



# TEST REPORT

No. I17D00023-SAR01

*For*

**Client: LENOVO (SHANGHAI) ELECTRONICS  
TECHNOLOGY CO LTD**

**Brand name: Lenovo**

**Production: Portable Tablet Computer**

**Model Name: Lenovo TB-8504F**

**Standard: ANSI C95.1-1999**

**FCC 47 CFR Part 2 ( 2.1093)**

**RSS 102 issue 5**

**FCC ID: O57TB8504F**

**IC: 10407A-TB8504F**

**Hardware Version: Lenovo Tablet TB-8504F**

**Software Version: TB-8504F\_RF01\_170208**

**Issued date: 2017-4-27**

**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**

Report Number	Revision	Date	Memo
I17D00023-SAR01	00	2017-4-27	Initial creation of test report

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## 1. Test Laboratory

### 1.1. Testing Location

Company Name:	ECIT Shanghai, East China Institute of Telecommunications
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Postal Code:	200001
Telephone:	(+86)-021-63843300
Fax:	(+86)-021-63843301
IC OAT S Test Site Registration Number	10766A-1

### 1.2. Testing Environment

Normal Temperature:	18-25°C
Relative Humidity:	30-70%
Ambient noise & Reflection:	< 0.012 W/kg

### 1.3. Project Data

Project Leader:	Xu Yuting
Testing Start Date:	2017-03-26
Testing End Date:	2017-03-28

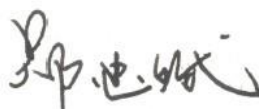
### 1.4. Signature



Yan Hang  
(Prepared this test report)



Song Kaihua  
(Reviewed this test report)



Zheng Zhongbin  
Director of the laboratory  
(Approved this test report)

## 2. Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for **Lenovo TB-8504F** are as follows ( with expanded uncertainty 22.4%)

**Table 2.1: Main Supply 3+32G Max. SAR Measured(1g)**

Band	Position	SAR 1g (W/Kg)
WIFI 2450	Head	0.315
WIFI 2450	Body(0mm)	0.982

**Table 2.2: Secondary Supply 3+32G Max. SAR Measured(1g)**

Band	Position	SAR 1g (W/Kg)
WIFI 2450	Body(0mm)	0.926

**Table 2.3: Main Supply 2+16G Max. SAR Measured(1g)**

Band	Position	SAR 1g (W/Kg)
WIFI 2450	Body(0mm)	0.892

**Table 2.4: Secondary Supply 2+16G Max. SAR Measured(1g)**

Band	Position	SAR 1g (W/Kg)
WIFI 2450	Body(0mm)	0.678

**Table 2.3: The maximum of SAR values**

Band	Maximum SAR value for Head	Maximum SAR value for Hotspot
WIFI	0.315	0.982

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 and RSS 102 issue 5 . For body worn operation, this device has been tested and meets FCC RF exposure guidelines when used with any accessory that contains no metal. Use of other accessories may not ensure compliance with FCC RF exposure guidelines.

### 3. Client Information

#### 3.1. Applicant Information

Company Name: Lenovo(Shanghai) Electronics Technology Co., Ltd.  
Address: NO.68 BUILDING, 199 FENJU RD, China (Shanghai) Pilot Free Trade Zone,  
200131, CHINA  
Email: 18116117205  
Contact: JiaZhenzhen

#### 3.2. Manufacturer Information

Company Name: Lenovo PC HK Limited  
Address: 23/F, Lincoln House, Taikoo Place 979 King's Road, Quarry Bay, Hong Kong  
Email: 18116117205  
Contact: JiaZhenzhen



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

### 4.1. About EUT

Description:	Portable Tablet Computer
Model name:	Lenovo TB-8504F
Operation Model(s):	WIFI2450
Tx Frequency:	2412- 2462 MHz (Wi-Fi) 2400-2483.5 MHz (BT)
Test device Production information:	Production unit
Device type:	Portable device
Antenna type:	Inner antenna
Accessories/Body-worn configurations:	N/A
Hotspot Mode:	Support simultaneous transmission of hotspot and voice ( or data)
Dimensions:	21cm × 12.5 cm x 0.9 cm
FCC ID:	O57TB8504F
IC:	10407A-TB8504F

### Main Supply 3+32G (Sample1)

Part Name	Model Name	supplier	Remark
LCD+TP	8" WXGA On-cell +0.7mm sodalime cover glass,White	AUO	White
	8" WXGA On-cell +0.7mm sodalime cover glass,Black	AUO	Black
Flash	KMRX1000BM-B614	SAMSUNG	
Speaker	QS171219AW00	KEYSOUND	
Front Camera	PC0KE0039A	Sunrise	
Back Camera	CCM F5695AV 5M OV5695 COB 30PIN BtoB	Qtech	
Battery	L16D1P34	Suwnoda	
USB Cable	DL1_MICRO5_1M2A_B LK_HL1	Saibao	
Charger	C-P56	Acbel	US
	C-P60	Huntkey	Argentina

### Main Supply 2+16G (Sample3)

Part Name	Model Name	supplier	Remark
LCD+TP	8" WXGA On-cell +0.7mm sodalime cover glass,White	AUO	White
	8" WXGA On-cell +0.7mm sodalime cover glass,Black	AUO	Black
Flash	KMQE10013M-B318	Samsung	
Speaker	QS171219AW00	KEYSOUND	
Front Camera	PC0KE0039A	Sunrise	
Back Camera	CCM F5695AV 5M OV5695 COB 30PIN BtoB	Qtech	
Battery	L16D1P34	Suwnoda	
USB Cable	DL1_MICRO5_1M2A_B LK_HL1	Saibao	
Charger	C-P56	Acbel	US
	C-P60	Huntkey	Argentina

**Secondary Supply 3+32G (Sample2)**

Part Name	Model Name	supplier	Remark
LCD+TP	8" WXGA In-cell +0.7mm sodalime cover glass,White	INX	White
	8" WXGA In-cell +0.7mm sodalime cover glass,Black	INX	Black
Flash	H9TQ26ADFTBCUR-KUM	Hynix	
Speaker	QS171219AW00	KEYSOUND	
Front Camera	H7P2-P3588FHQ	Kingcome	
Back Camera	CCM F5V08B 5M OV5695 COB 30PIN BtoB	Sunny	
Battery	L16D1P34	SCUD	
USB Cable	DL1_MICRO5_0.7M_BLK_ HL1	Jieye	
Charger	C-P56	Huntkey	US

**Secondary Supply2+16G (Sample4)**

Part Name	Model Name	supplier	Remark
LCD+TP	8" WXGA In-cell +0.7mm sodalime cover glass,White	INX	White
	8" WXGA In-cell +0.7mm sodalime cover glass,Black	INX	Black
Flash	H9TQ17ABJTBCUR-KUM	Hynix	
Speaker	QS171219AW00	KEYSOUND	
Front Camera	H7P2-P3588FHQ	Kingcome	
Back Camera	CCM F5V08B 5M OV5695 COB 30PIN BtoB	Sunny	
Battery	L16D1P34	SCUD	
USB Cable	DL1_MICRO5_0.7M_BLK_ _HL1	Jieye	
Charger	C-P56	Huntkey	US

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

EUT ID*	SN or IMEI	HW Version	SW Version:
N19(Sample1)	HGAD85GY(11)	Lenovo Tablet TB-8504F	TB-8504F_RF01_170208
N32(Sample2)	HGAD85NP(11)	Lenovo Tablet TB-8504F	TB-8504F_RF01_170208
N47(Sample3)	HGAD85C5(10)	Lenovo Tablet TB-8504F	TB-8504F_RF01_170208
N51(Sample4)	HGAD66EX(10)	Lenovo Tablet TB-8504F	TB-8504F_RF01_170208

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

Sample1 is Main Supply 3+32G

Sample2 is Secondary Supply 3+32G

Sample3 is Main Supply 2+16G

Sample4 is Secondary Supply 2+16G

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

AE ID*	Description	Model	SN	Manufacturer
N/A	N/A	N/A	N/A	N/A

\*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.

**FCC 47 CFR Part 2 ( 2.1093):** Radiofrequency radiation exposure evaluation: portable devices.  
**RSS-102 issue 5: 2015:** Radio Frequency (RF) Exposure Compliance of Radio communication Apparatus (All Frequency Bands)

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.

**KDB648474 D04 Handset SAR v01r03:**SAR Evaluation Considerations for Wireless Handsets.

**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 D04 v01r02:** SAR for laptop and tablets

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

**KDB941225 D06 hotspot SAR v02r01:**SAR Evaluation Procedures for Portable Devices with Wireless Router Capabilities.

NOTE: KDB and FCC 47 CFR Part 2 ( 2.1093) 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
2450	Head	1.80	1.71~1.89	39.2	37.2~41.2
2450	Body	1.95	1.85~2.05	52.7	50.1~55.3

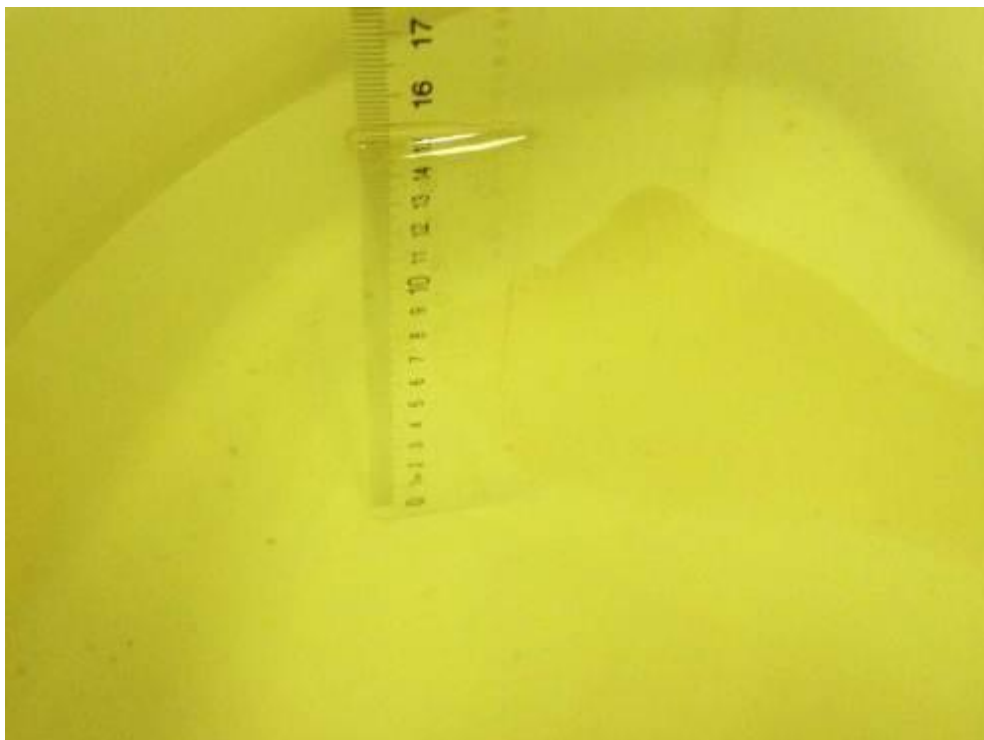
### 7.2. Dielectric Performance

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

Measurement Value						
Liquid Temperature: 22.5 °C						
Type	Frequency	Permittivity $\epsilon$	Drift (%)	Conductivity $\sigma$	Drift (%)	Test Date
Head	2450 MHz	40.607	3.59%	1.811	0.61%	2017-03-28
Body	2450 MHz	53.646	1.80%	1.908	-2.15%	2017-03-26



**Picture 7-5: Liquid depth in the Flat Phantom (2450 MHz Head)**



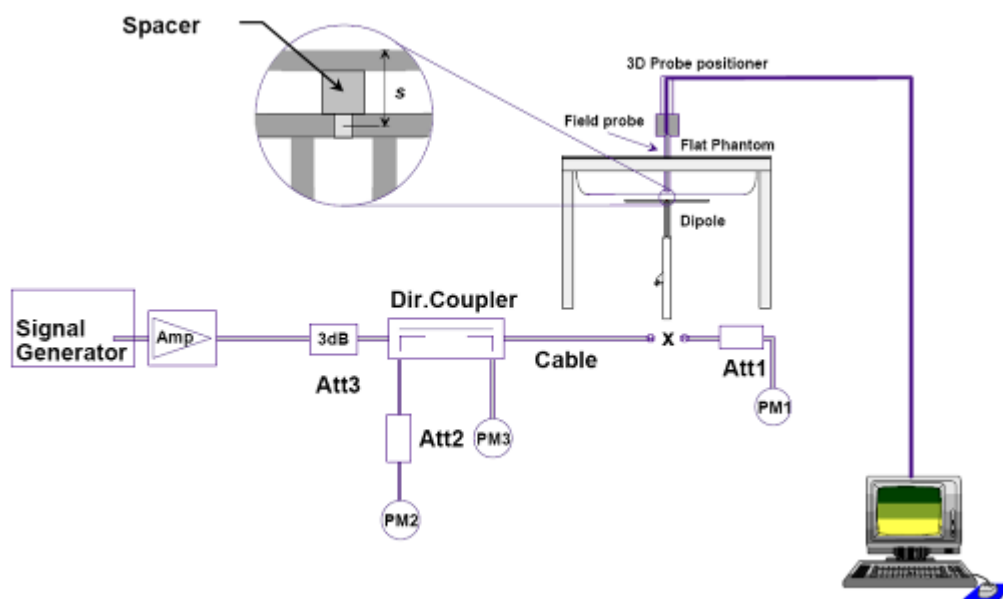
**Picture 7-6: Liquid depth in the Flat Phantom (2450 MHz Body)**



## 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 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 Head**

<b>Verification Results</b>							
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	
2450 MHz	24.3	52.9	25.08	53.2	3.21%	0.57%	2017-03-28

**Table 8.2: 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	
2450 MHz	24.7	53.1	23.64	51.6	-4.29%	-2.82%	2017-03-26

## 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.

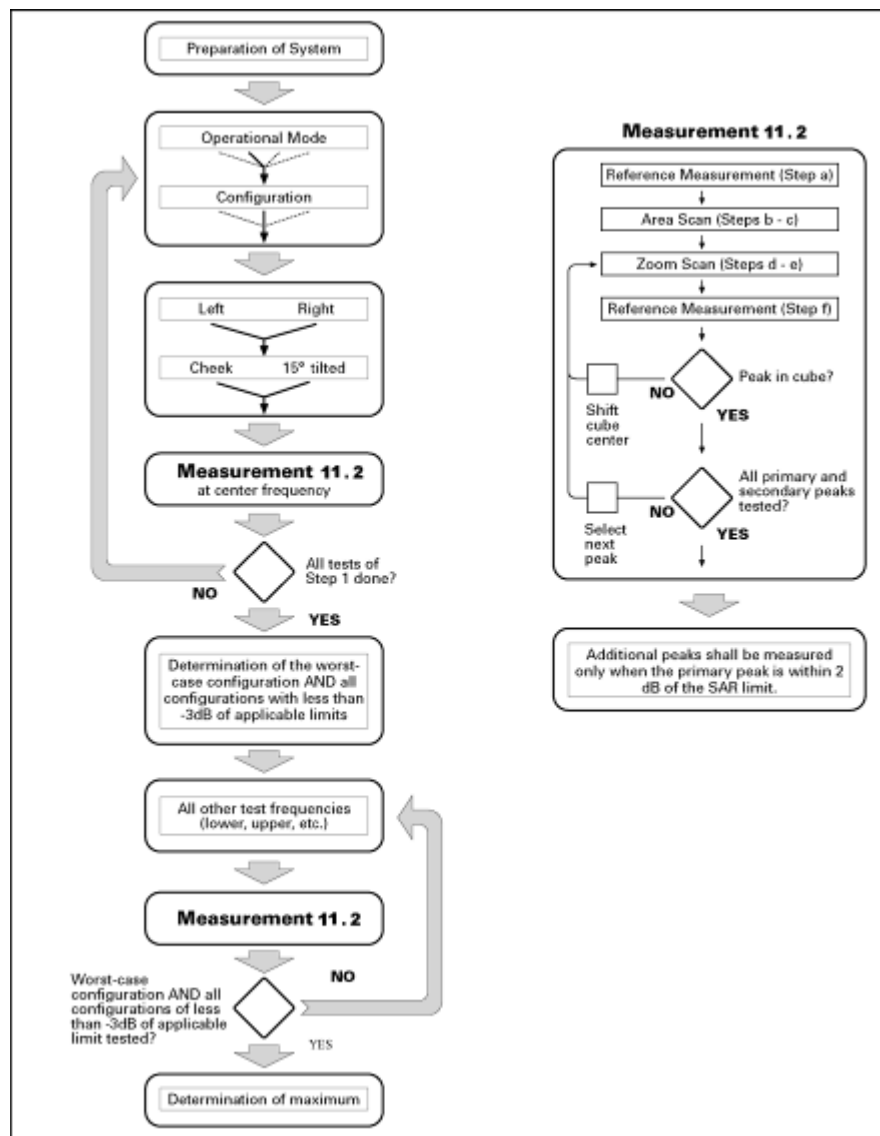
**Step 1:** The tests described in 11.2 shall be performed at the channel that is closest to the centre of the transmit frequency band ( $f_c$ ) for:

- 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 peak 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 grid 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 further 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 if 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. 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.

### **9.4. 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 14 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 11.10: WiFi**

802.11b			
Channel	Channel 1	Channel 6	Channel 11
Maximum Target Value (dBm)	16.5	16.5	16.5
802.11g			
Channel	Channel 1	Channel 6	Channel 11
Maximum Target Value (dBm)	14.5	14.5	14.5
802.11n			
Channel	Channel 1	Channel 6	Channel 11
Maximum Target Value (dBm)	16	16	16

**Table 11.11: Bluetooth**

Bluetooth 2.1			
Channel	Channel 0	Channel 39	Channel 78
Maximum Target Value (dBm)	3.5	3.5	3.5

**11.2. Wi-Fi and BT Measurement result**

**Table 11.18: The conducted power for Bluetooth**

<b>GFSK</b>			
Channel	Ch0 (2402 MHz)	Ch39 (2441MHz)	CH78 (2480MHz)
Conducted Output Power (dBm)	3.12	3.16	3.04
<b><math>\pi/4</math> DQPSK</b>			
Channel	Ch0 (2402 MHz)	Ch39 (2441MHz)	CH78 (2480MHz)
Conducted Output Power (dBm)	3.20	3.21	3.19
<b>8DPSK</b>			
Channel	Ch0 (2402 MHz)	Ch39 (2441MHz)	CH78 (2480MHz)
Conducted Output Power (dBm)	3.24	3.3	3.14

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

According to RSS 102 issue5 section 2.5.1 Exemption Limits for Routine Evaluation – SAR Evaluation, BT standalone SAR are not required, because maximum average output power is less than 4mW.

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of $\leq 5$ mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
$\leq 300$	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

**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 100%.

**Table 11.19: The average conducted power for WiFi**

Mode	Channel	Frequency	Average power(dBm)
802.11 b	1	2412 MHZ	16.12
	6	2437 MHZ	16.31
	11	2462 MHZ	16.43
802.11 g	1	2412 MHZ	13.81
	6	2437 MHZ	14.06
	11	2462 MHZ	14.11
802.11 n 20M	1	2412 MHZ	15
	6	2437 MHZ	15.96
	11	2462 MHZ	15.01

**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.

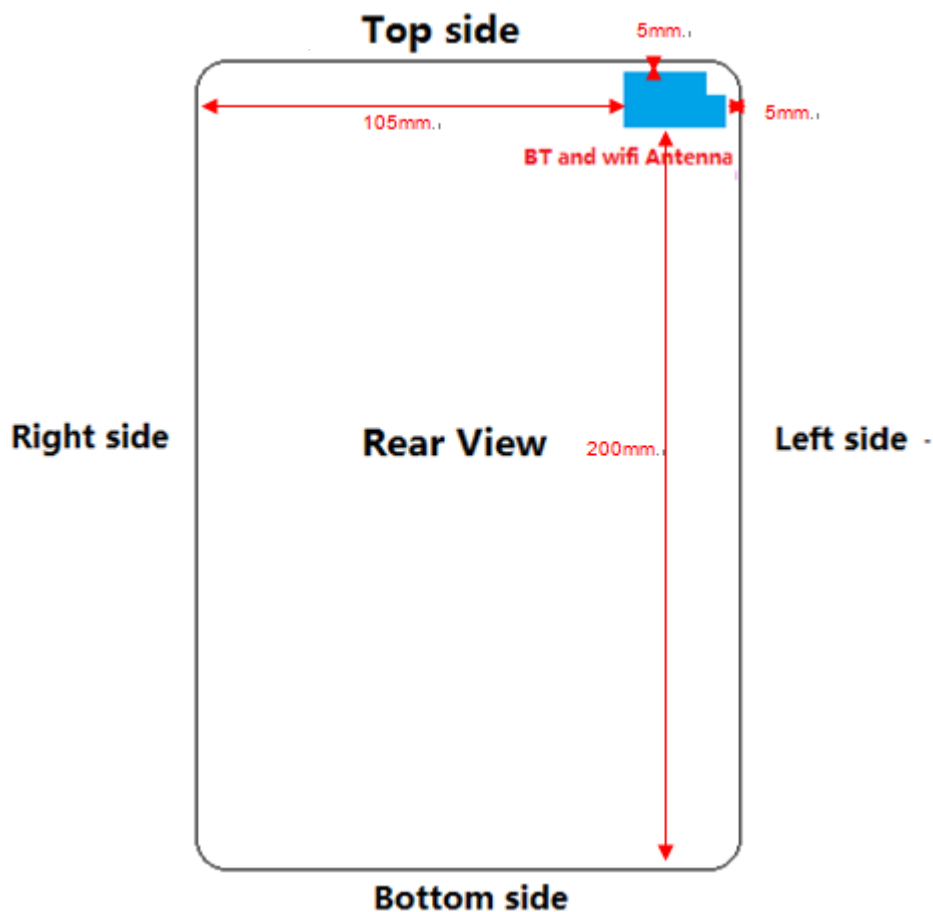
## 12. Simultaneous TX SAR Considerations

### 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 simultaneously with other transmitters.

### 12.2. Transmit Antenna Separation Distances



Picture 12.1 Antenna Locations

**12.3. Standalone SAR Test Exclusion Considerations**

According to KDB447498 D01 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:

$$\frac{[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] \leq 3.0 \text{ for 1-g SAR, where}$$

- 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=0.996 < 3.0

Based on the above equation, WiFi SAR was required:

Evaluation=14.07 > 3.0

According to RSS 102 issue5 section 2.5.1 Exemption Limits for Routine Evaluation – SAR Evaluation, BT standalone SAR are not required, because maximum average output power is less than 4mW. Wifi standalone SAR is required, because maximum average output power is than 4mW.

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

## 12.4. SAR Measurement Positions

The following SAR test exclusion Thresholds based on KDB 447498 D01 General RF Exposure Guidance v06 4.3.1

Exposure Position	Wireless Interface	WLAN
		802.11 b
	Maximum power	16.5
	Maximum rated power(mW)	44.67
Rear view	Antenna to user (mm)	5
	SAR exclusion threshold	19.17
	SAR testing required?	<b>Yes</b>
Top	Antenna to user (mm)	5
	SAR exclusion threshold	19.17
	SAR testing required?	<b>Yes</b>
Left	Antenna to user (mm)	5
	SAR exclusion threshold	19.17
	SAR testing required?	<b>Yes</b>
Bottom	Antenna to user (mm)	200
	SAR exclusion threshold	1596
	SAR testing required?	<b>No</b>
Right	Antenna to user (mm)	105
	SAR exclusion threshold	646
	SAR testing required?	<b>No</b>

### Note:

- Maximum power is the source-based time-average power and represents the maximum RF output power among production units
- Per KDB 447498 D01v06, for larger devices, the test separation distance of adjacent edge configuration is determined by the closest separation between the antenna and the user.
- Per KDB 447498 D01v06, standalone SAR test exclusion threshold is applied; If the distance of the antenna to the user is < 5mm, 5mm is used to determine SAR exclusion threshold
- Per KDB 447498 D01v06, the 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at *test separation distances* ≤ 50 mm are determined by:
 
$$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] \leq 3.0$$
 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR  
 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  
 For < 50 mm distance, we just calculate mW of the exclusion threshold value (3.0) to do compare.  
 This formula is  $[3.0] / [\sqrt{f(\text{GHz})}] \cdot [(\text{min. test separation distance, mm})] = \text{exclusion threshold of mW}$ .
- Per KDB 447498 D01v06, at 100 MHz to 6 GHz and for *test separation distances* > 50 mm, the SAR test exclusion threshold is determined according to the following

- a) [Threshold at 50 mm in step 1) + (test separation distance - 50 mm)·( f(MHz)/150)] mW, at 100 MHz to 1500 MHz
  - b) [Threshold at 50 mm in step 1) + (test separation distance - 50 mm)·10] mW at > 1500 MHz and ≤ 6 GHz
6. When the minimum *test separation distance* is < 5 mm, a distance of 5 mm according to 5) in section 4.1 is applied to determine SAR test exclusion.

### **13. Evaluation of Simultaneous**

The EUT only one TX antenna, So simultaneous transmission SAR evaluation is not required.



## 14. SAR Test Result

### 14.1. SAR results for Fast SAR

**Table 14.1: Duty Cycle**

Duty Cycle	
WiFi	1:1

**Table 14.6: SAR Values (WiFi2450- Head) Sample1**

Frequency		Side	Test Position	Figure No.	Measured average power(dBm)	Maximum allowed Power (dBm)	Scaling factor	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.									
2462	11	Left	Touch	/	16.43	16.5	1.016	0.147	0.149	0.09
2462	11	Left	Touch	/	16.43	16.5	1.016	0.144	0.146	0.12
2462	11	Right	Touch	Fig.1	16.43	16.5	1.016	0.31	0.315	-0.11
2462	11	Right	Tilt	/	16.43	16.5	1.016	0.304	0.309	0.13
2412	1	Right	Touch	/	16.12	16.5	1.091	0.256	0.279	0.09
2437	6	Right	Touch	/	16.31	16.5	1.045	0.281	0.294	0.12

**Table 14.11: SAR Values (WiFi2450 - Body) Sample1**

Frequency		Mode	Test Position	Figure No.	Measured average power(dBm)	Maximum allowed Power (dBm)	Scaling factor	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.									
2462	11	802.11 b	Ground	Fig.2	16.43	16.5	1.016	0.958	0.974	0.01
2462	11	802.11 b	Left	/	16.43	16.5	1.016	0.400	0.406	0.16
2462	11	802.11 b	Top	/	16.43	16.5	1.016	0.394	0.400	0.13
2412	1	802.11 b	Ground	/	16.12	16.5	1.091	0.866	0.945	0.12
2437	6	802.11 b	Ground	/	16.31	16.5	1.045	0.876	0.915	0.09
Repeated										
2462	11	802.11 b	Ground	Fig.3	16.43	16.5	1.016	0.966	0.982	0.03

Note: The distance between the EUT and the phantom bottom is 0mm.

**Table 14.11: SAR Values (WiFi2450 - Body) Sample2**

Frequency		Mode	Test Position	Figure No.	Measured average power(dBm)	Maximum allowed Power (dBm)	Scaling factor	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.									
2462	11	802.11 b	Ground	/	16.43	16.5	1.016	0.756	0.768	0.13
2412	1	802.11 b	Ground	Fig.4	16.12	16.5	1.091	0.845	0.922	0.10
2437	6	802.11 b	Ground	/	16.31	16.5	1.045	0.742	0.775	0.19
Repeated										
2412	1	802.11 b	Ground	Fig.5	16.12	16.5	1.091	0.848	0.926	0.10

Note: The distance between the EUT and the phantom bottom is 0mm.

**Table 14.11:SAR Values (WiFi2450 - Body) Sample3**

Frequency		Mode	Test Position	Figure No.	Measured average power(dBm)	Maximum allowed Power (dBm)	Scaling factor	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.									
2462	11	802.11 b	Ground	Fig.6	16.43	16.5	1.016	0.878	0.892	0.10
2412	1	802.11 b	Ground	/	16.12	16.5	1.091	0.436	0.476	0.18
2437	6	802.11 b	Ground	/	16.31	16.5	1.045	0.850	0.888	0.09
Repeated										
2462	11	802.11 b	Ground	Fig.7	16.43	16.5	1.016	0.875	0.889	0.20

**Table 14.11:SAR Values (WiFi2450 - Body) Sample4**

Frequency		Mode	Test Position	Figure No.	Measured average power(dBm)	Maximum allowed Power (dBm)	Scaling factor	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.									
2462	11	802.11 b	Ground	Fig.8	16.43	16.5	1.016	0.667	0.678	0.20

Note: The distance between the EUT and the phantom bottom is 0mm.

### SAR results for Standard procedure

There is zoom scan measurement to be added for the highest measured SAR in each exposure configuration/band.

**Table 14.12: SAR Values for Head**

Frequency		Side	Test Position	Figure No.	Measured average power(dBm)	Maximum allowed Power (dBm)	Scaling factor	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.									
2462	11	Right	Touch	Fig.1	16.43	16.5	1.016	0.31	0.315	-0.11

**Table 14.13: SAR Values for Body**

Frequency		Mode (number of timeslots)	Test Position	Figure No.	Measured average power(dBm)	Maximum allowed Power (dBm)	Scaling factor	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.									
2462	11	802.11 b	Ground	Fig.2	16.43	16.5	1.016	0.958	0.974	0.01
2462	11	802.11 b	Ground	Fig.3	16.43	16.5	1.016	0.966	0.982	0.03
2412	1	802.11 b	Ground	Fig.4	16.12	16.5	1.091	0.845	0.922	0.10
2412	1	802.11 b	Ground	Fig.5	16.12	16.5	1.091	0.848	0.926	0.10
2462	11	802.11 b	Ground	Fig.6	16.43	16.5	1.016	0.878	0.892	0.10
2462	11	802.11 b	Ground	Fig.7	16.43	16.5	1.016	0.875	0.889	0.20
2462	11	802.11 b	Ground	Fig.8	16.43	16.5	1.016	0.667	0.678	0.20

Note: The distance between the EUT and the phantom bottom is 0mm.

## 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)	second repeated (1g)(W/kg)	The Ratio
MHz	Ch.					
2462	11	Ground	0.958	0.966	N/A	1.008
2412	1	Ground	0.845	0.848	N/A	1.004
2462	11	Ground	0.878	0.875	N/A	1.003

**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 <sub>i</sub> 1g	c <sub>i</sub> 10g	Std.Unc ±%,1g	Std.Unc ±%,10g	V <sub>i</sub> V <sub>eff</sub>
<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>	

**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	Jan 6, 2017	1 year
02	Power meter	NRVD	102257	May 12, 2016	1 year
03	Power sensor	NRV-Z5	100241		
			100644		
04	Signal Generator	E4438C	MY49072044	Jan 6, 2017	1 Year
05	Amplifier	NTWPA-0086010F	12023024	No Calibration Requested	
06	Coupler	778D	MY4825551	May 12, 2016	1 year
07	BTS	E5515C	MY50266468	Jan 18, 2016	1 year
08	E-field Probe	EX3DV4	3754	Jan 13, 2017	1 year
09	DAE	SPEAG DAE4	1244	Dec 12,2016	1 year
10	Dipole Validation Kit	SPEAG D2450V2	858	Oct 30,2015	2 year

**ANNEX A. GRAPH RESULTS**

**WiFi 802.11b Right Cheek High**

Date/Time: 2017/3/28

Electronics: DAE4 Sn1244

Medium: Head 2450MHz

Medium parameters used:  $f = 2462 \text{ MHz}$ ;  $\sigma = 1.82 \text{ S/m}$ ;  $\epsilon_r = 40.58$ ;  $\rho = 1000 \text{ kg/m}^3$

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

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

Probe: EX3DV4 - SN3754ConvF(7.26, 7.26, 7.26); Calibrated: 1/13/2017

**WiFi 802.11b Right Cheek High/Area Scan (71x91x1):**

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

Maximum value of SAR (Measurement) = 0.422 W/kg

**WiFi 802.11b Right Cheek High/Zoom Scan (7x7x7)/Cube 0:**

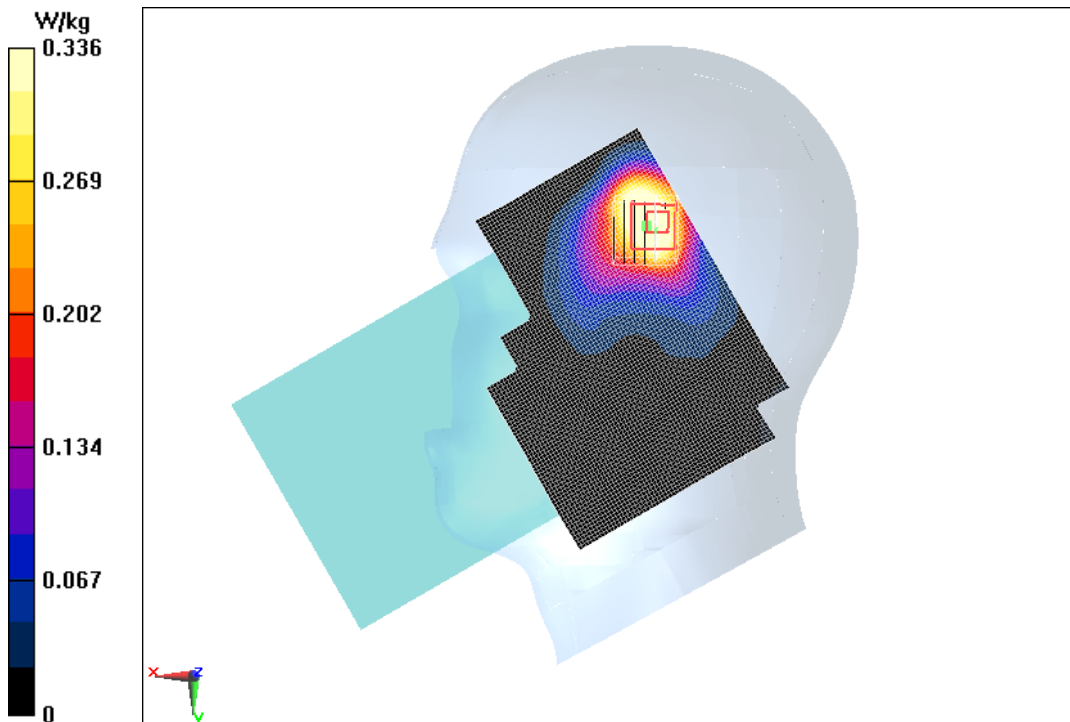
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 7.062 V/m; Power Drift = -0.11 dB

Peak SAR (extrapolated) = 0.616 W/kg

SAR(1 g) = 0.310 W/kg; SAR(10 g) = 0.159 W/kg

Maximum value of SAR (measured) = 0.336 W/kg



**Fig.1 WiFi 802.11b Right Cheek High**

**WiFi 802.11b Ground Mode High**

Date/Time: 2017/3/26

Electronics: DAE4 Sn1244

Medium: Body 2450MHz

Medium parameters used:  $f = 2462 \text{ MHz}$ ;  $\sigma = 1.921 \text{ S/m}$ ;  $\epsilon_r = 53.617$ ;  $\rho = 1000 \text{ kg/m}^3$

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

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

Probe: EX3DV4 - SN3754ConvF(7.22, 7.22, 7.22); Calibrated: 1/13/2017

**WiFi 802.11b Ground Mode High/Area Scan (111x81x1):**

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

Maximum value of SAR (Measurement) = 1.95 W/kg

**WiFi 802.11b Ground Mode High/Zoom Scan (7x7x7)/Cube 0:**

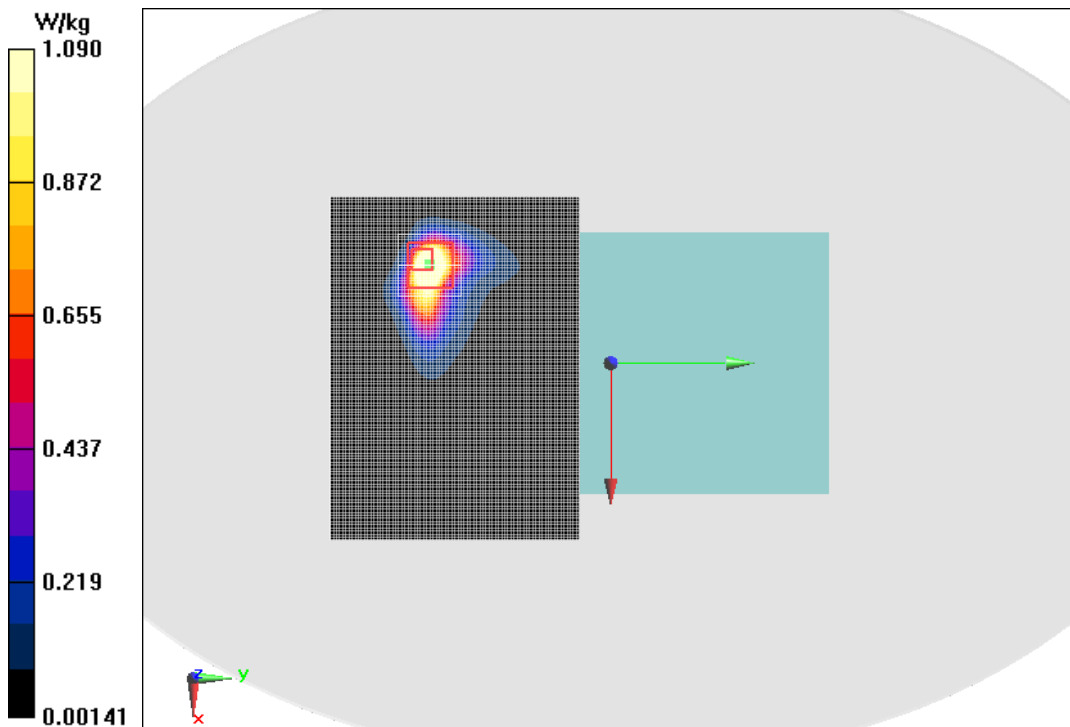
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 1.012 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 2.70 W/kg

SAR(1 g) = 0.958 W/kg; SAR(10 g) = 0.406 W/kg

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



**Fig.2 WiFi 802.11b Ground Mode High**

**WiFi 802.11b Ground Mode High Repeated**

Date/Time: 2017/3/26

Electronics: DAE4 Sn1244

Medium: Body 2450MHz

Medium parameters used:  $f = 2462 \text{ MHz}$ ;  $\sigma = 1.921 \text{ S/m}$ ;  $\epsilon_r = 53.617$ ;  $\rho = 1000 \text{ kg/m}^3$

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

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

Probe: EX3DV4 - SN3754ConvF(7.22, 7.22, 7.22); Calibrated: 1/13/2017

**WiFi 802.11b Ground Mode High Repeated/Area Scan (111x81x1):**

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

Maximum value of SAR (Measurement) = 1.91 W/kg

**WiFi 802.11b Ground Mode High Repeated/Zoom Scan (7x7x7)/Cube 0:**

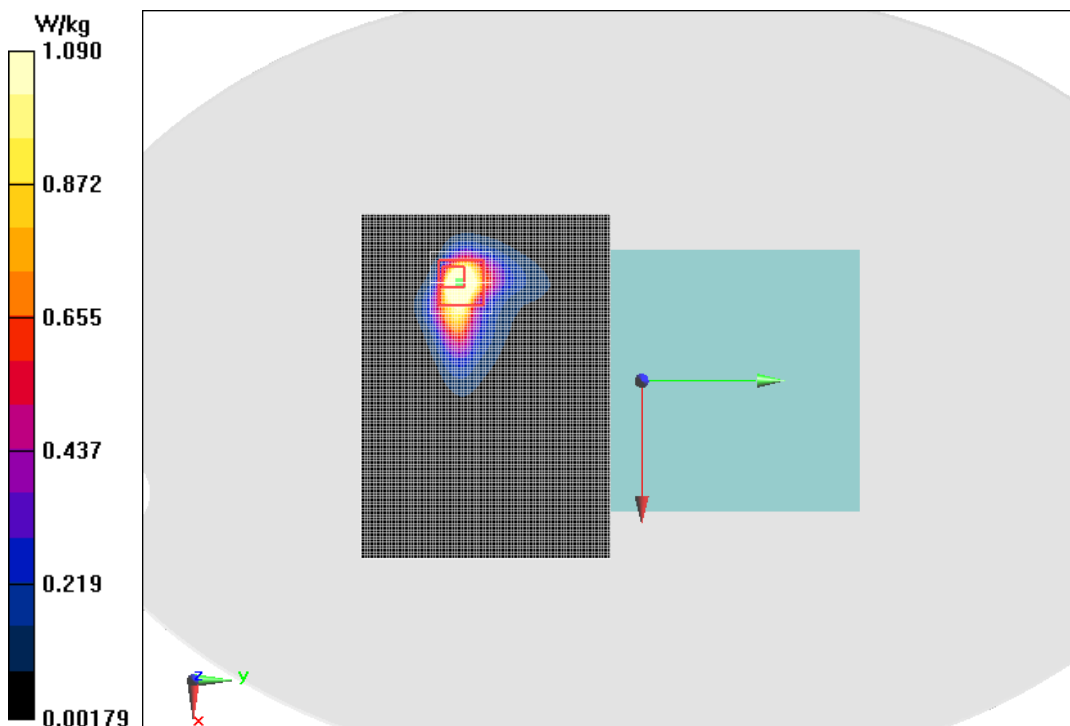
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 1.234 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 2.72 W/kg

SAR(1 g) = 0.966 W/kg; SAR(10 g) = 0.406 W/kg

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



**Fig.3 WiFi 802.11b Ground Mode High Repeated**



**WiFi 802.11b Ground Mode Low**

Date/Time: 2017/3/26

Electronics: DAE4 Sn1244

Medium: Body 2450MHz

Medium parameters used:  $f = 2412 \text{ MHz}$ ;  $\sigma = 1.859 \text{ S/m}$ ;  $\epsilon_r = 53.625$ ;  $\rho = 1000 \text{ kg/m}^3$

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

Communication System: Wifi 2450 2450MHz;    Frequency: 2412 MHz; Duty Cycle: 1:1

Probe: EX3DV4 - SN3754ConvF(7.22, 7.22, 7.22); Calibrated: 1/13/2017

**WiFi 802.11b Ground Mode Low/Area Scan (111x81x1):**

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

Maximum value of SAR (Measurement) = 1.35 W/kg

**WiFi 802.11b Ground Mode Low/Zoom Scan (7x7x7)/Cube 0:**

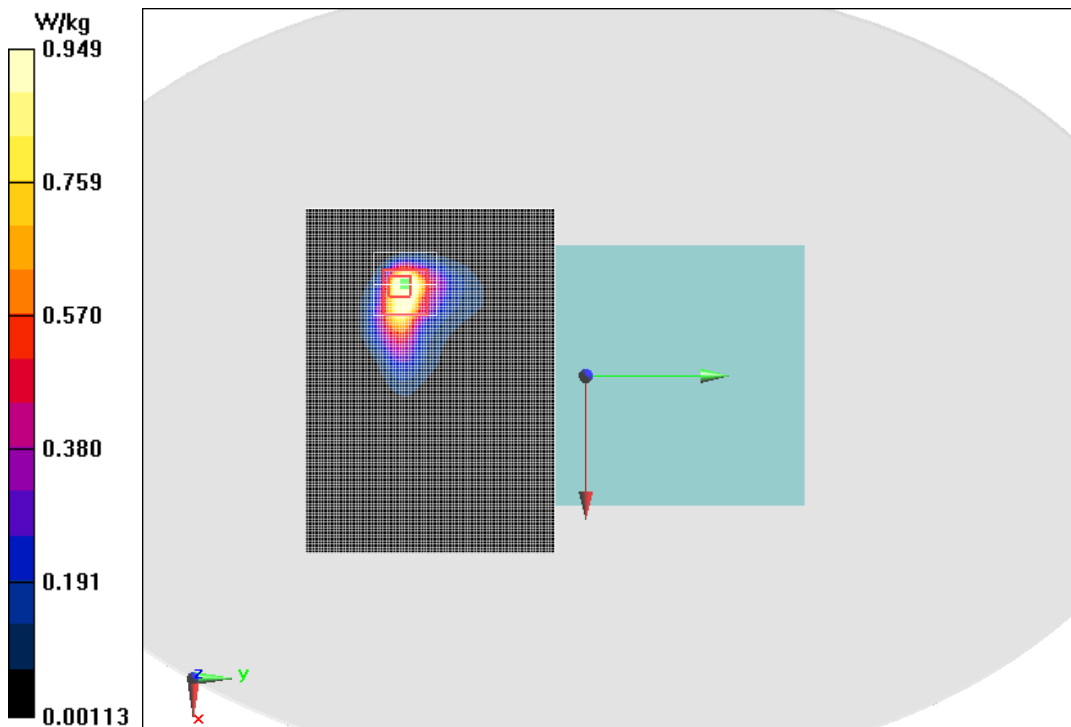
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 0.914 V/m; Power Drift = 0.10 dB

Peak SAR (extrapolated) = 2.32 W/kg

SAR(1 g) = 0.845 W/kg; SAR(10 g) = 0.358 W/kg

Maximum value of SAR (measured) = 0.949 W/kg



**Fig.4 WiFi 802.11b Ground Mode Low**

## WiFi 802.11b Ground Mode Low Repeated

Date/Time: 2017/3/26

Electronics: DAE4 Sn1244

Medium: Body 2450MHz

Medium parameters used:  $f = 2412$  MHz;  $\sigma = 1.859$  S/m;  $\epsilon_r = 53.625$ ;  $\rho = 1000$  kg/m<sup>3</sup>

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

Communication System: Wifi 2450 2450MHz;    Frequency: 2412 MHz; Duty Cycle: 1:1

Probe: EX3DV4 - SN3754ConvF(7.22, 7.22, 7.22); Calibrated: 1/13/2017

## WiFi 802.11b Ground Mode Low Repeated /Area Scan (111x81x1):

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

Maximum value of SAR (Measurement) = 1.68 W/kg

## WiFi 802.11b Ground Mode Low Repeated /Zoom Scan (7x7x7)/Cube 0:

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

Reference Value = 0.978 V/m; Power Drift = 0.10 dB

Peak SAR (extrapolated) = 2.34 W/kg

SAR(1 g) = 0.848 W/kg; SAR(10 g) = 0.359 W/kg

Maximum value of SAR (measured) = 0.949 W/kg

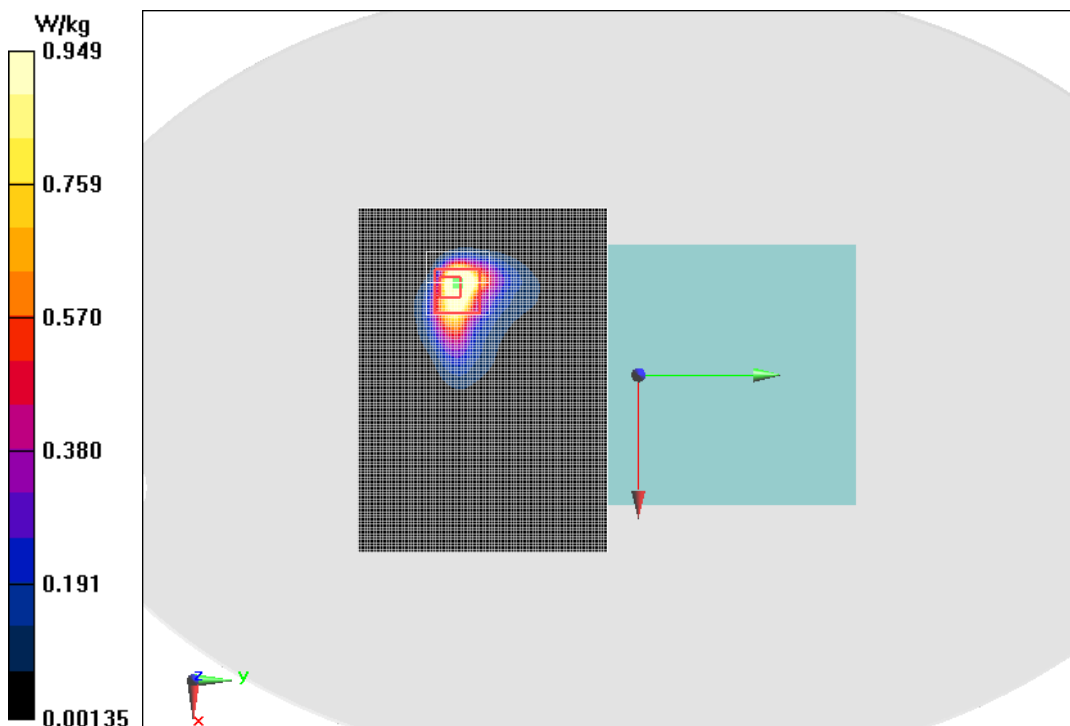


Fig.5 WiFi 802.11b Ground Mode Low Repeated

## WiFi 802.11b Ground Mode High

Date/Time: 2017/3/26

Electronics: DAE4 Sn1244

Medium: Body 2450MHz

Medium parameters used:  $f = 2462$  MHz;  $\sigma = 1.921$  S/m;  $\epsilon_r = 53.617$ ;  $\rho = 1000$  kg/m<sup>3</sup>

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

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

Probe: EX3DV4 - SN3754ConvF(7.22, 7.22, 7.22); Calibrated: 1/13/2017

## WiFi 802.11b Ground Mode High/Area Scan (81x61x1):

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

Maximum value of SAR (Measurement) = 1.36 W/kg

## WiFi 802.11b Ground Mode High/Zoom Scan (7x7x7)/Cube 0:

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

Reference Value = 0.997 V/m; Power Drift = 0.10 dB

Peak SAR (extrapolated) = 2.83 W/kg

SAR(1 g) = 0.878 W/kg; SAR(10 g) = 0.363 W/kg

Maximum of SAR (measured) = 0.954 W/kg

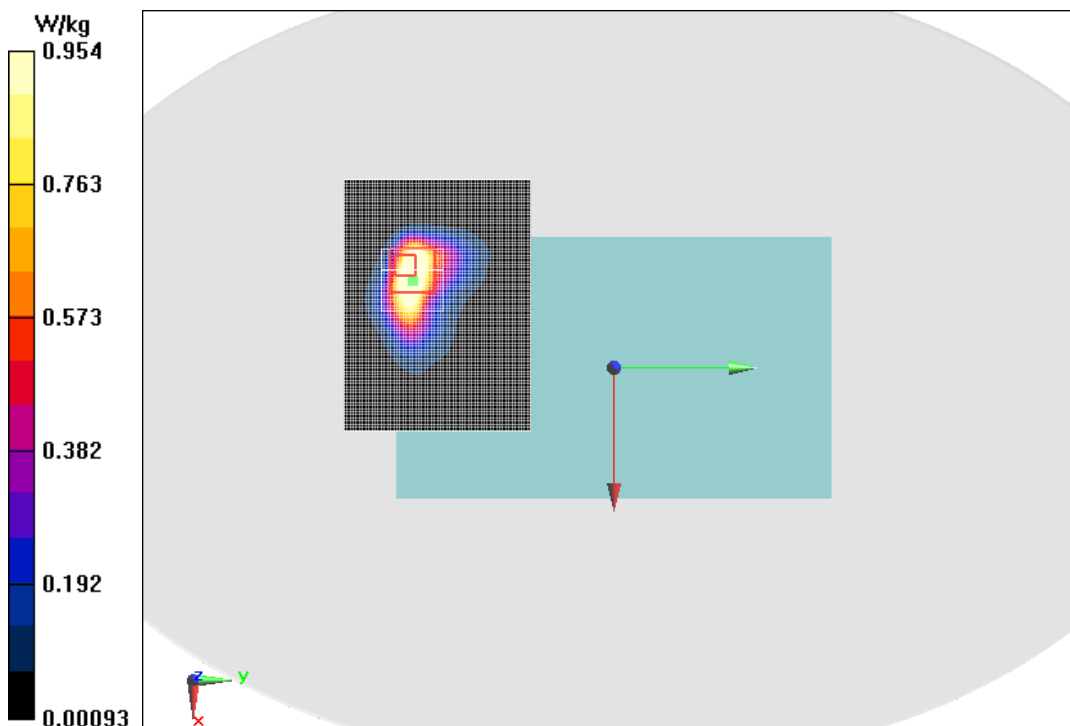


Fig.6 WiFi 802.11b Ground Mode High

**WiFi 802.11b Ground Mode High Repeated**

Date/Time: 2017/3/26

Electronics: DAE4 Sn1244

Medium: Body 2450MHz

Medium parameters used:  $f = 2462 \text{ MHz}$ ;  $\sigma = 1.921 \text{ S/m}$ ;  $\epsilon_r = 53.617$ ;  $\rho = 1000 \text{ kg/m}^3$

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

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

Probe: EX3DV4 - SN3754ConvF(7.22, 7.22, 7.22); Calibrated: 1/13/2017

**WiFi 802.11b Ground Mode High Repeated/Area Scan (81x61x1):**

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

Maximum value of SAR (Measurement) = 1.66 W/kg

**WiFi 802.11b Ground Mode High Repeated/Zoom Scan (7x7x7)/Cube 0:**

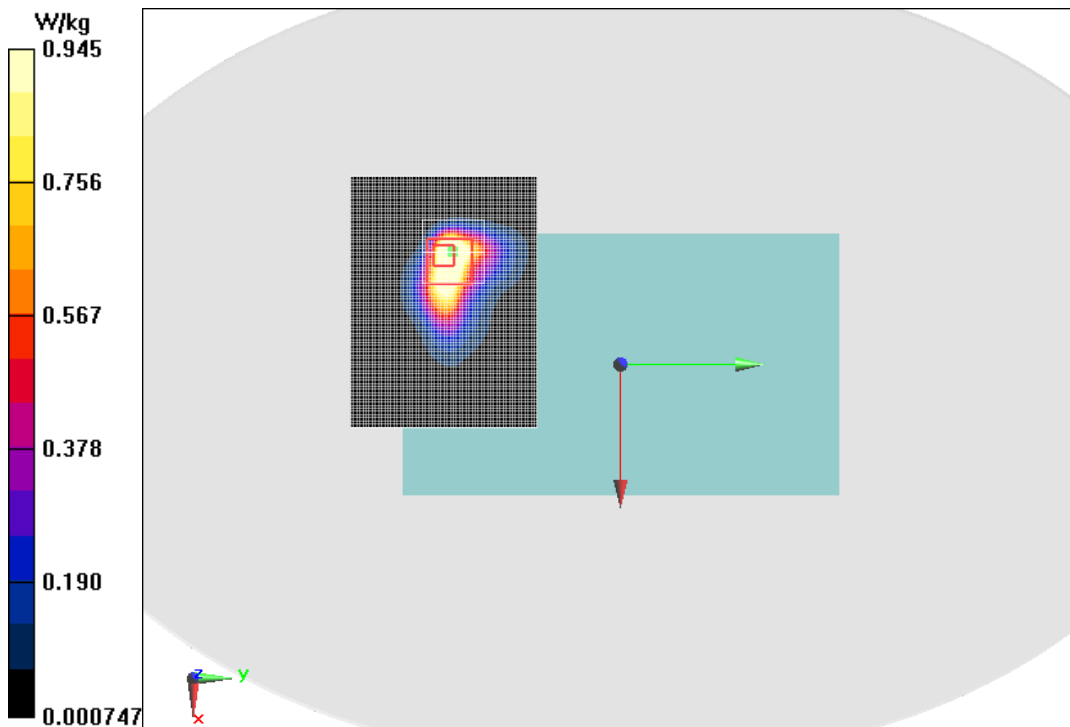
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 1.023 V/m; Power Drift = 0.20 dB

Peak SAR (extrapolated) = 2.75 W/kg

SAR(1 g) = 0.875 W/kg; SAR(10 g) = 0.366 W/kg

Maximum of SAR (measured) = 0.945 W/kg



**Fig.7 WiFi 802.11b Ground Mode High Repeated**

**WiFi 802.11b Ground Mode High**

Date/Time: 2017/3/26

Electronics: DAE4 Sn1244

Medium: Body 2450MHz

Medium parameters used:  $f = 2462 \text{ MHz}$ ;  $\sigma = 1.921 \text{ S/m}$ ;  $\epsilon_r = 53.617$ ;  $\rho = 1000 \text{ kg/m}^3$

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

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

Probe: EX3DV4 - SN3754ConvF(7.22, 7.22, 7.22); Calibrated: 1/13/2017

**WiFi 802.11b Ground Mode High/Area Scan (111x81x1):**

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

Maximum value of SAR (Measurement) = 1.55 W/kg

**WiFi 802.11b Ground Mode High/Zoom Scan (7x7x7)/Cube 0:**

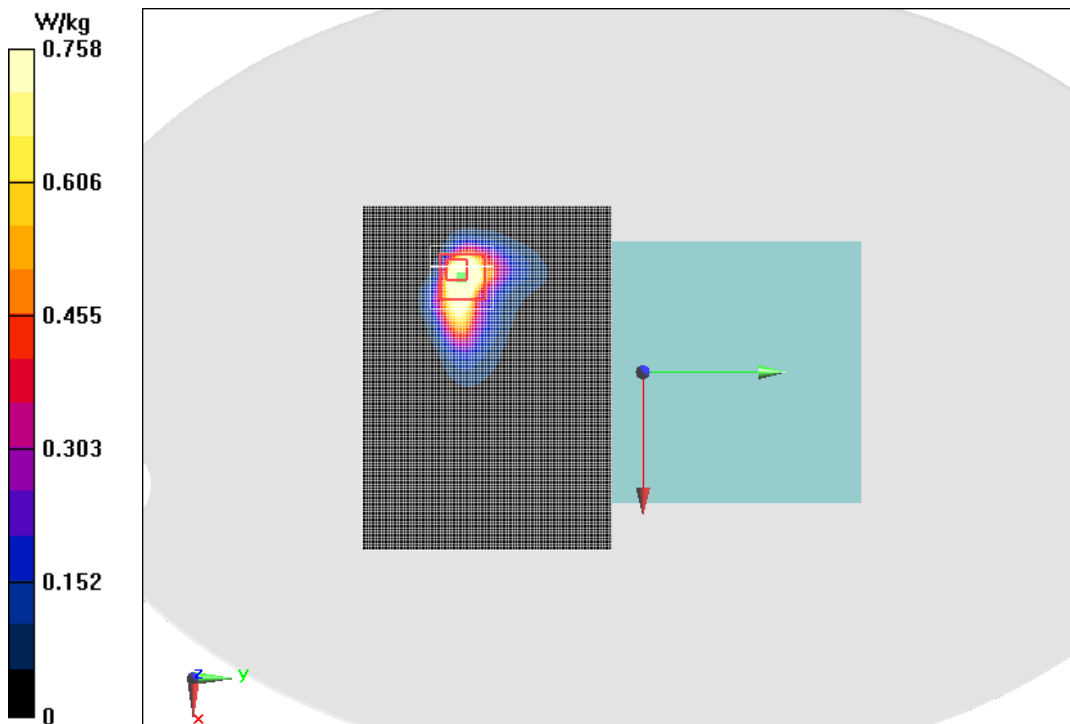
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 1.012 V/m; Power Drift = 0.20 dB

Peak SAR (extrapolated) = 1.95 W/kg

SAR(1 g) = 0.667 W/kg; SAR(10 g) = 0.287 W/kg

Maximum value of SAR (measured) = 0.758 W/kg



**Fig.8 WiFi 802.11b Ground Mode High**

## ANNEX B. SYSTEM VALIDATION RESULTS

### Body 2450MHz

Date/Time: 2017/3/26

Electronics: DAE4 Sn1244

Medium: Body 2450MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.908$  S/m;  $\epsilon_r = 53.646$ ;  $\rho = 1000$  kg/m<sup>3</sup>

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

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

Probe: EX3DV4 - SN3754ConvF(7.22, 7.22, 7.22); Calibrated: 1/13/2017

#### System Validation/Area Scan /Area Scan (71x61x1):

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

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

#### System Validation/Zoom Scan (7x7x7)/Cube 0:

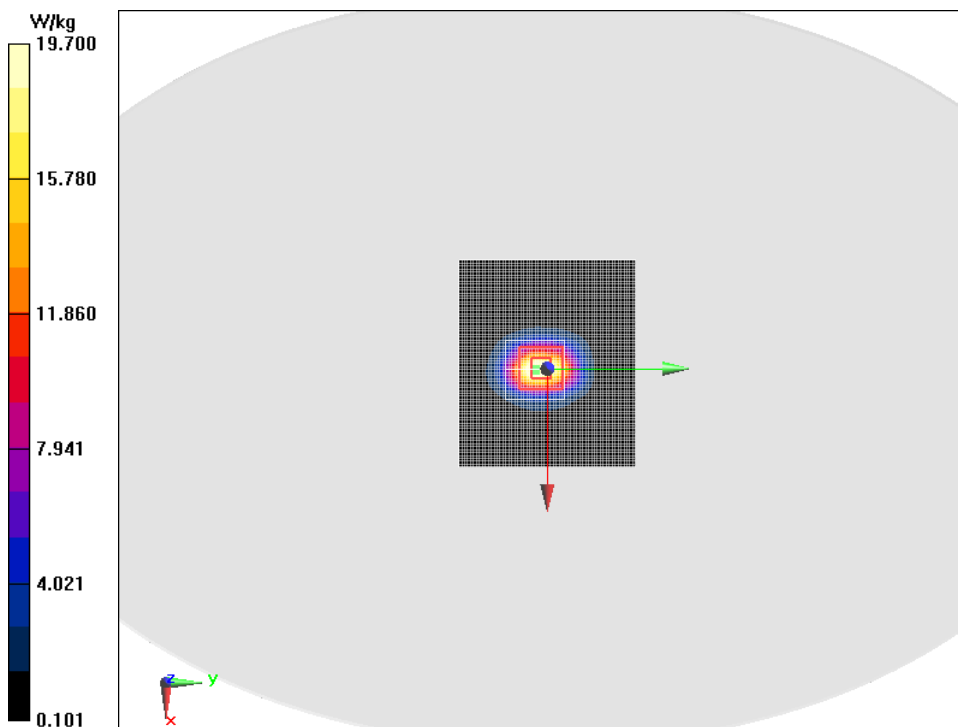
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 107.5 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 26.4 W/kg

SAR(1 g) = 12.9 W/kg; SAR(10 g) = 5.91 W/kg

Maximum value of SAR (measured) = 19.7 W/kg



## Head 2450MHz

Date/Time: 2017/3/28

Electronics: DAE4 Sn1244

Medium: Head 2450MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.811$  S/m;  $\epsilon_r = 40.607$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature:22.5°C      Liquid Temperature:22.5°C

Communication System: CW (0);    Frequency: 2450 MHz; Duty Cycle: 1:1

Probe: EX3DV4 - SN3754ConvF(7.26, 7.26, 7.26)

### System Validation/Area Scan (60x60x1):

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

Maximum value of SAR (Measurement) = 20.1 W/kg

### System Validation/Zoom Scan (7x7x7)/Cube 0:

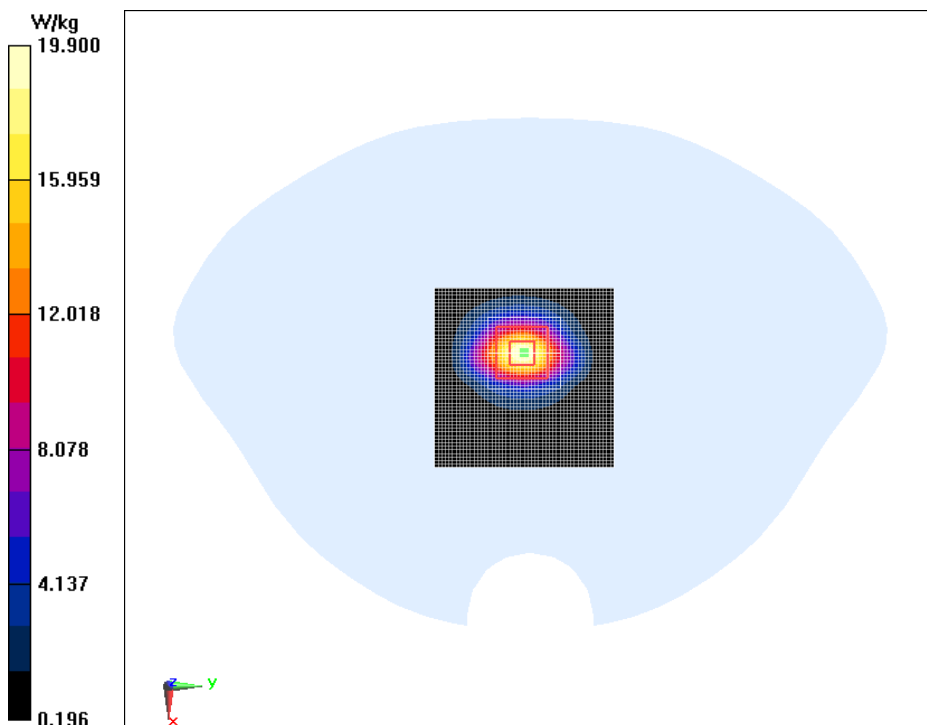
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 89.35 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 26.9 W/kg

SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.27 W/kg

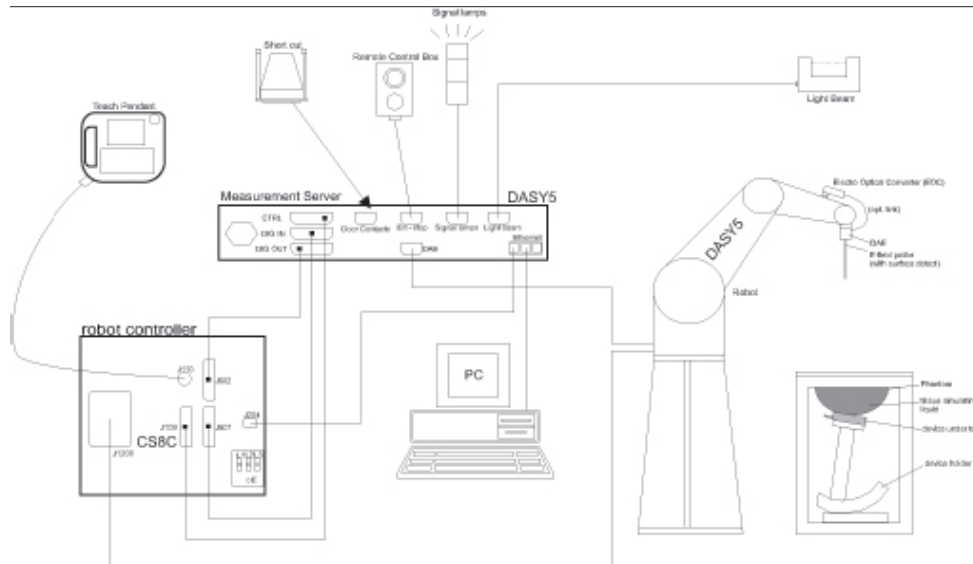
Maximum value of SAR (measured) = 19.9 W/kg



## 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, EX3DV4

**Frequency**

**Range:** 700MHz — 2.6GHz(ES3DV3)

**Calibration:** In head and body simulating tissue at  
Frequencies from 835 up to 2450MHz

**Linearity:**

$\pm 0.2$  dB(700MHz — 2.0GHz) for ES3DV3

**Dynamic Range:** 10 mW/kg — 100W/kg

**Probe Length:** 330 mm

**Probe Tip**

**Length:** 20 mm

**Body Diameter:** 12 mm

**Tip Diameter:** 2.5 mm (3.9 mm for ES3DV3)

**Tip-Center:** 1 mm (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.

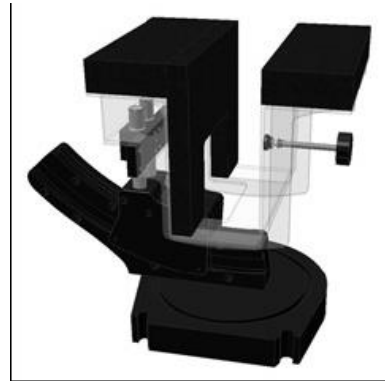
<Laptop Extension Kit>

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



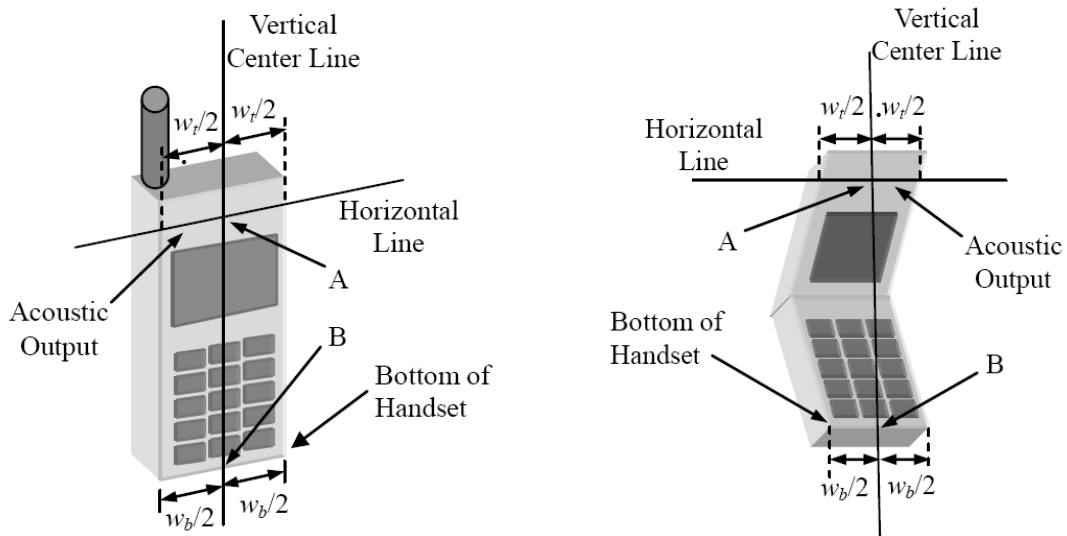
**Picture C.9: SAM Twin Phantom**



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

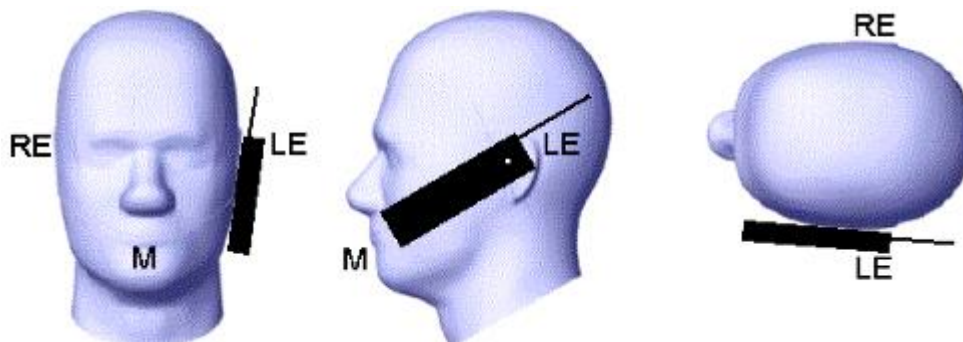
### D.1. General considerations

This standard specifies two handset test positions against the head phantom – the “cheek” position and the “tilt” position.

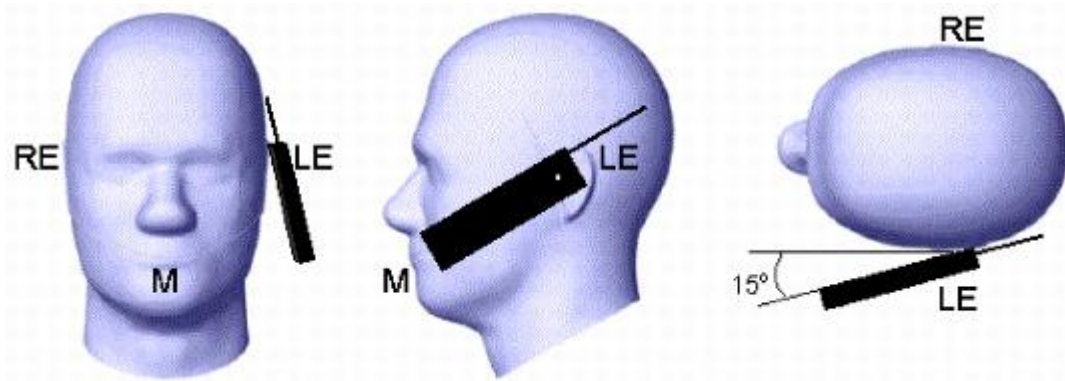


- $w_t$  Width of the handset at the level of the acoustic
- $w_b$  Width of the bottom of the handset
- A Midpoint of the width  $w_t$  of the handset at the level of the acoustic output
- B Midpoint of the width  $w_b$  of the bottom of the handset

**Picture D.1-a Typical “fixed” case handset    Picture D.1-b Typical “clam-shell” case handset**



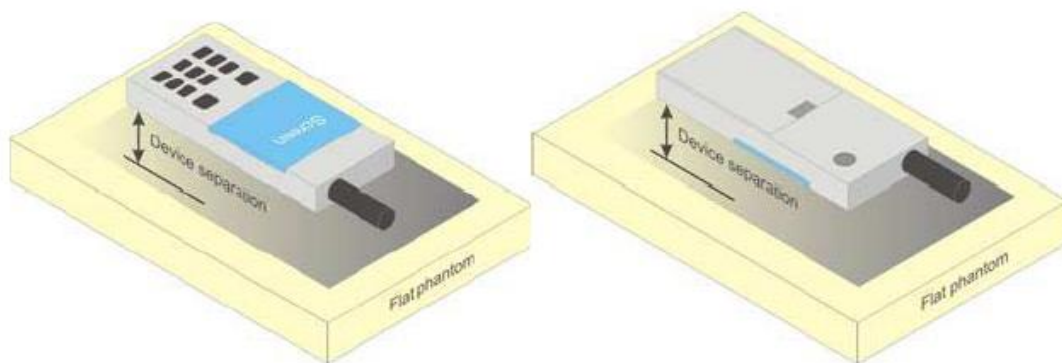
**Picture D.2 Cheek position of the wireless device on the left side of SAM**



**Picture D.3 Tilt position of the wireless device on the left side of SAM**

### D.2. Body-worn device

A typical example of a body-worn device is a mobile phone, wireless enabled PDA or other battery operated wireless device with the ability to transmit while mounted on a person's body using a carry accessory approved by the wireless device manufacturer.

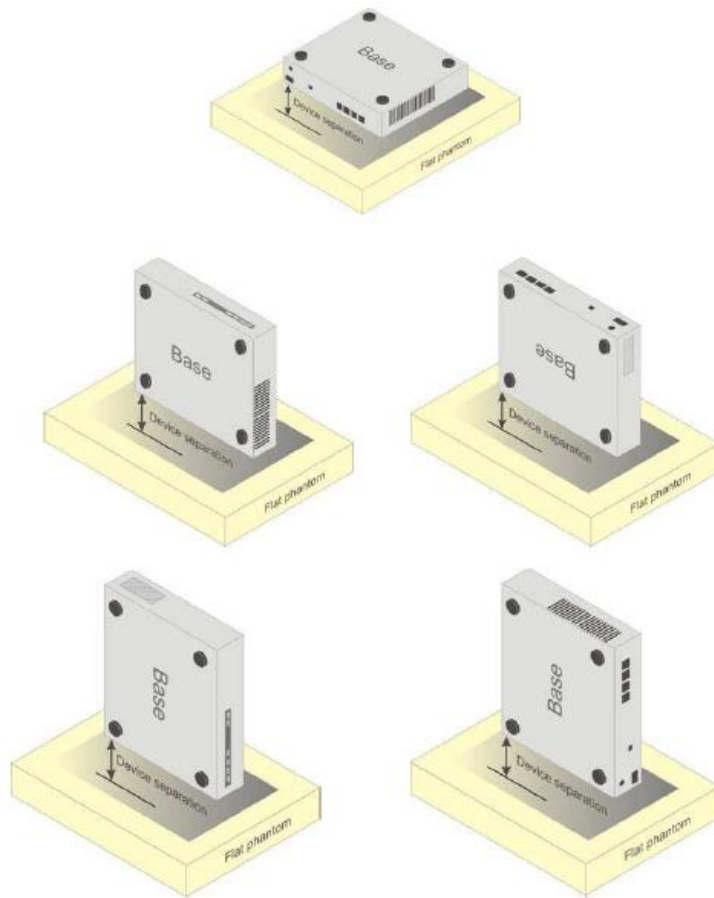


**Picture D.4 Test positions for body-worn devices**

### D.3. 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	3754	Head 2450MHz	Mar 28, 2017	2450MHz	40.607	1.811
2	3754	Body 2450MHz	Mar 26, 2017	2450MHz	53.646	1.908

**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

Schmid & Partner Engineering AG

Zeughausstrasse 43, 8004 Zurich, Switzerland  
Phone +41 44 245 9700, Fax +41 44 245 9779  
info@speag.com, http://www.speag.com

s p e a g

### IMPORTANT NOTICE

1244

#### USAGE OF THE DAE 4

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

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

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

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

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

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

**Important Note:**

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

**Important Note:**

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

**Important Note:**

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

Schmid & Partner Engineering

TN\_BR040315AD DAE4.doc

11.12.2009



**Calibration Laboratory of  
Schmid & Partner  
Engineering AG**  
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Accreditation No.: **SCS 0108**

Client **TMC - SH (Auden)**

Certificate No: **DAE4-1244\_Dec16**

## CALIBRATION CERTIFICATE

Object: **DAE4 - SD 000 D04 BM - SN: 1244**

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



Calibration date: **December 12, 2016**

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
Keithley Multimeter Type 2001	SN: 0810278	09-Sep-16 (No:19065)	Sep-17
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	05-Jan-16 (in house check)	In house check: Jan-17
Calibrator Box V2.1	SE UMS 006 AA 1002	05-Jan-16 (in house check)	In house check: Jan-17

	Name	Function	Signature
Calibrated by:	Dominique Steffen	Technician	
Approved by:	Fin Bomholt	Deputy Technical Manager	

Issued: December 13, 2016

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Accreditation No.: **SCS 0108**

## Glossary

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

## Methods Applied and Interpretation of Parameters

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

### DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1μV, 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	403.872 ± 0.02% (k=2)	403.613 ± 0.02% (k=2)	404.527 ± 0.02% (k=2)
Low Range	3.95409 ± 1.50% (k=2)	3.97148 ± 1.50% (k=2)	3.98215 ± 1.50% (k=2)

### Connector Angle

Connector Angle to be used in DASY system	22.0 ° ± 1 °
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## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

High Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	199995.09	-0.83	-0.00
Channel X + Input	20004.47	2.58	0.01
Channel X - Input	-19997.82	2.60	-0.01
Channel Y + Input	199993.65	-2.29	-0.00
Channel Y + Input	20001.27	-0.51	-0.00
Channel Y - Input	-19997.58	2.97	-0.01
Channel Z + Input	199992.15	-3.40	-0.00
Channel Z + Input	19999.95	-1.78	-0.01
Channel Z - Input	-20002.51	-1.92	0.01

Low Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	2002.00	0.39	0.02
Channel X + Input	202.04	0.13	0.07
Channel X - Input	-197.82	0.13	-0.06
Channel Y + Input	2000.90	-0.59	-0.03
Channel Y + Input	202.65	0.73	0.36
Channel Y - Input	-197.74	0.13	-0.06
Channel Z + Input	2001.79	0.42	0.02
Channel Z + Input	200.75	-1.05	-0.52
Channel Z - Input	-199.15	-1.06	0.53

### 2. Common mode sensitivity

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

	Common mode Input Voltage (mV)	High Range Average Reading ( $\mu\text{V}$ )	Low Range Average Reading ( $\mu\text{V}$ )
Channel X	200	-3.59	-5.16
	-200	6.94	5.14
Channel Y	200	-3.41	-3.57
	-200	2.60	2.96
Channel Z	200	-8.21	-8.18
	-200	5.71	5.56

### 3. Channel separation

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

	Input Voltage (mV)	Channel X ( $\mu\text{V}$ )	Channel Y ( $\mu\text{V}$ )	Channel Z ( $\mu\text{V}$ )
Channel X	200	-	1.06	-4.10
Channel Y	200	7.19	-	1.88
Channel Z	200	9.77	4.29	-

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

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

	High Range (LSB)	Low Range (LSB)
Channel X	16885	16322
Channel Y	16457	16417
Channel Z	15874	17196

#### 5. Input Offset Measurement

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

Input 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	-0.50	-1.93	1.16	0.62
Channel Y	0.32	-1.78	2.06	0.72
Channel Z	-2.19	-4.30	-0.47	0.66

#### 6. Input Offset Current

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

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

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

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

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

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

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



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Client **ECIT**

Certificate No: **Z17-97010**

## CALIBRATION CERTIFICATE

Object: **EX3DV4 - SN:3754**

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

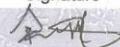


Calibration date: **January 13, 2017**

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-16 (CTTL, No.J16X04777)	Jun-17
Power sensor NRP-Z91	101547	27-Jun-16 (CTTL, No.J16X04777)	Jun-17
Power sensor NRP-Z91	101548	27-Jun-16 (CTTL, No.J16X04777)	Jun-17
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 1331	21-Jan-16(SPEAG, No.DAE4-1331_Jan16)	Jan -17
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
SignalGeneratorMG3700A	6201052605	27-Jun-16 (CTTL, No.J16X04776)	Jun-17
Network Analyzer E5071C	MY46110673	26-Jan-16 (CTTL, No.J16X00894)	Jan -17

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

Issued: January 14, 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, "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
- 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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# Probe EX3DV4

## SN: 3754

Calibrated: January 13, 2017

Calibrated for DASY/EASY Systems

(Note: non-compatible with DASY2 system!)



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## DASY/EASY – Parameters of Probe: EX3DV4 – SN: 3754

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	0.48	0.41	0.59	$\pm 10.8\%$
DCP(mV) <sup>B</sup>	102.4	100.9	102.7	

### 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	198.9	$\pm 2.0\%$
		Y	0.0	0.0	1.0		175.6	
		Z	0.0	0.0	1.0		221.1	

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<sup>2</sup>-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: EX3DV4 – SN: 3754

### 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	9.41	9.41	9.41	0.30	0.70	±12%
900	41.5	0.97	9.10	9.10	9.10	0.13	1.52	±12%
1750	40.1	1.37	8.08	8.08	8.08	0.17	1.23	±12%
1900	40.0	1.40	7.85	7.85	7.85	0.24	1.05	±12%
2100	39.8	1.49	7.73	7.73	7.73	0.23	1.12	±12%
2300	39.5	1.67	7.58	7.58	7.58	0.56	0.72	±12%
2450	39.2	1.80	7.26	7.26	7.26	0.55	0.73	±12%
2600	39.0	1.96	7.05	7.05	7.05	0.60	0.70	±12%
5250	35.9	4.71	5.20	5.20	5.20	0.45	1.30	±13%
5600	35.5	5.07	4.62	4.62	4.62	0.45	1.35	±13%
5750	35.4	5.22	4.73	4.73	4.73	0.45	1.55	±13%

<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: EX3DV4 – SN: 3754

### 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	9.66	9.66	9.66	0.40	0.85	±12%
900	55.0	1.05	9.31	9.31	9.31	0.23	1.17	±12%
1750	53.4	1.49	7.80	7.80	7.80	0.22	1.14	±12%
1900	53.3	1.52	7.60	7.60	7.60	0.20	1.22	±12%
2100	53.2	1.62	7.96	7.96	7.96	0.23	1.24	±12%
2300	52.9	1.81	7.43	7.43	7.43	0.41	1.01	±12%
2450	52.7	1.95	7.22	7.22	7.22	0.40	1.04	±12%
2600	52.5	2.16	7.15	7.15	7.15	0.45	0.92	±12%
5250	48.9	5.36	4.79	4.79	4.79	0.50	1.55	±13%
5600	48.5	5.77	4.09	4.09	4.09	0.55	1.50	±13%
5750	48.3	5.94	4.55	4.55	4.55	0.58	1.70	±13%

<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.

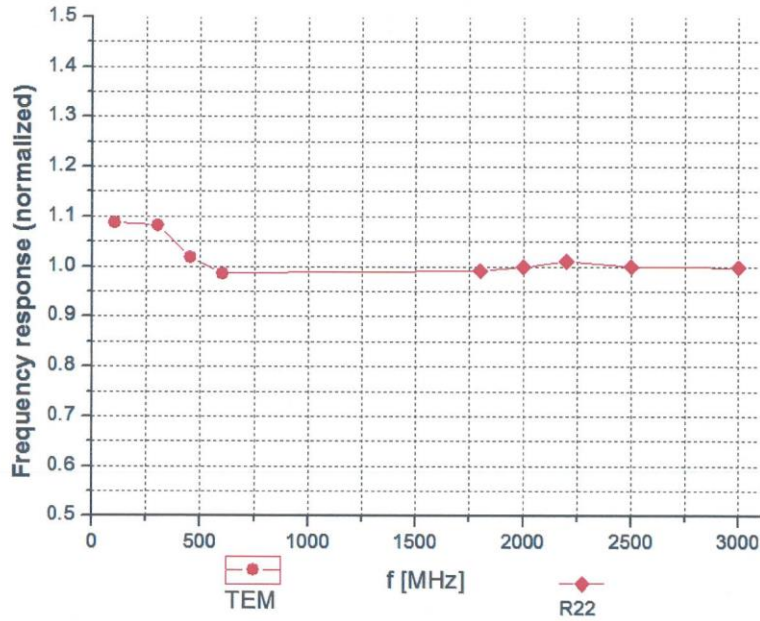
<sup>F</sup> At frequency below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ±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:  $\pm 7.5\%$  (k=2)



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

**f=600 MHz, TEM**

**f=1800 MHz, R22**

