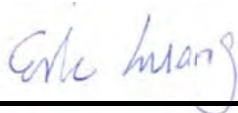


# FCC SAR Test Report

**APPLICANT** : Lenovo (Shanghai) Electronics Technology Co., Ltd.  
**EQUIPMENT** : Portable Tablet Computer  
**BRAND NAME** : lenovo  
**MODEL NAME** : YOGA Tablet 2 Pro-1380F  
**FCC ID** : O57YT2PRO1380F  
**STANDARD** : FCC 47 CFR Part 2 (2.1093)  
ANSI/IEEE C95.1-1992  
IEEE 1528-2003

We, SPORTON INTERNATIONAL (XI'AN) INC., would like to declare that the tested sample has been evaluated in accordance with the procedures and had been in compliance with the applicable technical standards.

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



Reviewed by: Eric Huang / Deputy Manager



Approved by: Jones Tsai / Manager



**SPORTON INTERNATIONAL (XI'AN) INC.**

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### Revision History

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FA471003	Rev. 01	Initial issue of report	Sep. 03, 2014



### 1. Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for **Lenovo (Shanghai) Electronics Technology Co., Ltd., Portable Tablet Computer, YOGA Tablet 2 Pro–1380F** are as follows.

Equipment Class	Frequency Band	Operating Mode	Highest SAR Summary	
			Body 1g SAR (W/kg) Gap(0cm)	Simultaneous Transmission SAR (W/kg)
DTS	WLAN 2.4GHz Band	Data	1.24	
NII	WLAN 5.2GHz Band	Data	1.47	
	WLAN 5.8GHz Band	Data	1.49	
DSS	Bluetooth	Data	<0.10	
Date of Testing:		Aug. 07, 2014 ~ Aug. 25, 2014		

This device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (1.6 W/kg) specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1992, and had been tested in accordance with the measurement methods and procedures specified in IEEE 1528-2003.

## **2. Administration Data**

<b>Testing Laboratory</b>	
<b>Test Site</b>	SPORTON INTERNATIONAL (XI'AN) INC.
<b>Test Site Location</b>	1F, Building A3, No. 39 Chuangye Rd., Xi'an Hi-tech Zone, Shanxi Province, P. R. C. TEL: +86-029-8860-8767 FAX: +86-029-8860-8791

<b>Applicant</b>	
<b>Company Name</b>	Lenovo (Shanghai) Electronics Technology Co., Ltd.
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<b>Manufacturer</b>	
<b>Company Name</b>	Lenovo PC HK Limited
<b>Address</b>	23/F, Lincoln House, Taikoo Place 979 King's Road, Quarry Bay, Hong Kong

<b>Factory 1</b>	
<b>Company Name</b>	LENOVO MOBILE COMMUNICATION TECHNOLOGY CO., LTD
<b>Address</b>	NO.999 QISHAN NORTH 2ND ROAD, INFORMATION & OPTOELECTRONICS PARK, TORCH HIGH TECH, XIAMEN FUJIAN 361009, CHINA

<b>Factory 2</b>	
<b>Company Name</b>	LENOVO MOBILE COMMUNICATION (WUHAN) CO., LTD
<b>Address</b>	19 GAOXIN 4TH RD EAST LAKE HIGH-TECH, ZONE WUHAN HUBEI 430205, CHINA

## **3. Guidance Standard**

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

- FCC 47 CFR Part 2 (2.1093)
- ANSI/IEEE C95.1-1992
- IEEE 1528-2003
- FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r03
- FCC KDB 865664 D02 SAR Reporting v01r01
- FCC KDB 447498 D01 General RF Exposure Guidance v05r02
- FCC KDB 248227 D01 SAR meas for 802 11abg v01r02
- FCC KDB 616217 D04 SAR for laptop and tablets v01r01

**4. Equipment Under Test (EUT)**

**4.1 General Information**

Product Feature & Specification	
Equipment Name	Portable Tablet Computer
Brand Name	lenovo
Model Name	YOGA Tablet 2 Pro-1380F
FCC ID	O57YT2PRO1380F
Wireless Technology and Frequency Range	WLAN 2.4GHz Band: 2412 MHz ~ 2472 MHz WLAN 5GHz Band: 5180 MHz ~ 5240 MHz, 5745 MHz ~ 5825 MHz Bluetooth: 2402 MHz ~ 2480 MHz
Mode	<ul style="list-style-type: none"> <li>• 802.11a/b/g/n HT20/HT40</li> <li>• Bluetooth v3.0+EDR, Bluetooth v4.0 LE</li> </ul>
HW Version	S100
SW Version	H001
EUT Stage	Identical Prototype
<b>Remark:</b> 1. This device has no voice function. 2. There are two types of EUT sample 1 and sample 2, the differences between two samples is only different supplier for Battery/EMMC/Panel/Touch panel/front and back camera. For SAR test, only perform sample 1 for all test, and sample 2 verified the worse mode.	



**4.2 Maximum Tune-up Limit**

Mode			Maximum Average Power (dBm)	
2.4GHz	802.11b	Chain Port 0	14.0	
		Chain Port 1	15.0	
	802.11g	Chain Port 0	14.5	
		Chain Port 1	11.0	
	802.11n HT20	Chain Port 0	12.5	
		Chain Port 1	12.5	
		Chain Port 0+1	12.5	
	802.11n HT40	Chain Port 0	10.5	
		Chain Port 1	10.5	
		Chain Port 0+1	11.5	
5.2GHz	802.11a	Chain Port 0	CH 36	8.0
			CH 40	6.5
			CH 44	6.5
			CH 48	8.0
	Chain Port 1	10.5		
5.2GH	802.11n HT20	Chain Port 0	CH 36	5.5
			CH 40	4.5
			CH 44	5.0
			CH 48	5.0
	Chain Port 1	11.5		
	Chain Port 0+1	11.5		
	802.11n HT40	Chain Port 0	5.5	
		Chain Port 1	10.5	
Chain Port 0+1		10.5		
5.8GHz	802.11a	Chain Port 0	CH 149	4.0
			CH 153	4.0
			CH 157	4.0
			CH 161	4.0
			CH 165	4.5
	Chain Port 1	7.5		
	802.11n HT20	Chain Port 0	4.0	
		Chain Port 1	7.5	
		Chain Port 0+1	12.5	
	802.11n HT40	Chain Port 0	6.0	
		Chain Port 1	8.5	
Chain Port 0+1		10.5		
Bluetooth v3.0+EDR			10.5	
Bluetooth v4.0 LE			9.0	

**5. RF Exposure Limits**

**5.1 Uncontrolled Environment**

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

**5.2 Controlled Environment**

Controlled Environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. The exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

**Limits for Occupational/Controlled Exposure (W/kg)**

Whole-Body	Partial-Body	Hands, Wrists, Feet and Ankles
0.4	8.0	20.0

**Limits for General Population/Uncontrolled Exposure (W/kg)**

Whole-Body	Partial-Body	Hands, Wrists, Feet and Ankles
0.08	1.6	4.0

1. Whole-Body SAR is averaged over the entire body, partial-body SAR is averaged over any 1gram of tissue defined as a tissue volume in the shape of a cube. SAR for hands, wrists, feet and ankles is averaged over any 10 grams of tissue defined as a tissue volume in the shape of a cube.



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

### **6.1 Introduction**

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

### **6.2 SAR Definition**

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

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

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

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

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



## **8. Measurement Procedures**

The measurement procedures are as follows:

### <Conducted power measurement>

- (a) For WLAN/BT power measurement, use engineering software to configure EUT WLAN/BT continuously transmission, at maximum RF power in each supported wireless interface and frequency band
- (b) Connect EUT RF port through RF cable to the power meter, and measure WLAN/BT output power

### <SAR measurement>

- (a) Engineering software to configure EUT WLAN/BT continuously transmission, at maximum RF power, in the highest power channel.
- (b) Place the EUT in the positions as Appendix D demonstrates.
- (c) Set scan area, grid size and other setting on the DASY software.
- (d) Measure SAR results for the highest power channel on each testing position.
- (e) Find out the largest SAR result on these testing positions of each band
- (f) Measure SAR results for other channels in worst SAR testing position if the reported SAR of highest power channel is larger than 0.8 W/kg

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

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

### **8.1 Spatial Peak SAR Evaluation**

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

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

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

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

**8.2 Power Reference Measurement**

The Power Reference Measurement and Power Drift Measurements are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

**8.3 Area Scan**

The area scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum found in the scanned area, within a range of the global maximum. The range (in dB0 is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE standard 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan), if only one zoom scan follows the area scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of zoom scans has to be increased accordingly.

Area scan parameters extracted from FCC KDB 865664 D01v01r03 SAR measurement 100 MHz to 6 GHz.

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	30° ± 1°	20° ± 1°
Maximum area scan spatial resolution: $\Delta x_{Area}, \Delta y_{Area}$	≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 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 ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

**8.4 Zoom Scan**

Zoom scans are used assess the peak spatial SAR values within a cubic averaging volume containing 1 gram and 10 gram of simulated tissue. The zoom scan measures points (refer to table below) within a cube shoes base faces are centered on the maxima found in a preceding area scan job within the same procedure. When the measurement is done, the zoom scan evaluates the averaged SAR for 1 gram and 10 gram and displays these values next to the job's label.

Zoom scan parameters extracted from FCC KDB 865664 D01v01r03 SAR measurement 100 MHz to 6 GHz.

		≤ 3 GHz	> 3 GHz	
Maximum zoom scan spatial resolution: $\Delta x_{Zoom}, \Delta y_{Zoom}$		$\leq 2$ GHz: $\leq 8$ mm 2 – 3 GHz: $\leq 5$ mm*	3 – 4 GHz: $\leq 5$ mm* 4 – 6 GHz: $\leq 4$ mm*	
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$	$\leq 5$ mm	3 – 4 GHz: $\leq 4$ mm 4 – 5 GHz: $\leq 3$ mm 5 – 6 GHz: $\leq 2$ mm	
	graded grid	$\Delta z_{Zoom}(1)$ : between 1 <sup>st</sup> two points closest to phantom surface	$\leq 4$ mm	3 – 4 GHz: $\leq 3$ mm 4 – 5 GHz: $\leq 2.5$ mm 5 – 6 GHz: $\leq 2$ mm
		$\Delta z_{Zoom}(n>1)$ : between subsequent points	$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z	$\geq 30$ mm	3 – 4 GHz: $\geq 28$ mm 4 – 5 GHz: $\geq 25$ mm 5 – 6 GHz: $\geq 22$ 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 <i>reported</i> SAR from the <i>area scan based 1-g SAR estimation</i> procedures of KDB 447498 is $\leq 1.4$ W/kg, $\leq 8$ mm, $\leq 7$ mm and $\leq 5$ 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.				

**8.5 Volume Scan Procedures**

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

**8.6 Power Drift Monitoring**

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



**9. Test Equipment List**

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	2450MHz System Validation Kit	D2450V2	908	Mar. 26, 2013	Mar. 24, 2015
SPEAG	2450MHz System Validation Kit	D2450V2	924	Nov. 13, 2013	Nov. 12, 2014
SPEAG	5000MHz System Validation Kit	D5000V2	1006	Sep. 23, 2013	Sep. 22, 2014
SPEAG	Data Acquisition Electronics	DAE4	1358	Apr. 30, 2014	Apr. 29, 2015
SPEAG	Data Acquisition Electronics	DAE4	1210	May 19, 2014	May 18, 2015
SPEAG	Dosimetric E-Field Probe	EX3DV4	3911	Apr. 22, 2014	Apr. 21, 2015
SPEAG	Dosimetric E-Field Probe	EX3DV4	3857	May 23, 2014	May 22, 2015
SPEAG	Phone Positioner	N/A	N/A	NCR	NCR
Agilent	Signal Generator	N5181A	MY50145381	Jan. 04, 2014	Jan. 03, 2015
Agilent	ENA Series Network Analyzer	E5071C	MY46111157	Dec. 30, 2013	Dec. 29, 2014
Agilent	Dielectric Probe Kit	85070E	MY44300751	NCR	NCR
Anritsu	Power Meter	ML2495A	1005002	Feb. 27, 2014	Feb. 26, 2015
Anritsu	Power Sensor	MA2411B	917070	Feb. 27, 2014	Feb. 26, 2015
R&S	Spectrum Analyzer	FSP7	101045	Dec. 30, 2013	Dec. 29, 2014
SPEAG	ELI5 Phantom	QD OVA 002 AA	TP-1201	NCR	NCR
Agilent	Dual Directional Coupler	778D	50422	Note 1	
Woken	Attenuator	WK0602-XX	N/A	Note 1	
PE	Attenuator	PE7005-10	N/A	Note 1	
PE	Attenuator	PE7005- 3	N/A	Note 1	
AR	Power Amplifier	5S1G4M2	0328767	Note 1	
Mini-Circuits	Power Amplifier	ZVE-3W	162601250	Note 1	
Mini-Circuits	Power Amplifier	ZHL-42W+	13440021344	Note 1	

**General Note:**

1. Prior to system verification and validation, the path loss from the signal generator to the system check source and the power meter, which includes the amplifier, cable, attenuator and directional coupler, was measured by the network analyzer. The reading of the power meter was offset by the path loss difference between the path to the power meter and the path to the system check source to monitor the actual power level fed to the system check source.
2. Referring to KDB 865664 D01v01r03, the dipole calibration interval can be extended to 3 years with justification. The dipoles are also not physically damaged, or repaired during the interval.
3. The justification data of dipole D2450V2, SN: 908 can be found in appendix C. The return loss is < -20dB, within 20% of prior calibration, the impedance is within 5 ohm of prior calibration.

## **10. System Verification**

### **10.1 Tissue Verification**

The following tissue formulations are provided for reference only as some of the parameters have not been thoroughly verified. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation.

Frequency (MHz)	Water (%)	Sugar (%)	Cellulose (%)	Salt (%)	Preventol (%)	DGBE (%)	Conductivity ( $\sigma$ )	Permittivity ( $\epsilon_r$ )
For Body								
2450	68.6	0	0	0	0	31.4	1.95	52.7

#### Simulating Liquid for 5GHz, Manufactured by SPEAG

Ingredients	(% by weight)
Water	64~78%
Mineral oil	11~18%
Emulsifiers	9~15%
Additives and Salt	2~3%

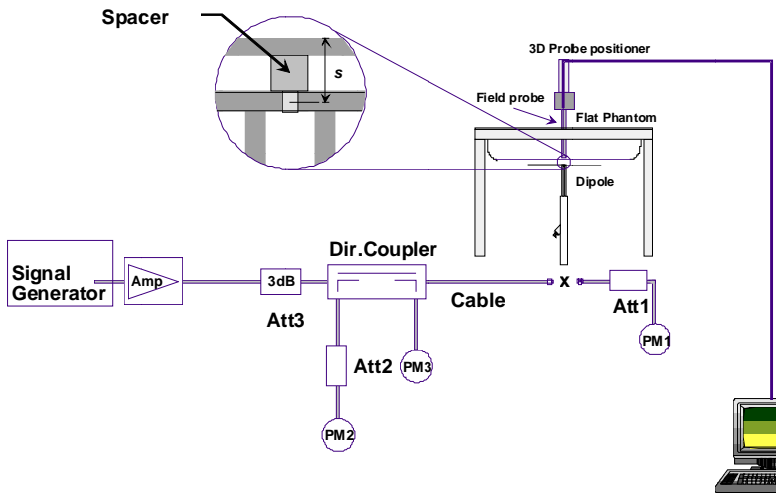
#### <Tissue Dielectric Parameter Check Results>

Frequency (MHz)	Tissue Type	Liquid Temp. (°C)	Conductivity ( $\sigma$ )	Permittivity ( $\epsilon_r$ )	Conductivity Target ( $\sigma$ )	Permittivity Target ( $\epsilon_r$ )	Delta ( $\sigma$ ) (%)	Delta ( $\epsilon_r$ ) (%)	Limit (%)	Date
2450	Body	22.6	1.949	53.894	1.95	52.70	-0.05	2.27	±5	Aug. 12, 2014
2450	Body	22.8	1.943	50.960	1.95	52.70	-0.36	-3.30	±5	Aug. 25, 2014
5200	Body	22.9	5.373	48.526	5.30	49.00	1.38	-0.97	±5	Aug. 15, 2014
5800	Body	22.7	6.219	47.128	6.00	48.20	3.65	-2.22	±5	Aug. 07, 2014

**10.2 System Performance Check Results**

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

Date	Frequency (MHz)	Tissue Type	Input Power (mW)	Dipole S/N	Probe S/N	DAE S/N	Measured SAR (W/kg)	Targeted SAR (W/kg)	Normalized SAR (W/kg)	Deviation (%)
Aug. 12, 2014	2450	Body	250	908	3911	1358	13.10	50.40	52.4	3.97
Aug. 25, 2014	2450	Body	250	924	3857	1210	12.40	50.20	49.6	-1.20
Aug. 15, 2014	5200	Body	100	1006	3857	1210	7.44	71.50	74.4	4.06
Aug. 07, 2014	5800	Body	100	1006	3857	1210	7.34	72.30	73.4	1.52



**Fig 8.3.1 System Performance Check Setup**



**Fig 8.3.2 Setup Photo**





## **11. RF Exposure Positions**

### **11.1 SAR Testing for Tablet**

This device can be used also in full sized tablet exposure conditions, due to its size. Per FCC KDB 616217, the back surface and edges of the tablet should be tested for SAR compliance with the tablet touching the phantom. The SAR exclusion threshold in KDB 447498 D01v05r02 can be applied to determine SAR test exclusion for adjacent edge configurations. The closest distance from the antenna to an adjacent tablet edge is used to determine if SAR testing is required for the adjacent edges, with the adjacent edge positioned against the phantom and the edge containing the antenna positioned perpendicular to the phantom.

**12. Conducted RF Output Power (Unit: dBm)**

**<Bluetooth Conducted Power>**

**General Note:**

1. The burst average power is the average power level during the "ON" burst of Bluetooth transmitter.
2. Bluetooth SAR testing was performed at the data rate of 1Mbps, due to highest burst average power.

Bluetooth Burst Average Power (dBm)_DH5					Tune up Limit (dBm)
Channel	Frequency (MHz)	v3.0+EDR			
		1Mbps	2Mbps	3Mbps	
CH 00	2402	10.09	9.28	9.18	10.5
CH 39	2441	10.07	8.64	9.22	
CH 78	2480	9.47	7.86	8.16	

Bluetooth Burst Average power (dBm)			Tune up Limit (dBm)
Channel	Frequency (MHz)	v4.0 LE	
CH 00	2402	8.09	8.5
CH 19	2440	8.25	
CH 39	2480	8.27	

**<WLAN Conducted Power>**

**General Note:**

1. Per KDB 248227, SAR for MIMO was measured with both transmitting simultaneously and was evaluated independently of SISO operation. For 2.4/5.2/5.8GHz MIMO, 802.11n was evaluated.
2. For SAR testing was performed on single antenna RF power in SISO mode is larger or equal to the single antenna RF power in MIMO mode, and for RF exposure assessment of MIMO mode simultaneous transmission exclusion analysis was performed with SAR test results of each antenna in SISO mode.
3. For IEEE802.11b/g SAR testing, highest average RF output power channel for the lowest data rate for 802.11b were selected for SAR evaluation. 802.11g was investigated at worst position of b mode since the average output powers include turn-up was more than 0.25 dB higher than the tested channel in the lowest data rate of 802.11b mode.
4. For IEEE802.11n, SAR testing can be conducted on channel with the highest output power when taking into consideration tune-up tolerance for same test configuration that was identified during SAR evaluations for IEEE802.11b/g (as applicable) provided bandwidth and test position are the same.
5. For IEEE802.11n with multiple channel BW configurations, highest channel BW configuration with highest output power limit shall be tested.
6. Testing of lower BW configurations is not required when the maximum average output of the default test channels in each lower BW configuration is less than 1/4dB higher than the default test channel in the highest BW configuration.

**<WLAN 2.4GHz>**

WLAN 2.4GHz 802.11b Average Power (dBm)								
Power vs. Channel				Power vs. Data Rate				Tune up Limit (dBm)
Channel	Frequency (MHz)	Chain Port	Data Rate 1Mbps	Channel	2Mbps	5.5Mbps	11Mbps	
CH 01	2412	0	13.32	CH 11	13.53	13.39	13.42	14.0
CH 06	2437	0	13.42					
CH 11	2462	0	13.58					
CH 01	2412	1	14.67	CH 01	14.60	14.64	14.57	15.0
CH 06	2437	1	14.47					
CH 11	2462	1	14.21					

WLAN 2.4GHz 802.11g Average Power (dBm)												
Power vs. Channel				Power vs. Data Rate								Tune up Limit (dBm)
Channel	Frequency (MHz)	Chain Port	Data Rate 6Mbps	Channel	9Mbps	12Mbps	18Mbps	24Mbps	36Mbps	48Mbps	54Mbps	
CH 01	2412	0	14.17	CH 11	14.17	14.30	14.20	14.33	14.18	14.33	14.35	14.5
CH 06	2437	0	14.13									
CH 11	2462	0	14.36									
CH 01	2412	1	10.45	CH 01	10.42	10.36	10.41	10.36	10.43	10.42	10.04	11.0
CH 06	2437	1	10.24									
CH 11	2462	1	10.02									



WLAN 2.4GHz 802.11n HT20 Average Power (dBm)												
Power vs. Channel				Power vs. MCS Index								Tune up Limit (dBm)
Channel	Frequency (MHz)	Chain Port	MCS Index MCS0	Channel	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	
CH 01	2412	0	11.60	CH 06	11.88	11.62	11.63	11.79	11.79	11.83	11.70	12.5
CH 06	2437	0	12.05									
CH 11	2462	0	11.85									
CH 01	2412	1	12.25	CH 01	12.18	12.10	12.03	12.06	12.22	12.04	12.05	12.5
CH 06	2437	1	12.07									
CH 11	2462	1	11.67									
Channel	Frequency (MHz)	Chain Port	MCS Index MCS8	Channel	MCS9	MCS10	MCS11	MCS12	MCS13	MCS14	MCS15	Tune up Limit (dBm)
CH 01	2412	0+1	12.22	CH 11	12.34	12.26	12.38	12.37	12.44	12.40	12.46	12.5
CH 06	2437	0+1	12.33									
CH 11	2462	0+1	12.47									

WLAN 2.4GHz 802.11n HT40 Average Power (dBm)												
Power vs. Channel				Power vs. MCS Index								Tune up Limit (dBm)
Channel	Frequency (MHz)	Chain Port	MCS Index MCS0	Channel	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	
CH 03	2422	0	9.98	CH 03	9.75	9.78	9.62	9.80	9.84	9.54	9.42	10.5
CH 06	2437	0	9.75									
CH 09	2452	0	9.76									
CH 03	2422	1	10.09	CH 03	10.06	10.07	9.94	9.69	9.76	9.73	9.89	10.5
CH 06	2437	1	9.30									
CH 09	2452	1	9.48									
Channel	Frequency (MHz)	Chain Port	MCS Index MCS8	Channel	MCS9	MCS10	MCS11	MCS12	MCS13	MCS14	MCS15	Tune up Limit (dBm)
CH 03	2422	0+1	11.27	CH 03	11.22	11.26	11.11	11.25	11.23	11.23	11.17	11.5
CH 06	2437	0+1	10.77									
CH 09	2452	0+1	10.64									



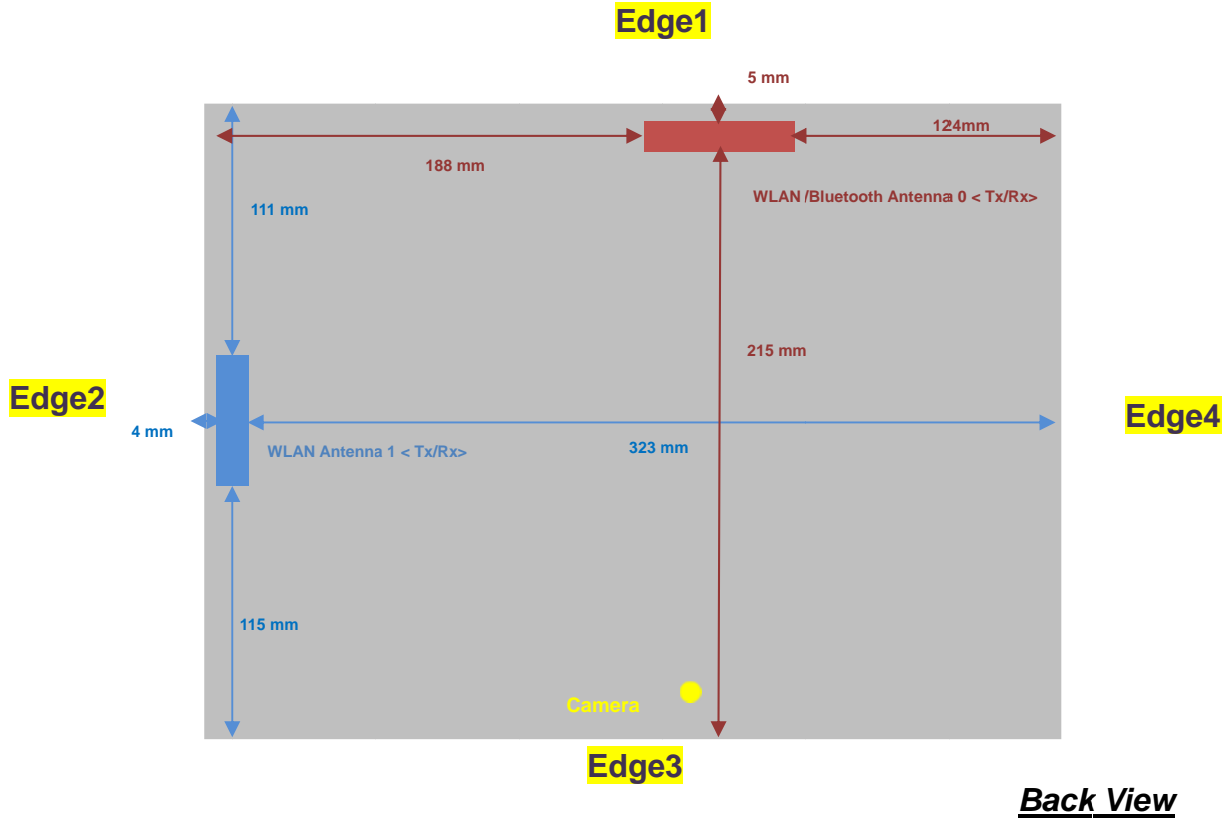
<5GHz WLAN>

WLAN 5GHz 802.11a Average Power (dBm)												
Power vs. Channel				Power vs. Data Rate								Tune up Limit (dBm)
Channel	Frequency (MHz)	Chain Port	Data Rate 6Mbps	Channel	9Mbps	12Mbps	18Mbps	24Mbps	36Mbps	48Mbps	54Mbps	
CH 36	5180	0	7.79	CH 36	7.78	7.74	7.59	7.60	7.62	7.72	7.67	8.0
CH 40	5200	0	6.34									6.5
CH 44	5220	0	6.25									6.5
CH 48	5240	0	7.09									8.0
CH 149	5745	0	3.54	CH 165	4.31	4.27	4.23	4.26	4.18	4.27	4.12	4.0
CH 153	5765	0	3.51									4.0
CH 157	5785	0	3.48									4.0
CH 161	5805	0	3.62									4.0
CH 165	5825	0	4.34									4.5
CH 36	5180	1	10.21	CH 48	10.15	10.15	10.03	10.03	10.08	10.16	10.06	10.5
CH 40	5200	1	10.11									
CH 44	5220	1	9.88									
CH 48	5240	1	10.31									
CH 149	5745	1	7.07	CH 165	7.33	7.32	7.36	7.34	7.29	7.40	7.38	7.5
CH 153	5765	1	7.02									
CH 157	5785	1	6.84									
CH 161	5805	1	6.51									
CH 165	5825	1	7.41									

WLAN 5GHz 802.11n HT20 Average Power (dBm)												
Power vs. Channel				Power vs. MCS Index								Tune up Limit (dBm)
Channel	Frequency (MHz)	Chain Port	MCS Index	Channel	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	
CH 36	5180	0	5.28	CH 36	5.04	5.19	5.17	5.18	5.22	5.25	5.23	5.5
CH 40	5200	0	4.29									4.5
CH 44	5220	0	4.88									5.0
CH 48	5240	0	4.44									5.0
CH 149	5745	0	3.51	CH 165	3.85	3.84	3.86	3.83	3.90	3.89	3.88	4.0
CH 153	5765	0	3.54									
CH 157	5785	0	3.74									
CH 161	5805	0	3.62									
CH 165	5825	0	3.91									
CH 36	5180	1	11.46									
CH 40	5200	1	11.25	CH 36	11.38	11.35	11.35	11.46	11.36	11.39	11.44	11.5
CH 44	5220	1	11.34									
CH 48	5240	1	11.43									
CH 149	5745	1	6.89									
CH 153	5765	1	6.62	CH 157	7.02	6.77	6.89	7.04	7.08	6.98	6.83	7.5
CH 157	5785	1	7.11									
CH 161	5805	1	6.87									
CH 165	5825	1	6.94									
CH 36	5180	0+1	11.47									
Channel	Frequency (MHz)	Chain Port	MCS Index	Channel	MCS9	MCS10	MCS11	MCS12	MCS13	MCS14	MCS15	Tune up Limit (dBm)
CH 36	5180	0+1	11.47	CH 36	11.45	11.46	11.42	11.43	11.44	11.43	11.41	11.5
CH 40	5200	0+1	10.42									
CH 44	5220	0+1	10.99									
CH 48	5240	0+1	11.23									
CH 149	5745	0+1	12.42	CH 157	12.08	12.40	12.17	12.39	12.39	12.15	12.44	12.5
CH 153	5765	0+1	12.32									
CH 157	5785	0+1	12.45									
CH 161	5805	0+1	12.11									
CH 165	5825	0+1	12.42									

WLAN 5GHz 802.11n HT40 Average Power (dBm)												
Power vs. Channel				Power vs. MCS Index								Tune up Limit (dBm)
Channel	Frequency (MHz)	Chain Port	MCS Index MCS0	Channel	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	
CH 38	5190	0	5.43	CH 38	5.38	5.22	5.34	5.09	5.40	5.27	5.21	5.5
CH 46	5230	0	5.37									
CH 151	5755	0	5.76	CH 151	5.46	5.44	5.29	5.28	5.32	5.35	5.23	6.0
CH 159	5795	0	5.69									
CH 38	5190	1	10.27	CH 38	10.01	9.52	9.44	9.45	9.39	9.23	9.21	10.5
CH 46	5230	1	9.89									
CH 151	5755	1	7.93	CH 159	7.79	7.50	7.33	7.30	7.37	7.28	7.35	8.5
CH 159	5795	1	8.06									
Channel	Frequency (MHz)	Chain Port	MCS Index MCS8	Channel	MCS9	MCS10	MCS11	MCS12	MCS13	MCS14	MCS15	Tune up Limit (dBm)
CH 38	5190	0+1	10.46	CH 38	10.32	10.18	10.03	10.05	10.02	10.12	10.16	10.5
CH 46	5230	0+1	10.03									
CH 151	5755	0+1	10.34	CH 151	9.62	9.47	9.31	9.32	9.25	9.37	9.39	10.5
CH 159	5795	0+1	10.24									

### 13. Antenna Location



**<Transmission configuration>**

Wireless Interface	SISO Mode		MIMO Mode
	Antenna 0 <Tx/Rx>	Antenna 1 <Tx/Rx>	Antenna 0+1 <Tx/Rx>
WLAN 2.4GHz 802.11b/g	yes	yes	
WLAN 2.4GHz 802.11n HT20/ HT40	yes	yes	yes
WLAN 5GHz 802.11a	yes	yes	
WLAN 5GHz 802.11n HT20/ HT40	yes	yes	yes
Bluetooth	yes		



**General Note:**

1. The below table, when the distance is < 50 mm exclusion threshold is "Ratio", when the distance is > 50 mm exclusion threshold is "mW".
2. Maximum power is the source-based time-average power and represents the maximum RF output power among production units
3. Per KDB 447498 D01v05r02, for larger devices, the test separation distance of adjacent edge configuration is determined by the closest separation between the antenna and the user.
4. Per KDB 447498 D01v05r02, standalone SAR test exclusion threshold is applied; If the test separation distance is < 5mm, 5mm is used to determine SAR exclusion threshold.
5. Per KDB 447498 D01v05r02, at 100 MHz to 6 GHz and for *test separation distances* > 50 mm, the SAR test exclusion threshold is determined according to the following
  - a) [Threshold at 50 mm in step 1) + (test separation distance - 50 mm)·( f(MHz)/150)] mW, at 100 MHz to 1500 MHz
  - b) [Threshold at 50 mm in step 1) + (test separation distance - 50 mm)·10] mW at > 1500 MHz and ≤ 6 GHz

**SAR test exclusion table distance is ≤ 50mm**

Exposure Position	Wireless Interface	WLAN 2.4GHz 802.11b Ant.0	WLAN 5.2GHz 802.11a Ant.0	WLAN 5.8GHz 802.11a Ant.0	Bluetooth	WLAN 2.4GHz 802.11b Ant.1	WLAN 5.2GHz 802.11a Ant.1	WLAN 5.8GHz 802.11a Ant.1
	Calculated Frequency (MHz)	2462	5240	5825	2480	2462	5240	5825
	Tune-up Maximum power (dBm)	14.0	8.0	4.5	10.5	15.0	10.5	7.5
Bottom Face	Antenna to user (mm)	0				0		
	SAR exclusion threshold	8	3	1	3	10	5	3
	SAR testing required?	Yes	No	No	No	Yes	Yes	No
Edge 1	Antenna to user (mm)	5						
	SAR exclusion threshold	8	3	1	3			
	SAR testing required?	Yes	No	No	No			
Edge 2	Antenna to user (mm)					4		
	SAR exclusion threshold					10	5	3
	SAR testing required?					Yes	Yes	No

**SAR test exclusion table distance is > 50mm**

Exposure Position	Wireless Interface	WLAN 2.4GHz 802.11b Ant.0	WLAN 5.2GHz 802.11a Ant.0	WLAN 5.8GHz 802.11a Ant.0	Bluetooth	WLAN 2.4GHz 802.11b Ant.1	WLAN 5.2GHz 802.11a Ant.1	WLAN 5.8GHz 802.11a Ant.1
	Calculated Frequency (MHz)	2462	5240	5825	2480	2462	5240	5825
	Tune-up Maximum power (dBm)	14.0	8.0	4.5	10.5	15.0	10.5	7.5
	Tune-up Maximum rated power (mW)	25	6	3	11	32	11	6
Edge 1	Antenna to user (mm)					111		
	SAR exclusion threshold					706	676	672
	SAR testing required?					No	No	No
Edge 2	Antenna to user (mm)	188						
	SAR exclusion threshold	1476	1446	1442	1475			
	SAR testing required?	No	No	No	No			
Edge 3	Antenna to user (mm)	215				115		
	SAR exclusion threshold	1746	1716	1712	1745	746	716	712
	SAR testing required?	No	No	No	No	No	No	No
Edge 4	Antenna to user (mm)	124				323		
	SAR exclusion threshold	836	806	802	835	2826	2796	2792
	SAR testing required?	No	No	No	No	No	No	No



## **14. SAR Test Results**

### **General Note:**

1. Per KDB 447498 D01v05r02, the reported SAR is the measured SAR value adjusted for maximum tune-up tolerance.
  - a. Tune-up scaling Factor = tune-up limit power (mW) / EUT RF power (mW), where tune-up limit is the maximum rated power among all production units.
  - b. For SAR testing of WLAN signal with non-100% duty cycle, the measured SAR is scaled-up by the duty cycle scaling factor which is equal to "1/(duty cycle)"
  - c. For WWAN: Reported SAR(W/kg)= Measured SAR(W/kg)\*Tune-up Scaling Factor
  - d. For WLAN: Reported SAR(W/kg)= Measured SAR(W/kg)\* Duty Cycle scaling factor \* Tune-up scaling factor
2. Per KDB 447498 D01v05r02, for each exposure position, testing of other required channels within the operating mode of a frequency band is not required when the *reported* 1-g or 10-g SAR for the mid-band or highest output power channel is:
  - $\leq 0.8$  W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is  $\leq 100$  MHz
  - $\leq 0.6$  W/kg or 1.5 W/kg, for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz
  - $\leq 0.4$  W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is  $\geq 200$  MHz
3. Considering the curvature transition from bottom face to the edge, SAR testing at the curvature was performed. The SAR test setup is included in test setup photo exhibit, and the details of the curvature are included in operation description exhibit.
4. Curved region diagram of the device according to the test setup photo(exterior radius dimension), X=4.14 mm, Y=2.44mm, Z=1.07mm and complied X>Z, Y>Z, Per KDB 616217 D04v01r01, curved SAR evaluation should be verified.
5. For SAR testing of the curved region of the device, the device was placed directly against the phantom at the point where the distance between the antenna and device exterior is a minimum.



14.1 Body SAR

<DTS WLAN SAR>

Plot No.	Band	Mode	Test Position	Gap (cm)	Ant.	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Duty Cycle %	Duty Cycle Scaling Factor	Sample	Power Drift (dB)	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
	WLAN 2.4GHz	802.11b 1Mbps	Bottom Face	0	Ant 0	11	2462	13.58	14.00	1.102	100	1.000	#1	-0.02	0.937	1.032
	WLAN 2.4GHz	802.11b 1Mbps	Edge 1	0	Ant 0	11	2462	13.58	14.00	1.102	100	1.000	#1	-0.02	0.324	0.357
	WLAN 2.4GHz	802.11b 1Mbps	Curved surface of Edge 1	0	Ant 0	11	2462	13.58	14.00	1.102	100	1.000	#1	-0.01	0.743	0.818
#01	WLAN 2.4GHz	802.11g 6Mbps	Bottom Face	0	Ant 0	11	2462	14.36	14.50	1.033	95.3	1.049	#1	-0.01	1.140	1.235
	WLAN 2.4GHz	802.11n HT40 MCS0	Bottom Face	0	Ant 0	3	2422	9.98	10.50	1.127	89.66	1.115	#1	-0.09	0.343	0.431
	WLAN 2.4GHz	802.11n HT20 MCS0	Bottom Face	0	Ant 0	6	2437	12.05	12.50	1.109	94.95	1.053	#1	-0.07	0.583	0.681
	WLAN 2.4GHz	802.11b 1Mbps	Bottom Face	0	Ant 0	1	2412	13.32	14.00	1.169	100	1.000	#1	-0.07	0.871	1.019
	WLAN 2.4GHz	802.11b 1Mbps	Bottom Face	0	Ant 0	6	2437	13.42	14.00	1.143	100	1.000	#1	-0.05	0.892	1.019
	WLAN 2.4GHz	802.11g 6Mbps	Bottom Face	0	Ant 0	1	2412	14.17	14.50	1.079	95.3	1.049	#1	-0.02	1.030	1.166
	WLAN 2.4GHz	802.11g 6Mbps	Bottom Face	0	Ant 0	6	2437	14.13	14.50	1.089	95.3	1.049	#1	-0.09	0.971	1.109
	WLAN 2.4GHz	802.11b 1Mbps	Curved surface of Edge 1	0	Ant 0	1	2412	13.32	14.00	1.169	100	1.000	#1	-0.09	0.706	0.826
	WLAN 2.4GHz	802.11b 1Mbps	Curved surface of Edge 1	0	Ant 0	6	2437	13.42	14.00	1.143	100	1.000	#1	-0.01	0.752	0.859
	WLAN 2.4GHz	802.11g 6Mbps	Bottom Face	0	Ant 0	11	2462	14.36	14.50	1.033	95.3	1.049	#2	-0.03	1.050	1.138
	WLAN 2.4GHz	802.11g 6Mbps	Bottom Face	0	Ant 0	1	2412	14.17	14.50	1.079	95.3	1.049	#2	-0.08	0.861	0.974
	WLAN 2.4GHz	802.11g 6Mbps	Bottom Face	0	Ant 0	6	2437	14.13	14.50	1.089	95.3	1.049	#2	-0.05	1.020	1.165
	WLAN 2.4GHz	802.11b 1Mbps	Bottom Face	0	Ant 1	1	2412	14.67	15.00	1.079	100	1.000	#1	0.01	0.426	0.460
	WLAN 2.4GHz	802.11b 1Mbps	Edge 2	0	Ant 1	1	2412	14.67	15.00	1.079	100	1.000	#1	-0.02	0.188	0.203
	WLAN 2.4GHz	802.11b 1Mbps	Curved surface of Edge 2	0	Ant 1	1	2412	14.67	15.00	1.079	100	1.000	#1	-0.03	0.386	0.416
	WLAN 2.4GHz	802.11n HT40 MCS0	Bottom Face	0	Ant 1	3	2422	10.09	10.50	1.099	90.63	1.103	#1	0.03	0.163	0.198
	WLAN 2.4GHz	802.11n HT20 MCS0	Bottom Face	0	Ant 1	1	2412	12.25	12.50	1.059	95.04	1.052	#1	0.07	0.278	0.310
	WLAN 2.4GHz	802.11b 1Mbps	Bottom Face	0	Ant 1	6	2437	14.47	15.00	1.130	100	1.000	#1	0.05	0.433	0.489
	WLAN 2.4GHz	802.11b 1Mbps	Bottom Face	0	Ant 1	11	2462	14.21	15.00	1.199	100	1.000	#1	0.09	0.389	0.467
	WLAN 2.4GHz	802.11b 1Mbps	Bottom Face	0	Ant 1	6	2437	14.47	15.00	1.130	100	1.000	#2	0.04	0.349	0.394



Plot No.	Band	Mode	Test Position	Gap (cm)	Ant.	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Duty Cycle %	Duty Cycle Scaling Factor	Sample	Power Drift (dB)	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
	WLAN 2.4GHz	802.11n-HT20 MCS8	Bottom Face	0	Ant 0+1	11	2462	12.47	12.50	1.007	90.83	1.101	#1	-0.07	0.404	0.448
	WLAN 2.4GHz	802.11n-HT20 MCS8	Edge 1	0	Ant 0+1	11	2462	12.47	12.50	1.007	90.83	1.101	#1	-0.04	0.126	0.140
	WLAN 2.4GHz	802.11n-HT20 MCS8	Edge 2	0	Ant 0+1	11	2462	12.47	12.50	1.007	90.83	1.101	#1	-0.09	0.067	0.074
	WLAN 2.4GHz	802.11n-HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	11	2462	12.47	12.50	1.007	90.83	1.101	#1	-0.09	0.294	0.326
	WLAN 2.4GHz	802.11n-HT20 MCS8	Curved surface of Edge 2	0	Ant 0+1	11	2462	12.47	12.50	1.007	90.83	1.101	#1	-0.03	0.218	0.242
	WLAN 2.4GHz	802.11n-HT40 MCS8	Bottom Face	0	Ant 0+1	3	2422	11.27	11.50	1.054	83.61	1.196	#1	-0.13	0.097	0.122
	WLAN 2.4GHz	802.11n-HT20 MCS8	Bottom Face	0	Ant 0+1	1	2412	12.22	12.50	1.067	90.83	1.101	#1	-0.05	0.354	0.416
	WLAN 2.4GHz	802.11n-HT20 MCS8	Bottom Face	0	Ant 0+1	6	2437	12.33	12.50	1.040	90.83	1.101	#1	-0.08	0.372	0.426
	WLAN 2.4GHz	802.11n-HT20 MCS8	Bottom Face	0	Ant 0+1	11	2462	12.47	12.50	1.007	90.83	1.101	#2	-0.04	0.329	0.365

<Bluetooth SAR>

Plot No.	Band	Mode	Test Position	Gap (cm)	Ant.	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Sample	Power Drift (dB)	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
	Bluetooth	1Mbps DH5	Bottom Face	0	Ant 0	0	2402	10.09	10.5	1.099	#1	-0.02	0.000592	<0.010
	Bluetooth	1Mbps DH5	Curved surface of Edge 1	0	Ant 0	0	2402	10.09	10.5	1.099	#1	-0.056	9.36E-05	<0.010
	Bluetooth	1Mbps DH5	Edge1	0	Ant 0	0	2402	10.09	10.5	1.099	#1	-0.19	9.35E-05	<0.010
	Bluetooth	1Mbps DH5	Bottom Face	0	Ant 0	39	2441	10.07	10.5	1.104	#1	-0.06	0.00017	<0.010
#02	Bluetooth	1Mbps DH5	Bottom Face	0	Ant 0	78	2480	9.47	10.5	1.268	#1	0.13	0.002	<b>0.003</b>
	Bluetooth	1Mbps DH5	Bottom Face	0	Ant 0	78	2480	9.47	10.5	1.268	#2	-0.06	0.000241	<0.010



<NII WLAN SAR>

Plot No.	Band	Mode	Test Position	Gap (cm)	Ant.	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Duty Cycle %	Duty Cycle Scaling Factor	Sample	Power Drift (dB)	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
	WLAN 5.2GHz	802.11a 6Mbps	Bottom Face	0	Ant 0	36	5180	7.79	8.0	1.050	95.39	1.048	#1	-0.06	0.610	0.671
	WLAN 5.2GHz	802.11a 6Mbps	Edge1	0	Ant 0	36	5180	7.79	8.0	1.050	95.39	1.048	#1	-0.05	0.157	0.173
	WLAN 5.2GHz	802.11a 6Mbps	Curved surface of Edge 1	0	Ant 0	36	5180	7.79	8.0	1.050	95.39	1.048	#1	-0.06	0.711	0.782
	WLAN 5.2GHz	802.11n-HT40 MCS0	Curved surface of Edge 1	0	Ant 0	36	5190	5.43	5.5	1.016	95.05	1.052	#1	-0.16	1.200	1.283
	WLAN 5.2GHz	802.11n-HT40 MCS0	Curved surface of Edge 1	0	Ant 0	46	5230	5.37	5.5	1.030	95.05	1.052	#1	-0.10	1.130	1.225
	WLAN 5.2GHz	802.11n-HT40 MCS0	Curved surface of Edge 1	0	Ant 0	36	5190	5.43	5.5	1.016	95.05	1.052	#2	-0.06	0.915	0.978
	WLAN 5.2GHz	802.11n-HT40 MCS0	Curved surface of Edge 1	0	Ant 0	48	5230	5.37	5.5	1.030	95.05	1.052	#2	-0.10	0.955	1.035
	WLAN 5.2GHz	802.11a 6Mbps	Bottom Face	0	Ant 1	48	5240	10.31	10.5	1.045	95.48	1.047	#1	0.05	0.102	0.112
	WLAN 5.2GHz	802.11a 6Mbps	Edge2	0	Ant 1	48	5240	10.31	10.5	1.045	95.48	1.047	#1	-0.12	0.312	0.341
	WLAN 5.2GHz	802.11a 6Mbps	Curved surface of Edge 2	0	Ant 1	48	5240	10.31	10.5	1.045	95.48	1.047	#1	-0.15	0.236	0.258
	WLAN 5.2GHz	802.11n-HT40 MCS0	Edge2	0	Ant 1	36	5190	10.27	10.5	1.054	95.17	1.051	#1	-0.15	0.258	0.286
	WLAN 5.2GHz	802.11n-HT20 MCS0	Edge2	0	Ant 1	36	5180	11.46	11.5	1.009	95.17	1.051	#1	-0.10	0.489	0.519
	WLAN 5.2GHz	802.11n-HT20 MCS0	Edge2	0	Ant 1	48	5240	11.43	11.5	1.016	95.17	1.051	#1	-0.13	0.351	0.375
	WLAN 5.2GHz	802.11n-HT20 MCS0	Edge2	0	Ant 1	36	5180	11.46	11.5	1.009	95.17	1.051	#2	-0.05	0.674	0.715
	WLAN 5.2GHz	802.11n-HT20 MCS8	Bottom Face	0	Ant 0+1	36	5180	11.47	11.5	1.007	90.13	1.110	#1	-0.07	1.160	1.297
	WLAN 5.2GHz	802.11n-HT20 MCS8	Edge1	0	Ant 0+1	36	5180	11.47	11.5	1.007	90.13	1.110	#1	-0.08	0.468	0.523
	WLAN 5.2GHz	802.11n-HT20 MCS8	Edge2	0	Ant 0+1	36	5180	11.47	11.5	1.007	90.13	1.110	#1	-0.04	0.275	0.307
	WLAN 5.2GHz	802.11n-HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	36	5180	11.47	11.5	1.007	90.13	1.110	#1	-0.07	1.280	1.431
	WLAN 5.2GHz	802.11n-HT20 MCS8	Curved surface of Edge 2	0	Ant 0+1	36	5180	11.47	11.5	1.007	90.13	1.110	#1	-0.07	0.210	0.235
	WLAN 5.2GHz	802.11n-HT20 MCS8	Bottom Face	0	Ant 0+1	48	5240	11.23	11.5	1.064	90.13	1.110	#1	0.03	1.000	1.181
#03	WLAN 5.2GHz	802.11n-HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	48	5240	11.23	11.5	1.064	90.13	1.110	#1	-0.05	1.240	1.465
	WLAN 5.2GHz	802.11n-HT40 MCS8	Curved surface of Edge 1	0	Ant 0+1	38	5190	10.46	10.5	1.009	90.79	1.101	#1	0.17	1.150	1.278
	WLAN 5.2GHz	802.11n-HT40 MCS8	Curved surface of Edge 1	0	Ant 0+1	46	5230	10.03	10.5	1.114	90.79	1.101	#1	-0.05	1.020	1.251
	WLAN 5.2GHz	802.11n-HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	48	5240	11.23	11.5	1.064	90.13	1.110	#2	-0.05	1.060	1.252
	WLAN 5.2GHz	802.11n-HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	36	5180	11.47	11.5	1.007	90.13	1.110	#2	-0.06	1.050	1.174



Plot No.	Band	Mode	Test Position	Gap (cm)	Ant.	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Duty Cycle %	Duty Cycle Scaling Factor	Sample	Power Drift (dB)	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
	WLAN 5.8GHz	802.11a 6Mbps	Bottom Face	0	Ant 0	165	5825	4.34	4.5	1.038	95.39	1.048	#1	-0.11	1.130	1.229
	WLAN 5.8GHz	802.11a 6Mbps	Edge1	0	Ant 0	165	5825	4.34	4.5	1.038	95.39	1.048	#1	-0.01	0.403	0.438
	WLAN 5.8GHz	802.11a 6Mbps	Curved surface of Edge 1	0	Ant 0	165	5825	4.34	4.5	1.038	95.39	1.048	#1	-0.16	1.320	1.435
	WLAN 5.8GHz	802.11a 6Mbps	Bottom Face	0	Ant 0	149	5745	3.54	4.0	1.112	95.39	1.048	#1	0.12	0.441	0.514
	WLAN 5.8GHz	802.11a 6Mbps	Bottom Face	0	Ant 0	157	5785	3.48	4.0	1.127	95.39	1.048	#1	-0.09	0.798	0.943
	WLAN 5.8GHz	802.11a 6Mbps	Curved surface of Edge 1	0	Ant 0	149	5745	3.54	4.0	1.112	95.39	1.048	#1	0.03	0.918	1.070
	WLAN 5.8GHz	802.11a 6Mbps	Curved surface of Edge 1	0	Ant 0	157	5785	3.48	4.0	1.127	95.39	1.048	#1	-0.06	0.934	1.103
	WLAN 5.8GHz	802.11n HT40 MCS0	Curved surface of Edge 1	0	Ant 0	151	5755	5.76	6.0	1.057	95.05	1.052	#1	0.16	0.646	0.718
	WLAN 5.8GHz	802.11n HT40 MCS0	Curved surface of Edge 1	0	Ant 0	159	5795	5.69	6.0	1.074	95.05	1.052	#1	-0.15	1.150	1.299
	WLAN 5.8GHz	802.11a 6Mbps	Curved surface of Edge 1	0	Ant 0	165	5825	4.34	4.5	1.038	95.38	1.048	#2	-0.15	0.951	1.034
	WLAN 5.8GHz	802.11a 6Mbps	Curved surface of Edge 1	0	Ant 0	149	5745	3.54	4.0	1.112	95.38	1.048	#2	0.13	0.483	0.563
	WLAN 5.8GHz	802.11a 6Mbps	Curved surface of Edge 1	0	Ant 0	157	5785	3.48	4.0	1.127	95.38	1.048	#2	-0.09	0.732	0.865
	WLAN 5.8GHz	802.11a 6Mbps	Bottom Face	0	Ant 1	165	5825	7.41	7.5	1.021	95.48	1.047	#1	0.06	0.252	0.269
	WLAN 5.8GHz	802.11a 6Mbps	Edge2	0	Ant 1	165	5825	7.41	7.5	1.021	95.48	1.047	#1	-0.01	0.951	1.017
	WLAN 5.8GHz	802.11a 6Mbps	Curved surface of Edge 2	0	Ant 1	165	5825	7.41	7.5	1.021	95.48	1.047	#1	0.03	0.729	0.779
	WLAN 5.8GHz	802.11a 6Mbps	Edge2	0	Ant 1	149	5745	7.07	7.5	1.104	95.48	1.047	#1	-0.01	0.854	0.987
	WLAN 5.8GHz	802.11a 6Mbps	Edge2	0	Ant 1	157	5785	6.84	7.5	1.164	95.48	1.047	#1	-0.11	0.880	1.073
	WLAN 5.8GHz	802.11a 6Mbps	Curved surface of Edge 2	0	Ant 1	149	5745	7.07	7.5	1.104	95.48	1.047	#1	0.14	0.654	0.756
	WLAN 5.8GHz	802.11a 6Mbps	Curved surface of Edge 2	0	Ant 1	157	5785	6.84	7.5	1.164	95.48	1.047	#1	0.07	0.658	0.802
	WLAN 5.8GHz	802.11n HT40 MCS0	Edge2	0	Ant 1	159	5795	7.93	8.5	1.140	95.17	1.051	#1	-0.01	0.971	1.164
	WLAN 5.8GHz	802.11n HT40 MCS0	Edge2	0	Ant 1	151	5755	8.06	8.5	1.107	95.17	1.051	#1	-0.13	0.934	1.086
	WLAN 5.8GHz	802.11n HT40 MCS0	Edge2	0	Ant 1	159	5795	7.93	8.5	1.140	95.17	1.051	#2	-0.06	1.160	1.390
	WLAN 5.8GHz	802.11n HT40 MCS0	Edge2	0	Ant 1	151	5755	8.06	8.5	1.107	95.17	1.051	#2	-0.08	1.150	1.338

Plot No.	Band	Mode	Test Position	Gap (cm)	Ant.	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Duty Cycle %	Duty Cycle Scaling Factor	Sample	Power Drift (dB)	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
	WLAN 5.8GHz	802.11n HT20 MCS8	Bottom Face	0	Ant 0+1	157	5785	12.45	12.5	1.012	90.13	1.110	#1	0.04	0.829	0.931
	WLAN 5.8GHz	802.11n HT20 MCS8	Edge1	0	Ant 0+1	157	5785	12.45	12.5	1.012	90.13	1.110	#1	-0.07	0.381	0.428
	WLAN 5.8GHz	802.11n HT20 MCS8	Edge2	0	Ant 0+1	157	5785	12.45	12.5	1.012	90.13	1.110	#1	-0.07	0.042	0.047
	WLAN 5.8GHz	802.11n HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	157	5785	12.45	12.5	1.012	90.13	1.110	#1	0.04	0.872	0.979
	WLAN 5.8GHz	802.11n HT20 MCS8	Curved surface of Edge 2	0	Ant 0+1	157	5785	12.45	12.5	1.012	90.13	1.110	#1	0.15	0.444	0.499
	WLAN 5.8GHz	802.11n HT20 MCS8	Bottom Face	0	Ant 0+1	149	5745	12.42	12.5	1.019	90.13	1.110	#1	-0.17	0.496	0.561
	WLAN 5.8GHz	802.11n HT20 MCS8	Bottom Face	0	Ant 0+1	165	5825	12.42	12.5	1.019	90.13	1.110	#1	-0.14	1.100	1.244
	WLAN 5.8GHz	802.11n HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	149	5745	12.42	12.5	1.019	90.13	1.110	#1	0.08	0.576	0.651
	WLAN 5.8GHz	802.11n HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	165	5825	12.42	12.5	1.019	90.13	1.110	#1	-0.05	1.270	1.436
	WLAN 5.8GHz	802.11n HT40 MCS8	Curved surface of Edge 1	0	Ant 0+1	151	5755	10.34	10.5	1.038	90.79	1.101	#1	-0.06	0.782	0.893
	WLAN 5.8GHz	802.11n HT40 MCS8	Curved surface of Edge 1	0	Ant 0+1	159	5795	10.24	10.5	1.062	90.79	1.101	#1	-0.08	1.190	1.391
#04	WLAN 5.8GHz	802.11n HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	165	5825	12.42	12.5	1.019	90.13	1.110	#2	-0.16	1.320	<b>1.492</b>
	WLAN 5.8GHz	802.11n HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	149	5745	12.42	12.5	1.019	90.13	1.110	#2	-0.09	0.448	0.507
	WLAN 5.8GHz	802.11n HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	157	5785	12.45	12.5	1.012	90.13	1.110	#2	-0.09	0.972	1.091

**14.2 Repeated SAR Measurement**

No.	Band	Mode	Test Position	Gap (cm)	Ant.	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Duty Cycle %	Duty Cycle Scaling Factor	Power Drift (dB)	Measured 1g SAR (W/kg)	Ratio	Reported 1g SAR (W/kg)
1st	WLAN 2.4GHz	802.11g 6Mbps	Bottom Face	0	Ant 0	11	2462	14.36	14.50	1.033	95.3	1.049	-0.01	1.140	1	1.235
2nd	WLAN 2.4GHz	802.11g 6Mbps	Bottom Face	0	Ant 0	11	2462	14.36	14.50	1.033	95.3	1.049	-0.03	1.070	1.066	1.159
1st	WLAN 5.2GHz	802.11n-HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	36	5180	11.47	11.5	1.007	90.13	1.110	-0.07	1.280	1	1.431
2nd	WLAN 5.2GHz	802.11n-HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	36	5180	11.47	11.5	1.007	90.13	1.110	-0.01	1.250	1.024	1.397
1st	WLAN 5.2GHz	802.11n-HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	165	5825	12.42	12.5	1.019	90.13	1.110	-0.16	1.320	1	1.492
2nd	WLAN 5.2GHz	802.11n-HT20 MCS8	Curved surface of Edge 1	0	Ant 0+1	165	5825	12.42	12.5	1.019	90.13	1.110	-0.12	1.300	1.015	1.470

**General Note:**

1. Per KDB 865664 D01v01r03, for each frequency band, repeated SAR measurement is required only when the measured SAR is  $\geq 0.8W/kg$
2. Per KDB 865664 D01v01r03, if the ratio among the repeated measurement is  $\leq 1.2$  and the measured SAR  $< 1.45W/kg$ , only one repeated measurement is required.
3. The ratio is the difference in percentage between original and repeated *measured SAR*.
4. All measurement SAR result is scaled-up to account for tune-up tolerance and is compliant.





**15. Simultaneous Transmission Analysis**

NO.	Simultaneous Transmission Configurations
1.	None

**General Note:**

1. WLAN and Bluetooth share the same antenna, and cannot transmit simultaneously.
2. EUT will choose either WLAN 2.4GHz or WLAN 5GHz according to the network signal condition; therefore, 2.4GHz WLAN and 5GHz WLAN will not operate simultaneously at any moment.

**Test Engineer :** Kat Yin

## 16. Uncertainty Assessment

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

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

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

Uncertainty Distributions	Normal	Rectangular	Triangular	U-Shape
Multi-plying Factor <sup>(a)</sup>	1/ $\kappa$ <sup>(b)</sup>	1/ $\sqrt{3}$	1/ $\sqrt{6}$	1/ $\sqrt{2}$

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

(b)  $\kappa$  is the coverage factor

**Table 16.1. Standard Uncertainty for Assumed Distribution**

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

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

Error Description	Uncertainty Value (±%)	Probability Distribution	Divisor	Ci (1g)	Ci (10g)	Standard Uncertainty (1g)	Standard Uncertainty (10g)
<b>Measurement System</b>							
Probe Calibration	6.0	Normal	1	1	1	± 6.0 %	± 6.0 %
Axial Isotropy	4.7	Rectangular	√3	0.7	0.7	± 1.9 %	± 1.9 %
Hemispherical Isotropy	9.6	Rectangular	√3	0.7	0.7	± 3.9 %	± 3.9 %
Boundary Effects	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
Linearity	4.7	Rectangular	√3	1	1	± 2.7 %	± 2.7 %
System Detection Limits	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
Readout Electronics	0.3	Normal	1	1	1	± 0.3 %	± 0.3 %
Response Time	0.8	Rectangular	√3	1	1	± 0.5 %	± 0.5 %
Integration Time	2.6	Rectangular	√3	1	1	± 1.5 %	± 1.5 %
RF Ambient Noise	3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %
RF Ambient Reflections	3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %
Probe Positioner	0.4	Rectangular	√3	1	1	± 0.2 %	± 0.2 %
Probe Positioning	2.9	Rectangular	√3	1	1	± 1.7 %	± 1.7 %
Max. SAR Eval.	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
<b>Test Sample Related</b>							
Device Positioning	2.9	Normal	1	1	1	± 2.9 %	± 2.9 %
Device Holder	3.6	Normal	1	1	1	± 3.6 %	± 3.6 %
Power Drift	5.0	Rectangular	√3	1	1	± 2.9 %	± 2.9 %
<b>Phantom and Setup</b>							
Phantom Uncertainty	4.0	Rectangular	√3	1	1	± 2.3 %	± 2.3 %
Liquid Conductivity (Target)	5.0	Rectangular	√3	0.64	0.43	± 1.8 %	± 1.2 %
Liquid Conductivity (Meas.)	2.5	Normal	1	0.64	0.43	± 1.6 %	± 1.1 %
Liquid Permittivity (Target)	5.0	Rectangular	√3	0.6	0.49	± 1.7 %	± 1.4 %
Liquid Permittivity (Meas.)	2.5	Normal	1	0.6	0.49	± 1.5 %	± 1.2 %
<b>Combined Standard Uncertainty</b>						± 11.0 %	± 10.8 %
<b>Coverage Factor for 95 %</b>						K=2	
<b>Expanded Uncertainty</b>						± 22.0 %	± 21.5 %

**Table 16.2. Uncertainty Budget for frequency range 300 MHz to 3 GHz**

Error Description	Uncertainty Value (±%)	Probability Distribution	Divisor	Ci (1g)	Ci (10g)	Standard Uncertainty (1g)	Standard Uncertainty (10g)
<b>Measurement System</b>							
Probe Calibration	6.55	Normal	1	1	1	± 6.55 %	± 6.55 %
Axial Isotropy	4.7	Rectangular	√3	0.7	0.7	± 1.9 %	± 1.9 %
Hemispherical Isotropy	9.6	Rectangular	√3	0.7	0.7	± 3.9 %	± 3.9 %
Boundary Effects	2.0	Rectangular	√3	1	1	± 1.2 %	± 1.2 %
Linearity	4.7	Rectangular	√3	1	1	± 2.7 %	± 2.7 %
System Detection Limits	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
Readout Electronics	0.3	Normal	1	1	1	± 0.3 %	± 0.3 %
Response Time	0.8	Rectangular	√3	1	1	± 0.5 %	± 0.5 %
Integration Time	2.6	Rectangular	√3	1	1	± 1.5 %	± 1.5 %
RF Ambient Noise	3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %
RF Ambient Reflections	3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %
Probe Positioner	0.8	Rectangular	√3	1	1	± 0.5 %	± 0.5 %
Probe Positioning	9.9	Rectangular	√3	1	1	± 5.7 %	± 5.7 %
Max. SAR Eval.	4.0	Rectangular	√3	1	1	± 2.3 %	± 2.3 %
<b>Test Sample Related</b>							
Device Positioning	2.9	Normal	1	1	1	± 2.9 %	± 2.9 %
Device Holder	3.6	Normal	1	1	1	± 3.6 %	± 3.6 %
Power Drift	5.0	Rectangular	√3	1	1	± 2.9 %	± 2.9 %
<b>Phantom and Setup</b>							
Phantom Uncertainty	4.0	Rectangular	√3	1	1	± 2.3 %	± 2.3 %
Liquid Conductivity (Target)	5.0	Rectangular	√3	0.64	0.43	± 1.8 %	± 1.2 %
Liquid Conductivity (Meas.)	2.5	Normal	1	0.64	0.43	± 1.6 %	± 1.1 %
Liquid Permittivity (Target)	5.0	Rectangular	√3	0.6	0.49	± 1.7 %	± 1.4 %
Liquid Permittivity (Meas.)	2.5	Normal	1	0.6	0.49	± 1.5 %	± 1.2 %
<b>Combined Standard Uncertainty</b>						± 12.8 %	± 12.6 %
<b>Coverage Factor for 95 %</b>						K=2	
<b>Expanded Uncertainty</b>						± 25.6 %	± 25.2 %

**Table 16.3. Uncertainty Budget for frequency range 3 GHz to 6 GHz**



## **17. References**

- [1] FCC 47 CFR Part 2 "Frequency Allocations and Radio Treaty Matters; General Rules and Regulations"
- [2] ANSI/IEEE Std. C95.1-1992, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz", September 1992
- [3] IEEE Std. 1528-2003, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
- [4] SPEAG DASY System Handbook
- [5] FCC KDB 248227 D01 v01r02, "SAR Measurement Procedures for 802.11 a/b/g Transmitters", May 2007
- [6] FCC KDB 447498 D01 v05r02, "Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies", Feb 2014
- [7] FCC KDB 616217 D04 v01r01, "SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers", May 2013
- [8] FCC KDB 865664 D01 v01r03, "SAR Measurement Requirements for 100 MHz to 6 GHz", Feb 2014.
- [9] FCC KDB 865664 D02 v01r01, "RF Exposure Compliance Reporting and Documentation Considerations" May 2013.



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

The plots are shown as follows.

## System Check\_Body\_2450MHz\_140812

### DUT: Dipole 2450 MHz D2450V2

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

Medium: MSL\_2450\_140812 Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.949$  S/m;  $\epsilon_r = 53.894$ ;  $\rho = 1000$  kg/m<sup>3</sup>

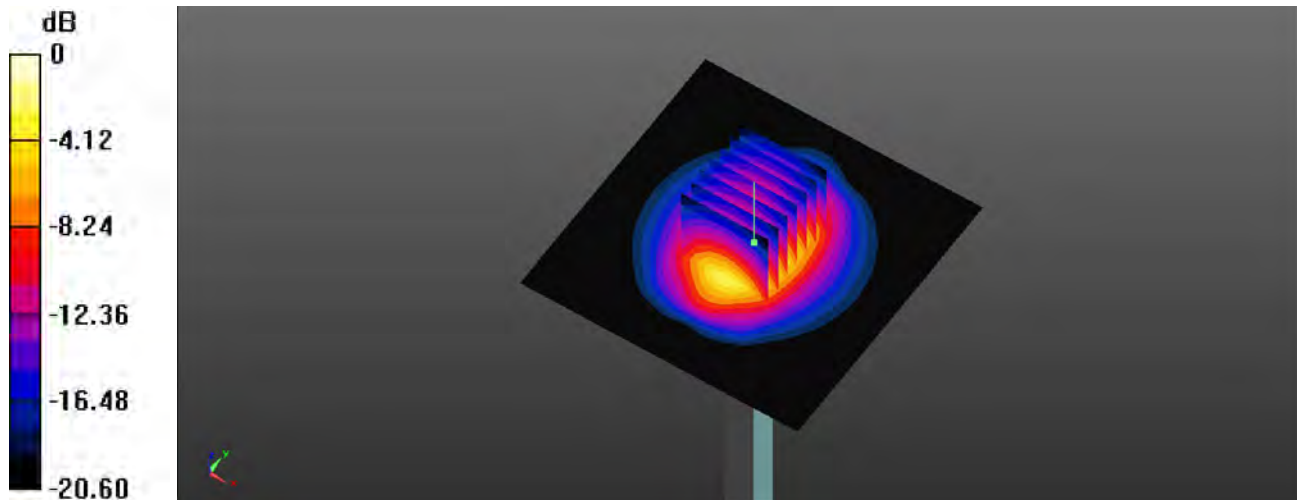
Ambient Temperature : 23.5 °C ; Liquid Temperature : 22.6 °C

#### DASY5 Configuration:

- Probe: EX3DV4 - SN3911; ConvF(7.32, 7.32, 7.32); Calibrated: 2014/4/22;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1358; Calibrated: 2014/4/30
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1201
- Measurement SW: DASY52, Version 52.8 (5); SEMCAD X Version 14.6.8 (7028)

**Pin=250mW/Area Scan (81x81x1):** Interpolated grid: dx=12mm, dy=12mm  
Maximum value of SAR (interpolated) = 19.5 W/kg

**Pin=250mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm  
Reference Value = 86.868 V/m; Power Drift = -0.07 dB  
Peak SAR (extrapolated) = 26.4 W/kg  
**SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.13 W/kg**  
Maximum value of SAR (measured) = 19.8 W/kg



0 dB = 19.8 W/kg

### System Check\_Body\_2450MHz\_140825

**DUT: D2450V2 - SN:736**

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

Medium: MSL\_2450\_140825 Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.943$  mho/m;  $\epsilon_r =$

$50.96$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.2 °C ; Liquid Temperature : 22.8 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN3857; ConvF(7.14, 7.14, 7.14); Calibrated: 2014.05.23
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1210; Calibrated: 2014.05.19
- Phantom: SAM3; Type: SAM; Serial: TP-1079
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.4.5 (3634)

**Pin=250mW/Area Scan (81x81x1):** Measurement grid: dx=12mm, dy=12mm

Maximum value of SAR (interpolated) = 18.490 mW/g

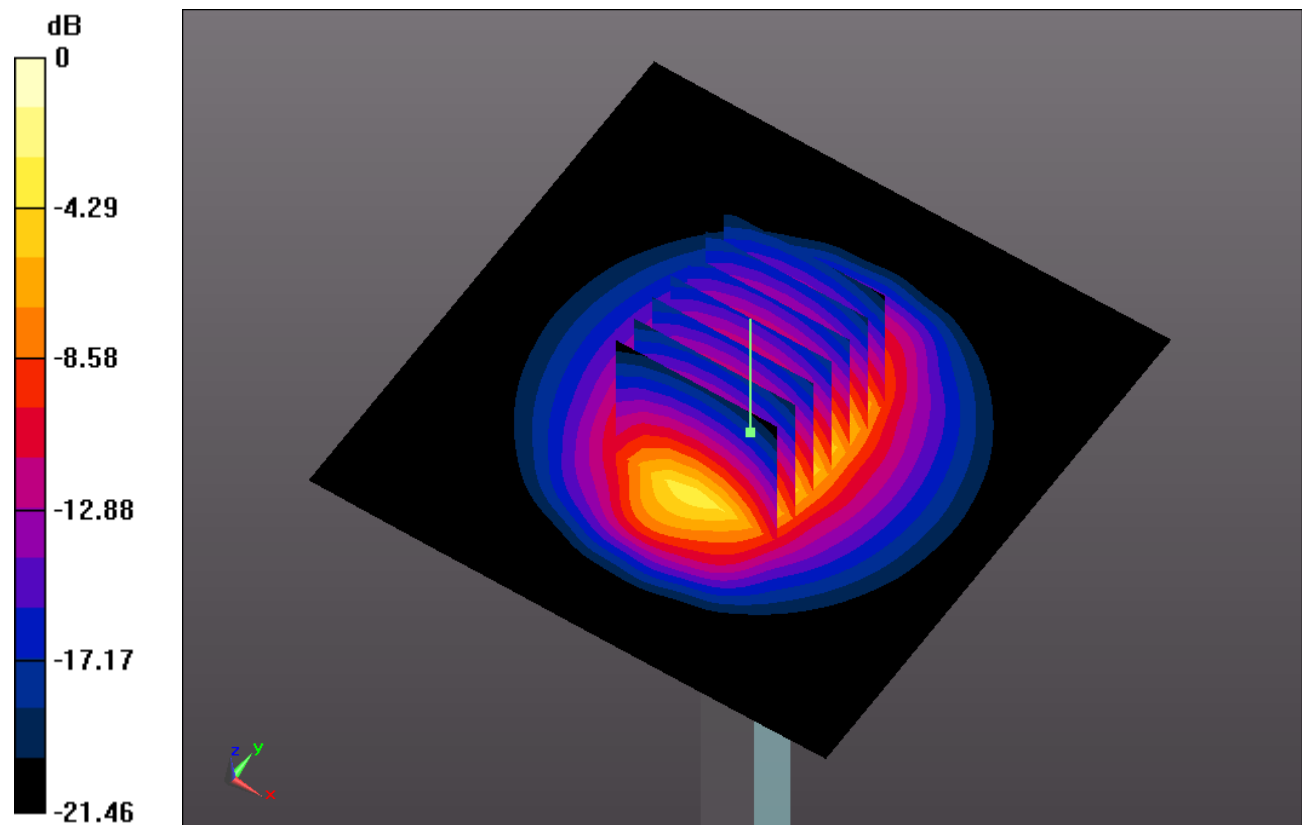
**Pin=250mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 85.452 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 25.090 W/kg

**SAR(1 g) = 12.4 mW/g; SAR(10 g) = 5.81 mW/g**

Maximum value of SAR (measured) = 18.804 mW/g



0 dB = 18.800mW/g



### System Check\_Body\_5200MHz\_140815

#### DUT: D5GHzV2-SN:1006

Communication System: CW; Frequency: 5200 MHz; Duty Cycle: 1:1

Medium: MSL\_5000\_140815 Medium parameters used:  $f = 5200$  MHz;  $\sigma = 5.373$  mho/m;  $\epsilon_r =$

$48.526$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.4 °C ; Liquid Temperature : 22.9 °C

#### DASY5 Configuration:

- Probe: EX3DV4 - SN3857; ConvF(4.54, 4.54, 4.54); Calibrated: 2014.05.23
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1210; Calibrated: 2014.05.19
- Phantom: SAM3; Type: SAM; Serial: TP-1079
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.4.5 (3634)

**Pin=100mW/Area Scan (71x71x1):** Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (interpolated) = 17.655 mW/g

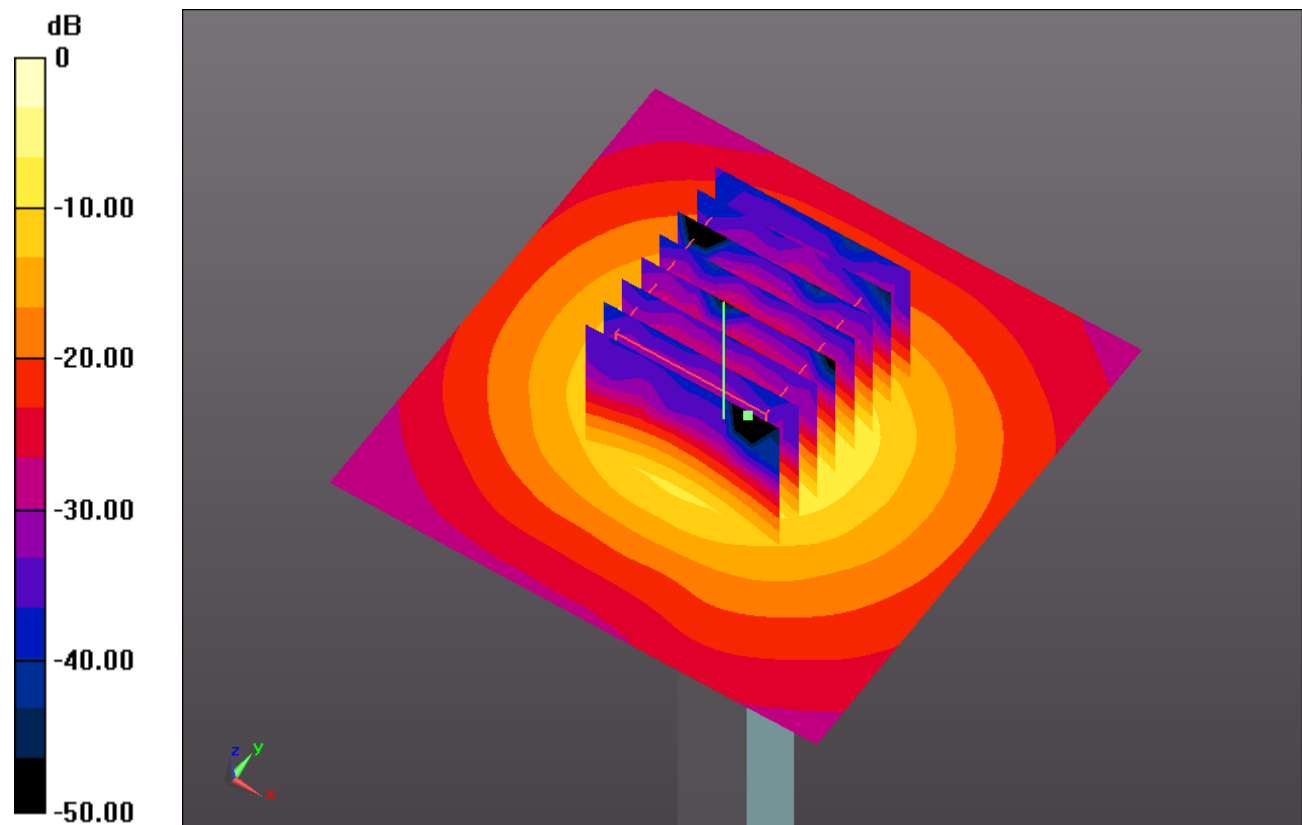
**Pin=100mW/Zoom Scan (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 40.689 V/m; Power Drift = -0.10 dB

Peak SAR (extrapolated) = 30.661 W/kg

**SAR(1 g) = 7.44 mW/g; SAR(10 g) = 2.1 mW/g**

Maximum value of SAR (measured) = 17.791 mW/g



0 dB = 17.790mW/g

### System Check\_Body\_5800MHz\_140807

#### DUT: D5GHzV2-SN:1006

Communication System: CW; Frequency: 5800 MHz; Duty Cycle: 1:1

Medium: MSL\_5000\_140807 Medium parameters used:  $f = 5800$  MHz;  $\sigma = 6.219$  mho/m;  $\epsilon_r =$

$47.128$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.3 °C ; Liquid Temperature : 22.7 °C

#### DASY5 Configuration:

- Probe: EX3DV4 - SN3857; ConvF(4.21, 4.21, 4.21); Calibrated: 2014.05.23
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1210; Calibrated: 2014.05.19
- Phantom: SAM3; Type: SAM; Serial: TP-1079
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.4.5 (3634)

**Pin=100mW/Area Scan (71x71x1):** Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (interpolated) = 18.253 mW/g

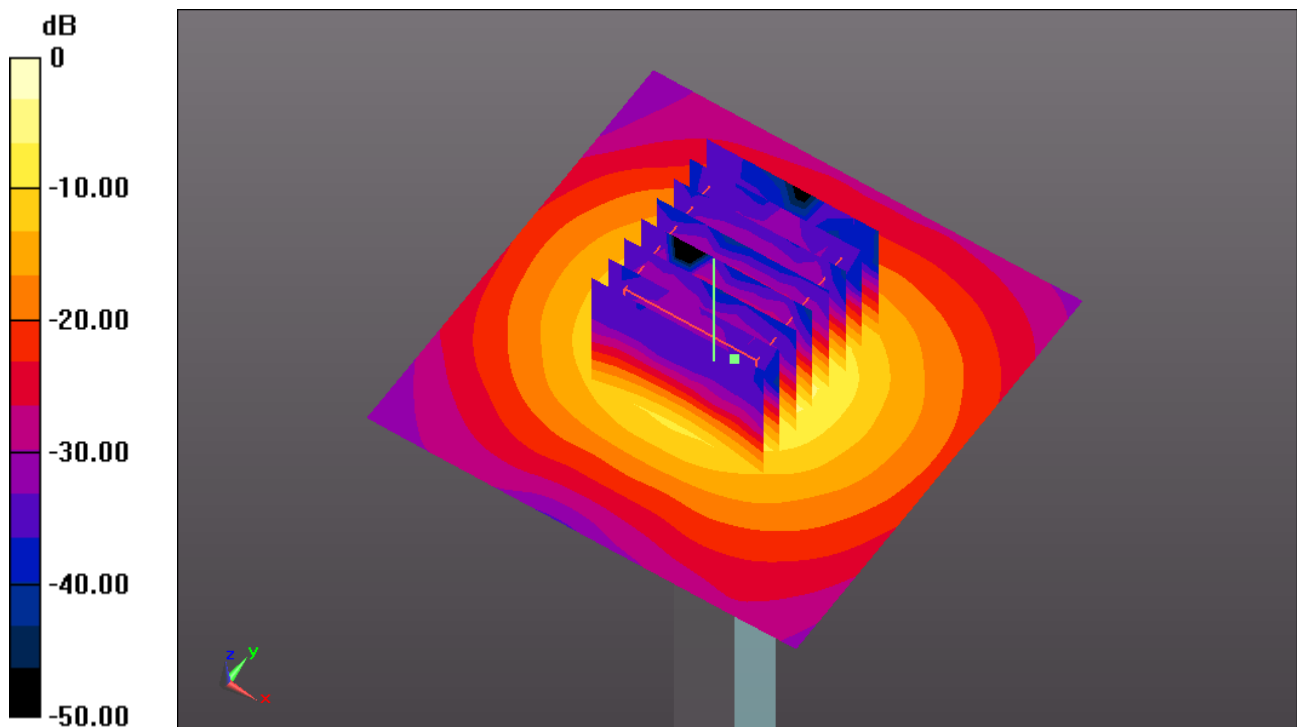
**Pin=100mW/Zoom Scan (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 36.905 V/m; Power Drift = -0.14 dB

Peak SAR (extrapolated) = 33.221 W/kg

**SAR(1 g) = 7.34 mW/g; SAR(10 g) = 2.05 mW/g**

Maximum value of SAR (measured) = 18.000 mW/g



0 dB = 18.000mW/g



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

The plots are shown as follows.

**#01 WLAN 2.4GHz\_8802.11g 6Mbps\_Bottom Face\_0cm\_Ch11\_Ant 0\_Sample 1**

Communication System: 802.11g; Frequency: 2462 MHz; Duty Cycle: 1:1.049

Medium: MSL\_2450\_140812 Medium parameters used:  $f = 2462$  MHz;  $\sigma = 1.974$  S/m;  $\epsilon_r = 53.843$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.5 °C ; Liquid Temperature : 22.6 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN3911; ConvF(7.32, 7.32, 7.32); Calibrated: 2014/4/22;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1358; Calibrated: 2014/4/30
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1201
- Measurement SW: DASY52, Version 52.8 (5); SEMCAD X Version 14.6.8 (7028)

**Ch11/Area Scan (91x161x1):** Interpolated grid: dx=12mm, dy=12mm

Maximum value of SAR (interpolated) = 2.20 W/kg

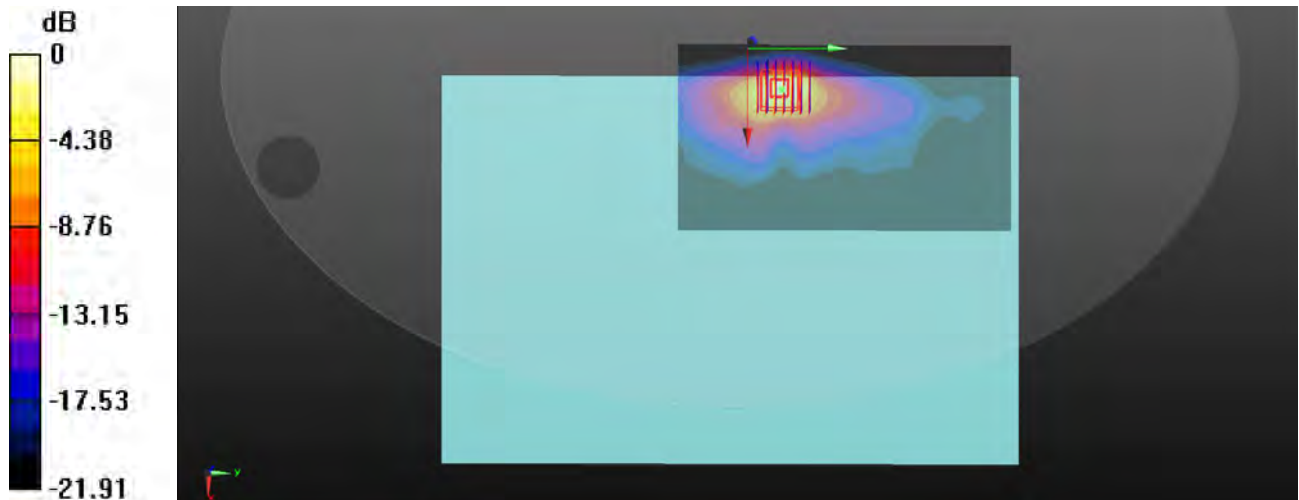
**Ch11/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 5.618 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 2.42 W/kg

**SAR(1 g) = 1.14 W/kg; SAR(10 g) = 0.469 W/kg**

Maximum value of SAR (measured) = 1.75 W/kg



0 dB = 1.75 W/kg

### #02\_WLAN Bluetooth\_1Mbps DH5\_Bottom Face 0cm\_Ch78\_Ant.0\_Sample 1

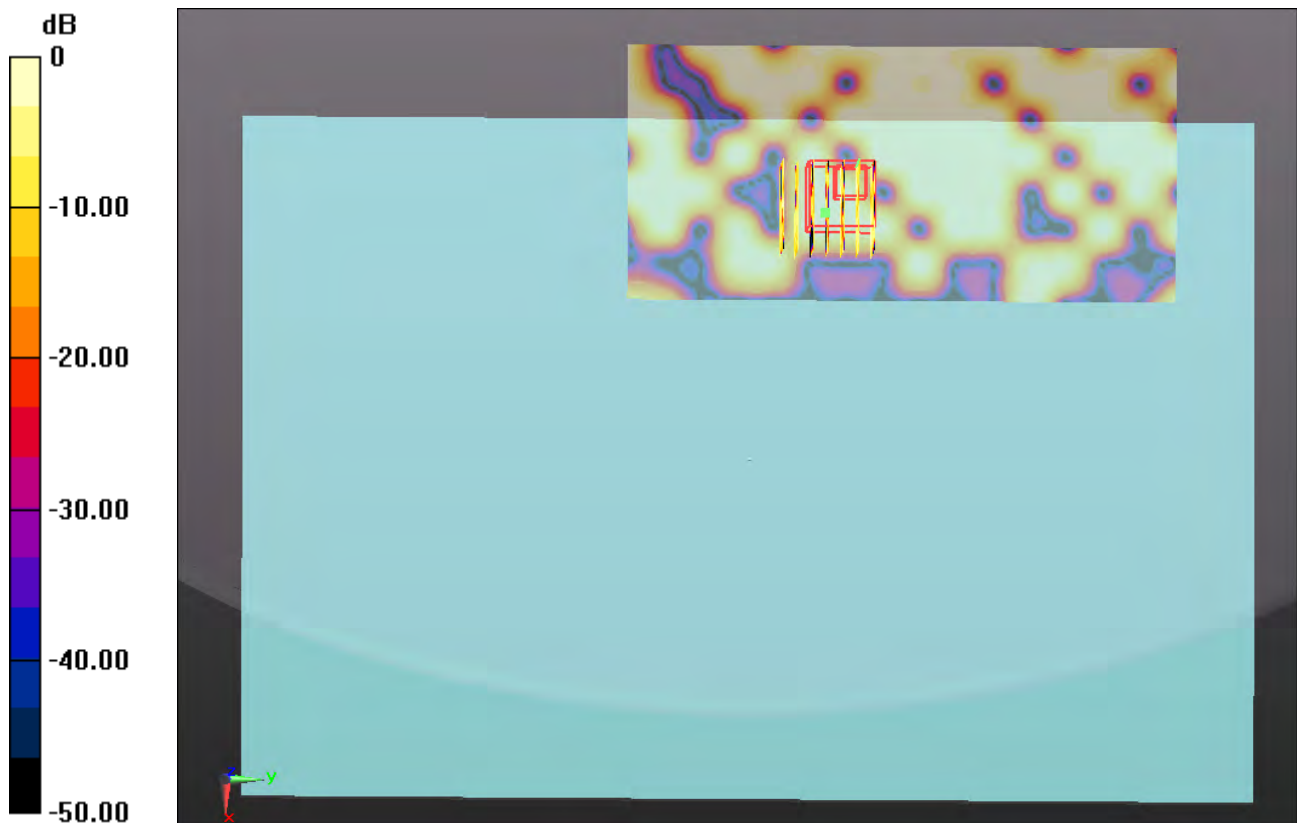
Communication System: Bluetooth (0); Frequency: 2480 MHz; Duty Cycle: 1:1.2  
Medium: MSL\_2450\_140825 Medium parameters used:  $f = 2480$  MHz;  $\sigma = 1.983$  mho/m;  $\epsilon_r = 50.815$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Ambient Temperature : 23.2 °C ; Liquid Temperature : 22.8 °C

#### DASY5 Configuration:

- Probe: EX3DV4 - SN3857; ConvF(7.14, 7.14, 7.14); Calibrated: 2014.05.23
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1210; Calibrated: 2014.05.19
- Phantom: SAM3; Type: SAM; Serial: TP-1079
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.4.5 (3634)

**Ch78/Area Scan (71x151x1):** Measurement grid: dx=12mm, dy=12mm  
Maximum value of SAR (interpolated) = 0.022 mW/g

**Ch78/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm  
Reference Value = 0 V/m; Power Drift = 0.13 dB  
Peak SAR (extrapolated) = 0.016 W/kg  
**SAR(1 g) = 0.002 mW/g; SAR(10 g) = 0.000351 mW/g**  
Maximum value of SAR (measured) = 0.00662 mW/g



0 dB = 0.0066mW/g

**#03\_WLAN 5.2GHz\_802.11n-HT20\_MCS0\_Curved surface of Edge 1\_Ch48\_Ant.0+1\_Sample 1**

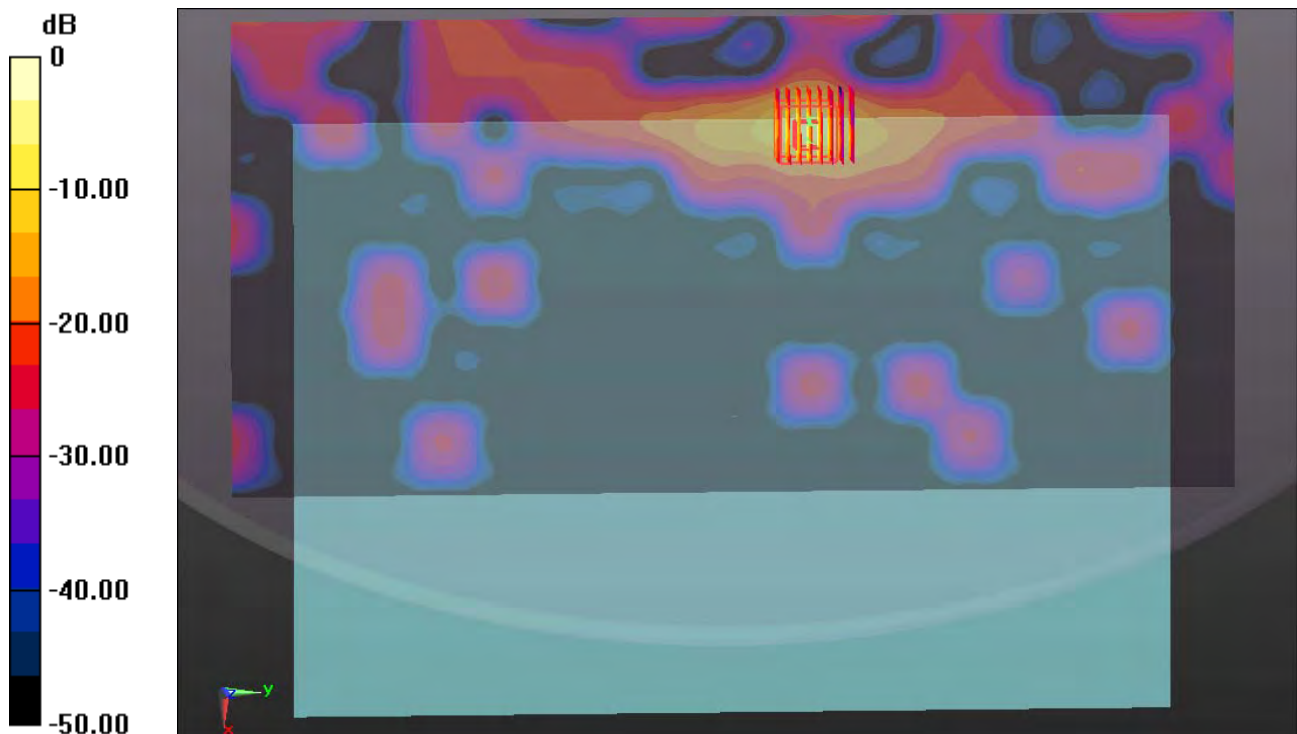
Communication System: WIFI (0); Frequency: 5240 MHz; Duty Cycle: 1:1.11  
Medium: MSL\_5000\_140815 Medium parameters used:  $f = 5240$  MHz;  $\sigma = 5.423$  mho/m;  $\epsilon_r = 48.422$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Ambient Temperature : 23.4 °C ; Liquid Temperature : 22.9 °C

**DASY5 Configuration:**

- Probe: EX3DV4 - SN3857; ConvF(4.54, 4.54, 4.54); Calibrated: 2014.05.23
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1210; Calibrated: 2014.05.19
- Phantom: SAM3; Type: SAM; Serial: TP-1079
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.4.5 (3634)

**Ch48/Area Scan (181x381x1):** Measurement grid: dx=10mm, dy=10mm  
Maximum value of SAR (interpolated) = 1.406 mW/g

**Ch48/Zoom Scan (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
Reference Value = 4.008 V/m; Power Drift = -0.05 dB  
Peak SAR (extrapolated) = 4.965 W/kg  
**SAR(1 g) = 1.24 mW/g; SAR(10 g) = 0.291 mW/g**  
Maximum value of SAR (measured) = 3.193 mW/g



0 dB = 3.190mW/g

**#04\_WLAN 5.8GHz\_802.11n-HT20\_MCS0\_Curved surface of Edge 1  
0cm\_Ch165\_Ant.0+1\_Sample 2**

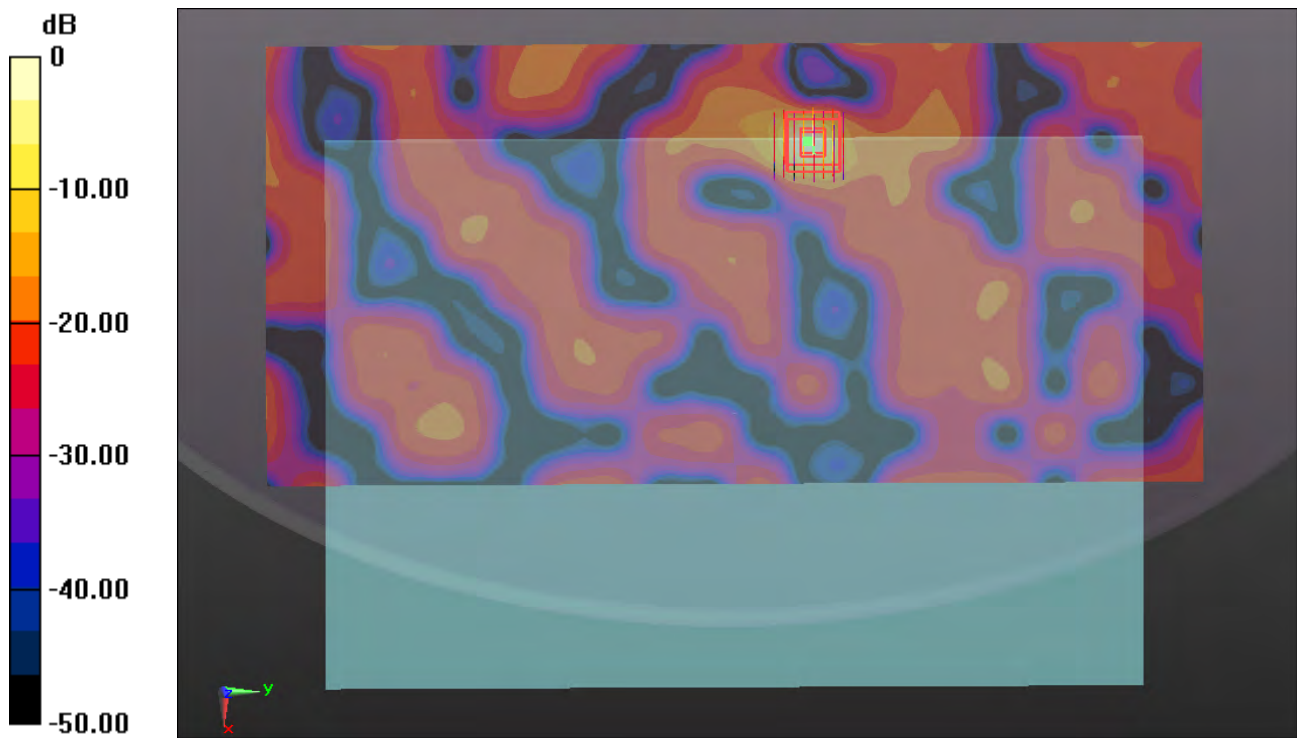
Communication System: WIFI (0); Frequency: 5825 MHz; Duty Cycle: 1:1.11  
Medium: MSL\_5000\_140807 Medium parameters used:  $f = 5825$  MHz;  $\sigma = 6.264$  mho/m;  $\epsilon_r = 47.046$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Ambient Temperature : 23.3 °C ; Liquid Temperature : 22.7 °C

**DASY5 Configuration:**

- Probe: EX3DV4 - SN3857; ConvF(4.21, 4.21, 4.21); Calibrated: 2014.05.23
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1210; Calibrated: 2014.05.19
- Phantom: SAM3; Type: SAM; Serial: TP-1079
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.4.5 (3634)

**Ch165/Area Scan (181x381x1):** Measurement grid: dx=10mm, dy=10mm  
Maximum value of SAR (interpolated) = 3.651 mW/g

**Ch165/Zoom Scan (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm  
Reference Value = 3.465 V/m; Power Drift = -0.16 dB  
Peak SAR (extrapolated) = 5.920 W/kg  
**SAR(1 g) = 1.32 mW/g; SAR(10 g) = 0.255 mW/g**  
Maximum value of SAR (measured) = 3.489 mW/g



0 dB = 3.490mW/g



**Appendix C. DASYS Calibration Certificate**

The DASYS calibration certificates are shown as follows.





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 108**

Client **Sporton-KS (Auden)**

Certificate No: **D2450V2-908\_Mar13**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 908**

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

Calibration date: **March 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  $(22 \pm 3)^{\circ}\text{C}$  and humidity  $< 70\%$ .

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	01-Nov-12 (No. 217-01640)	Oct-13
Power sensor HP 8481A	US37292783	01-Nov-12 (No. 217-01640)	Oct-13
Reference 20 dB Attenuator	SN: 5058 (20k)	27-Mar-12 (No. 217-01530)	Apr-13
Type-N mismatch combination	SN: 5047,3 / 06327	27-Mar-12 (No. 217-01533)	Apr-13
Reference Probe ES3DV3	SN: 3205	28-Dec-12 (No. ES3-3205_Dec12)	Dec-13
DAE4	SN: 601	27-Jun-12 (No. DAE4-601_Jun12)	Jun-13
Secondary Standards	ID #	Check Date (In house)	Scheduled Check
Power sensor HP 8481A	MY41092317	18-Oct-02 (In house check Oct-11)	In house check: Oct-13
RF generator R&S SMT-06	100005	04-Aug-99 (In house check Oct-11)	In house check: Oct-13
Network Analyzer HP 8753E	US37390585 54206	18-Oct-01 (In house check Oct-12)	In house check: Oct-13

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

Signature

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

Issued: March 26, 2013

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 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:**

- a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
- b) 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
- c) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

**Additional Documentation:**

- d) DAS4/5 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	V52.8.5
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	37.8 $\pm$ 6 %	1.85 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	13.8 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>54.0 W/kg <math>\pm</math> 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.36 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>25.1 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## 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	50.7 $\pm$ 6 %	2.01 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	12.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>50.4 W/kg <math>\pm</math> 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.94 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>23.4 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Appendix

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	56.5 $\Omega$ - 0.1 j $\Omega$
Return Loss	- 24.3 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	52.6 $\Omega$ + 1.9 j $\Omega$
Return Loss	- 30.0 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.156 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	December 19, 2012

## DASY5 Validation Report for Head TSL

Date: 26.03.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 908**

Communication System: CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.85$  S/m;  $\epsilon_r = 37.8$ ;  $\rho = 1000$  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: 27.06.2012
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.5(1059); SEMCAD X 14.6.8(7028)

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

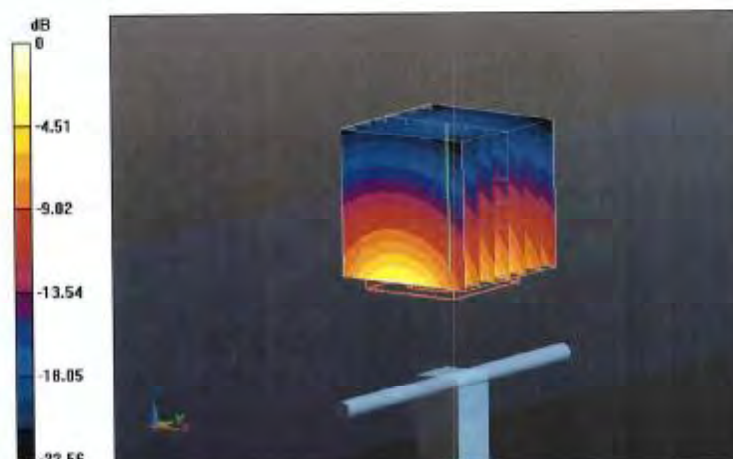
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 94.957 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 28.8 W/kg

**SAR(1 g) = 13.8 W/kg; SAR(10 g) = 6.36 W/kg**

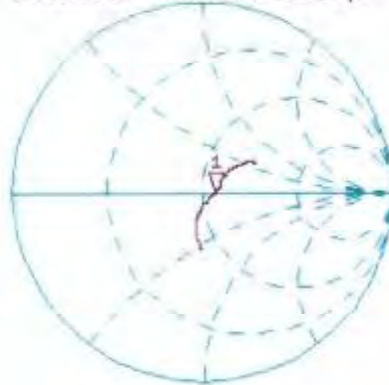
Maximum value of SAR (measured) = 17.9 W/kg



# Impedance Measurement Plot for Head TSL

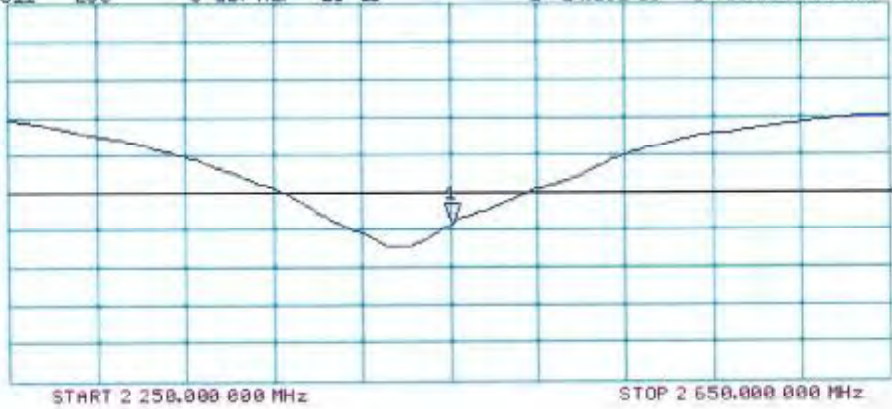
25 Mar 2013 18:42:12  
 CH1 S11 1 U FS  $\Delta$ : 56.531  $\Omega$  -125.00 m $\Omega$  519.69 pF 2 450.000 000 MHz

De1  
 Ca  
 Avg  
 16  
 H1d



CH2 S11 LOG 5 dB/REF -20 dB 1:-24.254 dB 2 450.000 000 MHz

CA  
 Avg  
 16  
 H1d



## DASY5 Validation Report for Body TSL

Date: 26.03.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 908**

Communication System: CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.01$  S/m;  $\epsilon_r = 50.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.42, 4.42, 4.42); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.06.2012
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.5(1059); SEMCAD X 14.6.8(7028)

### Dipole Calibration for Body Tissue/ $P_{in}=250$ mW, $d=10$ mm/Zoom Scan (7x7x7)/Cube 0:

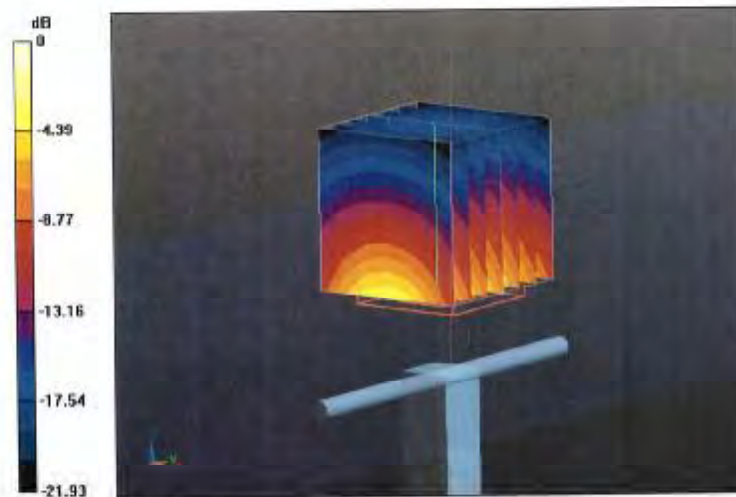
Measurement grid:  $dx=5$ mm,  $dy=5$ mm,  $dz=5$ mm

Reference Value = 94.957 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 27.0 W/kg

**SAR(1 g) = 12.9 W/kg; SAR(10 g) = 5.94 W/kg**

Maximum value of SAR (measured) = 17.1 W/kg

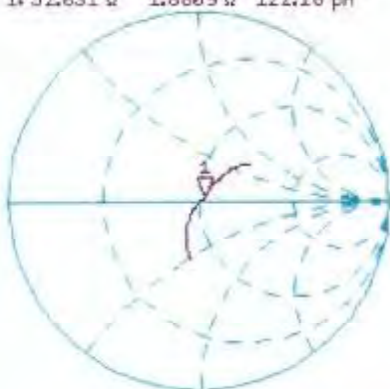


0 dB = 17.1 W/kg = 12.33 dBW/kg

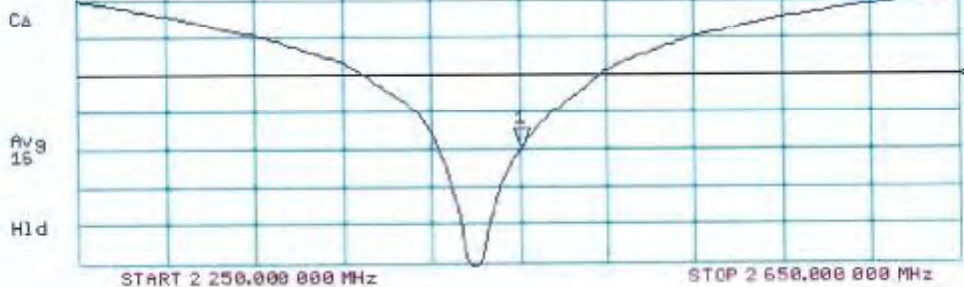
# Impedance Measurement Plot for Body TSL

26 Mar 2013 10:42:53  
 CH1 S11 1 U FS 1: 52.631  $\Omega$  1.8809  $\Omega$  122.18  $\mu\text{H}$  2 450.000 000 MHz

\*  
 Del  
 CA  
 Avg  
 15  
 H1d



CH2 S11 LOG 5 dB/REF -20 dB 1: -38.033 dB 2 450.000 000 MHz



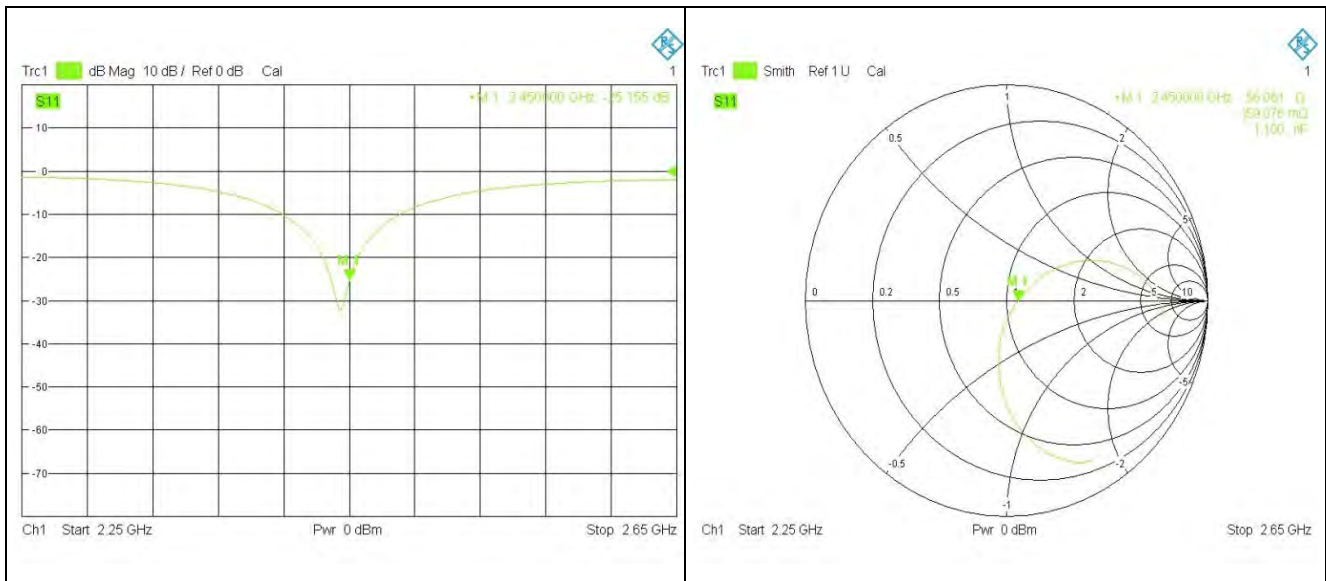


## Extended Dipole Calibrations

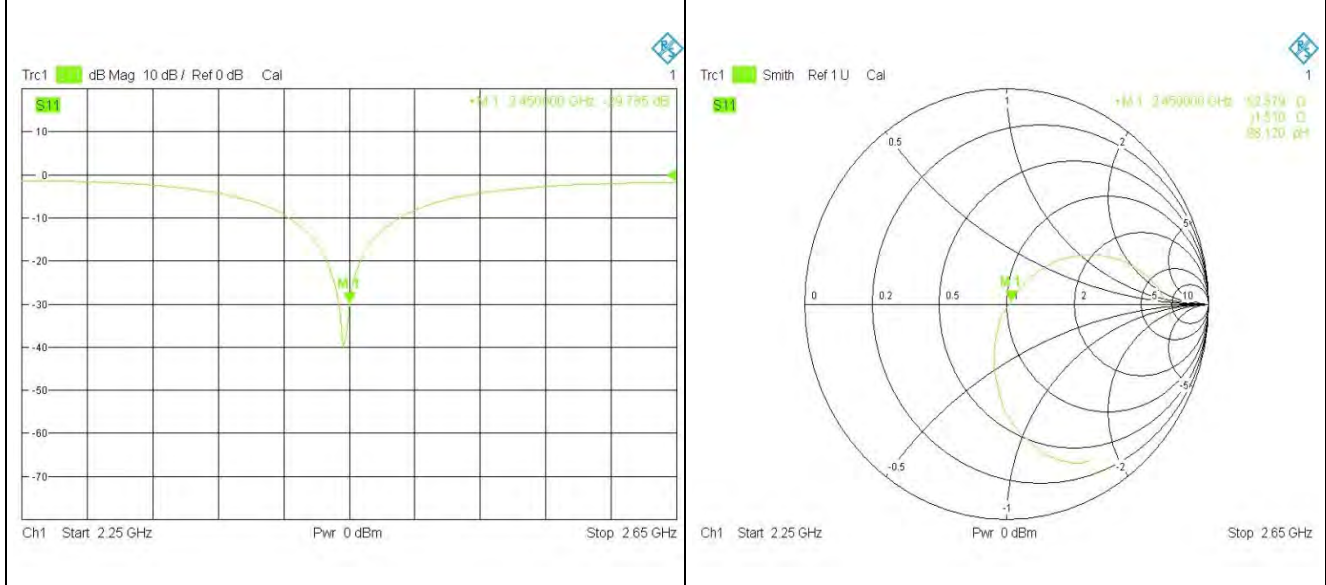
Referring to KDB 865664 D01 v01r03, if dipoles are verified in return loss ( $<-20\text{dB}$ , within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

### <Dipole Verification Data> - D2450V2, serial no. 908(Date of Measurement 03.25.2014)

#### 2450MHz - Head



#### 2450MHz – Body





**<Justification of the extended calibration>**

D2450V2 – serial no. 908												
TSL	Head						Body					
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
03.26.2013	-24.251		56.531		-0.125		-30.033		52.631		1.881	
03.25.2014	-25.155	-0.373	56.061	-0.47	-0.059	0.066	-29.785	0.826	52.379	-0.252	1.510	-0.371

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



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **Sporton-TW (Auden)**

Certificate No: **D2450V2-924\_Nov13**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 924**

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

Calibration date: **November 13, 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: November 13, 2013

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



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Multilateral Agreement for the recognition of calibration certificates

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:**

- a) 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
- b) 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
- c) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

- d) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

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

## Head TSL parameters

The following parameters and calculations were applied.

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

## SAR result with Head TSL

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

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	6.08 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>24.2 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

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

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	12.8 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>50.2 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	250 mW input power	5.92 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>23.4 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Appendix

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.1 $\Omega$ + 2.6 j $\Omega$
Return Loss	- 28.2 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.6 $\Omega$ + 4.3 j $\Omega$
Return Loss	- 27.3 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.154 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	September 26, 2013

# DASY5 Validation Report for Head TSL

Date: 13.11.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 924**

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 (7x7x7)/Cube 0:

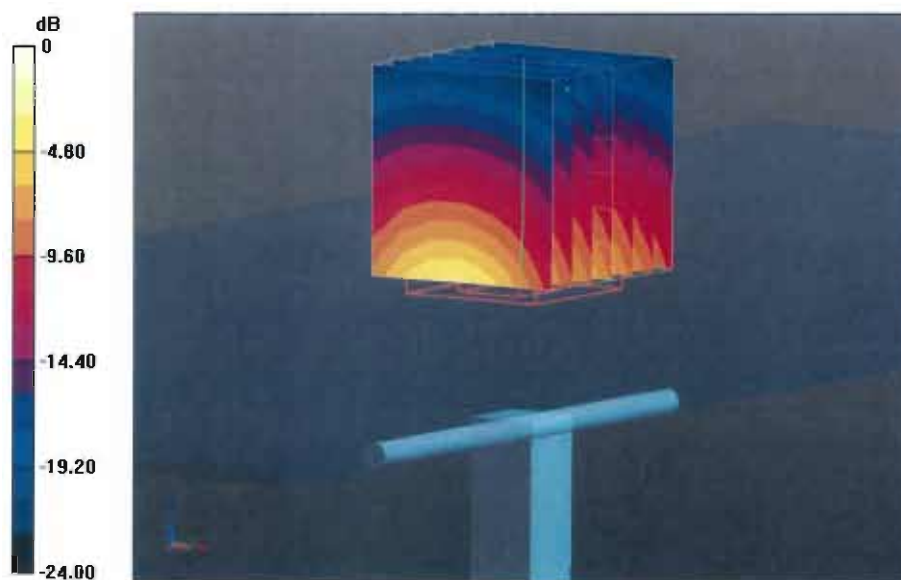
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 98.75 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 27.5 W/kg

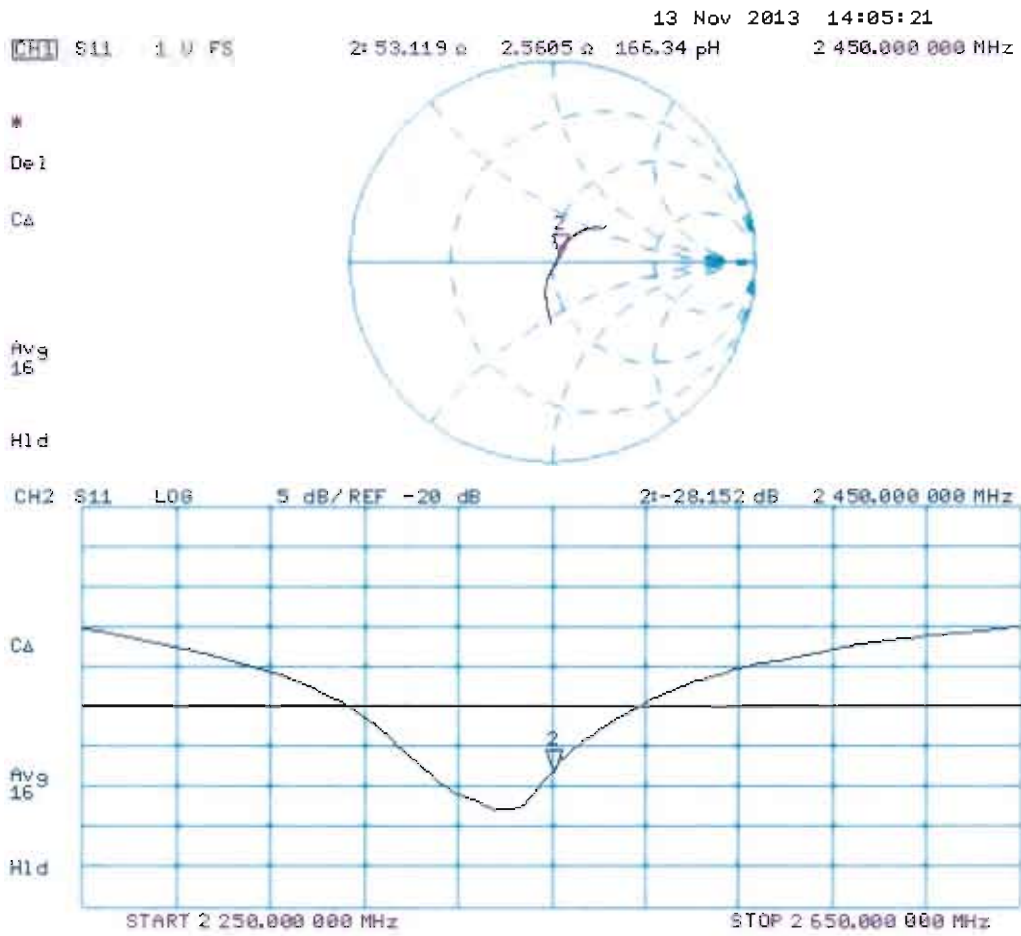
**SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.08 W/kg**

Maximum value of SAR (measured) = 16.7 W/kg



0 dB = 16.7 W/kg = 12.23 dBW/kg

# Impedance Measurement Plot for Head TSL





# DASY5 Validation Report for Body TSL

Date: 13.11.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 924**

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:

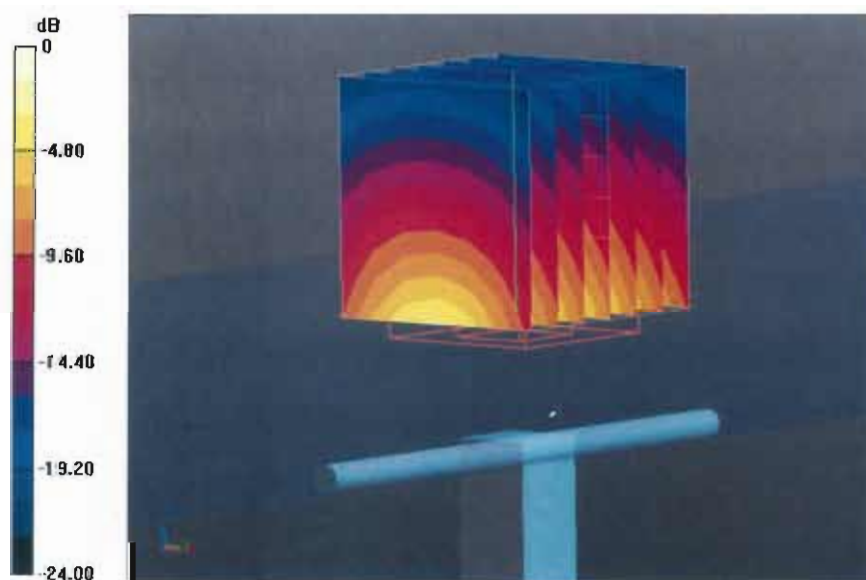
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 93.726 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 26.8 W/kg

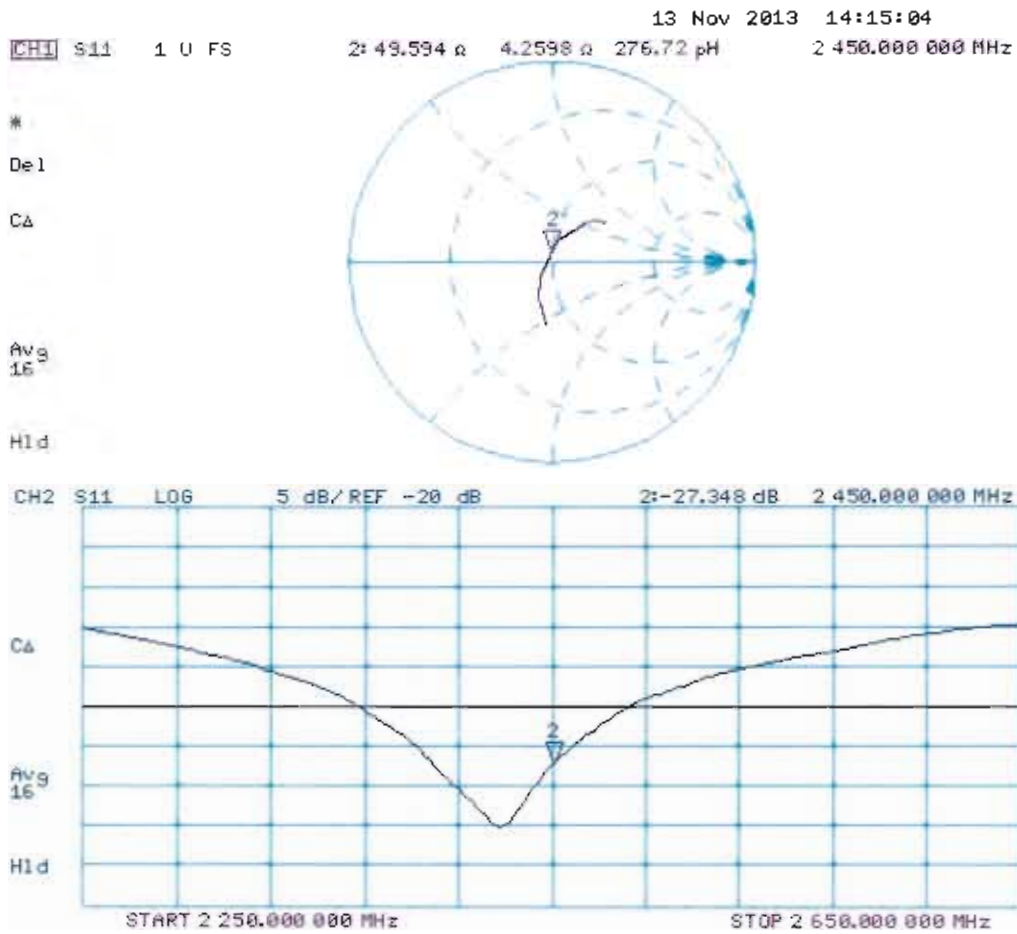
**SAR(1 g) = 12.8 W/kg; SAR(10 g) = 5.92 W/kg**

Maximum value of SAR (measured) = 16.8 W/kg



0 dB = 16.8 W/kg = 12.25 dBW/kg

# Impedance Measurement Plot for Body TSL





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Accreditation No.: **SCS 108**

Client **Sporton-TW (Auden)**

Certificate No: **D5GHzV2-1006\_Sep13**

## CALIBRATION CERTIFICATE

Object: **D5GHzV2 - SN: 1006**

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

Calibration date: **September 23, 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 ± 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	01-Nov-12 (No. 217-01640)	Oct-13
Power sensor HP 8481A	US37292783	01-Nov-12 (No. 217-01640)	Oct-13
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 EX3DV4	SN: 3503	28-Dec-12 (No. EX3-3503_Dec12)	Dec-13
DAE4	SN: 601	25-Apr-13 (No. DAE4-601_Apr13)	Apr-14
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP 8481A	MY41092317	18-Oct-02 (in house check Oct-11)	In house check: Oct-13
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-11)	In house check: Oct-13
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-12)	In house check: Oct-13

	Name	Function	Signature
Calibrated by:	Leif Klysner	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: September 24, 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"

### Additional Documentation:

- DASY4/5 System Handbook

### Methods Applied and Interpretation of Parameters:

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

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

## Measurement Conditions

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

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

## Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	36.0	4.66 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	35.8 ± 6 %	4.48 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL at 5200 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	7.68 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>76.6 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	2.20 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>21.9 W/kg ± 19.5 % (k=2)</b>

### Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.6 ± 6 %	4.62 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.06 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>80.4 W / kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.0 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	35.2 ± 6 %	4.86 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.02 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>79.9 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>22.7 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	35.0 ± 6 %	5.07 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

## SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.66 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>76.3 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.17 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>21.6 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	48.3 ± 6 %	5.36 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	7.17 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>71.5 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	1.99 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>19.8 W/kg ± 19.5 % (k=2)</b>

### 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	48.1 ± 6 %	5.56 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	7.54 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>75.2 W/kg ± 19.9 % (k=2)</b>

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	<b>21.0 W/kg ± 19.5 % (k=2)</b>



### 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	47.6 ± 6 %	5.88 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	7.80 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>77.8 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.16 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>21.5 W/kg ± 19.5 % (k=2)</b>

### 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	47.3 ± 6 %	6.17 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	7.25 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>72.3 W/kg ± 19.9 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.00 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>19.9 W/kg ± 19.5 % (k=2)</b>

## Appendix

### Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	52.5 $\Omega$ - 8.7 j $\Omega$
Return Loss	- 21.1 dB

### Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	57.1 $\Omega$ - 2.8 j $\Omega$
Return Loss	- 22.9 dB

### Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	56.6 $\Omega$ - 5.6 j $\Omega$
Return Loss	- 21.9 dB

### Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	56.2 $\Omega$ + 5.1 j $\Omega$
Return Loss	- 22.4 dB

### Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	51.8 $\Omega$ - 9.3 j $\Omega$
Return Loss	- 20.6 dB

### Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	56.0 $\Omega$ + 0.5 j $\Omega$
Return Loss	- 25.0 dB

### Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	56.6 $\Omega$ - 3.7 j $\Omega$
Return Loss	- 22.9 dB

### Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	59.2 $\Omega$ + 8.2 j $\Omega$
Return Loss	- 18.9 dB

## General Antenna Parameters and Design

Electrical Delay (one direction)	1.200 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	August 28, 2003

## DASY5 Validation Report for Head TSL

Date: 23.09.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1006**

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

Medium parameters used:  $f = 5200$  MHz;  $\sigma = 4.48$  S/m;  $\epsilon_r = 35.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5300$  MHz;  $\sigma = 4.62$  S/m;  $\epsilon_r = 35.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5600$  MHz;  $\sigma = 4.86$  S/m;  $\epsilon_r = 35.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5800$  MHz;  $\sigma = 5.07$  S/m;  $\epsilon_r = 35$ ;  $\rho = 1000$  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(4.76, 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 = 63.982 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 27.9 W/kg

**SAR(1 g) = 7.68 W/kg; SAR(10 g) = 2.2 W/kg**

Maximum value of SAR (measured) = 17.8 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 = 64.816 V/m; Power Drift = 0.09 dB

Peak SAR (extrapolated) = 29.8 W/kg

**SAR(1 g) = 8.06 W/kg; SAR(10 g) = 2.31 W/kg**

Maximum value of SAR (measured) = 19.0 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

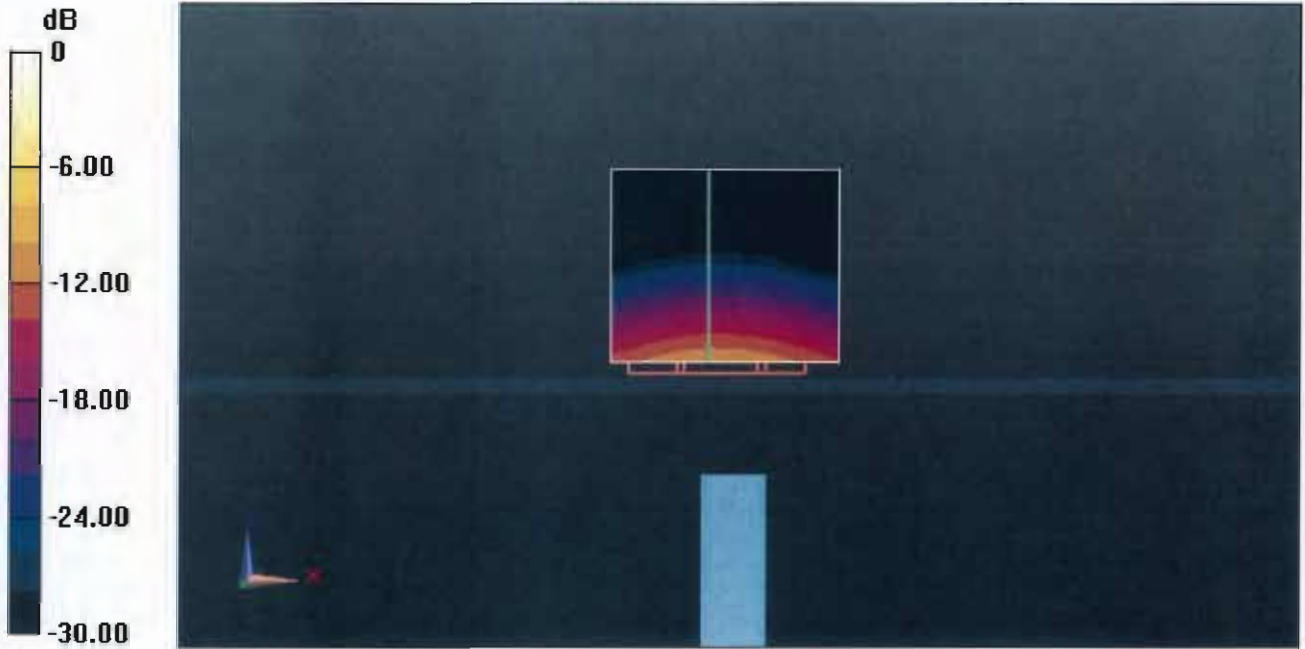
Reference Value = 63.442 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 31.2 W/kg

**SAR(1 g) = 8.02 W/kg; SAR(10 g) = 2.28 W/kg**

Maximum value of SAR (measured) = 19.3 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 = 61.293 V/m; Power Drift = 0.04 dB  
Peak SAR (extrapolated) = 31.2 W/kg  
**SAR(1 g) = 7.66 W/kg; SAR(10 g) = 2.17 W/kg**  
Maximum value of SAR (measured) = 18.7 W/kg



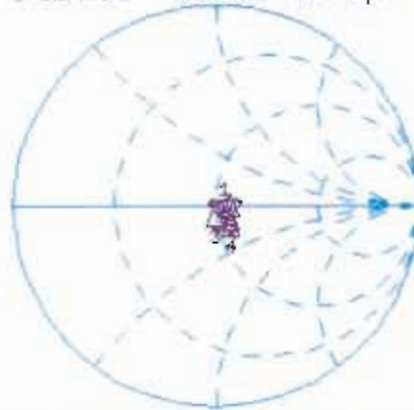
0 dB = 18.7 W/kg = 12.72 dBW/kg

# Impedance Measurement Plot for Head TSL

23 Sep 2013 11:08:40

CH1 S11 1 U FS 1: 52.486  $\Omega$  -8.6699  $\Omega$  3.5302 pF 5 200.000 000 MHz

\*  
De1  
Cor  
Avg  
16  
H1d

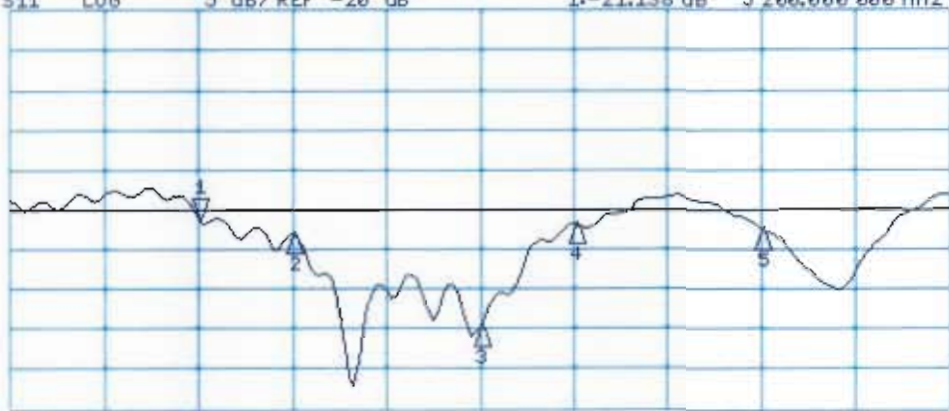


CH1 Markers

- 2: 57.111  $\Omega$   
-2.7988  $\Omega$   
5.30000 GHz
- 3: 48.270  $\Omega$   
-6.2103  $\Omega$   
5.50000 GHz
- 4: 56.580  $\Omega$   
-5.5625  $\Omega$   
5.60000 GHz
- 5: 56.195  $\Omega$   
5.0079  $\Omega$   
5.80000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1: -21.138 dB 5 200.000 000 MHz

Cor  
Avg  
16  
H1d



CH2 Markers

- 2: -22.934 dB  
5.30000 GHz
- 3: -34.567 dB  
5.50000 GHz
- 4: -21.855 dB  
5.60000 GHz
- 5: -22.450 dB  
5.80000 GHz

START 5 000.000 000 MHz

STOP 5 800.000 000 MHz

## DASY5 Validation Report for Body TSL

Date: 20.09.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1006**

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

Medium parameters used:  $f = 5200$  MHz;  $\sigma = 5.36$  S/m;  $\epsilon_r = 48.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5300$  MHz;  $\sigma = 5.56$  S/m;  $\epsilon_r = 48.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5600$  MHz;  $\sigma = 5.88$  S/m;  $\epsilon_r = 47.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5800$  MHz;  $\sigma = 6.17$  S/m;  $\epsilon_r = 47.3$ ;  $\rho = 1000$  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(4.22, 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 = 58.601 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 28.0 W/kg

**SAR(1 g) = 7.17 W/kg; SAR(10 g) = 1.99 W/kg**

Maximum value of SAR (measured) = 17.2 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 = 58.846 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 30.2 W/kg

**SAR(1 g) = 7.54 W/kg; SAR(10 g) = 2.11 W/kg**

Maximum value of SAR (measured) = 18.3 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

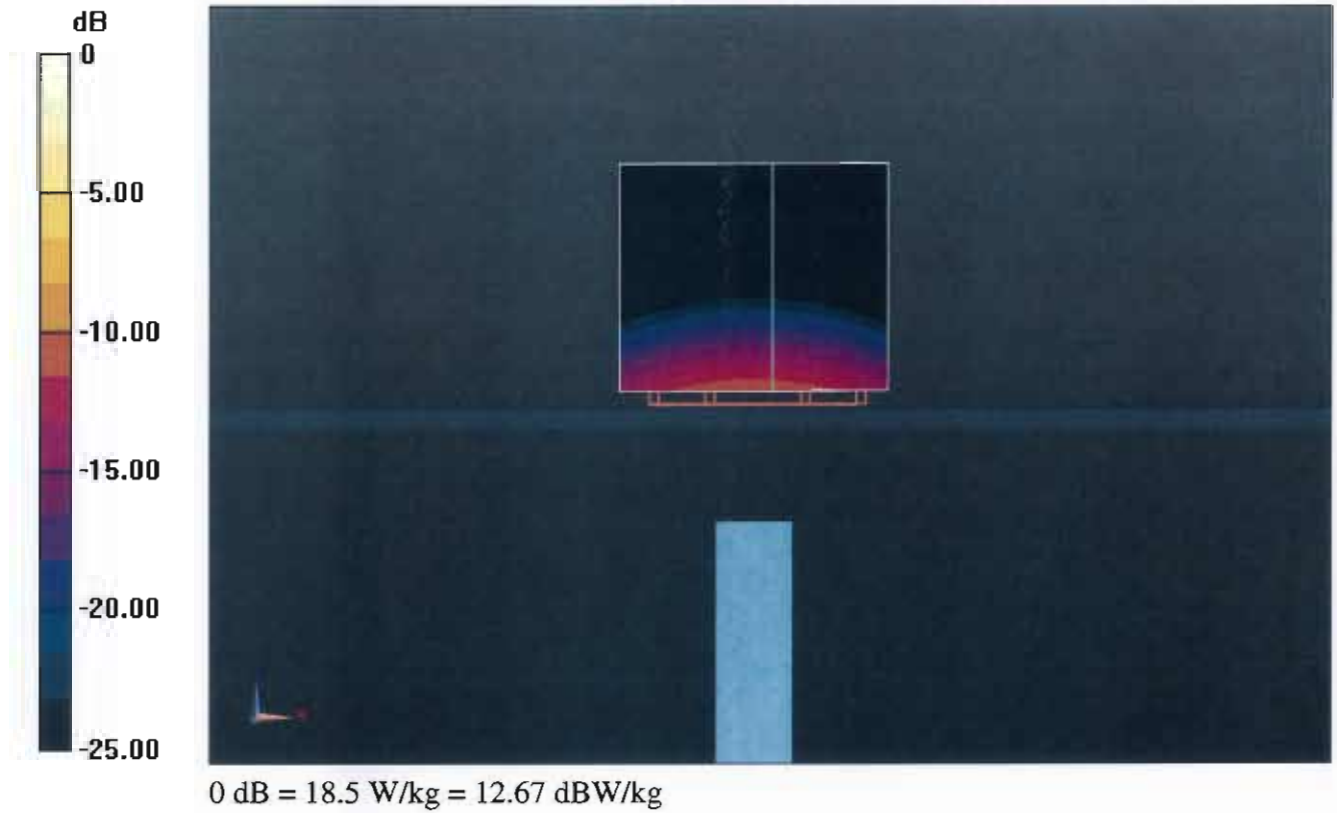
Reference Value = 58.294 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 34.4 W/kg

**SAR(1 g) = 7.8 W/kg; SAR(10 g) = 2.16 W/kg**

Maximum value of SAR (measured) = 19.6 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 = 54.918 V/m; Power Drift = -0.04 dB  
Peak SAR (extrapolated) = 33.5 W/kg  
**SAR(1 g) = 7.25 W/kg; SAR(10 g) = 2 W/kg**  
Maximum value of SAR (measured) = 18.5 W/kg



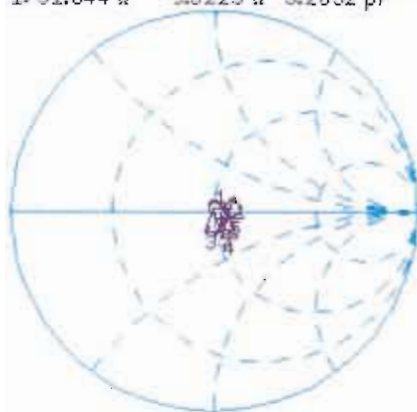


# Impedance Measurement Plot for Body TSL

20 Sep 2013 12:15:50

CH1 S11 1 U FS 1: 51.844  $\Omega$  -3.3223  $\Omega$  3.2832 pF 5 200.000 000 MHz

De1  
Cor  
Avg 16  
H1 d



CH1 Markers

- 2: 55.957  $\Omega$
- 3: 8.5313  $\Omega$
- 5: 300000 GHz
- 3: 48.886  $\Omega$
- 107.42  $\Omega$
- 5: 50000 GHz
- 4: 56.619  $\Omega$
- 3.7383  $\Omega$
- 5: 60000 GHz
- 5: 59.213  $\Omega$
- 8.2482  $\Omega$
- 5: 80000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1: -20.636 dB 5 200.000 000 MHz

Cor  
Avg 16  
H1 d



CH2 Markers

- 2: -24.963 dB
- 5: 300000 GHz
- 3: -34.184 dB
- 5: 50000 GHz
- 4: -22.938 dB
- 5: 60000 GHz
- 5: -18.946 dB
- 5: 80000 GHz

## IMPORTANT NOTICE

### USAGE OF THE DAE 4

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

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

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

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

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

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

**Important Note:**

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

**Important Note:**

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

**Important Note:**

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



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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **Sporton CN (Auden)**

Certificate No: **DAE4-1358\_Apr14**

## CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BJ - SN: 1358**

Calibration procedure(s) **QA CAL-06.v26**  
**Calibration procedure for the data acquisition electronics (DAE)**

Calibration date: **April 30, 2014**

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
Keithley Multimeter Type 2001	SN: 0810278	01-Oct-13 (No:13976)	Oct-14
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	07-Jan-14 (in house check)	In house check: Jan-15
Calibrator Box V2.1	SE UMS 006 AA 1002	07-Jan-14 (in house check)	In house check: Jan-15

	Name	Function	Signature
Calibrated by:	R.Mayoraz	Technician	
Approved by:	Fin Bomholt	Deputy Technical Manager	

Issued: April 30, 2014

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 108**

## 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	403.476 $\pm$ 0.02% (k=2)	403.505 $\pm$ 0.02% (k=2)	403.509 $\pm$ 0.02% (k=2)
Low Range	3.96075 $\pm$ 1.50% (k=2)	3.98590 $\pm$ 1.50% (k=2)	3.99195 $\pm$ 1.50% (k=2)

## Connector Angle

Connector Angle to be used in DASY system	136.0 $^{\circ}$ $\pm$ 1 $^{\circ}$
---	-------------------------------------

## Appendix

### 1. DC Voltage Linearity

High Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	200038.03	1.76	0.00
Channel X + Input	20005.43	1.37	0.01
Channel X - Input	-20004.06	1.92	-0.01
Channel Y + Input	200034.40	-1.98	-0.00
Channel Y + Input	20002.81	-0.99	-0.00
Channel Y - Input	-20005.22	0.94	-0.00
Channel Z + Input	200037.68	1.44	0.00
Channel Z + Input	20002.59	-1.11	-0.01
Channel Z - Input	-20007.07	-0.94	0.00

Low Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	2000.15	-0.26	-0.01
Channel X + Input	201.04	0.44	0.22
Channel X - Input	-198.78	0.53	-0.27
Channel Y + Input	2000.38	0.18	0.01
Channel Y + Input	200.06	-0.29	-0.15
Channel Y - Input	-200.10	-0.50	0.25
Channel Z + Input	2000.16	-0.17	-0.01
Channel Z + Input	198.55	-1.98	-0.99
Channel Z - Input	-201.27	-1.72	0.86

### 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	23.14	21.30
	- 200	-20.01	-21.49
Channel Y	200	-27.07	-27.39
	- 200	27.21	26.98
Channel Z	200	-11.40	-11.75
	- 200	9.24	9.23

### 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	-	3.10	-3.59
Channel Y	200	9.08	-	3.89
Channel Z	200	9.17	6.05	-

#### 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	15575	16462
Channel Y	16051	15758
Channel Z	16070	16201

#### 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	-1.05	-2.31	-0.30	0.37
Channel Y	-0.30	-1.37	0.51	0.40
Channel Z	-1.60	-2.40	-0.66	0.37

#### 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

## IMPORTANT NOTICE

### USAGE OF THE DAE 4

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

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

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

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

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

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

**Important Note:**

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

**Important Note:**

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

**Important Note:**

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





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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **Sporton-CN (Auden)**

Certificate No: **DAE4-1210\_May14**

## CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BM - SN: 1210**

Calibration procedure(s) **QA CAL-06.v26  
Calibration procedure for the data acquisition electronics (DAE)**

Calibration date: **May 19, 2014**

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
Keithley Multimeter Type 2001	SN: 0810278	01-Oct-13 (No:13976)	Oct-14
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	07-Jan-14 (in house check)	In house check: Jan-15
Calibrator Box V2.1	SE UMS 006 AA 1002	07-Jan-14 (in house check)	In house check: Jan-15

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

Issued: May 20, 2014

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

## 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	404.126 $\pm$ 0.02% (k=2)	404.956 $\pm$ 0.02% (k=2)	405.065 $\pm$ 0.02% (k=2)
Low Range	4.00002 $\pm$ 1.50% (k=2)	3.98327 $\pm$ 1.50% (k=2)	4.00021 $\pm$ 1.50% (k=2)

## Connector Angle

Connector Angle to be used in DASY system	123.5 $^{\circ}$ $\pm$ 1 $^{\circ}$
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## Appendix

### 1. DC Voltage Linearity

High Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	199993.16	-3.08	-0.00
Channel X + Input	20001.58	0.86	0.00
Channel X - Input	-19997.88	2.96	-0.01
Channel Y + Input	199997.46	1.25	0.00
Channel Y + Input	20001.02	0.31	0.00
Channel Y - Input	-20000.67	0.41	-0.00
Channel Z + Input	199997.96	1.16	0.00
Channel Z + Input	20000.22	-0.47	-0.00
Channel Z - Input	-20000.31	0.71	-0.00

Low Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	2001.44	0.40	0.02
Channel X + Input	201.65	0.25	0.12
Channel X - Input	-198.86	-0.60	0.30
Channel Y + Input	2001.05	0.10	0.01
Channel Y + Input	200.89	-0.51	-0.25
Channel Y - Input	-198.70	-0.35	0.18
Channel Z + Input	2001.15	0.23	0.01
Channel Z + Input	200.32	-1.08	-0.54
Channel Z - Input	-199.61	-1.14	0.57

### 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	-5.19	-7.07
	- 200	7.82	6.50
Channel Y	200	-3.56	-3.90
	- 200	4.19	4.35
Channel Z	200	12.21	11.95
	- 200	-14.51	-14.28

### 3. Channel separation

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

	Input Voltage (mV)	Channel X ( $\mu\text{V}$ )	Channel Y ( $\mu\text{V}$ )	Channel Z ( $\mu\text{V}$ )
Channel X	200	-	1.78	-3.94
Channel Y	200	8.13	-	2.67
Channel Z	200	9.14	6.43	-

#### 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	15954	15797
Channel Y	15962	16451
Channel Z	15874	16936

#### 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	-0.85	-1.82	-0.15	0.34
Channel Y	-0.27	-1.81	0.54	0.39
Channel Z	-0.30	-1.29	0.94	0.43

#### 6. Input Offset Current

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

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

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

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

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

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

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



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Accreditation No.: **SCS 108**

Client **Sporton-CN (Auden)**

Certificate No: **EX3-3911\_Apr14**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3911**

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

Calibration date: **April 22, 2014**

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	03-Apr-14 (No. 217-01911)	Apr-15
Power sensor E4412A	MY41498087	03-Apr-14 (No. 217-01911)	Apr-15
Reference 3 dB Attenuator	SN: S5054 (3c)	03-Apr-14 (No. 217-01915)	Apr-15
Reference 20 dB Attenuator	SN: S5277 (20x)	03-Apr-14 (No. 217-01919)	Apr-15
Reference 30 dB Attenuator	SN: S5129 (30b)	03-Apr-14 (No. 217-01920)	Apr-15
Reference Probe ES3DV2	SN: 3013	30-Dec-13 (No. ES3-3013_Dec13)	Dec-14
DAE4	SN: 660	13-Dec-13 (No. DAE4-660_Dec13)	Dec-14
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-13)	In house check: Oct-14

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

Issued: April 23, 2014

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Accreditation No.: **SCS 108**

**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:**

- a) 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
- b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

**Methods Applied and Interpretation of Parameters:**

- *NORM<sub>x,y,z</sub>*: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). *NORM<sub>x,y,z</sub>* are only intermediate values, i.e., the uncertainties of *NORM<sub>x,y,z</sub>* does not affect the  $E^2$ -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:3911

Manufactured: September 4, 2012  
Calibrated: April 22, 2014

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



## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3911

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	0.46	0.45	0.55	$\pm 10.1\%$
DCP (mV) <sup>B</sup>	100.0	96.7	97.5	

### Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc <sup>E</sup> (k=2)
0	CW	X	0.0	0.0	1.0	0.00	131.2	$\pm 3.5\%$
		Y	0.0	0.0	1.0		131.9	
		Z	0.0	0.0	1.0		144.7	

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

<sup>A</sup> The uncertainties of NormX,Y,Z do not affect the  $E^2$ -field uncertainty inside TSL (see Pages 5 and 6).

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

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3911

### Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unct. (k=2)
750	41.9	0.89	10.27	10.27	10.27	0.25	1.18	± 12.0 %
835	41.5	0.90	9.84	9.84	9.84	0.38	0.86	± 12.0 %
900	41.5	0.97	9.62	9.62	9.62	0.23	1.23	± 12.0 %
1750	40.1	1.37	8.52	8.52	8.52	0.80	0.50	± 12.0 %
1900	40.0	1.40	8.09	8.09	8.09	0.36	0.78	± 12.0 %
2000	40.0	1.40	7.98	7.98	7.98	0.80	0.54	± 12.0 %
2300	39.5	1.67	7.56	7.56	7.56	0.70	0.59	± 12.0 %
2450	39.2	1.80	7.04	7.04	7.04	0.56	0.67	± 12.0 %
2600	39.0	1.96	6.87	6.87	6.87	0.44	0.80	± 12.0 %

<sup>C</sup> Frequency validity 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.

<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:3911

### Calibration Parameter Determined in Body Tissue Simulating Media

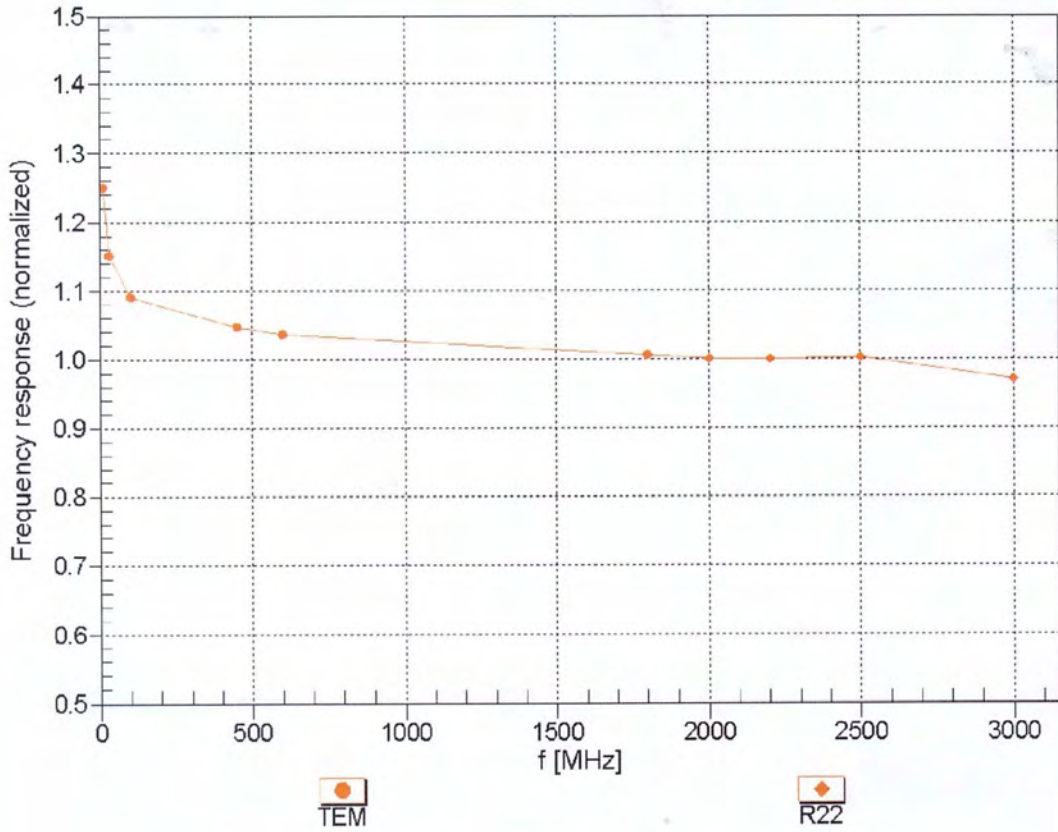
f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unct. (k=2)
750	55.5	0.96	10.06	10.06	10.06	0.24	1.17	± 12.0 %
835	55.2	0.97	10.02	10.02	10.02	0.46	0.80	± 12.0 %
900	55.0	1.05	9.74	9.74	9.74	0.28	1.04	± 12.0 %
1750	53.4	1.49	8.11	8.11	8.11	0.36	0.84	± 12.0 %
1900	53.3	1.52	7.83	7.83	7.83	0.32	0.92	± 12.0 %
2000	53.3	1.52	7.94	7.94	7.94	0.51	0.72	± 12.0 %
2300	52.9	1.81	7.53	7.53	7.53	0.38	0.83	± 12.0 %
2450	52.7	1.95	7.32	7.32	7.32	0.80	0.56	± 12.0 %
2600	52.5	2.16	7.09	7.09	7.09	0.80	0.57	± 12.0 %

<sup>C</sup> Frequency validity 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.

<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.

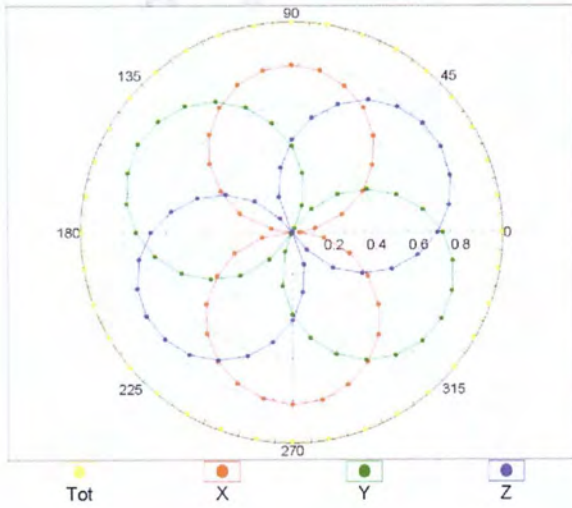
### Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



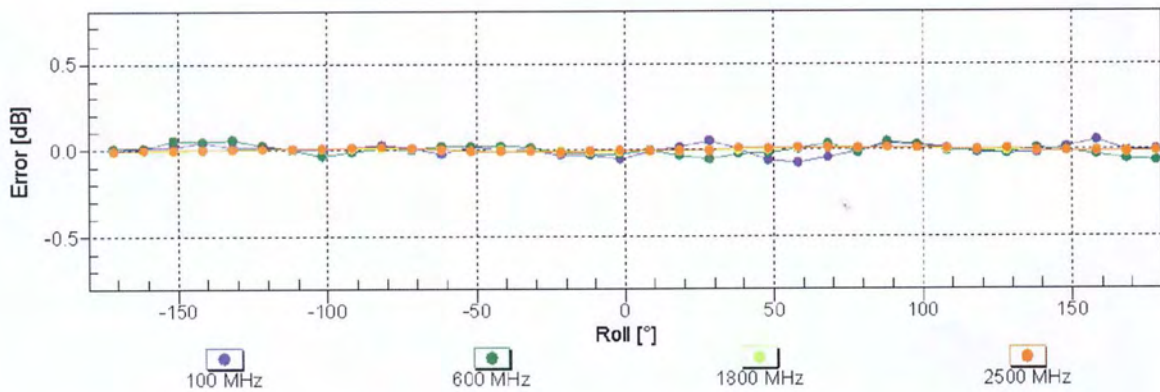
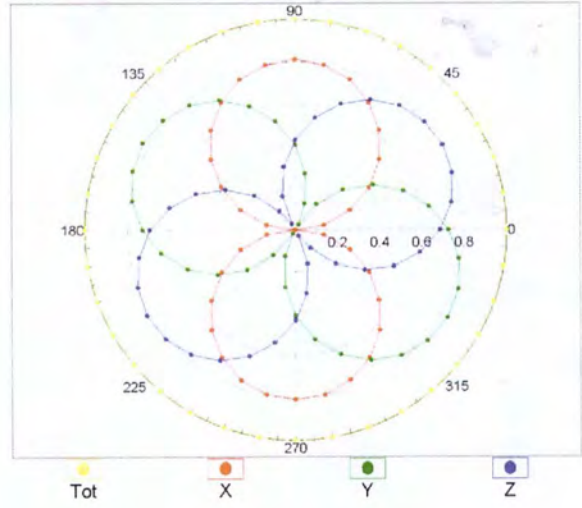
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

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

f=600 MHz,TEM

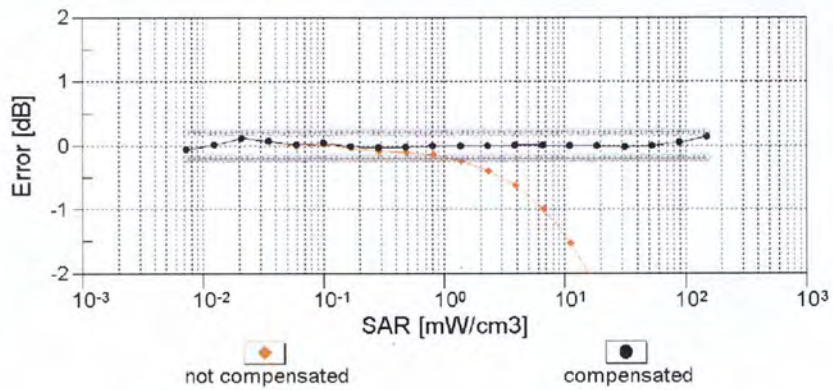
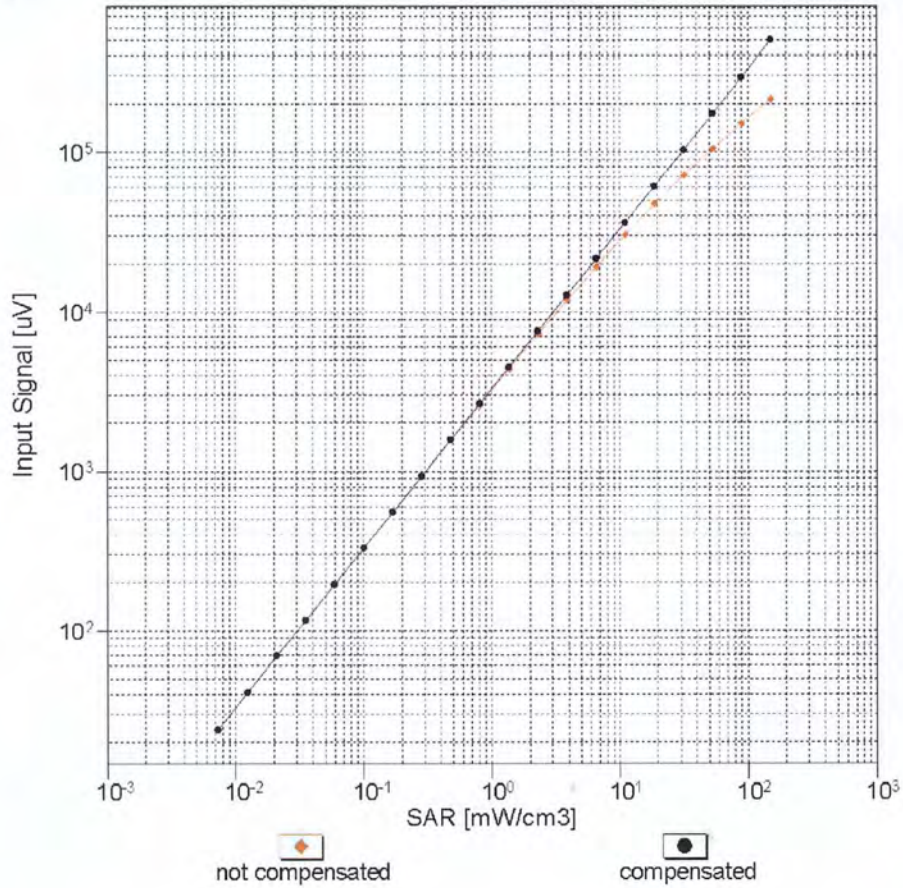


f=1800 MHz,R22



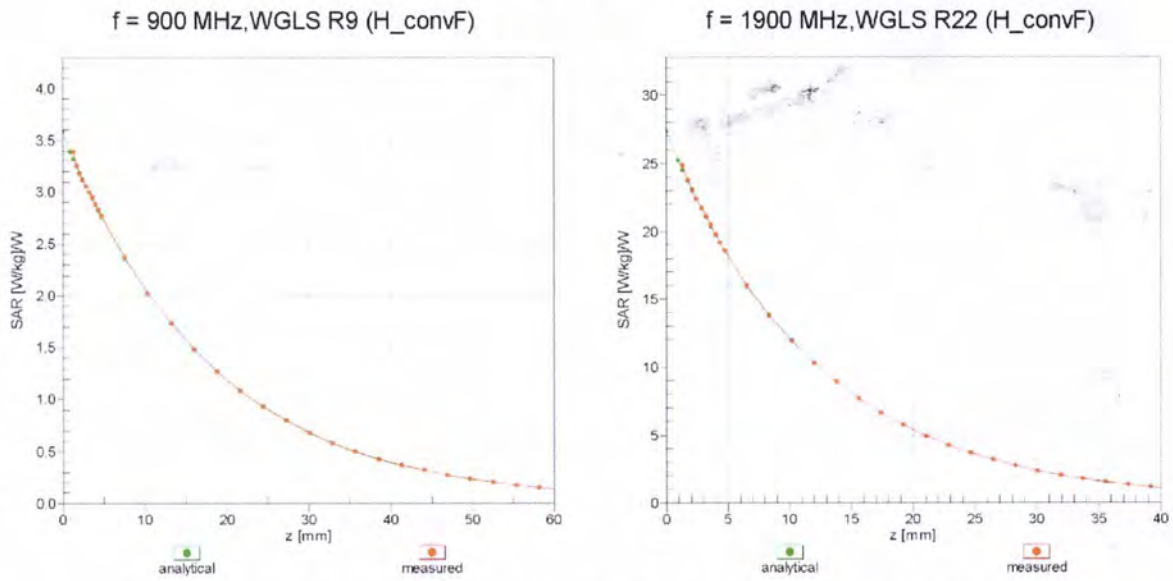
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)

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

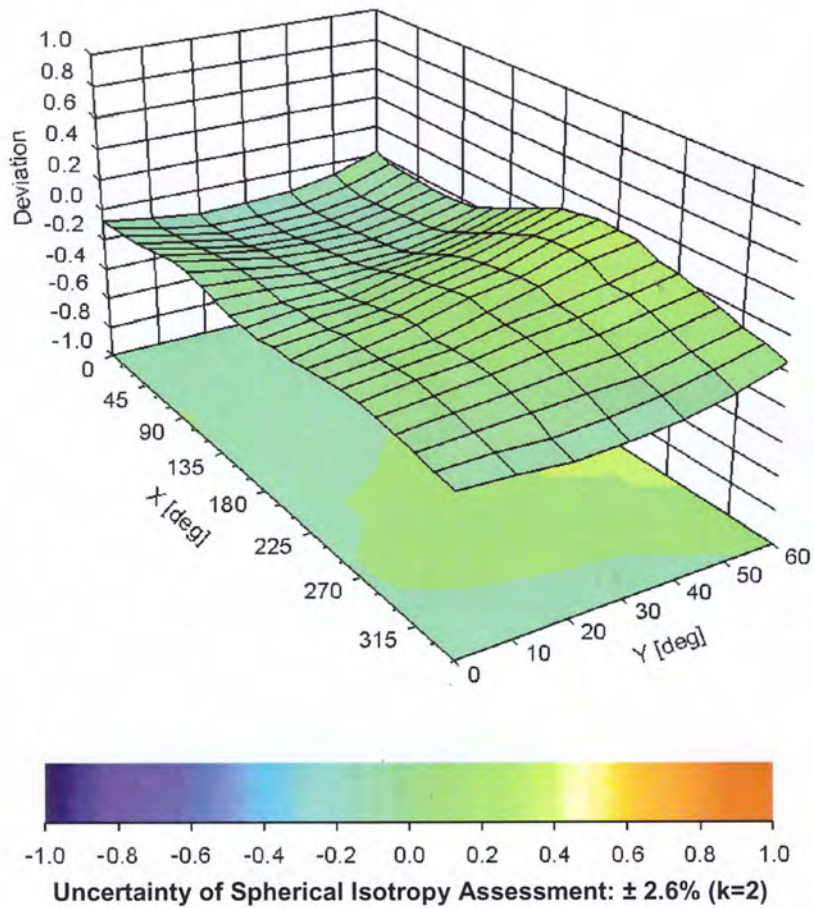


Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

# Conversion Factor Assessment



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



## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3911

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	8.2
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	2 mm





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Accreditation No.: **SCS 108**

Client **Sporton-CN (Auden)**

Certificate No: **EX3-3857\_May14**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3857**

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

Calibration date: **May 23, 2014**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	03-Apr-14 (No. 217-01911)	Apr-15
Power sensor E4412A	MY41498087	03-Apr-14 (No. 217-01911)	Apr-15
Reference 3 dB Attenuator	SN: S5054 (3c)	03-Apr-14 (No. 217-01915)	Apr-15
Reference 20 dB Attenuator	SN: S5277 (20x)	03-Apr-14 (No. 217-01919)	Apr-15
Reference 30 dB Attenuator	SN: S5129 (30b)	03-Apr-14 (No. 217-01920)	Apr-15
Reference Probe ES3DV2	SN: 3013	30-Dec-13 (No. ES3-3013_Dec13)	Dec-14
DAE4	SN: 660	13-Dec-13 (No. DAE4-660_Dec13)	Dec-14
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-13)	In house check: Oct-14

Calibrated by:	Name Claudio Leubler	Function Laboratory Technician	Signature 
Approved by:	Katja Pokovic	Technical Manager	

Issued: May 23, 2014

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Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 108**

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Multilateral Agreement for the recognition of calibration certificates

### Glossary:

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

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

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

### Methods Applied and Interpretation of Parameters:

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

# Probe EX3DV4

## SN:3857

Manufactured: January 23, 2012  
Calibrated: May 23, 2014

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3857

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	0.18	0.44	0.46	$\pm 10.1 \%$
DCP (mV) <sup>B</sup>	94.2	98.6	99.4	

### 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	132.0	$\pm 3.8 \%$
		Y	0.0	0.0	1.0		149.4	
		Z	0.0	0.0	1.0		149.1	

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

<sup>A</sup> The uncertainties of NormX,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:3857

### Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unct. (k=2)
750	41.9	0.89	9.92	9.92	9.92	0.44	0.82	± 12.0 %
835	41.5	0.90	9.41	9.41	9.41	0.30	1.01	± 12.0 %
900	41.5	0.97	9.20	9.20	9.20	0.80	0.50	± 12.0 %
1750	40.1	1.37	8.55	8.55	8.55	0.80	0.59	± 12.0 %
1900	40.0	1.40	8.40	8.40	8.40	0.69	0.65	± 12.0 %
2000	40.0	1.40	8.31	8.31	8.31	0.77	0.56	± 12.0 %
2450	39.2	1.80	7.48	7.48	7.48	0.78	0.58	± 12.0 %
2600	39.0	1.96	7.30	7.30	7.30	0.42	0.87	± 12.0 %
5200	36.0	4.66	5.35	5.35	5.35	0.30	1.80	± 13.1 %
5300	35.9	4.76	5.12	5.12	5.12	0.30	1.80	± 13.1 %
5500	35.6	4.96	4.99	4.99	4.99	0.35	1.80	± 13.1 %
5600	35.5	5.07	4.56	4.56	4.56	0.45	1.80	± 13.1 %
5800	35.3	5.27	4.79	4.79	4.79	0.40	1.80	± 13.1 %

<sup>C</sup> Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. Above 5 GHz frequency validity can be extended to ± 110 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

<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:3857

### Calibration Parameter Determined in Body Tissue Simulating Media

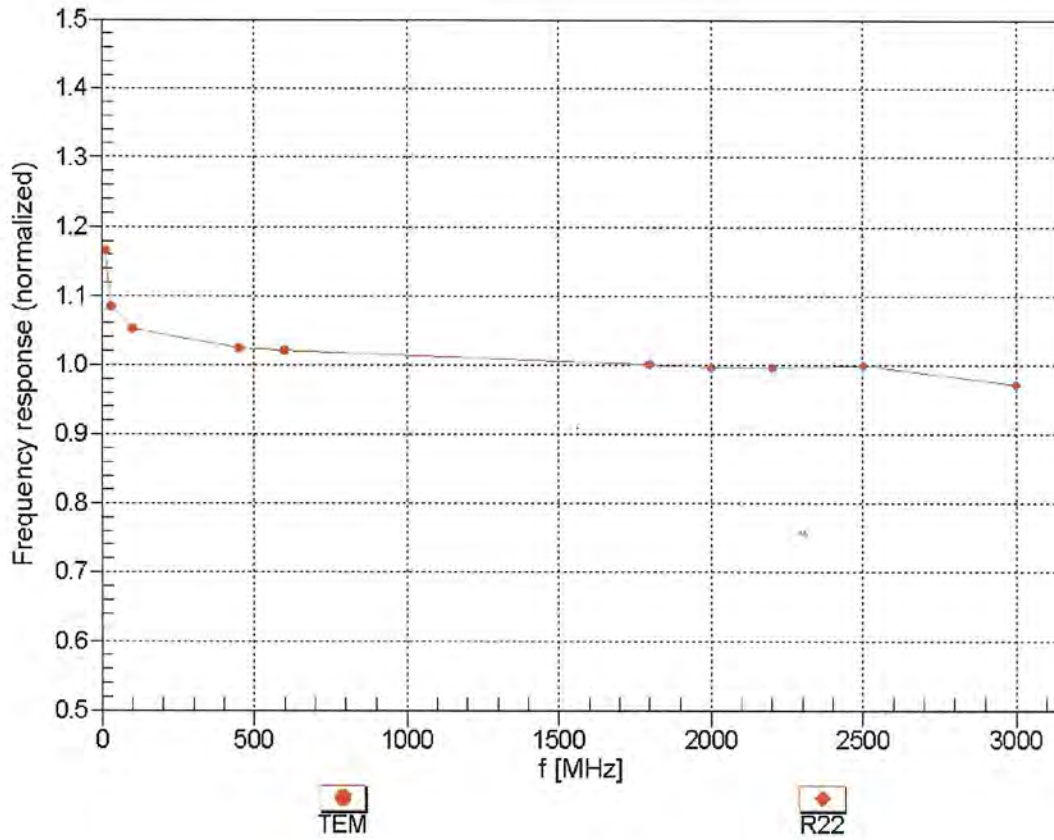
f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unct. (k=2)
750	55.5	0.96	9.46	9.46	9.46	0.47	0.84	± 12.0 %
835	55.2	0.97	9.31	9.31	9.31	0.31	1.06	± 12.0 %
900	55.0	1.05	9.13	9.13	9.13	0.80	0.61	± 12.0 %
1750	53.4	1.49	7.89	7.89	7.89	0.80	0.60	± 12.0 %
1900	53.3	1.52	7.56	7.56	7.56	0.59	0.71	± 12.0 %
2000	53.3	1.52	7.73	7.73	7.73	0.29	1.00	± 12.0 %
2450	52.7	1.95	7.14	7.14	7.14	0.76	0.57	± 12.0 %
2600	52.5	2.16	6.82	6.82	6.82	0.73	0.61	± 12.0 %
5200	49.0	5.30	4.54	4.54	4.54	0.40	1.90	± 13.1 %
5300	48.9	5.42	4.37	4.37	4.37	0.40	1.90	± 13.1 %
5500	48.6	5.65	4.15	4.15	4.15	0.40	1.90	± 13.1 %
5600	48.5	5.77	3.98	3.98	3.98	0.40	1.90	± 13.1 %
5800	48.2	6.00	4.21	4.21	4.21	0.50	1.90	± 13.1 %

<sup>C</sup> Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. Above 5 GHz frequency validity can be extended to ± 110 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

<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.

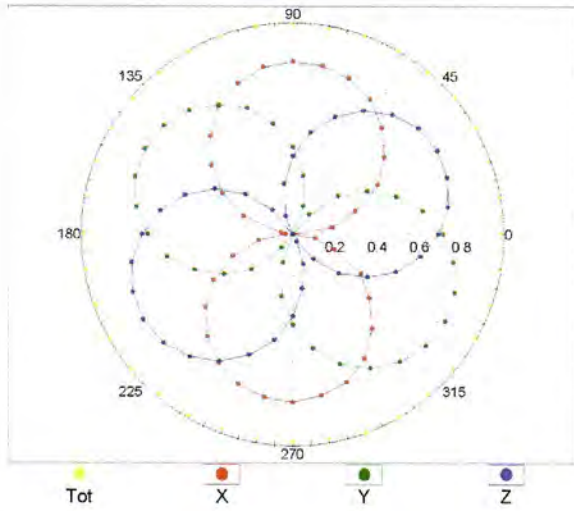
### Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



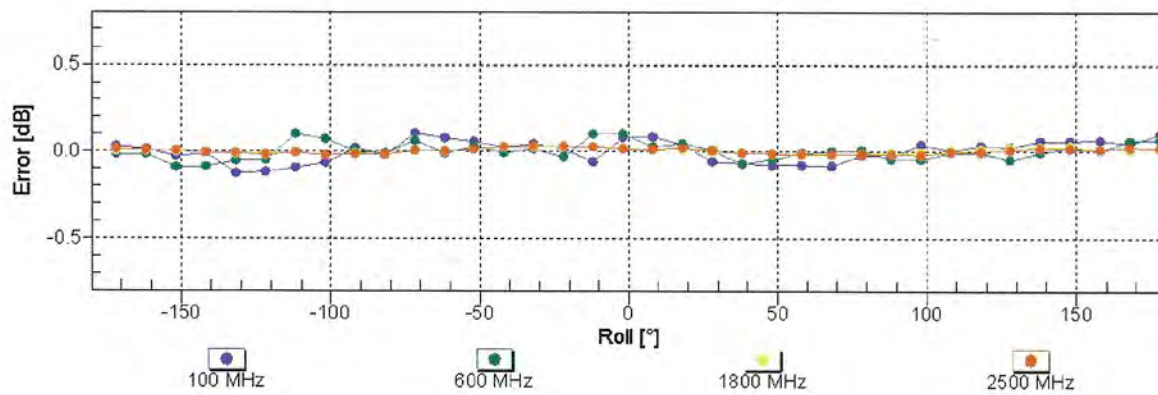
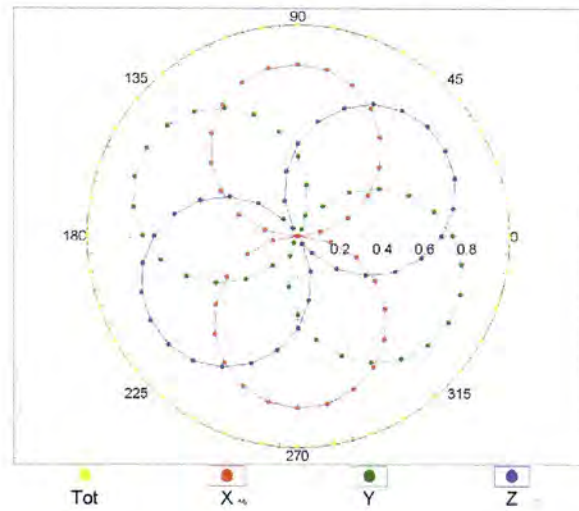
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

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

f=600 MHz, TEM



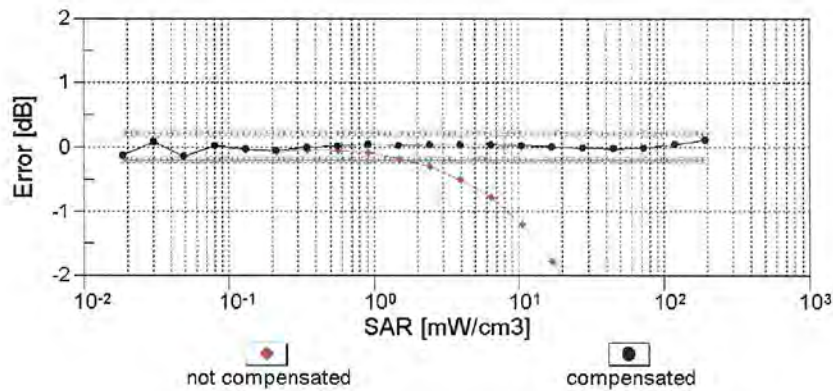
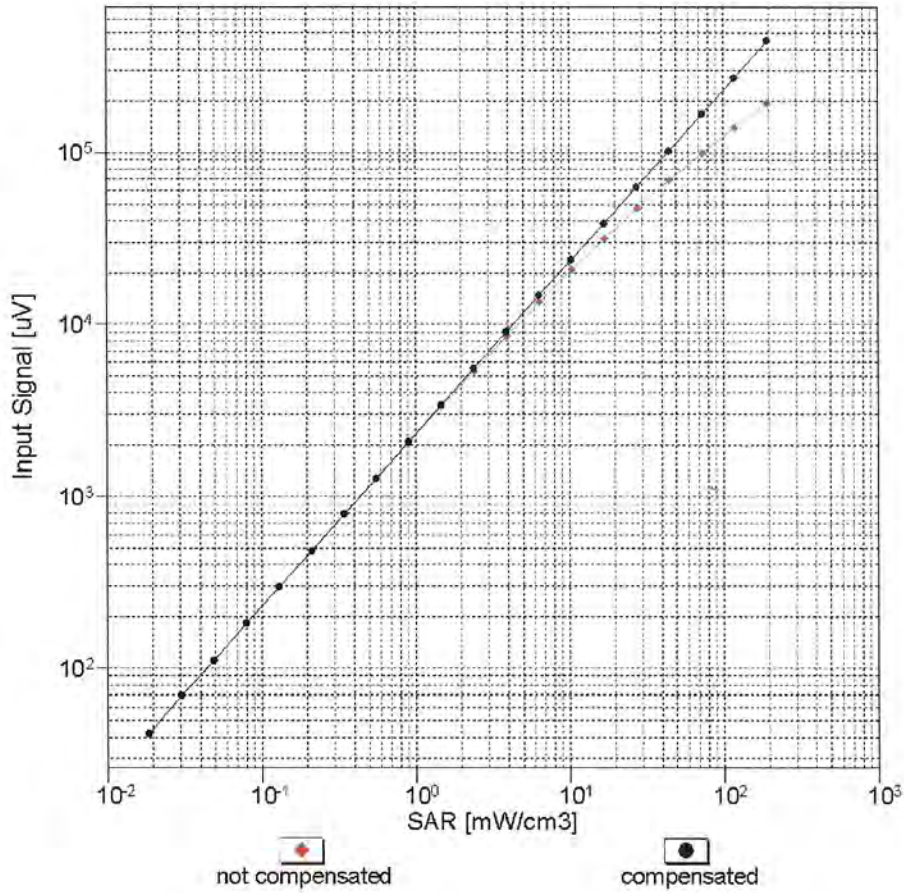
f=1800 MHz, R22



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

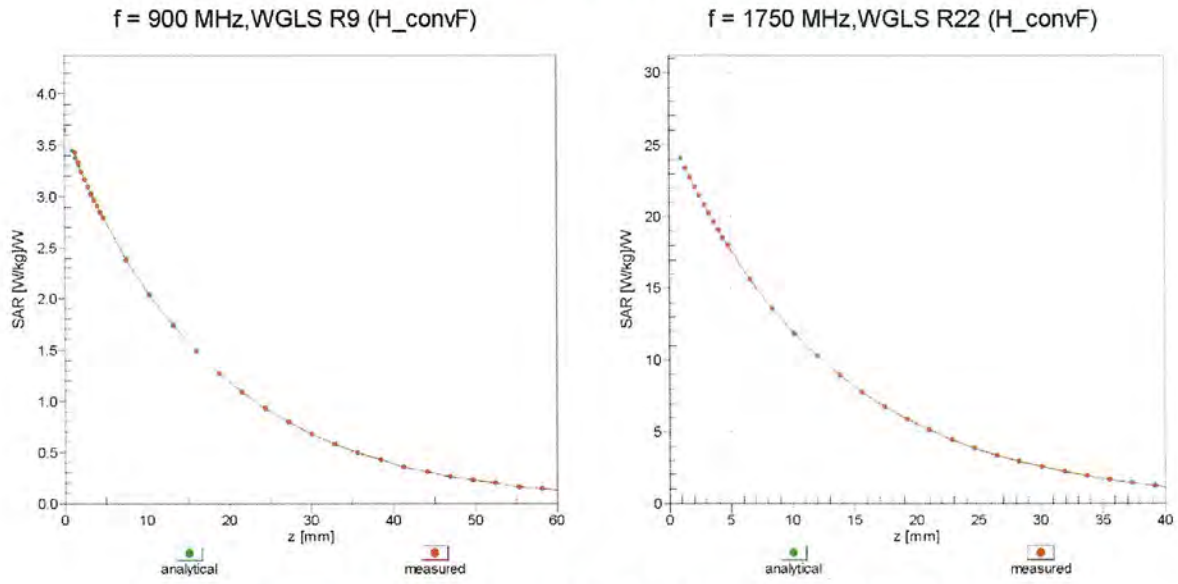


### Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell , $f_{\text{eval}} = 1900 \text{ MHz}$ )

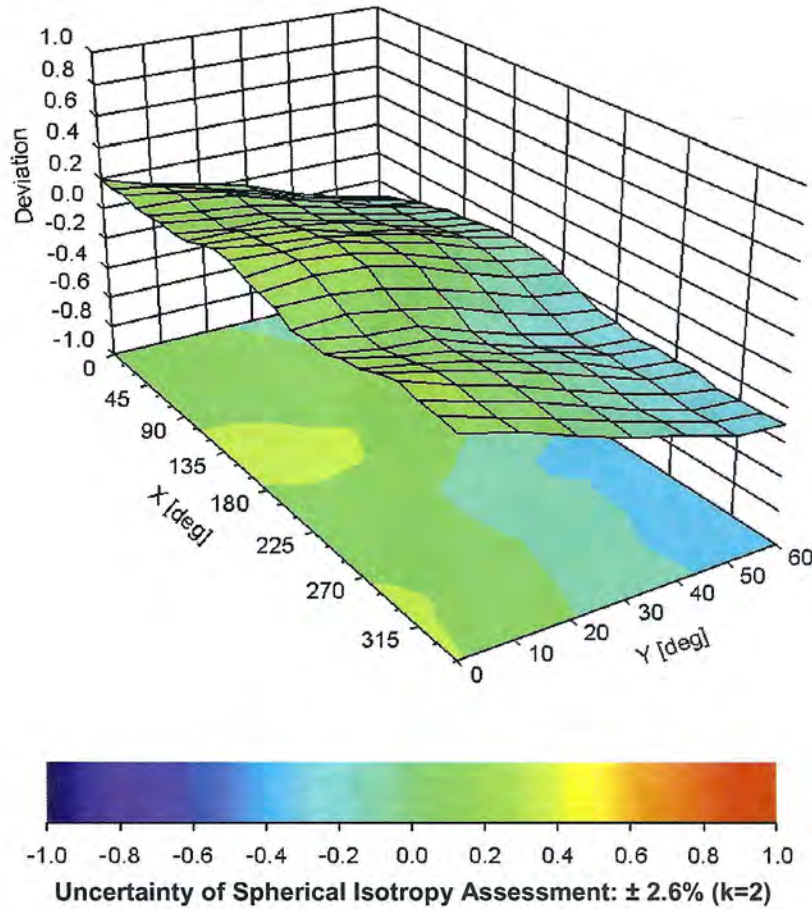


Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

# Conversion Factor Assessment



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



## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3857

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-41.9
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	2 mm