}$ ,  $dy=10 \text{ mm}$

Maximum value of SAR (Measurement) =  $0.423 \text{ W/kg}$

**WIFI2450 Right Mode High 0mm/Zoom Scan (7x7x7)/Cube 0:**

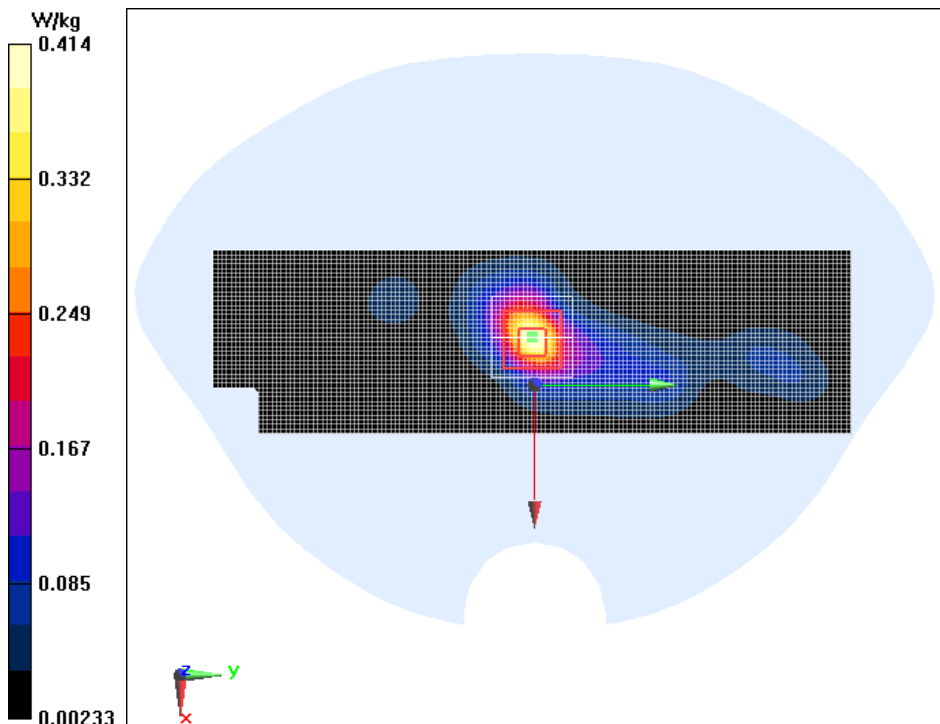
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value =  $14.63 \text{ V/m}$ ; Power Drift =  $-0.08 \text{ dB}$

Peak SAR (extrapolated) =  $0.761 \text{ W/kg}$

SAR(1 g) =  $0.361 \text{ W/kg}$ ; SAR(10 g) =  $0.166 \text{ W/kg}$

Maximum value of SAR (measured) =  $0.414 \text{ W/kg}$



**Fig.5 WIFI2450 Right Mode High 0mm**



## ANNEX B. SYSTEM VALIDATION RESULTS

### Body 835MHz

Date/Time: 2018/3/23

Electronics: DAE4 Sn1244

Medium parameters used:  $f = 835 \text{ MHz}$ ;  $\sigma = 0.998 \text{ S/m}$ ;  $\epsilon_r = 56.727$ ;  $\rho = 1000 \text{ kg/m}^3$

Ambient Temperature: 22 °C      Liquid Temperature: 22 °C

Communication System: CW 835MHz;    Frequency: 835 MHz; Duty Cycle: 1:1

Probe: ES3DV3 - SN3252ConvF(6.14, 6.14, 6.14); Calibrated: 8/31/2017

#### Body 835MHz /Area Scan (61x131x1):

Measurement grid:  $dx=10 \text{ mm}$ ,  $dy=10 \text{ mm}$

Maximum value of SAR (Measurement) = 2.56 W/kg

#### Body 835MHz /Zoom Scan (7x7x7) /Cube 0:

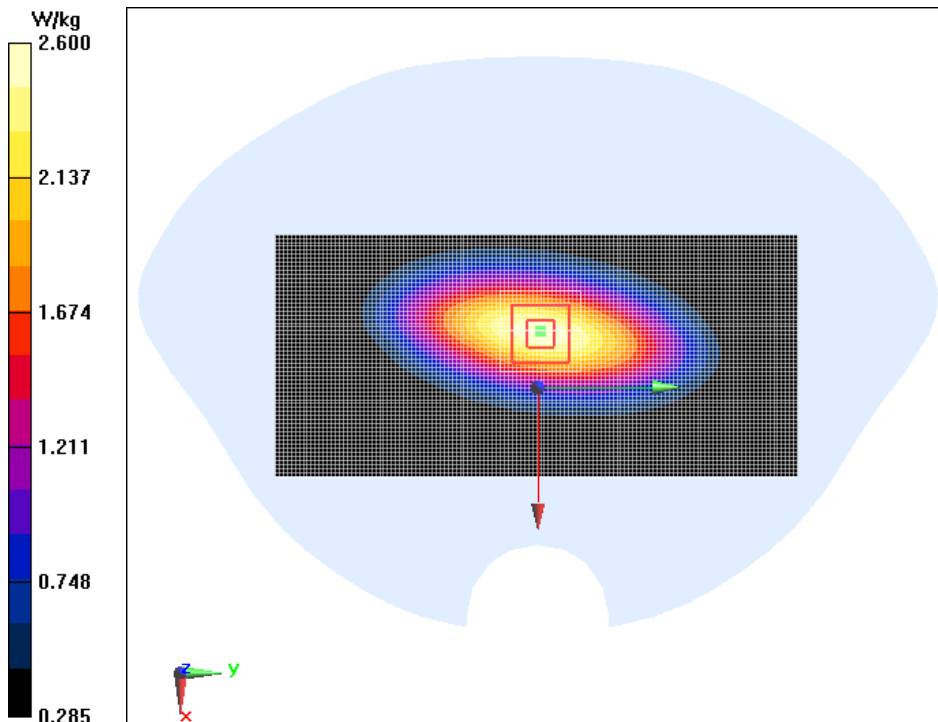
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 50.92 V/m; Power Drift = 0.10 dB

Peak SAR (extrapolated) = 3.46 W/kg

SAR(1 g) = 2.41 W/kg; SAR(10 g) = 1.62 W/kg

Maximum value of SAR (measured) = 2.60 W/kg



## Body1900MHz

Date/Time: 2018/3/21

Electronics: DAE4 Sn1244

Medium parameters used:  $f = 1900 \text{ MHz}$ ;  $\sigma = 1.554 \text{ S/m}$ ;  $\epsilon_r = 54.865$ ;  $\rho = 1000 \text{ kg/m}^3$

Ambient Temperature:  $22 \text{ }^\circ\text{C}$       Liquid Temperature:  $22 \text{ }^\circ\text{C}$

Communication System: CW 1900MHz;    Frequency: 1900 MHz; Duty Cycle: 1:1

Probe: ES3DV3 - SN3252ConvF(4.69, 4.69, 4.69); Calibrated: 8/31/2017

### Body1900MHz /Area Scan (61x61x1):

Measurement grid:  $dx=10 \text{ mm}$ ,  $dy=10 \text{ mm}$

Maximum value of SAR (Measurement) =  $12.0 \text{ W/kg}$

### Body1900MHz /Zoom Scan (7x7x7) Cube 0:

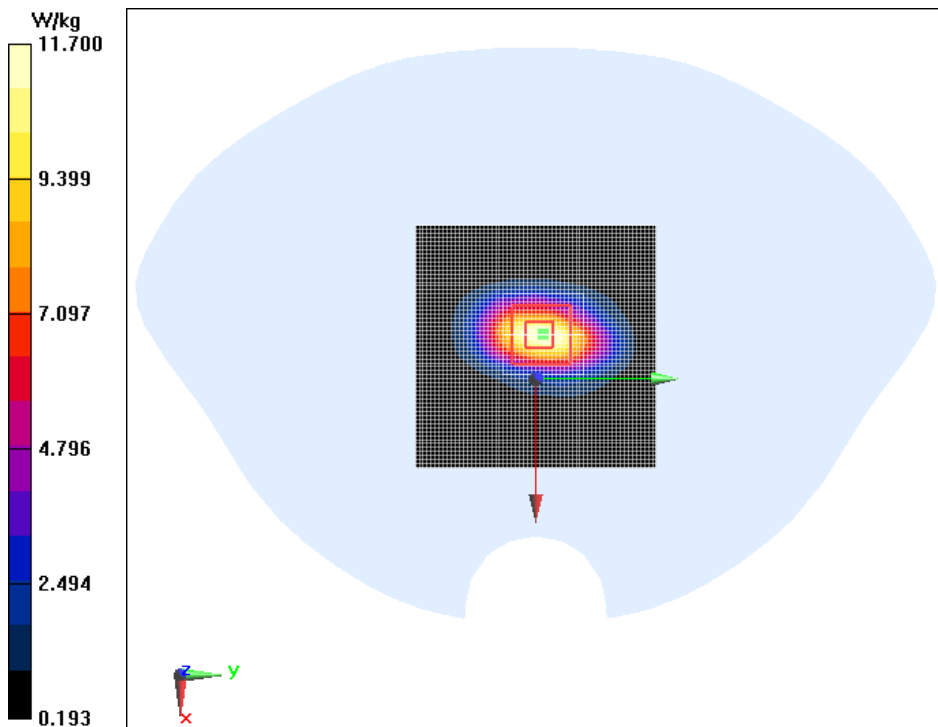
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value =  $86.57 \text{ V/m}$ ; Power Drift =  $-0.05 \text{ dB}$

Peak SAR (extrapolated) =  $19.7 \text{ W/kg}$

SAR(1 g) =  $10.4 \text{ W/kg}$ ; SAR(10 g) =  $5.29 \text{ W/kg}$

Maximum value of SAR (measured) =  $11.7 \text{ W/kg}$



**Body 2450MHz**

Date/Time: 2018/3/25

Electronics: DAE4 Sn1244

Medium parameters used:  $f = 2450 \text{ MHz}$ ;  $\sigma = 1.976 \text{ S/m}$ ;  $\epsilon_r = 52.97$ ;  $\rho = 1000 \text{ kg/m}^3$ 

Ambient Temperature: 22 °C      Liquid Temperature: 22 °C

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

Probe: ES3DV3 - SN3252ConvF(4.42, 4.42, 4.42); Calibrated: 8/31/2017

**Body 2450MHz/Area Scan (71x61x1):**Measurement grid:  $dx=10 \text{ mm}$ ,  $dy=10 \text{ mm}$ 

Maximum value of SAR (Measurement) = 15.5 W/kg

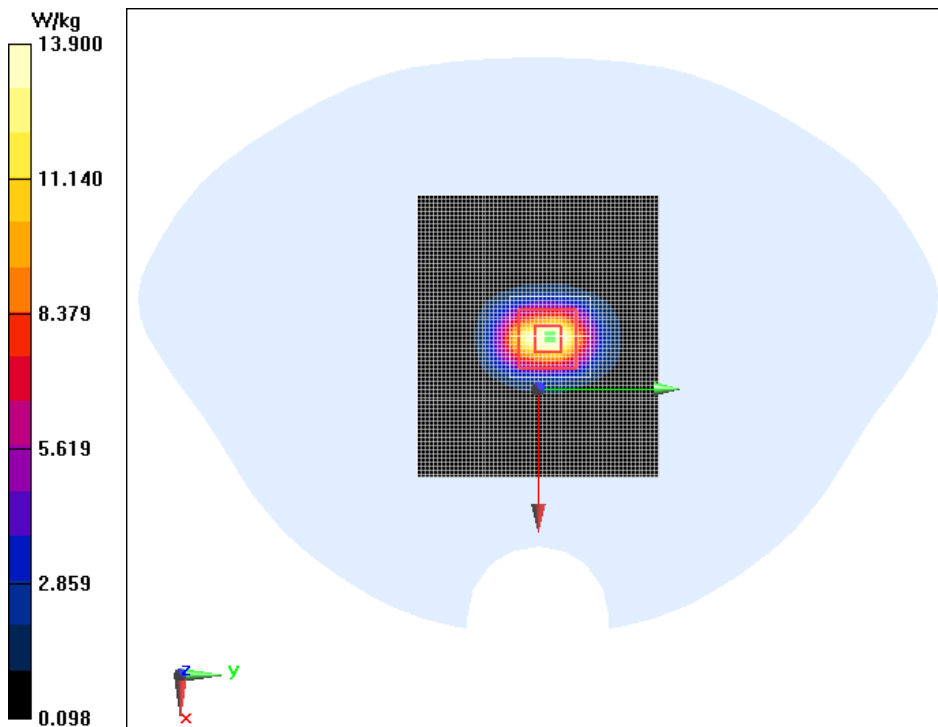
**Body 2450MHz/Zoom Scan (7x7x7) (7x7x7)/Cube 0:**Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$ 

Reference Value = 83.58 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 24.4 W/kg

SAR(1 g) = 12.6 W/kg; SAR(10 g) = 5.87 W/kg

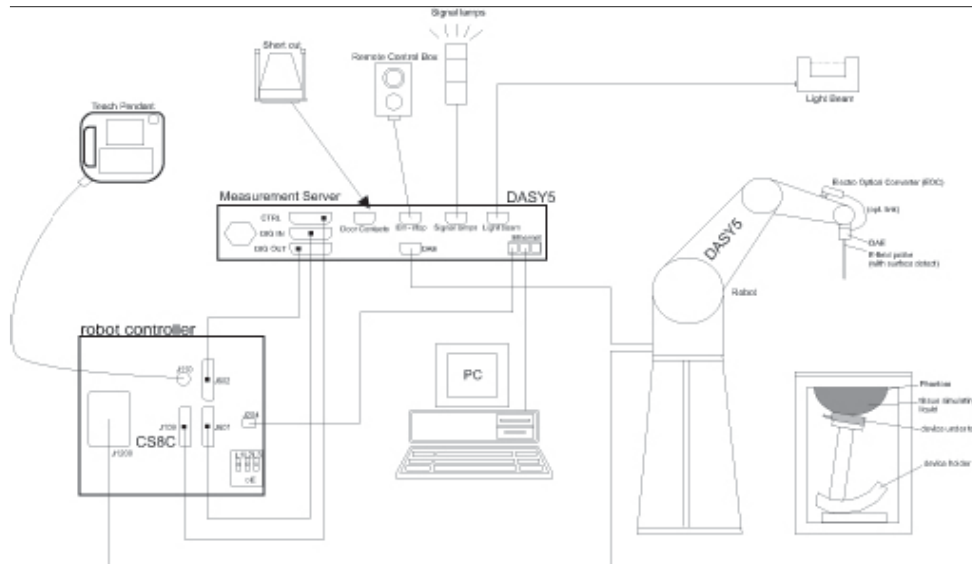
Maximum value of SAR (measured) = 13.9 W/kg



## ANNEX C. SAR Measurement Setup

### C.1. Measurement Set-up

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



**Picture C.1 SAR Lab Test Measurement Set-up**

- A standard high precision 6-axis robot (Stäubli TX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP and the DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as
- warning lamps, etc.

- The phantom, the device holder and other accessories according to the targeted measurement.

## C.2. DASY5 E-field Probe System

The SAR measurements were conducted with the dosimetric probe designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multifiber line ending at the front of the probe tip. It is connected to the EOC box 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 2<sup>nd</sup> order curve fitting. The approach is stopped at reaching the maximum.

### Probe Specifications:

**Model:** ES3DV3

**Frequency**

**Range:** 700MHz — 2.6GHz(ES3DV3)

**Calibration:** In head and body simulating tissue at  
Frequencies from 750 up to 2600 MHz

**Linearity:**

$\pm 0.2$  dB(700MHz — 4.0GHz) for ES3DV3

**Dynamic Range:** 10 mW/kg — 100W/kg

**Probe Length:** 330 mm

**Probe Tip**

**Length:** 20 mm

**Body Diameter:** 12 mm

**Tip Diameter:** 3.9 mm for ES3DV3

**Tip-Center:** 2.0mm for ES3DV3

**Application:**SAR Dosimetry Testing

Compliance tests of mobile phones

Dosimetry in strong gradient fields



Picture C.2 Near-field Probe



Picture C.3 E-field Probe

### **C.3. E-field Probe Calibration**

Each E-Probe/Probe Amplifier combination has unique calibration parameters. A TEM cell calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the probe to a known E-field density (1 mW/cm<sup>2</sup>) using an RF Signal generator, TEM cell, and RF Power Meter.

The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and in a waveguide or other methodologies above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees until the three channels show the maximum reading. The power density readings equate to 1 mW/ cm<sup>2</sup>.

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The E-field in the medium correlates with the temperature rise in the dielectric medium. For temperature correlation calibration a RF transparent thermistor-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 (kg/m<sup>3</sup>).

### **C.4. Other Test Equipment**

#### **C.4.1. Data Acquisition Electronics(DAE)**

The data acquisition electronics consist 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 with a 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 mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection.

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



**PictureC.4: DAE**



### C.4.2. Robot

The SPEAG DASY system uses the high precision robots (DASY5: RX90L) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability 0.02mm)
- High reliability (industrial design)
- Low maintenance costs (virtually maintenance free due to direct drive gears; no belt drives)
- Jerk-free straight movements (brushless synchron motors; no stepper motors)
- Low ELF interference (motor control fields shielded via the closed metallic construction shields)



**Picture C.5 DASY 5**

### C.4.3. Measurement Server

The Measurement server is based on a PC/104 CPU board with CPU (DASY5: 400 MHz, Intel Celeron), chipdisk (DASY5: 128MB), RAM (DASY5: 128MB). 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 real-time data evaluation of field measurements and surface detection, controls robot movements and handles safety operation. The PC operating system cannot interfere with these time critical processes. All connections are supervised by a watchdog, and disconnection of any of the cables to the measurement server will automatically disarm the robot and disable all program-controlled robot movements. Furthermore, the measurement server is equipped with an expansion port which is reserved for future applications. Please note that this expansion port does not have a standardized pinout, and therefore only devices provided by SPEAG can be connected. Devices from any other supplier could seriously damage the measurement server.



**Picture C.6 Server for DASY 5**

#### **C.4.4. Device Holder for 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 5mm distance, a positioning uncertainty of  $\pm 0.5\text{mm}$  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 the different positions given in the standard. It has two scales for device rotation (with respect to the body axis) and device inclination (with respect to the line between the ear reference points). The rotation centers for both scales is the ear reference point (ERP). 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.

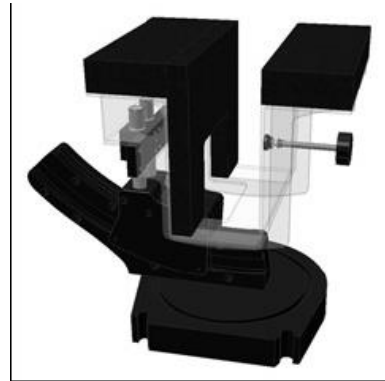
<Laptop Extension Kit>

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 positioner. The extension is fully compatible with

the Twin-SAM and ELI phantoms.



**Picture C.7: Device Holder**



**Picture C.8: Laptop Extension Kit**

### C.4.5. Phantom

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a table. The shape of the shell is based on data from an anatomical study designed to represent the 90<sup>th</sup> percentile of the population. The phantom enables the dissymmetric evaluation of SAR for both left and right handed handset usage, as well as body-worn usage using the flat phantom region. 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. The shell phantom has a 2mm shell thickness (except the ear region where shell thickness increases to 6 mm).

Shell Thickness:  $2 \pm 0.2$  mm

Filling Volume: Approx. 25 liters

Dimensions: 810 x 1000 x 500 mm (H x L x W)

Available: Special



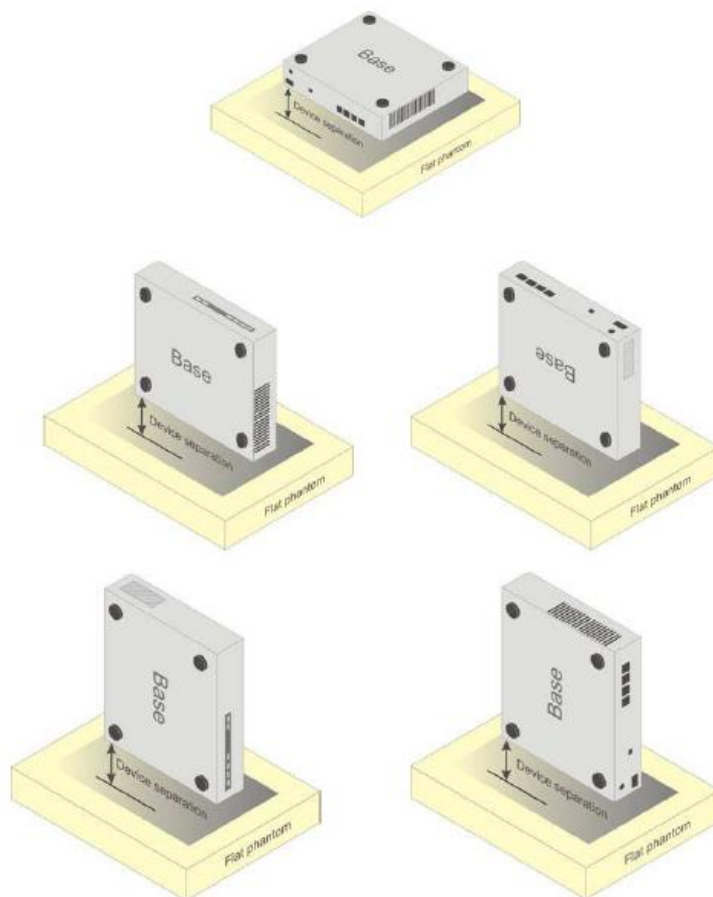
**Picture C.9: SAM Twin Phantom**

## ANNEX D. Position of the wireless device in relation to the phantom

### D.1. Desktop device

A typical example of a desktop device is a wireless enabled desktop computer placed on a table or desk when used.

The DUT shall be positioned at the distance and in the orientation to the phantom that corresponds to the intended use as specified by the manufacturer in the user instructions. For devices that employ an external antenna with variable positions, tests shall be performed for all antenna positions specified. Picture 8.5 show positions for desktop device SAR tests. If the intended use is not specified, the device shall be tested directly against the flat phantom.



**Picture D.5 Test positions for desktop devices**

**D.4. DUT Setup Photos****Picture D.6 DSY5 system Set-up****Note:**

The photos of test sample and test positions show in additional document.

## ANNEX E. Equivalent Media Recipes

The liquid used for the frequency range of 800-3000 MHz consisted of water, sugar, salt, preventol, glycol monobutyl and Cellulose. The liquid has been previously proven to be suited for worst-case. The Table E.1 shows the detail solution. It's satisfying the latest tissue dielectric parameters requirements proposed by the IEEE 1528 and IEC 62209.

**Table E.1: Composition of the Tissue Equivalent Matter**

Frequency (MHz)	835 Head	835 Body	1900 Head	1900 Body	2450 Head	2450 Body
Ingredients (% by weight)						
Water	41.45	52.5	55.242	69.91	58.79	72.60
Sugar	56.0	45.0	\	\	\	\
Salt	1.45	1.4	0.306	0.13	0.06	0.18
Preventol	0.1	0.1	\	\	\	\
Cellulose	1.0	1.0	\	\	\	\
Glycol Monobutyl	\	\	44.452	29.96	41.15	27.22
Dielectric Parameters Target Value	$\epsilon=41.5$ $\sigma=0.90$	$\epsilon=55.2$ $\sigma=0.97$	$\epsilon=40.0$ $\sigma=1.40$	$\epsilon=53.3$ $\sigma=1.52$	$\epsilon=39.2$ $\sigma=1.80$	$\epsilon=52.7$ $\sigma=1.95$

## ANNEX F. System Validation

The SAR system must be validated against its performance specifications before it is deployed.

When SAR probes, system components or software are changed, upgraded or recalibrated, these must be validated with the SAR system(s) that operates with such components.

**Table F.1: System Validation Part 1**

System No.	Probe SN.	Liquid name	Validation date	Frequency point	Permittivity $\epsilon$	Conductivity $\sigma$ (S/m)
1	3252	Body 835MHz	2018/3/23	835MHz	56.727	0.998
2	3252	Body 1900MHz	2018/3/21	1900MHz	54.865	1.554
3	3252	Body 2450MHz	2018/3/25	2450MHz	52.97	1.976

**Table F.2: System Validation Part 2**

CW Validation	Sensitivity	PASS	PASS
	Probe linearity	PASS	PASS
	Probe Isotropy	PASS	PASS
Mod Validation	MOD.type	GMSK	GMSK
	MOD.type	OFDM	OFDM
	Duty factor	PASS	PASS
	PAR	PASS	PASS



ANNEX G. Probe and DAE Calibration Certificate



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E-mail: cttl@chinattl.com Http://www.chinattl.cn

Client : **ECIT** Certificate No: **Z17-97266**

**CALIBRATION CERTIFICATE**

Object: **DAE4 - SN: 1244**

Calibration Procedure(s): **FF-Z11-002-01  
Calibration Procedure for the Data Acquisition Electronics (DAEx)**

Calibration date: **December 04, 2017**

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)℃ and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Process Calibrator 753	1971018	27-Jun-17 (CTTL, No.J17X05859)	June-18

	Name	Function	Signature
Calibrated by:	Yu Zongying	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: December 05, 2017

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

Certificate No: Z17-97266 Page 1 of 3



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### Glossary:

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

### Methods Applied and Interpretation of Parameters:

- *DC Voltage Measurement*: Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The report provide only calibration results for DAE, it does not contain other performance test results.



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### DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1μV, full range = -100...+300 mV

Low Range: 1LSB = 61nV, full range = -1.....+3mV

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

Calibration Factors	X	Y	Z
High Range	403.862 ± 0.15% (k=2)	403.603 ± 0.15% (k=2)	404.516 ± 0.15% (k=2)
Low Range	3.95366 ± 0.7% (k=2)	3.96972 ± 0.7% (k=2)	3.97929 ± 0.7% (k=2)

### Connector Angle

Connector Angle to be used in DASY system	22.5° ± 1 °
-------------------------------------------	-------------



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 Client **ECIT**

 Certificate No: **Z17-97112**

## CALIBRATION CERTIFICATE

Object: **ES3DV3 - SN:3252**

Calibration Procedure(s): **FF-Z11-004-01**  
 Calibration Procedures for Dosimetric E-field Probes

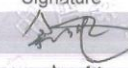


Calibration date: **August 31, 2017**

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(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	101919	27-Jun-17 (CTTL, No.J17X05857)	Jun-18
Power sensor NRP-Z91	101547	27-Jun-17 (CTTL, No.J17X05857)	Jun-18
Power sensor NRP-Z91	101548	27-Jun-17 (CTTL, No.J17X05857)	Jun-18
Reference10dBAttenuator	18N50W-10dB	13-Mar-16(CTTL,No.J16X01547)	Mar-18
Reference20dBAttenuator	18N50W-20dB	13-Mar-16(CTTL, No.J16X01548)	Mar-18
Reference Probe EX3DV4	SN 7433	26-Sep-16(SPEAG,No.EX3-7433_Sep16)	Sep-17
DAE4	SN 549	13-Dec-16(SPEAG, No.DAE4-549_Dec16)	Dec -17
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
SignalGeneratorMG3700A	6201052605	27-Jun-17 (CTTL, No.J17X05858)	Jun-18
Network Analyzer E5071C	MY46110673	13-Jan-17 (CTTL, No.J17X00285)	Jan -18

	Name	Function	Signature
Calibrated by:	Yu Zongying	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: September 01, 2017

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## Glossary:

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

Connector Angle information used in DASY system to align probe sensor X to the robot coordinate system

## Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\theta=0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not effect the  $E^2$ -field uncertainty inside TSL (see below ConvF).
- NORM(f)<sub>x,y,z</sub> = NORM<sub>x,y,z</sub> \* frequency\_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP<sub>x,y,z</sub>**: DCP are numerical linearization parameters assessed based on the data of power sweep (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>; VR<sub>x,y,z</sub>**: A,B,C 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 valued 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).



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## Glossary:

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

Connector Angle information used in DASY system to align probe sensor X to the robot coordinate system

## Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\theta=0$  ( $f \leq 900\text{MHz}$  in TEM-cell;  $f > 1800\text{MHz}$ : waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not effect the  $E^2$ -field uncertainty inside TSL (see below ConvF).
- NORM(f)<sub>x,y,z</sub> = NORM<sub>x,y,z</sub> \* frequency\_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP<sub>x,y,z</sub>**: DCP are numerical linearization parameters assessed based on the data of power sweep (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>; VR<sub>x,y,z</sub>**: A,B,C 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  $f \leq 800\text{MHz}$ ) and inside waveguide using analytical field distributions based on power measurements for  $f > 800\text{MHz}$ . The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty valued 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  $\pm 50\text{MHz}$  to  $\pm 100\text{MHz}$ .
- 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).



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## DASY/EASY – Parameters of Probe: ES3DV3 - SN: 3252

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	1.32	1.40	1.37	$\pm 10.0\%$
DCP(mV) <sup>B</sup>	101.5	101.9	101.5	

### 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	278.4	$\pm 2.5\%$
		Y	0.0	0.0	1.0		287.4	
		Z	0.0	0.0	1.0		284.8	

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

<sup>A</sup> The uncertainties of Norm X, Y, Z do not affect the  $E^2$ -field uncertainty inside TSL (see Page 5 and Page 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: ES3DV3 - SN: 3252

### Calibration Parameter Determined in Head Tissue Simulating Media

f [MHz] <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unct. (k=2)
750	41.9	0.89	6.25	6.25	6.25	0.50	1.25	±12.1%
835	41.5	0.90	6.19	6.19	6.19	0.32	1.66	±12.1%
900	41.5	0.97	6.16	6.16	6.16	0.36	1.62	±12.1%
1750	40.1	1.37	5.30	5.30	5.30	0.42	1.62	±12.1%
1900	40.0	1.40	5.11	5.11	5.11	0.73	1.18	±12.1%
2000	40.0	1.40	4.97	4.97	4.97	0.76	1.19	±12.1%
2300	39.5	1.67	4.90	4.90	4.90	0.90	1.10	±12.1%
2450	39.2	1.80	4.75	4.75	4.75	0.90	1.10	±12.1%
2600	39.0	1.96	4.44	4.44	4.44	0.90	1.15	±12.1%

<sup>C</sup> Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of 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 frequency 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 the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.





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## DASY/EASY – Parameters of Probe: ES3DV3 - SN: 3252

### Calibration Parameter Determined in Body Tissue Simulating Media

f [MHz] <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unct. (k=2)
750	55.5	0.96	6.34	6.34	6.34	0.60	1.20	±12.1%
850	55.2	0.99	6.14	6.14	6.14	0.38	1.63	±12.1%
900	55.0	1.05	6.06	6.06	6.06	0.46	1.49	±12.1%
1750	53.4	1.49	4.95	4.95	4.95	0.49	1.52	±12.1%
1900	53.3	1.52	4.69	4.69	4.69	0.67	1.33	±12.1%
2000	53.3	1.52	4.89	4.89	4.89	0.69	1.25	±12.1%
2300	52.9	1.81	4.58	4.58	4.58	0.57	1.65	±12.1%
2450	52.7	1.95	4.42	4.42	4.42	0.68	1.42	±12.1%
2600	52.5	2.16	4.22	4.22	4.22	0.56	1.66	±12.1%

<sup>C</sup> Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of 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.

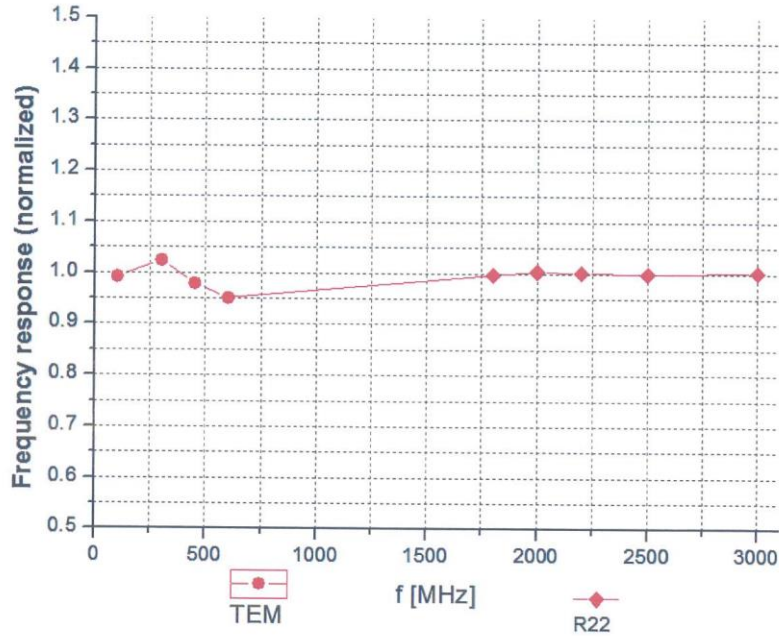
<sup>F</sup> At frequency below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ±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 the 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)



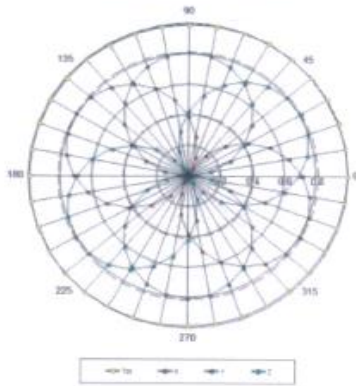
Uncertainty of Frequency Response of E-field:  $\pm 7.4\%$  (k=2)



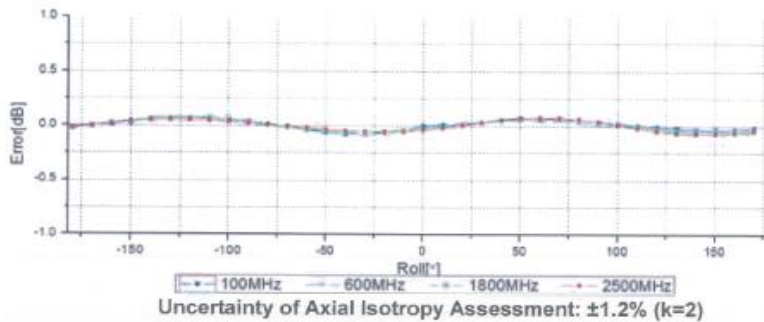
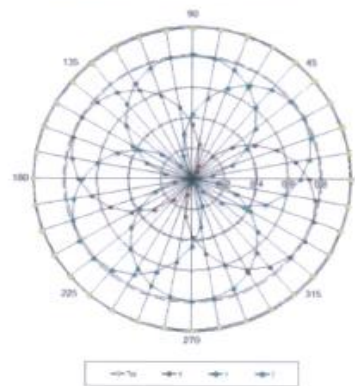
Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China  
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## Receiving Pattern ( $\Phi$ ), $\theta=0^\circ$

f=600 MHz, TEM



f=1800 MHz, R22



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Input Signal [ $\mu$ V]

Error (dB)

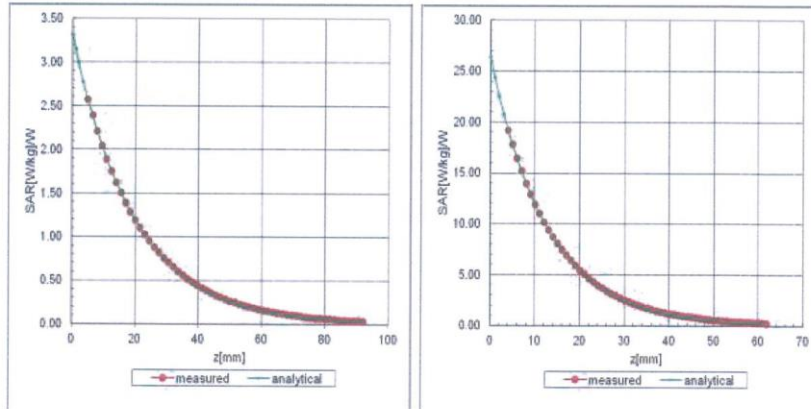


Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China  
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E-mail: cttl@chinattl.com [Http://www.chinattl.cn](http://www.chinattl.cn)

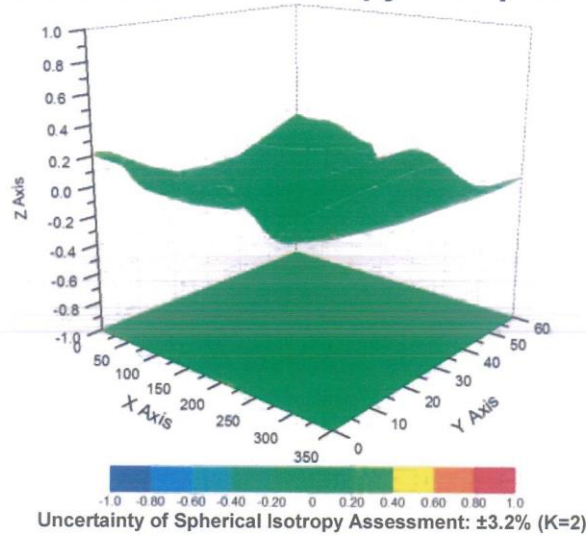
## Conversion Factor Assessment

f=835 MHz, WGLS R9(H\_convF)

f=1750 MHz, WGLS R22(H\_convF)



## Deviation from Isotropy in Liquid





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## DASY/EASY – Parameters of Probe: ES3DV3 - SN: 3252

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	130.2
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disable
Probe Overall Length	337mm
Probe Body Diameter	10mm
Tip Length	10mm
Tip Diameter	4mm
Probe Tip to Sensor X Calibration Point	2mm
Probe Tip to Sensor Y Calibration Point	2mm
Probe Tip to Sensor Z Calibration Point	2mm
Recommended Measurement Distance from Surface	3mm



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Client **ECIT** Certificate No: **Z15-97165**

## CALIBRATION CERTIFICATE

Object **D835V2 - SN: 4d112**

Calibration Procedure(s) **FD-Z11-2-003-01  
 Calibration Procedures for dipole validation kits**



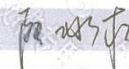
Calibration date: **October 22, 2015**

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(S). 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(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	101919	01-Jul-15 (CTTL, No.J15X04256)	Jun-16
Power sensor NRP-Z91	101547	01-Jul-15 (CTTL, No.J15X04256)	Jun-16
Reference Probe EX3DV4	SN 3617	26-Aug-15(SPEAG,No.EX3-3617_Aug15)	Aug -16
DAE4	SN 777	26-Aug-15(SPEAG,No.DAE4-777_Aug15)	Aug -16
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Signal Generator E4438C	MY49071430	02-Feb-15 (CTTL, No.J15X00729)	Feb-16
Network Analyzer E5071C	MY46110673	03-Feb-15 (CTTL, No.J15X00728)	Feb-16

	Name	Function	Signature
Calibrated by:	Zhao Jing	SAR Test Engineer	
Reviewed by:	Qi Dianyuan	SAR Project Leader	
Approved by:	Lu Bingsong	Deputy Director of the laboratory	

Issued: October 26, 2015

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



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**Glossary:**

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM <sub>x,y,z</sub>
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 300MHz to 3GHz)", February 2005
- KDB865664, 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%.



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### Measurement Conditions

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

DASY Version	DASY52	52.8.8.1222
Extrapolation	Advanced Extrapolation	
Phantom	Triple Flat Phantom 5.1C	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	835 MHz $\pm$ 1 MHz	

### Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.5	0.90 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	42.2 $\pm$ 6 %	0.91 mho/m $\pm$ 6 %
Head TSL temperature change during test	<1.0 °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	2.31 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>9.22 mW / g <math>\pm</math> 20.8 % (k=2)</b>
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	1.51 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	<b>6.03 mW / g <math>\pm</math> 20.4 % (k=2)</b>

### Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.2	0.97 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	55.1 $\pm$ 6 %	0.96 mho/m $\pm$ 6 %
Body TSL temperature change during test	<1.0 °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	2.37 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	<b>9.57 mW / g <math>\pm</math> 20.8 % (k=2)</b>
SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	Condition	
SAR measured	250 mW input power	1.56 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	<b>6.29 mW / g <math>\pm</math> 20.4 % (k=2)</b>





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## Appendix

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.1Ω- 4.20jΩ
Return Loss	- 27.3dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.2Ω- 4.79jΩ
Return Loss	- 23.9dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.502 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
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**DASY5 Validation Report for Head TSL**

Date: 10.22.2015

Test Laboratory: CTTL, Beijing, China

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d112**

Communication System: UID 0, CW; Frequency: 835 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 835 \text{ MHz}$ ;  $\sigma = 0.907 \text{ S/m}$ ;  $\epsilon_r = 42.15$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Center Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV4 - SN3617; ConvF(9.56, 9.56, 9.56); Calibrated: 8/26/2015;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn777; Calibrated: 8/26/2015
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/1
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

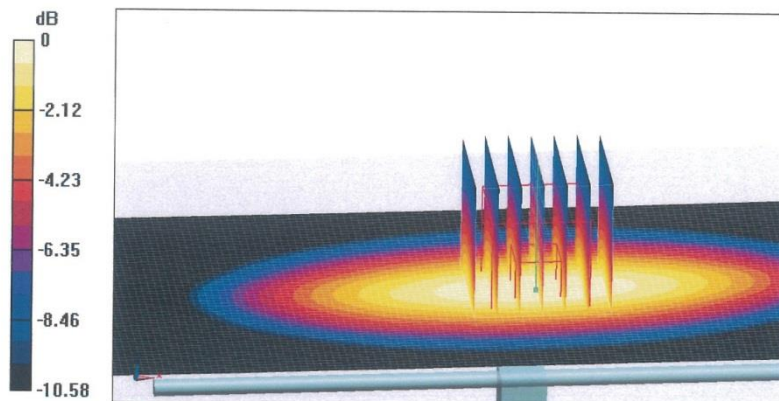
**Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 58.15 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 3.46 W/kg

**SAR(1 g) = 2.31 W/kg; SAR(10 g) = 1.51 W/kg**

Maximum value of SAR (measured) = 2.93 W/kg



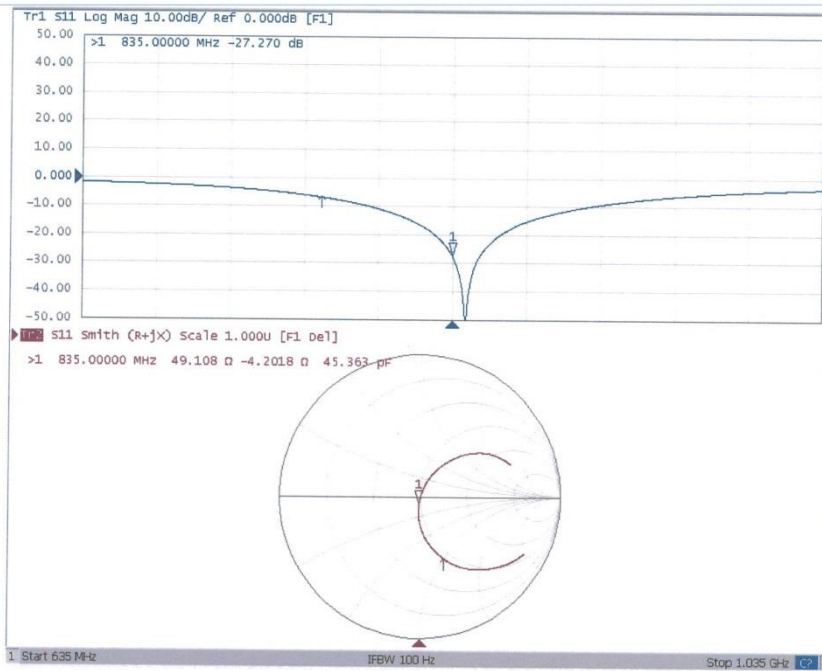
0 dB = 2.93 W/kg = 4.67 dBW/kg



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## Impedance Measurement Plot for Head TSL





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**DASY5 Validation Report for Body TSL**

Date: 10.22.2015

Test Laboratory: CTTL, Beijing, China

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d112**

Communication System: UID 0, CW; Frequency: 835 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 835 \text{ MHz}$ ;  $\sigma = 0.958 \text{ S/m}$ ;  $\epsilon_r = 55.11$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Right Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV4 - SN3617; ConvF(9.71, 9.71, 9.71); Calibrated: 8/26/2015;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn777; Calibrated: 8/26/2015
- Phantom: Triple Flat Phantom 5.1C; Type: QD 000 P51 CA; Serial: 1161/1
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

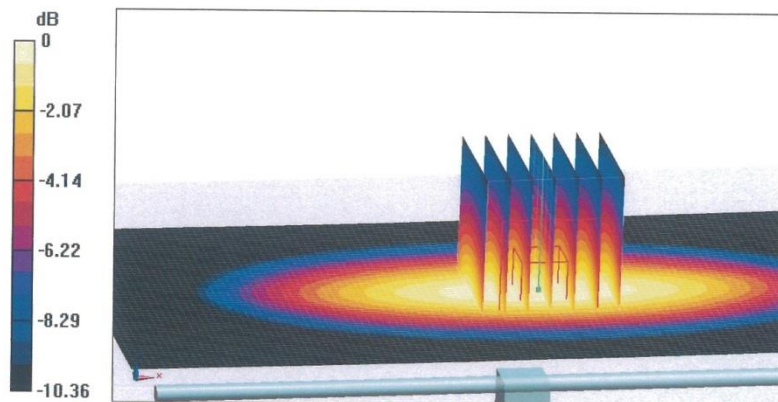
**Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 56.68 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 3.51 W/kg

**SAR(1 g) = 2.37 W/kg; SAR(10 g) = 1.56 W/kg**

Maximum value of SAR (measured) = 2.99 W/kg

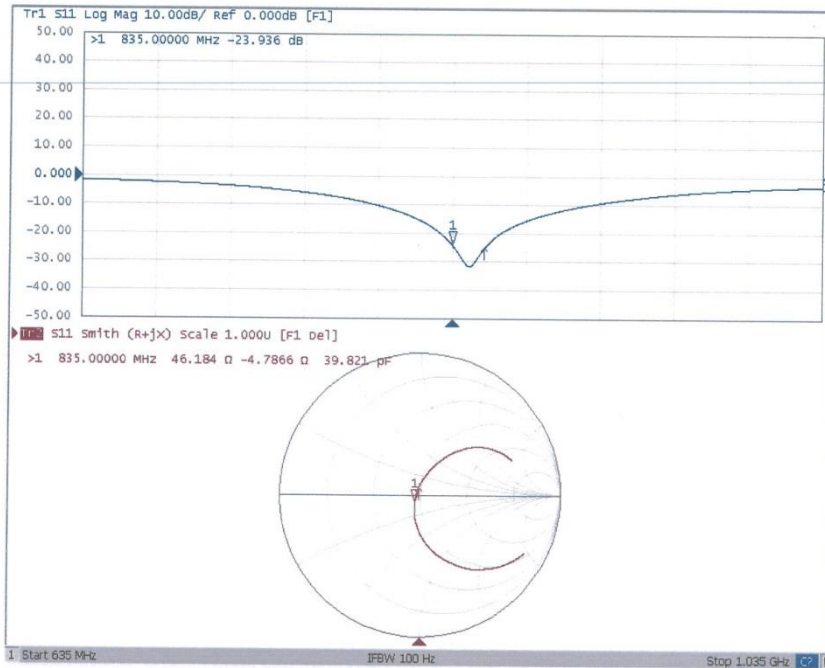




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## Impedance Measurement Plot for Body TSL



**D835V2,Serial No.4d112 Extended Dipole Calibrations**

Per IEEE Std 1528-2013,the dipole should have a return loss better than -20dB at the test frequency to reduce uncertainty in the power measurement.

Per KDB 865664 D01,if dipoles are verified in return loss(<-20dB,within 20% of prior calibration),and in impedance (within 5 ohm of prior calibration),the annual calibration is not necessary and the calibration interval can be extended.

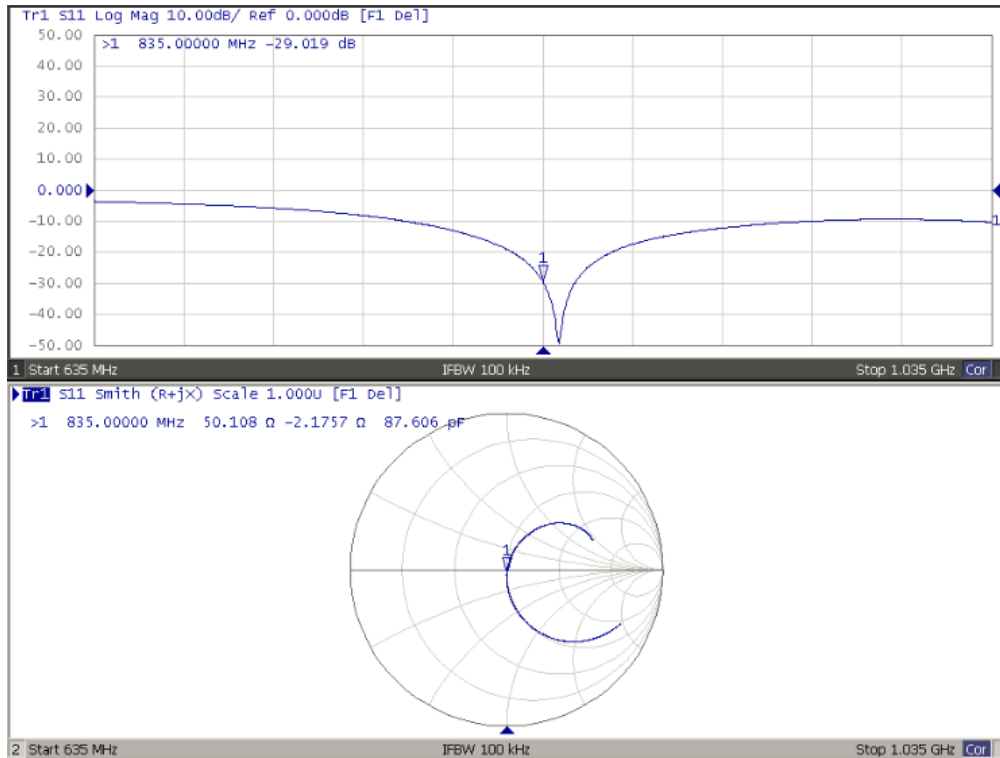
**Justification of the extended calibration**

D835V2 Serial No.4d112						
835 Head						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
10.22.2015	-27.27	--	49.108	--	-4.2018	--
10.21.2016	-29.019	6.41	50.108	1	-2.1757	2.0261

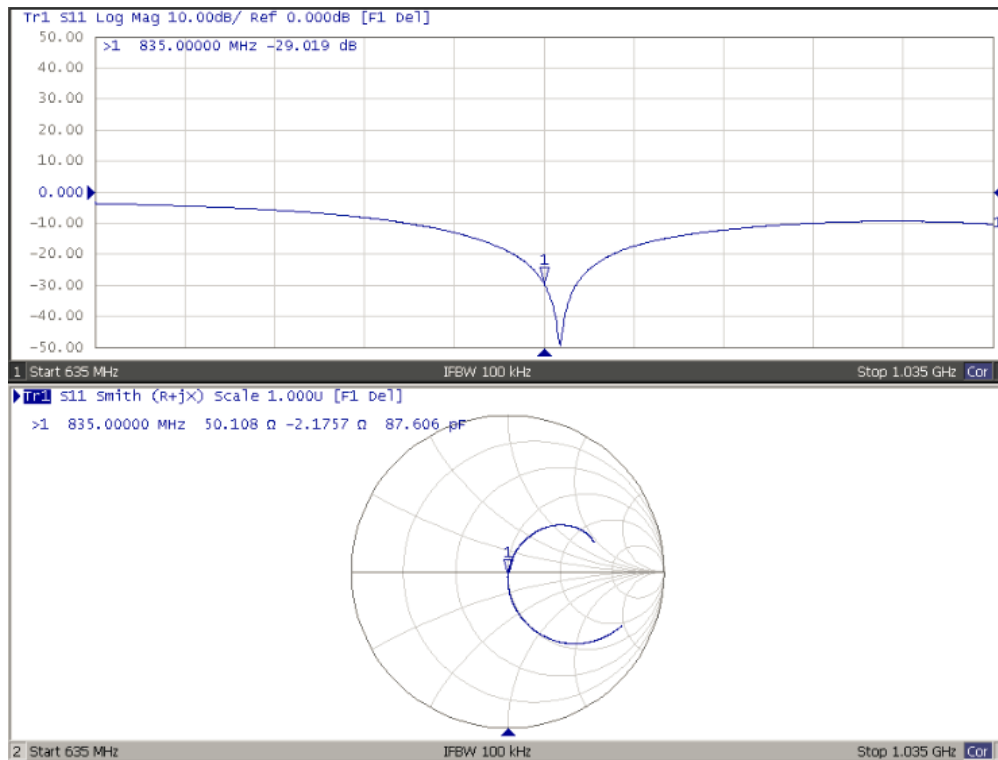
D835V2 Serial No.4d112						
835 Body						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
10.22.2015	-23.036	--	46.184	--	-4.7866	--
10.21.2016	-23.131	0.56	47.003	0.819	-2.9072	1.8794

The return loss is < -20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

## Dipole Verification Data D835V2 Serial No.4d112 835MHz - Head



## 835MHz - Body



## Justification of the extended calibration

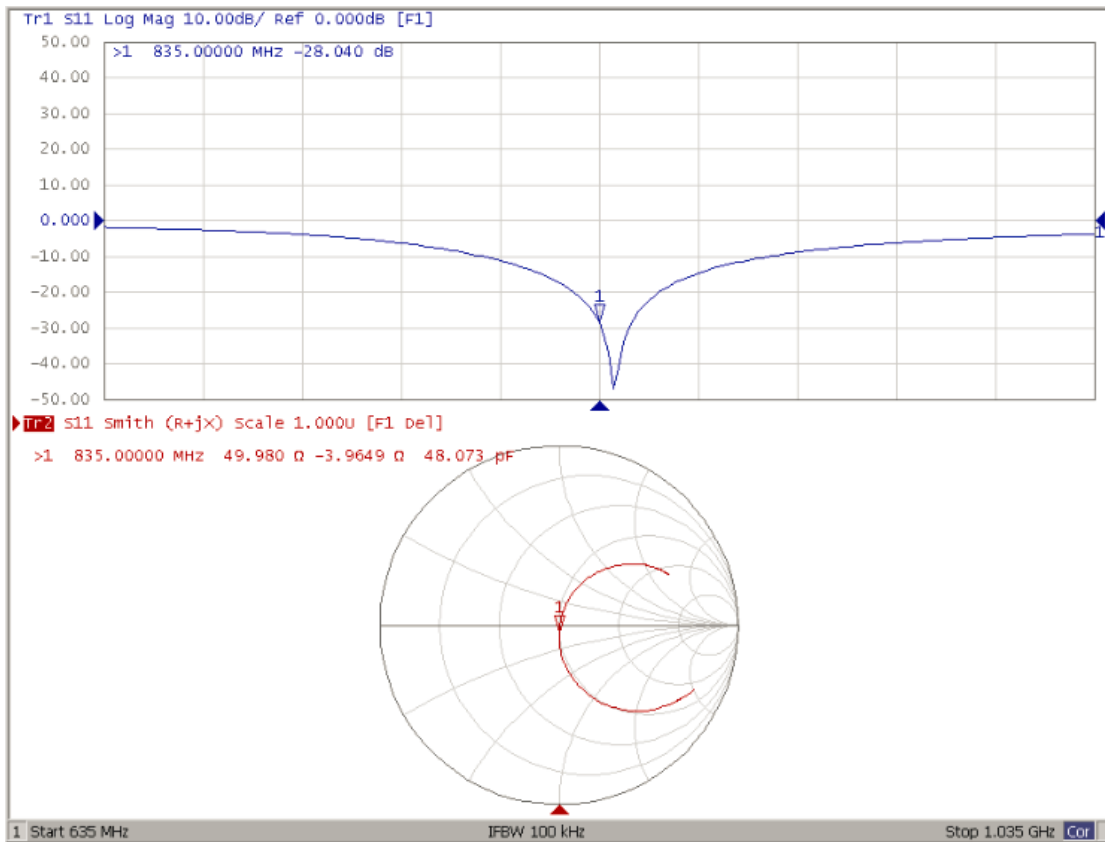
D835V2 Serial No.4d112						
835 Head						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
10.22.2015	-27.27	--	49.108	--	-4.2018	--
10.21.2016	-29.019	6.41	50.108	1	-2.1757	2.0261
10.20.2017	-28.040	3.37	49.98	0.128	-3.965	1.789

D835V2 Serial No.4d112						
835 Body						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
10.22.2015	-23.036	--	46.184	--	-4.7866	--
10.21.2016	-23.131	0.56	47.003	0.819	-2.9072	1.8794
10.20.2017	-24.962	7.92	47.613	0.61	-4.977	2.07

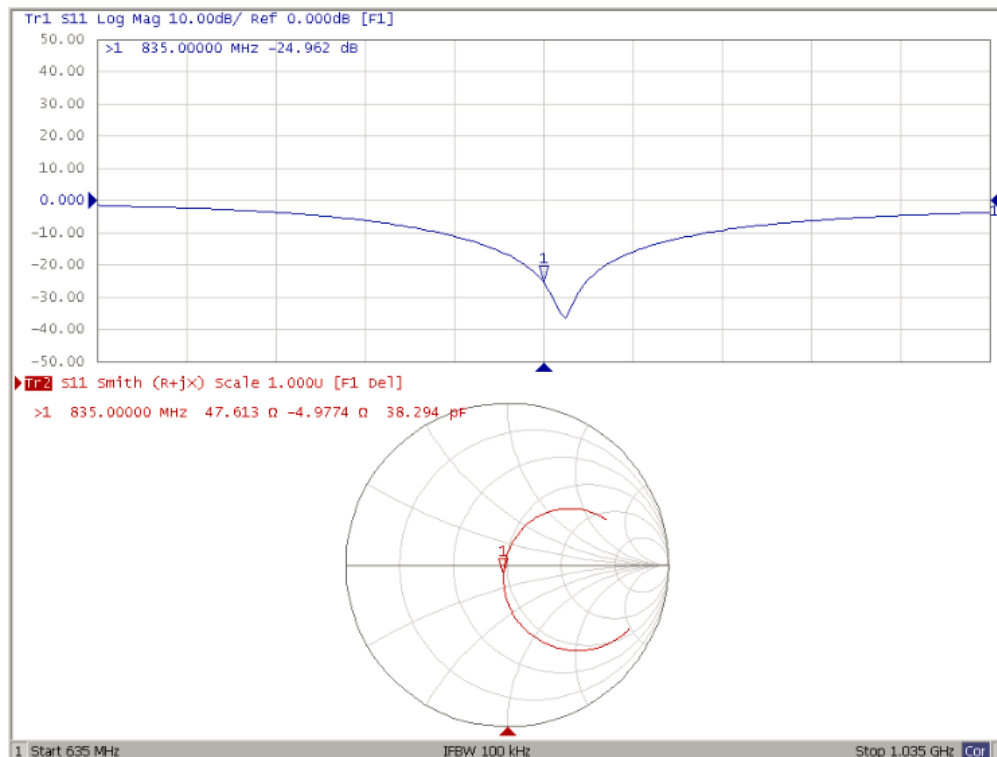
The return loss is < -20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.



## Dipole Verification Data D835V2 Serial No.4d112 835MHz-Head



## 835MHz - Body



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



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Client **Auden**

Certificate No: **D1900V2-5d018\_Jun17**

## CALIBRATION CERTIFICATE

Object **D1900V2 - SN:5d018**  
 Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**  
 Calibration date: **June 28, 2017**

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 NRP	SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	31-May-17 (No. EX3-7349_May17)	May-18
DAE4	SN: 601	28-Mar-17 (No. DAE4-601_Mar17)	Mar-18
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

	Name	Function	Signature
Calibrated by:	Johannes Kurikka	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: June 29, 2017

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