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Report No.: SZEM160400202401  
Rev.00  
Page : 1 of 40

## ***FCC SAR TEST REPORT***

**Application No:** SZEM1604002024RG(SHEM160300141301)  
**Applicant:** Hangzhou Hikvision Digital Technology Co., Ltd.  
**Manufacturer:** Hangzhou Hikvision Digital Technology Co., Ltd.  
**Factory:** Hangzhou Hikvision Technology Co., Ltd.  
    **Product Name:** Action Camera  
    **Model No.(EUT):** CS-SP208  
    **Add Model No.:** CS-SP200, CS-SP206, CS-SP300, CS-SP306, CS-SP308  
**FCC ID:** 2ADTD-CSSP  
**Standards:** FCC 47CFR §2.1093  
**Date of Receipt:** 2016-05-20  
**Date of Test:** 2016-05-21 to 2016-05-22  
**Date of Issue:** 2016-07-06  
**Test Result :** **PASS \***

\* In the configuration tested, the EUT detailed in this report complied with the standards specified above.

Authorized Signature:

Derek Yang

Wireless Laboratory Manager

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## REVISION HISTORY

Revision Record				
Version	Chapter	Date	Modifier	Remark
00		2016-07-06		Original



## TEST SUMMARY

Frequency Band	Test position	Test mode	Max Report SAR1g (W/kg)	SAR limit (W/kg)	Verdict
WI-FI (2.4GHz)	Body	802.11b	1.078	1.6	PASS
WI-FI (5GHz)	Body	802.11a	1.070	1.6	PASS

Approved & Released by

Simon Ling

SAR Manager

Tested by

Evan Mi

SAR Engineer



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## 1 General Information

### 1.1 Details of Client

Applicant:	Hangzhou Hikvision Digital Technology Co., Ltd.
Address:	No. 555 Qianmo Road, Binjiang District, Hangzhou 310052, China
Manufacturer:	Hangzhou Hikvision Digital Technology Co., Ltd.
Address:	No. 555 Qianmo Road, Binjiang District, Hangzhou 310052, China
Factory:	Hangzhou Hikvision Technology Co., Ltd.
Address:	No. 700 Dongliu Road, Binjiang District, Hangzhou 310052, Zhejiang, China

### 1.2 Test Location

Company: SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch E&E Lab  
Address: No. 1 Workshop, M-10, Middle section, Science & Technology Park, Shenzhen, Guangdong, China  
Post code: 518057  
Telephone: +86 (0) 755 2601 2053  
Fax: +86 (0) 755 2671 0594  
E-mail: ee.shenzhen@sgs.com



### 1.3 Test Facility

The test facility is recognized, certified, or accredited by the following organizations:

- **CNAS (No. CNAS L2929)**

CNAS has accredited SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch EMC Lab to ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories (CNAS-CL01 Accreditation Criteria for the Competence of Testing and Calibration Laboratories) for the competence in the field of testing.

- **A2LA (Certificate No. 3816.01)**

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory is accredited by the American Association for Laboratory Accreditation(A2LA). Certificate No. 3816.01.

- **VCCI**

The 10m Semi-anechoic chamber and Shielded Room of SGS-CSTC Standards Technical Services Co., Ltd. have been registered in accordance with the Regulations for Voluntary Control Measures with Registration No.: G-823, R-4188, T-1153 and C-2383 respectively.

- **FCC – Registration No.: 556682**

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Registration No.: 556682.

- **Industry Canada (IC)**

Two 3m Semi-anechoic chambers and the 10m Semi-anechoic chamber of SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch EMC Lab have been registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing with Registration No.: 4620C-1, 4620C-2, 4620C-3.



## 1.4 General Description of EUT

Product Name:	Action Camera		
Model No.:	CS-SP208		
Add Model No.:	CS-SP200, CS-SP206, CS-SP300, CS-SP306, CS-SP308		
Product Phase:	production unit		
Device Type :	portable device		
Exposure Category:	uncontrolled environment / general population		
FCC ID	2ADTD-CSSP		
Hardware Version:	CS-SP208		
Software Version:	V 2.1.1		
Antenna Type:	Inner Antenna		
Device Operating Configurations :			
Modulation Mode:	WIFI: DSSS,OFDM BT:GFSK		
Frequency Bands:	Band	Tx (MHz)	Rx (MHz)
	WIFI(2.4GHz)	2412-2462	2412-2462
	WIFI(5.2GHz)	5150-5250	5150-5250
	WIFI(5.8GHz)	5725-5850	5725-5850
	BT	2402-2480	2402-2480
Battery Information	Normal Voltage :3.8V		
	Rated capacity :1200mAh		
	Battery Type :Rechargeable Lithium-ion Battery		
Remark :			
CS-SP208,CS-SP200,CS-SP206,CS-SP300, CS-SP306,CS-SP308,There are series models mentioned in this report, and they are the identical in electrical and electronic characters. Only the model CS-SP208 was tested since their differences were their naming and color silk.			



## 1.5 Test Specification

Identity	Document Title
FCC 47CFR §2.1093	Radiofrequency Radiation Exposure Evaluation: Portable Devices
IEEE Std C95.1 – 1991	IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz – 300 GHz.
KDB 447498 D01 v06	General RF Exposure Guidance
KDB 447498 D03 v01	Supplement C Cross-Reference
KDB 865664 D01 v01r04	SAR Measurement 100 MHz to 6 GHz
KDB 865664 D02 v01r02	RF Exposure Reporting
KDB 941225 D07 v01r02	UMPC Mini Tablet
KDB 248227 D01 v02r02	802.11 Wi-Fi SAR
Tracking Number	886749

## 1.6 RF exposure limits

Human Exposure	Uncontrolled Environment General Population	Controlled Environment Occupational
<b>Spatial Peak SAR*</b> (Brain)	1.60 mW/g	8.00 mW/g
<b>Spatial Average SAR**</b> (Whole Body)	0.08 mW/g	0.40 mW/g
<b>Spatial Peak SAR***</b> (Hands/Feet/Ankle/Wrist)	4.00 mW/g	20.00 mW/g

### Notes:

\* The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time

\*\* The Spatial Average value of the SAR averaged over the whole body.

\*\*\* The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

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

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

## 2 SAR Measurements System Configuration

## 2.1 The SAR Measurement System

This SAR Measurement System uses a Computer-controlled 3-D stepper motor system (SPEAG DASY5 professional system). A E-field probe is used to determine the internal electric fields. The SAR can be obtained from the equation  $SAR = \sigma |E|^2 / \rho$  where  $\sigma$  and  $\rho$  are the conductivity and mass density of the tissue-Simulate.

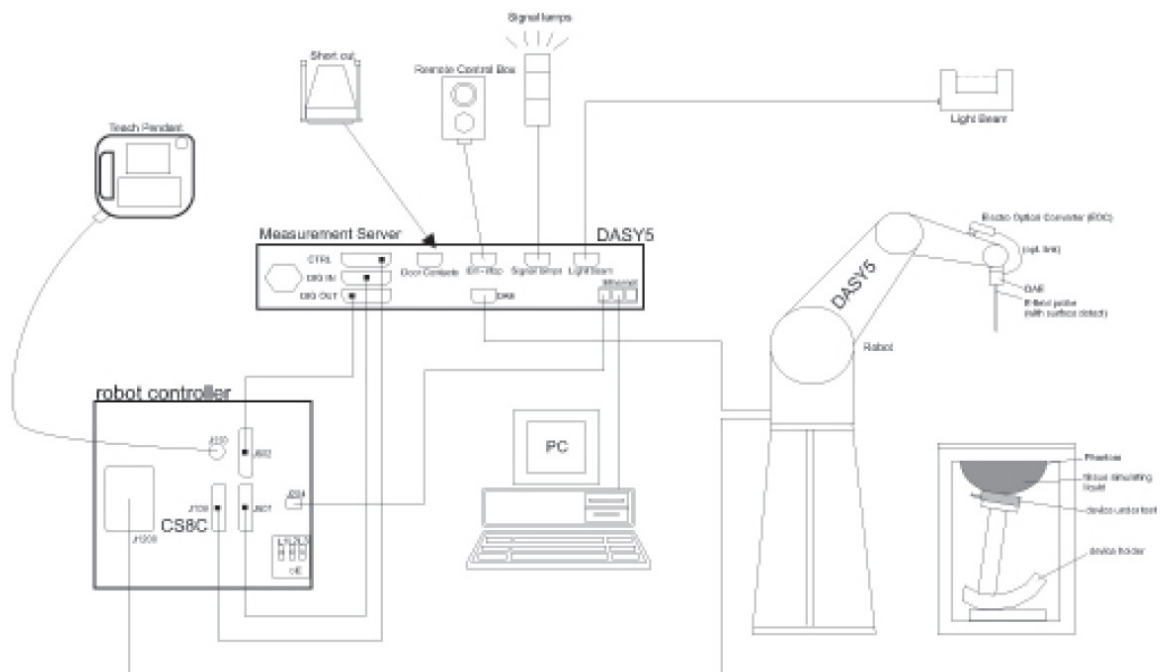
The DASY5 system for performing compliance tests consists of the following items:

A standard high precision 6-axis robot (Stabile RX family) with controller, teach pendant and software .An arm extension for accommodation the data acquisition electronics (DAE).

A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.

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 between optical and electrical of the signals for the digital communication to DAE and for the analog signal from the optical surface detection. The EOC is connected to the measurement server.



### F-1. SAR Measurement System Configuration

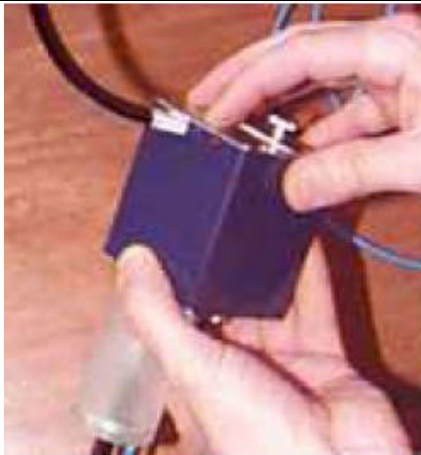
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
- A computer operating Windows 7.
- DASY5 software.
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom enabling testing left-hand, right-hand and Body Worn usage.
- The device holder for handheld mobile phones.
- Tissue simulating liquid mixed according to the given recipes.
- Validation dipole kits allowing to validating the proper functioning of the system.

## 2.2 Isotropic E-field Probe EX3DV4


	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
<b>Calibration</b>	ISO/IEC 17025 <a href="#">calibration service</a> available.
<b>Frequency</b>	10 MHz to > 6 GHz Linearity: $\pm 0.2$ dB (30 MHz to 6 GHz)
<b>Directivity</b>	$\pm 0.3$ dB in TSL (rotation around probe axis) $\pm 0.5$ dB in TSL (rotation normal to probe axis)
<b>Dynamic Range</b>	10 $\mu$ W/g to > 100 mW/g Linearity: $\pm 0.2$ dB (noise: typically < 1 $\mu$ W/g)
<b>Dimensions</b>	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm
<b>Application</b>	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields); the only probe that enables compliance testing for frequencies up to 6 GHz with precision of better 30%.
<b>Compatibility</b>	DASY3, DASY4, DASY52 SAR and higher, EASY4/MRI



## 2.3 Data Acquisition Electronics (DAE)

<b>Model</b>	DAE3,DAE4	
<b>Construction</b>	Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY4/5 embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop.	
<b>Measurement Range</b>	-100 to +300 mV (16 bit resolution and two range settings: 4mV,400mV)	
<b>Input Offset Voltage</b>	< 5μV (with auto zero)	
<b>Input Bias Current</b>	< 50 f A	
<b>Dimensions</b>	60 x 60 x 68 mm	

## 2.4 SAM Twin Phantom


<b>Material</b>	Vynlester, glass fiber reinforced (VE-GF)	
<b>Liquid Compatibility</b>	Compatible with all SPEAG tissue simulating liquids (incl. DGBE type)	
<b>Shell Thickness</b>	2 ± 0.2 mm (6 ± 0.2 mm at ear point)	
<b>Dimensions (incl. Wooden Support)</b>	Length: 1000 mm Width: 500 mm Height: adjustable feet	
<b>Filling Volume</b>	approx. 25 liters	
<b>Wooden Support</b>	SPEAG standard phantom table	

The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.

Twin SAM V5.0 has the same shell geometry and is manufactured from the same material as Twin SAM V4.0, but has reinforced top structure.



## 2.5 ELI Phantom

<b>Material</b>	Vynlester, glass fiber reinforced (VE-GF)	
<b>Liquid Compatibility</b>	Compatible with all SPEAG tissue simulating liquids (incl. DGBE type)	
<b>Shell Thickness</b>	2.0 ± 0.2 mm (bottom plate)	
<b>Dimensions</b>	Major axis: 600 mm Minor axis: 400 mm	
<b>Filling Volume</b>	approx. 30 liters	
<b>Wooden Support</b>	SPEAG standard phantom table	

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

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

## 2.6 Device Holder for Transmitters



**F-2. Device Holder for Transmitters**

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



## **2.7 Measurement procedure**

### **2.7.1 Scanning procedure**

#### **Step 1: Power reference measurement**

The “reference” and “drift” measurements are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure.

#### **Step 2: Area scan**

The SAR distribution at the exposed side of the head was measured at a distance of 4mm from the inner surface of the shell. The area covered the entire dimension of the head and the horizontal grid spacing was 15mm\*15mm or 12mm\*12mm or 10mm\*10mm. Based on the area scan data, the area of the maximum absorption was determined by spline interpolation.

#### **Step 3: Zoom scan**

Around this point, a volume of 30mm\*30mm\*30mm (fine resolution volume scan, zoom scan) was assessed by measuring 5x5x7 points ( $\leq 2\text{GHz}$ ) and 7x7x7 points ( $\geq 2\text{GHz}$ ). On this basis of this data set, the spatial peak SAR value was evaluated with the following procedure:

The data at the surface was extrapolated, since the centre of the dipoles is 2.0mm away from the tip of the probe and the distance between the surface and the lowest measuring point is 1.2mm. (This can be variable. Refer to the probe specification). The extrapolation was based on a least square algorithm. A polynomial of the fourth order was calculated through the points in z-axes. This polynomial was then used to evaluate the points between the surface and the probe tip. The maximum interpolated value was searched with a straight-forward algorithm. Around this maximum the SAR values averaged over the spatial volumes (1g or 10g) were computed using the 3D-Spline interpolation algorithm. The volume was integrated with the trapezoidal algorithm. One thousand points were interpolated to calculate the average. All neighbouring volumes were evaluated until no neighboring volume with a higher average value was found.

The area and zoom scan resolutions specified in the table below must be applied to the SAR measurements. Probe boundary effect error compensation is required for measurements with the probe tip closer than half a probe tip diameter to the phantom surface. Both the probe tip diameter and sensor offset distance must satisfy measurement protocols; to ensure probe boundary effect errors are minimized and the higher fields closest to the phantom surface can be correctly measured and extrapolated to the phantom surface for computing 1-g SAR. Tolerances of the post-processing algorithms must be verified by the test laboratory for the scan resolutions used in the SAR measurements, according to the reference distribution functions specified in IEEE Std. 1528-2003.



			$\leq 3 \text{ GHz}$	$> 3 \text{ GHz}$
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface			$5 \pm 1 \text{ mm}$	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5 \text{ mm}$
Maximum probe angle from probe axis to phantom surface normal at the measurement location			$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$
Maximum area scan spatial resolution: $\Delta x_{\text{Area}}, \Delta y_{\text{Area}}$			$\leq 2 \text{ GHz}: \leq 15 \text{ mm}$ $2 - 3 \text{ GHz}: \leq 12 \text{ mm}$	$3 - 4 \text{ GHz}: \leq 12 \text{ mm}$ $4 - 6 \text{ GHz}: \leq 10 \text{ mm}$
			When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	
Maximum zoom scan spatial resolution: $\Delta x_{\text{Zoom}}, \Delta y_{\text{Zoom}}$			$\leq 2 \text{ GHz}: \leq 8 \text{ mm}$ $2 - 3 \text{ GHz}: \leq 5 \text{ mm}^*$	$3 - 4 \text{ GHz}: \leq 5 \text{ mm}^*$ $4 - 6 \text{ GHz}: \leq 4 \text{ mm}^*$
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{\text{Zoom}}(n)$		$\leq 5 \text{ mm}$	$3 - 4 \text{ GHz}: \leq 4 \text{ mm}$ $4 - 5 \text{ GHz}: \leq 3 \text{ mm}$ $5 - 6 \text{ GHz}: \leq 2 \text{ mm}$
	graded grid	$\Delta z_{\text{Zoom}}(1)$ : between 1 <sup>st</sup> two points closest to phantom surface	$\leq 4 \text{ mm}$	$3 - 4 \text{ GHz}: \leq 3 \text{ mm}$ $4 - 5 \text{ GHz}: \leq 2.5 \text{ mm}$ $5 - 6 \text{ GHz}: \leq 2 \text{ mm}$
		$\Delta z_{\text{Zoom}}(n>1)$ : between subsequent points	$\leq 1.5 \cdot \Delta z_{\text{Zoom}}(n-1)$	
Minimum zoom scan volume	x, y, z		$\geq 30 \text{ mm}$	$3 - 4 \text{ GHz}: \geq 28 \text{ mm}$ $4 - 5 \text{ GHz}: \geq 25 \text{ mm}$ $5 - 6 \text{ GHz}: \geq 22 \text{ mm}$
Note: $\delta$ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.				
* When zoom scan is required and the <u>reported</u> SAR from the <u>area scan based 1-g SAR estimation</u> procedures of KDB 447498 is $\leq 1.4 \text{ W/kg}$ , $\leq 8 \text{ mm}$ , $\leq 7 \text{ mm}$ and $\leq 5 \text{ mm}$ zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.				

#### Step 4: Power reference measurement (drift)

The Power Drift Measurement job measures the field at the same location as the most recent power reference measurement job within the same procedure, and with the same settings. The indicated drift is mainly the variation of the DUT's output power and should vary max.  $\pm 5 \%$



## 2.7.2 Data Storage

The DASY software stores the acquired data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files with the extension ".DAE3". The software evaluates the desired unit and format for output each time the data is visualized or exported. This allows verification of the complete software setup even after the measurement and allows correction of incorrect parameter settings. For example, if a measurement has been performed with a wrong crest factor parameter in the device setup, the parameter can be corrected afterwards and the data can be re-evaluated. The measured data can be visualized or exported in different units or formats, depending on the selected probe type ([V/m], [A/m], [°C], [m W/g], [m W/cm²], [dBrel], etc.). Some of these units are not available in certain situations or show meaningless results, e.g., a SAR output in a lossless media will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

## 2.7.3 Data Evaluation by SEMCAD

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

Probe parameters:	- Sensitivity	Normi, ai0, ai1, ai2
- Conversion factor	ConvFi	
- Diode compression point	Dcpi	
Device parameters:	- Frequency	f
- Crest factor	cf	
Media parameters:	- Conductivity	ε
- Density	ρ	

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

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics.

If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power.

The formula for each channel can be given as:

$$V_i = U_i + U_i^2 \cdot cf / dcpi$$

With  $V_i$  = compensated signal of channel i (i = x, y, z)

$U_i$  = input signal of channel i (i = x, y, z)

cf = crest factor of exciting field (DASY parameter)

dcpi = diode compression point (DASY parameter)

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

E-field probes:



$$E_i = (V_i / Norm_i \cdot ConvF)^{1/2}$$

H-field probes:

$$H_i = (V_i)^{1/2} \cdot (a_{i0} + a_{i1}f + a_{i2}f^2) / f$$

With  $V_i$  = compensated signal of channel i (i = x, y, z)

$Norm_i$  = sensor sensitivity of channel i (i = x, y, z)

[mV/(V/m)<sup>2</sup>] for E-field Probes

$ConvF$  = sensitivity enhancement in solution

$a_{ij}$  = sensor sensitivity factors for H-field probes

$f$  = carrier frequency [GHz]

$E_i$  = electric field strength of channel i in V/m

$H_i$  = magnetic field strength of channel i in A/m

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

$$E_{tot} = (E_x^2 + E_y^2 + E_z^2)^{1/2}$$

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

$$SAR = (E_{tot}^2 \cdot \sigma) / (\epsilon \cdot 1000)$$

with SAR = local specific absorption rate in mW/g

$E_{tot}$  = total field strength in V/m

$\sigma$  = conductivity in [mho/m] or [Siemens/m]

$\epsilon$  = equivalent tissue density in g/cm<sup>3</sup>

Note that the density is normally set to 1 (or 1.06), to account for actual brain density rather than the density of the simulation liquid. The power flow density is calculated assuming the excitation field to be a free space field.

$$P_{pwe} = E_{tot}^2 / 3770 \text{ or } P_{pwe} = H_{tot}^2 \cdot 37.7$$

with  $P_{pwe}$  = equivalent power density of a plane wave in mW/cm<sup>2</sup>

$E_{tot}$  = total electric field strength in V/m

$H_{tot}$  = total magnetic field strength in A/m



### **3 Description of Test Position**

#### **3.1 The Body Test Position**

Devices must be tested for 1-g SAR on all surfaces and side edges with a transmitting antenna located at  $\leq 25$  mm from that surface or edge, at 5 mm separation from a flat phantom.





## 4 SAR System Verification Procedure

### 4.1 Tissue Simulate Liquid

#### 4.1.1 Recipes for Tissue Simulate Liquid

The following tables give the recipes for tissue simulating liquids to be used in different frequency bands:

Ingredients (% by weight)	Frequency (MHz)			
	450	835	1800-2000	2450
Tissue Type	Body	Body	Body	Body
Water	51.16	50.75	70.17	68.53
Salt (NaCl)	1.49	0.94	0.39	0.1
Sucrose	46.78	48.21	0	0
HEC	0.52	0	0	0
Bactericide	0.05	0.10	0	0
Tween	0	0	29.44	31.37
Salt: 99+% Pure Sodium Chloride                      Sucrose: 98+% Pure Sucrose				
Water: De-ionized, 16 MΩ <sup>+</sup> resistivity                      HEC: Hydroxyethyl Cellulose				
Tween: Polyoxyethylene (20) sorbitan monolaurate				
MSL5GHz is composed of the following ingredients:				
Water: 50-65%				
Mineral oil: 10-30%				
Emulsifiers: 8-25%				
Sodium salt: 0-1.5%				

Table 1 : Recipe of Tissue Simulate Liquid





#### 4.1.2 Measurement for Tissue Simulate Liquid

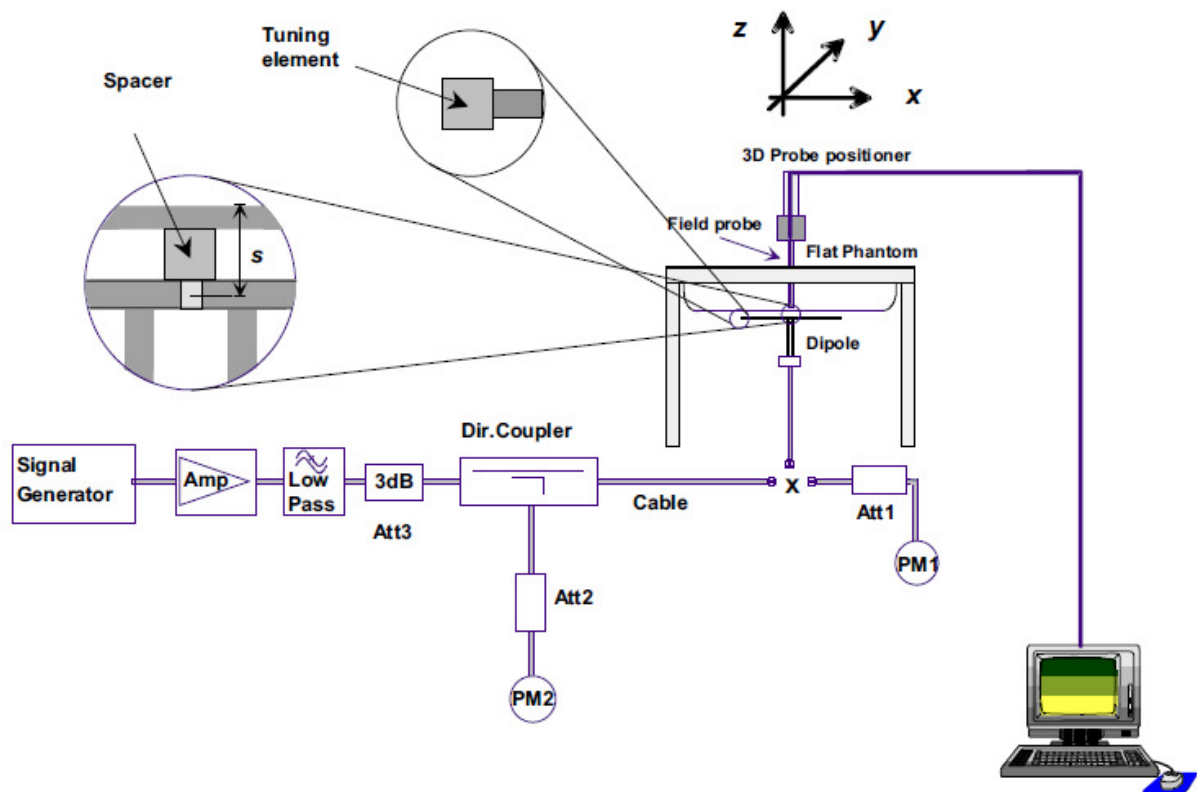
The dielectric properties for this Tissue Simulate Liquids were measured by using the Agilent Model 85070E Dielectric Probe in conjunction with Agilent E5071C Network Analyzer (300 KHz-8500 MHz). The Conductivity ( $\sigma$ ) and Permittivity ( $\rho$ ) are listed in Table 1. For the SAR measurement given in this report. The temperature variation of the Tissue Simulate Liquids was  $22 \pm 1^\circ\text{C}$ .

Tissue Type	Measured Frequency (MHz)	Target Tissue ( $\pm 5\%$ )		Measured Tissue		Liquid Temp. ( $^\circ\text{C}$ )	Measured Date
		$\epsilon_r$	$\sigma(\text{S/m})$	$\epsilon_r$	$\sigma(\text{S/m})$		
2450 Body	2450	52.70 (50.07~55.34)	1.95 (1.85~2.05)	51.93	1.978	21.9	2016/5/21
5200 Body	5200	49.01 (46.56~51.46)	5.30 (5.03~5.57)	47.697	5.259	21.9	2016/5/22
5800 Body	5800	48.2 (45.79~50.61)	6.00 (5.70~6.30)	46.363	6.153	22.5	2016/5/22

Table 2 : Measurement result of Tissue electric parameters

## 4.2 SAR System Validation

The microwave circuit arrangement for system verification is sketched in F-12. The daily system accuracy verification occurs within the flat section of the SAM phantom. A SAR measurement was performed to see if the measured SAR was within  $\pm 10\%$  from the target SAR values. The tests were conducted on the same days as the measurement of the EUT. The obtained results from the system accuracy verification are displayed in the table 5 (A power level of 250mw was input to the dipole antenna). During the tests, the ambient temperature of the laboratory was in the range  $22 \pm 1^\circ\text{C}$ , the relative humidity was in the range 60% and the liquid depth above the ear reference points was above 15 cm in all the cases. It is seen that the system is operating within its specification, as the results are within acceptable tolerance of the reference values.



F-3. the microwave circuit arrangement used for SAR system verification



#### **4.2.1 Justification for Extended SAR Dipole Calibrations**

1) Referring to KDB865664 D01 requirements for dipole calibration, instead of the typical annual calibration recommended by measurement standards, longer calibration intervals of up to three years may be considered when it is demonstrated that the SAR target, impedance and return loss of a dipole have remain stable according to the following requirements. Each measured dipole is expected to evaluate with the following criteria at least on annual interval in Appendix C.

- a) There is no physical damage on the dipole;
- b) System check with specific dipole is within 10% of calibrated value;
- c) Return-loss is within 10% of calibrated measurement;
- d) Impedance is within  $5\Omega$  from the previous measurement.

2) Network analyzer probe calibration against air, distilled water and a shorting block performed before measuring liquid parameters.



#### 4.2.2 Summary System Validation Result(s)

Validation Kit		Measured SAR 250mW	Measured SAR (normalized to 1w)	Target SAR (normalized to 1w) (±10%)	Liquid Temp. (°C)	Measured Date
		1g (W/kg)	1g (W/kg)	1-g(W/kg)		
D2450V2	Body	12.8	51.2	49.4 (44.46~54.34)	21.9	2016/5/21
Validation Kit		Measured SAR 100mW	Measured SAR (normalized to 1w)	Target SAR (normalized to 1w) (±10%)	Liquid Temp. (°C)	Measured Date
		10g (W/kg)	10g (W/kg)	10-g(W/kg)		
D5GHzV2	Body(5.2GHz)	7.68	76.8	74.2 (66.78~81.62)	22.3	2016/5/22
	Body(5.8GHz)	8.18	81.8	75.8 (68.22~83.38)	22.5	2016/5/22

Table 3 : SAR System Validation Result

#### 4.2.3 Detailed System Validation Results

Please see the Appendix A

## 5 Test results and Measurement Data

### 5.1.1 WiFi Test Configuration

A Wi-Fi device must be configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor supported by the test mode tools for SAR measurement.

#### 5.1.1.1 Initial Test Position SAR Test Reduction Procedure

DSSS and OFDM configurations are considered separately according to the required SAR procedures. SAR is measured in the initial test position using the 802.11 transmission mode configuration required by the DSSS procedure or initial test configuration and subsequent test configuration(s) according to the OFDM procedures. The initial test position procedure is described in the following:

- 1) . When the reported SAR of the initial test position is  $\leq 0.4$  W/kg, further SAR measurement is not required for the other (remaining) test positions in that exposure configuration and 802.11 transmission mode combinations within the frequency band or aggregated band. SAR is also not required for that exposure configuration in the subsequent test configuration(s).
- 2) . When the reported SAR of the initial test position is  $> 0.4$  W/kg, SAR is repeated for the 802.11 transmission mode configuration tested in the initial test position using subsequent highest extrapolated or estimated 1-g SAR conditions determined by area scans or next closest/smallest test separation distance and maximum RF coupling test positions based on manufacturer justification, on the highest maximum output power channel, until the reported SAR is  $\leq 0.8$  W/kg or all required test positions (left, right, touch, tilt or subsequent surfaces and edges) are tested.
- 3) . For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is  $> 0.8$  W/kg, SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is  $\leq 1.2$  W/kg or all required channels are tested. a) Additional power measurements may be required for this step, which should be limited to those necessary for identifying the subsequent highest output power channels.

#### 5.1.1.2 Initial Test Configuration Procedures

An initial test configuration is determined for OFDM transmission modes according to the channel bandwidth, modulation and data rate combination(s) with the highest maximum output power specified for production units in each standalone and aggregated frequency band. SAR is measured using the highest measured maximum output power channel. For configurations with the same specified or measured maximum output power, additional transmission mode and test channel selection procedures are required. SAR test reduction for subsequent highest output test channels is determined according to *reported* SAR of the initial test configuration.

For next to the ear, hotspot mode and UMC mini-tablet exposure configurations where multiple test positions are required, the initial test position procedure is applied to minimize the number of test positions required for SAR measurement using the initial test configuration transmission mode. For fixed exposure conditions that do not have multiple SAR test positions, SAR is measured in the transmission mode determined by the initial test configuration.

When the *reported* SAR of the initial test configuration is  $> 0.8$  W/kg, SAR measurement is required for subsequent next highest measured output power channel(s) in the initial test configuration until *reported* SAR is  $\leq 1.2$  W/kg or all required channels are tested.

#### 5.1.1.3 Subsequent Test Configuration Procedures

SAR measurement requirements for the remaining 802.11 transmission mode configurations that have not been tested in the initial test configuration are determined separately for each standalone and aggregated frequency band, in each exposure condition, according to the maximum output power specified for production units. The initial test position procedure is applied to next to the ear, UMPC mini-tablet and hotspot mode configurations. When the same maximum output power is specified for multiple transmission modes, additional power measurements may be required to determine if SAR measurements are required for subsequent highest output power channels in a subsequent test configuration. The subsequent test configuration and SAR measurement procedures are described in the following.



- 1) . When SAR test exclusion provisions of KDB Publication 447498 are applicable and SAR measurement is not required for the initial test configuration, SAR is also not required for the next highest maximum output power transmission mode subsequent test configuration(s) in that frequency band or aggregated band and exposure configuration.
- 2) . When the highest *reported* SAR for the initial test configuration (when applicable, include subsequent highest output channels), according to the initial test position or fixed exposure position requirements, is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is  $\leq 1.2$  W/kg, SAR is not required for that subsequent test configuration.
- 3) . The number of channels in the initial test configuration and subsequent test configuration can be different due to differences in channel bandwidth. When SAR measurement is required for a subsequent test configuration and the channel bandwidth is smaller than that in the initial test configuration, all channels in the subsequent test configuration that overlap with the larger bandwidth channel tested in the initial test configuration should be used to determine the highest maximum output power channel. This step requires additional power measurement to identify the highest maximum output power channel in the subsequent test configuration to determine SAR test reduction.
  - a) SAR should first be measured for the channel with highest measured output power in the subsequent test configuration.
  - b) SAR for subsequent highest measured maximum output power channels in the subsequent test configuration is required only when the *reported* SAR of the preceding higher maximum output power channel(s) in the subsequent test configuration is  $> 1.2$  W/kg or until all required channels are tested. i) For channels with the same measured maximum output power, SAR should be measured using the channel closest to the center frequency of the larger channel bandwidth channel in the initial test configuration.
- 4) . SAR measurements for the remaining highest specified maximum output power OFDM transmission mode configurations that have not been tested in the initial test configuration (highest maximum output) or subsequent test configuration(s) (subsequent next highest maximum output power) is determined by recursively applying the subsequent test configuration procedures in this section to the remaining configurations according to the following:
  - a) replace "subsequent test configuration" with "next subsequent test configuration" (i.e., subsequent next highest specified maximum output power configuration)
  - b) replace "initial test configuration" with "all tested higher output power configurations"

#### **5.1.1.4 2.4 GHz SAR Procedures**

Separate SAR procedures are applied to DSSS and OFDM configurations in the 2.4 GHz band to simplify DSSS test requirements. For 802.11b DSSS SAR measurements, DSSS SAR procedure applies to fixed exposure test position and initial test position procedure applies to multiple exposure test positions. When SAR measurement is required for an OFDM configuration, the initial test configuration, subsequent test configuration and initial test position procedures are applied. The SAR test exclusion requirements for 802.11g/n OFDM configurations are described in following.

##### **• 802.11b DSSS SAR Test Requirements**

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

- 1) . When the reported SAR of the highest measured maximum output power channel for the exposure configuration is  $\leq 0.8$  W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.
- 2) . When the reported SAR is  $> 0.8$  W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is  $> 1.2$  W/kg, SAR is required for the third channel; i.e., all channels require testing.

##### **• 2.4 GHz 802.11g/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 (section 5.3, including sub-sections). SAR is not required for the following 2.4 GHz OFDM conditions.

- 1) . When KDB Publication 447498 SAR test exclusion applies to the OFDM configuration.
- 2) . 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.





#### **5.1.1.5 Wi-Fi 5G SAR Test Procedures**

##### **A) U-NII-1 and U-NII-2A Bands**

For devices that operate in only one of the U-NII-1 and U-NII-2A bands, the normally required SAR procedures for OFDM configurations are applied. For devices that operate in both U-NII bands using the same transmitter and antenna(s), SAR test reduction is determined according to the following:

- 1) When the same maximum output power is specified for both bands, begin SAR measurement in U-NII-2A band by applying the OFDM SAR requirements. If the highest reported SAR for a test configuration is  $\leq 1.2$  W/kg, SAR is not required for U-NII-1 band for that configuration (802.11 mode and exposure condition); otherwise, both bands are tested independently for SAR.
- 2) When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest reported SAR for the tested configuration is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is  $\leq 1.2$  W/kg, SAR is not required for the band with lower maximum output power in that test configuration; otherwise, both bands are tested independently for SAR.
- 3) The two U-NII bands may be aggregated to support a 160 MHz channel on channel number 50. Without additional testing, the maximum output power for this is limited to the lower of the maximum output power certified for the two bands. When SAR measurement is required for at least one of the bands and the highest reported SAR adjusted by the ratio of specified maximum output power of aggregated to standalone band is  $> 1.2$  W/kg, SAR is required for the 160 MHz channel. This procedure does not apply to an aggregated band with maximum output higher than the standalone band(s); the aggregated band must be tested independently for SAR. SAR is not required when the 160 MHz channel is operating at a reduced maximum power and also qualifies for SAR test exclusion.

##### **B) OFDM Transmission Mode SAR Test Configuration and Channel Selection Requirements**

The initial test configuration for 2.4 GHz and 5 GHz OFDM transmission modes is determined by the 802.11 configuration with the highest maximum output power specified for production units, including tune-up tolerance, in each standalone and aggregated frequency band. SAR for the initial test configuration is measured using the highest maximum output power channel determined by the default power measurement procedures. When multiple configurations in a frequency band have the same specified maximum output power, the initial test configuration is determined according to the following steps applied sequentially.

- 1) The largest channel bandwidth configuration is selected among the multiple configurations with the same specified maximum output power.
  - 2) If multiple configurations have the same specified maximum output power and largest channel bandwidth, the lowest order modulation among the largest channel bandwidth configurations is selected.
  - 3) If multiple configurations have the same specified maximum output power, largest channel bandwidth and lowest order modulation, the lowest data rate configuration among these configurations is selected.
  - 4) When multiple transmission modes (802.11a/g/n/ac) have the same specified maximum output power, largest channel bandwidth, lowest order modulation and lowest data rate, the lowest order 802.11 mode is selected; i.e., 802.11a is chosen over 802.11n then 802.11ac or 802.11g is chosen over 802.11n.
- After an initial test configuration is determined, if multiple test channels have the same measured maximum output power, the channel chosen for SAR measurement is determined according to the following. These channel selection procedures apply to both the initial test configuration and subsequent test configuration(s), with respect to the default power measurement procedures or additional power measurements required for further SAR test reduction. The same procedures also apply to subsequent highest output power channel(s) selection.
- 1) The channel closest to mid-band frequency is selected for SAR measurement.
  - 2) For channels with equal separation from mid-band frequency; for example, high and low channels or two mid-band channels, the higher frequency (number) channel is selected for SAR measurement.

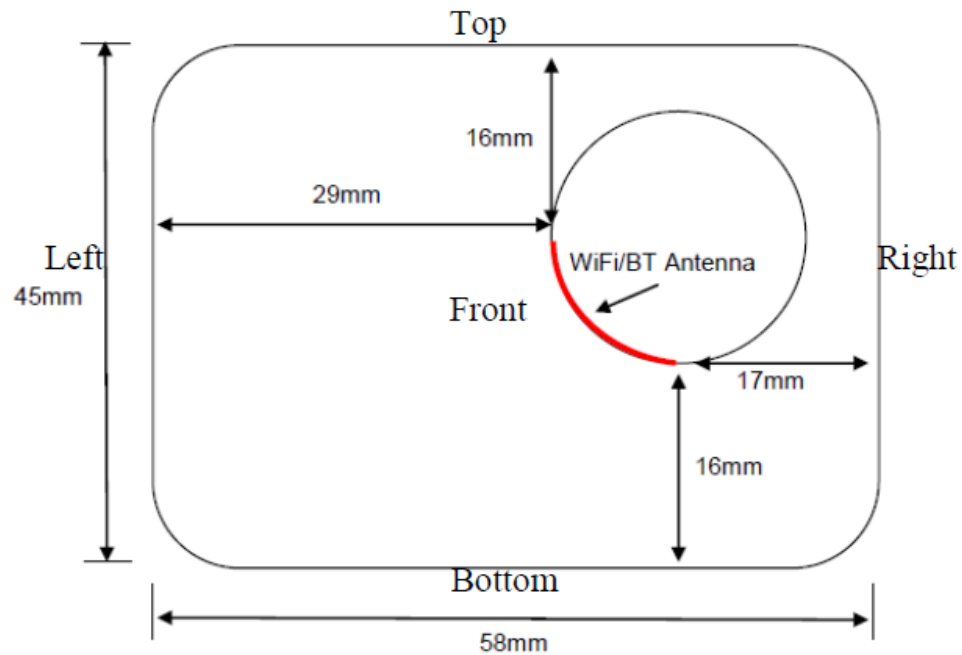


**C) SAR Test Requirements for OFDM configurations**

When SAR measurement is required for 802.11 a/g/n/ac OFDM configurations, each standalone and frequency aggregated band is considered separately for SAR test reduction. When the same transmitter and antenna(s) are used for U-NII-1 and U-NII-2A bands, additional SAR test reduction applies. When band gap channels between U-NII-2C band and 5.8 GHz U-NII-3 or §15.247 band are supported, the highest maximum output power transmission mode configuration and maximum output power channel across the bands must be used to determine SAR test reduction, according to the initial test configuration and subsequent test configuration requirements. In applying the initial test configuration and subsequent test configuration procedures, the 802.11 transmission configuration with the highest specified maximum output power and the channel within a test configuration with the highest measured maximum output power should be clearly distinguished to apply the procedures.



### 5.1.2 DUT Antenna Locations



### 5.1.3 EUT side for SAR Testing

Per Inquiry Tracking Number 613562 and KDB 941225 D07, devices must be tested for 1-g SAR on all surfaces and side edges with a transmitting antenna located at  $\leq 25$  mm from that surface or edge, at 5 mm separation from a flat phantom.

Antenna to surface or edge	front	back	left	right	top	bottom
Distance(mm)	<5mm	<5mm	29	17	16	16
Required test	YES	YES	NO	YES	YES	YES



## 5.2 Measurement of RF conducted Power

### 5.2.1 Conducted Power Of WIFI and BT

Wi-Fi 2450MHz	Average Power (dBm) for Data Rates (Mbps)								
	Channel	1	2	5.5	11	/	/	/	/
802.11b	1	<b>18.43</b>	18.42	18.23	18.14	/	/	/	/
	6	18.03	17.80	17.71	17.53	/	/	/	/
	11	18.09	18.10	18.09	17.93	/	/	/	/
802.11g	Channel	6	9	12	18	24	36	48	54
	1	14.26	14.14	13.92	13.89	14.06	13.81	13.95	13.87
	6	14.15	14.04	13.72	13.84	13.85	13.33	13.69	13.52
	11	14.32	14.16	14.01	13.75	14.17	13.46	13.62	13.35
802.11n HT20	Channel	6.5	13	19.5	26	39	52	58.5	65
	1	14.05	13.58	13.81	13.82	13.66	13.82	13.91	13.85
	6	13.99	13.49	13.28	13.91	13.46	13.59	13.48	13.41
	11	14.15	14.24	14.10	14.00	13.80	13.66	13.53	13.84
802.11n HT40	Channel	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
	3	13.27	13.06	12.93	12.72	12.88	12.55	12.40	12.54
	6	13.27	13.34	12.85	12.87	12.89	12.65	12.88	12.43
	9	13.37	13.04	12.94	12.80	13.35	12.82	13.13	13.12



Average Power (dBm) for Data Rates (Mbps)										
5GHz	mode	Channel	6	9	12	18	24	36	48	54
802.11a	U-NII-1	36	<b>7.87</b>	7.66	7.83	7.85	7.44	7.17	7.16	6.89
		40	7.65	7.63	7.73	7.55	7.28	7.39	6.97	6.88
		44	7.20	6.71	7.08	7.09	7.12	6.80	6.83	6.98
		48	7.58	6.36	7.48	6.92	6.66	6.67	6.69	6.97
	U-NII-3	149	<b>9.86</b>	9.98	9.18	9.50	9.19	9.32	8.84	8.67
		153	9.66	9.39	9.35	9.49	9.34	8.95	8.47	8.33
		157	8.83	8.57	8.58	8.36	8.41	8.39	8.27	8.18
		161	8.56	8.74	8.50	8.36	8.25	8.23	8.17	8.04
		165	8.48	8.35	8.30	8.14	8.04	8.16	8.12	8.08
5GHz	mode	Channel	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
802.11n- HT20	U-NII-1	36	7.01	7.09	6.84	7.05	6.99	6.48	6.80	6.67
		40	6.88	6.50	6.47	6.34	6.86	6.36	6.14	5.92
		44	6.69	6.61	6.19	6.21	6.60	6.15	6.34	6.09
		48	6.96	6.51	6.47	6.63	6.47	6.54	6.19	6.37
	U-NII-3	149	9.70	9.67	9.42	9.40	9.44	9.33	9.31	9.13
		153	9.27	9.31	9.30	9.30	8.91	8.80	8.71	8.59
		157	8.46	8.29	8.04	8.17	7.80	8.37	7.84	7.81
		161	8.35	8.55	7.92	8.29	8.09	8.13	8.05	7.62
		165	8.05	8.06	7.96	7.72	7.97	7.83	8.10	7.92
5GHz	mode	Channel	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
802.11n- HT40	U-NII-1	38	6.34	6.20	6.14	5.92	6.17	6.06	5.77	5.69
		46	6.54	6.38	6.48	6.47	6.04	6.08	5.95	5.96
	U-NII-3	151	8.93	8.42	8.13	8.27	8.66	8.68	8.29	8.08
		159	8.36	8.04	8.08	7.96	8.46	8.38	8.16	8.15



5GHz	mode	Channel	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
802.11ac 20M	U-NII-1	36	6.69	6.22	6.55	6.17	6.48	6.22	6.17	6.19
		40	6.74	6.67	5.91	6.02	6.20	6.08	5.81	5.83
		44	6.80	6.42	6.17	6.26	6.32	6.26	6.04	5.84
		48	6.79	6.31	6.52	6.59	6.55	6.28	6.14	6.01
	U-NII-3	149	9.42	8.91	9.53	9.28	9.43	8.91	9.06	8.94
		153	9.35	8.95	8.80	8.80	8.69	8.95	8.83	8.66
		157	8.42	8.02	8.08	7.97	8.31	8.15	7.81	8.06
		161	8.52	8.51	8.47	8.32	8.47	8.30	8.30	8.12
		165	8.05	8.06	7.96	7.72	7.97	7.83	8.10	7.92
5GHz	mode	Channel	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
802.11ac 40M	U-NII-1	38	6.27	6.04	6.32	6.01	5.98	5.85	5.80	5.84
		46	5.89	5.92	5.91	5.71	5.82	5.60	5.48	5.57
	U-NII-3	151	8.58	8.57	8.32	8.13	8.60	8.05	8.10	7.74
		159	7.64	7.47	7.18	7.40	7.41	7.50	7.62	7.40
5GHz	mode	Channel	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
802.11ac 80M	U-NII-1	42	4.10	4.09	3.73	3.94	3.87	4.07	3.77	3.99
	U-NII-3	155	6.51	6.29	6.39	6.10	6.13	6.10	6.07	5.86

Table 1: Conducted Power Of WIFI

BT		Average Conducted Power(dBm)		
Band	Channel	GFSK	$\pi/4$ DQPSK	8DPSK
BLE	0	0.60	/	/
	19	0.39	/	/
	39	0.14	/	/

Table 2: Conducted Power Of BT



## 5.3 Measurement of SAR Data

### 5.3.1 SAR Result Of WIFI (2.4GHz Band)

Test position	Test mode	Test Ch./Freq.	Duty Cycle	SAR (W/kg) 1-g	Power drift (dB)	Conducted power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp. (°C)	SAR limit (W/kg)
Body Test data(Separate 5mm)											
Front side	802.11b	1/2412	1:1	0.945	-0.08	18.43	19	1.140	<b>1.078</b>	22.4	1.6
Back side	802.11b	1/2412	1:1	0.181	-0.16	18.43	19	1.140	0.206	22.4	1.6
Right side	802.11b	1/2412	1:1	0.215	0.11	18.43	19	1.140	0.245	22.4	1.6
Top side	802.11b	1/2412	1:1	0.273	-0.15	18.43	19	1.140	0.311	22.4	1.6
Bottom side	802.11b	1/2412	1:1	0.313	-0.15	18.43	19	1.140	0.357	22.4	1.6
Front side	802.11b	6/2437	1:1	0.829	0.08	18.03	19	1.250	1.036	22.4	1.6
Front side	802.11b	11/2462	1:1	0.821	0.15	18.09	19	1.233	1.012	22.4	1.6
Front side - repeat	802.11b	1/2412	1:1	0.931	-0.09	18.43	19	1.140	1.062	22.4	1.6

Table 3: SAR of WIFI for Body

Note:

- 1) Test positions of EUT(the distance between the EUT and the phantom is 5mm for all sides)
- 2) The maximum Scaled SAR value is marked in bold. Graph results refer to Appendix B
- 3) Per FCC KDB Publication 447498 D01v06, if the reported (scaled) SAR measured at the middle channel or highest output power channel for each test configuration is  $\leq 0.8$  W/kg then testing at the other channels is not required for such test configuration(s).

Test Position	Channel/Frequency (MHz)	Measured SAR (1g)	1 <sup>st</sup> Repeated SAR (1g)	Ratio	2 <sup>nd</sup> Repeated SAR (1g)	3 <sup>rd</sup> Repeated SAR (1g)
Front side	1/2412	0.945	0.931	1.02	N/A	N/A

- Note: 1) When the original highest measured SAR is  $\geq 0.80$  W/kg, the measurement was repeated once.
- 2) A second repeated measurement was performed only if the ratio of largest to smallest SAR for the original and first repeated measurements was  $> 1.20$  or when the original or repeated measurement was  $\geq 1.45$  W/kg (~ 10% from the 1-g SAR limit).
- 3) A third repeated measurement was performed only if the original, first or second repeated measurement was  $\geq 1.5$  W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is  $> 1.20$ .
- 4) Repeated measurements are not required when the original highest measured SAR is  $< 0.80$  W/kg

Table 4: SAR Measurement Variability Results (Wi-Fi 2.4GHz Band )



Test position	Test mode	Test Ch./Freq.	Duty Cycle	SAR (W/kg) 1-g	Power drift(dB)	Conducted power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp. (°C)	SAR limit (W/kg)
Body Test data(Separate 5mm)											
Front side	802.11a	36/5180	1:1	<b>0.817</b>	-0.15	7.87	8	1.030	<b>0.842</b>	22.1	1.6
Back side	802.11a	36/5180	1:1	0.112	-0.15	7.87	8	1.030	0.115	22.1	1.6
Right side	802.11a	36/5180	1:1	0.136	-0.10	7.87	8	1.030	0.140	22.1	1.6
Top side	802.11a	36/5180	1:1	0.178	0.16	7.87	8	1.030	0.183	22.1	1.6
Bottom side	802.11a	36/5180	1:1	0.268	0.16	7.87	8	1.030	0.276	22.1	1.6
Front side	802.11a	40/5200	1:1	0.727	-0.09	7.65	8	1.085	0.789	22.1	1.6
Front side	802.11a	48/5240	1:1	0.734	0.16	7.58	8	1.102	0.809	22.1	1.6
Front side - repeat	802.11a	36/5180	1:1	0.806	-0.03	7.87	8	1.030	0.830	22.1	1.6

### 5.3.1 SAR Result Of WIFI (5.2GHz Band)

Table 5: SAR of WIFI for Body

Note:

- 1) Test positions of EUT(the distance between the EUT and the phantom is 5mm for all sides)
- 2) The maximum Scaled SAR value is marked in bold. Graph results refer to Appendix B
- 3) Per FCC KDB Publication 447498 D01v06, if the reported (scaled) SAR measured at the middle channel or highest output power channel for each test configuration is  $\leq 0.8$  W/kg then testing at the other channels is not required for such test configuration(s).

Test Position	Channel/Frequency (MHz)	Measured SAR (1g)	1 <sup>st</sup> Repeated SAR (1g)	Ratio	2 <sup>nd</sup> Repeated SAR (1g)	3 <sup>rd</sup> Repeated SAR (1g)
Front side	36/5180	0.817	0.806	1.01	N/A	N/A

Note: 1) When the original highest measured SAR is  $\geq 0.80$  W/kg, the measurement was repeated once.

2) A second repeated measurement was performed only if the ratio of largest to smallest SAR for the original and first repeated measurements was  $> 1.20$  or when the original or repeated measurement was  $\geq 1.45$  W/kg (~ 10% from the 1-g SAR limit).

3) A third repeated measurement was performed only if the original, first or second repeated measurement was  $\geq 1.5$  W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is  $> 1.20$ .

4) Repeated measurements are not required when the original highest measured SAR is  $< 0.80$  W/kg

Table 6: SAR Measurement Variability Results (Wi-Fi 5.2GHz Band)



### 5.3.1 SAR Result Of WIFI (5.8GHz Band)

Test position	Test mode	Test Ch./Freq.	Duty Cycle	SAR (W/kg) 1-g	Power drift (dB)	Conducted power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp. (°C)	SAR limit (W/kg)
Body Test data(Separate 5mm)											
Front Side	802.11a	149/5745	1:1	<b>0.923</b>	0.06	9.86	10.5	1.159	<b>1.070</b>	22.1	1.6
Back Side	802.11a	149/5745	1:1	0.112	0.06	9.86	10.5	1.159	0.130	22.1	1.6
Right Side	802.11a	149/5745	1:1	0.134	-0.04	9.86	10.5	1.159	0.155	22.1	1.6
Top Side	802.11a	149/5745	1:1	0.182	0.13	9.86	10.5	1.159	0.211	22.1	1.6
Bottom	802.11a	149/5745	1:1	0.235	0.13	9.86	10.5	1.159	0.272	22.1	1.6
Front side	802.11a	153/5765	1:1	0.872	0.19	9.66	10.5	1.213	1.058	22.1	1.6
Front side	802.11a	165/5825	1:1	0.613	-0.12	8.48	10.5	1.592	0.976	22.1	1.6
Front side - repeat	802.11a	149/5745	1:1	0.913	-0.17	9.86	10.5	1.159	1.058	22.1	1.6

Table 7: SAR of WIFI for Body

Note:

- 1) Test positions of EUT(the distance between the EUT and the phantom is 5mm for all sides)
- 2) The maximum Scaled SAR value is marked in bold. Graph results refer to Appendix B
- 3) Per FCC KDB Publication 447498 D01v06, if the reported (scaled) SAR measured at the middle channel or highest output power channel for each test configuration is  $\leq 0.8$  W/kg then testing at the other channels is not required for such test configuration(s).

Test Position	Channel/Frequency (MHz)	Measured SAR (1g)	1 <sup>st</sup> Repeated SAR (1g)	Ratio	2 <sup>nd</sup> Repeated SAR (1g)	3 <sup>rd</sup> Repeated SAR (1g)
Front side	149/5745	0.923	0.913	1.01	N/A	N/A

- Note: 1) When the original highest measured SAR is  $\geq 0.80$  W/kg, the measurement was repeated once.
- 2) A second repeated measurement was performed only if the ratio of largest to smallest SAR for the original and first repeated measurements was  $> 1.20$  or when the original or repeated measurement was  $\geq 1.45$  W/kg ( $\sim 10\%$  from the 1-g SAR limit).
- 3) A third repeated measurement was performed only if the original, first or second repeated measurement was  $\geq 1.5$  W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is  $> 1.20$ .
- 4) Repeated measurements are not required when the original highest measured SAR is  $< 0.80$  W/kg

Table 8: SAR Measurement Variability Results (Wi-Fi 5.2GHz Band)



## 5.4 Multiple Transmitter Evaluation

### 5.4.1 Simultaneous SAR test evaluation

#### 1) Simultaneous Transmission

NO.	Simultaneous Transmission Configuration	Body
1	BT+ Wi-Fi (They share the same antenna and cannot transmit at the same time by design.)	NO





## 6 Equipment list

Test Platform		SPEAG DASY5 Professional				
Location		SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch E&E Lab				
Description		SAR Test System (Frequency range 300MHz-6GHz)				
Software Reference		DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)				
Hardware Reference						
Equipment		Manufacturer	Model	Serial Number	Calibration Date	Due date of calibration
<input checked="" type="checkbox"/>	Robot	Staubli	RX90L	F03/5V32A1/A01	NCR	NCR
<input checked="" type="checkbox"/>	Twin Phantom	SPEAG	SAM 1	TP-1283	NCR	NCR
<input checked="" type="checkbox"/>	Flat Phantom	SPEAG	ELI 5.0	1128	NCR	NCR
<input checked="" type="checkbox"/>	DAE	SPEAG	DAE3	569	2015-11-24	2016-11-23
<input checked="" type="checkbox"/>	E-Field Probe	SPEAG	EX3DV4	3962	2015-11-27	2016-11-26
<input type="checkbox"/>	Validation Kits	SPEAG	D835V2	4d015	2013-11-25	2016-11-24
<input type="checkbox"/>	Validation Kits	SPEAG	D1900V2	184	2013-11-27	2016-11-26
<input checked="" type="checkbox"/>	Validation Kits	SPEAG	D2450V2	733	2013-11-26	2016-11-25
<input checked="" type="checkbox"/>	Validation Kits	SPEAG	D5GHzV2	1165	2013-12-11	2016-12-10
<input checked="" type="checkbox"/>	Agilent Network Analyzer	Agilent	E5071C	MY46523590	2016-03-08	2017-03-08
<input checked="" type="checkbox"/>	Dielectric Probe Kit	Agilent	85070E	US01440210	NCR	NCR
<input type="checkbox"/>	Universal Radio Communication Tester	R&S	CMU200	123090	2015-10-23	2016-10-23
<input type="checkbox"/>	Universal Radio Communication Tester	R&S	CMW500	152271	2016-03-08	2017-03-08
<input checked="" type="checkbox"/>	RF Bi-Directional Coupler	Agilent	86205-60001	MY31400031	NCR	NCR
<input checked="" type="checkbox"/>	Signal Generator	Agilent	N5171B	MY53050736	2016-03-08	2017-03-08
<input checked="" type="checkbox"/>	Preamplifier	Mini-Circuits	ZHL-42W	15542	NCR	NCR
<input checked="" type="checkbox"/>	Power Meter	Agilent	E4416A	GB41292095	2016-03-08	2017-03-08
<input checked="" type="checkbox"/>	Power Sensor	Agilent	8481H	MY41091234	2016-03-08	2017-03-08
<input checked="" type="checkbox"/>	Power Sensor	R&S	NRP-Z92	100025	2016-03-08	2017-03-08
<input checked="" type="checkbox"/>	Attenuator	SHX	TS2-3dB	30704	NCR	NCR
<input checked="" type="checkbox"/>	Coaxial low pass filter	Mini-Circuits	VLF-2500(+)	NA	NCR	NCR
<input checked="" type="checkbox"/>	Coaxial low pass filter	Microlab Fxr	LA-F13	NA	NCR	NCR
<input checked="" type="checkbox"/>	50 Ω coaxial load	Mini-Circuits	KARN-50+	00850	NCR	NCR
<input checked="" type="checkbox"/>	DC POWER SUPPLY	SAKO	SK1730SL 5A	NA	NCR	NCR



## 7 Measurement Uncertainty

Measurements and results are all in compliance with the standards listed in section 12 of this report. All measurements and results are recorded and maintained at the laboratory performing the tests and measurement uncertainties are taken into account when comparing measurements to pass/ fail criteria. The Expanded uncertainty (95% CONFIDENCE INTERVAL) is **21.36%**.

A	b1	c	d	e = f(d,k)	g	i = C*g/e	k
Uncertainty Component	Section in P1528	Tol (%)	Prob . Dist.	Div.	Ci (1g)	1g ui (%)	Vi (Veff)
Probe calibration	E.2.1	6.3	N	1	1	6.30	∞
Axial isotropy	E.2.2	0.5	R	$\sqrt{3}$	$(1 - C_p)^{1/2}$	0.20	∞
hemispherical isotropy	E.2.2	2.6	R	$\sqrt{3}$	$\sqrt{C_p}$	1.06	∞
Boundary effect	E.2.3	1.0	R	$\sqrt{3}$	1	0.58	∞
Linearity	E.2.4	0.6	R	$\sqrt{3}$	1	0.35	∞
System detection limit	E.2.5	0.25	R	$\sqrt{3}$	1	0.14	∞
Readout electronics	E.2.6	0.3	N	1	1	0.30	∞
Response time	E.2.7	0	R	$\sqrt{3}$	1	0.00	∞
Integration time	E.2.8	2.6	R	$\sqrt{3}$	1	1.50	∞
RF ambient Condition –Noise	E.6.1	3	R	$\sqrt{3}$	1	1.73	∞
RF ambient Condition - reflections	E.6.1	3	R	$\sqrt{3}$	1	1.73	∞
Probe positioning- mechanical tolerance	E.6.2	1.5	R	$\sqrt{3}$	1	0.87	∞
Probe positioning- with respect to phantom	E.6.3	2.9	R	$\sqrt{3}$	1	1.67	∞
Max. SAR evaluation	E.5.2	1	R	$\sqrt{3}$	1	0.58	∞
Test sample positioning	E.4.2	3.7	N	1	1	3.70	9
Device holder uncertainty	E.4.1	3.6	N	1	1	3.60	∞
Output power variation –SAR drift measurement	6.6.2	5	R	$\sqrt{3}$	1	2.89	∞
Phantom uncertainty (shape and thickness tolerances)	E.3.1	4	R	$\sqrt{3}$	1	2.31	∞
Liquid conductivity - deviation from target values	E.3.2	5	R	$\sqrt{3}$	0.64	1.85	∞
Liquid conductivity - measurement uncertainty	E.3.2	5.78	N	1	0.64	3.68	5
Liquid permittivity - deviation from target values	E.3.3	5	R	$\sqrt{3}$	0.6	1.73	∞



Liquid permittivity - measurement uncertainty	E.3.3	0.62	N	1	0.6	0.372	5
Combined standard uncertainty				RSS		10.68	430
Expanded uncertainty (95% CONFIDENCE INTERVAL)				K=2		<b>21.36</b>	

Table 9 : Measurement Uncertainty

## 8 Calibration certificate

Please see the Appendix C

## 9 Photographs

Please see the Appendix D



## **Appendix A: Detailed System Validation Results**

## **Appendix B: Detailed Test Results**

## **Appendix C: Calibration certificate**

## **Appendix D: Photographs**

**---END---**

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# **Appendix A**

## **Detailed System Validation Results**

1. System Performance Check for Body
System Performance Check 2450MHz Body
System Performance Check D5.2GHz Body
System Performance Check D5.8GHz Body

Test Laboratory: SGS-SAR Lab

## System Performance Check 2450MHz Body

**DUT: D2450V2; Type: D2450V2; Serial: 733**

Communication System: UID 0, CW; Frequency: 2450 MHz; Duty Cycle: 1:1

Medium: MSL2450; Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.978$  S/m;  $\epsilon_r = 51.93$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY 5 Configuration:

- Probe: EX3DV4 - SN3962; ConvF(7.7, 7.7, 7.7); Calibrated: 2015-11-27;
- Sensor-Surface: 4mm (Mechanical Surface Detection),  $z = 1.0, 31.0$
- Electronics: DAE3 Sn569; Calibrated: 2015-11-24
- Phantom: SAM 1; Type: SAM V4.0; Serial: TP-1283
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Body/d=10mm, Pin=250mW/Area Scan (8x11x1):** Measurement grid:  $dx=12$ mm,  $dy=12$ mm

Maximum value of SAR (measured) = 17.8 W/kg

**Body/d=10mm, Pin=250mW/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid:

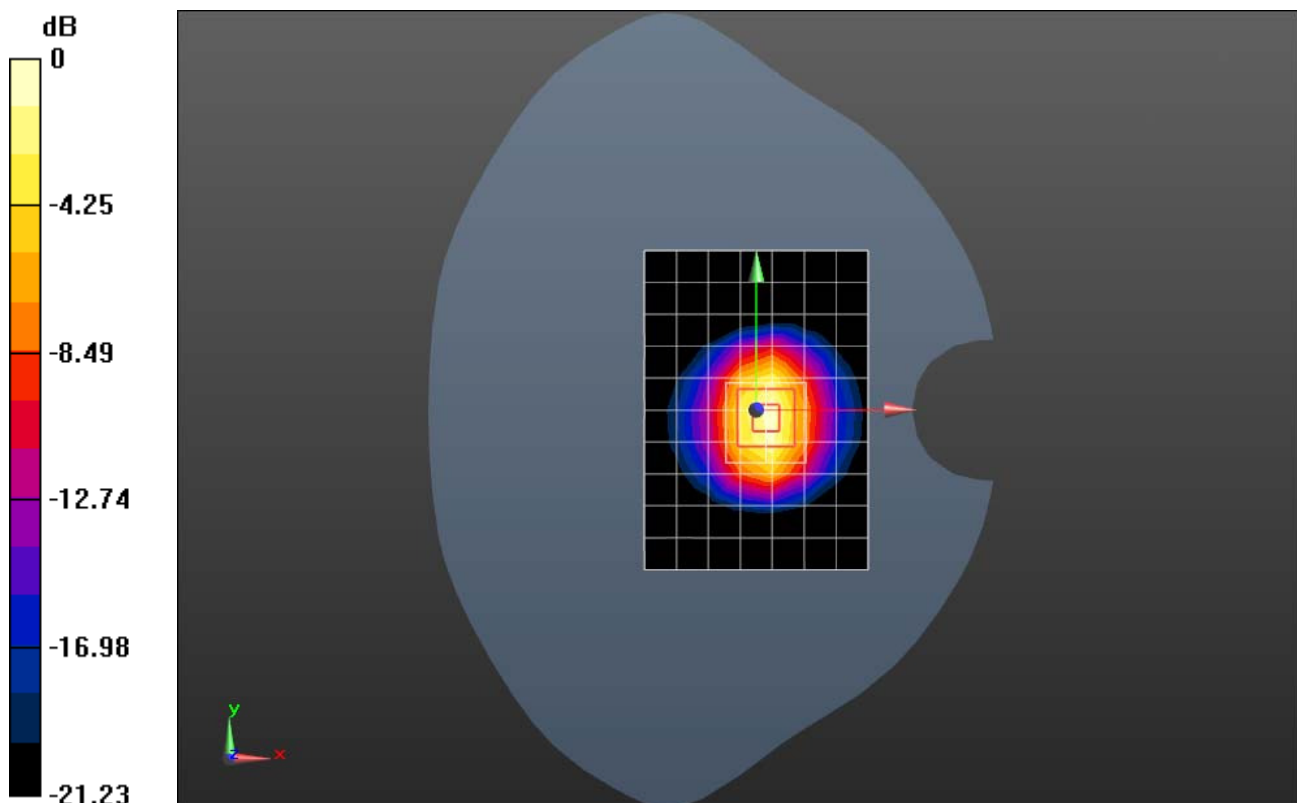
$dx=5$ mm,  $dy=5$ mm,  $dz=5$ mm

Reference Value = 92.59 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 36.4 W/kg

**SAR(1 g) = 12.8 W/kg; SAR(10 g) = 5.86 W/kg**

Maximum value of SAR (measured) = 19.3 W/kg



$$0 \text{ dB} = 19.3 \text{ W/kg} = 12.86 \text{ dBW/kg}$$



Test Laboratory: SGS-SAR Lab

## System Performance Check D5.2GHz Body

**DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: 1165**

Communication System: UID 0, CW (0); Frequency: 5200 MHz; Duty Cycle: 1:1

Medium: MSL5GHz; Medium parameters used:  $f = 5200$  MHz;  $\sigma = 5.259$  S/m;  $\epsilon_r = 47.697$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY 5 Configuration:

- Probe: EX3DV4 - SN3962; ConvF(4.15, 4.15, 4.15); Calibrated: 2015-11-27;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection),  $z = 1.0, 25.0$
- Electronics: DAE3 Sn569; Calibrated: 2015-11-24
- Phantom: ELI V5.0; Type: ELI; Serial: 1128
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Body/d=10mm, Pin=100mW, f=5200 MHz/Area Scan (10x10x1):** Measurement grid:

$dx=10$ mm,  $dy=10$ mm

Maximum value of SAR (measured) = 18.1 W/kg

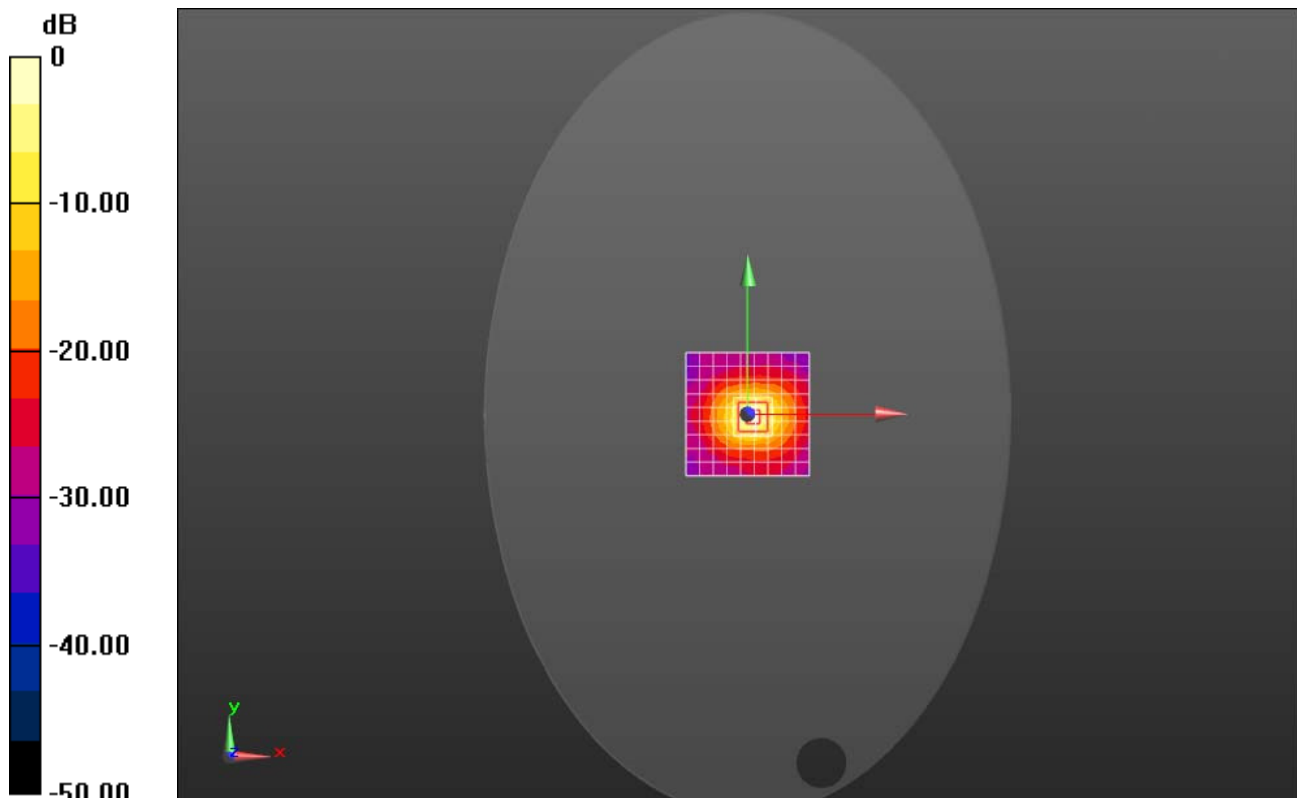
**Body/d=10mm, Pin=100mW, f=5200 MHz/Zoom Scan (4x4x1.4mm, graded),**

**dist=1.4mm (8x8x7)/Cube 0:** Measurement grid:  $dx=4$ mm,  $dy=4$ mm,  $dz=1.4$ mm

Reference Value = 61.40 V/m; Power Drift = -0.16 dB

Peak SAR (extrapolated) = 32.3 W/kg

**SAR(1 g) = 7.68 W/kg; SAR(10 g) = 2.12 W/kg**



$$0 \text{ dB} = 18.1 \text{ W/kg} = 12.58 \text{ dBW/kg}$$

Test Laboratory: SGS-SAR Lab

## System Performance Check D5.8GHz Body

**DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: 1165**

Communication System: UID 0, CW (0); Frequency: 5800 MHz; Duty Cycle: 1:1

Medium: MSL5GHz; Medium parameters used:  $f = 5800 \text{ MHz}$ ;  $\sigma = 6.153 \text{ S/m}$ ;  $\epsilon_r = 46.363$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

DASY 5 Configuration:

- Probe: EX3DV4 - SN3962; ConvF(3.7, 3.7, 3.7); Calibrated: 2015-11-27;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection),  $z = 1.0, 25.0$
- Electronics: DAE3 Sn569; Calibrated: 2015-11-24
- Phantom: ELI V5.0; Type: ELI; Serial: 1128
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Body/d=10mm, Pin=100mW, f=5800 MHz/Area Scan (10x10x1):** Measurement grid:

$dx=10\text{mm}$ ,  $dy=10\text{mm}$

Maximum value of SAR (measured) = 20.8 W/kg

**Body/d=10mm, Pin=100mW, f=5800 MHz/Zoom Scan (4x4x1.4mm, graded),**

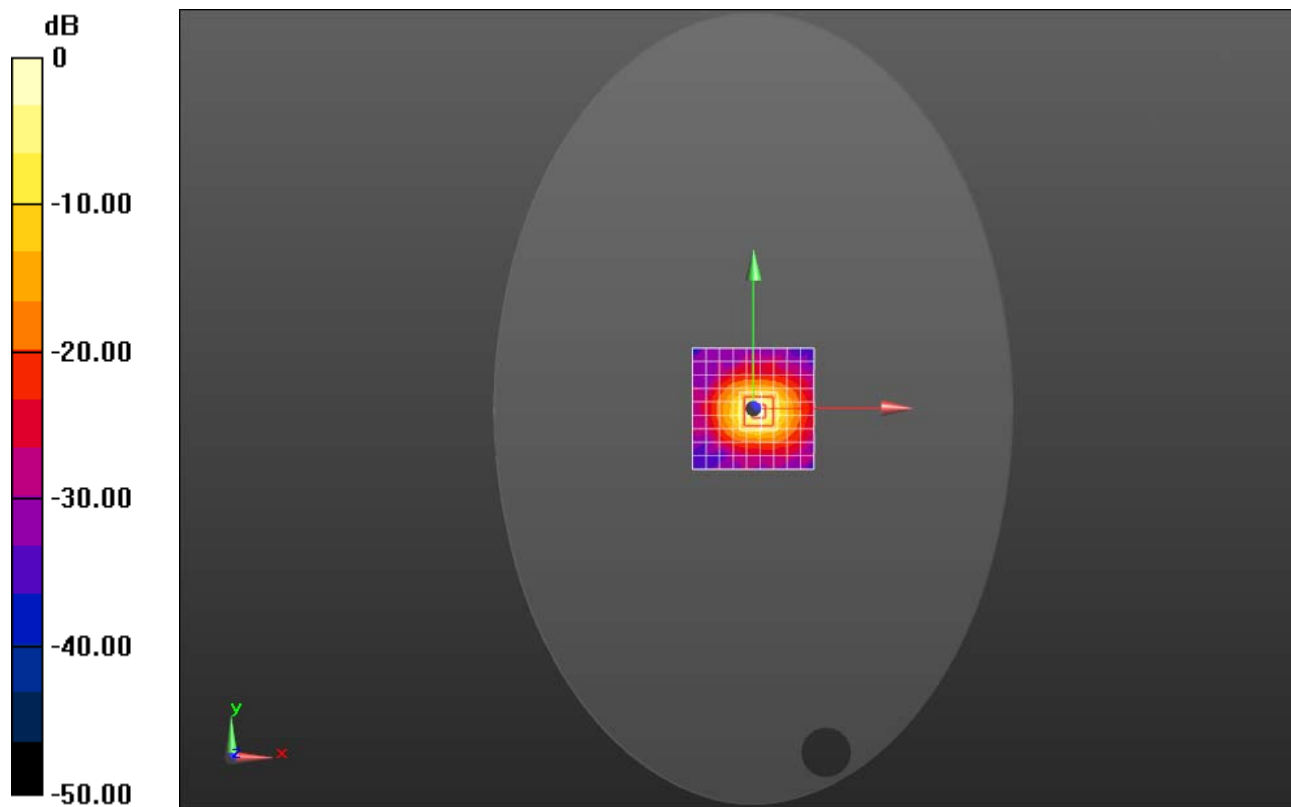
**dist=1.4mm (8x8x7)/Cube 0:** Measurement grid:  $dx=4\text{mm}$ ,  $dy=4\text{mm}$ ,  $dz=1.4\text{mm}$

Reference Value = 60.17 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 37.9 W/kg

**SAR(1 g) = 8.18 W/kg; SAR(10 g) = 2.24 W/kg**

Maximum value of SAR (measured) = 21.1 W/kg



0 dB = 21.1 W/kg = 13.24 dBW/kg



# Appendix B

## Detailed Test Results

1. WIFI
WIFI 802.11b 1CH for Body
WIFI 802.11a 36CH for Body
WIFI 802.11a 149CH for Body

Test Laboratory: SGS-SAR Lab

## CS-SP208 WI-FI 802.11b 1CH Front Side 5mm

**DUT: CS-SP208; Type: Action Camera; Serial: NA**

Communication System: UID 0, WI-FI(2.4GHz) (0); Frequency: 2412 MHz;Duty Cycle: 1:1

Medium: MSL2450;Medium parameters used:  $f = 2412$  MHz;  $\sigma = 1.931$  S/m;  $\epsilon_r = 51.975$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY 5 Configuration:

- Probe: EX3DV4 - SN3962; ConvF(7.7, 7.7, 7.7); Calibrated: 2015-11-27;
- Sensor-Surface: 4mm (Mechanical Surface Detection),  $z = 1.0, 31.0$
- Electronics: DAE3 Sn569; Calibrated: 2015-11-24
- Phantom: SAM 1; Type: SAM V4.0; Serial: TP-1283
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Configuration/Body/Area Scan (6x8x1):** Measurement grid:  $dx=12$ mm,  $dy=12$ mm

Maximum value of SAR (measured) = 0.821 W/kg

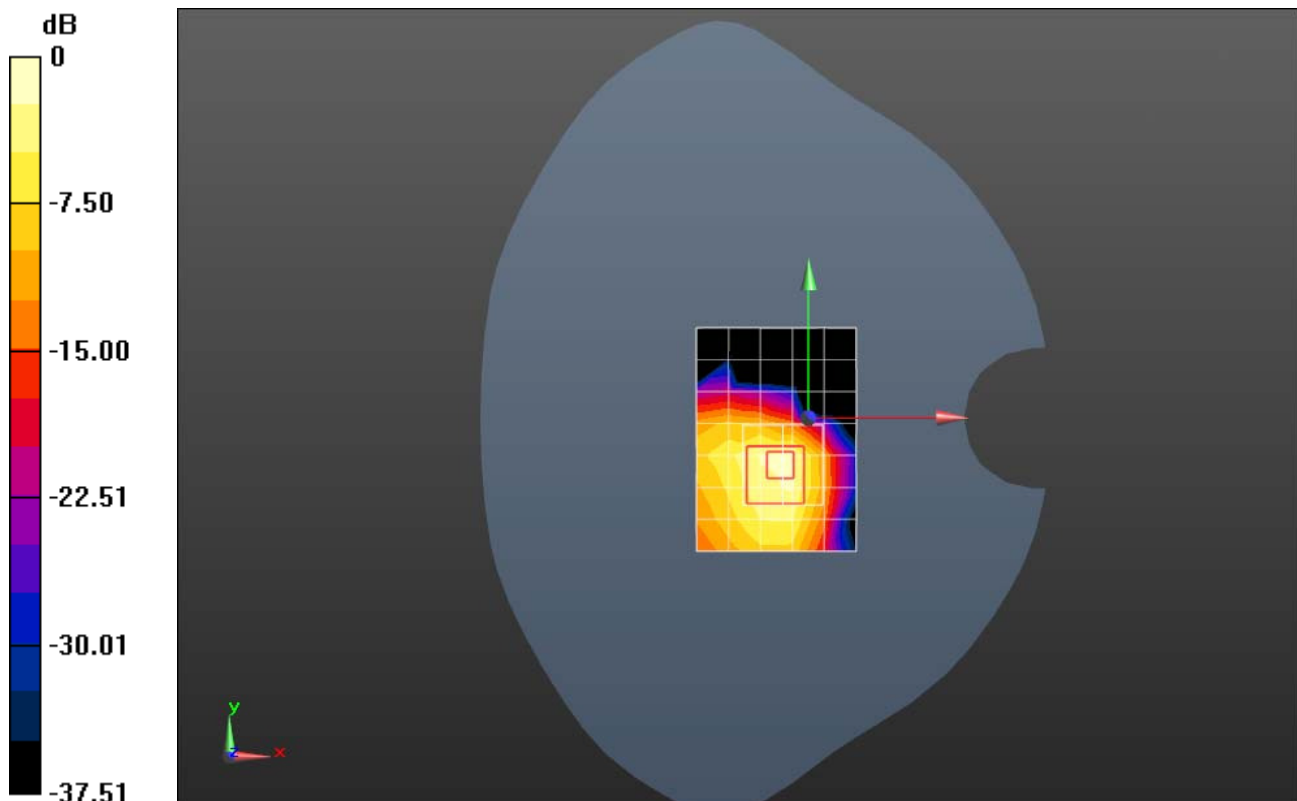
**Configuration/Body/Zoom Scan (7x7x7)/Cube 0:** Measurement grid:  $dx=5$ mm,  $dy=5$ mm,  $dz=5$ mm

Reference Value = 6.014 V/m; Power Drift = 0.08 dB

Peak SAR (extrapolated) = 2.57 W/kg

**SAR(1 g) = 0.945 W/kg; SAR(10 g) = 0.412 W/kg**

Maximum value of SAR (measured) = 1.21 W/kg



$$0 \text{ dB} = 1.21 \text{ W/kg} = 0.828 \text{ dBW/kg}$$



Test Laboratory: SGS-SAR Lab

## CS-SP208 WI-FI 802.11a 36CH Front side 5mm

**DUT: CS-SP208; Type: Action Camera; Serial: NA**

Communication System: UID 0, WI-FI(5GHz) (0); Frequency: 5180 MHz;Duty Cycle: 1:1

Medium: MSL5G;Medium parameters used:  $f = 5180$  MHz;  $\sigma = 5.238$  S/m;  $\epsilon_r = 47.785$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section

DASY 5 Configuration:

- Probe: EX3DV4 - SN3962; ConvF(4.15, 4.15, 4.15); Calibrated: 2015-11-27;
- Sensor-Surface: 2mm (Mechanical Surface Detection),  $z = 1.0, 23.0$
- Electronics: DAE3 Sn569; Calibrated: 2015-11-24
- Phantom: ELI V5.0; Type: ELI; Serial: 1128
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Configuration/Body/Area Scan (7x10x1):** Measurement grid:  $dx=10$ mm,  $dy=10$ mm

Maximum value of SAR (measured) = 1.52 W/kg

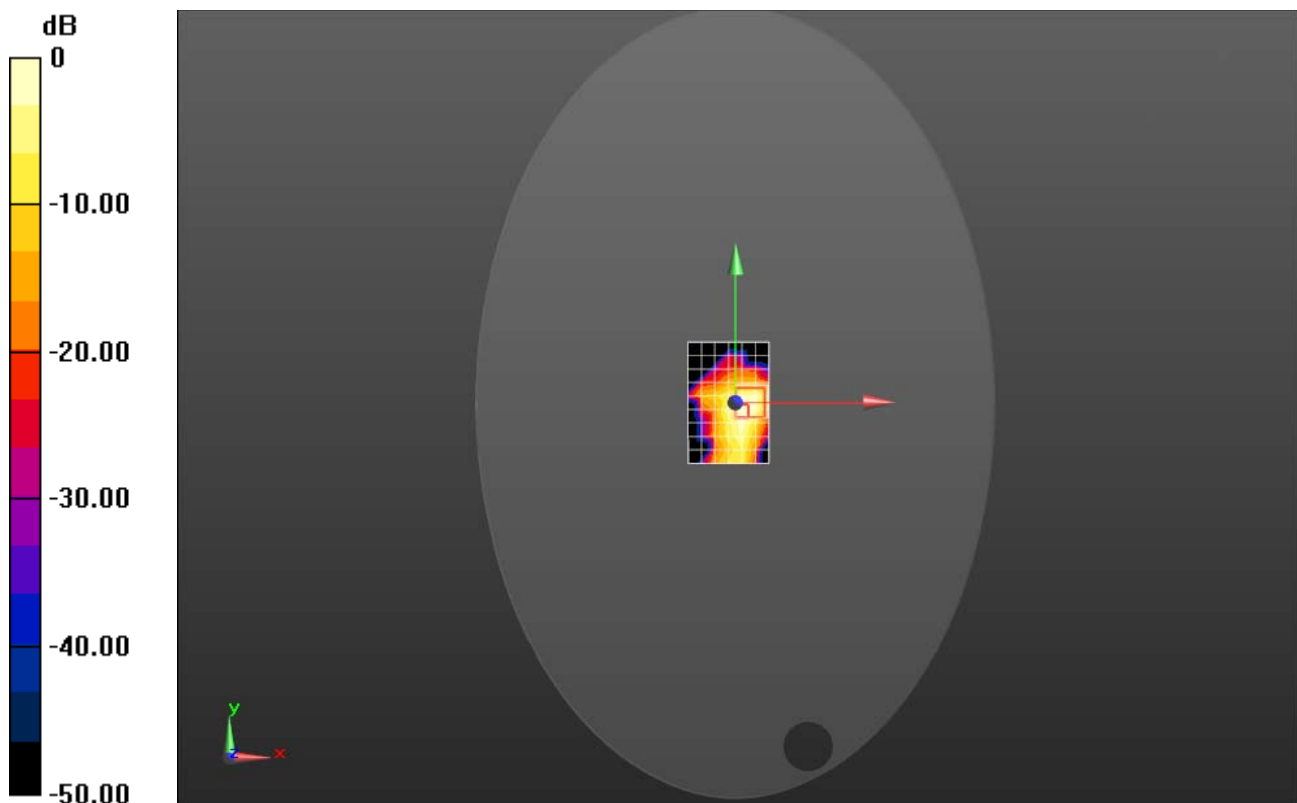
**Configuration/Body/Zoom Scan (7x7x12)/Cube 0:** Measurement grid:  $dx=4$ mm,  $dy=4$ mm,  $dz=2$ mm

Reference Value = 11.87 V/m; Power Drift = -0.15 dB

Peak SAR (extrapolated) = 3.80 W/kg

**SAR(1 g) = 0.817 W/kg; SAR(10 g) = 0.167 W/kg**

Maximum value of SAR (measured) = 1.56 W/kg



$$0 \text{ dB} = 1.56 \text{ W/kg} = 1.93 \text{ dBW/kg}$$

Test Laboratory: SGS-SAR Lab

## **CS-SP208 WI-FI 802.11a 149CH Front side 5mm**

**DUT: CS-SP208; Type: Action Camera; Serial: NA**

Communication System: UID 0, WI-FI(5GHz) (0); Frequency: 5745 MHz;Duty Cycle: 1:1

Medium: MSL5G;Medium parameters used (interpolated):  $f = 5745$  MHz;  $\sigma = 6.1$  S/m;  $\epsilon_r = 46.462$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY 5 Configuration:

- Probe: EX3DV4 - SN3962; ConvF(3.7, 3.7, 3.7); Calibrated: 2015-11-27;
- Sensor-Surface: 2mm (Mechanical Surface Detection),  $z = 1.0, 23.0$
- Electronics: DAE3 Sn569; Calibrated: 2015-11-24
- Phantom: ELI V5.0; Type: ELI; Serial: 1128
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Configuration/Body/Area Scan (7x10x1):** Measurement grid:  $dx=10$ mm,  $dy=10$ mm

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 0.996 W/kg

**Configuration/Body/Zoom Scan (7x7x12)/Cube 0:** Measurement grid:  $dx=4$ mm,  $dy=4$ mm,  $dz=2$ mm

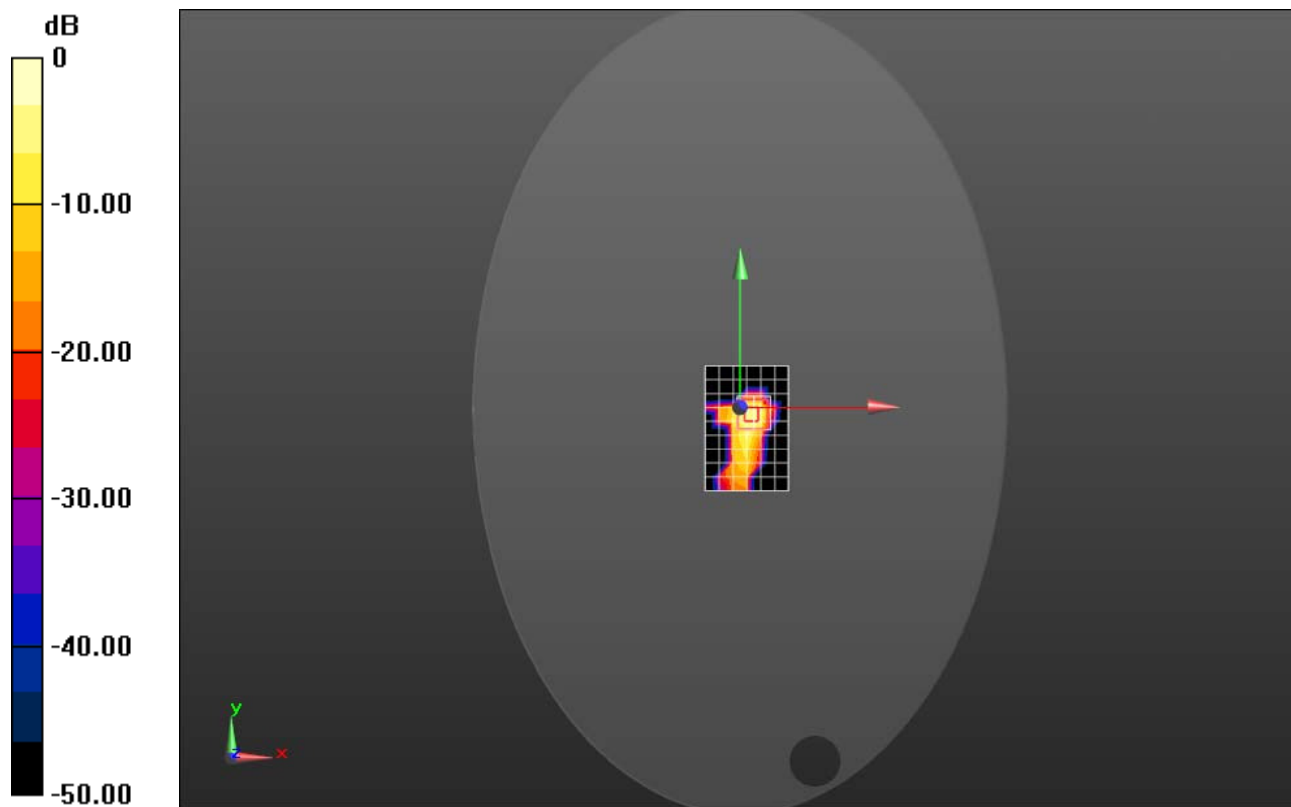
Reference Value = 5.849 V/m; Power Drift = 0.19 dB

Peak SAR (extrapolated) = 4.43 W/kg

**SAR(1 g) = 0.923 W/kg; SAR(10 g) = 0.210 W/kg**

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 2.13 W/kg





# Appendix C

## Calibration certificate

1. Dipole
D2450V2-SN 733(2013-11-26)
D5GHzV2-SN 1165(2013-12-11)
2. DAE
DAE3-SN 569(2015-11-24)
3. Probe
EX3DV4-SN 3962(2015-11-27)



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Accreditation No.: **SCS 108**

The Swiss Accreditation Service is one of the signatories to the EA  
 Multilateral Agreement for the recognition of calibration certificates

Client **SGS-SZ (Auden)**

Certificate No: **D2450V2-733\_Nov13**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 733**

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

Calibration date: **November 26, 2013**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	09-Oct-13 (No. 217-01827)	Oct-14
Power sensor HP 8481A	US37292783	09-Oct-13 (No. 217-01827)	Oct-14
Power sensor HP 8481A	MY41092317	09-Oct-13 (No. 217-01828)	Oct-14
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-13 (No. 217-01736)	Apr-14
Type-N mismatch combination	SN: 5047.3 / 06327	04-Apr-13 (No. 217-01739)	Apr-14
Reference Probe ES3DV3	SN: 3205	28-Dec-12 (No. ES3-3205_Dec12)	Dec-13
DAE4	SN: 601	25-Apr-13 (No. DAE4-601_Apr13)	Apr-14
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-15
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-13)	In house check: Oct-14

Calibrated by: **Name** **Function**  
**Claudio Leubler** **Laboratory Technician**

Signature

Approved by: **Katja Pokovic** **Technical Manager**

Issued: November 26, 2013

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





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Accreditation No.: **SCS 108**

### Glossary:

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

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

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

### Additional Documentation:

- DASY4/5 System Handbook

### Methods Applied and Interpretation of Parameters:

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

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



## Measurement Conditions

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

DASY Version	DASY5	V52.8.7
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	39.7 $\pm$ 6 %	1.84 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.2 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.4 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.10 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.3 W/kg $\pm$ 16.5 % (k=2)

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	52.1 $\pm$ 6 %	2.02 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.6 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	49.4 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.81 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.0 W/kg $\pm$ 16.5 % (k=2)

## Appendix

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	$54.2 \Omega + 2.5 j\Omega$
Return Loss	- 26.6 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	$51.0 \Omega + 4.2 j\Omega$
Return Loss	- 27.5 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.149 ns
----------------------------------	----------

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

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

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

### Additional EUT Data

Manufactured by	SPEAG
Manufactured on	May 07, 2003



## DASY5 Validation Report for Head TSL

Date: 26.11.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 733**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.84$  S/m;  $\epsilon_r = 39.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.52, 4.52, 4.52); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

### **Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (8x7x7)/Cube 0:**

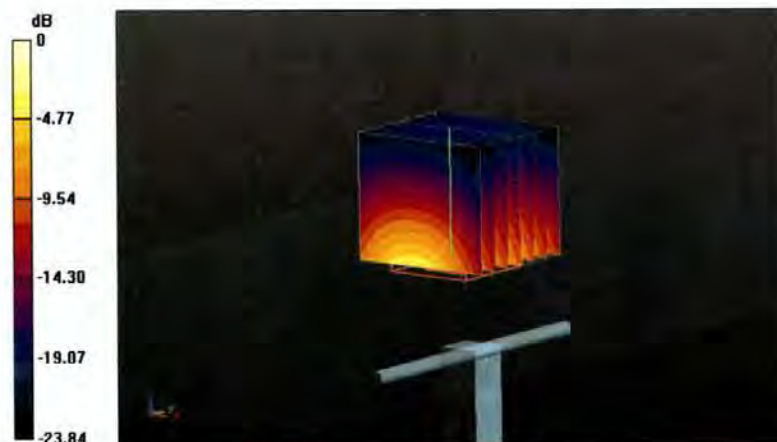
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 93.010 V/m; Power Drift = 0.09 dB

Peak SAR (extrapolated) = 27.4 W/kg

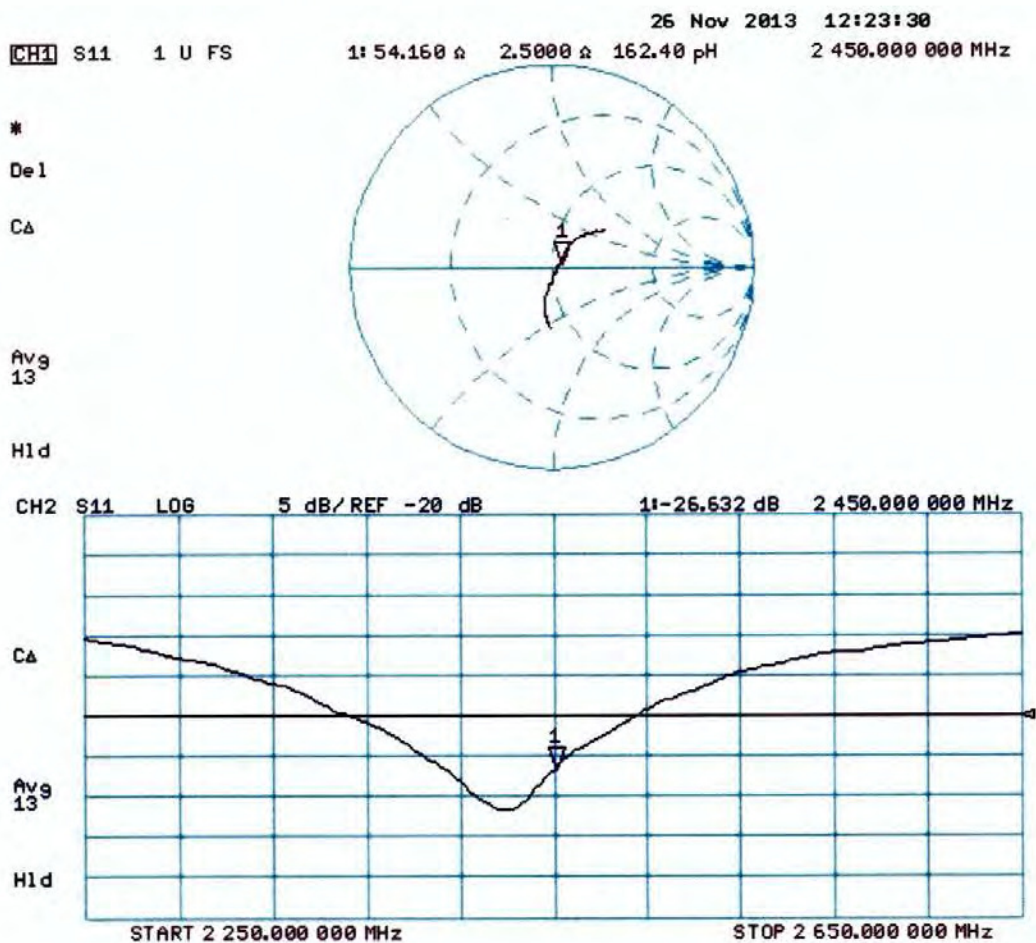
**SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.1 W/kg**

Maximum value of SAR (measured) = 17.4 W/kg



0 dB = 17.4 W/kg = 12.41 dBW/kg

Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 26.11.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 733**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.02$  S/m;  $\epsilon_r = 52.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.42, 4.42, 4.42); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

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

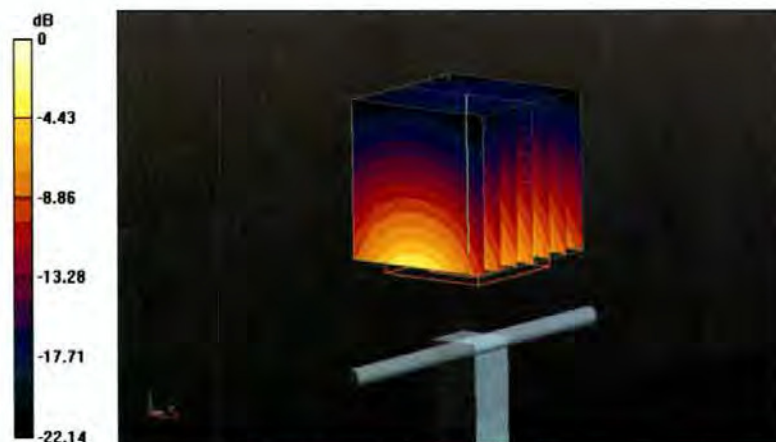
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 93.010 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 26.1 W/kg

**SAR(1 g) = 12.6 W/kg; SAR(10 g) = 5.81 W/kg**

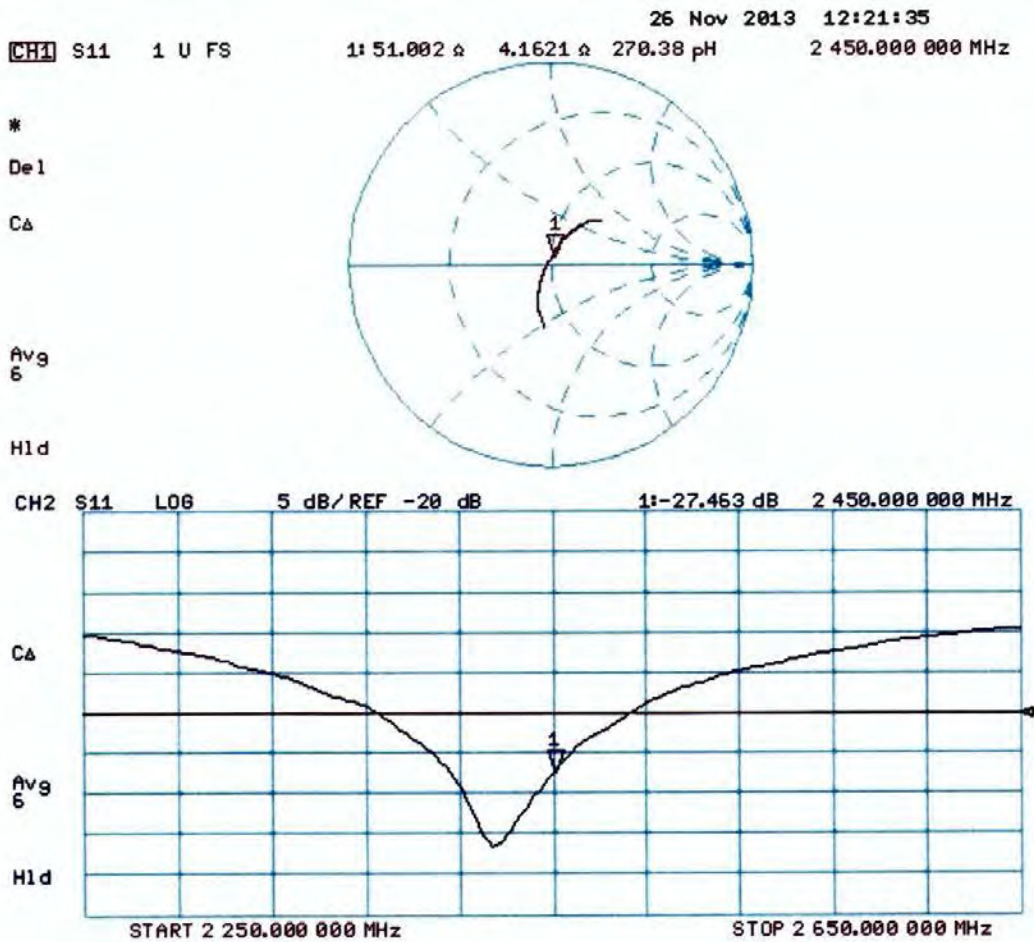
Maximum value of SAR (measured) = 16.4 W/kg



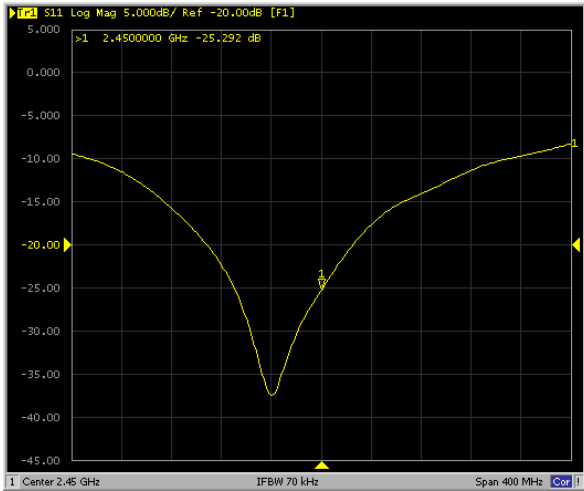
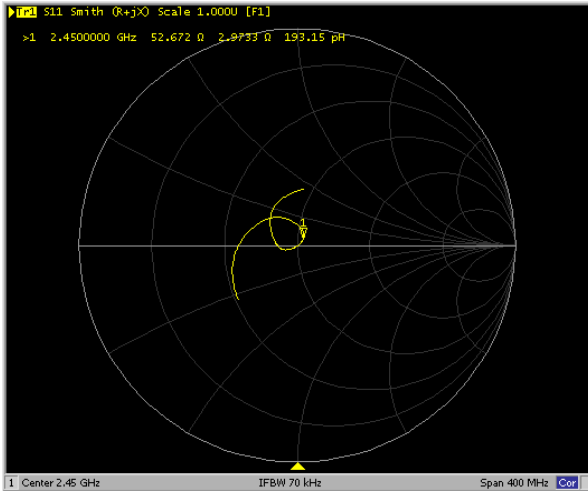
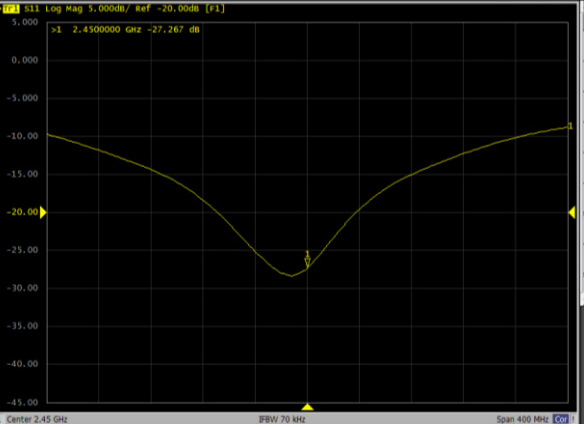
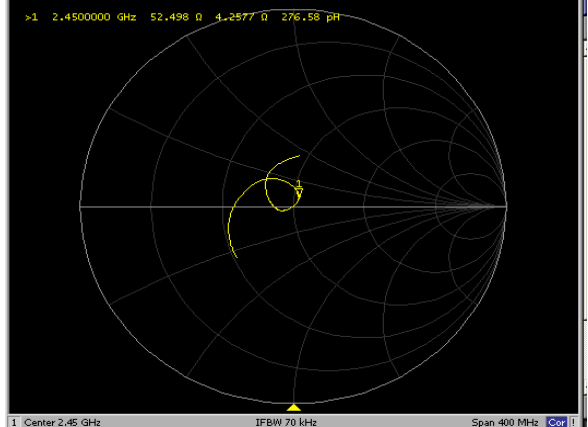
0 dB = 16.4 W/kg = 12.15 dBW/kg



Impedance Measurement Plot for Body TSL





Dipole Calibration for Impedance and Return-loss					
Model NO.:	D2450V2	Serial NO.:	733	Measurement Date:	2015-11-25
Liquid Type	Target Value:		Measured Value:		verdict
	Impedance	Return Loss	Impedance	Return Loss	
Head	54.2Ω+2.5jΩ	-26.6dB	52.7Ω+3.0jΩ	-25.3dB	Complied
Body	51.0Ω+4.2jΩ	-27.5dB	52.5Ω+4.3jΩ	-27.3dB	Complied
<p>Remark: According to KDB 865664 D01, instead of the typical annual calibration recommended by measurement standards, longer calibration intervals of up to three years may be considered when it is demonstrated that the SAR target, impedance and return loss of a dipole have remain stable according to the following requirements:</p> <p>1) The most recent return-loss result, measured at least annually, deviates by less than 20% from the previous measurement and meeting the required 20 dB minimum return-loss requirement.</p> <p>2) The most recent measurement of the real and imaginary parts of the impedance, measured at least annually, deviates by less than 5 Ω from the previous measurement.</p>					
Return Loss for Head			Impedance for Head		
					
Return Loss for Body			Impedance for Body		
					





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Client **SGS-SZ (Auden)**

Certificate No: **D5GHzV2-1165\_Dec13**

## CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN: 1165**

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

Calibration date: **December 11, 2013**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	09-Oct-13 (No. 217-01827)	Oct-14
Power sensor HP 8481A	US37292783	09-Oct-13 (No. 217-01827)	Oct-14
Power sensor HP 8481A	MY41092317	09-Oct-13 (No. 217-01828)	Oct-14
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-13 (No. 217-01736)	Apr-14
Type-N mismatch combination	SN: 5047.3 / 06327	04-Apr-13 (No. 217-01739)	Apr-14
Reference Probe ES3DV3	SN: 3205	28-Dec-12 (No. ES3-3205_Dec12)	Dec-13
DAE4	SN: 601	25-Apr-13 (No. DAE4-601_Apr13)	Apr-14
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-15
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-13)	In house check: Oct-14

	Name	Function	Signature
Calibrated by:	Israe El-Naouq	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: December 11, 2013

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Accreditation No.: **SCS 108**

### Glossary:

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

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

- IEC 62209-2, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures"; Part 2: "Procedure to determine the Specific Absorption Rate (SAR) for including accessories and multiple transmitters", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"
- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013

### Additional Documentation:

- DASY4/5 System Handbook

### Methods Applied and Interpretation of Parameters:

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

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

## Measurement Conditions

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

DASY Version	DASY5	V52.8.7
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz $\pm$ 1 MHz 5300 MHz $\pm$ 1 MHz 5500 MHz $\pm$ 1 MHz 5600 MHz $\pm$ 1 MHz 5800 MHz $\pm$ 1 MHz	

## Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	35.3 $\pm$ 6 %	4.54 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.05 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.1 W/kg $\pm$ 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.32 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.1 W/kg $\pm$ 19.5 % (k=2)

### Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.2 ± 6 %	4.64 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5300 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	8.40 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>83.6 W / kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	100 mW input power	2.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.9 W/kg ± 19.5 % (k=2)</b>

### Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.9 ± 6 %	4.83 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5500 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	8.62 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>85.7 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	100 mW input power	2.45 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>24.3 W/kg ± 19.5 % (k=2)</b>



### Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.7 ± 6 %	4.94 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5600 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	8.63 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>85.8 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	100 mW input power	2.45 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>24.3 W/kg ± 19.5 % (k=2)</b>

### Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.5 ± 6 %	5.14 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5800 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power <sup>2</sup>	8.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>82.6 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	100 mW input power	2.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.3 W/kg ± 19.5 % (k=2)</b>

### Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.2 ± 6 %	5.38 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.47 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	74.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.09 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.7 W/kg ± 19.5 % (k=2)

### Body TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.0 ± 6 %	5.52 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5300 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.64 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	75.8 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.14 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.2 W/kg ± 19.5 % (k=2)

### Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.7 ± 6 %	5.80 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.00 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	79.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.23 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	22.1 W/kg ± 19.5 % (k=2)

### Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.6 ± 6 %	5.92 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.12 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	80.6 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.25 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	22.3 W/kg ± 19.5 % (k=2)

### Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.2 ± 6 %	6.20 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.63 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	75.8 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.11 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.9 W/kg ± 19.5 % (k=2)



## Appendix

### Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	48.0 $\Omega$ - 7.7 j $\Omega$
Return Loss	- 21.8 dB

### Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	49.5 $\Omega$ - 5.6 j $\Omega$
Return Loss	- 25.0 dB

### Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	51.9 $\Omega$ - 1.8 j $\Omega$
Return Loss	- 31.7 dB

### Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	52.5 $\Omega$ - 1.0 j $\Omega$
Return Loss	- 31.5 dB

### Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	55.4 $\Omega$ - 3.0 j $\Omega$
Return Loss	- 24.7 dB

### Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	48.5 $\Omega$ - 6.0 j $\Omega$
Return Loss	- 24.0 dB

### Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	48.7 $\Omega$ - 3.9 j $\Omega$
Return Loss	- 27.7 dB

### Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	52.3 $\Omega$ - 0.4 j $\Omega$
Return Loss	- 32.9 dB

### Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	$54.2 \Omega + 0.2 j\Omega$
Return Loss	- 28.0 dB

### Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	$55.8 \Omega - 1.7 j\Omega$
Return Loss	- 24.9 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.208 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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

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

### Additional EUT Data

Manufactured by	SPEAG
Manufactured on	June 06, 2013

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## DASY5 Validation Report for Head TSL

Date: 11.12.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1165**

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used:  $f = 5200$  MHz;  $\sigma = 4.54$  S/m;  $\epsilon_r = 35.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5300$  MHz;  $\sigma = 4.64$  S/m;  $\epsilon_r = 35.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5500$  MHz;  $\sigma = 4.83$  S/m;  $\epsilon_r = 34.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5600$  MHz;  $\sigma = 4.94$  S/m;  $\epsilon_r = 34.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5800$  MHz;  $\sigma = 5.14$  S/m;  $\epsilon_r = 34.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

### DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.41, 5.41, 5.41); Calibrated: 28.12.2012, ConvF(5.1, 5.1, 5.1); Calibrated: 28.12.2012, ConvF(4.91, 4.91, 4.91); Calibrated: 28.12.2012, ConvF(4.76, 4.76, 4.76); Calibrated: 28.12.2012, ConvF(4.81, 4.81, 4.81); Calibrated: 28.12.2012;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

### **Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:**

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 64.799 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 29.3 W/kg

**SAR(1 g) = 8.05 W/kg; SAR(10 g) = 2.32 W/kg**

Maximum value of SAR (measured) = 18.7 W/kg

### **Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:**

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 65.575 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 31.3 W/kg

**SAR(1 g) = 8.4 W/kg; SAR(10 g) = 2.41 W/kg**

Maximum value of SAR (measured) = 19.6 W/kg

### **Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:**

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 65.400 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 33.5 W/kg

**SAR(1 g) = 8.62 W/kg; SAR(10 g) = 2.45 W/kg**

Maximum value of SAR (measured) = 20.6 W/kg



**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 64.163 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 34.3 W/kg

**SAR(1 g) = 8.63 W/kg; SAR(10 g) = 2.45 W/kg**

Maximum value of SAR (measured) = 20.9 W/kg

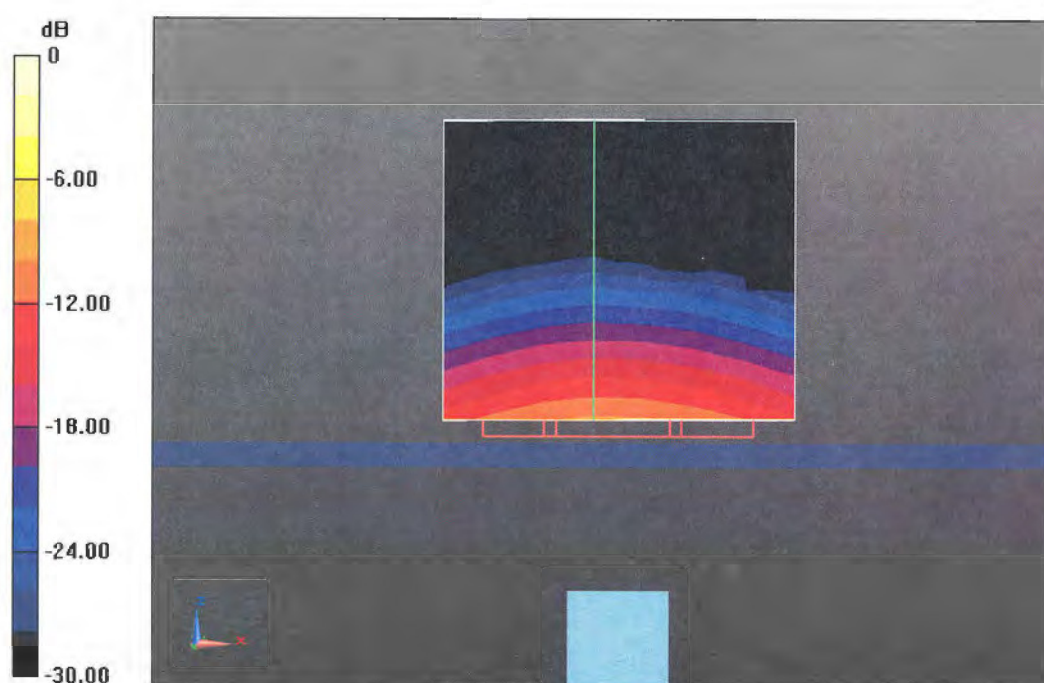
**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 61.980 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 34.7 W/kg

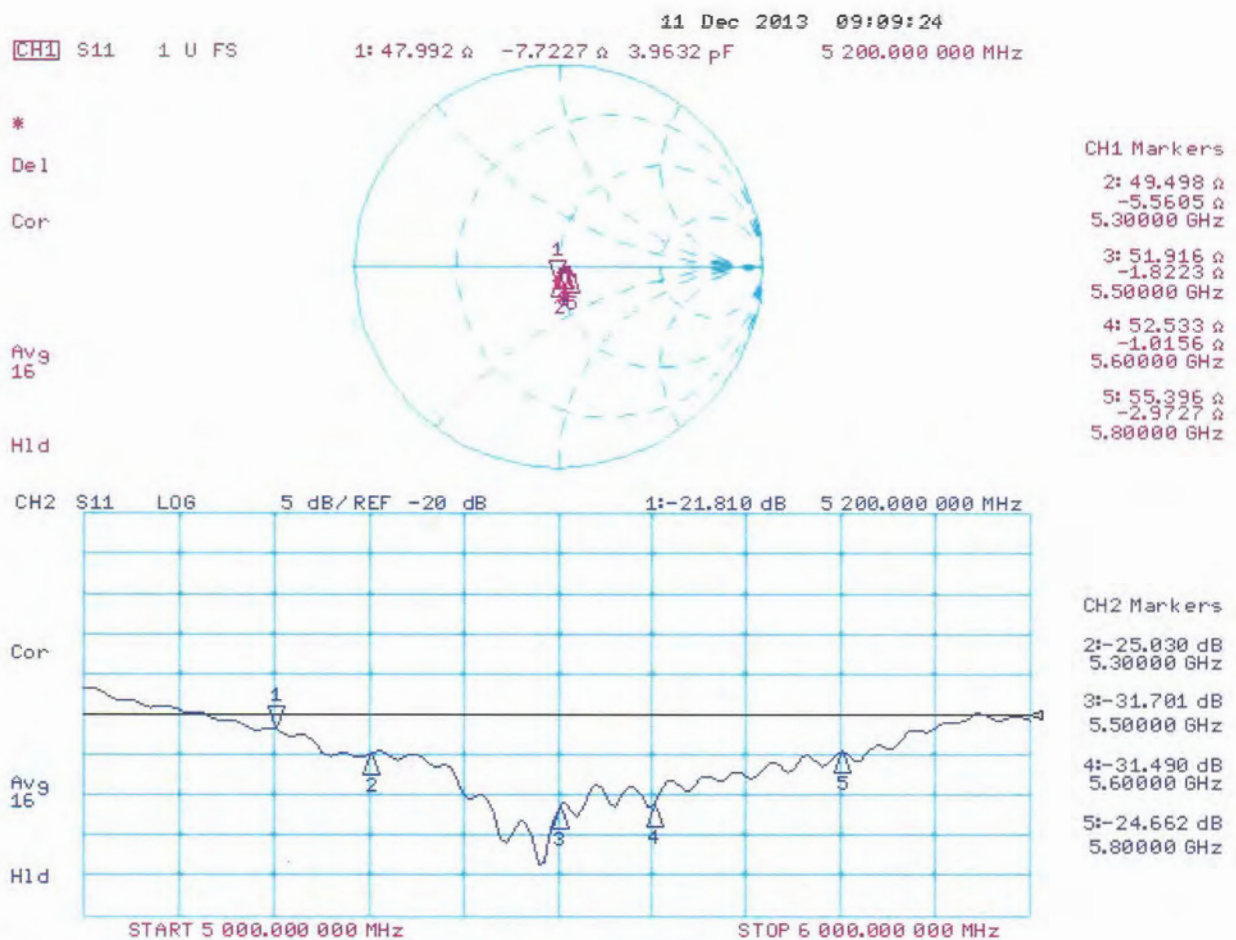
**SAR(1 g) = 8.31 W/kg; SAR(10 g) = 2.35 W/kg**

Maximum value of SAR (measured) = 20.4 W/kg



0 dB = 20.4 W/kg = 13.10 dBW/kg

# Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 10.12.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1165**

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used:  $f = 5200$  MHz;  $\sigma = 5.38$  S/m;  $\epsilon_r = 47.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5300$  MHz;  $\sigma = 5.52$  S/m;  $\epsilon_r = 47$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5500$  MHz;  $\sigma = 5.8$  S/m;  $\epsilon_r = 46.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5600$  MHz;  $\sigma = 5.92$  S/m;  $\epsilon_r = 46.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5800$  MHz;  $\sigma = 6.2$  S/m;  $\epsilon_r = 46.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

### DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(4.91, 4.91, 4.91); Calibrated: 28.12.2012, ConvF(4.67, 4.67, 4.67); Calibrated: 28.12.2012, ConvF(4.43, 4.43, 4.43); Calibrated: 28.12.2012, ConvF(4.22, 4.22, 4.22); Calibrated: 28.12.2012, ConvF(4.38, 4.38, 4.38); Calibrated: 28.12.2012;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

### **Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:**

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 59.518 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 30.2 W/kg

**SAR(1 g) = 7.47 W/kg; SAR(10 g) = 2.09 W/kg**

Maximum value of SAR (measured) = 17.8 W/kg

### **Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:**

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 59.536 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 31.4 W/kg

**SAR(1 g) = 7.64 W/kg; SAR(10 g) = 2.14 W/kg**

Maximum value of SAR (measured) = 18.2 W/kg

### **Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:**

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 59.440 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 34.9 W/kg

**SAR(1 g) = 8 W/kg; SAR(10 g) = 2.23 W/kg**

Maximum value of SAR (measured) = 19.5 W/kg



**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 59.140 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 36.6 W/kg

**SAR(1 g) = 8.12 W/kg; SAR(10 g) = 2.25 W/kg**

Maximum value of SAR (measured) = 20.0 W/kg

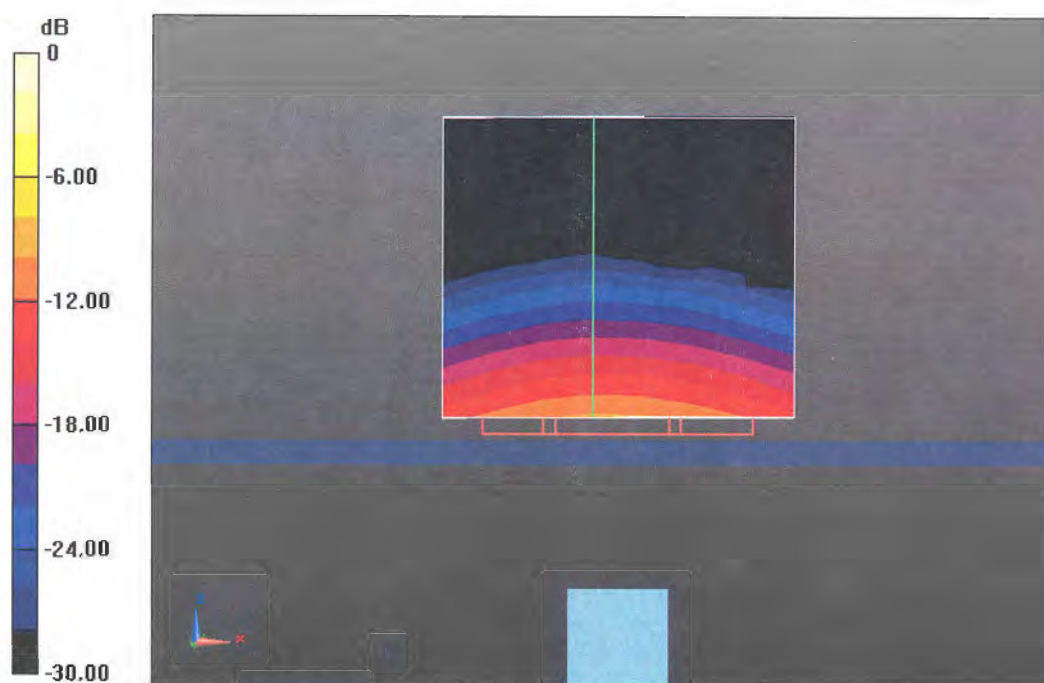
**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 56.258 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 36.2 W/kg

**SAR(1 g) = 7.63 W/kg; SAR(10 g) = 2.11 W/kg**

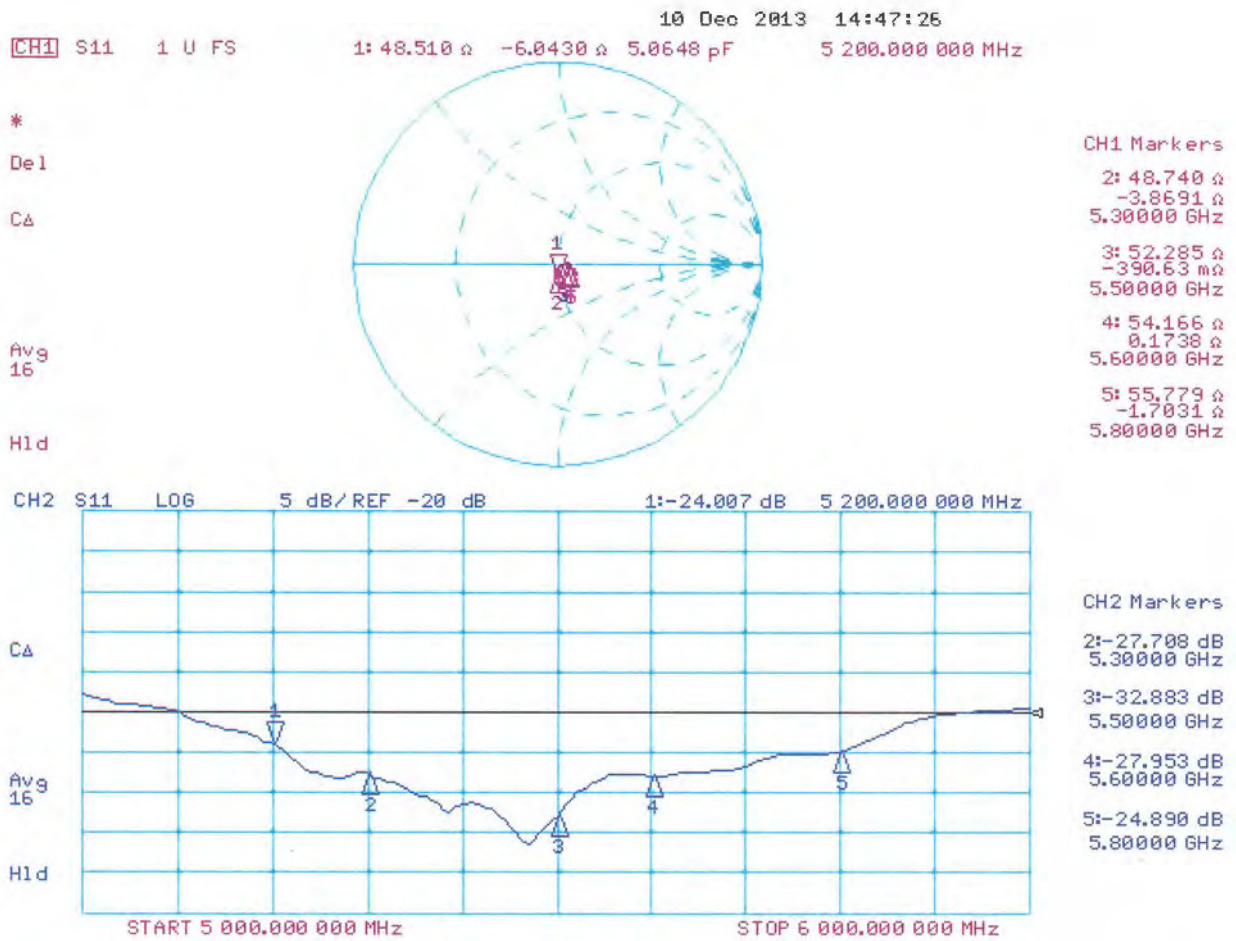
Maximum value of SAR (measured) = 19.1 W/kg



0 dB = 19.1 W/kg = 12.81 dBW/kg



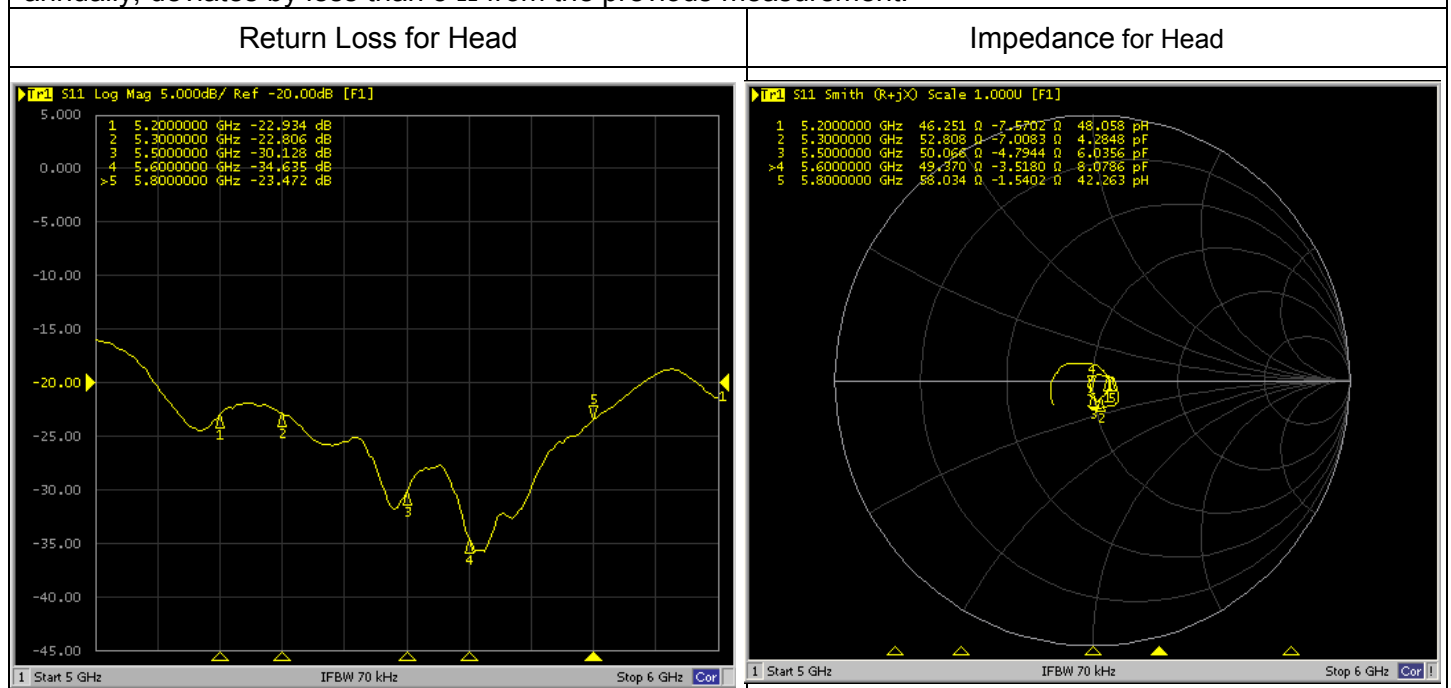
# Impedance Measurement Plot for Body TSL



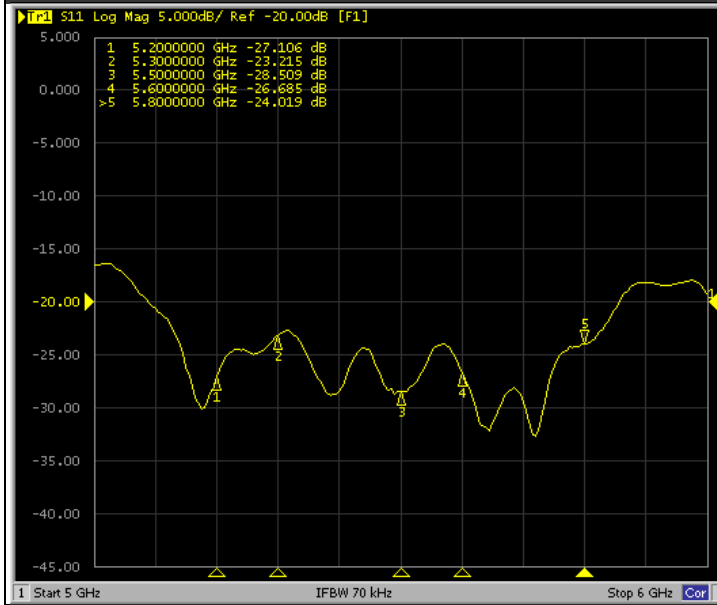
Dipole Calibration for Impedance and Return-loss						
Model NO.:		D5GHzV2	Serial NO.:	1165	Measurement Date:	2015-12-10
Liquid Type		Target Value:		Measured Value:		verdict
		Impedance	Return Loss	Impedance	Return Loss	
Head	5.2GHz	48.0 $\Omega$ -7.7j $\Omega$	-21.8dB	46.3 $\Omega$ -7.6j $\Omega$	-22.9dB	Complied
	5.3GHz	49.5 $\Omega$ -5.6j $\Omega$	-25.0dB	52.8 $\Omega$ -7.0j $\Omega$	-22.8dB	Complied
	5.5GHz	51.9 $\Omega$ -1.8j $\Omega$	-31.7dB	50.1 $\Omega$ -4.8j $\Omega$	-30.1dB	Complied
	5.6GHz	52.5 $\Omega$ -1.0j $\Omega$	-31.5dB	59.4 $\Omega$ -3.5j $\Omega$	-34.6dB	Complied
	5.8GHz	55.4 $\Omega$ -3.0j $\Omega$	-24.7dB	58.0 $\Omega$ -1.5j $\Omega$	-23.5dB	Complied
Body	5.2GHz	48.5 $\Omega$ -6.0j $\Omega$	-24.0dB	45.0 $\Omega$ -5.9j $\Omega$	-27.1dB	Complied
	5.3GHz	48.7 $\Omega$ -3.9j $\Omega$	-27.7dB	51.2 $\Omega$ -6.1j $\Omega$	-23.2dB	Complied
	5.5GHz	52.3 $\Omega$ -0.4j $\Omega$	-32.9dB	51.4 $\Omega$ -0.3j $\Omega$	-28.5dB	Complied
	5.6GHz	54.2 $\Omega$ +0.2j $\Omega$	-28.0dB	52.0 $\Omega$ -0.7j $\Omega$	-26.7dB	Complied
	5.8GHz	55.8 $\Omega$ -1.7j $\Omega$	-24.9dB	55.4 $\Omega$ -2.2j $\Omega$	-24.0dB	Complied

Remark: According to KDB 865664 D01, instead of the typical annual calibration recommended by measurement standards, longer calibration intervals of up to three years may be considered when it is demonstrated that the SAR target, impedance and return loss of a dipole have remain stable according to the following requirements:

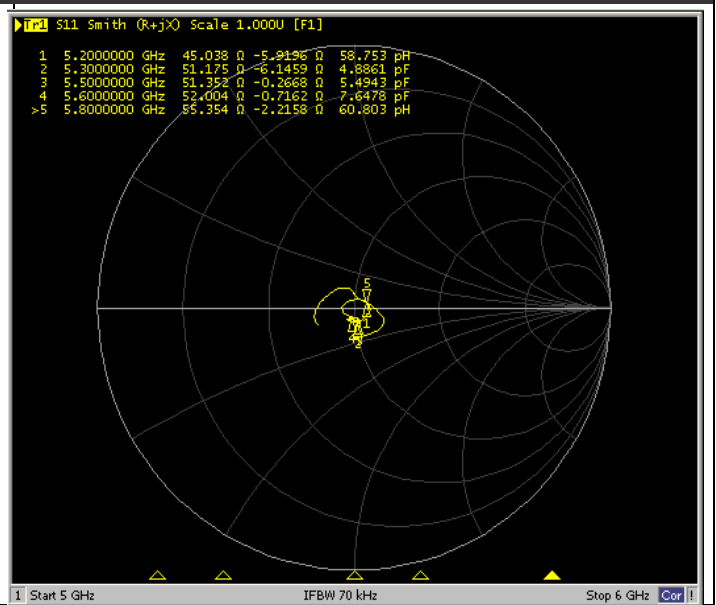
- 1) The most recent return-loss result, measured at least annually, deviates by less than 20% from the previous measurement and meeting the required 20 dB minimum return-loss requirement.
- 2) The most recent measurement of the real and imaginary parts of the impedance, measured at least annually, deviates by less than 5  $\Omega$  from the previous measurement.



### Return Loss for Body



### Impedance for Body



## IMPORTANT NOTICE

### USAGE OF THE DAE 3

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 DAE3 unit is connected to a fragile 3-pin battery connector. Customer is responsible to apply utmost caution not to bend or damage the connector when changing batteries.

**Shipping of the DAE:** Before shipping the DAE to SPEAG for calibration the customer shall 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 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, 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.**





Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Client **SGS-CN (Auden)**

Certificate No: **DAE3-569\_Nov15**

## CALIBRATION CERTIFICATE

Object **DAE3 - SD 000 D03 AA - SN: 569**

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

Calibration date: **November 24, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature  $(22 \pm 3)^{\circ}\text{C}$  and humidity  $< 70\%$ .

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	09-Sep-15 (No:17153)	Sep-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	06-Jan-15 (in house check)	In house check: Jan-16
Calibrator Box V2.1	SE UMS 006 AA 1002	06-Jan-15 (in house check)	In house check: Jan-16

Calibrated by:	Name	Function	Signature
	Dominique Steffen	Technician	

Approved by:	Name	Function
	Fin Bomholt	Deputy Technical Manager

Issued: November 24, 2015

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



Accredited by the Swiss Accreditation Service (SAS)

The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

## Glossary

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 = 6.1 $\mu$ V , 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	403.011 $\pm$ 0.02% (k=2)	403.408 $\pm$ 0.02% (k=2)	403.566 $\pm$ 0.02% (k=2)
Low Range	3.92816 $\pm$ 1.50% (k=2)	3.96473 $\pm$ 1.50% (k=2)	3.93879 $\pm$ 1.50% (k=2)

## Connector Angle

Connector Angle to be used in DASY system	250.5 ° $\pm$ 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	200038.63	1.85	0.00
Channel X	+ Input	20002.22	-2.58	-0.01
Channel X	- Input	-20005.78	-0.13	0.00
Channel Y	+ Input	200037.70	0.82	0.00
Channel Y	+ Input	20006.11	1.41	0.01
Channel Y	- Input	-20004.48	1.30	-0.01
Channel Z	+ Input	200037.10	0.46	0.00
Channel Z	+ Input	20001.64	-2.91	-0.01
Channel Z	- Input	-20004.65	1.21	-0.01

Low Range		Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X	+ Input	2001.49	0.54	0.03
Channel X	+ Input	200.86	0.01	0.00
Channel X	- Input	-199.57	-0.47	0.24
Channel Y	+ Input	2001.26	0.44	0.02
Channel Y	+ Input	200.62	-0.15	-0.08
Channel Y	- Input	-199.64	-0.49	0.25
Channel Z	+ Input	2000.84	0.00	0.00
Channel Z	+ Input	198.77	-1.91	-0.95
Channel Z	- Input	-200.55	-1.29	0.65

### 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	-0.03	-1.43
	- 200	2.82	0.59
Channel Y	200	5.00	4.82
	- 200	-6.64	-6.42
Channel Z	200	-12.60	-13.12
	- 200	10.49	10.86

### 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	-	2.48	-2.58
Channel Y	200	9.62	-	3.06
Channel Z	200	7.22	7.59	-

#### 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	16201	16686
Channel Y	16541	15406
Channel Z	15797	16180

#### 5. Input Offset Measurement

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

Input 10M $\Omega$

	Average ( $\mu$ V)	min. Offset ( $\mu$ V)	max. Offset ( $\mu$ V)	Std. Deviation ( $\mu$ V)
Channel X	0.08	-1.21	2.15	0.70
Channel Y	-0.12	-1.69	1.49	0.63
Channel Z	-1.24	-2.47	0.65	0.51

#### 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





Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA  
 Multilateral Agreement for the recognition of calibration certificates

Client **SGS-CN (Auden)**

Certificate No: **EX3-3962\_Nov15**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3962**

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



Calibration date: **November 27, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature  $(22 \pm 3)^{\circ}\text{C}$  and humidity  $< 70\%$ .

Calibration Equipment used (M&TE critical for calibration)

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

Calibrated by:	Name <b>Claudio Leubler</b>	Function <b>Laboratory Technician</b>	Signature 
Approved by:	<b>Katja Pokovic</b>	<b>Technical Manager</b>	
Issued: November 27, 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
NORM <sub>x,y,z</sub>	sensitivity in free space
ConvF	sensitivity in TSL / NORM <sub>x,y,z</sub>
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization $\varphi$	$\varphi$ rotation around probe axis
Polarization $\vartheta$	$\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

## Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- 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  $\vartheta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not affect the  $E^2$ -field uncertainty inside TSL (see below ConvF).
- NORM(f)<sub>x,y,z</sub>** = NORM<sub>x,y,z</sub> \* frequency\_response (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP<sub>x,y,z</sub>**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A<sub>x,y,z</sub>; B<sub>x,y,z</sub>; C<sub>x,y,z</sub>; D<sub>x,y,z</sub>; VR<sub>x,y,z</sub>**: A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for  $f \leq 800$  MHz) and inside waveguide using analytical field distributions based on power measurements for  $f > 800$  MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM<sub>x,y,z</sub> \* ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from  $\pm 50$  MHz to  $\pm 100$  MHz.
- Spherical isotropy (3D deviation from isotropy)**: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM<sub>x</sub> (no uncertainty required).

# Probe EX3DV4

## SN:3962

Manufactured: September 30, 2013  
Calibrated: November 27, 2015

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3962

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	0.43	0.46	0.44	± 10.1 %
DCP (mV) <sup>B</sup>	98.6	100.1	89.0	

### 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	121.1	±1.9 %
		Y	0.0	0.0	1.0		128.9	
		Z	0.0	0.0	1.0		120.6	

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 Pages 5 and 6).

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

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



## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3962

### 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)	Unc (k=2)
450	43.5	0.87	11.00	11.00	11.00	0.15	1.30	± 13.4 %
750	41.9	0.89	10.67	10.67	10.67	0.50	0.80	± 12.0 %
835	41.5	0.90	10.17	10.17	10.17	0.50	0.80	± 12.0 %
1750	40.1	1.37	8.77	8.77	8.77	0.37	0.80	± 12.0 %
1900	40.0	1.40	8.49	8.49	8.49	0.28	0.93	± 12.0 %
2300	39.5	1.67	8.02	8.02	8.02	0.25	1.09	± 12.0 %
2450	39.2	1.80	7.65	7.65	7.65	0.38	0.80	± 12.0 %
2600	39.0	1.96	7.35	7.35	7.35	0.22	1.23	± 12.0 %
5250	35.9	4.71	5.14	5.14	5.14	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.56	4.56	4.56	0.45	1.80	± 13.1 %
5750	35.4	5.22	4.79	4.79	4.79	0.45	1.80	± 13.1 %

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

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3962

### Calibration Parameter Determined in Body Tissue Simulating Media

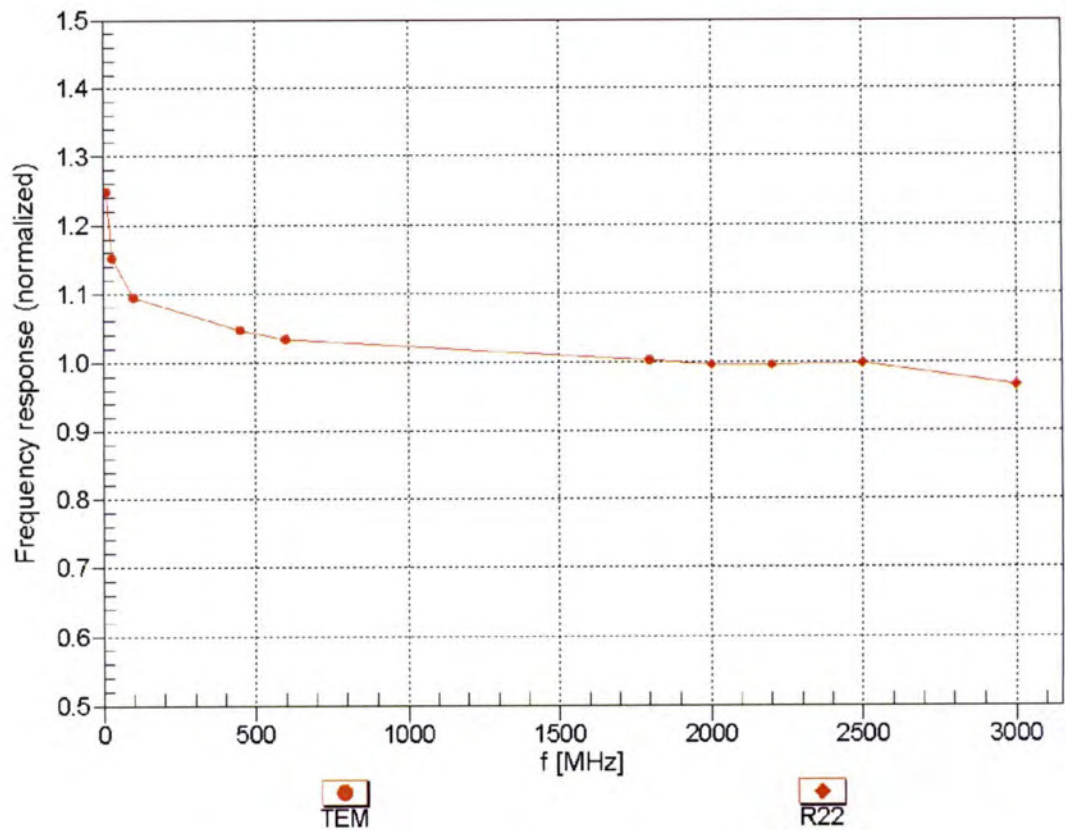
f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
450	56.7	0.94	11.33	11.33	11.33	0.08	1.20	± 13.4 %
750	55.5	0.96	10.41	10.41	10.41	0.50	0.80	± 12.0 %
835	55.2	0.97	10.16	10.16	10.16	0.50	0.80	± 12.0 %
1750	53.4	1.49	8.49	8.49	8.49	0.32	0.88	± 12.0 %
1900	53.3	1.52	8.20	8.20	8.20	0.33	0.89	± 12.0 %
2300	52.9	1.81	7.96	7.96	7.96	0.39	0.80	± 12.0 %
2450	52.7	1.95	7.70	7.70	7.70	0.38	0.80	± 12.0 %
2600	52.5	2.16	7.63	7.63	7.63	0.37	0.80	± 12.0 %
5250	48.9	5.36	4.15	4.15	4.15	0.50	1.90	± 13.1 %
5600	48.5	5.77	3.61	3.61	3.61	0.60	1.90	± 13.1 %
5750	48.3	5.94	3.70	3.70	3.70	0.60	1.90	± 13.1 %

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

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

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

**Frequency Response of E-Field**  
(TEM-Cell:ifi1110 EXX, Waveguide: R22)

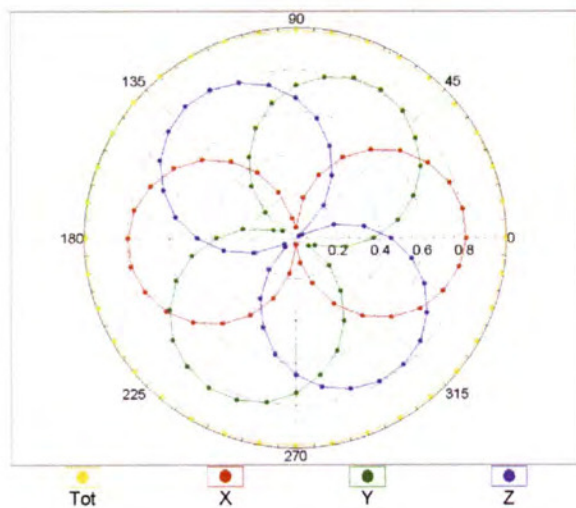


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

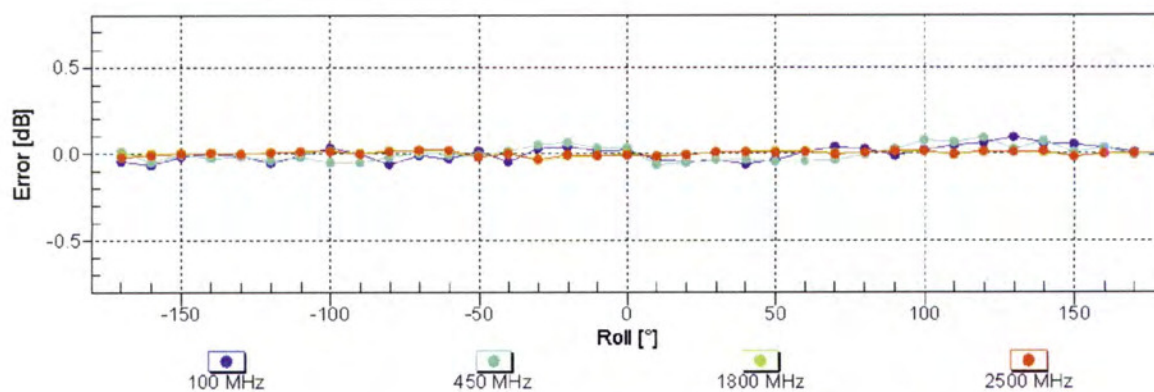
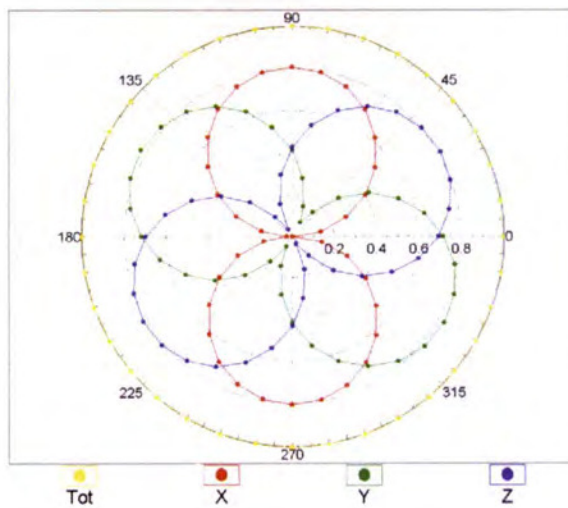


## Receiving Pattern ( $\phi$ ), $\vartheta = 0^\circ$

$f=450$  MHz, TEM

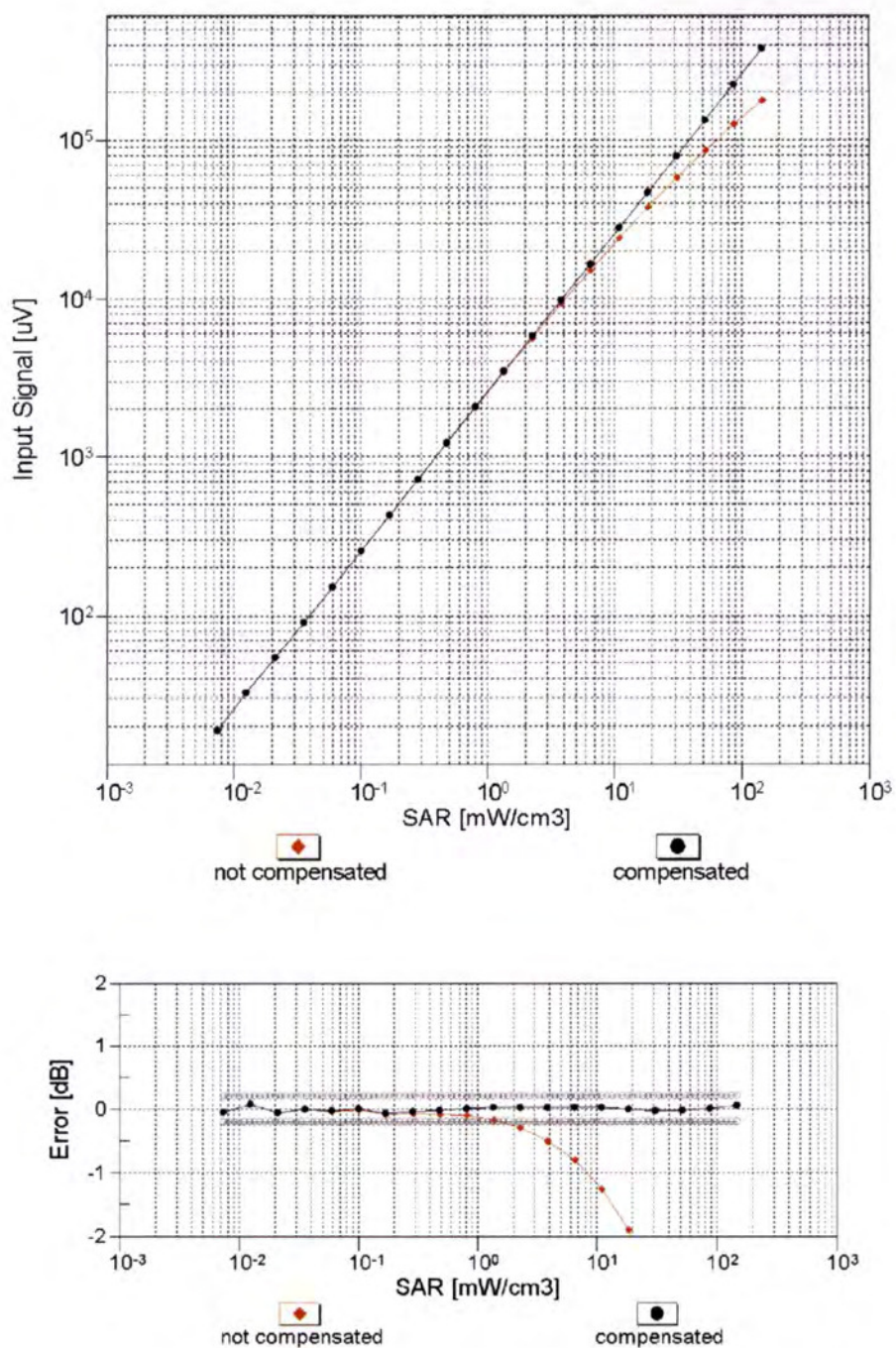


$f=1800$  MHz, R22



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

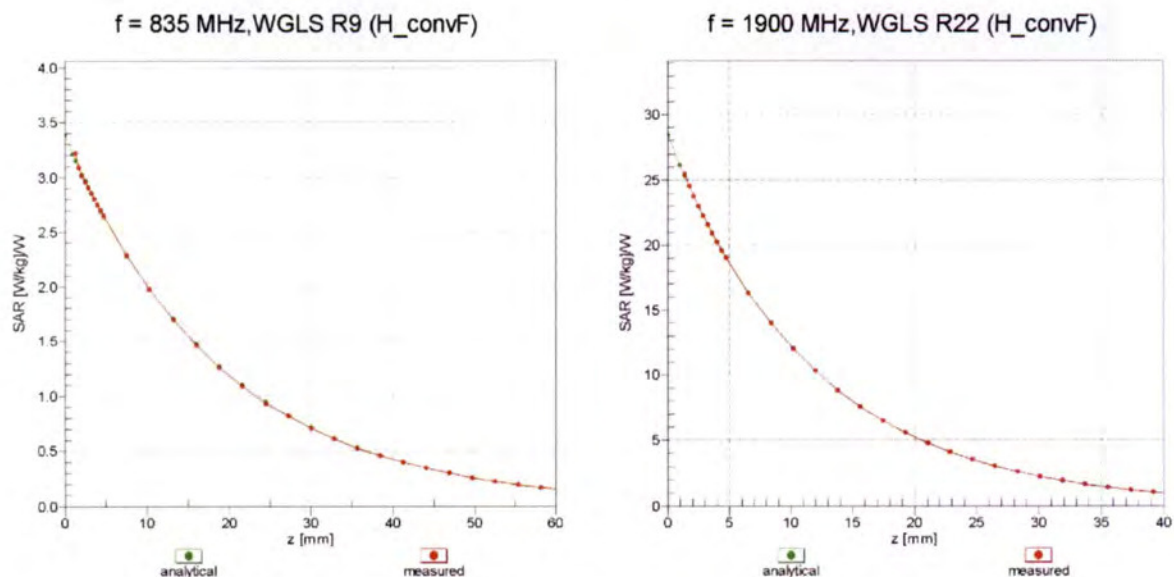
# Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell , $f_{\text{eval}} = 1900 \text{ MHz}$ )



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

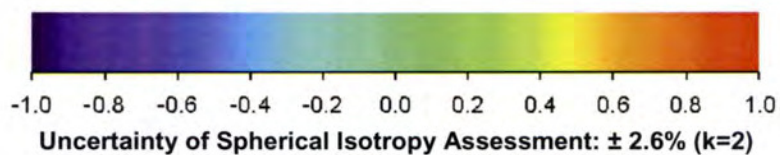
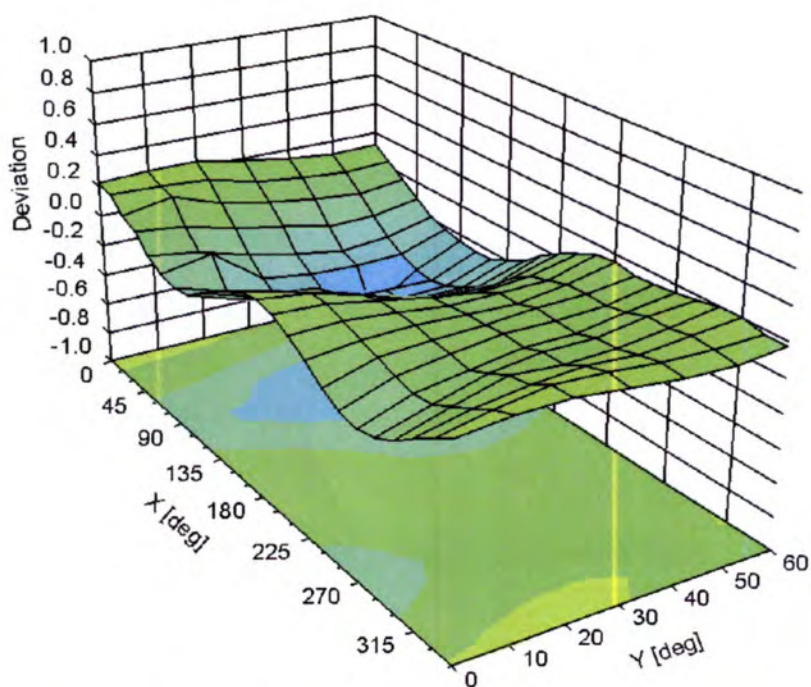


## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3962

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-30.1
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm



# **Appendix D**

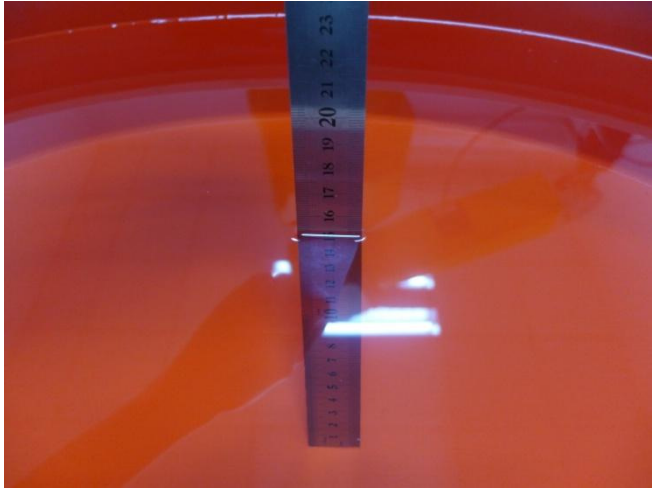

## **Photographs**

1. SAR measurement System
2. Photographs of Tissue Simulate Liquid
3. Photographs of EUT test position
4. EUT Constructional Details

## 1. SAR measurement System

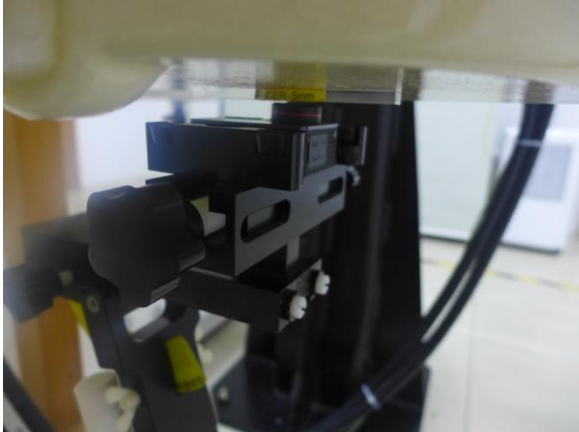
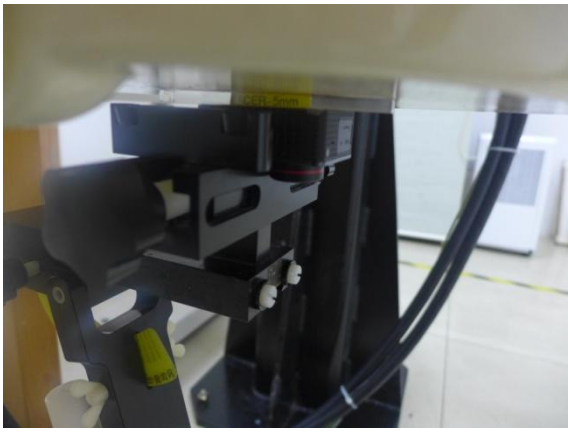
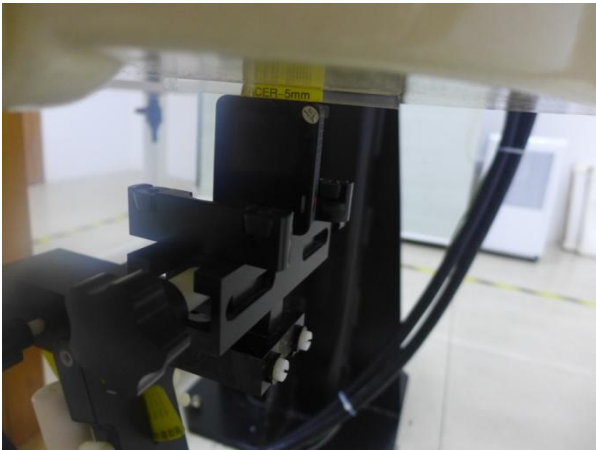
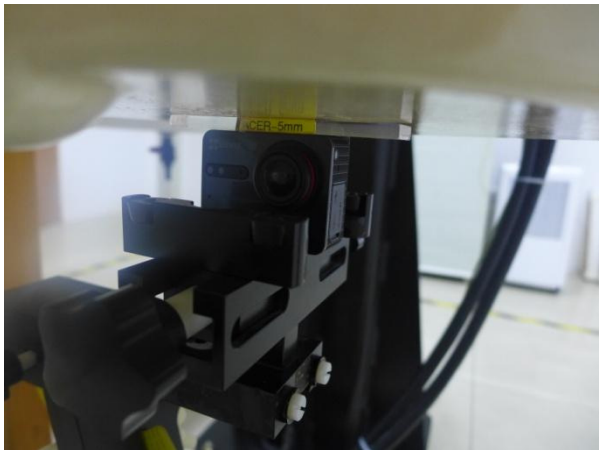
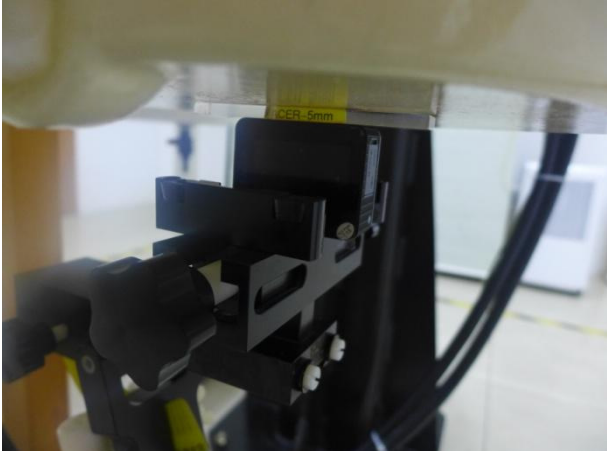


## 2. Photographs of Tissue Simulate Liquid

Photo 1: Tissue Simulant Liquid for Body 5G	Photo 2: Tissue Simulant Liquid for Body 2450
	



### 3. Photographs of EUT test position

<p><b>Photo 3: Front side 5mm</b></p>	<p><b>Photo 4: Back side 5mm</b></p>
	
<p><b>Photo 5: Right side 5mm</b></p>	<p><b>Photo 6: Top side 5mm</b></p>
	
<p><b>Photo 7: Bottom side 5mm</b></p>	<p><b>NA</b></p>
	<p><b>NA</b></p>

## 4. EUT Constructional Details

Photo 8: Front View	Photo 9: Back View
