



SAR EVALUATION REPORT

**FCC 47 CFR § 2.1093
IEEE Std. 1528-2013**

For
Action Camera

**FCC ID: 2AH6P-HSC0001
Model Name: snapcam360**

**Report Number: 4787440077-1-SAR
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Revision History



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V1.0	7/5/2016	Initial Issue	--

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1. Attestation of Test Results

Applicant Name	Miracle Elite (HK) Limited
FCC ID	2AH6P-HSC0001
Model Name	snapcam360
Applicable Standards	FCC 47 CFR § 2.1093 Published RF exposure KDB procedures IEEE Std 1528-2013
SAR Limits (W/Kg)	
Exposure Category	Peak spatial-average(1g of tissue)
General population / Uncontrolled exposure	1.6
The Highest Reported SAR (W/kg)	
RF Exposure Conditions	Equipment Class
	DTS
Body-worn	0.633
Hotspot	1.074
Date Tested	6/16/2016 to 6/16/2016; 7/5/2016 to 7/5/2016
Test Results	Pass
<p>UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.</p> <p>Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NALAP, NIST, any agency of the Federal Government, or any agency of any government. This report is written to support regulatory compliance of the applicable standards stated above.</p>	
Approved & Released By:	Prepared By:
	
Approved & Released By: Shawn Wen	Prepared By: James Qin

2. Test Specification, Methods and Procedures

The tests documented in this report were performed in accordance with FCC 47 CFR § 2.1093, IEEE Std. 1528-2013, the following FCC Published RF exposure KDB procedures:

- 248227 D01 802.11 Wi-Fi SAR
- 447498 D01 General RF Exposure Guidance
- 690783 D01 SAR Listings on Grants
- 865664 D01 SAR measurement 100 MHz to 6 GHz
- 865664 D02 RF Exposure Reporting
- 941225 D06 Hotspot Mode

3. Facilities and Accreditation

The test site and measurement facilities used to collect data are located at

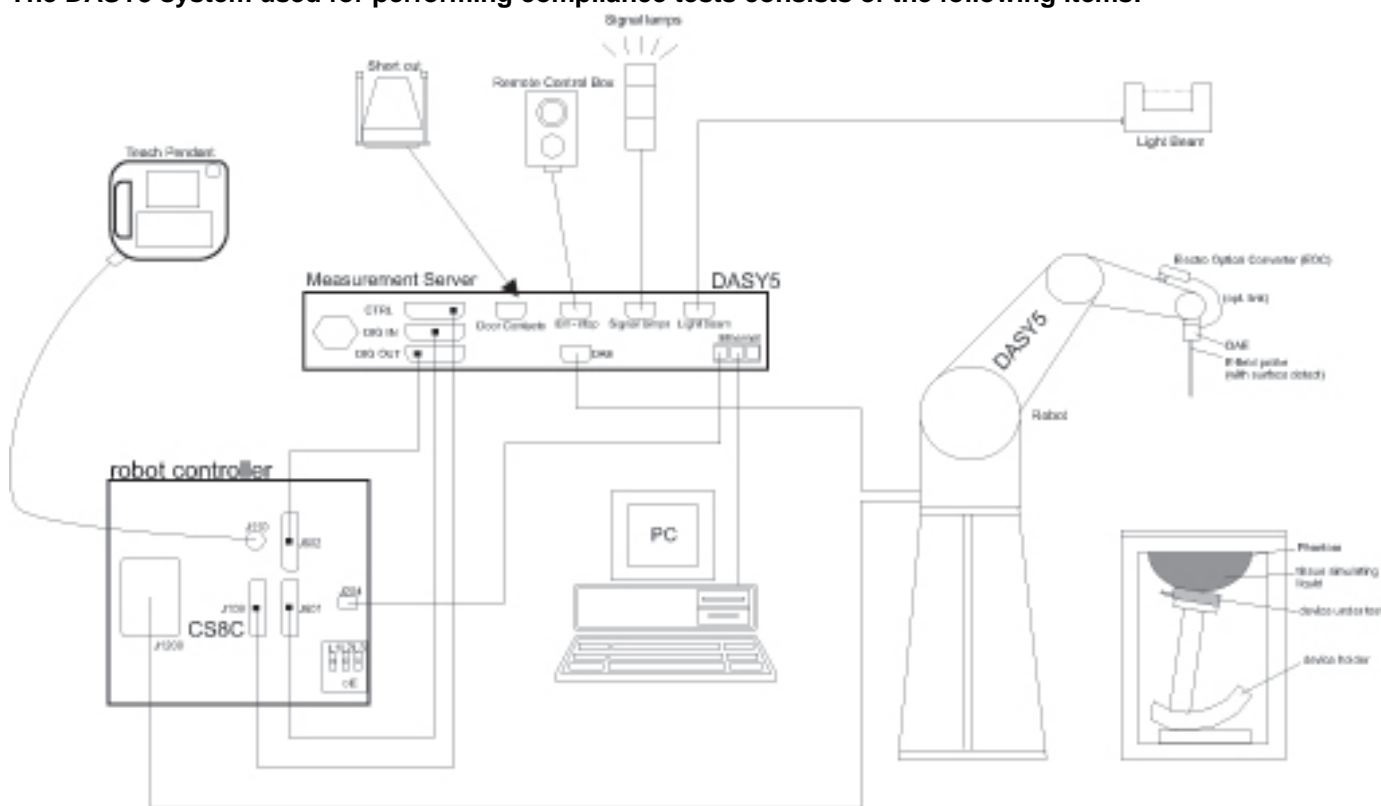
Ground Floor
SAR Test Room A

UL Verification Services Inc. is accredited by IAS & A2LA. Laboratory code TL-702 & 4102.01 respectively.

4. SAR Measurement System & Test Equipment

4.1. SAR Measurement System

The DASY5 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 Win7 and the DASY52 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.

4.2. SAR Scan Procedures

Step 1: 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. The minimum distance of probe sensors to surface is 2.1 mm. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

Step 2: 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 locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maximal 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 KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

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

Step 3: Zoom Scan

Zoom Scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g 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 g and 10 g and displays these values next to the job's label.

Zoom Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

			≤ 3 GHz	> 3 GHz
Maximum zoom scan spatial resolution: $\Delta x_{\text{Zoom}}, \Delta y_{\text{Zoom}}$			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{\text{Zoom}}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{\text{Zoom}}(1)$: between 1 st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 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		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm
Note: δ 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 area scan based <i>1-g SAR estimation</i> procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 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.				

Step 4: Power drift measurement

The Power Drift Measurement measures the field at the same location as the most recent power reference measurement within the same procedure, and with the same settings. The Power Drift Measurement gives the field difference in dB from the reading conducted within the last Power Reference Measurement. This allows a user to monitor the power drift of the device under test within a batch process. The measurement procedure is the same as Step 1.

Step 5: Z-Scan (FCC only)

The Z Scan measures points along a vertical straight line. The line runs along the Z-axis of a one-dimensional grid. In order to get a reasonable extrapolation the extrapolated distance should not be larger than the step size in Z-direction.

4.3. Test Equipment

The measuring equipment used to perform the tests documented in this report has been calibrated in accordance with the manufacturers' recommendations, and is traceable to recognized national standards.

	Name of equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
<input checked="" type="checkbox"/>	ENA Network Analyzer	Keysight	E5080A	MY55100583	2\26\1017
<input checked="" type="checkbox"/>	Dielectric Probe kit	SPEAG	SM DAK 040 SA	1155	NCR
<input checked="" type="checkbox"/>	DC power supply	Keysight	E36103A	MY55350020	2\27\1017
<input checked="" type="checkbox"/>	Signal Generator	Rohde & Schwarz	SME06	837633\001	5\18\1017
<input checked="" type="checkbox"/>	BI-Directional Coupler	WERLATONE	C8060-102	3423	2\26\1017
<input checked="" type="checkbox"/>	Peak and Average Power Sensor	Keysight	E9323A	MY55440013	2\26\1017
<input checked="" type="checkbox"/>	Peak and Average Power Sensor	Keysight	E9323A	MY55420006	2\26\1017
<input checked="" type="checkbox"/>	Dual Channel PK Power Meter	Keysight	N1912A	MY55416024	2\26\1017
<input checked="" type="checkbox"/>	Amplifier	CORAD TECHNOLOGY LTD	AMF-4D-00400600-50-30P	1983561	NCR
<input checked="" type="checkbox"/>	Dosimetric E-Field Probe	SPEAG	EX3DV4	7383	1\18\1017
<input checked="" type="checkbox"/>	Data Acquisition Electronic	SPEAG	DAE3	427	1\25\1017
<input type="checkbox"/>	Base Station Simulator	Rohde & Schwarz	CMW500	155523	12\30\2016
<input type="checkbox"/>	Dipole Kit 750 MHz	SPEAG	D750V3	1153	1\15\2019
<input type="checkbox"/>	Dipole Kit 835 MHz	SPEAG	D835V2	4d206	1\15\2019
<input type="checkbox"/>	Dipole Kit 900 MHz	SPEAG	D900V2	1d190	1\15\2019
<input type="checkbox"/>	Dipole Kit 1450 MHz	SPEAG	D1450V2	1064	1\11\2019
<input type="checkbox"/>	Dipole Kit 1800 MHz	SPEAG	D1800V2	2d212	1\11\2019
<input type="checkbox"/>	Dipole Kit 1900 MHz	SPEAG	D1900V2	5d212	1\14\2019
<input type="checkbox"/>	Dipole Kit 2100 MHz	SPEAG	D2100V2	1046	1\14\2019
<input type="checkbox"/>	Dipole Kit 2300 MHz	SPEAG	D2300V2	1065	1\14\2019
<input checked="" type="checkbox"/>	Dipole Kit 2450 MHz	SPEAG	D2450V2	977	1\14\2019
<input type="checkbox"/>	Dipole Kit 2600 MHz	SPEAG	D2600V2	1117	1\14\2019
<input type="checkbox"/>	Dipole Kit 3500 MHz	SPEAG	D3500V2	1047	1\13\2019
<input type="checkbox"/>	Dipole Kit 3700 MHz	SPEAG	D3700V2	1013	1\13\2019
<input type="checkbox"/>	Dipole Kit 5 GHz	SPEAG	D5GHzV2	1231	1\13\2019
<input checked="" type="checkbox"/>	Software	SPEAG	DASY52	N/A	NCR
<input checked="" type="checkbox"/>	Twin Phantom	SPEAG	SAM V5.0	1805	NCR
<input type="checkbox"/>	Flat Phantom	SPEAG	ELI V5.0	1235	NCR
<input checked="" type="checkbox"/>	Thermometer	Control Company	4242	150709653	02\26\2017
<input checked="" type="checkbox"/>	Thermometer	VICTOR	VC230	/	07\03\2017

Note:

1) Per KDB865664D01 requirements for dipole calibration, the test laboratory has adopted three-year extended calibration interval. Each measured dipole is expected to evaluate with the following criteria at least on annual interval in Appendix C.

- There is no physical damage on the dipole;
- System check with specific dipole is within 10% of calibrated value;
- The most recent return-loss result, measured at least annually, deviates by no more than 20% from the previous measurement.
- The most recent measurement of the real or imaginary parts of the impedance, measured at least

annually is within 5Ω from the previous measurement.

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

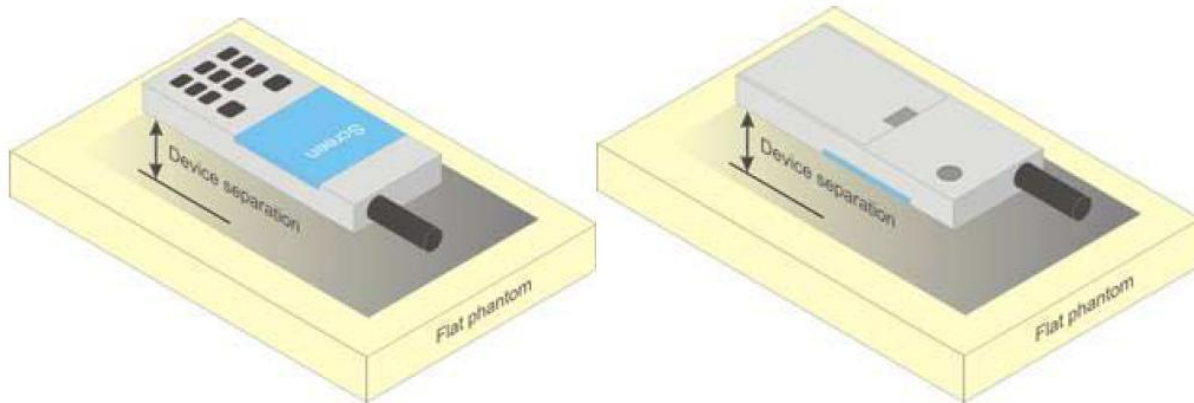
5. Measurement Uncertainty

Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz, when the highest measured 1-g SAR within a frequency band is $< 1.5 \text{ W/kg}$, the extensive SAR measurement uncertainty analysis described in IEEE Std. 1528-2013 is not required in SAR reports submitted for equipment approval. The equivalent ratio (1.5/1.6) is applied to extremity and occupational exposure conditions.

6. SAR Test Configuration

6.1. Body-worn

A separation distance 0 mm is selected, and the DUT just needed to perform SAR evaluation for front side and rear side(see *below figure*) for body-worn scenario.



6.2. Hotspot

For hotspot scenario, the DUT is placed against to the flat phantom to perform SAR evaluation for required surfaces and edges.

7. Device Under Test (DUT) Information

7.1. DUT Description

snapcam360 is a digital video camera, playing audio and video in SD card, audio recorder.	
Device Dimension	Overall (Length x Width): 125 mm x 40 mm
Battery Options	Rechargeable Lithium-ion battery, Rating 3.7 Vdc, 1000mAh, 3.7Wh
Accessory	Lanyard, Tripod

7.2. Wireless Technology

Wireless technology	Frequency band	Operating mode	Duty Cycle use for SAR testing
Wi-Fi	2.4 GHz	802.11 b 802.11 g 802.11 n(H20) 802.11 n(H40)	100%

7.3. Maximum Output Power from Tune-up Procedure

KDB 447498 sec.4.1.(3) at the maximum rated output power and within the tune-up tolerance range specified for the product, but not more than 2 dB lower than the maximum tune-up tolerance limit.

RF Air interface	mode	Max. RF Output Power(dBm)
Wi-Fi 2.4 GHz	802.11b	15
	802.11g	14
	802.11n HT20	14
	802.11n HT40	14

8. RF Exposure Conditions (Test Configurations)

Refer to the diagram inside the device which attached in Sec.12 for the specific details of the antenna-to-surfaces/edges distances.

Wireless Technology	RE Exposure Condition	DUT-to-User Separation	Test Position	Antenna-to-edge/surface	SAR Required
WLAN	Body worn	0mm	Front	<25mm	Yes
		0mm	Rear	<25mm	Yes
	Hotspot	0mm	Front	<25mm	Yes
		0mm	Rear	<25mm	Yes
		0mm	Left edge	<25mm	Yes
		0mm	Right edge	<25mm	Yes
		0mm	Top edge	>25mm	No
		0mm	Bottom edge	>25mm	No

Note:

SAR is not required for top edge and bottom edge, because the distance from the antenna to the edge is > 25 mm as per KDB 941225 D06 Hot Spot SAR. The Body-worn minimum separation distance is 0 mm, to cover both body-worn and hotspot RF exposure conditions.

9. Dielectric Property Measurements & System Check

9.1. Dielectric Property Measurements

The temperature of the tissue-equivalent medium used during measurement must also be within 18°C to 25°C and within $\pm 2^\circ\text{C}$ of the temperature when the tissue parameters are characterized.

The dielectric parameters must be measured before the tissue-equivalent medium is used in a series of SAR measurements. The parameters should be re-measured after each 3 – 4 days of use; or earlier if the dielectric parameters can become out of tolerance; for example, when the parameters are marginal at the beginning of the measurement series.

Tissue dielectric parameters were measured at the low, middle and high frequency of each operating frequency range of the test device.

Tissue Dielectric Parameters

FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

Target Frequency (MHz)	Head		Body	
	ϵ_r	σ (S/m)	ϵ_r	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 – 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5000	36.2	4.45	49.3	5.07
5100	36.1	4.55	49.1	5.18
5200	36.0	4.66	49.0	5.30
5300	35.9	4.76	48.9	5.42
5400	35.8	4.86	48.7	5.53
5500	35.6	4.96	48.6	5.65
5600	35.5	5.07	48.5	5.77
5700	35.4	5.17	48.3	5.88
5800	35.3	5.27	48.2	6.00

IEEE Std 1528-2013

Refer to Table 3 within the IEEE Std 1528-2013

Dielectric Property Measurements Results:

Liquid	Freq.	Liquid Parameters				Delta(%)		Limit (%)	Temp. (°C)	Test Date
		Measured		Target						
		ϵ _r	σ	ϵ _r	σ	ϵ _r	σ			
Body 2450	2410	50.95	1.97	52.76	1.91	-3.43	3.14	±5	22.1	6/16/2016
	2450	50.71	2.02	52.70	1.95	-3.78	3.59	±5	22.1	
	2475	50.57	2.06	52.67	1.99	-3.87	3.52	±5	22.1	
Body 2450	2410	50.41	1.95	52.76	1.91	-4.45	2.09	±5	22.3	7/5/2016
	2450	50.24	1.99	52.70	1.95	-4.65	2.05	±5	22.3	
	2475	50.11	2.02	52.67	1.99	-4.86	1.51	±5	22.3	

9.2. System Check

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media, probe calibration points and other system operating parameters required for measuring the SAR of a test device. The system verification must be performed for each frequency band and within the valid range of each probe calibration point required for testing the device. The same SAR probe(s) and tissue-equivalent media combinations used with each specific SAR system for system verification must be used for device testing. When multiple probe calibration points are required to cover substantially large transmission bands, independent system verifications are required for each probe calibration point. A system verification must be performed before each series of SAR measurements using the same probe calibration point and tissue-equivalent medium. Additional system verification should be considered according to the conditions of the tissue-equivalent medium and measured tissue dielectric parameters, typically every three to four days when the liquid parameters are re-measured or sooner when marginal liquid parameters are used at the beginning of a series of measurements.

System Performance Check Measurement Conditions:

- The measurements were performed in the flat section of the TWIN SAM or ELI phantom, shell thickness: 2.0 ± 0.2 mm (bottom plate) filled with Body or Head simulating liquid of the following parameters.
- The depth of tissue-equivalent liquid in a phantom must be ≥ 15.0 cm for SAR measurements ≤ 3 GHz and ≥ 10.0 cm for measurements > 3 GHz.
- The DASY system with an E-Field Probe was used for the measurements.
- The dipole was mounted on the small tripod so that the dipole feed point was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10mm (above 1GHz) and 15mm (below 1GHz) from dipole center to the simulating liquid surface.
- For area scan, standard grid spacing for head measurements is 15 mm in x- and y- dimension(≤ 2 GHz), 12 mm in x- and y-dimension(2-4 GHz) and 10mm in x- and y- dimension(4-6GHz).
- For zoom scan, $\Delta x_{\text{zoom}}, \Delta y_{\text{zoom}} \leq 2$ GHz - ≤ 8 mm, 2-4GHz - ≤ 5 mm and 4-6 GHz- ≤ 4 mm; $\Delta z_{\text{zoom}} \leq 3$ GHz - ≤ 5 mm, 3-4 GHz- ≤ 4 mm and 4-6GHz- ≤ 2 mm.
- Distance between probe sensors and phantom surface was set to 3 mm except for 5 GHz band. For 5GHz band, Distance between probe sensors and phantom surface was set to 2.5 mm
- The dipole input power (forward power) was set to 100 mW or 250 mW depend on the certificate of the dipoles.
- The results are normalized to 1 W input power.

System Check Results

The 1-g and 10-g SAR measured with a reference dipole, using the required tissue-equivalent medium at the test frequency, must be within 10% of the manufacturer calibrated dipole SAR target.

System Dipole	T.S. Liquid		Measured Results		Target (Ref. value)	Delta (%)	Limit (%)	Temp. (°C)	Test Date
Serial #			Zoom Scan (W/Kg)	Normalize to 1W (W/Kg)					
977	Body 2450	1-g	12.30	49.20	51.70	-4.84	±10	22.1	6/16/2016
		10-g	5.77	23.08	24.30	-5.02	±10	22.1	
977	Body 2450	1-g	12.10	48.40	51.70	-6.38	±10	22.3	7/5/2016
		10-g	5.68	22.72	24.30	-6.50	±10	22.3	

10. Conducted Output Power Measurement

10.1. Wi-Fi 2.4GHz (DTS Band)

Measured Results

Band	Mode	Date Rate	Ch.#	Freq.(MHz)	Avg. Pwr.(dBm)	SAR Test (Yes/No)
2.4G	802.11 b	1Mbps	1	2412	13.68	Yes
			6	2437	14.53	
			11	2462	14.65	
	802.11 g	6Mbps	1	2412	Not required	No
			6	2437	Not required	
			11	2462	Not required	
	802.11 n (H20)	6.5Mbps	1	2412	Not required	No
			6	2437	Not required	
			11	2462	Not required	
	802.11 n (H40)	13.5Mbps	3	2422	Not required	No
			6	2437	Not required	
			9	2452	Not required	

Note:

Output Power and SAR is not required for 802.11g/n HT20 & HT40 channels 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 ≤ 1.2 .

11. Measured and Reported (Scaled) SAR Results

SAR Test Reduction criteria are as follows:

KDB 447498 D01 General RF Exposure Guidance:

A) Per KDB447498 D01v05r02, all SAR measurement results are scaled to the maximum tune-up tolerance limit to demonstrate SAR compliance.

B) 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:

- ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz.
- ≤ 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.
- ≤ 0.4 W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≥ 200 MHz.

Per KDB865664 D01:

For each frequency band, repeated SAR measurement is required only when the measured SAR is ≥ 0.8 W/Kg; if the deviation among the repeated measurement is $\leq 20\%$, and the measured SAR < 1.45 W/Kg, only one repeated measurement is required.

Per KDB 248227 D01:

For Wi-Fi SAR testing, a communication link is set up with the testing software for Wi-Fi mode test. During the test, at the each test frequency channel, the EUT is operated at the RF continuous emission mode. The RF signal utilized in SAR measurement has 100% duty cycle and its crest factor is 1. The test procedures in KDB 248227D01 are applied. (Refer to KDB 248227D01 for more details)

Initial Test Position Procedure

For exposure condition with multiple test position, such as handsets operating next to the ear, devices with hotspot mode or UMPC mini-tablet, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all position in an exposure condition. The test position with the highest extrapolated(peak) SAR is used as the initial test position. When reported SAR for the initial test position is ≤ 0.4 W/kg, no additional testing for the remaining test position is required. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is ≤ 0.8 W/kg or all test position are measured. For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg, SAR is measured for these test positions /configurations on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or all required channels are tested.

Initial Test Configuration Procedure

An initial test configuration is determined for OFDM transmission modes according to the channel bandwidth, modulation and data rate combination(s) with the highest maximum output power specified for production units in each standalone and aggregated frequency band. SAR is measured using the highest measured maximum output power channel. For configurations with the same specified or measured maximum output power, additional transmission mode and test channel selection procedures are required (see section 5.3.2 of KDB 248227D01). SAR test reduction of subsequent highest output test channels is based on the reported SAR of the initial test configuration.

For next to the ear, hotspot mode and UMC mini-tablet exposure configurations where multiple test positions are required, the initial test position procedure is applied to minimize the number of test positions required for SAR measurement using the initial test configuration transmission mode. For fixed exposure conditions that do not have multiple SAR test positions, SAR is measured in the transmission mode determined by the initial test configuration. When the reported SAR of the initial test configuration is > 0.8 W/kg, SAR measurement is required for the subsequent next highest measured output power channel(s) in the initial test configuration until the reported SAR is ≤ 1.2 W/kg or all required channels are tested.

Sub Test Configuration Procedure

SAR measurement requirements for the remaining 802.11 transmission mode configurations that have not been tested in the initial test configuration are determined separately for each standalone and aggregated frequency band, in each exposure condition, according to the maximum output power specified for production units. When the highest reported SAR for the initial test configuration, according to the initial test position or fixed exposure position requirements, is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for that subsequent test configuration.

Wi-Fi 2.4G SAR Test Procedures

Separate SAR procedures are applied to DSSS and OFDM configurations in the 2.4 GHz band to simplify DSSS test requirements. For 802.11b DSSS SAR measurements, DSSS SAR procedure applies to fixed exposure test position and initial test position procedure applies to multiple exposure test positions.

A) 802.11b DSSS SAR Test Requirements

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

- 1) When the reported SAR of the highest measured maximum output power channel (section 3.1 of of KDB 248227D01) for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.
- 2) When the reported SAR is > 0.8 W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.

B) 2.4GHz 802.11g/n OFDM SAR Test Exclusion Requirements

When SAR measurement is required for 2.4 GHz 802.11g/n OFDM configurations, the measurement and test reduction procedures for OFDM are applied (section 5.3 of of KDB 248227D01). SAR is not required for the following 2.4 GHz OFDM conditions.

- 1) When KDB Publication 447498 SAR test exclusion applies to the OFDM configuration.
- 2) When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.

C) SAR Test Requirements for OFDM configurations

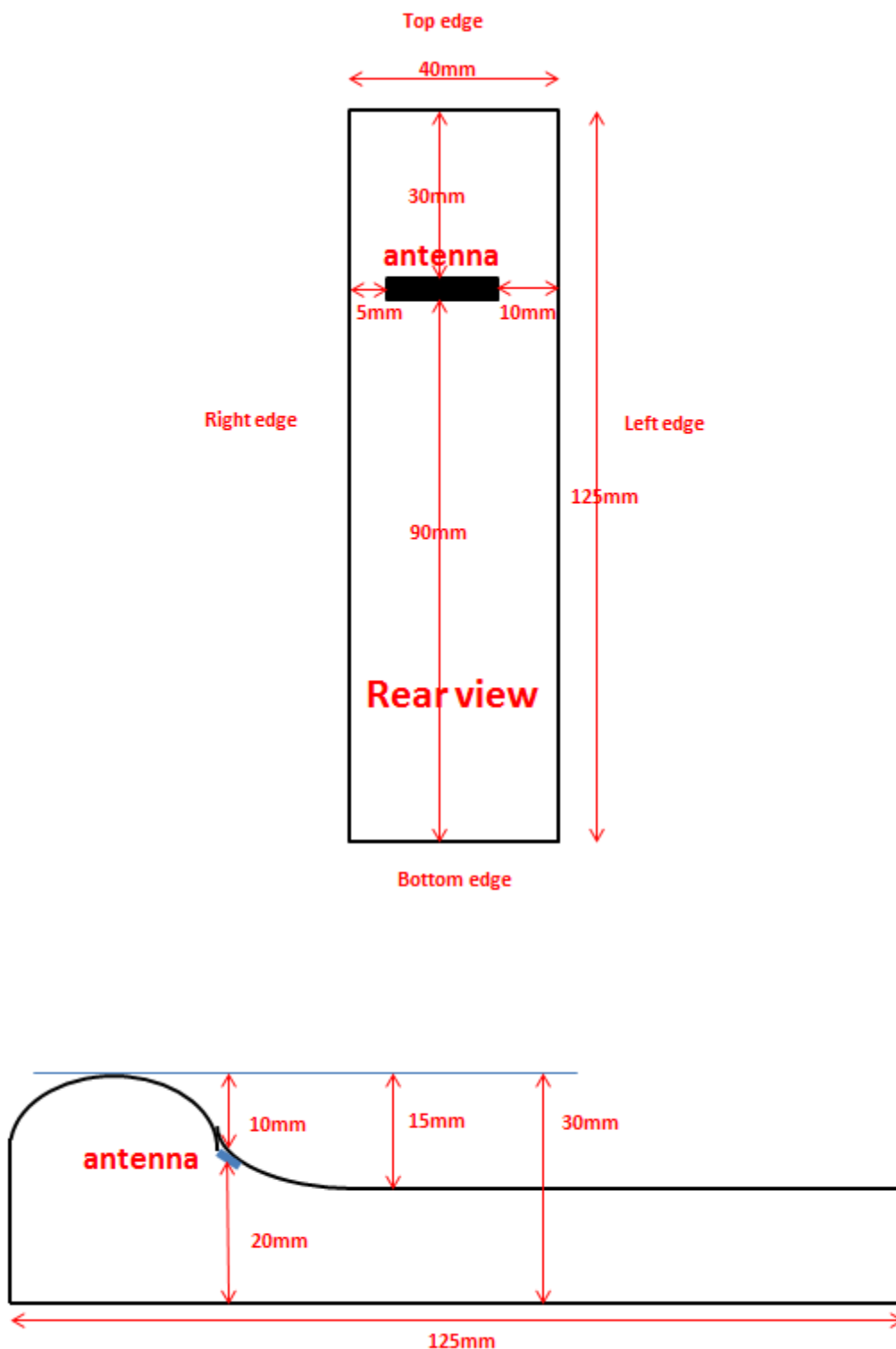
When SAR measurement is required for 802.11 g/n OFDM configurations, each standalone and frequency aggregated band is considered separately for SAR test reduction. In applying the initial test configuration and subsequent test configuration procedures, the 802.11 transmission configuration with the highest specified maximum output power and the channel within a test configuration with the highest measured maximum output power should be clearly distinguished to apply the procedures.

11.1. Wi-Fi 2.4GHz (DTS Band)

Test Positon (Hotspot)	Test Mode	Dist.	Channel/ Frequency	Power (dBm)		SAR Value		Power Drift (dB)	Scaled (W/Kg)
				Tune-up	Meas.	1-g (W/Kg)	10-g (W/Kg)		
Front Side	802.11b	0mm	11/2442	15.00	14.65	0.249	0.129	0.05	0.270
Rear Side	802.11b	0mm	11/2442	15.00	14.65	0.584	0.278	-0.15	0.633
Left Edge	802.11b	0mm	11/2442	15.00	14.65	0.991	0.426	-0.18	1.074
Left Edge-Repeated	802.11b	0mm	11/2442	15.00	14.65	0.975	0.413	0.15	1.057
Left Edge	802.11b	0mm	6/2437	15.00	14.53	0.953	0.416	0.11	1.062
Right Edge	802.11b	0mm	11/2442	15.00	14.65	0.883	0.341	-0.04	0.957
Right Edge	802.11b	0mm	6/2437	15.00	14.53	0.863	0.334	-0.06	0.962

12. Simultaneous Transmission SAR Analysis

The antenna diagram inside the device is showed as below, because there is only one antenna, so simultaneous transmission is not exist.



Appendixes

Refer to separated files for the following appendixes.

47870077-1-SAR_App A Photo

47870077-1-SAR_App B System Check Plots

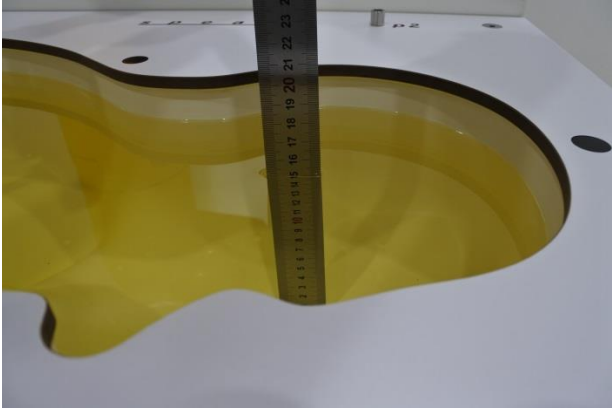


47870077-1-SAR_App C Highest Test Plots





47870077-1-SAR_App D Cal. Certificates

END OF REPORT

Appendix A

Photo

Liquid	
Body 2450 (15.4cm)	N/A
	N/A
Sample	
Front view	Rear view
	

Test position	
Front side(0mm)	Rear side(0mm)
	
Left edge(0mm)	Right edge(0mm)
	

Appendix B

System Check Plots

System perform check 2450 body
System perform check 2450 body

Test Laboratory: UL SSL SAR Lab

System perform check 2450 body

DUT: Dipole 2450 MHz D2450V2; Type: D2450V2;

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 2.02$ S/m; $\epsilon_r = 50.71$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7383; ConvF(7.54, 7.54, 7.54); Calibrated: 18/01/2016;
- Sensor-Surface: 3mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE3 Sn427; Calibrated: 25/01/2016
- Phantom: SAM; Type: SAM 5.0; Serial: 1805
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

Configuration/D2450V2/Area Scan (9x9x1): Measurement grid: $dx=12$ mm, $dy=12$ mm

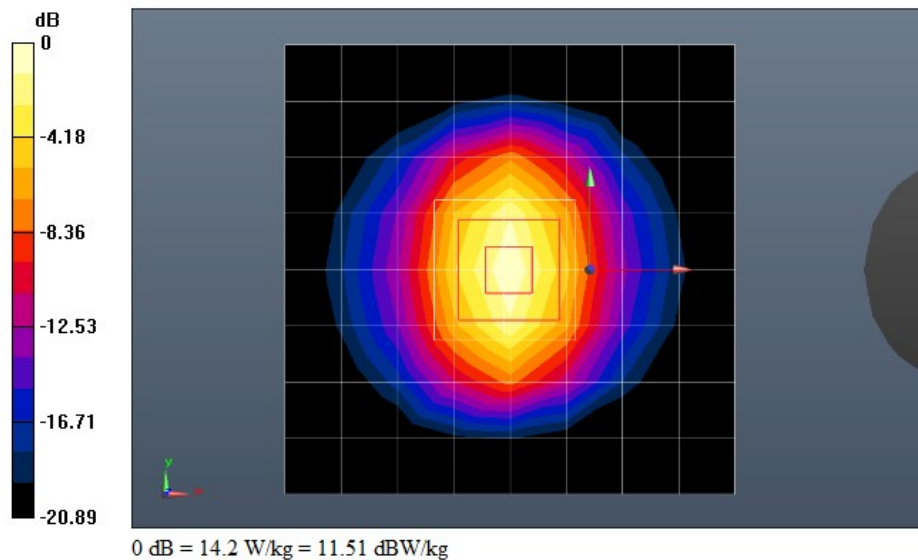
Maximum value of SAR (measured) = 14.2 W/kg

Configuration/D2450V2/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 83.70 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 24.8 W/kg

SAR(1 g) = 12.3 W/kg; SAR(10 g) = 5.77 W/kg



Test Laboratory: UL SSL SAR Lab

System Perform check 2450 body

DUT: Dipole 2450 MHz D2450V2; Type: D2450V2;

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.99$ S/m; $\epsilon_r = 50.24$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7383; ConvF(7.54, 7.54, 7.54); Calibrated: 18/01/2016;
- Sensor-Surface: 4mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE3 Sn427; Calibrated: 25/01/2016
- Phantom: SAM; Type: SAM 5.0; Serial: 1805
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

Configuration/D2450V2/Area Scan (9x9x1): Measurement grid: $dx=12$ mm, $dy=12$ mm

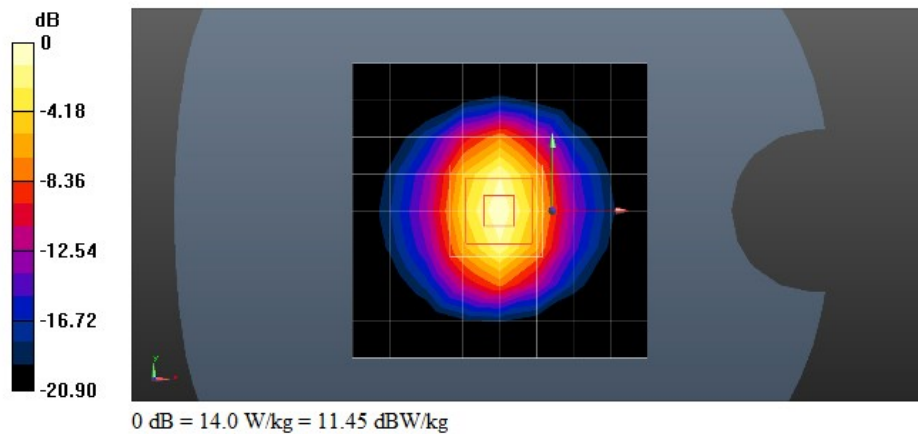
Maximum value of SAR (measured) = 14.0 W/kg

Configuration/D2450V2/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 82.90 V/m; Power Drift = 0.11 dB

Peak SAR (extrapolated) = 24.4 W/kg

SAR(1 g) = 12.1 W/kg; SAR(10 g) = 5.68 W/kg



Appendix C

Highest Test Plots

Snapcam360 2.4G WiFi 11CH rear side 0mm
Snapcam360 2.4G WiFi 11CH left edge 0mm

Test Laboratory: UL SSL SAR Lab

snapcam360 2.4G WiFi 11CH rear side 0mm

DUT: snapcam360; Type: Action Camera;

Communication System: UID 0, 802.11 (0); Frequency: 2462 MHz; Duty Cycle: 1:1
 Medium parameters used: $f = 2462$ MHz; $\sigma = 2.04$ S/m; $\epsilon_r = 50.62$; $\rho = 1000$ kg/m³
 Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7383; ConvF(7.54, 7.54, 7.54); Calibrated: 18/01/2016;
- Sensor-Surface: 3mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE3 Sn427; Calibrated: 25/01/2016
- Phantom: SAM; Type: SAM 5.0; Serial: 1805
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

Configuration/Body/Area Scan (7x13x1): Measurement grid: $dx=12$ mm, $dy=12$ mm

Maximum value of SAR (measured) = 0.725 W/kg

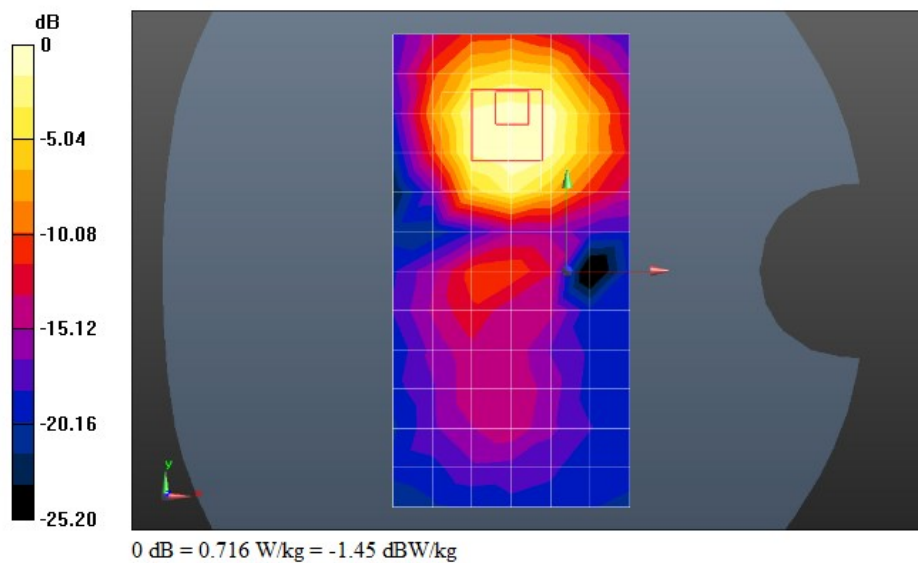
Configuration/Body/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 5.222 V/m; Power Drift = -0.15 dB

Peak SAR (extrapolated) = 1.03 W/kg

SAR(1 g) = 0.584 W/kg; SAR(10 g) = 0.278 W/kg

Maximum value of SAR (measured) = 0.716 W/kg



Test Laboratory: UL SSL SAR Lab

snapcam360 2.4G WiFi 11CH left edge 0mm

DUT: snapcam360; Type: Action Camera;

Communication System: UID 0, 802.11 (0); Frequency: 2462 MHz; Duty Cycle: 1:1
 Medium parameters used: $f = 2462$ MHz; $\sigma = 2.04$ S/m; $\epsilon_r = 50.62$; $\rho = 1000$ kg/m³
 Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7383; ConvF(7.54, 7.54, 7.54); Calibrated: 18/01/2016;
- Sensor-Surface: 3mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE3 Sn427; Calibrated: 25/01/2016
- Phantom: SAM; Type: SAM 5.0; Serial: 1805
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

Configuration/Body/Area Scan (7x13x1): Measurement grid: $dx=12$ mm, $dy=12$ mm

Maximum value of SAR (measured) = 1.65 W/kg

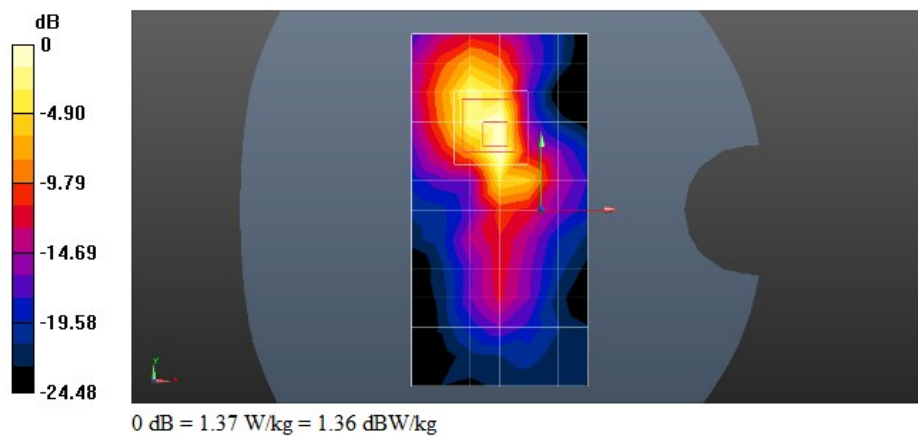
Configuration/Body/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 7.847 V/m; Power Drift = -0.18 dB

Peak SAR (extrapolated) = 2.55 W/kg

SAR(1 g) = 0.991 W/kg; SAR(10 g) = 0.426 W/kg

Maximum value of SAR (measured) = 1.37 W/kg



Appendix D

Calibration Certificates

D2450V2-SN:977

DAE3-SD000D03AA-SN:427

EX3DV4-SN:7383



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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **UL (Song Shan Lake) Branch**

Certificate No: **D2450V2-977_Jan16/2**

CALIBRATION CERTIFICATE (Replacement of No:D2450V2-977_Jan16)

Object **D2450V2 - SN: 977**

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

Calibration date: **January 14, 2016**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	US37292783	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	MY41092317	07-Oct-15 (No. 217-02223)	Oct-16
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: 7349	31-Dec-15 (No. EX3-7349_Dec15)	Dec-16
DAE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-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-15)	In house check: Oct-16

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

Approved by: **Katja Pokovic** Technical Manager

Signature

M. Weber

K. Pokovic

Issued: March 14, 2016

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



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 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	37.9 \pm 6 %	1.88 mho/m \pm 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.5 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.5 W/kg \pm 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.23 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.5 W/kg \pm 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 \pm 0.2) °C	52.2 \pm 6 %	2.03 mho/m \pm 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.2 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	51.7 W/kg \pm 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.14 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.3 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	55.3 Ω + 5.3 j Ω
Return Loss	- 23.0 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	52.1 Ω + 7.0 j Ω
Return Loss	- 22.9 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.157 ns
----------------------------------	----------

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

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	December 30, 2014

DASY5 Validation Report for Head TSL

Date: 14.01.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz ; Type: D2450V2; Serial: D2450V2 - SN: 977

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.88$ S/m; $\epsilon_r = 37.9$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.76, 7.76, 7.76); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

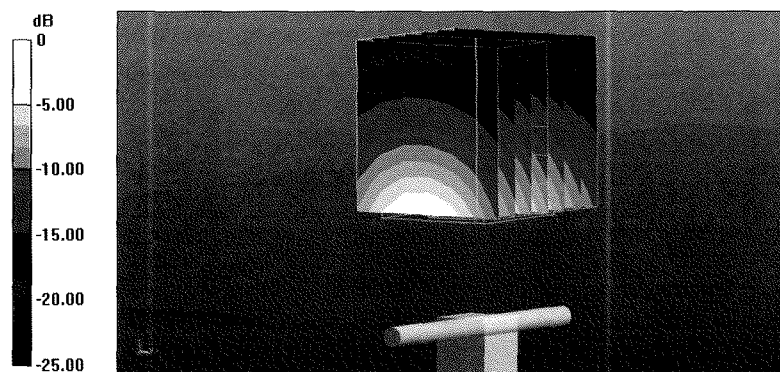
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 113.8 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 27.7 W/kg

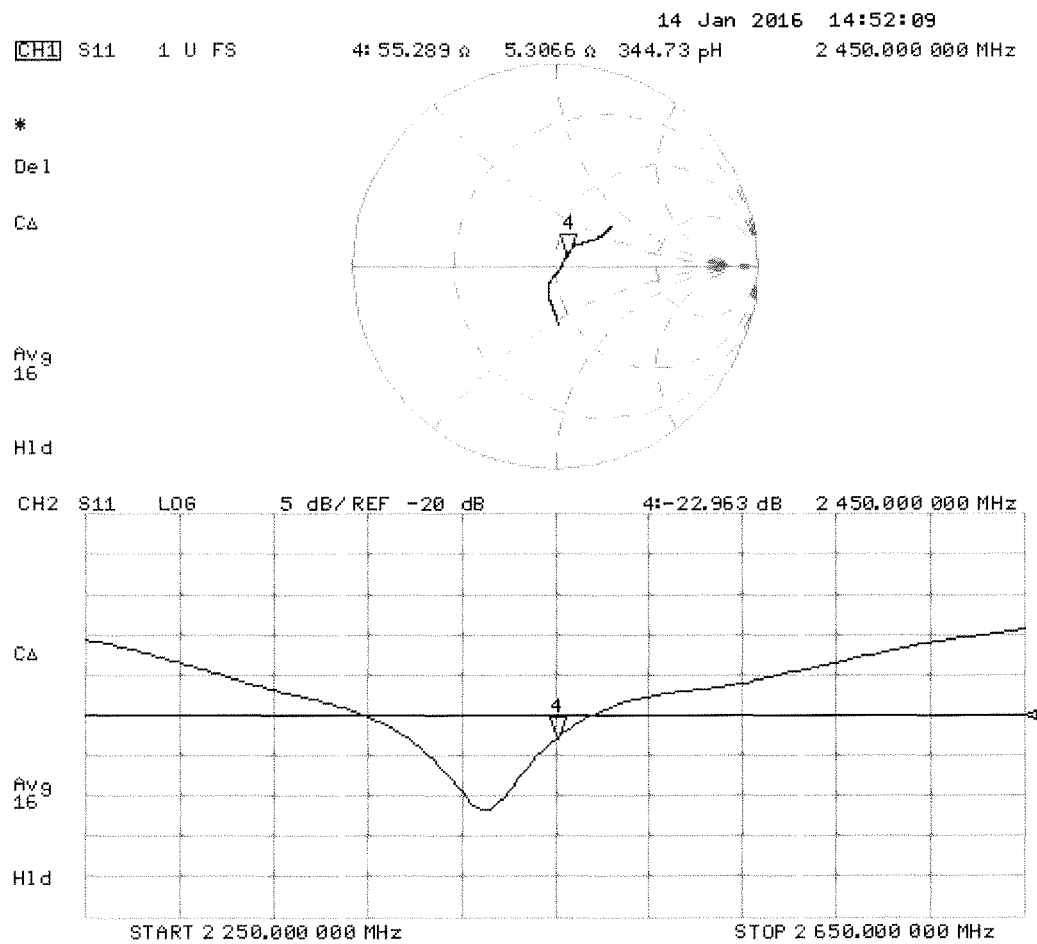
SAR(1 g) = 13.5 W/kg; SAR(10 g) = 6.23 W/kg

Maximum value of SAR (measured) = 22.1 W/kg



0 dB = 22.1 W/kg = 13.44 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 14.01.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz ; Type: D2450V2; Serial: D2450V2 - SN: 977

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 2.03$ S/m; $\epsilon_r = 52.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

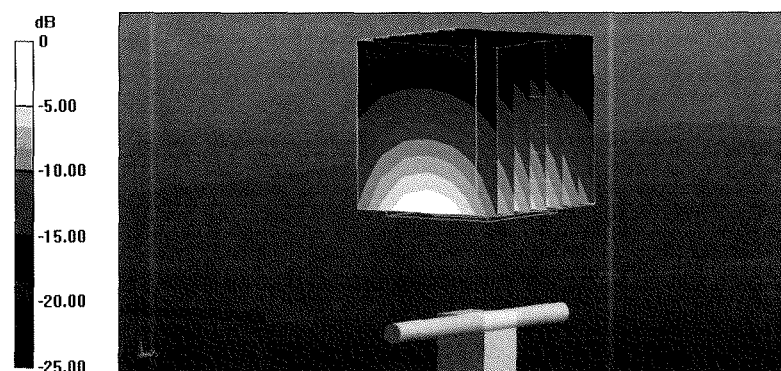
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 107.4 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 26.5 W/kg

SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.14 W/kg

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

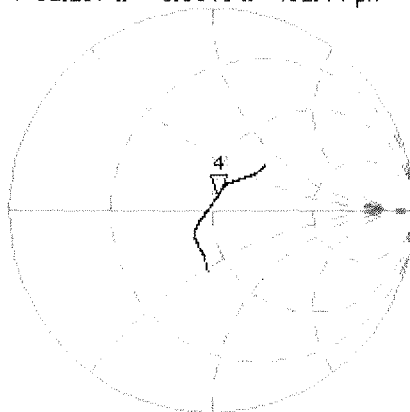


0 dB = 21.6 W/kg = 13.34 dBW/kg

Impedance Measurement Plot for Body TSL

14 Jan 2016 14:51:43
[CH1] S11 1 U FS 4: 52.137 Ω 6.9648 Ω 452.44 pF 2 450.000 000 MHz

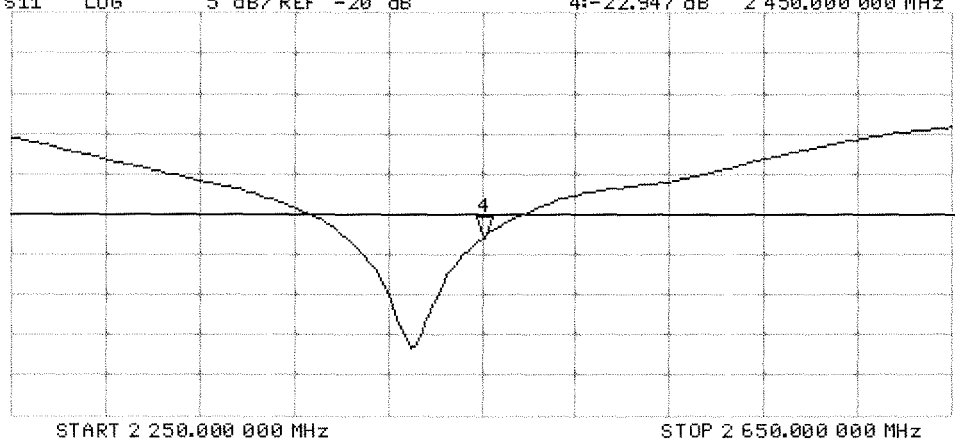
*
Del
CA



Avg
16
H1d

CH2 S11 LOG 5 dB/REF -20 dB 4:-22.947 dB 2 450.000 000 MHz

CA
Avg
16
H1d





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Accreditation No.: **SCS 0108**

Client **UL CCS USA**

Certificate No: **DAE3-427_Jan16**

CALIBRATION CERTIFICATE

Object **DAE3 - SD 000 D03 AA - SN: 427**

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

Calibration date: **January 25, 2016**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature $(22 \pm 3)^{\circ}\text{C}$ 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	05-Jan-16 (in house check)	In house check: Jan-17
Calibrator Box V2.1	SE UMS 006 AA 1002	05-Jan-16 (in house check)	In house check: Jan-17

Calibrated by:	Name	Function	Signature
	Dominique Steffen	Technician	

Approved by:	Name	Function
	Fin Bomholt	Deputy Technical Manager

Issued: January 25, 2016

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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 μ V , full range = -100...+300 mV

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

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

Calibration Factors	X	Y	Z
High Range	404.064 \pm 0.02% (k=2)	403.216 \pm 0.02% (k=2)	404.017 \pm 0.02% (k=2)
Low Range	3.95411 \pm 1.50% (k=2)	3.99049 \pm 1.50% (k=2)	4.00115 \pm 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	183.0 ° \pm 1 °
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Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	200032.77	-3.11	-0.00
Channel X + Input	20007.91	3.32	0.02
Channel X - Input	-20003.98	1.52	-0.01
Channel Y + Input	200033.00	-1.63	-0.00
Channel Y + Input	20005.04	0.40	0.00
Channel Y - Input	-20004.92	0.56	-0.00
Channel Z + Input	200032.95	-1.40	-0.00
Channel Z + Input	20004.13	-0.30	-0.00
Channel Z - Input	-20006.16	-0.43	0.00

Low Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	2000.80	-0.22	-0.01
Channel X + Input	201.61	0.62	0.31
Channel X - Input	-198.74	0.23	-0.12
Channel Y + Input	2001.19	0.32	0.02
Channel Y + Input	200.39	-0.37	-0.19
Channel Y - Input	-199.71	-0.72	0.36
Channel Z + Input	2000.18	-0.65	-0.03
Channel Z + Input	199.35	-1.39	-0.69
Channel Z - Input	-200.07	-1.02	0.51

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 (μV)	Low Range Average Reading (μV)
Channel X	200	15.24	13.36
	- 200	-12.10	-13.96
Channel Y	200	5.36	5.39
	- 200	-8.22	-8.47
Channel Z	200	-10.32	-10.58
	- 200	8.20	8.19

3. Channel separation

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

	Input Voltage (mV)	Channel X (μV)	Channel Y (μV)	Channel Z (μV)
Channel X	200	-	1.16	-5.21
Channel Y	200	7.75	-	2.37
Channel Z	200	9.60	5.91	-

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	15989	16365
Channel Y	15930	16615
Channel Z	15928	16119

5. Input Offset Measurement

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

Input 10M Ω

	Average (μ V)	min. Offset (μ V)	max. Offset (μ V)	Std. Deviation (μ V)
Channel X	0.79	-0.38	2.76	0.44
Channel Y	-0.26	-2.11	1.48	0.48
Channel Z	-1.36	-2.64	-0.31	0.42

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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IMPORTANT NOTICE

USAGE OF THE DAE 3

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

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

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

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

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

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

Important Note:

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

Important Note:

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

Important Note:

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



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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

Client **UL (Song Shan Lake) Branch**

Certificate No: **EX3-7383_Jan16/2**

CALIBRATION CERTIFICATE (Replacement of No: EX3-7383_Jan16)

Object **EX3DV4 - SN:7383**

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

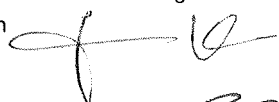

Calibration date: **January 18, 2016**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
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	31-Dec-15 (No. ES3-3013_Dec15)	Dec-16
DAE4	SN: 660	23-Dec-15 (No. DAE4-660_Dec15)	Dec-16
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-13)	In house check: Apr-16
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

Calibrated by:	Name Jeton Kastrati	Function Laboratory Technician	Signature 
Approved by:	Katja Pokovic	Technical Manager	
			Issued: March 15, 2016
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 _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,y,z}
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization ϕ	ϕ rotation around probe axis
Polarization ϑ	ϑ 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_{x,y,z}**: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E²-field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z} = NORM_{x,y,z} * 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_{x,y,z}**: 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_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}**: 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_{x,y,z} * 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 ± 50 MHz to ± 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_x (no uncertainty required).

Probe EX3DV4

SN:7383

Manufactured: April 13, 2015
Calibrated: January 18, 2016

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7383

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.37	0.49	0.53	± 10.1 %
DCP (mV) ^B	97.4	95.2	97.1	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	126.0	±3.0 %
		Y	0.0	0.0	1.0		135.0	
		Z	0.0	0.0	1.0		123.8	

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%.

^A The uncertainties of Norm X,Y,Z do not affect the E²-field uncertainty inside TSL (see Pages 5 and 6).

^B Numerical linearization parameter: uncertainty not required.

^E 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:7383

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc (k=2)
750	41.9	0.89	10.35	10.35	10.35	0.23	1.27	± 12.0 %
835	41.5	0.90	9.99	9.99	9.99	0.21	1.55	± 12.0 %
900	41.5	0.97	9.75	9.75	9.75	0.31	1.07	± 12.0 %
1450	40.5	1.20	8.47	8.47	8.47	0.20	1.19	± 12.0 %
1810	40.0	1.40	8.27	8.27	8.27	0.37	0.85	± 12.0 %
1900	40.0	1.40	8.24	8.24	8.24	0.34	0.80	± 12.0 %
2100	39.8	1.49	8.40	8.40	8.40	0.36	0.86	± 12.0 %
2300	39.5	1.67	7.76	7.76	7.76	0.34	0.80	± 12.0 %
2450	39.2	1.80	7.37	7.37	7.37	0.39	0.85	± 12.0 %
2600	39.0	1.96	7.16	7.16	7.16	0.32	1.01	± 12.0 %
3500	37.9	2.91	6.90	6.90	6.90	0.33	1.22	± 13.1 %
3700	37.7	3.12	6.75	6.75	6.75	0.29	1.31	± 13.1 %
5250	35.9	4.71	4.94	4.94	4.94	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.43	4.43	4.43	0.45	1.80	± 13.1 %
5750	35.4	5.22	4.66	4.66	4.66	0.45	1.80	± 13.1 %

^C 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.

^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) 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 (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G 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:7383

Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc (k=2)
750	55.5	0.96	10.39	10.39	10.39	0.31	1.14	± 12.0 %
835	55.2	0.97	10.16	10.16	10.16	0.24	1.35	± 12.0 %
900	55.0	1.05	10.07	10.07	10.07	0.29	1.17	± 12.0 %
1450	54.0	1.30	8.43	8.43	8.43	0.17	1.63	± 12.0 %
1810	53.3	1.52	7.98	7.98	7.98	0.42	0.80	± 12.0 %
1900	53.3	1.52	7.93	7.93	7.93	0.42	0.85	± 12.0 %
2100	53.2	1.62	8.21	8.21	8.21	0.35	0.80	± 12.0 %
2300	52.9	1.81	7.61	7.61	7.61	0.38	0.84	± 12.0 %
2450	52.7	1.95	7.54	7.54	7.54	0.37	0.88	± 12.0 %
2600	52.5	2.16	7.23	7.23	7.23	0.25	0.95	± 12.0 %
3500	51.3	3.31	6.73	6.73	6.73	0.31	1.25	± 13.1 %
3700	51.0	3.55	6.68	6.68	6.68	0.37	1.22	± 13.1 %
5250	48.9	5.36	4.33	4.33	4.33	0.50	1.90	± 13.1 %
5600	48.5	5.77	3.69	3.69	3.69	0.55	1.90	± 13.1 %
5750	48.3	5.94	3.93	3.93	3.93	0.55	1.90	± 13.1 %

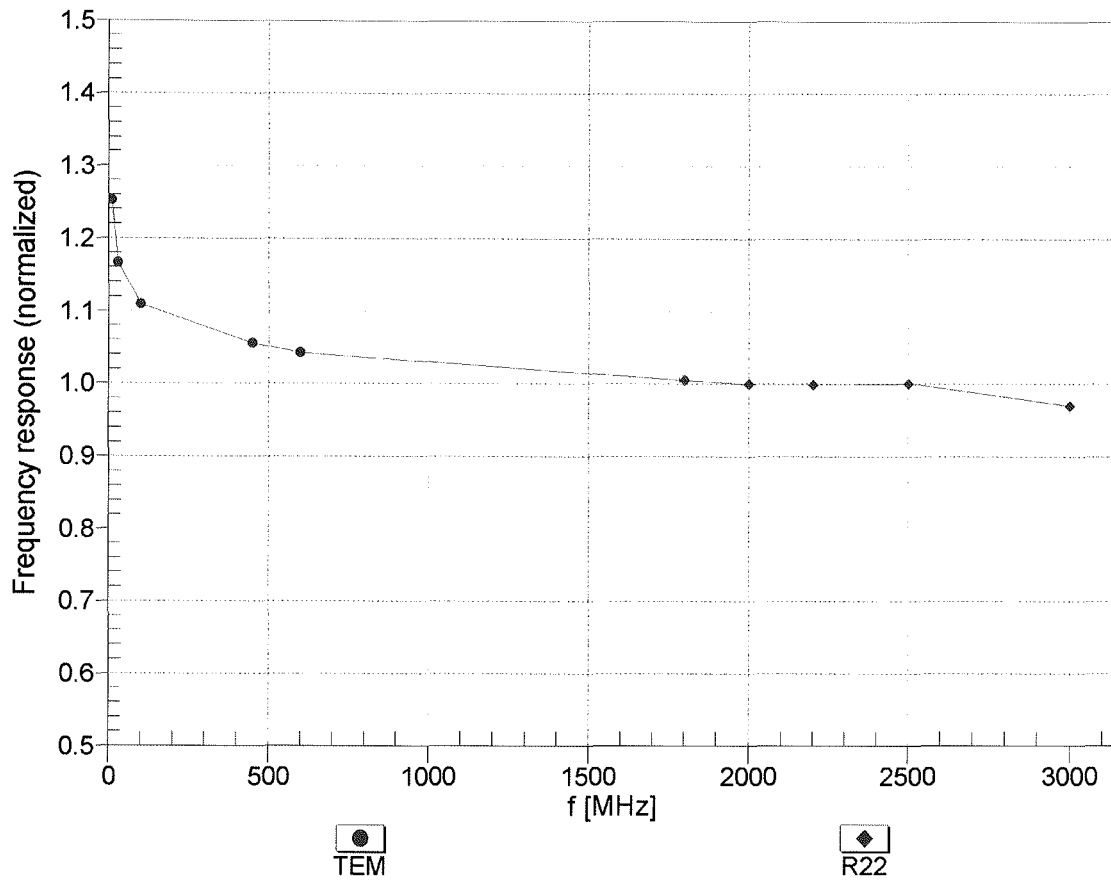
^C Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 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.

^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) 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 (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G 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

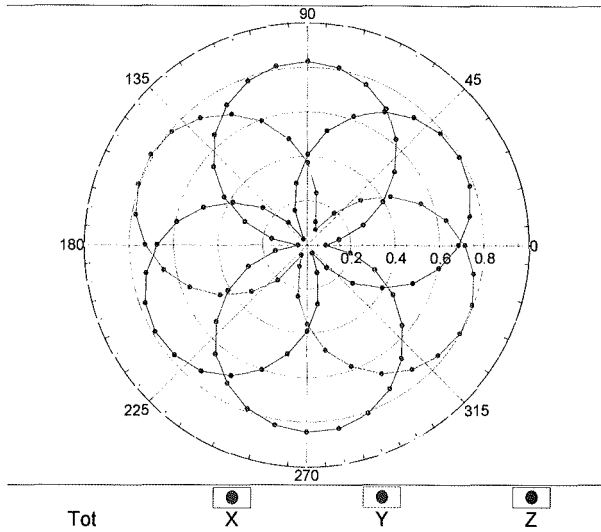
(TEM-Cell:ifi110 EXX, Waveguide: R22)



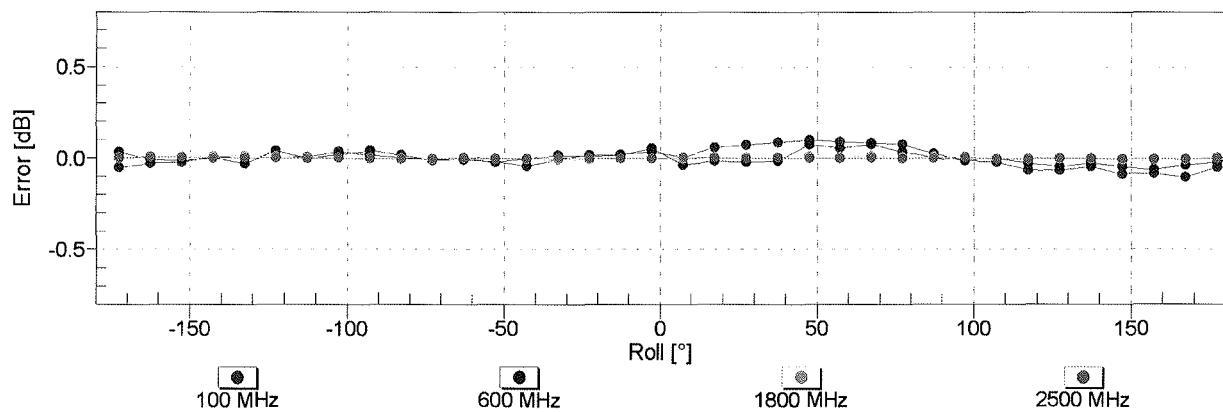
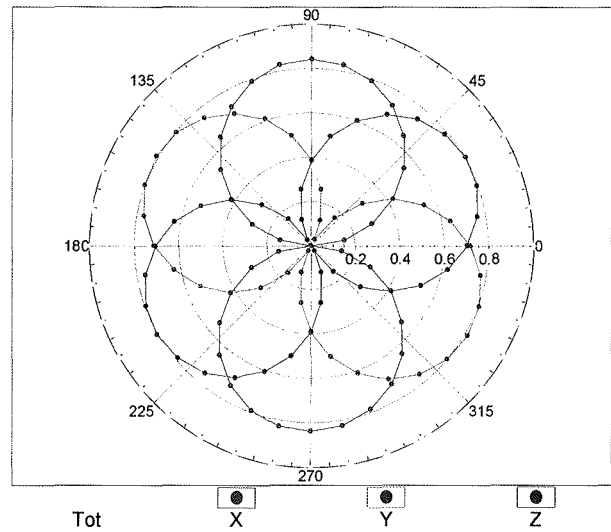
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

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

f=600 MHz,TEM

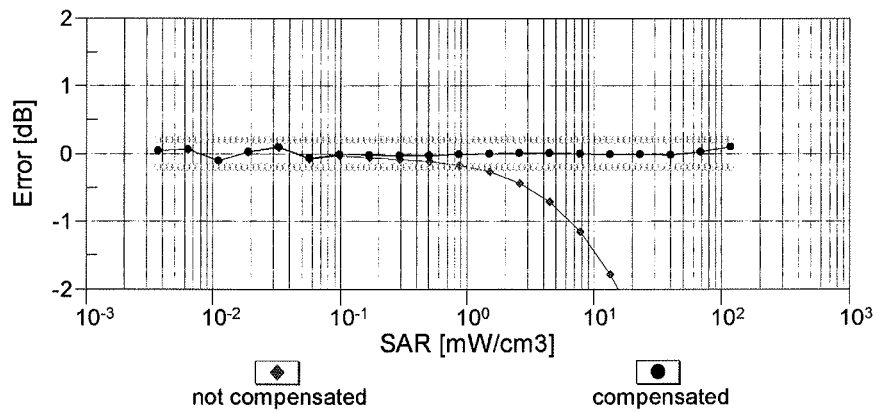
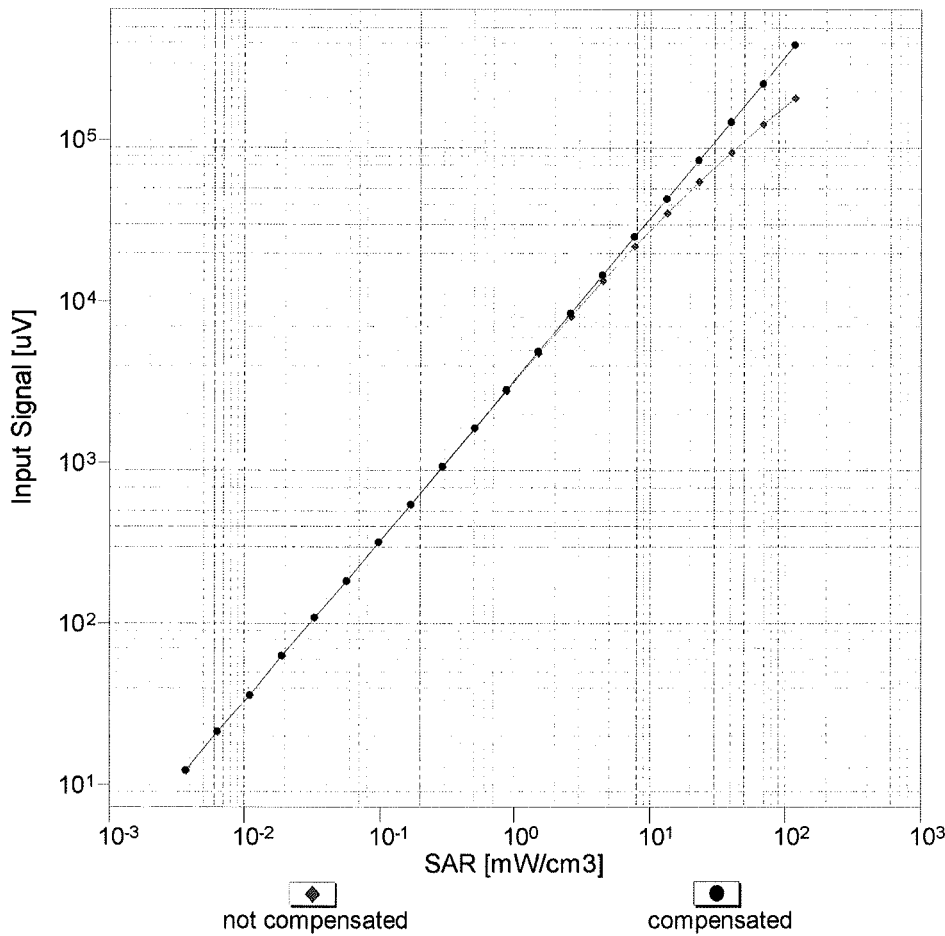


f=1800 MHz,R22



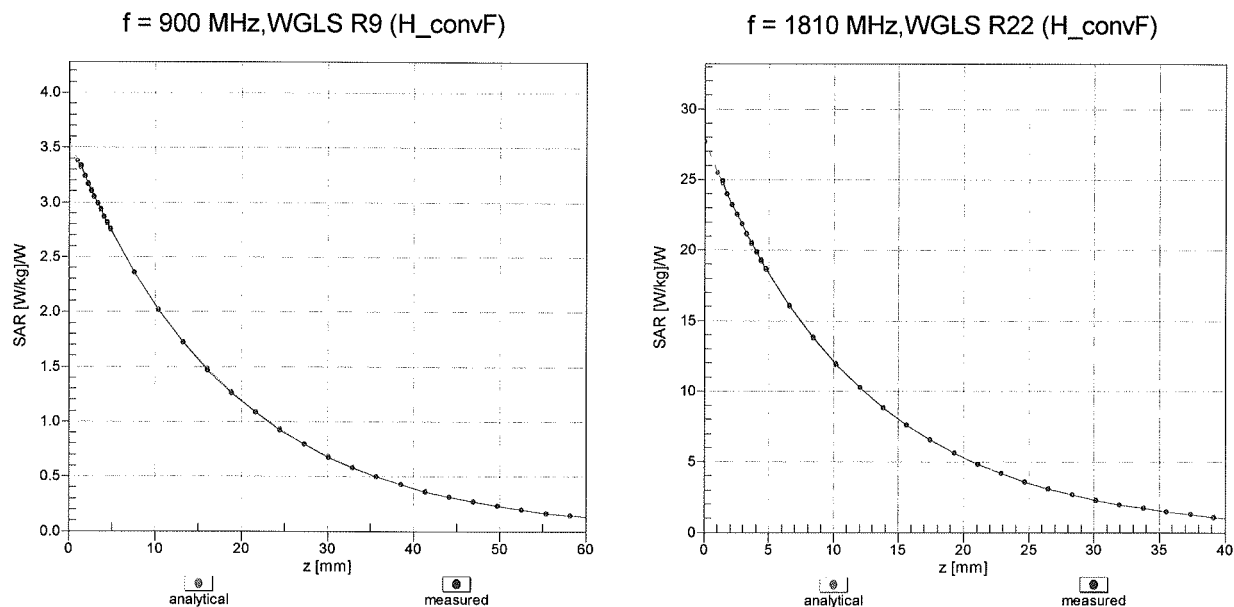
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

Dynamic Range f(SAR_{head})
(TEM cell , f_{eval}= 1900 MHz)



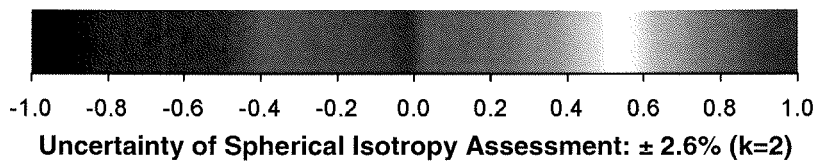
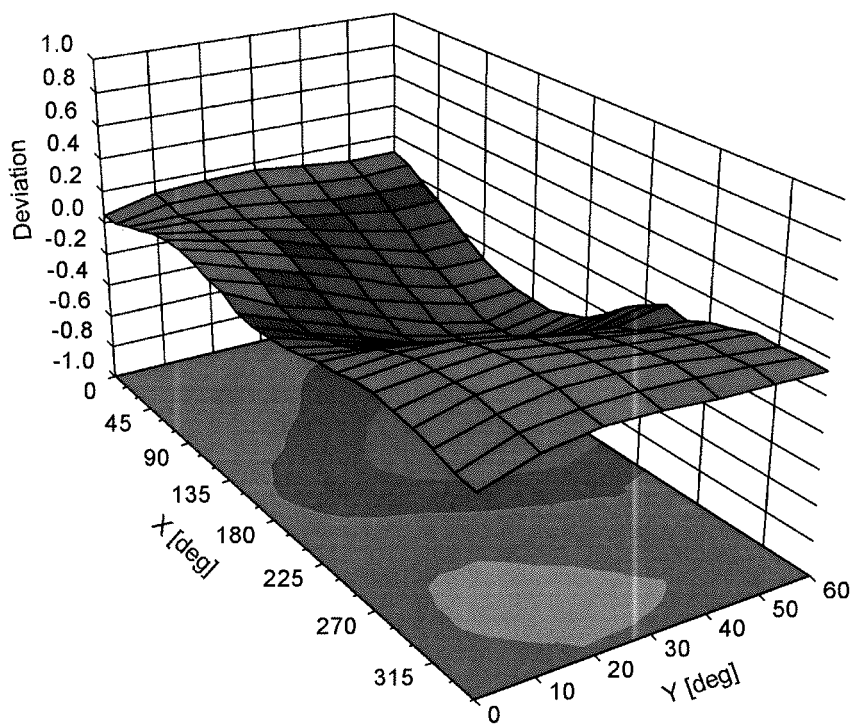
Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, ϑ) , $f = 900 \text{ MHz}$



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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7383

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	127.2
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm