

# FCC SAR Test Report

APPLICANT : Broadcom Corporation  
EQUIPMENT : 802.11b/g/n/a/ac WLAN + Bluetooth  
PCI-E NGFF 2230 Card  
BRAND NAME : Broadcom  
MODEL NAME : BCM94350ZAE  
FCC ID : QDS-BRCM1087  
FCC 47 CFR Part 2 (2.1093)  
STANDARD : ANSI/IEEE C95.1-1992  
IEEE 1528-2013

The product was installed into Portable Computer (Brand Name DELL, Model Name: P67G) during test.

We, SPORTON INTERNATIONAL 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 INC., the test report shall not be reproduced except in full.



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Approved by: Jones Tsai / Manager



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## **1. Statement of Compliance**

The maximum results of Specific Absorption Rate (SAR) found during testing for Broadcom Corporation, 802.11b/g/n/a/ac WLAN + Bluetooth PCI-E NGFF 2230 Card, BCM94350ZAE, are as follows.

Equipment Class	Frequency Band		Highest SAR Summary	Highest Simultaneous Transmission 1g SAR (W/kg)
			Body (Separation 0mm) 1g SAR (W/kg)	
DTS	WLAN	2.4GHz WLAN	1.00	1.15
NII		5GHz WLAN	1.17	1.32
DSS	2.4GHz Band	Bluetooth	0.01	1.17
Date of Testing:			2015/12/09 ~ 2016/01/07	

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 1528-2013 and FCC KDB publications

## **2. Administration Data**

Testing Laboratory	
Test Site	SPORTON INTERNATIONAL INC.
Test Site Location	No.52, Hwa Ya 1st Rd., Hwa Ya Technology Park, Kwei-Shan District, Taoyuan City, Taiwan (R.O.C.) TEL: +886-3-327-3456 FAX: +886-3-328-4978

Applicant	
Company Name	Broadcom Corporation
Address	190 Mathilda Place, Sunnyvale, CA 94086, USA

Manufacturer	
Company Name	Broadcom Corporation
Address	190 Mathilda Place, Sunnyvale, CA 94086, USA

### 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 1528-2013
- FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04
- FCC KDB 865664 D02 SAR Reporting v01r02
- FCC KDB 447498 D01 General RF Exposure Guidance v06
- FCC KDB 248227 D01 802.11 Wi-Fi SAR v02r02
- FCC KDB 616217 D04 SAR for laptop and tablets v01r02

### 4. Equipment Under Test (EUT) Information

#### 4.1 General Information

Product Feature & Specification	
Equipment Name	802.11b/g/n/a/ac WLAN + Bluetooth PCI-E NGFF 2230 Card
Brand Name	Broadcom
Model Name	BCM94350ZAE
FCC ID	QDS-BRCM1087
Wireless Technology and Frequency Range	WLAN 2.4GHz Band: 2412 MHz ~ 2472 MHz WLAN 5.2GHz Band: 5180 MHz ~ 5240 MHz WLAN 5.3GHz Band: 5260 MHz ~ 5320 MHz WLAN 5.5GHz Band: 5500 MHz ~ 5720MHz WLAN 5.8GHz Band: 5745 MHz ~ 5825 MHz Bluetooth: 2402 MHz ~ 2480 MHz
Mode	• 802.11a/b/g/n/ac HT20/HT40/VHT20/VHT40/VHT80 • Bluetooth v3.0+EDR • Bluetooth v4.1-LE
EUT Stage	Identical Prototype
<b>Remark:</b>	
1. This device will integrated into two different hosts perform testing on this filing, and the host have different configuration, antenna vendors, antenna location and housing material, for the battery option both hosts are included, the detail information as follow table, the different antenna location please refer to section12.	

Host Information						
Equipment Name		Portable Computer				
Brand Name		DELL				
Model Name		P67G				
WWAN with WLAN Host						
Sample 1	S/N	3807914100033	Housing material	Aluminum	Antenna Vender	Ethertronics Inc.
Sample 2		3807913300018		Carbon fiber		
Only WLAN Host						
Sample 3	S/N	3807913500008	Housing material	Aluminum	Antenna Vender	WNC & ACON
Sample 4		3806674700001		Carbon fiber		
Remark :						
1. In WWAN with WLAN Host if collocation battery 1 (34Wh), in this host also supports NFC function,but if collocation battery 2(43Wh) , in this host doesn't support NFC function						
2. In only WLAN Host does not support NEC function						

Battery Information				
	Brand Name	Model Name	Power Rating	Type
Battery 1	DELL	XCNR3	7.6Vdc,34Wh	Li-ion
Battery 2	DELL	P63NY	7.6Vdc,43Wh	Li-ion

Antenna Information								
WNC	Ant 1	Model No.	81EAAZ15.G47		Ant 2	Model No.	81EAAZ15.G47	
		Ant. Type	PIFA			Ant. Type	PIFA	
		Peak Gain (dBi)	2400~2483.5MHz :	-0.88		Peak Gain (dBi)	2400~2483.5MHz :	-2.94
			5150~5250MHz:	0			5150~5250MHz:	0.22
			5250~5350MHz:	0			5250~5350MHz:	0.22
			5470~5725MHz:	0.08			5470~5725MHz:	1.17
			5725~5850MHz:	0.44			5725~5850MHz:	0.04
ACON	Ant 1	Model No.	AML6Y-300000		Ant 2	Model No.	AML6Y-300000	
		Ant. Type	PIFA			Ant. Type	PIFA	
		Peak Gain (dBi)	2400~2483.5MHz :	-0.9		Peak Gain (dBi)	2400~2483.5MHz :	-2.15
			5150~5250MHz:	-0.8			5150~5250MHz:	-4.99
			5250~5350MHz:	-0.22			5250~5350MHz:	-3.99
			5470~5725MHz:	-2.37			5470~5725MHz:	-2.84
			5725~5850MHz:	-1.13			5725~5850MHz:	-3.06
Ethertronics Inc.	Ant 1	Model No.	5002131		Ant 2	Model No.	5002137	
		Ant. Type	PIFA			Ant. Type	PIFA	
		Peak Gain (dBi)	2400~2483.5MHz :	1.48		Peak Gain (dBi)	2400~2483.5MHz :	2.6
			5150~5250MHz:	0.75			5150~5250MHz:	-0.79
			5250~5350MHz:	-0.04			5250~5350MHz:	-0.79
			5470~5725MHz:	0.01			5470~5725MHz:	-0.32
			5725~5850MHz:	0.2			5725~5850MHz:	-0.32

## **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 (ρ). The equation description is as below:

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

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

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

Where: σ is the conductivity of the tissue, ρ is the mass density of the tissue and E is the RMS electrical field strength.



## 7. System Description and Setup

**The DASY system used for performing compliance tests consists of the following items:**




- A standard high precision 6-axis robot with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic Field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP or Win7 and the DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.


## 7.1 E-Field Probe

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

### <ES3DV3 Probe>

<b>Construction</b>	Symmetric design with triangular core Interleaved sensors Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
<b>Frequency</b>	10 MHz – 4 GHz; Linearity: $\pm 0.2$ dB (30 MHz – 4 GHz)	
<b>Directivity</b>	$\pm 0.2$ dB in TSL (rotation around probe axis) $\pm 0.3$ dB in TSL (rotation normal to probe axis)	
<b>Dynamic Range</b>	5 $\mu$ W/g – >100 mW/g; Linearity: $\pm 0.2$ dB	
<b>Dimensions</b>	Overall length: 337 mm (tip: 20 mm) Tip diameter: 3.9 mm (body: 12 mm) Distance from probe tip to dipole centers: 2.0 mm	

### <EX3DV4 Probe>

<b>Construction</b>	Symmetric design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
<b>Frequency</b>	10 MHz – >6 GHz Linearity: $\pm 0.2$ dB (30 MHz – 6 GHz)	
<b>Directivity</b>	$\pm 0.3$ dB in TSL (rotation around probe axis) $\pm 0.5$ dB in TSL (rotation normal to probe axis)	
<b>Dynamic Range</b>	10 $\mu$ W/g – >100 mW/g Linearity: $\pm 0.2$ dB (noise: typically <1 $\mu$ W/g)	
<b>Dimensions</b>	Overall length: 337 mm (tip: 20 mm) Tip diameter: 2.5 mm (body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm	

## 7.2 Data Acquisition Electronics (DAE)

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


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



**Fig 5.1 Photo of DAE**


### **7.3 Phantom**

#### **<SAM Twin Phantom>**

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

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

#### **<ELI Phantom>**

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

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

## **7.4 Device Holder**

### **<Mounting Device for Hand-Held Transmitter>**

In combination with the Twin SAM V5.0/V5.0c or ELI phantoms, the Mounting Device for Hand-Held Transmitters enables rotation of the mounted transmitter device to specified spherical coordinates. At the heads, the rotation axis is at the ear opening. Transmitter devices can be easily and accurately positioned according to IEC 62209-1, IEEE 1528, FCC, or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat). And upgrade kit to Mounting Device to enable easy mounting of wider devices like big smart-phones, e-books, small tablets, etc. It holds devices with width up to 140 mm.



Mounting Device for Hand-Held Transmitters



Mounting Device Adaptor for Wide-Phones

### **<Mounting Device for Laptops and other Body-Worn Transmitters>**

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



Mounting Device for Laptops

## **8. Measurement Procedures**

The measurement procedures are as follows:

### <Conducted power measurement>

- (a) For WWAN power measurement, use base station simulator to configure EUT WWAN transmission in conducted connection with RF cable, at maximum power in each supported wireless interface and frequency band.
- (b) Read the WWAN RF power level from the base station simulator.
- (c) 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
- (d) Connect EUT RF port through RF cable to the power meter, and measure WLAN/BT output power

### <SAR measurement>

- (a) Use base station simulator to configure EUT WWAN transmission in radiated connection, and 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 dB) 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 D01v01r04 SAR measurement 100 MHz to 6 GHz.

	$\leq 3$ GHz	$> 3$ GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	$5 \pm 1$ 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	$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$
Maximum area scan spatial resolution: $\Delta x_{Area}$ , $\Delta y_{Area}$	$\leq 2$ GHz: $\leq 15$ mm $2 - 3$ GHz: $\leq 12$ mm	$3 - 4$ GHz: $\leq 12$ mm $4 - 6$ GHz: $\leq 10$ 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 $\leq$ 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 to 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 whose 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 D01v01r04 SAR measurement 100 MHz to 6 GHz.

			$\leq 3$ GHz	$> 3$ GHz
Maximum zoom scan spatial resolution: $\Delta x_{\text{Zoom}}, \Delta y_{\text{Zoom}}$			$\leq 2$ 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: $\Delta z_{\text{Zoom}}(n)$		$\leq 5$ mm	3 – 4 GHz: $\leq 4$ mm 4 – 5 GHz: $\leq 3$ mm 5 – 6 GHz: $\leq 2$ mm
	graded grid	$\Delta z_{\text{Zoom}}(1)$ : 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
		$\Delta z_{\text{Zoom}}(n>1)$ : between subsequent points	$\leq 1.5 \cdot \Delta z_{\text{Zoom}}(n-1)$	
Minimum zoom scan volume	x, y, z		$\geq 30$ 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	736	Aug. 20, 2015	Aug. 19, 2016
SPEAG	5GHz System Validation Kit	D5GHzV2	1006	Oct. 06, 2015	Oct. 05, 2016
SPEAG	5GHz System Validation Kit	D5GHzV2	1128	Jul. 20, 2015	Jul. 19, 2016
SPEAG	Data Acquisition Electronics	DAE3	495	May. 22, 2015	May. 21, 2016
SPEAG	Data Acquisition Electronics	DAE4	778	Aug. 25, 2015	Aug. 24, 2016
SPEAG	Data Acquisition Electronics	DAE3	577	Sep. 24, 2015	Sep. 23, 2016
SPEAG	Data Acquisition Electronics	DAE4	1399	Nov. 23, 2015	Nov. 22, 2016
SPEAG	Dosimetric E-Field Probe	EX3DV4	3925	May. 27, 2015	May. 26, 2016
SPEAG	Dosimetric E-Field Probe	ES3DV3	3270	Sep. 28, 2015	Sep. 27, 2016
SPEAG	Dosimetric E-Field Probe	EX3DV4	3931	Oct. 01, 2015	Sep. 30, 2016
SPEAG	Dosimetric E-Field Probe	EX3DV4	3955	Nov. 24, 2015	Nov. 23, 2016
WonDer	Thermometer	WD-5015	TM281	Oct. 16, 2015	Oct. 15, 2016
Wisewind	Thermometer	HTC-1	TM560	Oct. 16, 2015	Oct. 15, 2016
Wisewind	Thermometer	HTC-1	TM225	Oct. 16, 2015	Oct. 15, 2016
H.M.IRIS	Thermometer	TH-08	TM356	Oct. 16, 2015	Oct. 15, 2016
SPEAG	Device Holder	N/A	N/A	N/A	N/A
R&S	Signal Generator	MG3710A	6201502524	May. 25, 2015	May. 24, 2016
Agilent	ENA Network Analyzer	E5071C	MY46316648	Feb. 11, 2015	Feb. 10, 2016
SPEAG	Dielectric Probe Kit	DAK-3.5	1126	Jul. 21, 2015	Jul. 20, 2016
LINE SEIKI	Digital Thermometer	LKMelectronic	DTM3000SPEZIAL	Jul. 17, 2015	Jul. 16, 2016
Anritsu	Power Meter	ML2495A	1419002	May. 13, 2015	May. 12, 2016
Anritsu	Power Sensor	MA2411B	1339124	May. 13, 2015	May. 12, 2016
Anritsu	Spectrum Analyzer	MS2830A	6201396378	Jun. 17, 2015	Jun. 16, 2016
ATM	Dual Directional Coupler	C122H-10	P610410z-02	Note 1	
Woken	Attenuator 1	WK0602-XX	N/A	Note 1	
PE	Attenuator 2	PE7005-10	N/A	Note 1	
PE	Attenuator 3	PE7005- 3	N/A	Note 1	
AR	Power Amplifier	5S1G4M2	0328767	Note 1	
Mini-Circuits	Power Amplifier	ZVE-3W	162601250	Note 1	

### General Note:

- 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.

## 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 Head								
750	41.1	57.0	0.2	1.4	0.2	0	0.89	41.9
835	40.3	57.9	0.2	1.4	0.2	0	0.90	41.5
900	40.3	57.9	0.2	1.4	0.2	0	0.97	41.5
1800, 1900, 2000	55.2	0	0	0.3	0	44.5	1.40	40.0
2450	55.0	0	0	0	0	45.0	1.80	39.2
2600	54.8	0	0	0.1	0	45.1	1.96	39.0
For Body								
750	51.7	47.2	0	0.9	0.1	0	0.96	55.5
835	50.8	48.2	0	0.9	0.1	0	0.97	55.2
900	50.8	48.2	0	0.9	0.1	0	1.05	55.0
1800, 1900, 2000	70.2	0	0	0.4	0	29.4	1.52	53.3
2450	68.6	0	0	0	0	31.4	1.95	52.7
2600	68.1	0	0	0.1	0	31.8	2.16	52.5

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%

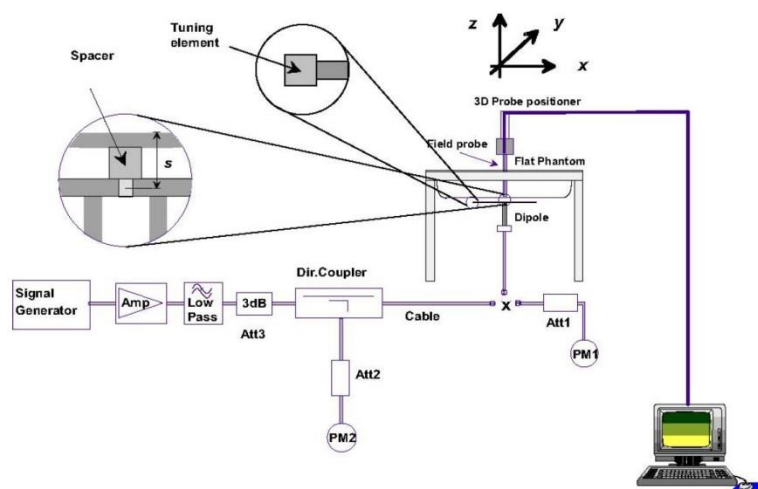
### <Tissue Dielectric Parameter Check Results>

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	MSL	22.3	1.998	53.455	1.95	52.70	2.46	1.43	±5	2015/12/9
2450	MSL	22.2	2.001	53.437	1.95	52.70	2.62	1.40	±5	2015/12/10
2450	MSL	22.7	2.001	53.437	1.95	52.70	2.62	1.40	±5	2015/12/10
2450	MSL	22.5	1.972	52.986	1.95	52.70	1.13	0.54	±5	2016/1/7
5250	MSL	22.5	5.543	46.845	5.36	48.93	3.41	-4.26	±5	2015/12/9
5250	MSL	22.5	5.543	46.845	5.36	48.93	3.41	-4.26	±5	2015/12/9
5300	MSL	22.7	5.575	47.163	5.42	48.90	2.86	-3.55	±5	2015/12/11
5600	MSL	22.2	6.003	46.253	5.77	48.50	4.04	-4.63	±5	2015/12/9
5600	MSL	22.5	6.003	46.253	5.77	48.50	4.04	-4.63	±5	2015/12/9
5600	MSL	22.7	5.899	47.089	5.77	48.50	2.24	-2.91	±5	2015/12/11
5750	MSL	22.2	6.208	46.019	5.94	48.27	4.51	-4.66	±5	2015/12/9
5750	MSL	22.5	6.208	46.019	5.94	48.28	4.51	-4.68	±5	2015/12/9
5800	MSL	22.7	6.260	46.928	6.00	48.20	4.33	-2.64	±5	2015/12/11

## 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 1g SAR (W/kg)	Targeted 1g SAR (W/kg)	Normalized 1g SAR (W/kg)	Deviation (%)
2015/12/9	2450	MSL	250	D2450V2-736	ES3DV3 - SN3270	DAE4 Sn778	13.80	51.90	55.2	6.36
2015/12/10	2450	MSL	250	D2450V2-736	EX3DV4 - SN3931	DAE3 Sn577	12.30	51.90	49.2	-5.20
2015/12/10	2450	MSL	250	D2450V2-736	EX3DV4 - SN3925	DAE3 Sn495	12.50	51.90	50	-3.66
2016/1/7	2450	MSL	250	D2450V2-736	ES3DV3 - SN3270	DAE4 Sn778	13.60	51.90	54.4	4.82
2015/12/9	5250	MSL	100	D5GHzV2-1128-5250	EX3DV4 - SN3931	DAE3 Sn577	8.00	76.20	80	4.99
2015/12/9	5250	MSL	100	D5GHzV2-1128-5250	EX3DV4 - SN3955	DAE4 Sn1399	7.22	76.20	72.2	-5.25
2015/12/11	5300	MSL	100	D5GHzV2-1006-5300	EX3DV4 - SN3925	DAE3 Sn495	7.59	79.50	75.9	-4.53
2015/12/9	5600	MSL	100	D5GHzV2-1128-5600	EX3DV4 - SN3931	DAE3 Sn577	8.39	79.30	83.9	5.80
2015/12/9	5600	MSL	100	D5GHzV2-1128-5600	EX3DV4 - SN3955	DAE4 Sn1399	7.86	79.30	78.6	-0.88
2015/12/11	5600	MSL	100	D5GHzV2-1006-5600	EX3DV4 - SN3925	DAE3 Sn495	8.67	82.30	86.7	5.35
2015/12/9	5750	MSL	100	D5GHzV2-1128-5750	EX3DV4 - SN3931	DAE3 Sn577	7.61	75.90	76.1	0.26
2015/12/9	5750	MSL	100	D5GHzV2-1128-5750	EX3DV4 - SN3955	DAE4 Sn1399	7.28	75.90	72.8	-4.08
2015/12/11	5800	MSL	100	D5GHzV2-1006-5800	EX3DV4 - SN3925	DAE3 Sn495	8.31	79.00	83.1	5.19



**Fig 8.3.1 System Performance Check Setup**



**Fig 8.3.2 Setup Photo**

## **11. Conducted RF Output Power (Unit: dBm)**

### **<WLAN Conducted Power>**

#### **General Note:**

1. For WLAN 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.
2. Per KDB 248227 D01v02r02, the simultaneous SAR provisions in KDB publication 447498 should be applied to determine simultaneous transmission SAR test exclusion for WiFi MIMO. If the sum of 1g single transmission chain SAR measurements is  $< 1.6\text{W/kg}$  and SAR peak to location ratio  $< 0.04$ , no additional SAR measurements for MIMO.
3. Per KDB 248227 D01v02r02, SAR test reduction is determined according to 802.11 transmission mode configurations and certain exposure conditions with multiple test positions. In the 2.4 GHz band, separate SAR procedures are applied to DSSS and OFDM configurations to simplify DSSS test requirements. For OFDM, in both 2.4 and 5 GHz bands, an initial test configuration must be determined for each standalone and aggregated frequency band, according to the transmission mode configuration with the highest maximum output power specified for production units to perform SAR measurements. If the same highest maximum output power applies to different combinations of channel bandwidths, modulations and data rates, additional procedures are applied to determine which test configurations require SAR measurement. When applicable, an initial test position may be applied to reduce the number of SAR measurements required for next to the ear, UMPC mini-tablet or hotspot mode configurations with multiple test positions.
4. For 2.4 GHz 802.11b DSSS, either the initial test position procedure for multiple exposure test positions or the DSSS procedure for fixed exposure position is applied; these are mutually exclusive. For 2.4 GHz and 5 GHz OFDM configurations, the initial test configuration is applied to measure SAR using either the initial test position procedure for multiple exposure test position configurations or the initial test configuration procedures for fixed exposure test conditions. Based on the reported SAR of the measured configurations and maximum output power of the transmission mode configurations that are not included in the initial test configuration, the subsequent test configuration and initial test position procedures are applied to determine if SAR measurements are required for the remaining OFDM transmission configurations. In general, the number of test channels that require SAR measurement is minimized based on maximum output power measured for the test sample(s).
5. For OFDM transmission configurations in the 2.4 GHz and 5 GHz bands, When the same maximum power is specified for multiple transmission modes in a frequency band, the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order 802.11a/g/n/ac mode is used for SAR measurement, on the highest measured output power channel for each frequency band.
6. DSSS and OFDM configurations are considered separately according to the required SAR procedures. SAR is measured in the initial test position using the 802.11 transmission mode configuration required by the DSSS procedure or initial test configuration and subsequent test configuration(s) according to the OFDM procedures.<sup>18</sup> The initial test position procedure is described in the following:
  - a. When the reported SAR of the initial test position is  $\leq 0.4\text{ W/kg}$ , further SAR measurement is not required for the other test positions in that exposure configuration and 802.11 transmission mode combinations within the frequency band or aggregated band.
  - b. When the reported SAR of the test position is  $> 0.4\text{ W/kg}$ , SAR is repeated for the 802.11 transmission mode configuration tested in the initial test position to measure the subsequent next closet/smallest test separation distance and maximum coupling test position on the highest maximum output power channel, until the report SAR is  $\leq 0.8\text{ W/kg}$  or all required test position are tested.
  - c. For all positions/configurations, when the reported SAR is  $> 0.8\text{ W/kg}$ , SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is  $\leq 1.2\text{ W/kg}$  or all required channels are tested.

**<2.4GHz WLAN ANT 1>**

	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
2.4GHz WLAN ANT 1	802.11b	CH 1	2412	1Mbps	14.97	15.00	95.41
		CH 7	2442		14.84	15.00	
		CH 11	2462		14.92	15.00	
		CH 12	2467		14.90	15.00	
		CH 13	2472		12.95	13.00	
	802.11g	CH 1	2412	6Mbps	14.61	15.00	95.41
		CH 7	2442		14.58	15.00	
		CH 11	2462		14.65	15.00	
		CH 12	2467		14.64	15.00	
		CH 13	2472		9.86	10.00	
	802.11n-HT20	CH 1	2412	MCS0	14.87	15.00	95.05
		CH 7	2442		14.74	15.00	
		CH 11	2462		14.80	15.00	
		CH 12	2467		14.81	15.00	
		CH 13	2472		9.86	10.00	
	802.11n-HT40	CH 3	2422	MCS0	13.29	13.50	89.77
		CH 7	2442		14.84	15.00	
		CH 11	2462		11.93	12.00	

**<2.4GHz WLAN ANT 2>**

	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
2.4GHz WLAN ANT 2	802.11b	CH 1	2412	1Mbps	14.65	15.00	95.41
		CH 7	2442		14.88	15.00	
		CH 11	2462		14.67	15.00	
		CH 12	2467		14.65	15.00	
		CH 13	2472		12.90	13.00	
	802.11g	CH 1	2412	6Mbps	14.81	15.00	95.41
		CH 7	2442		14.70	15.00	
		CH 11	2462		14.90	15.00	
		CH 12	2467		14.89	15.00	
		CH 13	2472		9.94	10.00	
	802.11n-HT20	CH 1	2412	MCS0	14.86	15.00	95.05
		CH 7	2442		14.84	15.00	
		CH 11	2462		14.80	15.00	
		CH 12	2467		14.79	15.00	
		CH 13	2472		9.86	10.00	
	802.11n-HT40	CH 3	2422	MCS0	13.23	13.50	89.77
		CH 7	2442		14.84	15.00	
		CH 11	2462		11.92	12.00	

**<2.4GHz WLAN ANT 1+2>**

	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
2.4GHz WLAN ANT 1+2	802.11b	CH 1	2412	1Mbps	17.95	18.00	94.95
		CH 7	2442		17.96	18.00	
		CH 11	2462		17.33	18.00	
		CH 12	2467		17.78	18.00	
		CH 13	2472		15.90	16.00	
	802.11g	CH 1	2412	6Mbps	17.87	18.00	94.50
		CH 7	2442		17.93	18.00	
		CH 11	2462		17.33	17.50	
		CH 12	2467		17.85	18.00	
		CH 13	2472		12.90	13.00	
	802.11n-HT20	CH 1	2412	MCS0	17.91	18.00	94.49
		CH 7	2442		17.92	18.00	
		CH 11	2462		17.45	17.50	
		CH 12	2467		17.90	18.00	
		CH 13	2472		12.91	13.00	
	802.11n-HT40	CH 3	2422	MCS0	12.98	13.00	90.48
		CH 7	2442		17.72	18.00	
		CH 11	2462		13.85	14.00	

**<5GHz WLAN ANT1>**

	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
5.2GHz WLAN ANT 1	802.11a	CH 36	5180	6Mbps	13.24	13.50	95.41
		CH 40	5200		13.17	13.50	
		CH 44	5220		13.12	13.50	
		CH 48	5240		13.45	13.50	
	802.11n-HT20	CH 36	5180	MCS0	13.18	13.50	95.24
		CH 40	5200		13.11	13.50	
		CH 44	5220		13.05	13.50	
		CH 48	5240		13.31	13.50	
	802.11n-HT40	CH 38	5190	MCS0	13.29	13.50	90.38
		CH 46	5230		13.48	13.50	
	802.11ac-VHT80	CH 42	5210	MCS0	13.36	13.50	94.31

5.3GHz WLAN ANT 1	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
	802.11a	CH 52	5260	6Mbps	13.38	13.50	95.41
		CH 56	5280		13.26	13.50	
		CH 60	5300		13.48	13.50	
		CH 64	5320		13.31	13.50	
	802.11n-HT20	CH 52	5260	MCS0	13.44	13.50	95.24
		CH 56	5280		13.23	13.50	
		CH 60	5300		13.21	13.50	
		CH 64	5320		13.11	13.50	
	802.11n-HT40	CH 54	5270	MCS0	13.39	13.50	90.38
		CH 62	5310		13.21	13.50	
	802.11ac-VHT80	CH 58	5290	MCS0	13.17	13.50	94.31

5.5GHz WLAN ANT 1	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
	802.11a	CH 100	5500	6Mbps	13.78	14.00	95.41
		CH 116	5580		13.70	14.00	
		CH 124	5620		13.80	14.00	
		CH 132	5660		13.74	14.00	
		CH 144	5720		13.81	14.00	
	802.11n-HT20	CH 100	5500	MCS0	13.89	14.00	95.24
		CH 116	5580		13.78	14.00	
		CH 124	5620		13.81	14.00	
		CH 132	5660		13.84	14.00	
		CH 144	5720		13.89	14.00	
	802.11n-HT40	CH 102	5510	MCS0	13.91	14.00	90.38
		CH 110	5550		13.77	14.00	
		CH 126	5630		13.76	14.00	
		CH 134	5670		13.86	14.00	
		CH 142	5710		13.80	14.00	
	802.11ac-VHT80	CH 106	5530	MCS0	13.86	14.00	94.31
		CH 122	5610		13.69	14.00	
		CH 138	5690		13.90	14.00	

	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
5.8GHz WLAN ANT 1	802.11a	CH 149	5745	MCS0	13.29	13.50	95.41
		CH 157	5785		13.40	13.50	
		CH 165	5825		13.43	13.50	
	802.11n-HT20	CH 149	5745	MCS0	13.21	13.50	95.24
		CH 157	5785		13.40	13.50	
		CH 165	5825		13.24	13.50	
	802.11n-HT40	CH 151	5755	MCS0	13.38	13.50	90.38
		CH 159	5795		13.30	13.50	
	802.11ac-VHT80	CH 155	5775	MCS0	13.40	13.50	94.31

**<5GHz WLAN ANT2>**

	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
5.2GHz WLAN ANT 2	802.11a	CH 36	5180	6Mbps	13.23	13.50	95.41
		CH 40	5200		13.27	13.50	
		CH 44	5220		13.43	13.50	
		CH 48	5240		13.34	13.50	
	802.11n-HT20	CH 36	5180	MCS0	13.27	13.50	94.49
		CH 40	5200		13.34	13.50	
		CH 44	5220		13.43	13.50	
		CH 48	5240		13.26	13.50	
	802.11n-HT40	CH 38	5190	MCS0	13.43	13.50	90.48
		CH 46	5230		13.30	13.50	
	802.11ac-VHT80	CH 42	5210	MCS0	13.22	13.50	93.55

	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
5.3GHz WLAN ANT 2	802.11a	CH 52	5260	6Mbps	13.40	13.50	95.41
		CH 56	5280		13.37	13.50	
		CH 60	5300		13.48	13.50	
		CH 64	5320		13.30	13.50	
	802.11n-HT20	CH 52	5260	MCS0	13.42	13.50	94.49
		CH 56	5280		13.26	13.50	
		CH 60	5300		13.45	13.50	
		CH 64	5320		13.49	13.50	
	802.11n-HT40	CH 54	5270	MCS0	13.22	13.50	90.48
		CH 62	5310		13.45	13.50	
	802.11ac-VHT80	CH 58	5290	MCS0	13.13	13.50	93.55



5.5GHz WLAN ANT 2	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
	802.11a	CH 100	5500	6Mbps	13.73	14.00	95.41
		CH 116	5580		13.81	14.00	
		CH 124	5620		13.77	14.00	
		CH 132	5660		13.81	14.00	
		CH 144	5720		13.83	14.00	
	802.11n-HT20	CH 100	5500	MCS0	13.84	14.00	94.49
		CH 116	5580		13.77	14.00	
		CH 124	5620		13.79	14.00	
		CH 132	5660		13.83	14.00	
		CH 144	5720		13.55	14.00	
	802.11n-HT40	CH 102	5510	MCS0	13.92	14.00	90.48
		CH 110	5550		13.98	14.00	
		CH 126	5630		13.81	14.00	
		CH 134	5670		13.68	14.00	
		CH 142	5710		13.61	14.00	
	802.11ac-VHT80	CH 106	5530	MCS0	13.81	14.00	93.55
		CH 122	5610		13.69	14.00	
		CH 138	5690		13.56	14.00	

5.8GHz WLAN ANT 2	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
	802.11a	CH 149	5745	MCS0	13.27	13.50	95.41
		CH 157	5785		13.13	13.50	
		CH 165	5825		13.20	13.50	
	802.11n-HT20	CH 149	5745	MCS0	13.14	13.50	94.49
		CH 157	5785		13.39	13.50	
		CH 165	5825		13.17	13.50	
	802.11n-HT40	CH 151	5755	MCS0	13.27	13.50	90.48
		CH 159	5795		13.17	13.50	
	802.11ac-VHT80	CH 155	5775	MCS0	13.30	13.50	93.55

**<5GHz WLAN ANT1+2>**

	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
5.2GHz WLAN ANT 1+2	802.11a	CH 36	5180	6Mbps	15.17	15.50	94.89
		CH 40	5200		15.20	15.50	
		CH 44	5220		15.23	15.50	
		CH 48	5240		15.09	15.50	
	802.11n-HT20	CH 36	5180	MCS0	15.19	16.50	95.28
		CH 40	5200		15.11	16.50	
		CH 44	5220		15.15	16.50	
		CH 48	5240		15.10	16.50	
	802.11n-HT40	CH 38	5190	MCS0	16.21	16.50	90.38
		CH 46	5230		16.11	16.50	
	802.11ac-VHT80	CH 42	5210	MCS0	16.48	16.50	93.55

	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
5.3GHz WLAN ANT 1+2	802.11a	CH 52	5260	6Mbps	15.31	16.50	94.89
		CH 56	5280		15.22	16.50	
		CH 60	5300		15.33	16.50	
		CH 64	5320		15.15	16.50	
	802.11n-HT20	CH 52	5260	MCS0	16.27	16.50	95.28
		CH 56	5280		16.19	16.50	
		CH 60	5300		16.35	16.50	
		CH 64	5320		16.20	16.50	
	802.11n-HT40	CH 54	5270	MCS0	16.20	16.50	90.38
		CH 62	5310		16.16	16.50	
	802.11ac-VHT80	CH 58	5290	MCS0	15.48	15.50	93.55

5.5GHz WLAN ANT 1+2	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
	802.11a	CH 100	5500	6Mbps	16.85	17.00	94.89
		CH 116	5580		16.53	17.00	
		CH 124	5620		16.72	17.00	
		CH 132	5660		16.69	17.00	
		CH 144	5720		16.71	17.00	
	802.11n-HT20	CH 100	5500	MCS0	16.67	17.00	95.28
		CH 116	5580		16.62	17.00	
		CH 124	5620		16.74	17.00	
		CH 132	5660		16.80	17.00	
		CH 144	5720		16.98	17.00	
	802.11n-HT40	CH 102	5510	MCS0	16.66	17.00	90.38
		CH 110	5550		16.74	17.00	
		CH 126	5630		16.78	17.00	
		CH 134	5670		16.76	17.00	
		CH 142	5710		16.54	17.00	
	802.11ac-VHT80	CH 106	5530	MCS0	16.44	16.50	93.55
		CH 122	5610		16.40	16.50	
		CH 138	5690		16.63	17.00	

5.8GHz WLAN ANT 1+2	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-Up Limit	Duty Cycle %
	802.11a	CH 149	5745	MCS0	16.16	16.50	94.89
		CH 157	5785		16.30	16.50	
		CH 165	5825		16.36	16.50	
	802.11n-HT20	CH 149	5745	MCS0	16.41	16.50	95.28
		CH 157	5785		16.29	16.50	
		CH 165	5825		16.32	16.50	
	802.11n-HT40	CH 151	5755	MCS0	16.30	16.50	90.38
		CH 159	5795		16.31	16.50	
	802.11ac-VHT80	CH 155	5775	MCS0	16.22	16.50	93.55

**<2.4GHz Bluetooth>****General Note:**

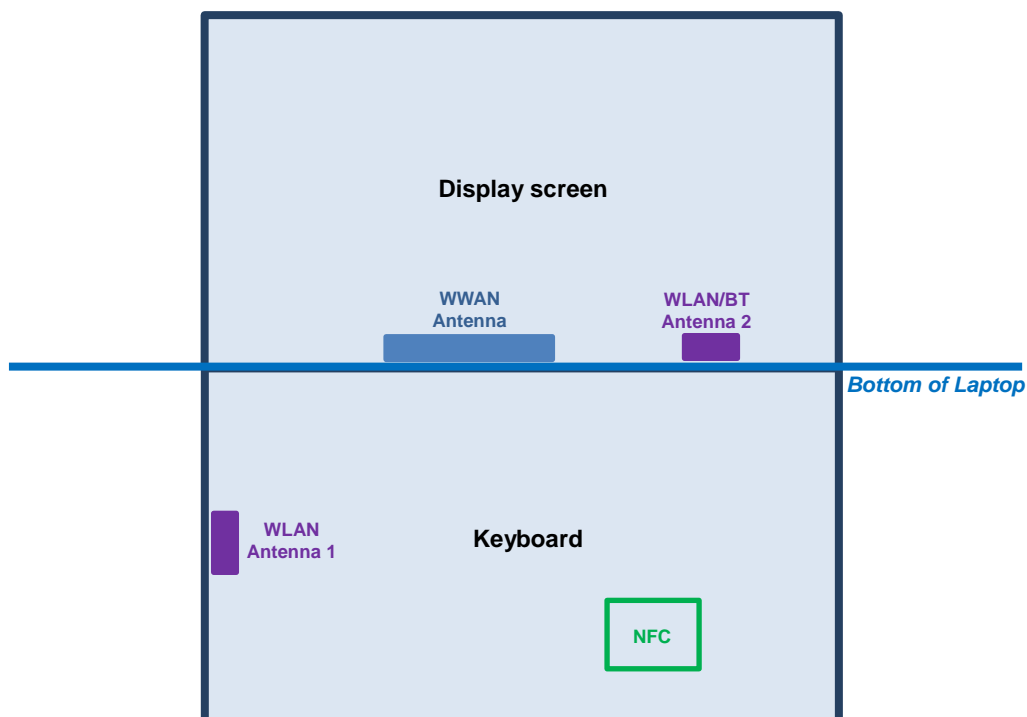
1. For 2.4GHz Bluetooth SAR testing was selected 1Mbps, due to its highest average power.
2. The duty factor is selected theoretical 83.3% perform Bluetooth SAR testing.

Mode	Channel	Frequency (MHz)	Average power (dBm)	
			1Mbps	3Mbps
v3.0 with EDR	CH 00	2402	8.73	5.30
	CH 39	2441	8.63	5.22
	CH 78	2480	7.98	4.73
Tune-up Limit			8.73	5.34

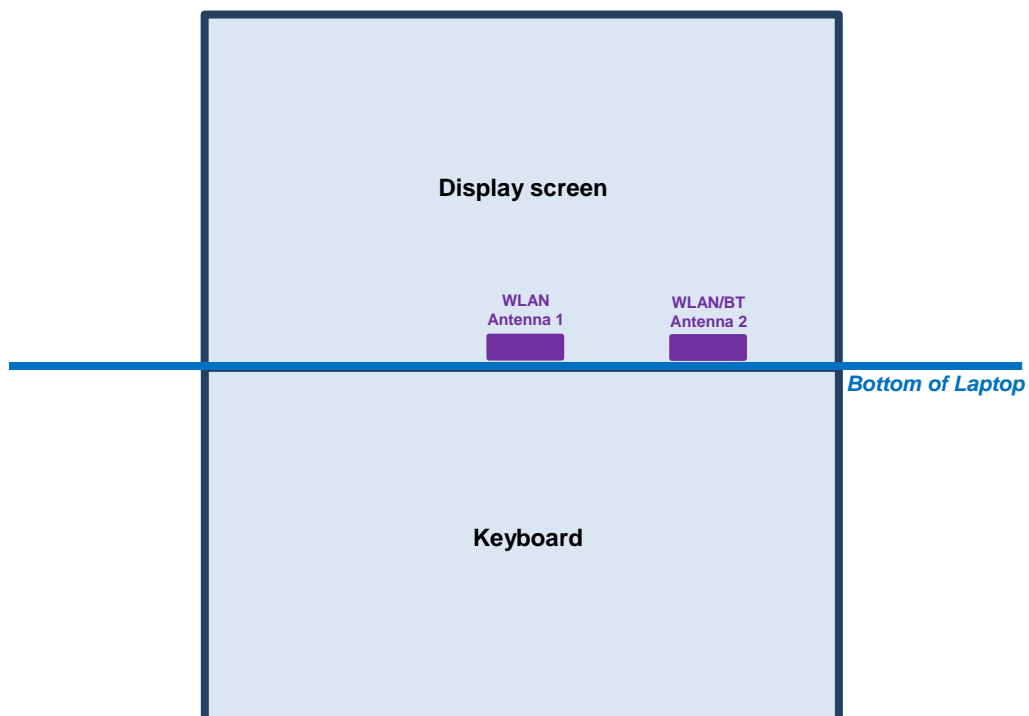
Mode	Channel	Frequency (MHz)	Average power (dBm)
			GFSK
v4.1 with LE	CH 00	2402	3.84
	CH 19	2440	3.76
	CH 39	2480	3.53
Tune-up Limit			3.85

## 12. Antenna Location

<WWAN with WLAN host>



<Only WLAN host>





### **13. SAR Test Results**

**General Note:**

1. Per KDB 447498 D01v06, 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 Bluetooth: 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 D01v06, 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. For additional battery, need repeat SAR testing at the worst position for each wireless mode and each band.

**WLAN Note:**

1. Per KDB 248227 D01v02r02, for 2.4GHz 802.11g/n SAR testing is not required when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is  $\leq 1.2$  W/kg.
2. Per KDB 248227 D01v02r02, for U-NII-1 Body SAR testing is not required when the U-NII-2A band highest reported SAR for a test configuration is  $\leq 1.2$  W/kg, SAR is not required for U-NII-1 band.
3. When the reported SAR of the test position is  $> 0.4$  W/kg, SAR is repeated for the 802.11 transmission mode configuration tested in the initial test position to measure the subsequent next closet/smallest test separation distance and maximum coupling test position on the highest maximum output power channel, until the report SAR is  $\leq 0.8$  W/kg or all required test position are tested.
4. For all positions / configurations, when the reported SAR is  $> 0.8$  W/kg, SAR is measured for these test positions / configurations on the subsequent next highest measured output power channel(s) until the reported SAR is  $\leq 1.2$  W/kg or all required channels are tested.
5. For WLAN 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.
6. Per KDB 248227 D01v02r02, the simultaneous SAR provisions in KDB publication 447498 should be applied to determine simultaneous transmission SAR test exclusion for WiFi MIMO. If the sum of 1g single transmission chain SAR measurements is  $< 1.6$ W/kg and SAR peak to location ratio  $< 0.04$ , no additional SAR measurements for MIMO.
7. During SAR testing the WLAN transmission was verified using a spectrum analyzer.



### 13.1 WWAN with WLAN host SAR results

**General Note:**

For WWAN with WLAN host, the WLAN RF exposure test procedure as follow:

- (a) Selected sample1 with battery1 as the main testing
- (b) Sample2 spot check (a) worse case perform
- (c) Battery2 spot check (a) / (b) worse case perform.

#### <WLAN SAR>

Plot No.	Band	Mode	Test Position	Gap (mm)	Sample	Antenna	Battery	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)	Reported 1g SAR (W/kg)
01	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample1	Ant 1	Battery1	1	2412	14.97	15.00	1.007	95.41	1.048	0.14	0.945	0.997
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample1	Ant 1	Battery1	7	2442	14.84	15.00	1.038	95.41	1.048	0.11	0.751	0.817
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample1	Ant 1	Battery1	11	2462	14.92	15.00	1.019	95.41	1.048	0.1	0.800	0.854
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample1	Ant 1	Battery1	12	2467	14.90	15.00	1.023	95.41	1.048	0.04	0.804	0.862
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample1	Ant 2	Battery1	7	2442	14.88	15.00	1.028	95.41	1.048	0.12	0.141	0.152
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample2	Ant 1	Battery1	1	2412	14.97	15.00	1.007	95.41	1.048	0.12	0.677	0.714
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample1	Ant 1	Battery2	1	2412	14.97	15.00	1.007	95.41	1.048	0.14	0.846	0.893
02	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample1	Ant 1	Battery1	58	5290	13.17	13.50	1.079	94.31	1.060	0.08	0.301	0.344
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample1	Ant 2	Battery1	58	5290	13.13	13.50	1.089	93.55	1.069	-0.12	0.255	0.297
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample2	Ant 1	Battery1	58	5290	13.17	13.50	1.079	94.31	1.060	-0.02	0.247	0.282
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample1	Ant 1	Battery2	58	5290	13.17	13.50	1.079	94.31	1.060	-0.13	0.272	0.311
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample1	Ant 1	Battery1	138	5690	13.90	14.00	1.023	94.31	1.060	0.08	0.617	0.669
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample1	Ant 1	Battery1	106	5530	13.86	14.00	1.033	94.31	1.060	-0.01	0.461	0.505
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample1	Ant 2	Battery1	106	5530	13.81	14.00	1.045	93.55	1.069	-0.03	0.413	0.461
03	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample2	Ant 1	Battery1	138	5690	13.90	14.00	1.023	94.31	1.060	0.1	0.726	0.787
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample2	Ant 1	Battery2	138	5690	13.90	14.00	1.023	94.31	1.060	-0.09	0.714	0.774
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample1	Ant 1	Battery1	155	5775	13.40	13.50	1.023	94.31	1.060	-0.01	0.471	0.511
04	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample1	Ant 2	Battery1	155	5775	13.30	13.50	1.047	93.55	1.069	0.13	0.474	0.531
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample2	Ant 2	Battery1	155	5775	13.30	13.50	1.047	93.55	1.069	-0.04	0.402	0.450
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample1	Ant 2	Battery2	155	5775	13.30	13.50	1.047	93.55	1.069	0.08	0.429	0.480

#### <Bluetooth SAR>

Plot No.	Band	Mode	Test Position	Gap (mm)	Sample	Battery	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Power Drift (dB)	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
05	Bluetooth	1Mbps	Bottom of Laptop	0mm	Sample1	Battery1	0	2402	8.73	8.73	1.000	0.12	0.001	0.001
	Bluetooth	1Mbps	Bottom of Laptop	0mm	Sample1	Battery1	39	2441	8.63	8.73	1.023	-0.16	0.001	0.001
	Bluetooth	1Mbps	Bottom of Laptop	0mm	Sample1	Battery1	78	2402	7.98	8.73	1.189	0.00	0.001	0.001
	Bluetooth	1Mbps	Bottom of Laptop	0mm	Sample2	Battery1	0	2402	8.73	8.73	1.000	0.01	0.001	0.001
	Bluetooth	1Mbps	Bottom of Laptop	0mm	Sample1	Battery2	0	2402	8.73	8.73	1.000	0.13	0.001	0.001



**13.2 Only WLAN host SAR results****General Note:**

For only WLAN host, the WLAN RF exposure test procedure as follow:

- (a) Selected sample3 with battery1 and ACON antenna as the main testing
- (b) Sample4 spot check (a) worse case perform
- (c) Battery2 spot check (a) / (b) worse case perform
- (d) WNC antenna vendor spot check (a) / (b) / (c) worse case perform

**<WLAN SAR>**

Plot No.	Band	Mode	Test Position	Gap (mm)	Sample	Antenna	Antenna Battery	Vendor	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)	Reported 1g SAR (W/kg)
06	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample3	Ant 1	Battery 1	ACON	1	2412	14.97	15.00	1.007	95.41	1.048	0.06	0.338	0.357
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample3	Ant 1	Battery 1	ACON	7	2442	14.84	15.00	1.038	95.41	1.048	-0.11	0.281	0.306
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample3	Ant 1	Battery 1	ACON	11	2462	14.92	15.00	1.019	95.41	1.048	-0.09	0.277	0.296
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample3	Ant 1	Battery 1	ACON	12	2467	14.90	15.00	1.023	95.41	1.048	0.01	0.278	0.298
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample3	Ant 2	Battery 1	ACON	7	2442	14.88	15.00	1.028	95.41	1.048	-0.01	0.188	0.203
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	ACON	1	2412	14.97	15.00	1.007	95.41	1.048	0	0.229	0.242
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample3	Ant 1	Battery 2	ACON	1	2412	14.97	15.00	1.007	95.41	1.048	0.06	0.241	0.254
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample3	Ant 1	Battery 1	WNC	1	2412	14.97	15.00	1.007	95.41	1.048	0.04	0.141	0.149
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample3	Ant 2	Battery 1	WNC	7	2442	14.88	15.00	1.028	95.41	1.048	0.04	0.110	0.119
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample3	Ant 1	Battery 1	ACON	58	5290	13.17	13.50	1.079	94.31	1.060	0.12	0.677	0.774
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample3	Ant 2	Battery 1	ACON	58	5290	13.13	13.50	1.089	93.55	1.069	-0.05	0.496	0.577
07	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	ACON	58	5290	13.17	13.50	1.079	94.31	1.060	-0.13	0.882	1.009
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 2	ACON	58	5290	13.17	13.50	1.079	94.31	1.060	-0.04	0.845	0.966
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	WNC	58	5290	13.17	13.50	1.079	94.31	1.060	-0.1	0.357	0.408
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample3	Ant 2	Battery 1	WNC	58	5290	13.13	13.50	1.089	93.55	1.069	0.15	0.442	0.515
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample3	Ant 1	Battery 1	ACON	138	5690	13.90	14.00	1.023	94.31	1.060	0.01	1.030	1.117
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample3	Ant 1	Battery 1	ACON	106	5530	13.86	14.00	1.033	94.31	1.060	-0.06	0.953	1.043
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample3	Ant 1	Battery 1	ACON	122	5610	13.69	14.00	1.074	94.31	1.060	0.03	0.971	1.105
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample3	Ant 2	Battery 1	ACON	106	5530	13.86	14.00	1.033	93.55	1.069	-0.11	0.636	0.702
08	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	ACON	138	5690	13.90	14.00	1.023	94.31	1.060	-0.1	1.080	1.171
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 2	ACON	138	5690	13.90	14.00	1.023	94.31	1.060	0	1.070	1.161
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	WNC	138	5690	13.90	14.00	1.023	94.31	1.060	-0.04	1.070	1.161
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample3	Ant 2	Battery 1	WNC	106	5530	13.81	14.00	1.045	93.55	1.069	0.13	0.599	0.669
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample3	Ant 1	Battery 1	ACON	155	5775	13.40	13.50	1.023	94.31	1.060	-0.08	0.700	0.759
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample3	Ant 2	Battery 1	ACON	155	5775	13.30	13.50	1.047	93.55	1.069	-0.04	0.421	0.471
09	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	ACON	155	5775	13.40	13.50	1.023	94.31	1.060	-0.13	0.904	0.981
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 2	ACON	155	5775	13.40	13.50	1.023	94.31	1.060	0.05	0.861	0.934
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	WNC	155	5775	13.40	13.50	1.023	94.31	1.060	-0.08	0.760	0.824
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample3	Ant 2	Battery 1	WNC	155	5775	13.30	13.50	1.047	93.55	1.069	0.04	0.590	0.660

**<Bluetooth SAR>**

Plot No.	Band	Mode	Test Position	Gap (mm)	Sample	Battery	Antenna Vender	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Power Drift (dB)	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
	Bluetooth	1Mbps	Bottom of Laptop	0mm	Sample3	Battery 1	ACON	0	2402	8.73	8.73	1.000	0.11	0.002	0.002
10	Bluetooth	1Mbps	Bottom of Laptop	0mm	Sample3	Battery 1	ACON	39	2441	8.63	8.73	1.023	-0.1	0.003	0.003
	Bluetooth	1Mbps	Bottom of Laptop	0mm	Sample3	Battery 1	ACON	78	2402	7.98	8.73	1.189	0.14	0.001	0.001
	Bluetooth	1Mbps	Bottom of Laptop	0mm	Sample4	Battery 1	ACON	39	2441	8.63	8.73	1.023	0.06	0.002	0.002
	Bluetooth	1Mbps	Bottom of Laptop	0mm	Sample3	Battery 2	ACON	39	2441	8.63	8.73	1.023	-0.14	0.002	0.002
	Bluetooth	1Mbps	Bottom of Laptop	0mm	Sample3	Battery 1	WNC	39	2441	8.63	8.73	1.023	-0.11	0.002	0.002

**13.3 Repeated SAR Measurement**

No.	Band	Mode	Test Position	Gap (mm)	Sample	Antenna	Battery	Vender	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	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample1	Ant 1	Battery1	Eth	1	2412	14.97	15.00	1.007	95.41	1.048	0.14	0.945	-	0.997
2nd	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Sample1	Ant 1	Battery1	Eth	1	2412	14.97	15.00	1.007	95.41	1.048	0.11	0.921	1.03	0.972
1st	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	ACON	58	5290	13.17	13.50	1.079	94.31	1.060	-0.13	0.882	-	1.009
2nd	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	ACON	58	5290	13.17	13.50	1.079	94.31	1.060	-0.11	0.849	1.04	0.971
1st	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	ACON	138	5690	13.90	14.00	1.023	94.31	1.060	-0.1	1.080	-	1.171
2nd	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	ACON	138	5690	13.90	14.00	1.023	94.31	1.060	0.04	0.994	1.09	1.078
1st	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	ACON	155	5775	13.40	13.50	1.023	94.31	1.060	-0.13	0.904	-	0.981
2nd	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Sample4	Ant 1	Battery 1	ACON	155	5775	13.40	13.50	1.023	94.31	1.060	-0.02	0.873	1.04	0.947

**General Note:**

1. Per KDB 865664 D01v01r04, for each frequency band, repeated SAR measurement is required only when the measured SAR is  $\geq 0.8$ W/kg.
2. Per KDB 865664 D01v01r04, if the ratio among the repeated measurement is  $\leq 1.2$  and the measured SAR  $< 1.45$ W/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.

## 14. Simultaneous Transmission Analysis

NO.	Simultaneous Transmission Configurations	Body
1.	WLAN Antenna 1 + WLAN Antenna 2	Yes
2.	WLAN Antenna 1 + Bluetooth Antenna 2	Yes

**General Note:**

1. The worst case WLAN reported SAR for each configuration was used for SAR summation; therefore, the following summations represent the absolute worst cases for simultaneous transmission with WLAN.
2. WLAN RF exposure assessment of MIMO mode simultaneous transmission exclusion analysis was performed with SAR test results of each antenna in SISO mode. Therefore SPLSR calculation was choose worst case with SAR test results of each antenna in SISO mode perform evaluation.
3. WLAN and Bluetooth share the same antenna2, and cannot transmit simultaneously.
4. 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.
5. The Scaled SAR summation is calculated based on the same configuration and test position.
6. Per KDB 447498 D01v06, simultaneous transmission SAR is compliant if,
  - i) Scalar SAR summation < 1.6W/kg.
  - ii)  $SPLSR = (SAR1 + SAR2)^{1.5} / (\min. \text{ separation distance, mm})$ , and the peak separation distance is determined from the square root of  $[(x1-x2)^2 + (y1-y2)^2 + (z1-z2)^2]$ , where (x1, y1, z1) and (x2, y2, z2) are the coordinates of the extrapolated peak SAR locations in the zoom scan.
  - iii) If  $SPLSR \leq 0.04$ , simultaneously transmission SAR measurement is not necessary.
  - iv) Simultaneously transmission SAR measurement, and the reported multi-band SAR < 1.6W/kg.
  - v) The SPLSR calculated results please refer to section 14.2.

## 14.1 Body Exposure Conditions

### <WWAN + WLAN Host>

Exposure Position	1	2	3	4	5	1+2 Summed 1g SAR (W/kg)	3+4 Summed 1g SAR (W/kg)	1+5 Summed 1g SAR (W/kg)	3+5 Summed 1g SAR (W/kg)
	2.4GHz WLAN Ant 1	2.4GHz WLAN Ant 2	5GHz WLAN Ant 1	5GHz WLAN Ant 2	2.4GHz Bluetooth Ant 2				
	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)				
Bottom of Laptop at 0mm	0.997	0.152	0.787	0.531	0.001	1.15	1.32	1.00	0.79

### <Only WLAN Host>

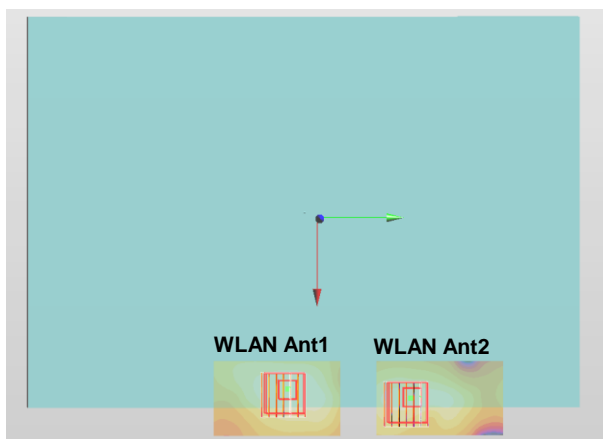
Exposure Position	1	2	3	4	5	1+2 Summed 1g SAR (W/kg)	3+4 Summed 1g SAR (W/kg)	1+5 Summed 1g SAR (W/kg)	3+5 Summed 1g SAR (W/kg)	SPLSR	Case No
	2.4GHz WLAN Ant 1	2.4GHz WLAN Ant 2	5GHz WLAN Ant 1	5GHz WLAN Ant 2	2.4GHz Bluetooth Ant 2						
	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)						
Bottom of Laptop at 0mm	0.357	0.203	1.171	0.702	0.003	0.56	1.87	0.36	1.17	0.040	Case 1

## 14.2 SPLSR Evaluation and Analysis

### General Note:

- SPLSR =  $(SAR_1 + SAR_2)^{1.5} / (min. \text{ separation distance, mm})$ . If  $SPLSR \leq 0.04$ , simultaneously transmission SAR measurement is not necessary

Case 1	Band	Position	SAR (W/kg)	Gap (cm)	SAR peak location (m)			3D distance (mm)	Summed SAR (W/kg)	SPLSR Results	Simultaneous SAR
					X	Y	Z				
	WLAN5GHz Ant 1	Bottom of Laptop	1.17	0	0.095	-0.009	-0.18	67.2	1.87	0.04	Not required
	WLAN5GHz Ant 2		0.702	0	0.1	0.058	-0.179				



**Test Engineer :** Bevis Chang Tom Jiang Steven Chang Kurt Liu Steven Chang and Thomas Wang

## 15. 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 15.1. 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	Divisor	(Ci) 1g	(Ci) 10g	Standard Uncertainty (1g) (±%)	Standard Uncertainty (10g) (±%)
<b>Measurement System</b>							
Probe Calibration	6.0	N	1	1	1	6.0	6.0
Axial Isotropy	4.7	R	1.732	0.7	0.7	1.9	1.9
Hemispherical Isotropy	9.6	R	1.732	0.7	0.7	3.9	3.9
Boundary Effects	1.0	R	1.732	1	1	0.6	0.6
Linearity	4.7	R	1.732	1	1	2.7	2.7
System Detection Limits	1.0	R	1.732	1	1	0.6	0.6
Modulation Response	3.2	R	1.732	1	1	1.8	1.8
Readout Electronics	0.3	N	1	1	1	0.3	0.3
Response Time	0.0	R	1.732	1	1	0.0	0.0
Integration Time	2.6	R	1.732	1	1	1.5	1.5
RF Ambient Noise	3.0	R	1.732	1	1	1.7	1.7
RF Ambient Reflections	3.0	R	1.732	1	1	1.7	1.7
Probe Positioner	0.4	R	1.732	1	1	0.2	0.2
Probe Positioning	2.9	R	1.732	1	1	1.7	1.7
Max. SAR Eval.	2.0	R	1.732	1	1	1.2	1.2
<b>Test Sample Related</b>							
Device Positioning	3.0	N	1	1	1	3.0	3.0
Device Holder	3.6	N	1	1	1	3.6	3.6
Power Drift	5.0	R	1.732	1	1	2.9	2.9
Power Scaling	0.0	R	1.732	1	1	0.0	0.0
<b>Phantom and Setup</b>							
Phantom Uncertainty	6.1	R	1.732	1	1	3.5	3.5
SAR correction	0.0	R	1.732	1	0.84	0.0	0.0
Liquid Conductivity Repeatability	0.2	N	1	0.78	0.71	0.1	0.1
Liquid Conductivity (target)	5.0	R	1.732	0.78	0.71	2.3	2.0
Liquid Conductivity (mea.)	2.5	R	1.732	0.78	0.71	1.1	1.0
Temp. unc. - Conductivity	3.4	R	1.732	0.78	0.71	1.5	1.4
Liquid Permittivity Repeatability	0.15	N	1	0.23	0.26	0.0	0.0
Liquid Permittivity (target)	5.0	R	1.732	0.23	0.26	0.7	0.8
Liquid Permittivity (mea.)	2.5	R	1.732	0.23	0.26	0.3	0.4
Temp. unc. - Permittivity	0.83	R	1.732	0.23	0.26	0.1	0.1
<b>Combined Std. Uncertainty</b>						11.4%	11.4%
<b>Coverage Factor for 95 %</b>						K=2	K=2
<b>Expanded STD Uncertainty</b>						22.9%	22.7%

**Table 15.2. Uncertainty Budget for frequency range 300 MHz to 3 GHz**

Error Description	Uncertainty Value (±%)	Probability	Divisor	(Ci) 1g	(Ci) 10g	Standard Uncertainty (1g) (±%)	Standard Uncertainty (10g) (±%)
<b>Measurement System</b>							
Probe Calibration	6.55	N	1	1	1	6.6	6.6
Axial Isotropy	4.7	R	1.732	0.7	0.7	1.9	1.9
Hemispherical Isotropy	9.6	R	1.732	0.7	0.7	3.9	3.9
Boundary Effects	2.0	R	1.732	1	1	1.2	1.2
Linearity	4.7	R	1.732	1	1	2.7	2.7
System Detection Limits	1.0	R	1.732	1	1	0.6	0.6
Modulation Response	3.2	R	1.732	1	1	1.8	1.8
Readout Electronics	0.3	N	1	1	1	0.3	0.3
Response Time	0.0	R	1.732	1	1	0.0	0.0
Integration Time	2.6	R	1.732	1	1	1.5	1.5
RF Ambient Noise	3.0	R	1.732	1	1	1.7	1.7
RF Ambient Reflections	3.0	R	1.732	1	1	1.7	1.7
Probe Positioner	0.4	R	1.732	1	1	0.2	0.2
Probe Positioning	6.7	R	1.732	1	1	3.9	3.9
Max. SAR Eval.	4.0	R	1.732	1	1	2.3	2.3
<b>Test Sample Related</b>							
Device Positioning	3.0	N	1	1	1	3.0	3.0
Device Holder	3.6	N	1	1	1	3.6	3.6
Power Drift	5.0	R	1.732	1	1	2.9	2.9
Power Scaling	0.0	R	1.732	1	1	0.0	0.0
<b>Phantom and Setup</b>							
Phantom Uncertainty	6.6	R	1.732	1	1	3.8	3.8
SAR correction	0.0	R	1.732	1	0.84	0.0	0.0
Liquid Conductivity Repeatability	0.2	N	1	0.78	0.71	0.1	0.1
Liquid Conductivity (target)	5.0	R	1.732	0.78	0.71	2.3	2.0
Liquid Conductivity (mea.)	2.5	R	1.732	0.78	0.71	1.1	1.0
Temp. unc. - Conductivity	3.4	R	1.732	0.78	0.71	1.5	1.4
Liquid Permittivity Repeatability	0.15	N	1	0.23	0.26	0.0	0.0
Liquid Permittivity (target)	5.0	R	1.732	0.23	0.26	0.7	0.8
Liquid Permittivity (mea.)	2.5	R	1.732	0.23	0.26	0.3	0.4
Temp. unc. - Permittivity	0.83	R	1.732	0.23	0.26	0.1	0.1
<b>Combined Std. Uncertainty</b>						12.5%	12.5%
<b>Coverage Factor for 95 %</b>						K=2	K=2
<b>Expanded STD Uncertainty</b>						25.0%	24.9%

**Table 15.3. Uncertainty Budget for frequency range 3 GHz to 6 GHz**

## **16. 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. 1528-2013, “IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques”, Sep 2013
- [4] SPEAG DASY System Handbook
- [5] FCC KDB 248227 D01 v02r02, “SAR Guidance for IEEE 802.11 (WiFi) Transmitters”, Oct 2015.
- [6] FCC KDB 447498 D01 v06, “Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies”, Oct 2015
- [7] FCC KDB 616217 D04 v01r02, “SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers”, Oct 2015
- [8] FCC KDB 865664 D01 v01r04, “SAR Measurement Requirements for 100 MHz to 6 GHz”, Aug 2015.
- [9] FCC KDB 865664 D02 v01r02, “RF Exposure Compliance Reporting and Documentation Considerations” Oct 2015.





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

The plots are shown as follows.

## System Check\_Body\_2450MHz\_151209

### DUT: D2450V2-736

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

Medium: MSL\_2450\_151209 Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.998$  S/m;  $\epsilon_r = 53.455$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.3 °C; Liquid Temperature : 22.3 °C

#### DASY5 Configuration:

- Probe: ES3DV3 - SN3270; ConvF(4.37, 4.37, 4.37); Calibrated: 2015/9/28;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn778; Calibrated: 2015/8/25
- Phantom: ELI v4.0\_Front; Type: QDOVA001BB; Serial: TP:1029
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=250mW/Area Scan (71x71x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 21.6 W/kg

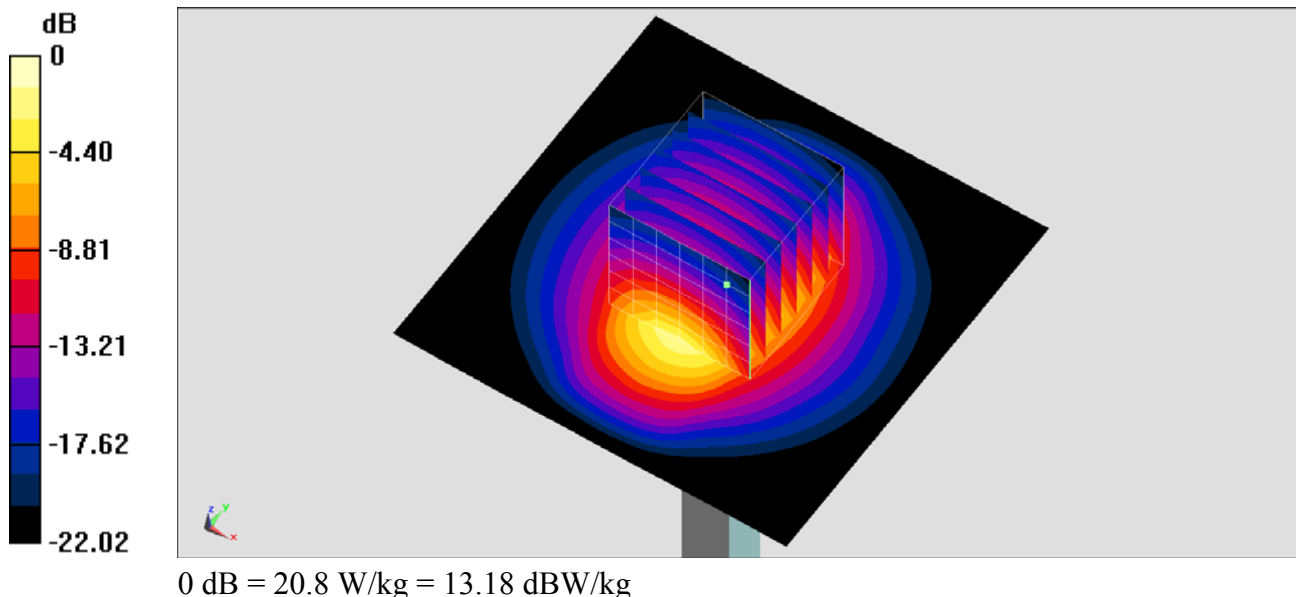
**Configuration/Pin=250mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 111.3 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 28.5 W/kg

**SAR(1 g) = 13.8 W/kg; SAR(10 g) = 6.34 W/kg**

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



## System Check\_Body\_2450MHz\_151210

### DUT: D2450V2-736

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

Medium: MSL\_2450\_151210 Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.001$  S/m;  $\epsilon_r = 53.437$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.2 °C; Liquid Temperature : 22.2 °C

### DASY5 Configuration

- Probe: EX3DV4 - SN3931; ConvF(7.54, 7.54, 7.54); Calibrated: 2015/10/1;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 2015/9/24
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=250mW/Area Scan (71x71x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

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

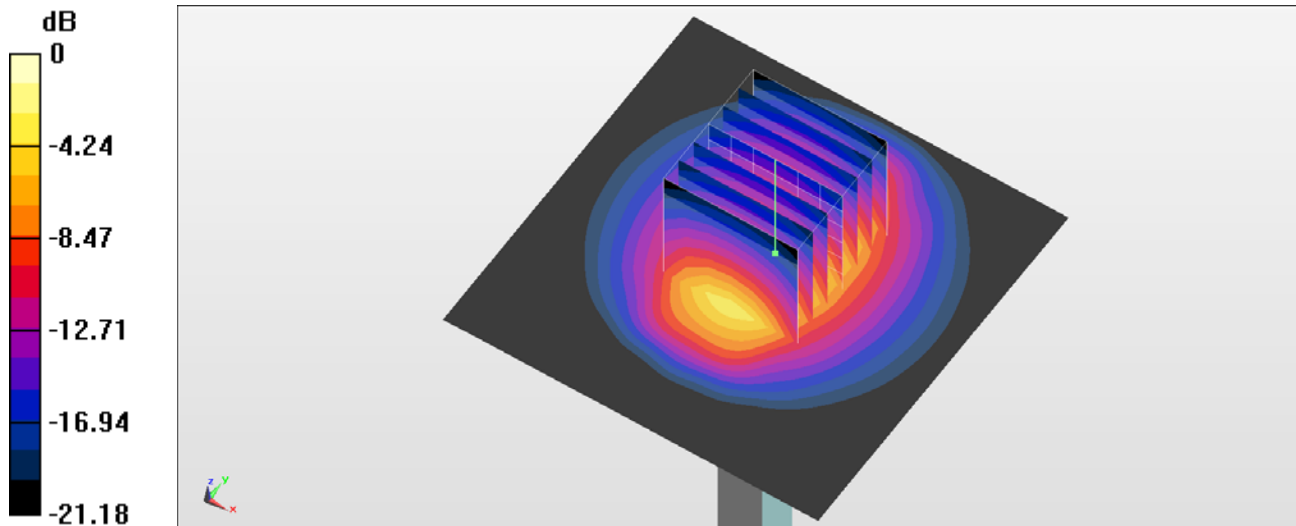
**Configuration/Pin=250mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 100.7 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 25.0 W/kg

**SAR(1 g) = 12.3 W/kg; SAR(10 g) = 5.73 W/kg**

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



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

**System Check\_Body\_2450MHz\_151210****DUT: D2450V2-736**

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

Medium: MSL\_2450\_151210 Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.001$  S/m;  $\epsilon_r = 53.437$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.7 °C; Liquid Temperature : 22.7 °C

**DASY5 Configuration**

- Probe: EX3DV4 - SN3925; ConvF(7.54, 7.54, 7.54); Calibrated: 2015/5/27;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn495; Calibrated: 2015/5/22
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=250mW/Area Scan (61x61x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

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

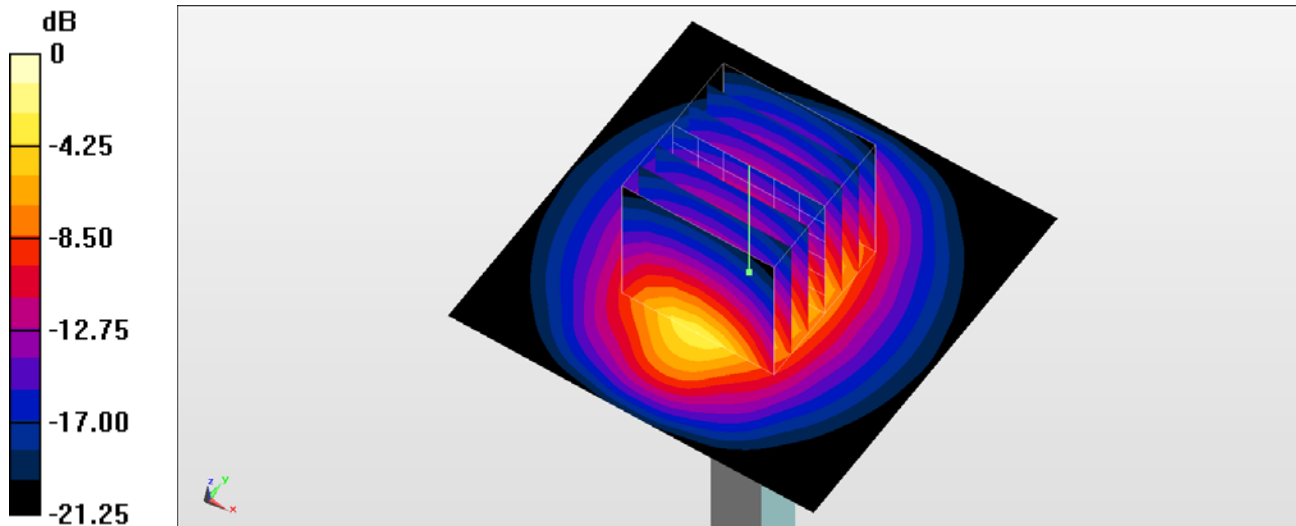
**Configuration/Pin=250mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 103.3 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 25.5 W/kg

**SAR(1 g) = 12.5 W/kg; SAR(10 g) = 5.83 W/kg**

Maximum value of SAR (measured) = 20.7 W/kg



0 dB = 20.7 W/kg = 13.16 dBW/kg

**System Check\_Body\_2450MHz\_160107****DUT: D2450V2-736**

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

Medium: MSL\_2450\_160107 Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.972$  S/m;  $\epsilon_r = 52.986$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.5 °C; Liquid Temperature : 22.5 °C

**DASY5 Configuration**

- Probe: ES3DV3 - SN3270; ConvF(4.37, 4.37, 4.37); Calibrated: 2015/9/28;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn778; Calibrated: 2015/8/25
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=250mW/Area Scan (71x71x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 21.3 W/kg

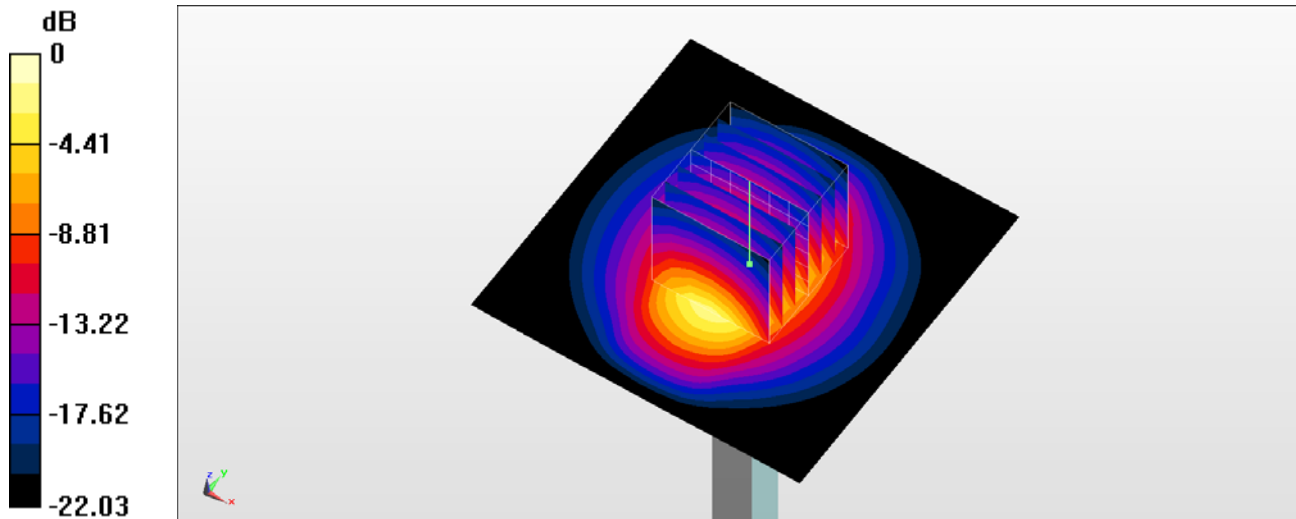
**Configuration/Pin=250mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 111.3 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 28.1 W/kg

**SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.26 W/kg**

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



0 dB = 20.6 W/kg = 13.14 dBW/kg

**System Check\_Body\_5250MHz\_151209****DUT: D5GHzV2-1128**

Communication System: CW; Frequency: 5250 MHz; Duty Cycle: 1:1

Medium: MSL\_5G\_151209 Medium parameters used:  $f = 5250$  MHz;  $\sigma = 5.543$  S/m;  $\epsilon_r = 46.845$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.2 °C; Liquid Temperature : 22.2 °C

**DASY5 Configuration**

- Probe: EX3DV4 - SN3931; ConvF(4.48, 4.48, 4.48); Calibrated: 2015/10/1;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 2015/9/24
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=100mW/Area Scan (71x71x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

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

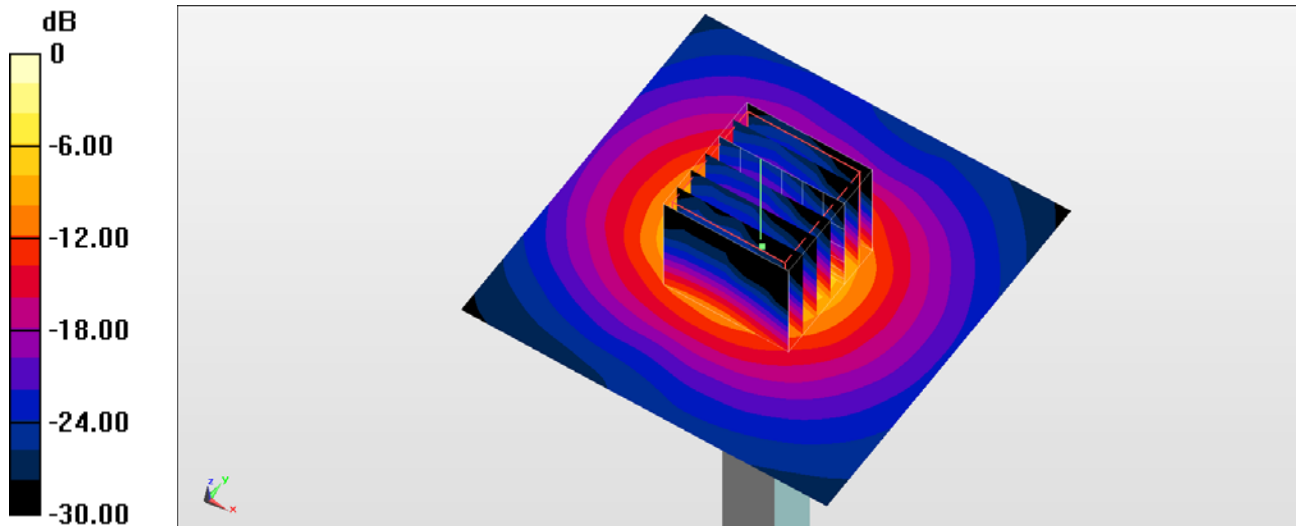
**Configuration/Pin=100mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 65.41 V/m; Power Drift = 0.18 dB

Peak SAR (extrapolated) = 32.5 W/kg

**SAR(1 g) = 8 W/kg; SAR(10 g) = 2.21 W/kg**

Maximum value of SAR (measured) = 19.8 W/kg



0 dB = 19.8 W/kg = 12.97 dBW/kg

**System Check\_Body\_5250MHz\_151209****DUT: D5GHzV2-1128**

Communication System: CW; Frequency: 5250 MHz; Duty Cycle: 1:1

Medium: MSL\_5G\_151209 Medium parameters used:  $f = 5250$  MHz;  $\sigma = 5.543$  S/m;  $\epsilon_r = 46.845$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.5 °C; Liquid Temperature : 22.5 °C

**DASY5 Configuration:**

- Probe: EX3DV4 - SN3955; ConvF(4.42, 4.42, 4.42); Calibrated: 2015/11/24;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1399; Calibrated: 2015/11/23
- Phantom: ELI v4.0\_Front; Type: QDOVA001BB; Serial: TP:1029
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=100mW/Area Scan (71x71x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

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

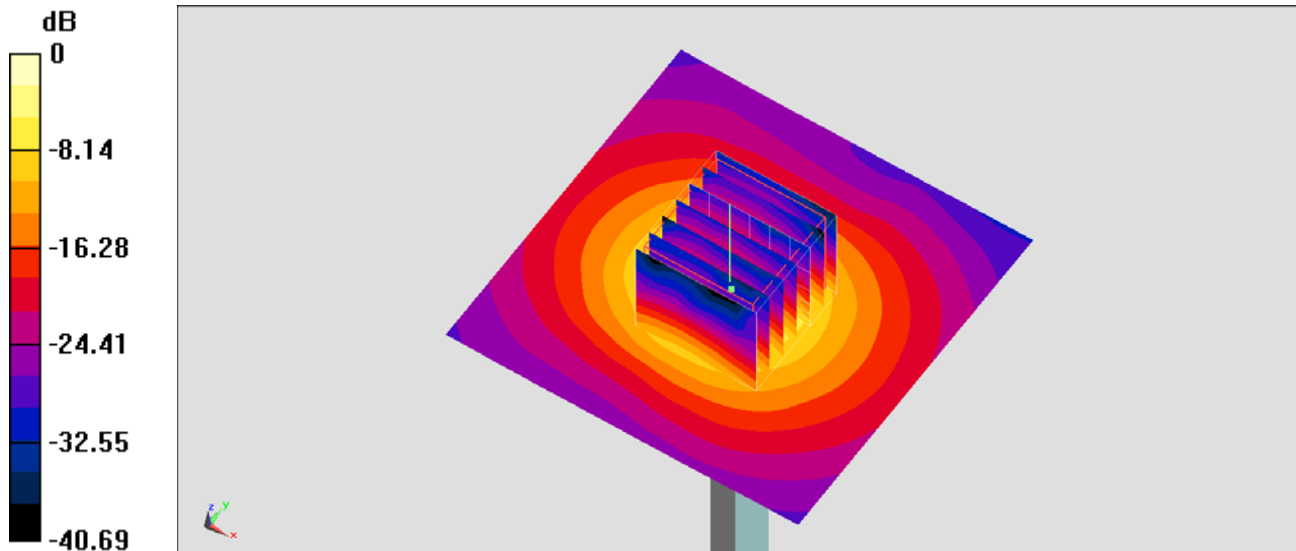
**Configuration/Pin=100mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 64.54 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 28.2 W/kg

**SAR(1 g) = 7.22 W/kg; SAR(10 g) = 2 W/kg**

Maximum value of SAR (measured) = 17.6 W/kg



0 dB = 17.6 W/kg = 12.46 dBW/kg

## System Check\_Body\_5300MHz\_151211

### DUT: D5GHzV2-1006

Communication System: CW ; Frequency: 5300 MHz;Duty Cycle: 1:1

Medium: MSL\_5G\_151211 Medium parameters used:  $f = 5300$  MHz;  $\sigma = 5.575$  S/m;  $\epsilon_r = 47.163$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.7 °C; Liquid Temperature : 22.7 °C

### DASY5 Configuration

- Probe: EX3DV4 - SN3925; ConvF(4.43, 4.43, 4.43); Calibrated: 2015/5/27;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn495; Calibrated: 2015/5/22
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=100mW/Area Scan (71x71x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 18.5 W/kg

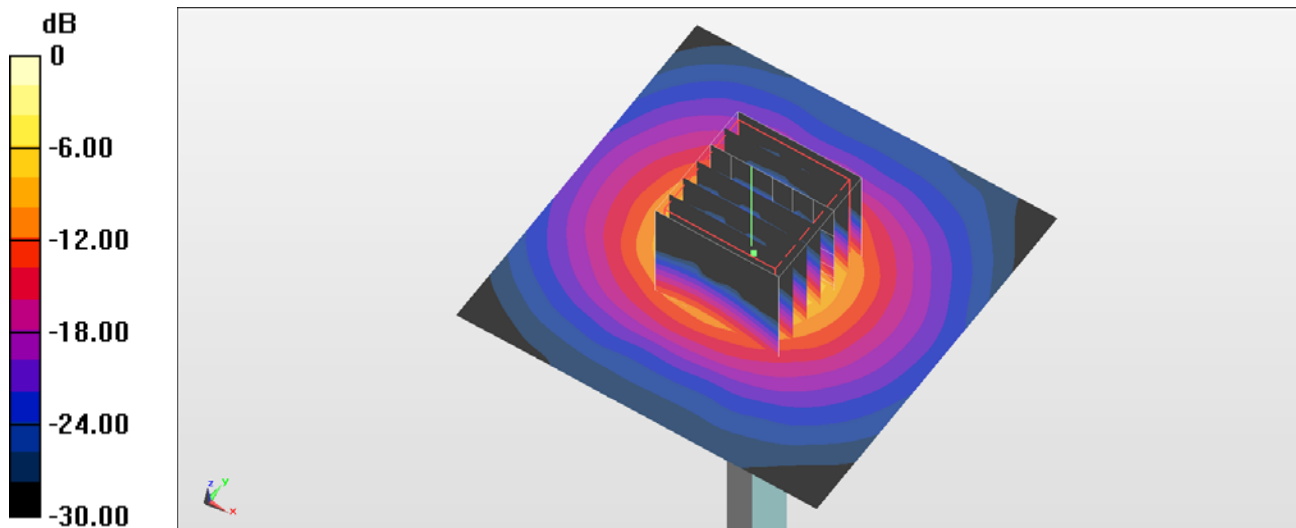
**Configuration/Pin=100mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 64.46 V/m; Power Drift = 0.12 dB

Peak SAR (extrapolated) = 34.3 W/kg

**SAR(1 g) = 7.59 W/kg; SAR(10 g) = 2.03 W/kg**

Maximum value of SAR (measured) = 18.9 W/kg



0 dB = 18.9 W/kg = 12.76 dBW/kg



**System Check\_Body\_5600MHz\_151209****DUT: D5GHzV2-1128**

Communication System: CW; Frequency: 5600 MHz; Duty Cycle: 1:1

Medium: MSL\_5G\_151209 Medium parameters used:  $f = 5600$  MHz;  $\sigma = 6.003$  S/m;  $\epsilon_r = 46.253$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.2 °C; Liquid Temperature : 22.2 °C

**DASY5 Configuration**

- Probe: EX3DV4 - SN3931; ConvF(3.84, 3.84, 3.84); Calibrated: 2015/10/1;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 2015/9/24
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=100mW/Area Scan (71x71x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 23.7 W/kg

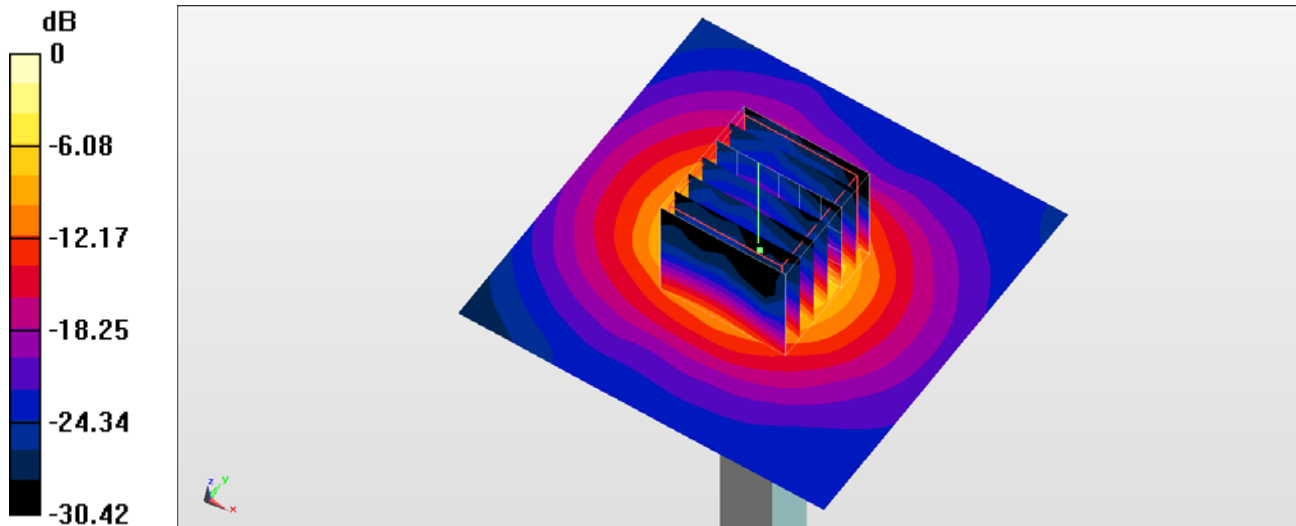
**Configuration/Pin=100mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 71.92 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 36.5 W/kg

**SAR(1 g) = 8.39 W/kg; SAR(10 g) = 2.28 W/kg**

Maximum value of SAR (measured) = 21.3 W/kg



0 dB = 21.3 W/kg = 13.28 dBW/kg

**System Check\_Body\_5600MHz\_151209****DUT: D5GHzV2-1128**

Communication System: CW; Frequency: 5600 MHz; Duty Cycle: 1:1

Medium: MSL\_5G\_151209 Medium parameters used:  $f = 5600$  MHz;  $\sigma = 6.003$  S/m;  $\epsilon_r = 46.253$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.5 °C; Liquid Temperature : 22.5 °C

**DASY5 Configuration:**

- Probe: EX3DV4 - SN3955; ConvF(3.81, 3.81, 3.81); Calibrated: 2015/11/24;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1399; Calibrated: 2015/11/23
- Phantom: ELI v4.0\_Front; Type: QDOVA001BB; Serial: TP:1029
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=100mW/Area Scan (71x71x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 20.5 W/kg

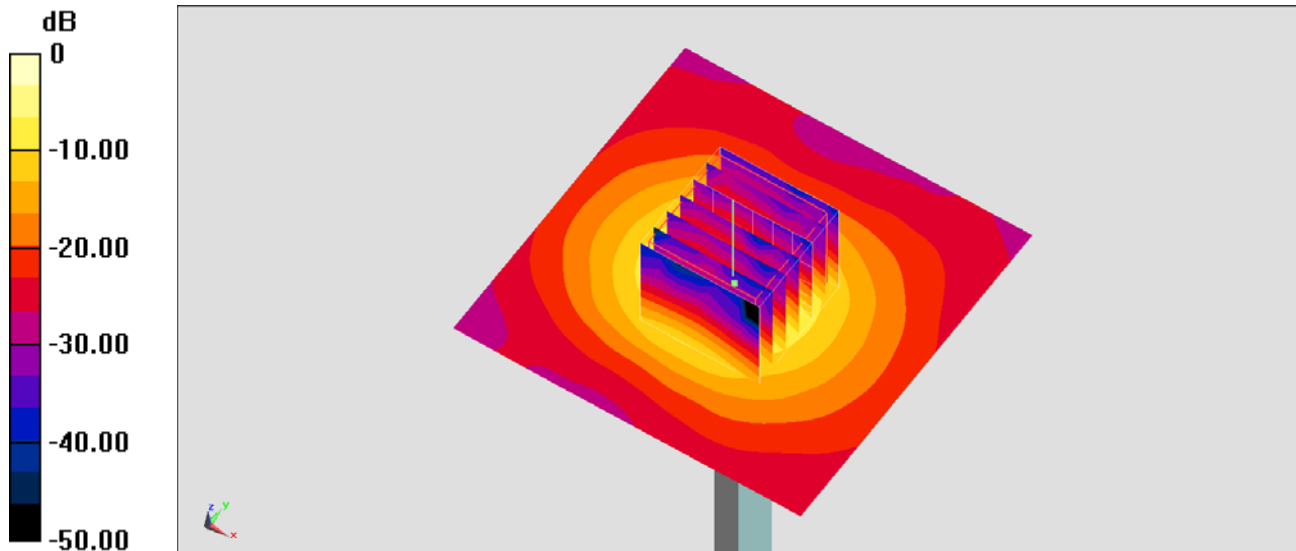
**Configuration/Pin=100mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 68.25 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 33.1 W/kg

**SAR(1 g) = 7.86 W/kg; SAR(10 g) = 2.14 W/kg**

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



0 dB = 20.0 W/kg = 13.01 dBW/kg

**System Check\_Body\_5600MHz\_151211****DUT: D5GHzV2-1006**

Communication System: CW ; Frequency: 5600 MHz; Duty Cycle: 1:1

Medium: MSL\_5G\_151211 Medium parameters used:  $f = 5600$  MHz;  $\sigma = 5.899$  S/m;  $\epsilon_r = 47.089$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.7 °C ; Liquid Temperature : 22.7 °C

**DASY5 Configuration**

- Probe: EX3DV4 - SN3925; ConvF(4.1, 4.1, 4.1); Calibrated: 2015/5/27;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn495; Calibrated: 2015/5/22
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=100mW/Area Scan (71x71x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 22.0 W/kg

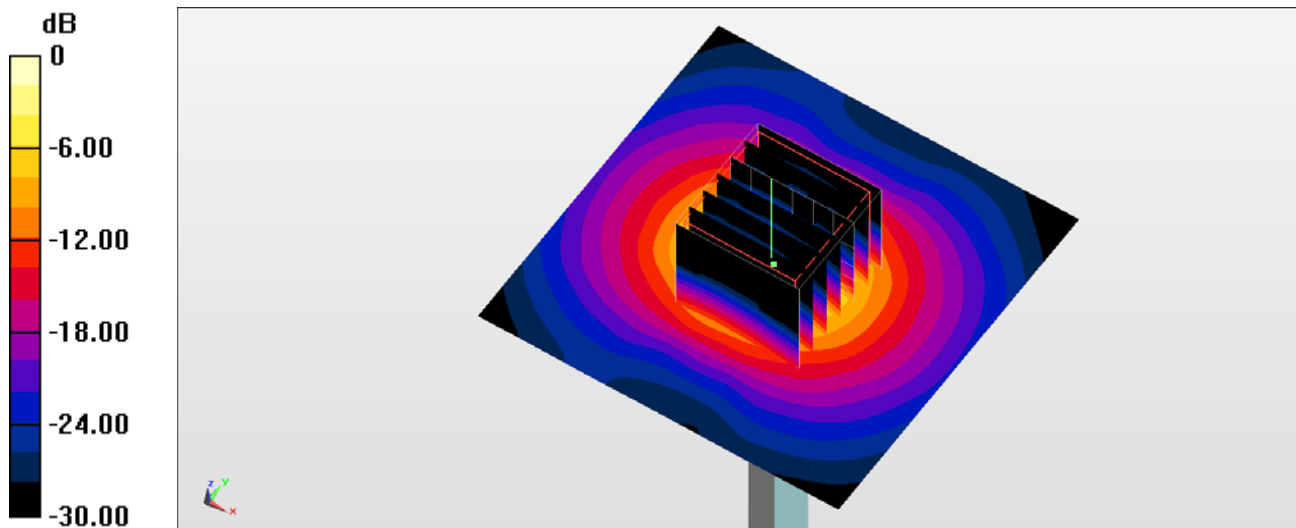
**Configuration/Pin=100mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 70.18 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 40.8 W/kg

**SAR(1 g) = 8.67 W/kg; SAR(10 g) = 2.33 W/kg**

Maximum value of SAR (measured) = 22.5 W/kg



0 dB = 22.5 W/kg = 13.52 dBW/kg

**System Check\_Body\_5750MHz\_151209****DUT: D5GHzV2-1128**

Communication System: CW; Frequency: 5750 MHz; Duty Cycle: 1:1

Medium: MSL\_5G\_151209 Medium parameters used:  $f = 5750$  MHz;  $\sigma = 6.208$  S/m;  $\epsilon_r = 46.019$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.2 °C; Liquid Temperature : 22.2 °C

**DASY5 Configuration**

- Probe: EX3DV4 - SN3931; ConvF(3.98, 3.98, 3.98); Calibrated: 2015/10/1;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 2015/9/24
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=100mW/Area Scan (71x71x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

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

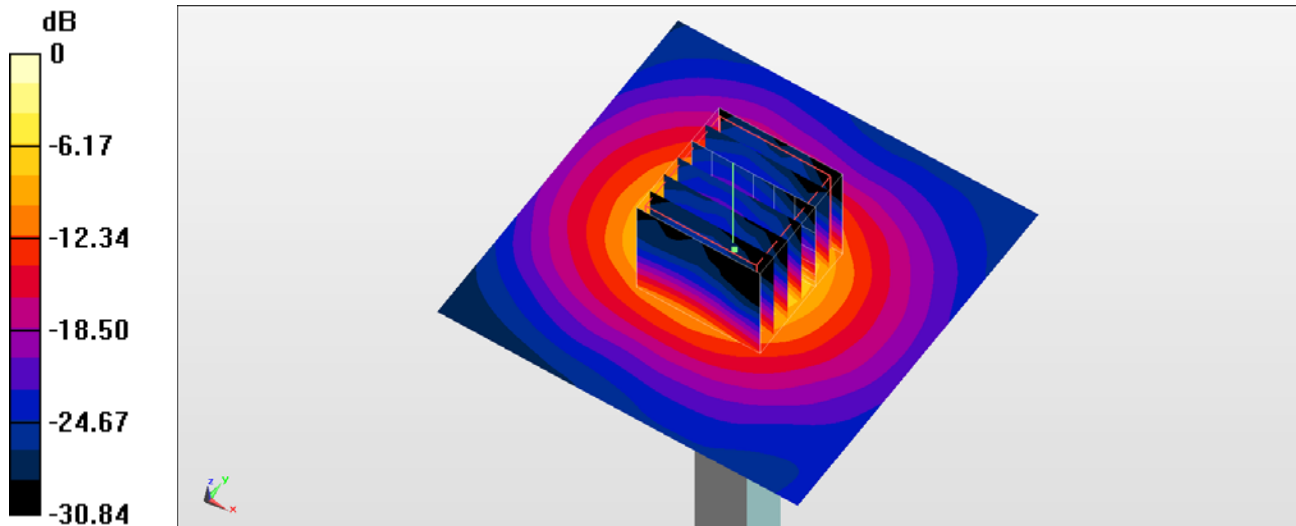
**Configuration/Pin=100mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 63.15 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 34.6 W/kg

**SAR(1 g) = 7.61 W/kg; SAR(10 g) = 2.09 W/kg**

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



0 dB = 19.5 W/kg = 12.90 dBW/kg

**System Check\_Body\_5750MHz\_151209****DUT: D5GHzV2-1128**

Communication System: CW; Frequency: 5750 MHz; Duty Cycle: 1:1

Medium: MSL\_5G\_151209 Medium parameters used:  $f = 5750$  MHz;  $\sigma = 6.208$  S/m;  $\epsilon_r = 46.019$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.5 °C; Liquid Temperature : 22.5 °C

**DASY5 Configuration:**

- Probe: EX3DV4 - SN3955; ConvF(3.92, 3.92, 3.92); Calibrated: 2015/11/24;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1399; Calibrated: 2015/11/23
- Phantom: ELI v4.0\_Front; Type: QDOVA001BB; Serial: TP:1029
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=100mW/Area Scan (71x71x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 17.6 W/kg

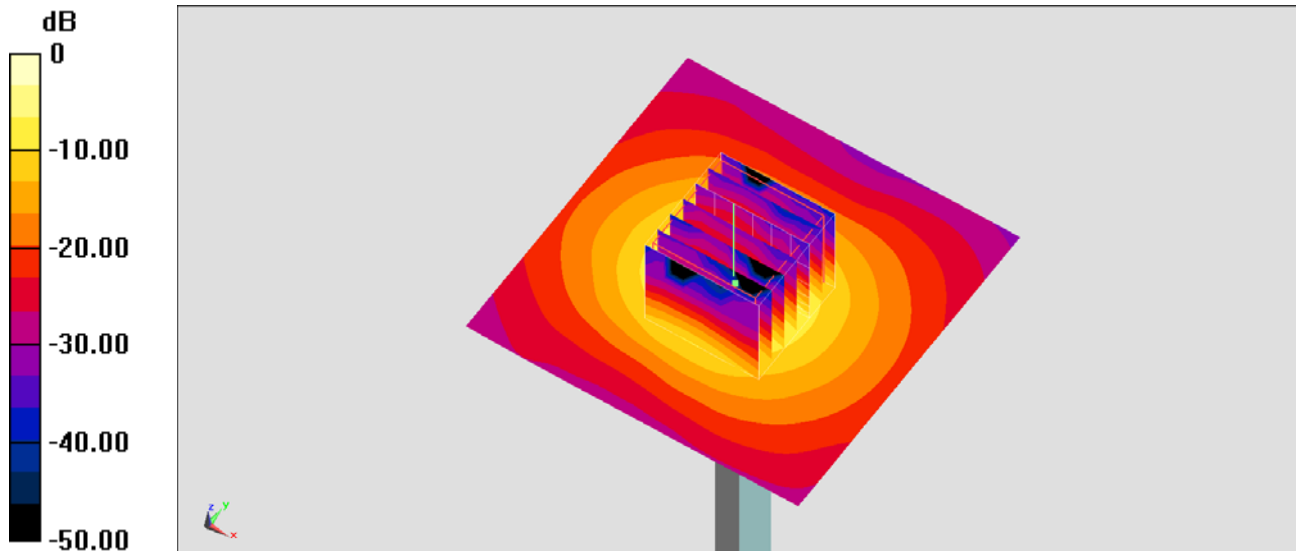
**Configuration/Pin=100mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 61.98 V/m; Power Drift = 0.15 dB

Peak SAR (extrapolated) = 30.6 W/kg

**SAR(1 g) = 7.28 W/kg; SAR(10 g) = 2.01 W/kg**

Maximum value of SAR (measured) = 18.6 W/kg



0 dB = 18.6 W/kg = 12.70 dBW/kg

## System Check\_Body\_5800MHz\_151211

### DUT: D5GHzV2-1006

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

Medium: MSL\_5G\_151211 Medium parameters used:  $f = 5800$  MHz;  $\sigma = 6.26$  S/m;  $\epsilon_r = 46.928$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.7 °C; Liquid Temperature : 22.7 °C

### DASY5 Configuration

- Probe: EX3DV4 - SN3925; ConvF(4.16, 4.16, 4.16); Calibrated: 2015/5/27;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn495; Calibrated: 2015/5/22
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Pin=100mW/Area Scan (71x71x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 21.8 W/kg

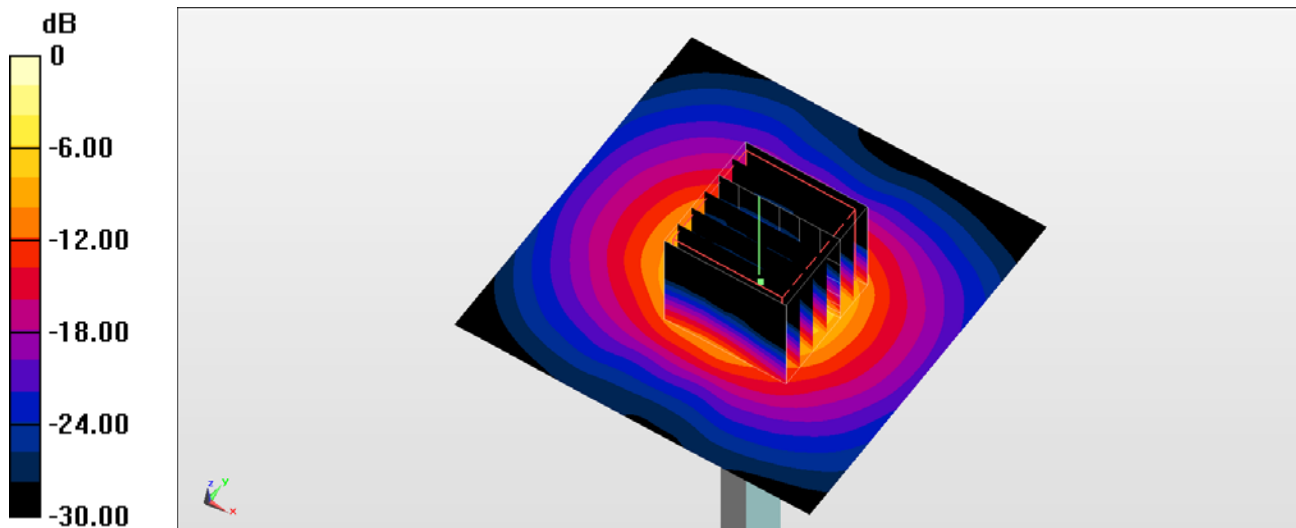
**Configuration/Pin=100mW/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 68.40 V/m; Power Drift = -0.14 dB

Peak SAR (extrapolated) = 40.9 W/kg

**SAR(1 g) = 8.31 W/kg; SAR(10 g) = 2.21 W/kg**

Maximum value of SAR (measured) = 21.7 W/kg



0 dB = 21.7 W/kg = 13.36 dBW/kg



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

The plots are shown as follows.

**#01\_WLAN2.4GHz\_802.11b 1Mbps\_Bottom of Laptop\_0mm\_Ch1;Ant 1**

Communication System: 802.11b ; Frequency: 2412 MHz;Duty Cycle: 1:1.048

Medium: MSL\_2450\_151209 Medium parameters used:  $f = 2412$  MHz;  $\sigma = 1.946$  S/m;  $\epsilon_r = 53.599$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.3 °C ; Liquid Temperature : 22.3 °C

**DASY5 Configuration:**

- Probe: ES3DV3 - SN3270; ConvF(4.37, 4.37, 4.37); Calibrated: 2015/9/28;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn778; Calibrated: 2015/8/25
- Phantom: ELI v4.0\_Front; Type: QDOVA001BB; Serial: TP:1029
- Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

**Configuration/Ch1/Area Scan (71x31x1):** Interpolated grid:  $dx=1.200$  mm,  $dy=1.200$  mm

Maximum value of SAR (interpolated) = 1.33 W/kg

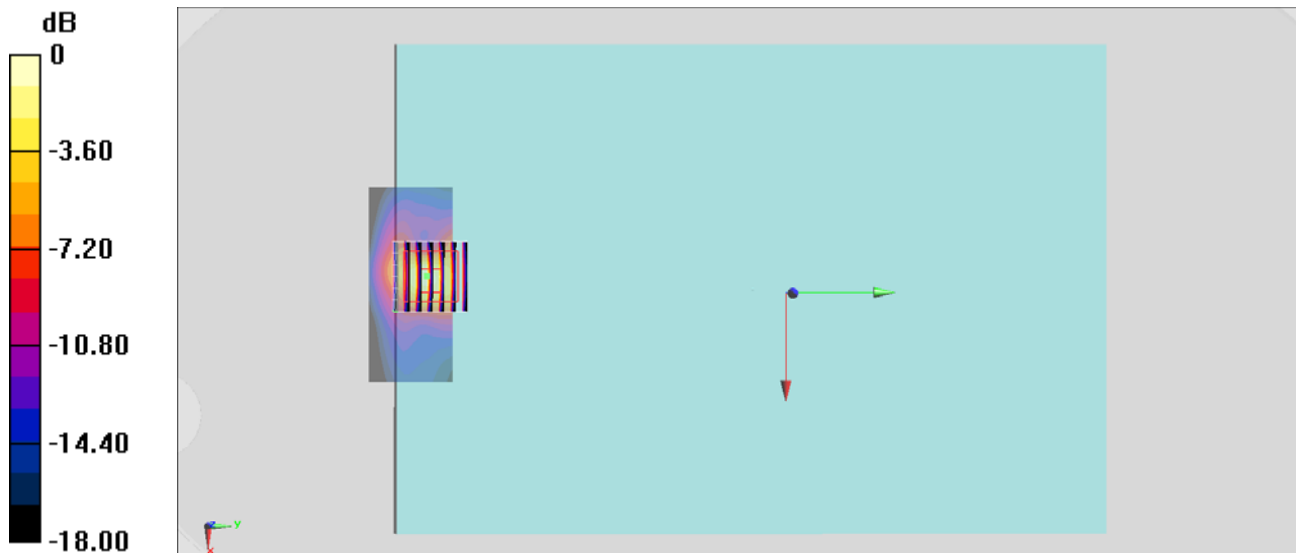
**Configuration/Ch1/Zoom Scan (7x7x7)/Cube 0:** Measurement grid:  $dx=5$ mm,  $dy=5$ mm,  $dz=5$ mm

Reference Value = 12.49 V/m; Power Drift = 0.14 dB

Peak SAR (extrapolated) = 2.31 W/kg

**SAR(1 g) = 0.945 W/kg; SAR(10 g) = 0.381 W/kg**

Maximum value of SAR (measured) = 1.44 W/kg





**#02\_WLAN5GHz\_802.11ac-VHT80 MCS0\_Bottom of Laptop\_0mm\_Ch58;Ant 1**

Communication System: 802.11ac ; Frequency: 5290 MHz;Duty Cycle: 1:1.06

Medium: MSL\_5G\_151209 Medium parameters used:  $f = 5290$  MHz;  $\sigma = 5.599$  S/m;  $\epsilon_r = 46.772$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.5 °C; Liquid Temperature : 22.5 °C

**DASY5 Configuration:**

- Probe: EX3DV4 - SN3955; ConvF(4.42, 4.42, 4.42); Calibrated: 2015/11/24;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1399; Calibrated: 2015/11/23
- Phantom: ELI v4.0\_Front; Type: QDOVA001BB; Serial: TP:1029
- Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

**Configuration/Ch58/Area Scan (81x41x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 0.744 W/kg

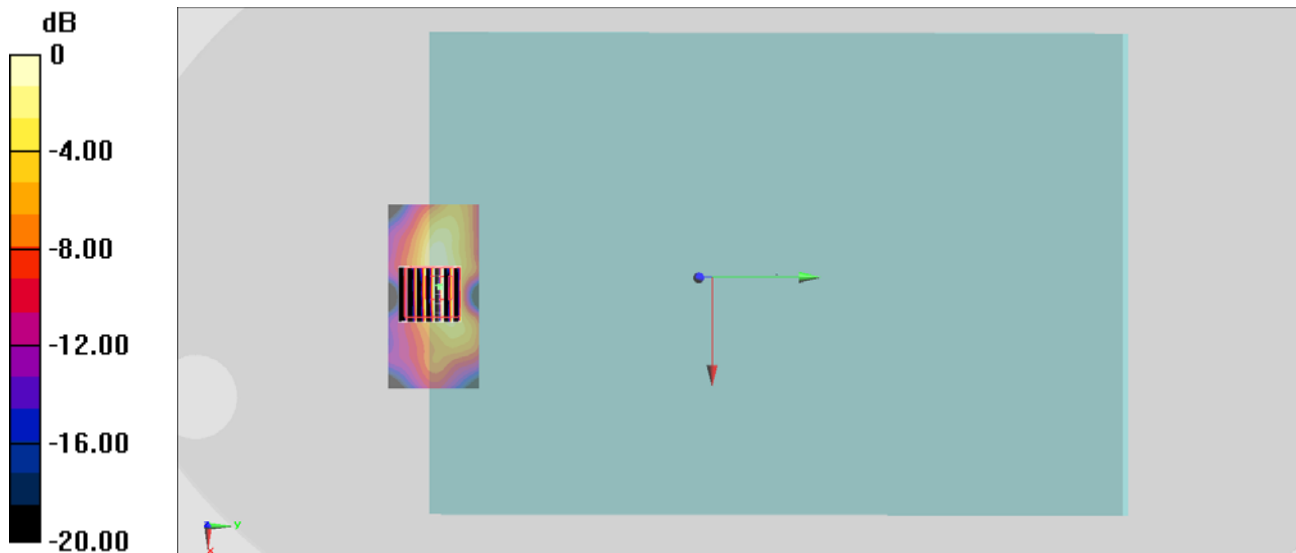
**Configuration/Ch58/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 12.66 V/m; Power Drift = 0.08 dB

Peak SAR (extrapolated) = 1.07 W/kg

**SAR(1 g) = 0.301 W/kg; SAR(10 g) = 0.090 W/kg**

Maximum value of SAR (measured) = 0.706 W/kg



0 dB = 0.706 W/kg = -1.51 dBW/kg

**#03\_WLAN5GHz\_802.11ac-VHT80 MCS0\_Bottom of Laptop\_0mm\_Ch138;Ant 1**

Communication System: 802.11ac; Frequency: 5690 MHz; Duty Cycle: 1:1.06

Medium: MSL\_5G\_151209 Medium parameters used:  $f = 5690$  MHz;  $\sigma = 6.123$  S/m;  $\epsilon_r = 46.101$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.5 °C ; Liquid Temperature : 22.5 °C

**DASY5 Configuration:**

- Probe: EX3DV4 - SN3955; ConvF(3.81, 3.81, 3.81); Calibrated: 2015/11/24;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1399; Calibrated: 2015/11/23
- Phantom: ELI v4.0\_Front; Type: QDOVA001BB; Serial: TP:1029
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Ch138/Area Scan (81x41x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm  
Maximum value of SAR (interpolated) = 1.73 W/kg

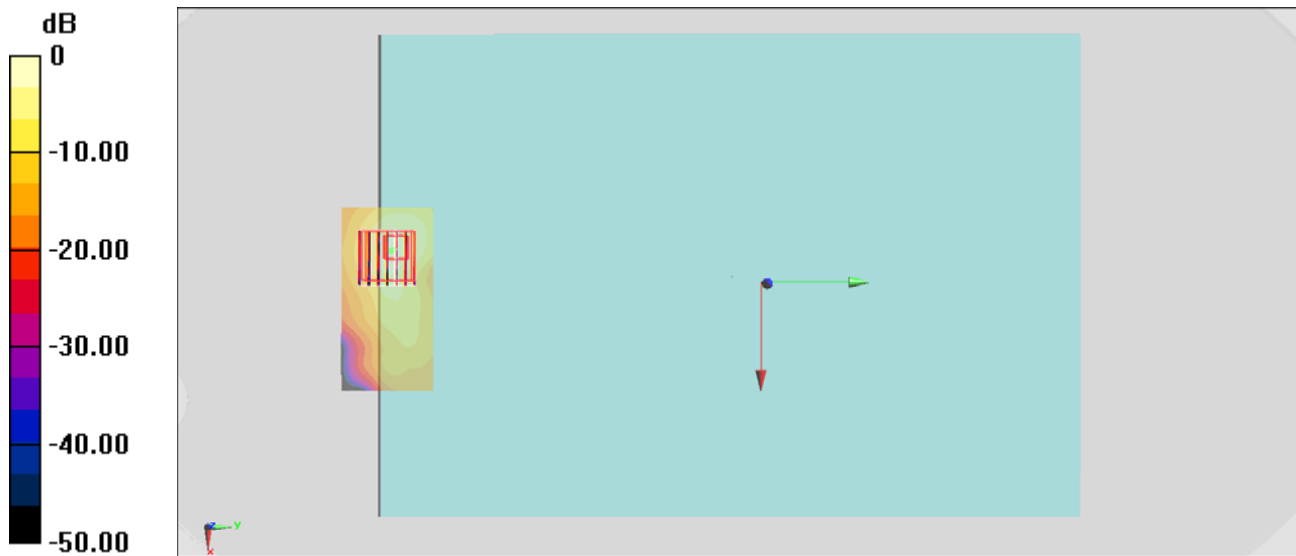
**Configuration/Ch138/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 15.16 V/m; Power Drift = 0.10 dB

Peak SAR (extrapolated) = 3.13 W/kg

**SAR(1 g) = 0.726 W/kg; SAR(10 g) = 0.201 W/kg**

Maximum value of SAR (measured) = 1.82 W/kg



0 dB = 1.82 W/kg = 2.60 dBW/kg

**#04\_WLAN5GHz\_802.11ac-VHT80 MCS0\_Bottom of Laptop\_0mm\_Ch155;Ant 2**

Communication System: 802.11ac; Frequency: 5775 MHz; Duty Cycle: 1:1.069

Medium: MSL\_5G\_151209 Medium parameters used:  $f = 5775$  MHz;  $\sigma = 6.24$  S/m;  $\epsilon_r = 45.983$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.5 °C; Liquid Temperature : 22.5 °C

**DASY5 Configuration:**

- Probe: EX3DV4 - SN3955; ConvF(3.92, 3.92, 3.92); Calibrated: 2015/11/24;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1399; Calibrated: 2015/11/23
- Phantom: ELI v4.0\_Front; Type: QDOVA001BB; Serial: TP:1029
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Ch155/Area Scan (41x81x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm  
Maximum value of SAR (interpolated) = 1.14 W/kg

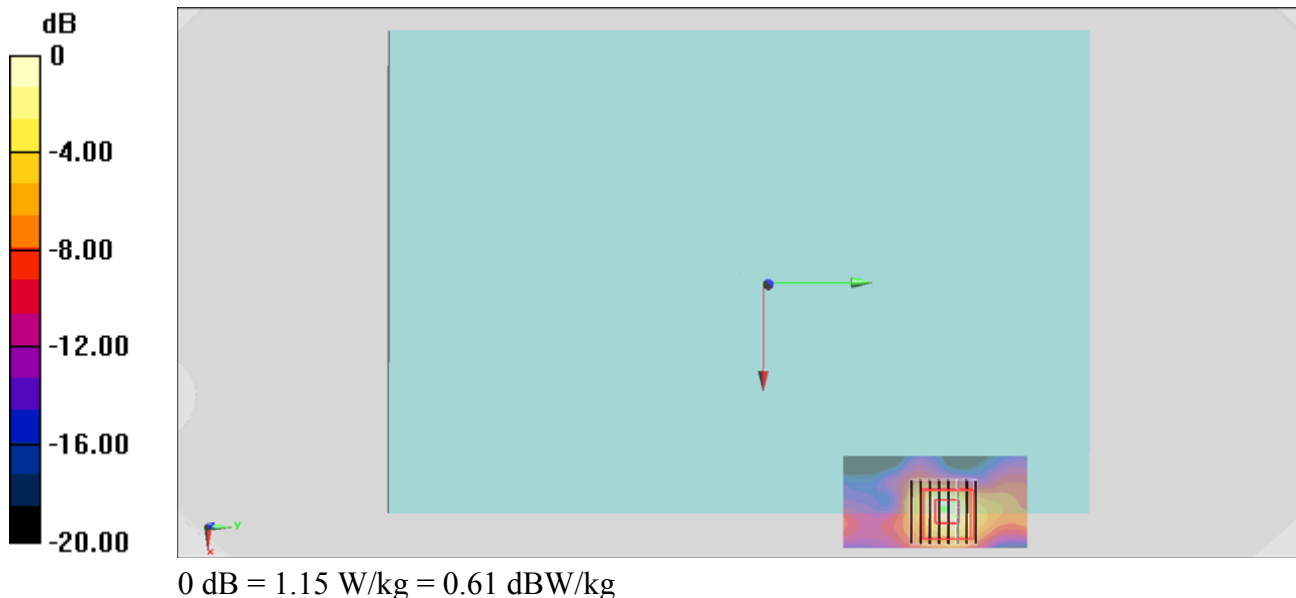
**Configuration/Ch155/Zoom Scan (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 14.49 V/m; Power Drift = 0.13 dB

Peak SAR (extrapolated) = 1.88 W/kg

**SAR(1 g) = 0.474 W/kg; SAR(10 g) = 0.148 W/kg**

Maximum value of SAR (measured) = 1.15 W/kg



**#05\_Bluetooth\_1Mbps\_Bottom of Laptop\_0mm\_Ch0**

Communication System: Bluetooth ; Frequency: 2402 MHz; Duty Cycle: 1:1.2

Medium: MSL\_2450\_160107 Medium parameters used:  $f = 2402$  MHz;  $\sigma = 1.91$  S/m;  $\epsilon_r = 53.154$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.5 °C; Liquid Temperature : 22.5 °C

**DASY5 Configuration**

- Probe: ES3DV3 - SN3270; ConvF(4.37, 4.37, 4.37); Calibrated: 2015/9/28;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn778; Calibrated: 2015/8/25
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Ch0/Area Scan (51x71x1):** Interpolated grid:  $dx=1.200$  mm,  $dy=1.200$  mm

Maximum value of SAR (interpolated) = 0.00116 W/kg

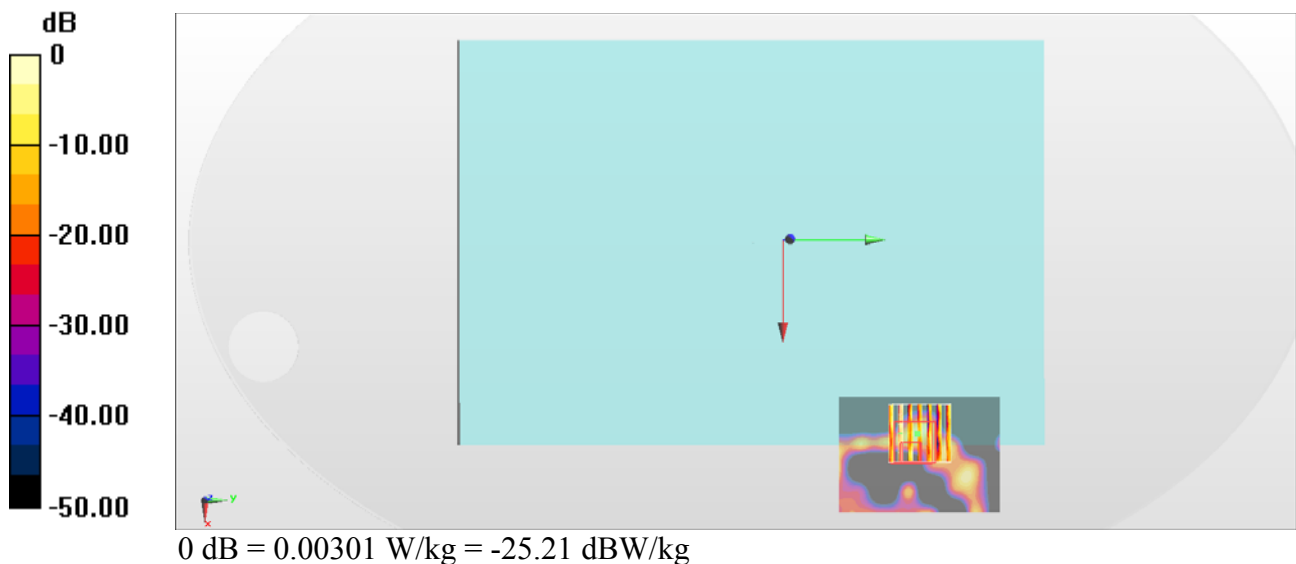
**Configuration/Ch0/Zoom Scan (7x7x7)/Cube 0:** Measurement grid:  $dx=5$ mm,  $dy=5$ mm,  $dz=5$ mm

Reference Value = 0.7370 V/m; Power Drift = 0.12 dB

Peak SAR (extrapolated) = 0.00363 W/kg

**SAR(1 g) = 0.000994 W/kg; SAR(10 g) = 0.000471 W/kg**

Maximum value of SAR (measured) = 0.00301 W/kg



**#06\_WLAN2.4GHz\_802.11b 1Mbps\_Bottom of Laptop\_0mm\_Ch1;Ant 1**

Communication System: 802.11b; Frequency: 2412 MHz; Duty Cycle: 1:1.048

Medium: MSL\_2450\_151210 Medium parameters used:  $f = 2412$  MHz;  $\sigma = 1.95$  S/m;  $\epsilon_r = 53.582$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.2 °C; Liquid Temperature : 22.2 °C

**DASY5 Configuration**

- Probe: EX3DV4 - SN3931; ConvF(7.54, 7.54, 7.54); Calibrated: 2015/10/1;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 2015/9/24
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Ch1/Area Scan (41x61x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 0.592 W/kg

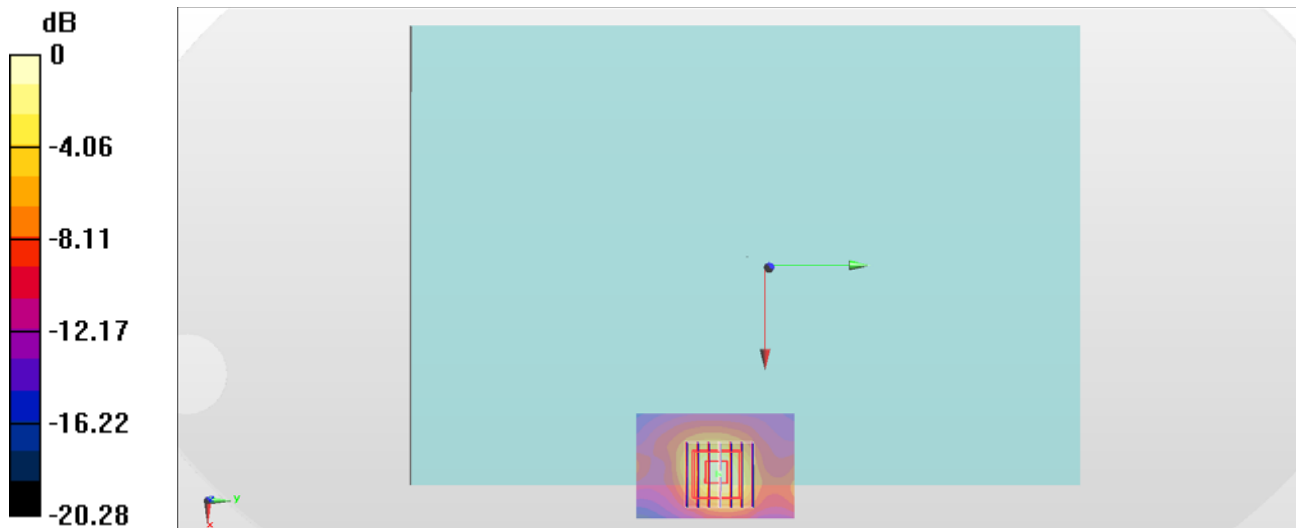
**Configuration/Ch1/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 15.31 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 0.740 W/kg

**SAR(1 g) = 0.338 W/kg; SAR(10 g) = 0.145 W/kg**

Maximum value of SAR (measured) = 0.568 W/kg



0 dB = 0.568 W/kg = -2.46 dBW/kg

**#07\_WLAN5GHz\_802.11ac-VHT80 MCS0\_Bottom of Laptop\_0mm\_Ch58;Ant 1**

Communication System: 802.11ac; Frequency: 5290 MHz; Duty Cycle: 1:1.060

Medium: MSL\_5G\_151209 Medium parameters used:  $f = 5290$  MHz;  $\sigma = 5.599$  S/m;  $\epsilon_r = 46.772$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.2 °C; Liquid Temperature : 22.2 °C

**DASY5 Configuration**

- Probe: EX3DV4 - SN3931; ConvF(4.48, 4.48, 4.48); Calibrated: 2015/10/1;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 2015/9/24
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Ch58/Area Scan (41x71x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 1.87 W/kg

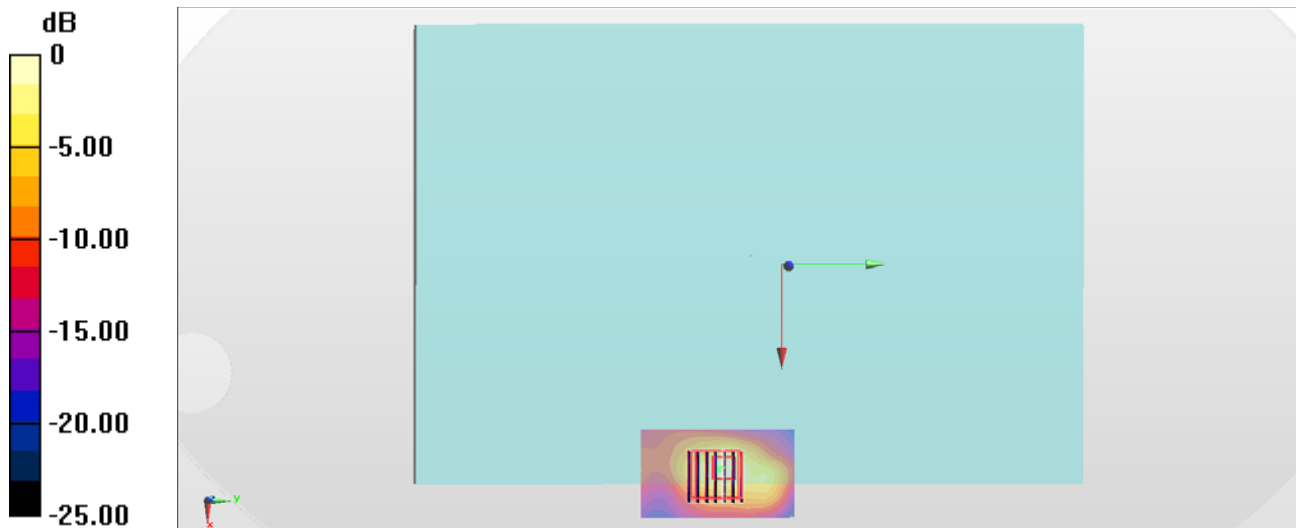
**Configuration/Ch58/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 18.48 V/m; Power Drift = -0.13 dB

Peak SAR (extrapolated) = 3.59 W/kg

**SAR(1 g) = 0.882 W/kg; SAR(10 g) = 0.260 W/kg**

Maximum value of SAR (measured) = 2.15 W/kg



0 dB = 2.15 W/kg = 3.32 dBW/kg

**#08\_WLAN5GHz\_802.11ac-VHT80 MCS0\_Bottom of Laptop\_0mm\_Ch138;Ant 1**

Communication System: 802.11ac ; Frequency: 5690 MHz;Duty Cycle: 1:1.060

Medium: MSL\_5G\_151209 Medium parameters used:  $f = 5690$  MHz;  $\sigma = 6.123$  S/m;  $\epsilon_r = 46.101$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.2 °C ; Liquid Temperature : 22.2 °C

**DASY5 Configuration**

- Probe: EX3DV4 - SN3931; ConvF(3.84, 3.84, 3.84); Calibrated: 2015/10/1;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 2015/9/24
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Ch138/Area Scan (41x71x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm  
Maximum value of SAR (interpolated) = 2.50 W/kg

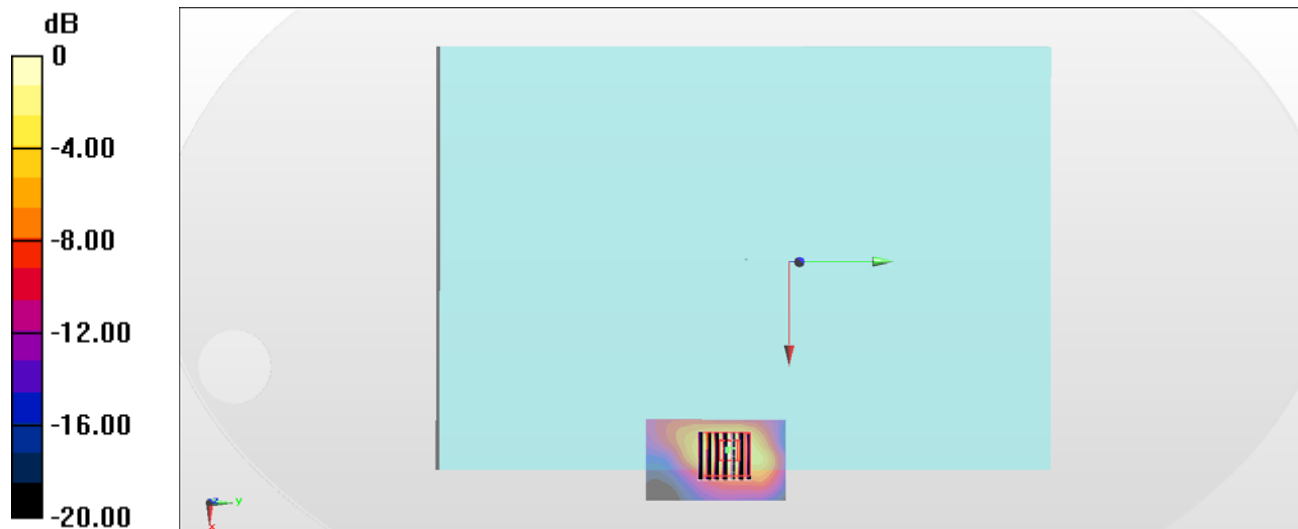
**Configuration/Ch138/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 16.12 V/m; Power Drift = -0.10 dB

Peak SAR (extrapolated) = 4.79 W/kg

**SAR(1 g) = 1.08 W/kg; SAR(10 g) = 0.333 W/kg**

Maximum value of SAR (measured) = 2.75 W/kg



0 dB = 2.75 W/kg = 4.39 dBW/kg

**#09\_WLAN5GHz\_802.11ac-VHT80 MCS0\_Bottom of Laptop\_0mm\_Ch155;Ant 1**

Communication System: 802.11ac; Frequency: 5775 MHz; Duty Cycle: 1:1.060

Medium: MSL\_5G\_151209 Medium parameters used:  $f = 5775$  MHz;  $\sigma = 6.24$  S/m;  $\epsilon_r = 45.983$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.2 °C; Liquid Temperature : 22.2 °C

**DASY5 Configuration**

- Probe: EX3DV4 - SN3931; ConvF(3.98, 3.98, 3.98); Calibrated: 2015/10/1;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 2015/9/24
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Ch155/Area Scan (41x71x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm  
Maximum value of SAR (interpolated) = 2.10 W/kg

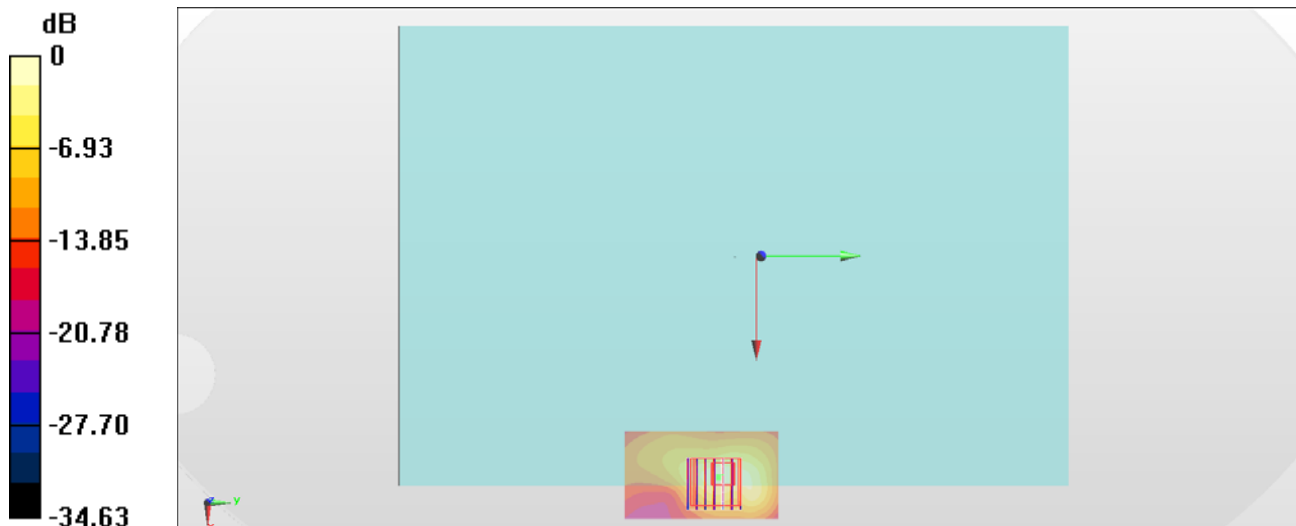
**Configuration/Ch155/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 15.02 V/m; Power Drift = -0.13 dB

Peak SAR (extrapolated) = 4.15 W/kg

**SAR(1 g) = 0.904 W/kg; SAR(10 g) = 0.255 W/kg**

Maximum value of SAR (measured) = 2.33 W/kg



0 dB = 2.33 W/kg = 3.67 dBW/kg



**#10\_Bluetooth\_1Mbps\_Bottom of Laptop\_0mm\_Ch39**

Communication System: Bluetooth; Frequency: 2441 MHz; Duty Cycle: 1:1.2

Medium: MSL\_2450\_160107 Medium parameters used:  $f = 2441$  MHz;  $\sigma = 1.961$  S/m;  $\epsilon_r = 53.016$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Ambient Temperature : 23.5 °C; Liquid Temperature : 22.5 °C

**DASY5 Configuration**

- Probe: ES3DV3 - SN3270; ConvF(4.37, 4.37, 4.37); Calibrated: 2015/9/28;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn778; Calibrated: 2015/8/25
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: TP:1227
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Configuration/Ch39/Area Scan (51x71x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm  
Maximum value of SAR (interpolated) = 0.00411 W/kg

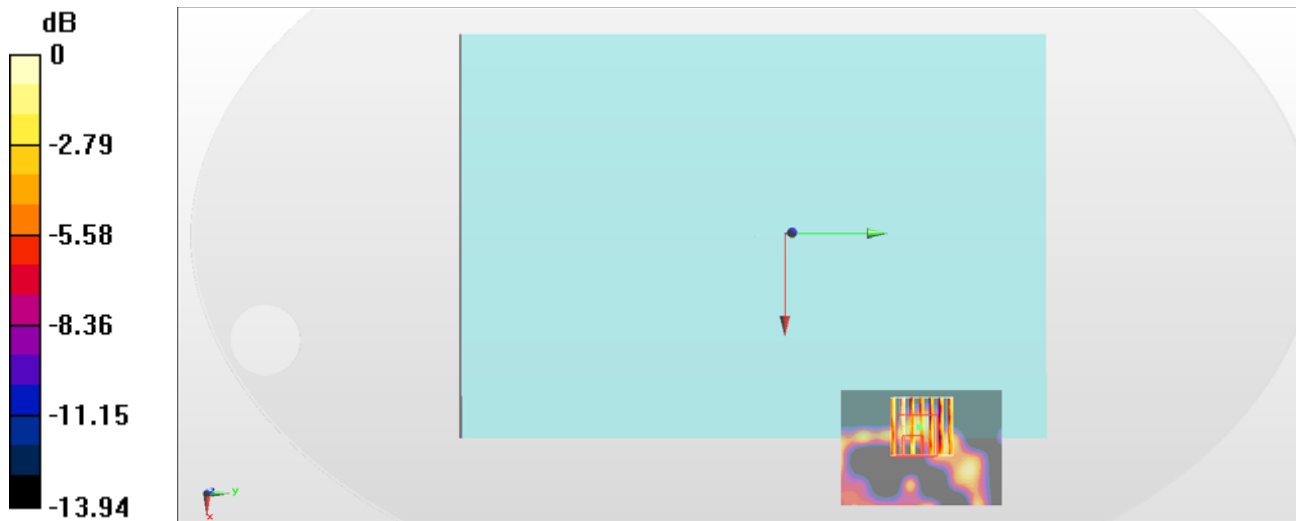
**Configuration/Ch39/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 0.9510 V/m; Power Drift = -0.10 dB

Peak SAR (extrapolated) = 0.00623 W/kg

**SAR(1 g) = 0.00283 W/kg; SAR(10 g) = 0.0022 W/kg**

Maximum value of SAR (measured) = 0.00443 W/kg



0 dB = 0.00443 W/kg = -23.54 dBW/kg



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

The DASY calibration certificates are shown as follows.



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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

Client **Sporton-TW (Auden)**

Certificate No: **D2450V2-736\_Aug15**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 736**

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

Calibration date: **August 20, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature ( $22 \pm 3$ )°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	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe ES3DV3	SN: 3205	30-Dec-14 (No. ES3-3205_Dec14)	Dec-15
DAE4	SN: 601	17-Aug-15 (No. DAE4-601_Aug15)	Aug-16

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-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by: **Michael Weber**

Function  
**Laboratory Technician**

Signature

Approved by: **Katja Pokovic**

Technical Manager

Issued: August 21, 2015

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



Accredited by the Swiss Accreditation Service (SAS)

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

Accreditation No.: **SCS 0108**

### Glossary:

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

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

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- DASY4/5 System Handbook

### Methods Applied and Interpretation of Parameters:

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

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

## Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	39.2 $\pm$ 6 %	1.87 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	13.6 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	53.4 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.2 W/kg $\pm$ 16.5 % (k=2)

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	53.2 $\pm$ 6 %	2.00 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	13.1 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	51.9 W/kg $\pm$ 17.0 % (k=2)

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

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.1 $\Omega$ + 2.3 j $\Omega$
Return Loss	- 27.0 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.6 $\Omega$ + 3.8 j $\Omega$
Return Loss	- 28.3 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.158 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 26, 2003

## DASY5 Validation Report for Head TSL

Date: 20.08.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 736**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.87$  S/m;  $\epsilon_r = 39.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.54, 4.54, 4.54); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

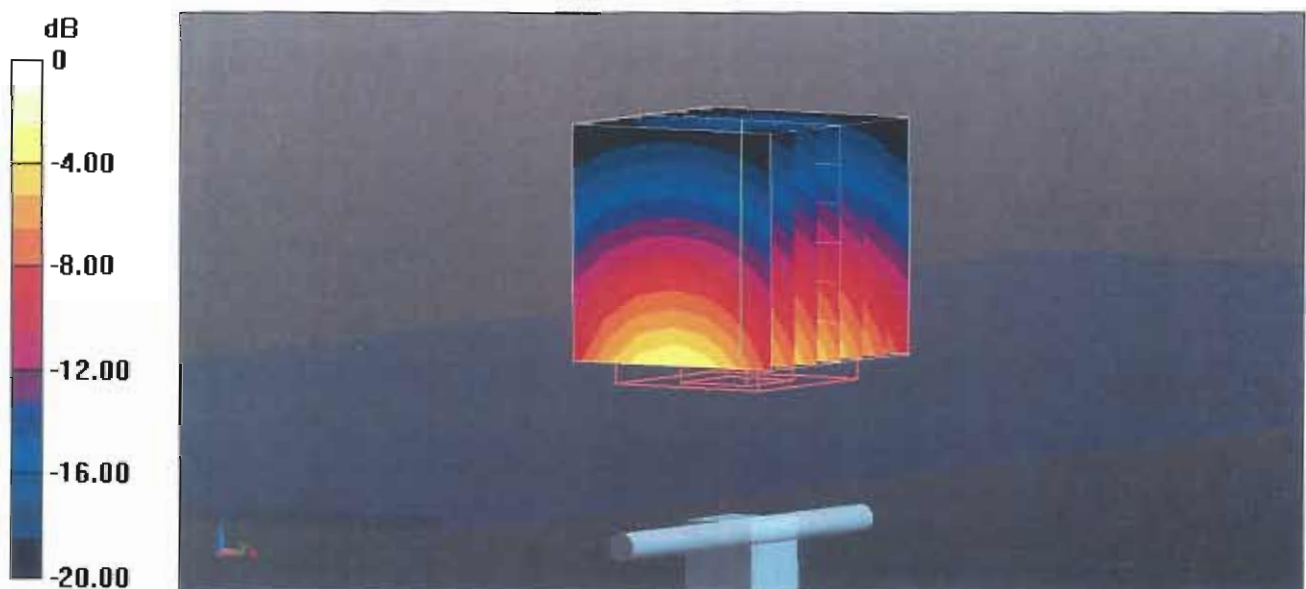
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 101.5 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 27.7 W/kg

**SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.35 W/kg**

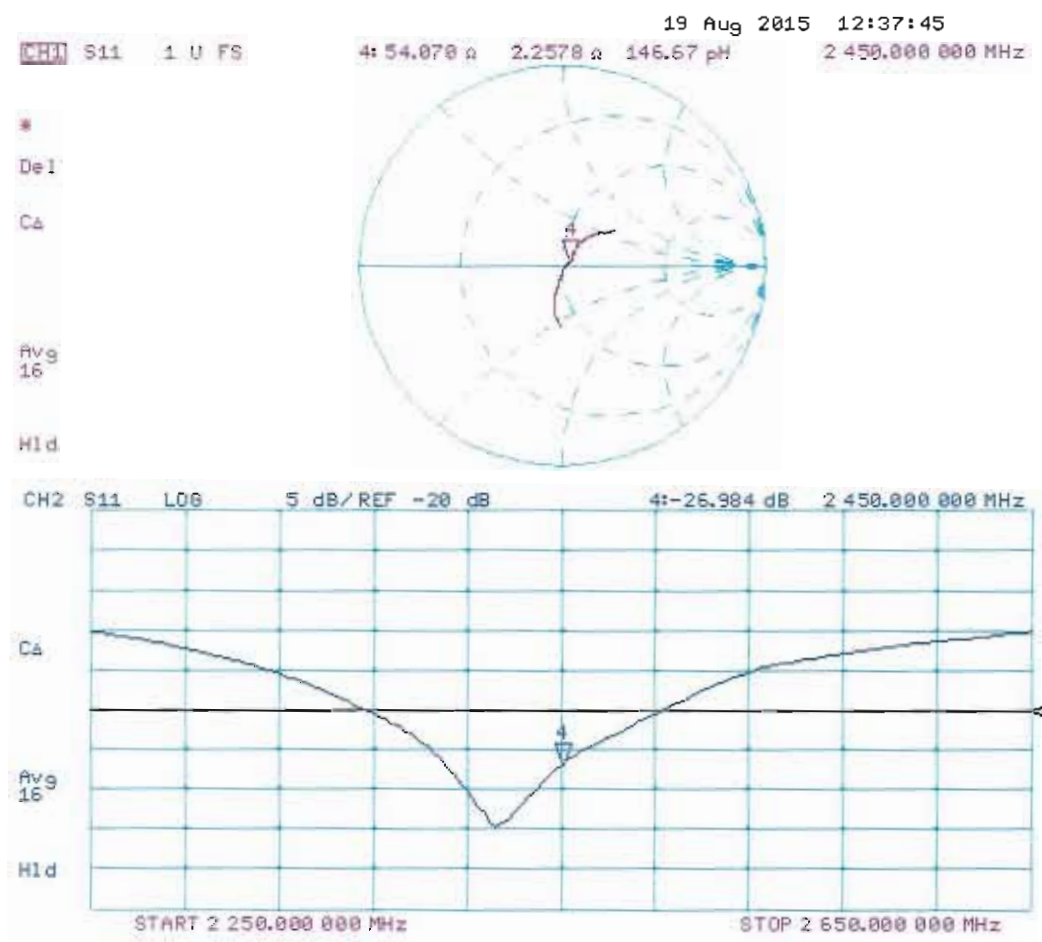
Maximum value of SAR (measured) = 18.0 W/kg



0 dB = 18.0 W/kg = 12.55 dBW/kg



Impedance Measurement Plot for Head TSL





## DASY5 Validation Report for Body TSL

Date: 19.08.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 736**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2$  S/m;  $\epsilon_r = 53.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.32, 4.32, 4.32); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

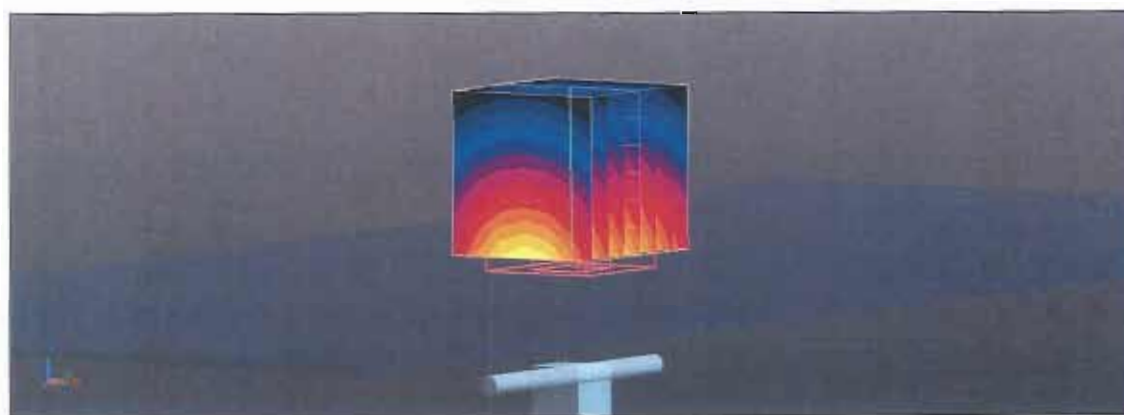
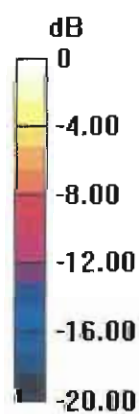
Measurement grid:  $dx=5$ mm,  $dy=5$ mm,  $dz=5$ mm

Reference Value = 95.81 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 26.8 W/kg

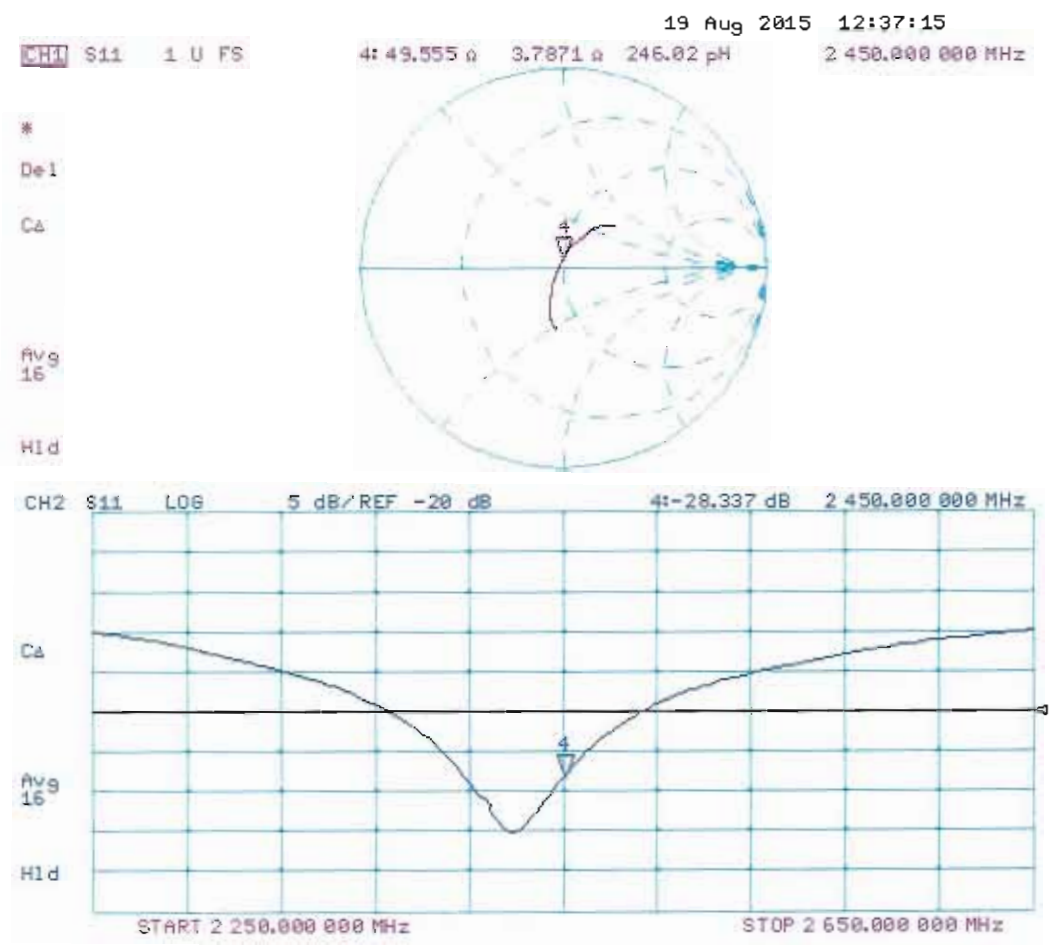
**SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.08 W/kg**

Maximum value of SAR (measured) = 17.3 W/kg



0 dB = 17.3 W/kg = 12.38 dBW/kg

Impedance Measurement Plot for Body TSL





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Accreditation No.: **SCS 0108**

Client **Sporton-TW (Auden)**

Certificate No: **D5GHzV2-1006\_Oct15**

## 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: **October 06, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature ( $22 \pm 3$ )°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	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe EX3DV4	SN: 3503	30-Dec-14 (No. EX3-3503_Dec14)	Dec-15
DAE4	SN: 601	17-Aug-15 (No. DAE4-601_Aug15)	Aug-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100972	15-Jun-15 (in house check Jun-15)	In house check: Jun-18
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by: **Israe Elnaouq** **Function**  
**Laboratory Technician**

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

**Signature**  
  


Issued: October 6, 2015

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Accreditation No.: **SCS 0108**

**Glossary:**

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

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

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

**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	V52.8.8
<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 $\pm$ 1 MHz 5300 MHz $\pm$ 1 MHz 5600 MHz $\pm$ 1 MHz 5800 MHz $\pm$ 1 MHz	

## Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	36.0	4.66 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	36.4 $\pm$ 6 %	4.57 mho/m $\pm$ 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	7.79 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>78.0 W/kg <math>\pm</math> 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	2.24 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>22.4 W/kg <math>\pm</math> 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	36.2 ± 6 %	4.68 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5300 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	8.44 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>84.5 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	2.43 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>24.3 W/kg ± 19.5 % (k=2)</b>

### Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.7 ± 6 %	5.03 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5600 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	8.47 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>84.8 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	100 mW input power	2.43 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>24.3 W/kg ± 19.5 % (k=2)</b>



### Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.3 ± 6 %	5.26 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	8.20 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>82.0 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	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.3 W/kg ± 19.5 % (k=2)</b>

### Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.4 ± 6 %	5.45 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5200 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	100 mW input power	7.61 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>75.6 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	100 mW input power	2.13 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>21.1 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	47.2 ± 6 %	5.59 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5300 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	100 mW input power	8.00 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>79.5 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	100 mW input power	2.26 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>22.4 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	46.7 ± 6 %	5.99 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5600 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	100 mW input power	8.28 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>82.3 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	100 mW input power	2.32 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>23.0 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	46.4 ± 6 %	6.27 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5800 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	100 mW input power	7.95 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>79.0 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	100 mW input power	2.21 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>21.9 W/kg ± 19.5 % (k=2)</b>

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	$51.5 \Omega - 9.8 j\Omega$
Return Loss	- 20.2 dB

### Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	$54.8 \Omega + 2.2 j\Omega$
Return Loss	- 26.0 dB

### Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	$58.1 \Omega - 5.7 j\Omega$
Return Loss	- 20.8 dB

### Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	$58.1 \Omega + 6.3 j\Omega$
Return Loss	- 20.4 dB

### Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	$51.8 \Omega - 8.8 j\Omega$
Return Loss	- 21.2 dB

### Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	$54.8 \Omega - 0.2 j\Omega$
Return Loss	- 26.7 dB

### Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	$58.9 \Omega - 4.1 j\Omega$
Return Loss	- 21.0 dB

### Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	$56.8\ \Omega + 7.0\ j\Omega$
Return Loss	- 20.8 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

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;  $\sigma = 4.57$  S/m;  $\epsilon_r = 36.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5300$  MHz;  $\sigma = 4.68$  S/m;  $\epsilon_r = 36.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5600$  MHz;  $\sigma = 5.03$  S/m;  $\epsilon_r = 35.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5800$  MHz;  $\sigma = 5.26$  S/m;  $\epsilon_r = 35.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.51, 5.51, 5.51); Calibrated: 30.12.2014, ConvF(5.21, 5.21, 5.21); Calibrated: 30.12.2014, ConvF(4.92, 4.92, 4.92); Calibrated: 30.12.2014, ConvF(4.9, 4.9, 4.9); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**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 = 72.99 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 28.4 W/kg

**SAR(1 g) = 7.79 W/kg; SAR(10 g) = 2.24 W/kg**

Maximum value of SAR (measured) = 17.9 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 = 74.56 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 31.9 W/kg

**SAR(1 g) = 8.44 W/kg; SAR(10 g) = 2.43 W/kg**

Maximum value of SAR (measured) = 19.7 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

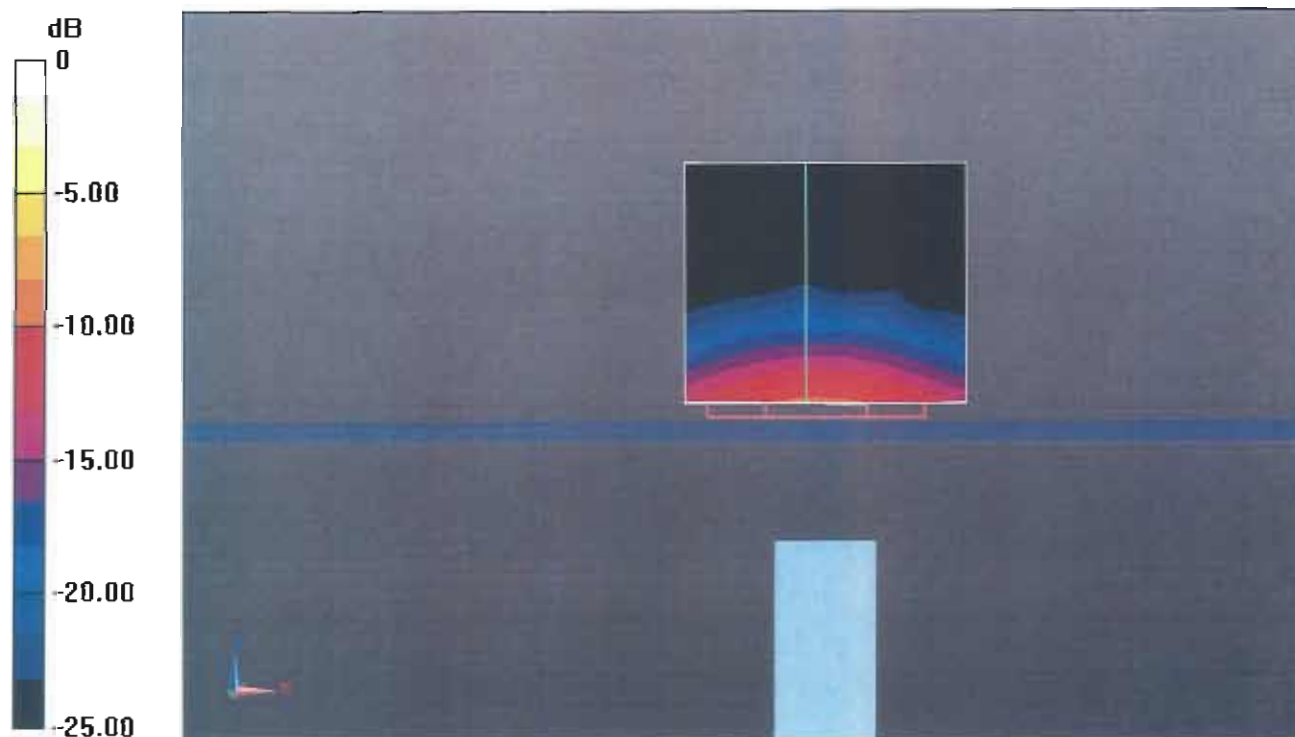
Reference Value = 73.58 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 33.5 W/kg

**SAR(1 g) = 8.47 W/kg; SAR(10 g) = 2.43 W/kg**

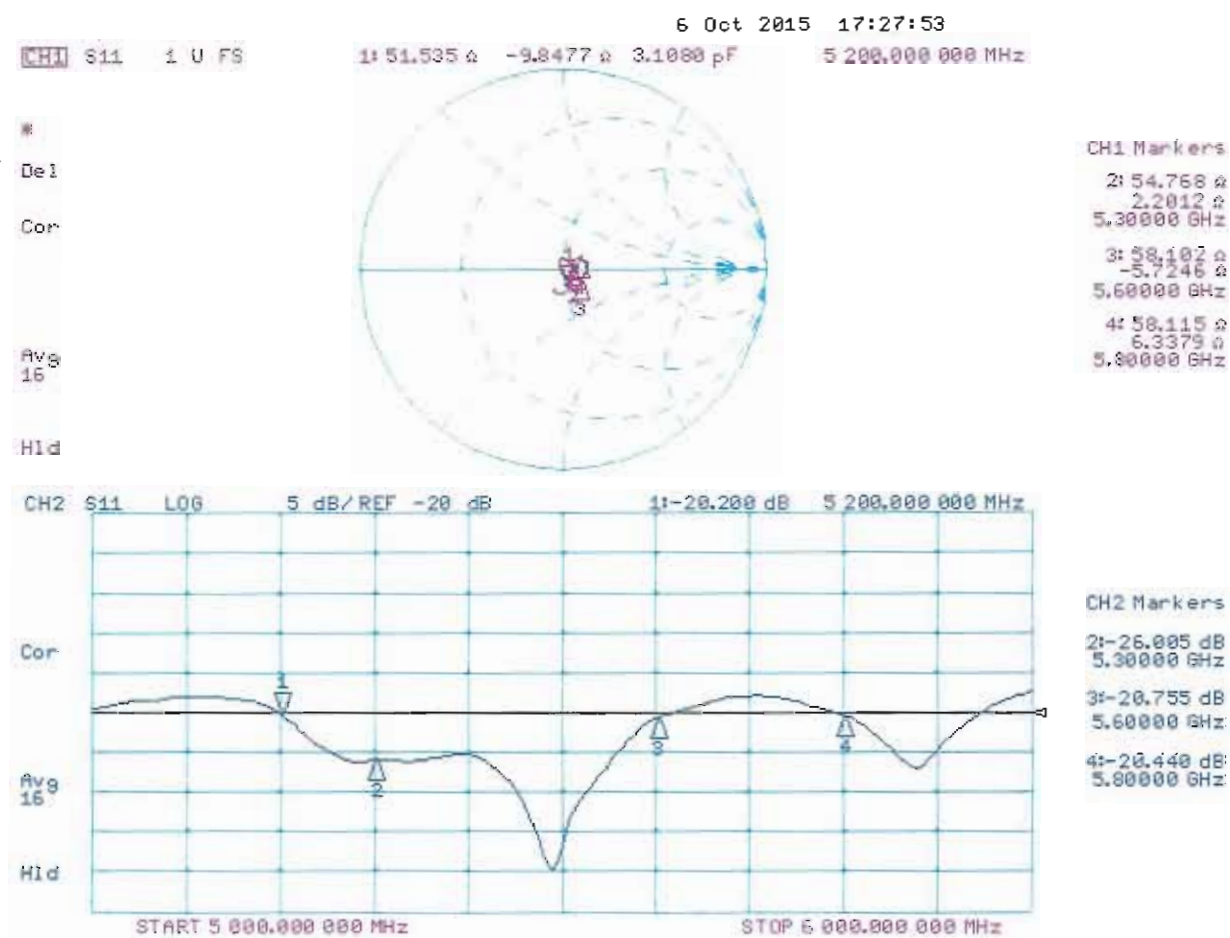
Maximum value of SAR (measured) = 20.1 W/kg

**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 = 71.49 V/m; Power Drift = 0.01 dB  
Peak SAR (extrapolated) = 34.7 W/kg  
**SAR(1 g) = 8.2 W/kg; SAR(10 g) = 2.33 W/kg**



0 dB = 17.9 W/kg = 12.53 dBW/kg

# Impedance Measurement Plot for Head TSL





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;  $\sigma = 5.45$  S/m;  $\epsilon_r = 47.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5300$  MHz;  $\sigma = 5.59$  S/m;  $\epsilon_r = 47.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5600$  MHz;  $\sigma = 5.99$  S/m;  $\epsilon_r = 46.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5800$  MHz;  $\sigma = 6.27$  S/m;  $\epsilon_r = 46.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(4.95, 4.95, 4.95); Calibrated: 30.12.2014, ConvF(4.78, 4.78, 4.78); Calibrated: 30.12.2014, ConvF(4.35, 4.35, 4.35); Calibrated: 30.12.2014, ConvF(4.32, 4.32, 4.32); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Dipole Calibration for Body Tissue 2/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 = 66.44 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 30.0 W/kg

**SAR(1 g) = 7.61 W/kg; SAR(10 g) = 2.13 W/kg**

Maximum value of SAR (measured) = 18.3 W/kg

**Dipole Calibration for Body Tissue 2/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 = 67.77 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 32.6 W/kg

**SAR(1 g) = 8 W/kg; SAR(10 g) = 2.26 W/kg**

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

**Dipole Calibration for Body Tissue 2/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 = 67.58 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 36.6 W/kg

**SAR(1 g) = 8.28 W/kg; SAR(10 g) = 2.32 W/kg**

Maximum value of SAR (measured) = 20.7 W/kg

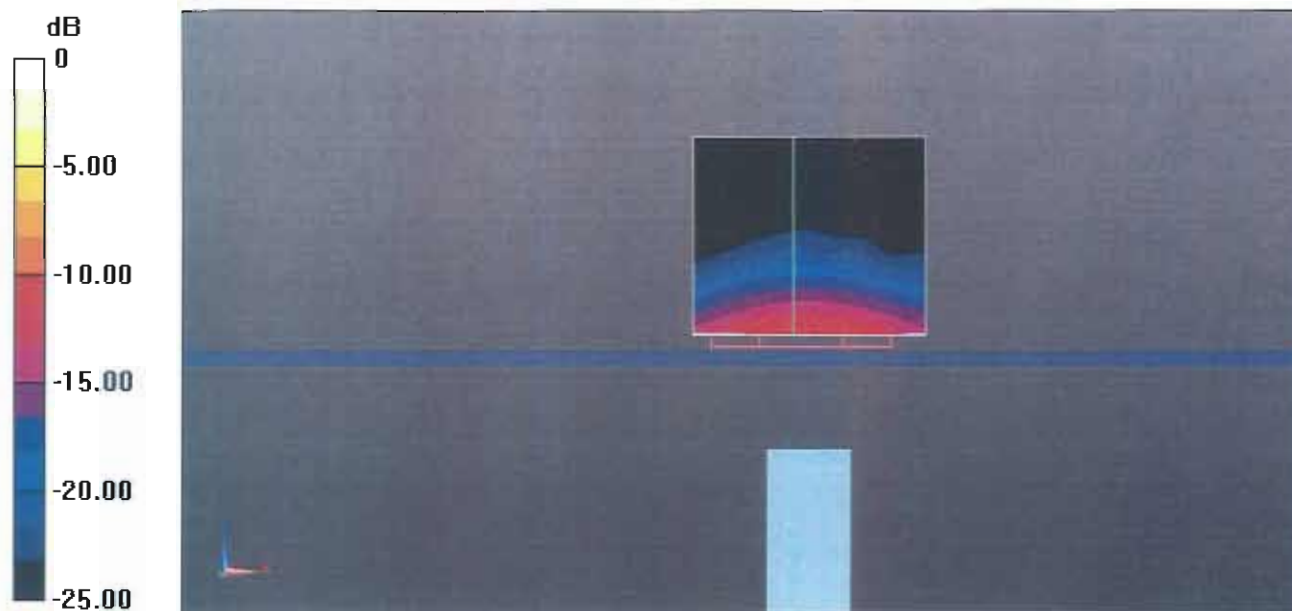
**Dipole Calibration for Body Tissue 2/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 64.90 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 37.4 W/kg

**SAR(1 g) = 7.95 W/kg; SAR(10 g) = 2.21 W/kg**

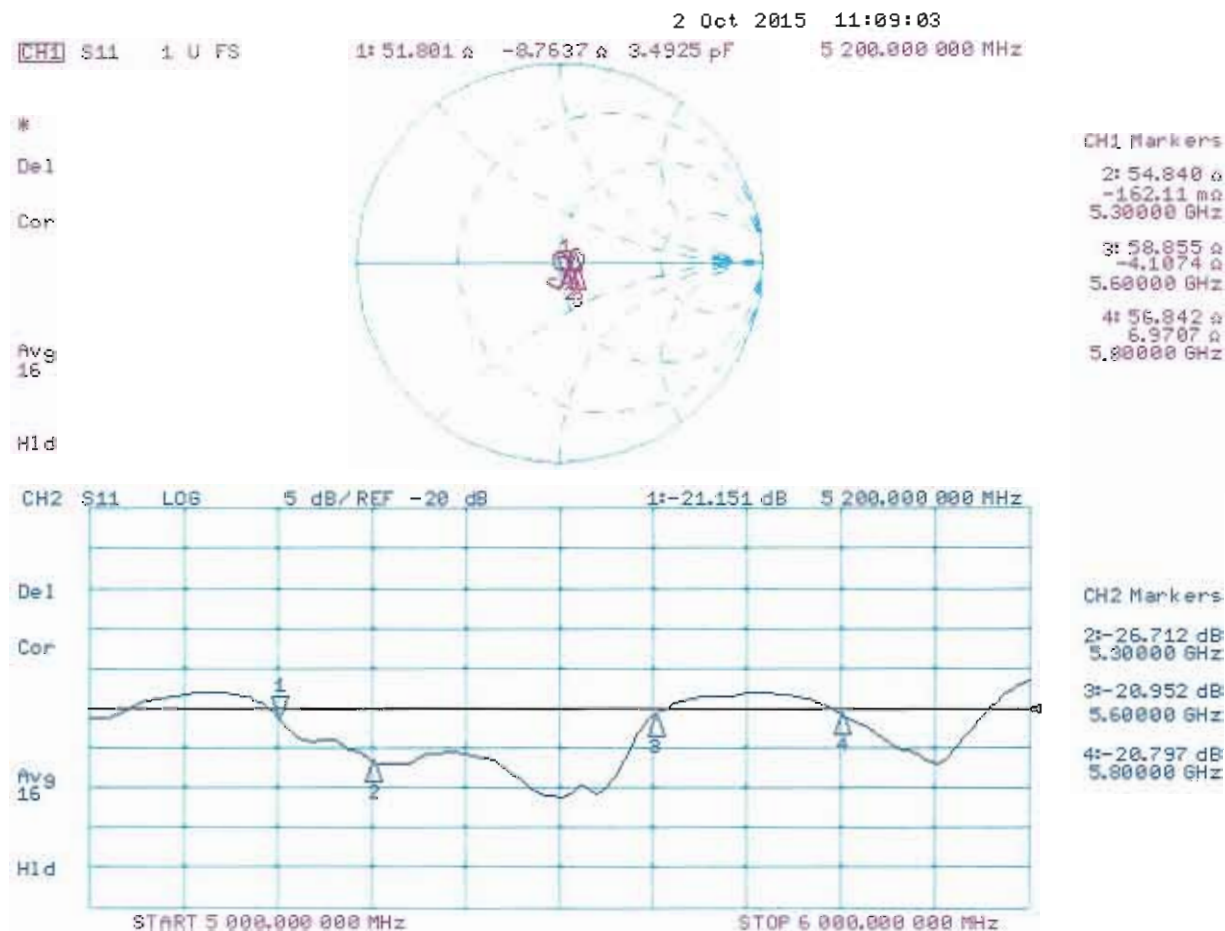
Maximum value of SAR (measured) = 20.3 W/kg



0 dB = 18.3 W/kg = 12.62 dBW/kg



Impedance Measurement Plot for Body TSL





Accredited by the Swiss Accreditation Service (SAS)  
 The Swiss Accreditation Service is one of the signatories to the EA  
 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Sporton-TW (Auden)**

Certificate No: **D5GHzV2-1128\_Jul15**

## CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN: 1128**

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

Calibration date: **July 20, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature ( $22 \pm 3$ )°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	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe EX3DV4	SN: 3503	30-Dec-14 (No. EX3-3503_Dec14)	Dec-15
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15
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-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by: **Michael Weber** **Laboratory Technician**

Signature

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

Issued: July 21, 2015

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



Accredited by the Swiss Accreditation Service (SAS)

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

Accreditation No.: **SCS 0108**

**Glossary:**

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

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

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

**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	V52.8.8
<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>	5250 MHz $\pm$ 1 MHz 5600 MHz $\pm$ 1 MHz 5750 MHz $\pm$ 1 MHz	

## Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	35.9	4.71 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	34.4 $\pm$ 6 %	4.55 mho/m $\pm$ 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL at 5250 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	8.16 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>80.8 W/kg <math>\pm</math> 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	100 mW input power	2.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.2 W/kg <math>\pm</math> 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	33.9 ± 6 %	4.89 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5600 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	8.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>82.0 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	2.37 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.4 W/kg ± 19.5 % (k=2)</b>

### Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	33.7 ± 6 %	5.04 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Head TSL at 5750 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	8.06 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>79.7 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	100 mW input power	2.30 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>22.7 W/kg ± 19.5 % (k=2)</b>

### Body TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.36 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.0 ± 6 %	5.53 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5250 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	100 mW input power	7.68 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>76.2 W/kg ± 19.9 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	100 mW input power	2.16 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>21.4 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	46.3 ± 6 %	6.00 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5600 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	100 mW input power	7.99 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>79.3 W/kg ± 19.9 % (k=2)</b>

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

### Body TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.3	5.94 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.1 ± 6 %	6.22 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

### SAR result with Body TSL at 5750 MHz

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	100 mW input power	7.65 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>75.9 W/kg ± 19.9 % (k=2)</b>

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

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	51.0 $\Omega$ - 2.7 j $\Omega$
Return Loss	- 30.8 dB

### Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	56.2 $\Omega$ + 0.6 j $\Omega$
Return Loss	- 24.6 dB

### Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	54.6 $\Omega$ + 2.7 j $\Omega$
Return Loss	- 25.9 dB

### Antenna Parameters with Body TSL at 5250 MHz

Impedance, transformed to feed point	51.7 $\Omega$ - 1.6 j $\Omega$
Return Loss	- 32.7 dB

### Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	55.9 $\Omega$ + 1.0 j $\Omega$
Return Loss	- 25.0 dB

### Antenna Parameters with Body TSL at 5750 MHz

Impedance, transformed to feed point	55.9 $\Omega$ + 4.3 j $\Omega$
Return Loss	- 23.2 dB

## General Antenna Parameters and Design

Electrical Delay (one direction)	1.209 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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

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

### Additional EUT Data

Manufactured by	SPEAG
Manufactured on	September 08, 2011



## DASY5 Validation Report for Head TSL

Date: 20.07.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1128**

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz  
Medium parameters used:  $f = 5250$  MHz;  $\sigma = 4.55$  S/m;  $\epsilon_r = 34.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5600$  MHz;  $\sigma = 4.89$  S/m;  $\epsilon_r = 33.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5750$  MHz;  $\sigma = 5.04$  S/m;  $\epsilon_r = 33.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.45, 5.45, 5.45); Calibrated: 30.12.2014, ConvF(4.92, 4.92, 4.92); Calibrated: 30.12.2014, ConvF(4.91, 4.91, 4.91); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 66.31 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 29.2 W/kg

**SAR(1 g) = 8.16 W/kg; SAR(10 g) = 2.35 W/kg**

Maximum value of SAR (measured) = 18.5 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 = 65.08 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 32.2 W/kg

**SAR(1 g) = 8.29 W/kg; SAR(10 g) = 2.37 W/kg**

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

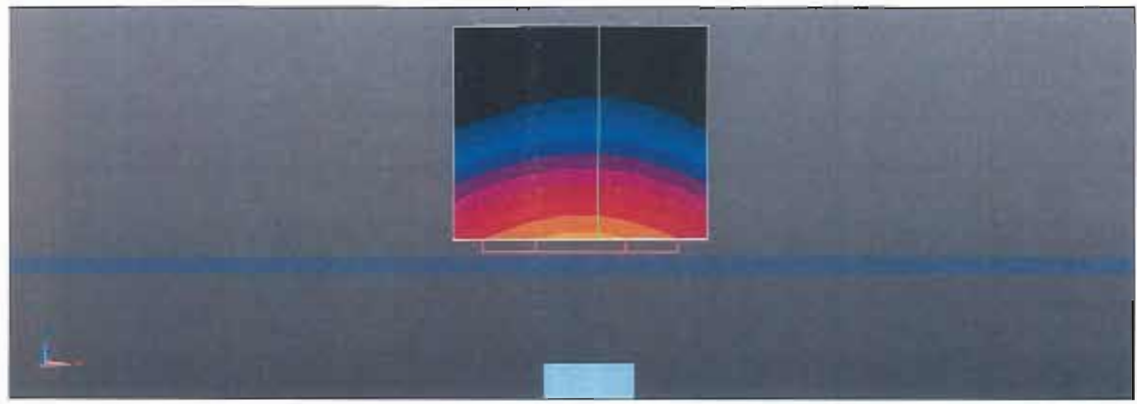
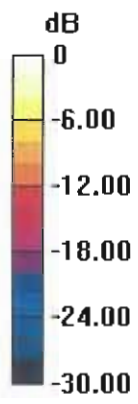
**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 63.40 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 32.4 W/kg

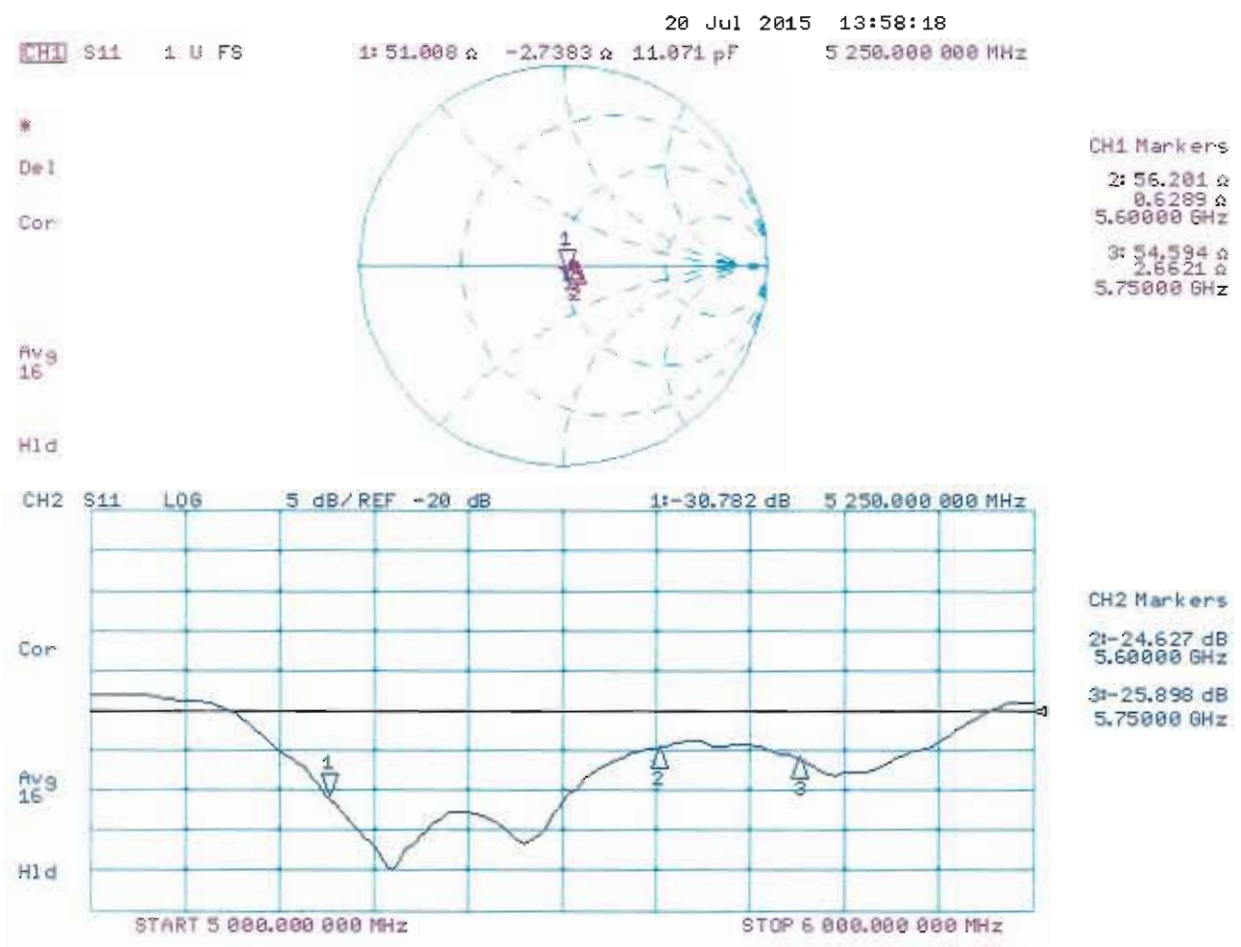
**SAR(1 g) = 8.06 W/kg; SAR(10 g) = 2.3 W/kg**

Maximum value of SAR (measured) = 19.0 W/kg



0 dB = 19.0 W/kg = 12.79 dBW/kg

Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 17.07.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1128**

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz  
Medium parameters used:  $f = 5250$  MHz;  $\sigma = 5.53$  S/m;  $\epsilon_r = 47$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5600$  MHz;  $\sigma = 6$  S/m;  $\epsilon_r = 46.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $f = 5750$  MHz;  $\sigma = 6.22$  S/m;  $\epsilon_r = 46.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(4.9, 4.9, 4.9); Calibrated: 30.12.2014, ConvF(4.35, 4.35, 4.35); Calibrated: 30.12.2014; ConvF(4.35, 4.35, 4.35); Calibrated: 30.12.2014
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 59.26 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 30.2 W/kg

**SAR(1 g) = 7.68 W/kg; SAR(10 g) = 2.16 W/kg**

Maximum value of SAR (measured) = 17.7 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 = 58.23 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 34.5 W/kg

**SAR(1 g) = 7.99 W/kg; SAR(10 g) = 2.23 W/kg**

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

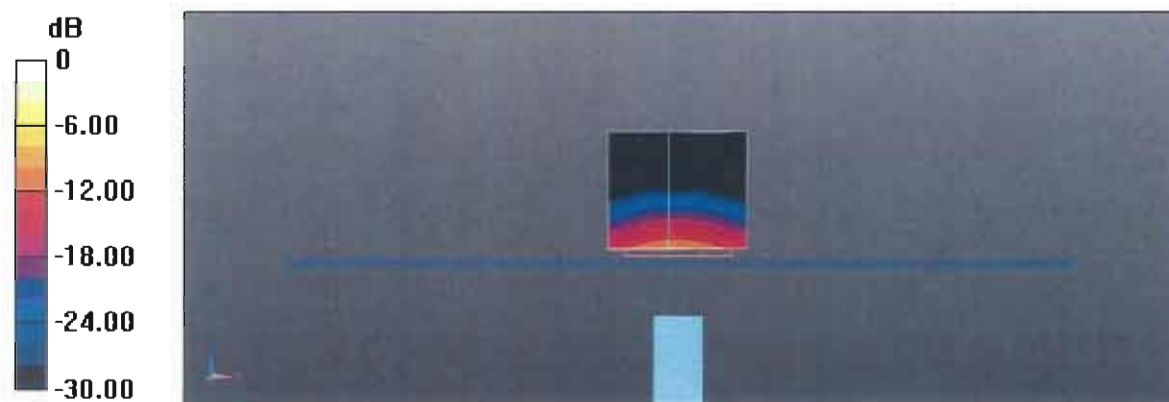
**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 56.02 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 34.5 W/kg

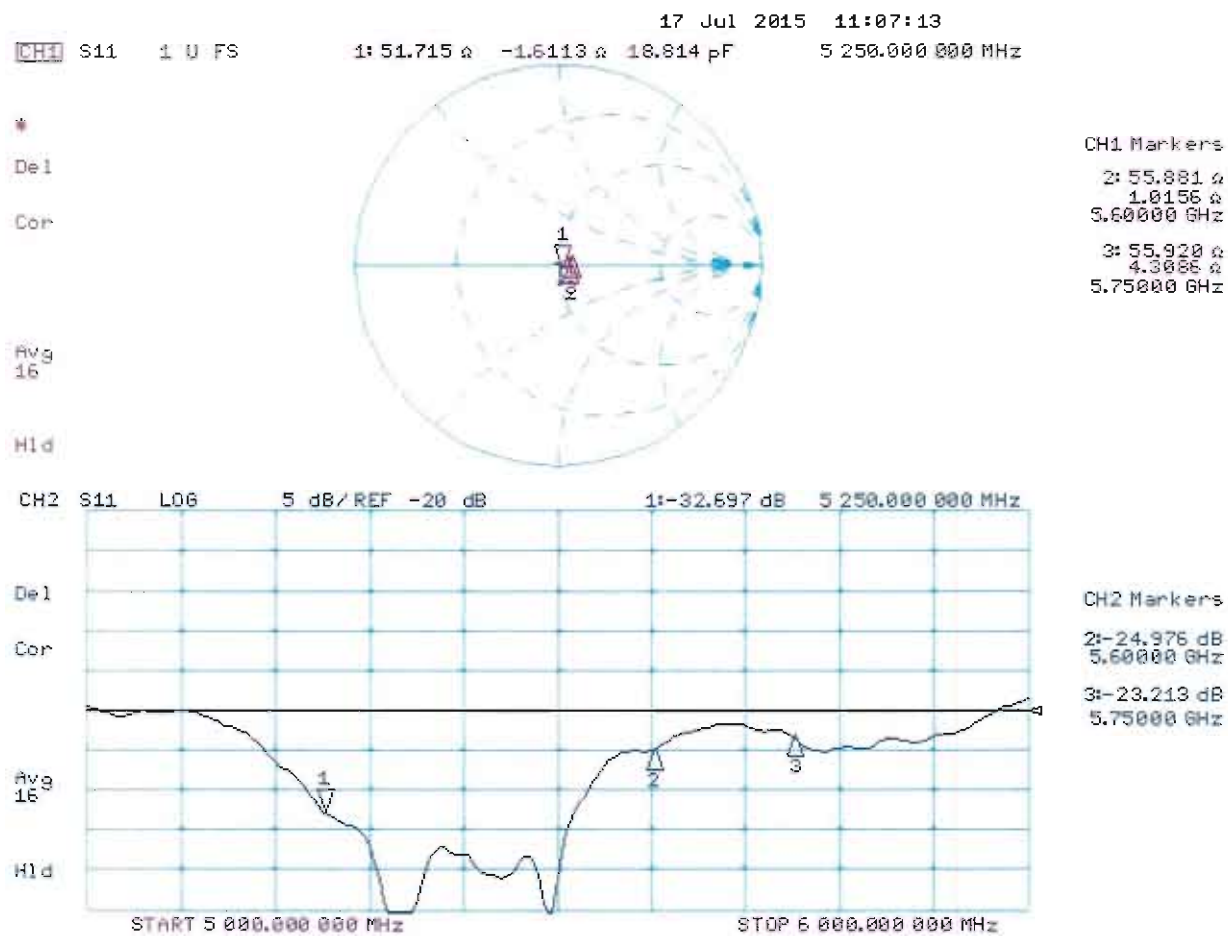
**SAR(1 g) = 7.65 W/kg; SAR(10 g) = 2.14 W/kg**

Maximum value of SAR (measured) = 18.5 W/kg



0 dB = 17.7 W/kg = 12.48 dBW/kg

Impedance Measurement Plot for Body TSL





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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Sporton-TW (Auden)**

Certificate No: **DAE3-495\_May15**

## CALIBRATION CERTIFICATE

Object **DAE3 - SD 000 D03 AD - SN: 495**

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

Calibration date: **May 22, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	03-Oct-14 (No:15573)	Oct-15
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	06-Jan-15 (in house check)	In house check: Jan-16
Calibrator Box V2.1	SE UMS 006 AA 1002	06-Jan-15 (in house check)	In house check: Jan-16

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

Issued: May 22, 2015

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

## Glossary

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

## Methods Applied and Interpretation of Parameters

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



## DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1 $\mu$ V, full range = -100...+300 mV

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

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

Calibration Factors	X	Y	Z
High Range	404.409 $\pm$ 0.02% (k=2)	405.388 $\pm$ 0.02% (k=2)	405.737 $\pm$ 0.02% (k=2)
Low Range	3.95310 $\pm$ 1.50% (k=2)	3.99143 $\pm$ 1.50% (k=2)	3.96657 $\pm$ 1.50% (k=2)

## Connector Angle

Connector Angle to be used in DASY system	77.5 ° $\pm$ 1 °
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## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

High Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	199994.22	-1.72	-0.00
Channel X + Input	20001.17	0.44	0.00
Channel X - Input	-19996.62	4.46	-0.02
Channel Y + Input	199992.43	-3.06	-0.00
Channel Y + Input	20000.37	-0.43	-0.00
Channel Y - Input	-19998.99	2.04	-0.01
Channel Z + Input	199994.10	-1.72	-0.00
Channel Z + Input	20002.82	2.13	0.01
Channel Z - Input	-19997.04	4.08	-0.02

Low Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	2000.70	-0.09	-0.00
Channel X + Input	201.65	0.55	0.27
Channel X - Input	-199.11	-0.29	0.15
Channel Y + Input	2000.75	-0.12	-0.01
Channel Y + Input	200.97	-0.14	-0.07
Channel Y - Input	-198.50	0.23	-0.12
Channel Z + Input	2000.99	0.28	0.01
Channel Z + Input	199.47	-1.59	-0.79
Channel Z - Input	-200.46	-1.65	0.83

### 2. Common mode sensitivity

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

	Common mode Input Voltage (mV)	High Range Average Reading ( $\mu\text{V}$ )	Low Range Average Reading ( $\mu\text{V}$ )
Channel X	200	3.75	2.04
	- 200	-1.76	-3.36
Channel Y	200	-0.19	-0.24
	- 200	-0.62	-0.54
Channel Z	200	1.80	2.15
	- 200	-5.03	-5.15

### 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	-	-0.87	-2.35
Channel Y	200	8.09	-	-0.25
Channel Z	200	4.57	6.06	-

#### 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	15818	17604
Channel Y	15761	17038
Channel Z	15902	16889

#### 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	-0.71	-2.27	0.76	0.60
Channel Y	-0.10	-1.74	1.10	0.60
Channel Z	-0.62	-2.47	1.28	0.71

#### 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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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Sporton - TW (Auden)**

Certificate No: **DAE4-778\_Aug15**

## CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BM - SN: 778**

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

Calibration date: **August 25, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature ( $22 \pm 3$ )°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	03-Oct-14 (No:15573)	Oct-15
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	06-Jan-15 (in house check)	In house check: Jan-16
Calibrator Box V2.1	SE UMS 006 AA 1002	06-Jan-15 (in house check)	In house check: Jan-16

Calibrated by: **Eric Hainfeld**

Function  
**Technician**

Signature

Approved by: **Fin Bornholt**

Deputy Technical Manager

Issued: August 25, 2015

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Accreditation No.: **SCS 0108**

## Glossary

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

## Methods Applied and Interpretation of Parameters

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

## DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1 $\mu$ 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	404.656 $\pm$ 0.02% (k=2)	403.464 $\pm$ 0.02% (k=2)	405.018 $\pm$ 0.02% (k=2)
Low Range	3.98590 $\pm$ 1.50% (k=2)	3.96400 $\pm$ 1.50% (k=2)	4.00088 $\pm$ 1.50% (k=2)

## Connector Angle

Connector Angle to be used in DASY system	280.5 ° $\pm$ 1 °
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## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

High Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	200032.03	-5.20	-0.00
Channel X + Input	20005.20	1.02	0.01
Channel X - Input	-20003.13	3.32	-0.02
Channel Y + Input	200036.32	-1.13	-0.00
Channel Y + Input	20003.24	-0.80	-0.00
Channel Y - Input	-20004.43	2.14	-0.01
Channel Z + Input	200036.09	-1.05	-0.00
Channel Z + Input	20000.94	-2.98	-0.01
Channel Z - Input	-20010.33	-3.75	0.02

Low Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	2000.43	0.05	0.00
Channel X + Input	199.83	-0.40	-0.20
Channel X - Input	-199.82	-0.18	0.09
Channel Y + Input	2000.55	0.27	0.01
Channel Y + Input	200.80	0.64	0.32
Channel Y - Input	-200.23	-0.50	0.25
Channel Z + Input	1999.96	-0.17	-0.01
Channel Z + Input	198.86	-1.27	-0.63
Channel Z - Input	-201.15	-1.37	0.69

### 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	-5.02	-5.64
	- 200	6.48	5.20
Channel Y	200	-1.48	-1.57
	- 200	0.41	0.04
Channel Z	200	-11.81	-11.73
	- 200	9.10	9.26

### 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	-	-0.58	-3.14
Channel Y	200	9.32	-	-0.10
Channel Z	200	4.11	6.98	-

#### 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	16052	16596
Channel Y	16174	16055
Channel Z	16437	15803

#### 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	0.91	-0.00	1.57	0.34
Channel Y	-0.04	-1.67	1.95	0.65
Channel Z	-0.86	-2.30	0.32	0.53

#### 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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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Sporton - TW (Auden)**

Certificate No: **DAE3-577\_Sep15**

## CALIBRATION CERTIFICATE

Object **DAE3 - SD 000 D03 AA - SN: 577**

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

Calibration date: **September 24, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

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

Calibrated by: **Name**  
**Eric Hainfeld** **Function**  
**Technician**

Signature

Approved by: **Fin Bomholt** **Deputy Technical Manager**

Issued: September 24, 2015

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## Glossary

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

## Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The 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	403.446 $\pm$ 0.02% (k=2)	403.437 $\pm$ 0.02% (k=2)	403.736 $\pm$ 0.02% (k=2)
Low Range	3.92535 $\pm$ 1.50% (k=2)	3.94168 $\pm$ 1.50% (k=2)	3.95914 $\pm$ 1.50% (k=2)

## Connector Angle

Connector Angle to be used in DASY system	190.5 $^{\circ}$ $\pm$ 1 $^{\circ}$
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## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

High Range		Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X	+ Input	199995.86	-1.48	-0.00
Channel X	+ Input	20007.21	5.80	0.03
Channel X	- Input	-19998.31	2.42	-0.01
Channel Y	+ Input	199999.72	2.39	0.00
Channel Y	+ Input	20002.53	1.11	0.01
Channel Y	- Input	-20002.71	-1.82	0.01
Channel Z	+ Input	199995.10	-2.04	-0.00
Channel Z	+ Input	20006.23	4.73	0.02
Channel Z	- Input	-20003.91	-3.09	0.02

Low Range		Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X	+ Input	2001.43	0.02	0.00
Channel X	+ Input	202.06	0.44	0.22
Channel X	- Input	-197.82	0.31	-0.16
Channel Y	+ Input	2001.31	0.03	0.00
Channel Y	+ Input	200.80	-0.74	-0.37
Channel Y	- Input	-199.49	-1.23	0.62
Channel Z	+ Input	2001.27	0.00	0.00
Channel Z	+ Input	200.45	-1.10	-0.55
Channel Z	- Input	-199.34	-1.04	0.52

### 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	-1.89	-4.12
	- 200	6.38	4.04
Channel Y	200	-14.39	-14.89
	- 200	12.34	12.13
Channel Z	200	2.79	3.03
	- 200	-5.18	-5.07

### 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	-	-1.72	-2.80
Channel Y	200	8.34	-	0.63
Channel Z	200	5.50	4.75	-

#### 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	16134	16124
Channel Y	16105	16757
Channel Z	16127	16353

#### 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	-0.09	-1.04	1.17	0.38
Channel Y	-1.25	-2.69	0.19	0.55
Channel Z	-0.90	-2.06	0.17	0.46

#### 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 0108**

Client **Sporton-TW (Auden)**

Certificate No: **DAE4-1399\_Nov15**

## CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BM - SN: 1399**

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

Calibration date: **November 23, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

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

Calibrated by: Name **Dominique Steffen** Function **Technician**

Signature

Approved by: **Fin Bomholt** Deputy Technical Manager

Issued: November 23, 2015

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Accreditation No.: **SCS 0108**

## Glossary

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

## Methods Applied and Interpretation of Parameters

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

## DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1 $\mu$ 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	403.569 $\pm$ 0.02% (k=2)	403.830 $\pm$ 0.02% (k=2)	403.686 $\pm$ 0.02% (k=2)
Low Range	3.98186 $\pm$ 1.50% (k=2)	3.99005 $\pm$ 1.50% (k=2)	3.98036 $\pm$ 1.50% (k=2)

## Connector Angle

Connector Angle to be used in DASY system	303.0 $^{\circ}$ $\pm$ 1 $^{\circ}$
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## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

High Range		Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X	+ Input	200034.20	-1.95	-0.00
Channel X	+ Input	20004.24	-0.55	-0.00
Channel X	- Input	-20004.68	0.95	-0.00
Channel Y	+ Input	200034.75	-2.81	-0.00
Channel Y	+ Input	20002.71	-1.97	-0.01
Channel Y	- Input	-20006.72	-0.91	0.00
Channel Z	+ Input	200034.35	-2.72	-0.00
Channel Z	+ Input	20002.74	-1.91	-0.01
Channel Z	- Input	-20007.13	-1.44	0.01

Low Range		Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X	+ Input	2000.90	-0.02	-0.00
Channel X	+ Input	201.19	0.32	0.16
Channel X	- Input	-198.77	0.20	-0.10
Channel Y	+ Input	2000.69	-0.23	-0.01
Channel Y	+ Input	200.19	-0.57	-0.29
Channel Y	- Input	-199.64	-0.59	0.29
Channel Z	+ Input	2000.76	-0.09	-0.00
Channel Z	+ Input	199.54	-1.29	-0.64
Channel Z	- Input	-200.88	-1.78	0.90

### 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	-5.42	-6.82
	- 200	8.31	6.25
Channel Y	200	-5.59	-5.99
	- 200	4.78	4.49
Channel Z	200	-7.36	-7.21
	- 200	4.34	4.37

### 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	-	5.03	-1.50
Channel Y	200	9.40	-	5.92
Channel Z	200	8.43	7.65	-

#### 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	15830	16396
Channel Y	16113	15933
Channel Z	15887	15858

#### 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	0.38	-0.36	1.37	0.35
Channel Y	0.35	-0.44	1.17	0.34
Channel Z	-2.61	-3.42	-1.45	0.39

#### 6. Input Offset Current

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

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

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

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

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

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

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



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Client **Sporton-TW (Auden)**

Certificate No: **EX3-3925\_May15**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3925**

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 27, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

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

	Name	Function	Signature
Calibrated by:	Israe Elnaouq	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	
Issued: June 1, 2015			
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### Glossary:

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

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

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

### 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:3925

Manufactured: March 8, 2013  
Calibrated: May 27, 2015

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3925

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	0.59	0.52	0.50	± 10.1 %
DCP (mV) <sup>B</sup>	95.1	100.6	100.1	

### 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	129.8	±2.5 %
		Y	0.0	0.0	1.0		142.9	
		Z	0.0	0.0	1.0		137.5	

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:3925

### 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	10.15	10.15	10.15	0.28	1.18	± 12.0 %
835	41.5	0.90	9.80	9.80	9.80	0.31	1.05	± 12.0 %
900	41.5	0.97	9.59	9.59	9.59	0.26	1.26	± 12.0 %
1750	40.1	1.37	8.43	8.43	8.43	0.32	0.93	± 12.0 %
1900	40.0	1.40	8.18	8.18	8.18	0.36	0.80	± 12.0 %
2000	40.0	1.40	8.15	8.15	8.15	0.40	0.80	± 12.0 %
2150	39.7	1.53	7.89	7.89	7.89	0.35	0.80	± 12.0 %
2450	39.2	1.80	7.38	7.38	7.38	0.41	0.80	± 12.0 %
2600	39.0	1.96	7.17	7.17	7.17	0.36	0.92	± 12.0 %
3500	37.9	2.91	7.18	7.18	7.18	0.33	1.28	± 13.1 %
5200	36.0	4.66	5.35	5.35	5.35	0.35	1.80	± 13.1 %
5300	35.9	4.76	5.14	5.14	5.14	0.35	1.80	± 13.1 %
5500	35.6	4.96	4.79	4.79	4.79	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.68	4.68	4.68	0.40	1.80	± 13.1 %
5800	35.3	5.27	4.72	4.72	4.72	0.40	1.80	± 13.1 %

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

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

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3925

### 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	10.14	10.14	10.14	0.30	1.15	± 12.0 %
835	55.2	0.97	9.93	9.93	9.93	0.32	1.14	± 12.0 %
900	55.0	1.05	9.83	9.83	9.83	0.33	1.09	± 12.0 %
1750	53.4	1.49	8.10	8.10	8.10	0.39	0.85	± 12.0 %
1900	53.3	1.52	7.90	7.90	7.90	0.41	0.80	± 12.0 %
2000	53.3	1.52	8.01	8.01	8.01	0.34	0.86	± 12.0 %
2150	53.1	1.66	7.87	7.87	7.87	0.38	0.83	± 12.0 %
2450	52.7	1.95	7.54	7.54	7.54	0.24	0.80	± 12.0 %
2600	52.5	2.16	7.33	7.33	7.33	0.29	0.80	± 12.0 %
3500	51.3	3.31	6.67	6.67	6.67	0.25	1.98	± 13.1 %
5200	49.0	5.30	4.62	4.62	4.62	0.40	1.90	± 13.1 %
5300	48.9	5.42	4.43	4.43	4.43	0.40	1.90	± 13.1 %
5500	48.6	5.65	4.16	4.16	4.16	0.45	1.90	± 13.1 %
5600	48.5	5.77	4.10	4.10	4.10	0.45	1.90	± 13.1 %
5800	48.2	6.00	4.16	4.16	4.16	0.50	1.90	± 13.1 %

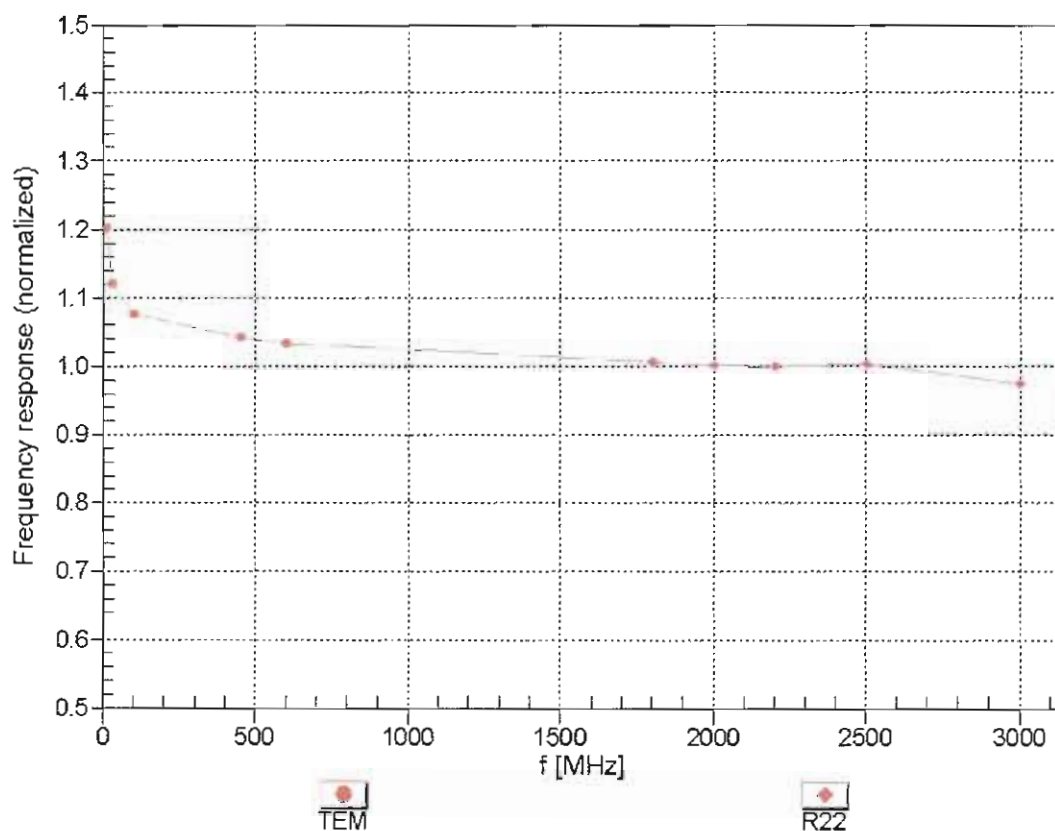
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below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

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

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



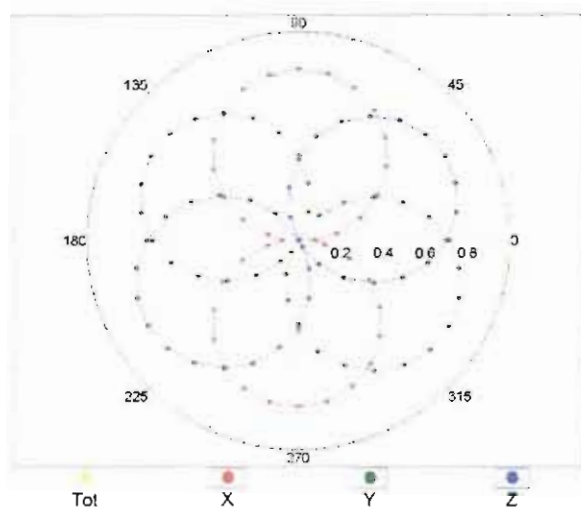
## Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



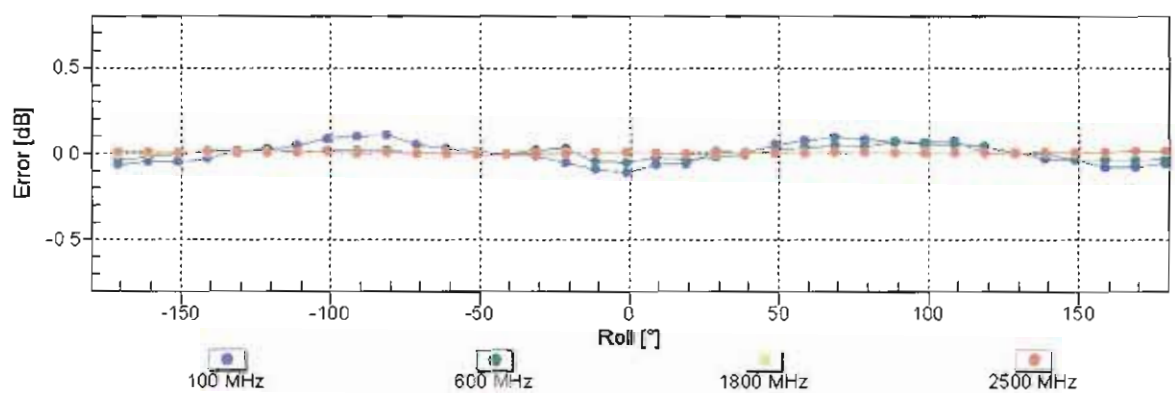
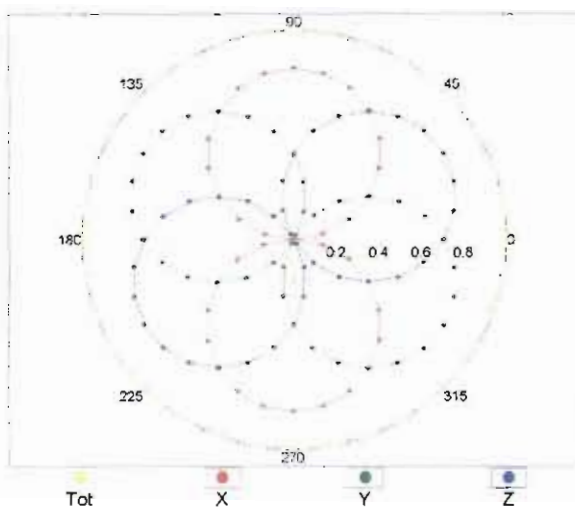
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz,TEM

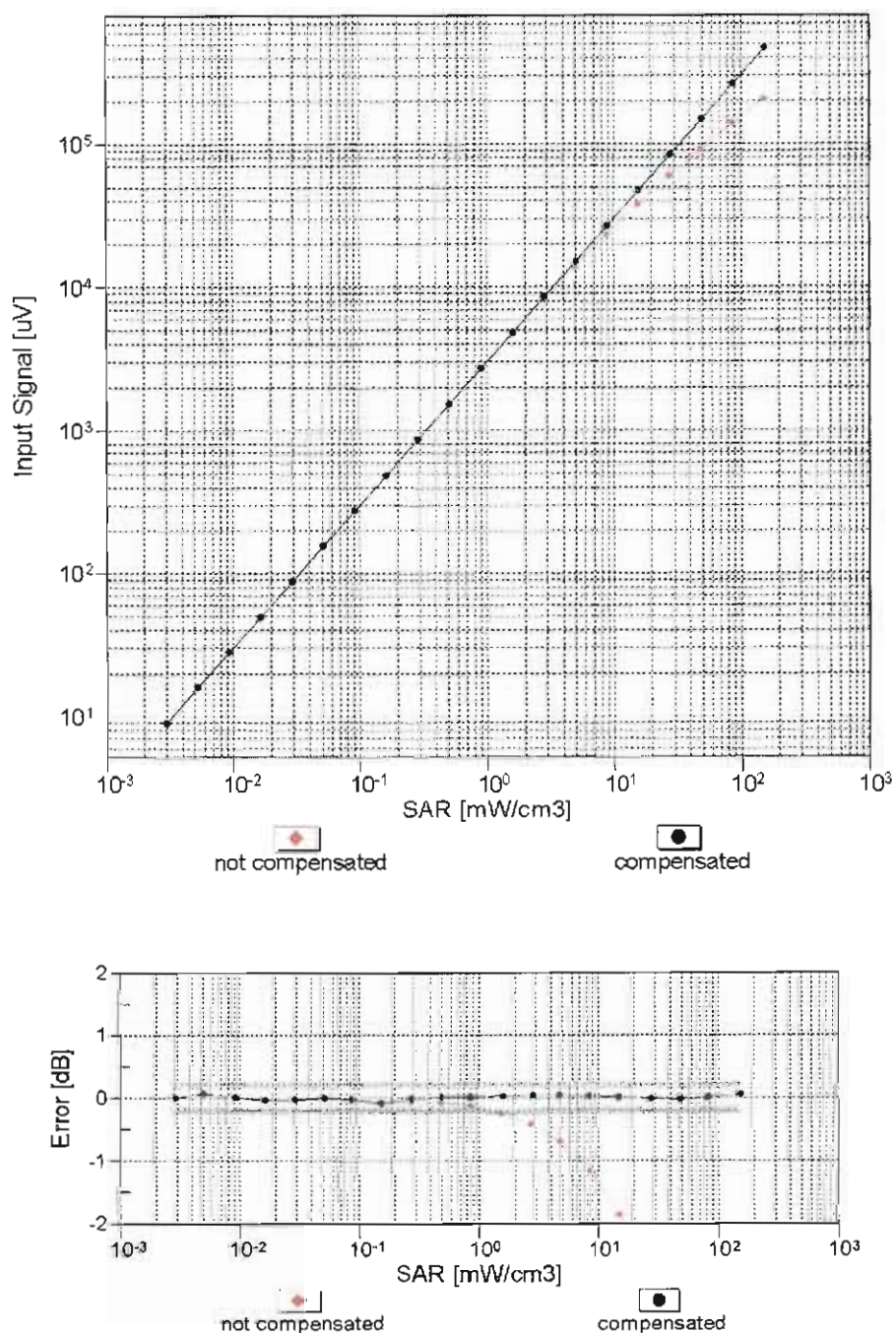


f=1800 MHz,R22



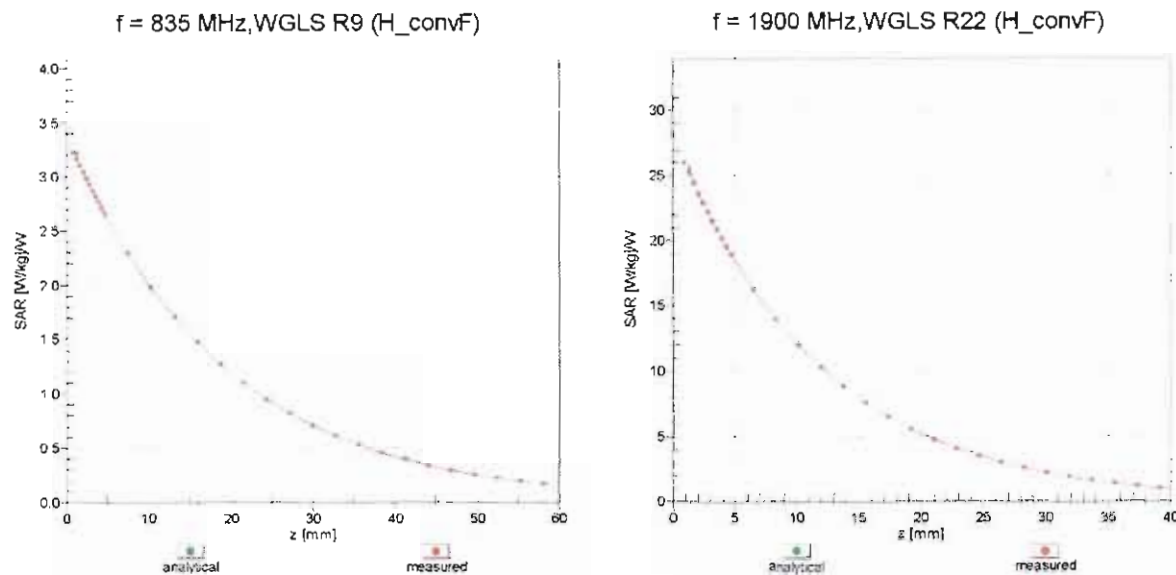
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

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



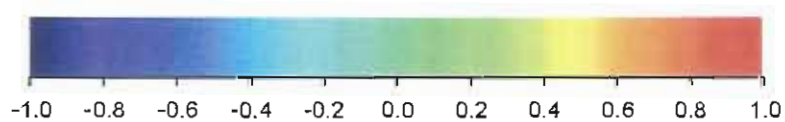
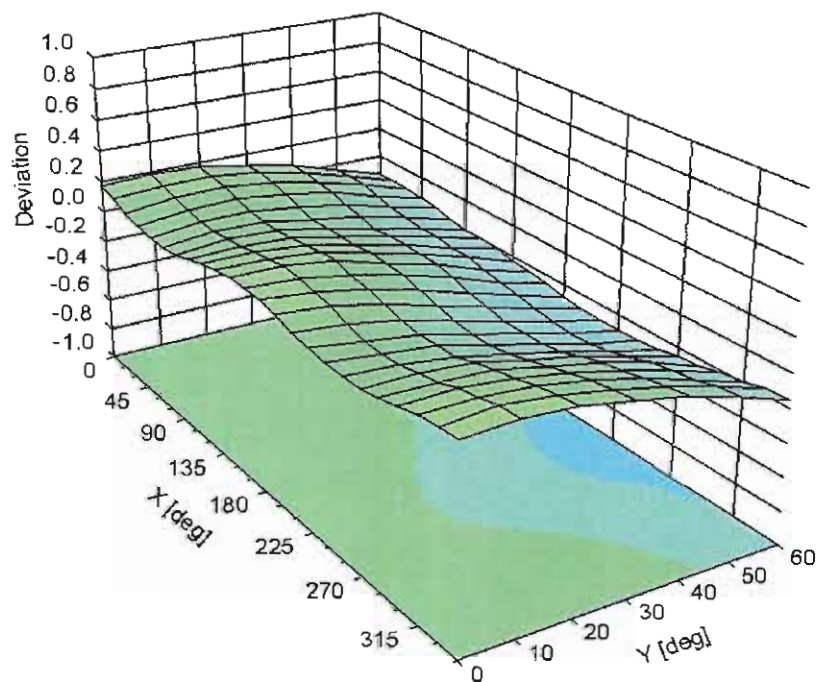
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



Uncertainty of Spherical Isotropy Assessment:  $\pm 2.6\%$  ( $k=2$ )

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3925

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	88.4
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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

Client **Sporton-TW (Auden)**

Certificate No: **ES3-3270\_Sep15**

## CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3270**

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

Calibration date: **September 28, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

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

	Name	Function	Signature
Calibrated by:	Israe Elnaouq	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	
Issued: September 30, 2015			
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			





Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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

### Glossary:

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

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

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not affect the E<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 ES3DV3

## SN:3270

Manufactured: February 25, 2010  
Calibrated: September 28, 2015

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



## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3270

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	1.10	1.19	1.21	± 10.1 %
DCP (mV) <sup>B</sup>	102.9	106.4	103.6	

### 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	193.7	±3.0 %
		Y	0.0	0.0	1.0		212.5	
		Z	0.0	0.0	1.0		204.6	

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

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

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

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

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3270

### Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
750	41.9	0.89	6.50	6.50	6.50	0.32	1.98	± 12.0 %
835	41.5	0.90	6.32	6.32	6.32	0.52	1.47	± 12.0 %
900	41.5	0.97	6.16	6.16	6.16	0.47	1.53	± 12.0 %
1750	40.1	1.37	5.32	5.32	5.32	0.71	1.25	± 12.0 %
1900	40.0	1.40	5.12	5.12	5.12	0.80	1.20	± 12.0 %
2000	40.0	1.40	5.12	5.12	5.12	0.60	1.38	± 12.0 %
2450	39.2	1.80	4.59	4.59	4.59	0.70	1.39	± 12.0 %
2600	39.0	1.96	4.44	4.44	4.44	0.73	1.37	± 12.0 %

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

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

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

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3270

### Calibration Parameter Determined in Body Tissue Simulating Media

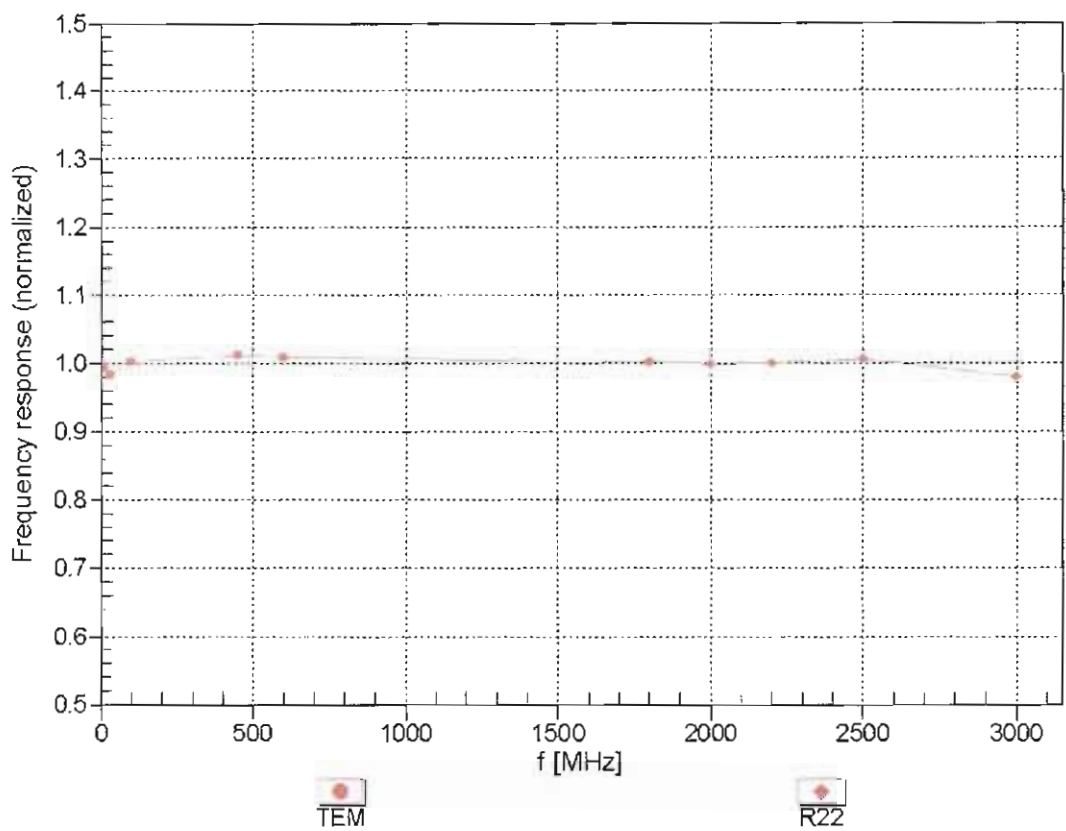
f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
750	55.5	0.96	6.30	6.30	6.30	0.43	1.61	± 12.0 %
835	55.2	0.97	6.24	6.24	6.24	0.30	2.13	± 12.0 %
1750	53.4	1.49	4.95	4.95	4.95	0.64	1.38	± 12.0 %
1900	53.3	1.52	4.78	4.78	4.78	0.64	1.43	± 12.0 %
2450	52.7	1.95	4.37	4.37	4.37	0.80	1.24	± 12.0 %
2600	52.5	2.16	4.27	4.27	4.27	0.80	1.20	± 12.0 %

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

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

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

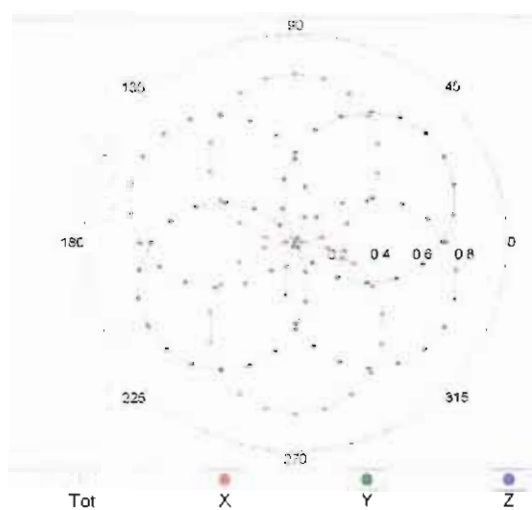
**Frequency Response of E-Field**  
(TEM-Cell:ifi110 EXX, Waveguide: R22)



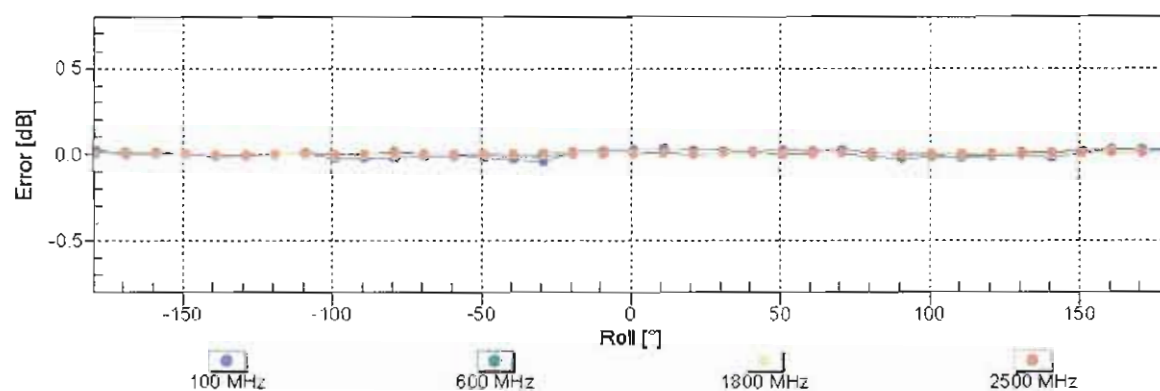
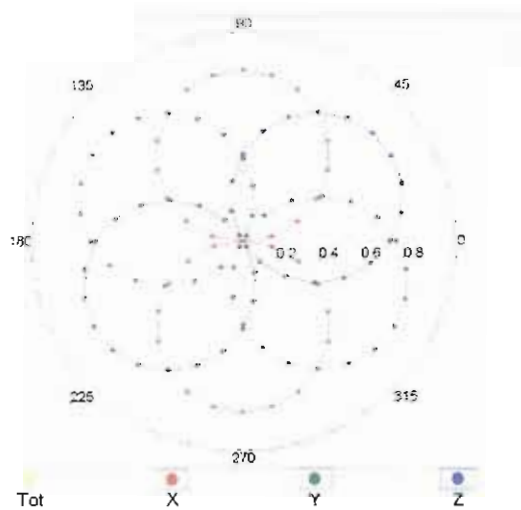
**Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )**

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

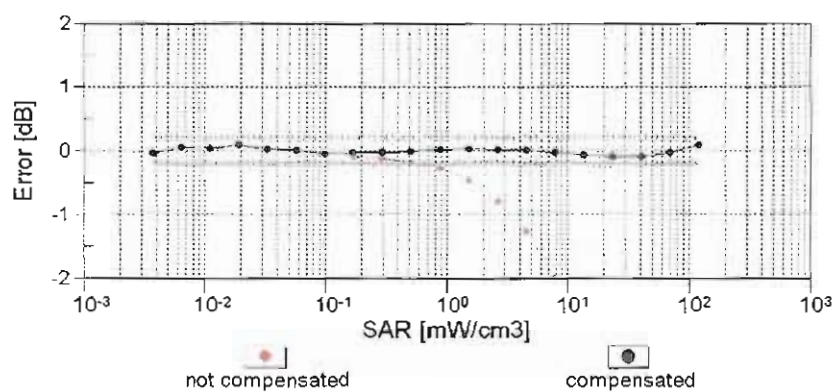
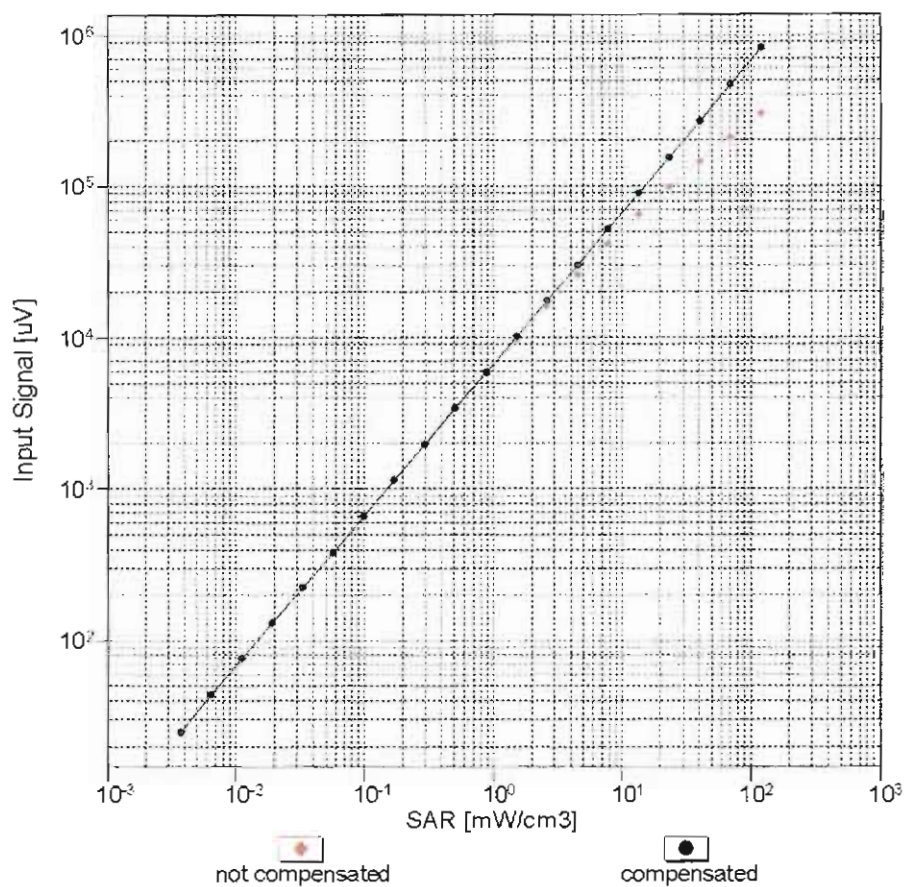
f=600 MHz,TEM



f=1800 MHz,R22

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

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

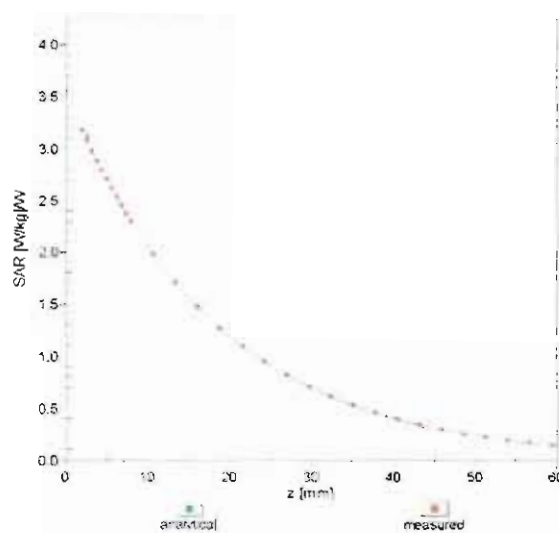


Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

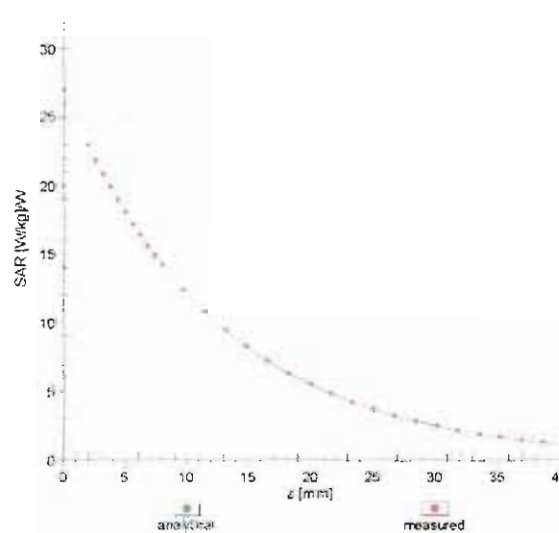


## Conversion Factor Assessment

$f = 900 \text{ MHz}$ , WGLS R9 (H\_convF)

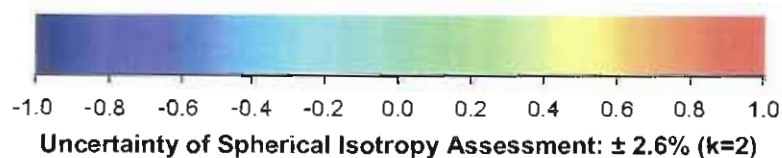
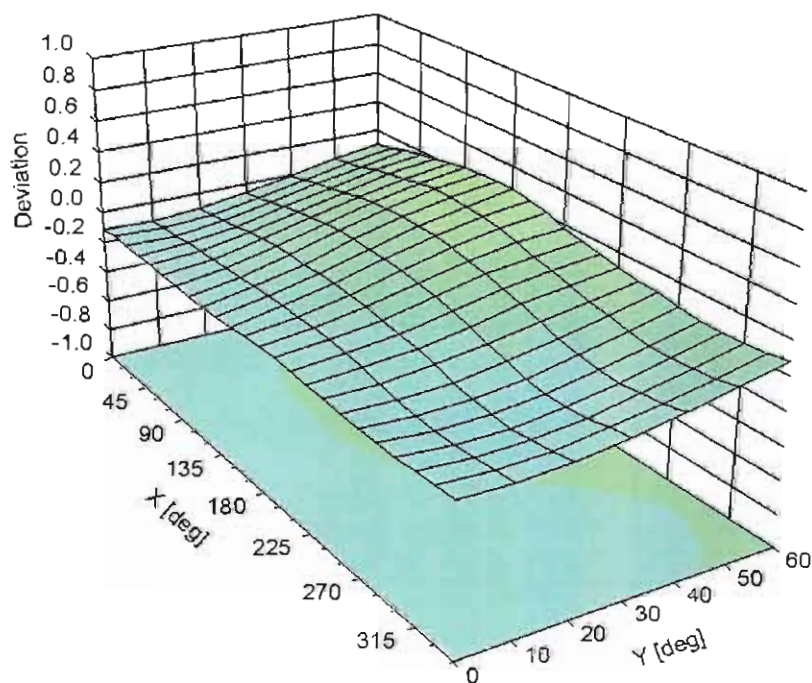


$f = 1750 \text{ MHz}$ , WGLS R22 (H\_convF)



## Deviation from Isotropy in Liquid

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



**DASY/EASY - Parameters of Probe: ES3DV3 - SN:3270****Other Probe Parameters**

Sensor Arrangement	Triangular
Connector Angle (°)	-18.7
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	4 mm
Probe Tip to Sensor X Calibration Point	2 mm
Probe Tip to Sensor Y Calibration Point	2 mm
Probe Tip to Sensor Z Calibration Point	2 mm
Recommended Measurement Distance from Surface	3 mm





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Client **Sporton-TW (Auden)**

Certificate No: **EX3-3931\_Oct15**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3931**

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: **October 1, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

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

	Name	Function	Signature
Calibrated by:	Israe Elnaouq	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	
Issued: October 2, 2015			
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			



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### Glossary:

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

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

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Methods Applied and Interpretation of Parameters:

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

# Probe EX3DV4

## SN:3931

Manufactured: July 24, 2013  
Calibrated: October 1, 2015

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3931

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	0.41	0.59	0.49	± 10.1 %
DCP (mV) <sup>B</sup>	102.9	100.1	104.7	

### Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc <sup>E</sup> (k=2)
0	CW	X	0.0	0.0	1.0	0.00	143.3	±2.7 %
		Y	0.0	0.0	1.0		153.8	
		Z	0.0	0.0	1.0		158.8	

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

<sup>A</sup> The uncertainties of Norm X,Y,Z do not affect the E<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:3931

### Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
750	41.9	0.89	10.46	10.46	10.46	0.23	1.33	± 12.0 %
835	41.5	0.90	10.04	10.04	10.04	0.29	1.19	± 12.0 %
900	41.5	0.97	9.83	9.83	9.83	0.27	1.25	± 12.0 %
1450	40.5	1.20	8.36	8.36	8.53	0.18	1.55	± 12.0 %
1750	40.1	1.37	8.58	8.58	8.58	0.36	0.80	± 12.0 %
1900	40.0	1.40	8.31	8.31	8.31	0.36	0.80	± 12.0 %
2000	40.0	1.40	8.33	8.33	8.33	0.36	0.85	± 12.0 %
2300	39.5	1.67	7.85	7.85	7.85	0.34	0.80	± 12.0 %
2450	39.2	1.80	7.51	7.51	7.51	0.37	0.85	± 12.0 %
2600	39.0	1.96	7.29	7.29	7.29	0.41	0.80	± 12.0 %
5250	35.9	4.71	5.13	5.13	5.13	0.40	1.80	± 14.0 %
5600	35.5	5.07	4.42	4.42	4.42	0.45	1.80	± 14.0 %
5750	35.4	5.22	4.58	4.58	4.58	0.45	1.80	± 14.0 %

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

<sup>F</sup> At frequencies up to 6 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. 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:3931

### Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
750	55.5	0.96	10.29	10.29	10.29	0.25	1.43	± 12.0 %
835	55.2	0.97	10.13	10.13	10.13	0.28	1.14	± 12.0 %
1450	54.0	1.30	8.41	8.41	8.41	0.19	1.49	± 12.0 %
1750	53.4	1.49	8.19	8.19	8.19	0.30	0.99	± 12.0 %
1900	53.3	1.52	7.94	7.94	7.94	0.44	0.80	± 12.0 %
2300	52.9	1.81	7.70	7.70	7.70	0.42	0.86	± 12.0 %
2450	52.7	1.95	7.54	7.54	7.54	0.40	0.85	± 12.0 %
2600	52.5	2.16	7.38	7.38	7.38	0.35	0.95	± 12.0 %
5250	48.9	5.36	4.48	4.48	4.48	0.50	1.90	± 14.0 %
5600	48.5	5.77	3.84	3.84	3.84	0.55	1.90	± 14.0 %
5750	48.3	5.94	3.98	3.98	3.98	0.55	1.90	± 14.0 %

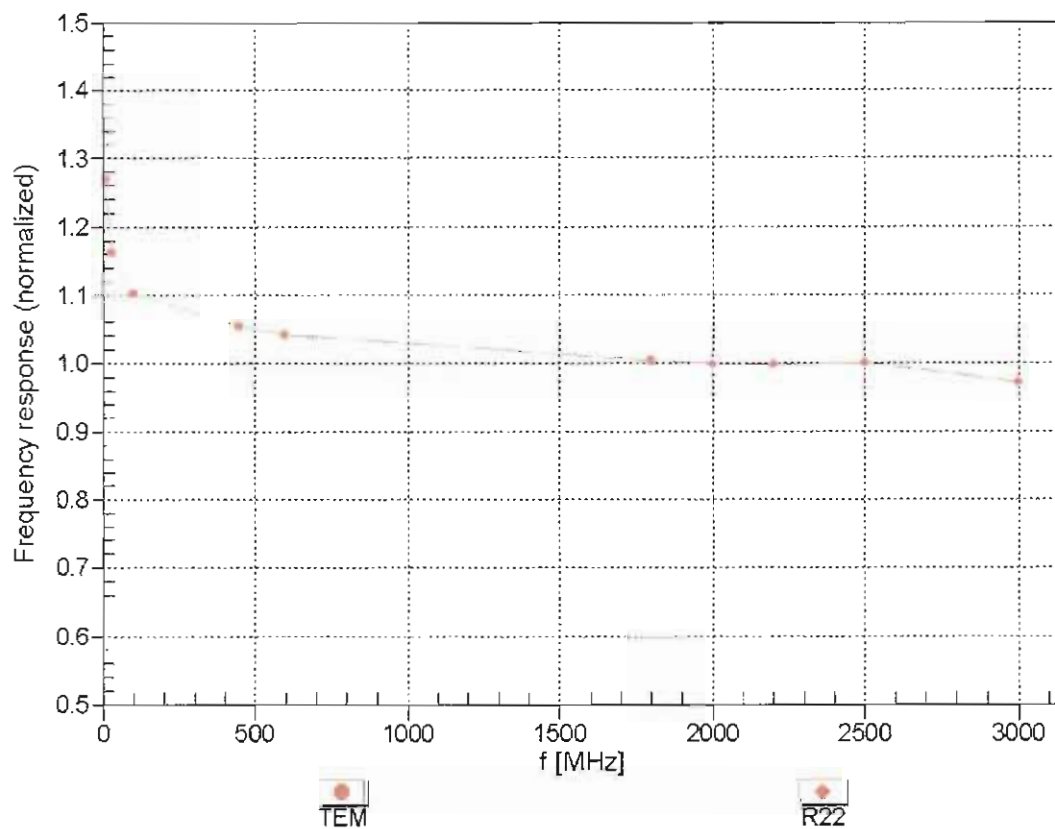
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below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

<sup>F</sup> At frequencies up to 6 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. 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

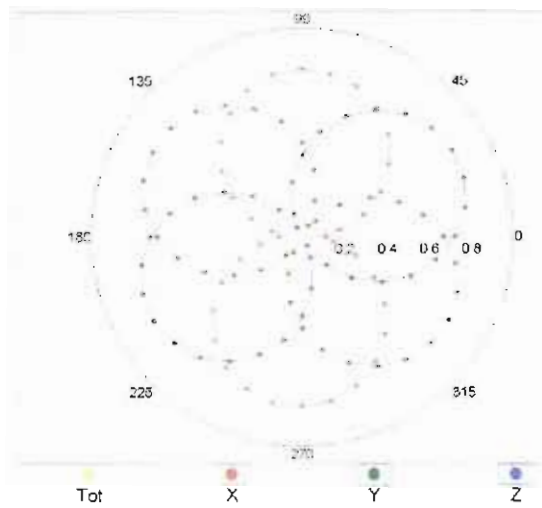
(TEM-Cell:ifi110 EXX, Waveguide: R22)



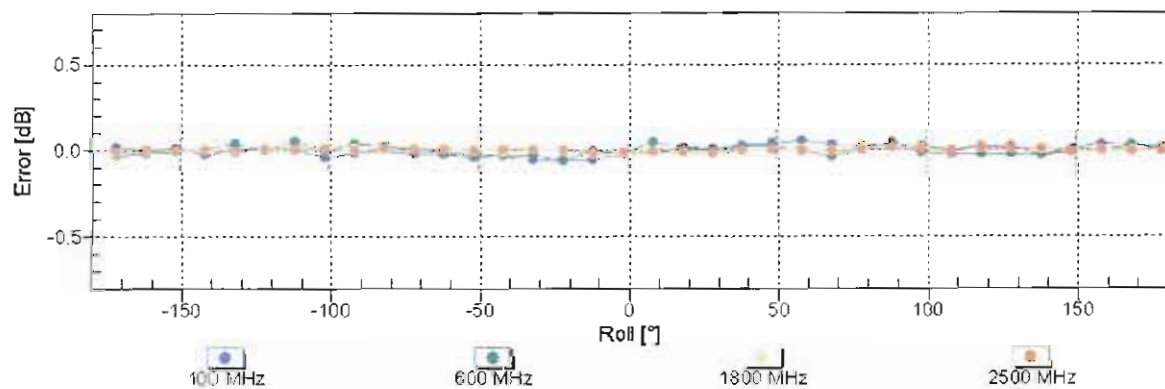
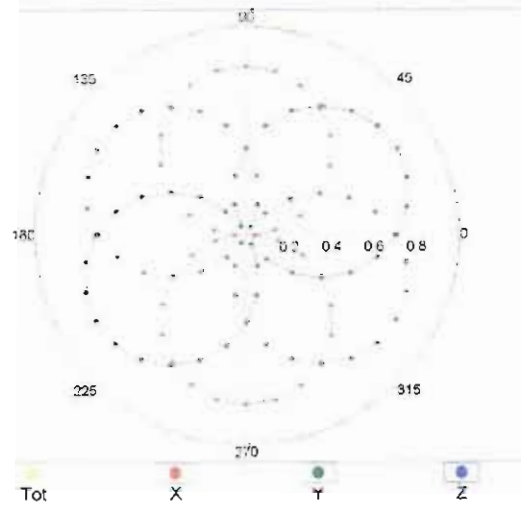
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz,TEM



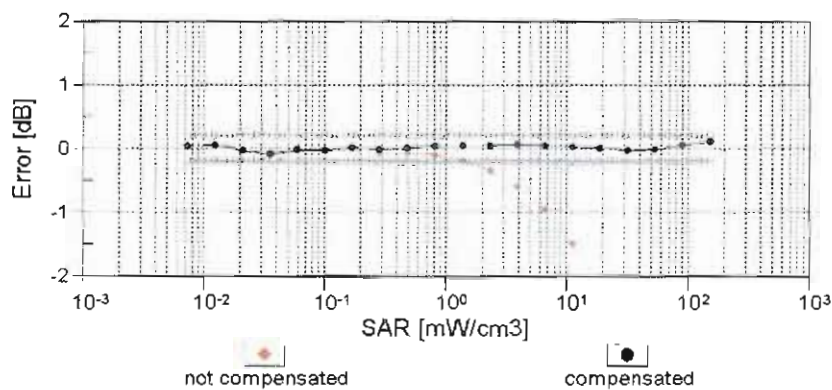
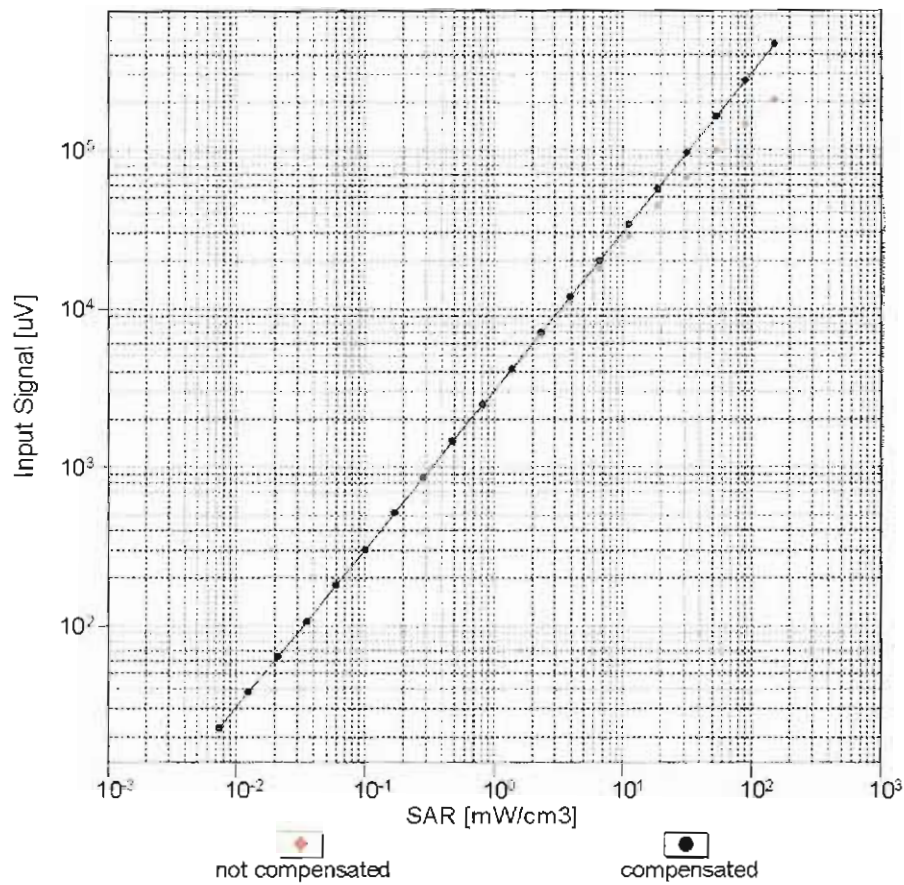
f=1800 MHz,R22



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

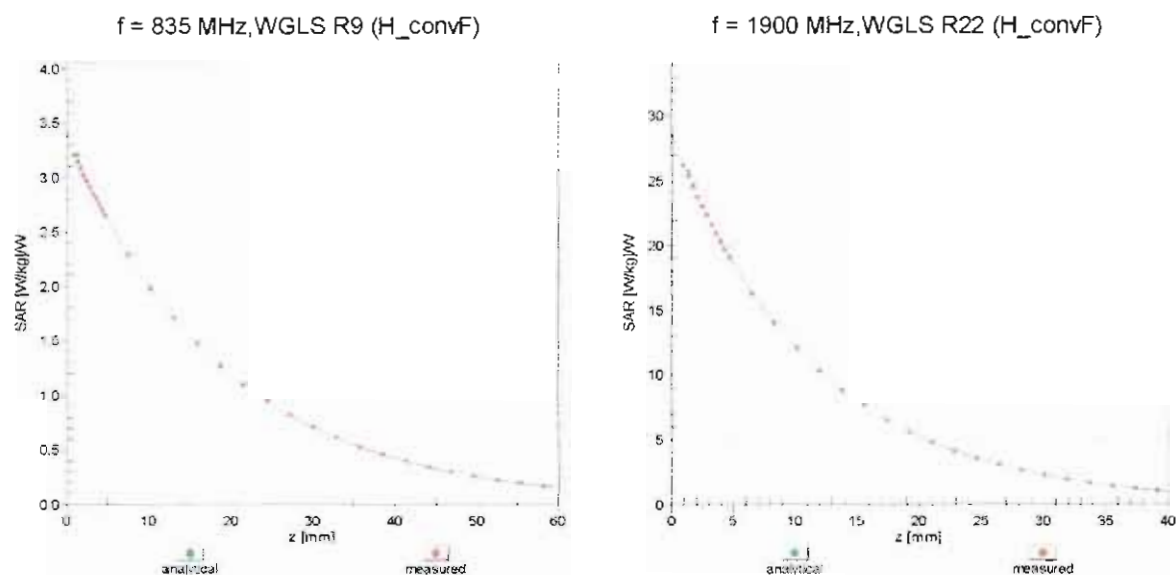


# Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell , $f_{\text{eval}} = 1900 \text{ MHz}$ )



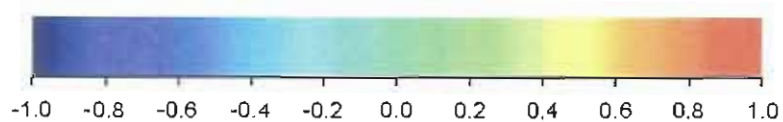
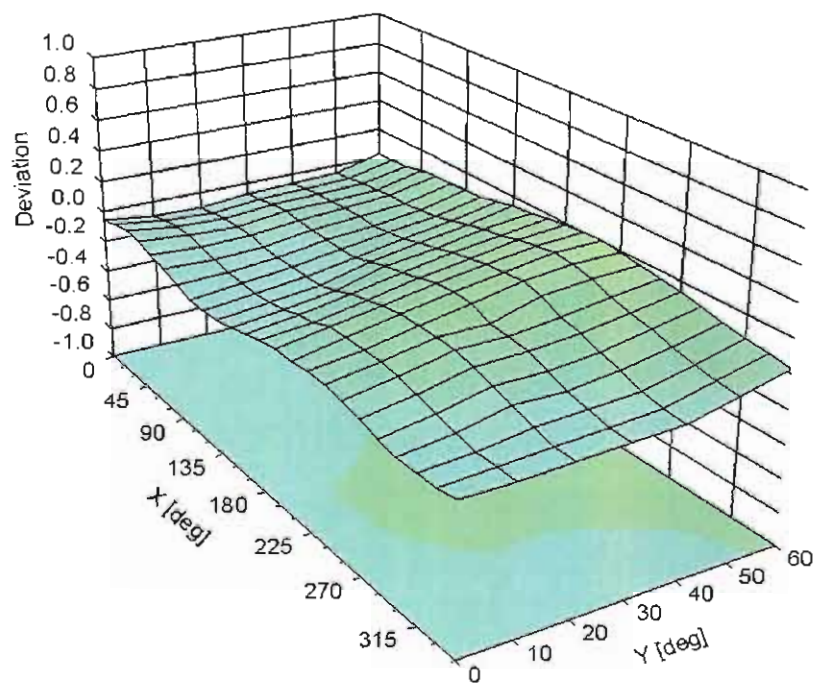
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



Uncertainty of Spherical Isotropy Assessment:  $\pm 2.6\%$  ( $k=2$ )

**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3931****Other Probe Parameters**

Sensor Arrangement	Triangular
Connector Angle (°)	-11.6
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm



Accreditation No.: **SCS 0108**

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

Client **Sporton-TW (Auden)**

Certificate No: **EX3-3955\_Nov15**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3955**

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: **November 24, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

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

	Name	Function	Signature
Calibrated by:	Claudio Leubler	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	
Issued: November 26, 2015			
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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

## Glossary:

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

## Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

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



# Probe EX3DV4

## SN:3955

Manufactured: August 6, 2013  
Calibrated: November 24, 2015

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3955

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	0.35	0.41	0.31	$\pm 10.1 \%$
DCP (mV) <sup>B</sup>	103.2	104.2	98.2	

### 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	130.3	$\pm 3.3 \%$
		Y	0.0	0.0	1.0		120.0	
		Z	0.0	0.0	1.0		132.8	

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

<sup>A</sup> The uncertainties of Norm X,Y,Z do not affect the  $E^2$ -field uncertainty inside TSL (see 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:3955

### Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
750	41.9	0.89	10.31	10.31	10.31	0.19	1.73	± 12.0 %
835	41.5	0.90	9.96	9.96	9.96	0.18	1.78	± 12.0 %
900	41.5	0.97	9.73	9.73	9.73	0.18	1.89	± 12.0 %
1750	40.1	1.37	8.69	8.69	8.69	0.26	0.85	± 12.0 %
1900	40.0	1.40	8.32	8.32	8.32	0.32	0.88	± 12.0 %
2000	40.0	1.40	8.24	8.24	8.24	0.25	1.01	± 12.0 %
2450	39.2	1.80	7.36	7.36	7.36	0.29	0.98	± 12.0 %
2600	39.0	1.96	7.20	7.20	7.20	0.29	0.99	± 12.0 %
5250	35.9	4.71	5.08	5.08	5.08	0.35	1.80	± 14.0 %
5600	35.5	5.07	4.39	4.39	4.39	0.50	1.80	± 14.0 %
5750	35.4	5.22	4.41	4.41	4.41	0.50	1.80	± 14.0 %

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

<sup>F</sup> At frequencies up to 6 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. 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:3955

### Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity (S/m) <sup>F</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k=2)
750	55.5	0.96	10.36	10.36	10.36	0.25	1.29	± 12.0 %
835	55.2	0.97	10.08	10.08	10.08	0.24	1.39	± 12.0 %
1750	53.4	1.49	8.25	8.25	8.25	0.42	0.80	± 12.0 %
1900	53.3	1.52	7.89	7.89	7.89	0.38	0.89	± 12.0 %
2450	52.7	1.95	7.53	7.53	7.53	0.60	0.70	± 12.0 %
2600	52.5	2.16	7.23	7.23	7.23	0.27	0.99	± 12.0 %
5250	48.9	5.36	4.42	4.42	4.42	0.50	1.90	± 14.0 %
5600	48.5	5.77	3.81	3.81	3.81	0.60	1.90	± 14.0 %
5750	48.3	5.94	3.92	3.92	3.92	0.60	1.90	± 14.0 %

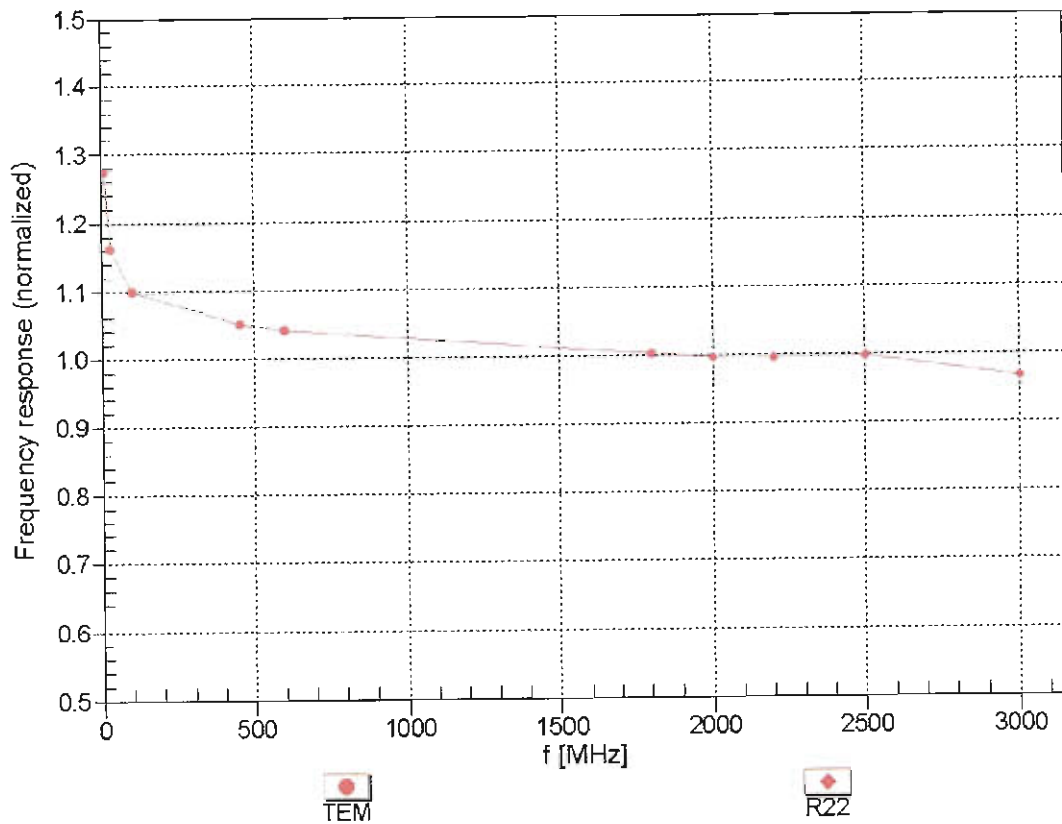
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below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

<sup>F</sup> At frequencies up to 6 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. 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

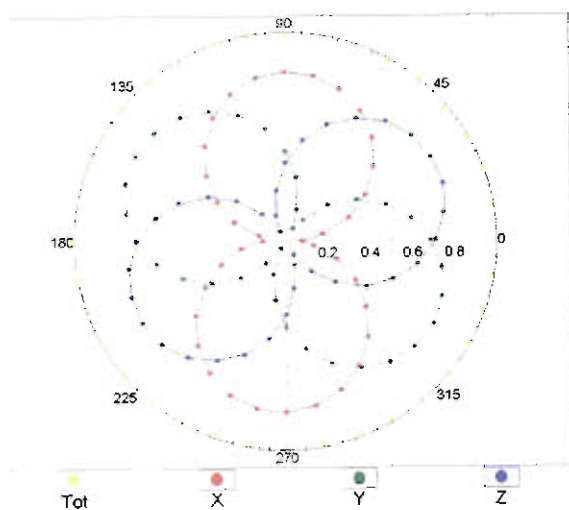
(TEM-Cell:ifi110 EXX, Waveguide: R22)



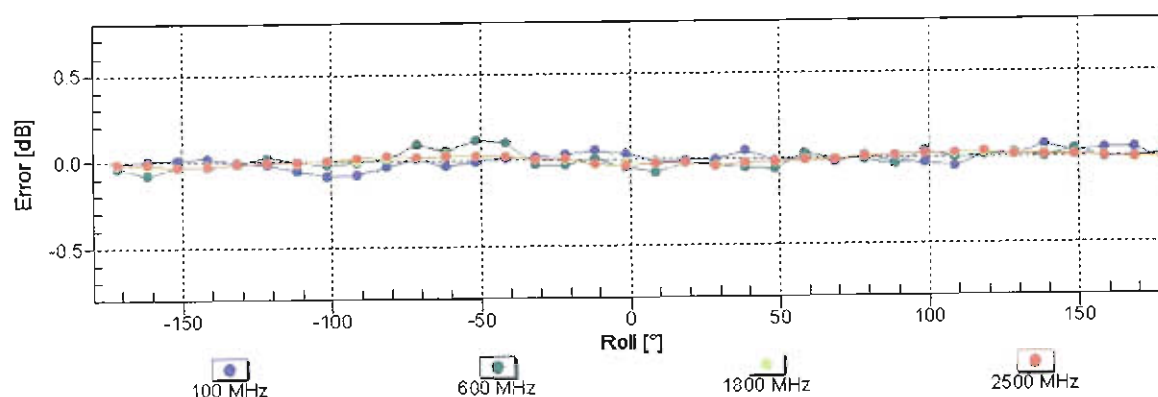
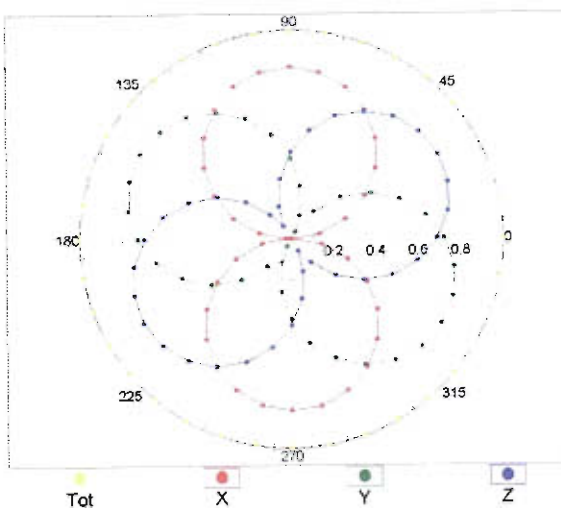
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz,TEM



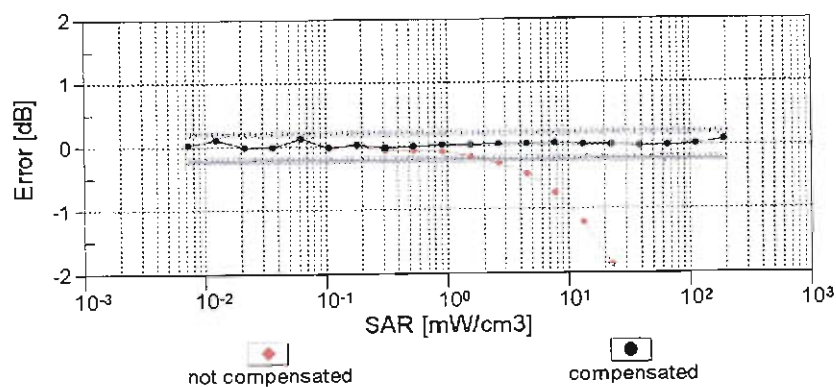
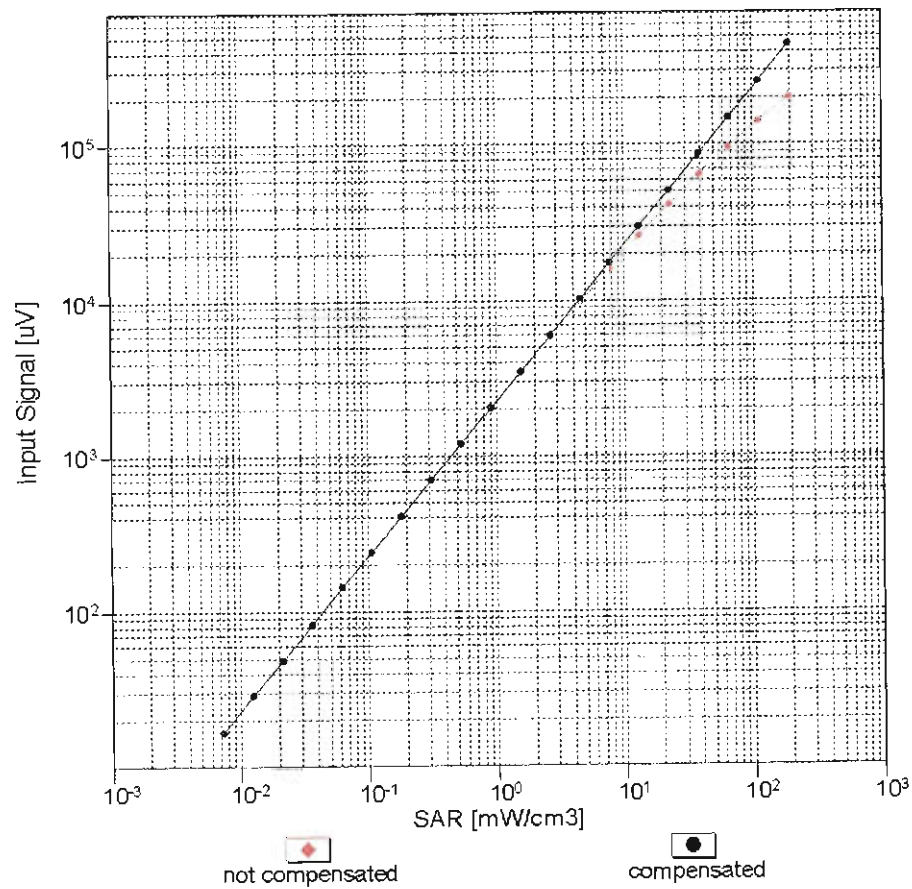
f=1800 MHz,R22



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

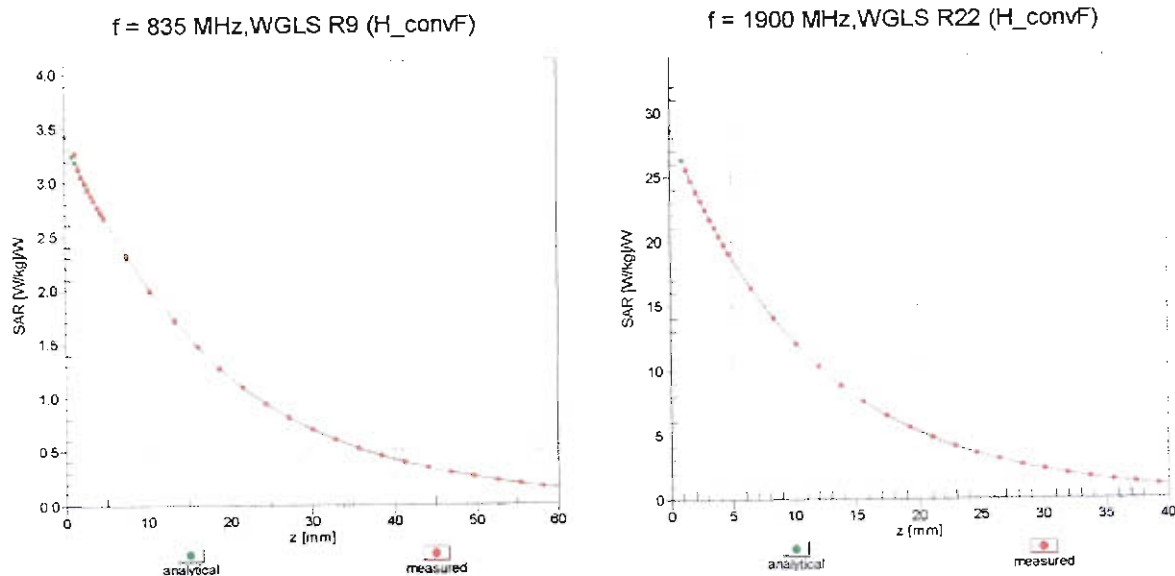
# Dynamic Range f(SAR<sub>head</sub>)

(TEM cell , f<sub>eval</sub>= 1900 MHz)



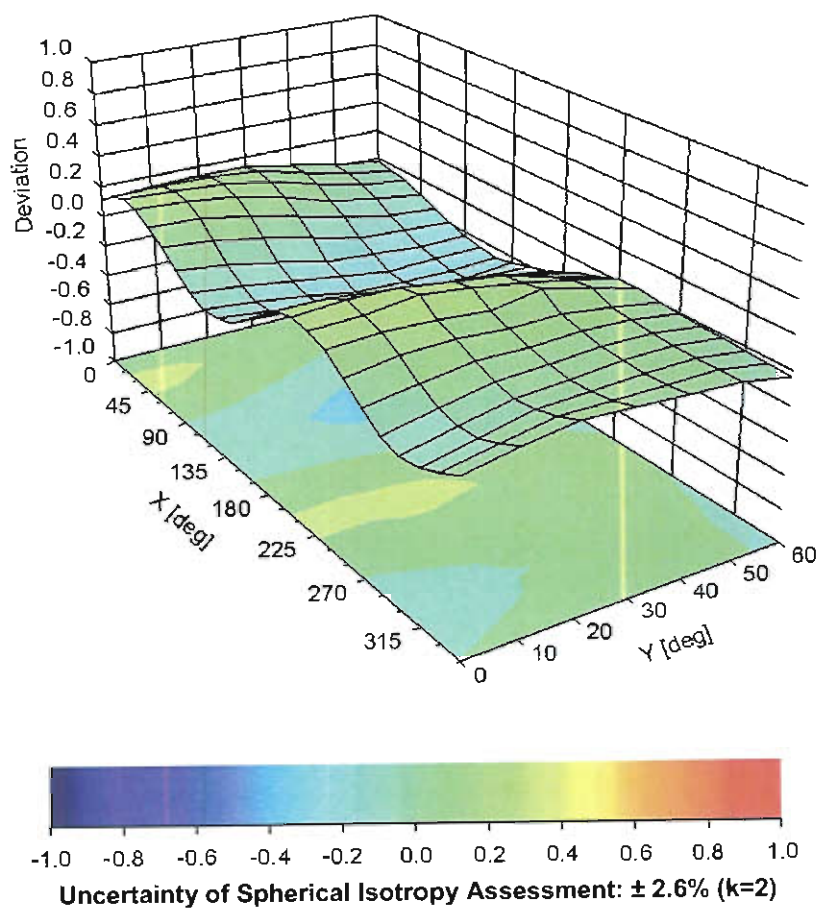
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  (k=2)

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3955

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	128.5
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm