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Vocera Communications SAR TEST REPORT

SCOPE OF WORK

SPECIFIC ABSORPTION RATE – COMMUNICATION BADGE

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SPECIFIC ABSORPTION RATE TEST REPORT

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Product Name: Communication Badge

Model Number: V5000

Standards: FCC Part 2.1093

RSS-102 Issue 5

Tested by:

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Lexington, KY 40510

Client:

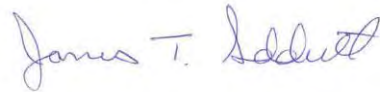
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1 INTRODUCTION

At the request of Vocera Communications the Communication Badge was evaluated for SAR in accordance with the requirements for FCC Part 2.1093 and RSS-102 Issue 5. Testing was performed in accordance with IEEE Std 1528:2013, IEC62209-2:2010, and the Office of Engineering and Technology KDB 447498. Testing was performed at the Intertek facility in Lexington, Kentucky.

For the evaluation, the dosimetric assessment system DASY52 was used. The total uncertainty for the evaluation of the spatial peak SAR values averaged over a cube of 1g tissue mass had been assessed for this system to be $\pm 22.2\%$ from 300MHz – 3GHz and 24.6% from 3GHz – 6GHz.

The Communication Badge was tested at the maximum output power measured by Intertek. Maximum output power measurements are tabulated under Section 10 Test Results. The maximum spatial peak SAR value for the sample device averaged over 1g (for body worn mode) and 10g (for hand held mode) is shown below.

Based on the worst-case data presented above, the Communication Badge was found to be **compliant** with the 1.6 W/kg and 4W/kg requirements for general population / uncontrolled exposure.

Table 1: Worst Case Reported SAR per Exposure Condition

Device Position	Transmit Mode	Separation Distance	Channel / Frequency (MHz)	Maximum Conducted Output Power (dBm)	Reported SAR (1g) (mW/g)	Limit (W/kg)
Left Ear Cheek Touch	802.11b (DSSS)	0mm	Channel 1 2412MHz	18dBm	1.281 mW/g	1.6mW/g
Right Ear Cheek Touch	802.11b (DSSS)	0mm	Channel 1 2412MHz	18dBm	0.856 mW/g	1.6mW/g
Body Position (Back Side of Device)	802.11b (DSSS)	5mm	Channel 6 2437MHz	18dBm	0.410 mW/g	1.6mW/g

Note: According to the manufacturer this device does not support simultaneous transmission for any of the radios listed above.



2 TEST SITE DESCRIPTION

The SAR test site located at 731 Enterprise Drive, Lexington KY 40510 is comprised of the SPEAG model DASY 5.2 automated near-field scanning system, which is a package, optimized for dosimetric evaluation of mobile radios [3]. This system is installed in an ambient-free shielded chamber. The ambient temperature is controlled to $22.0 \pm 2^\circ\text{C}$. During the SAR evaluations, the RF ambient conditions are monitored continuously for signals that might interfere with the test results. The tissue simulating liquid is also stored in this area in order to keep it at the same constant ambient temperature as the room.

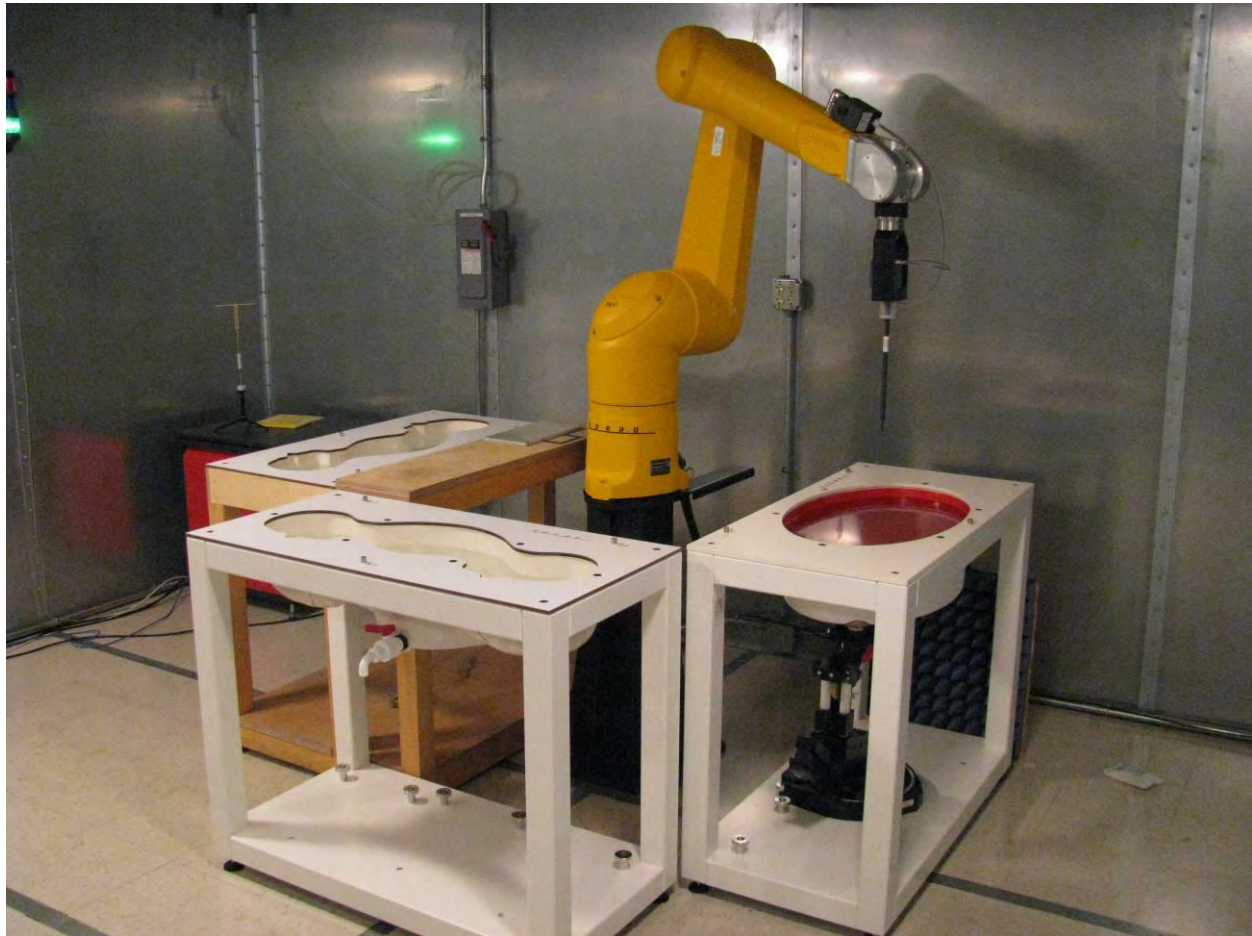


Figure 1: Intertek SAR Test Site



2.1 Measurement Equipment

The following major equipment/components were used for the SAR evaluation:

Table 2: Test Equipment Used for SAR Evaluation

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
SAR Probe	3516	Speag	EXDV3	11/15/2017	11/15/2018
System Verification Dipole	718	Speag	D2450V2	11/7/2017	11/7/2018
System Verification Dipole	1025	Speag	D5GH2V2	11/6/2017	11/6/2018
DAE	358	Speag	DAE4	11/7/2017	11/7/2018
Vector Signal Generator	257708	Rohde & Schwarz	SMBV100A	9/21/2018	9/21/2019
Network Analyzer	US39173983	Agilent	8753ES	3/6/2018	3/6/2019
USB Power Sensor	100155	Rohde & Schwarz	NRP-Z81	9/21/2018	9/21/2019
USB Power Sensor	100705	Rohde & Schwarz	NRP-Z51	9/21/2018	9/21/2019
Dielectric Probe Kit	1111	Speag	DAK-3.5	NCR	NCR
Spectrum Analyzer	3099	Rohde & Schwarz	FSP7	9/20/2018	9/20/2019
SAM Twin Phantom	1663	Speag	QD 000 P40 C	NCR	NCR
Oval Flat Phantom ELI 5.0	1108	Speag	QD OVA 002 A	NCR	NCR
6-axis robot	F11/5H1YA/A/01	Staubli	RX-90	NCR	NCR

**NCR – No Calibration Required*



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2.2 Measurement Uncertainty

The Tables below includes the uncertainty budget suggested by the IEEE Std 1528-2013 and IEC62209-2: 2010 as determined by SPEAG for the DASY5 measurement System.

Error Description	Uncertainty Value	Prob. Dist.	Div.	c_i (1g)	c_i (10g)	Std.Unc. (1g)	Std.Unc. (10g)	$(v_i)_{V_{eff}}$
Measurement System								
Probe Calibration	±6.0%	N	1	1	1	±6.0%	±6.0%	∞
Axial Isotropy	±4.7%	R	√3	0.7	0.7	±1.9%	±1.9%	∞
Hemispherical Isotropy	±9.6%	R	√3	0.7	0.7	±3.9%	±3.9%	∞
Boundary Effect	±1.0%	R	√3	1	1	±0.6%	±0.6%	∞
Linearity	±4.7%	R	√3	1	1	±2.7%	±2.7%	∞
System Detection Limits	±1.0%	R	√3	1	1	±0.6%	±0.6%	∞
Modulation Response	±2.4%	R	√3	1	1	±1.4%	±1.4%	∞
Readout Electronics	±0.3%	N	1	1	1	±0.3%	±0.3%	∞
Response Time	±0.8%	R	√3	1	1	±0.5%	±0.5%	∞
Integration Time	±2.6%	R	√3	1	1	±1.5%	±1.5%	∞
RF Ambient Noise	±3.0%	R	√3	1	1	±1.7%	±1.7%	∞
RF Ambient Reflections	±3.0%	R	√3	1	1	±1.7%	±1.7%	∞
Probe Positioner	±0.4%	R	√3	1	1	±0.2%	±0.2%	∞
Probe Positioning	±2.9%	R	√3	1	1	±1.7%	±1.7%	∞
Max. SAR Eval.	±2.0%	R	√3	1	1	±1.2%	±1.2%	∞
Test sample Related								
Device Positioning	±2.9%	N	1	1	1	±2.9%	±2.9%	145
Device Holder	±3.6%	N	1	1	1	±3.6%	±3.6%	5
Power Drift	±5.0%	R	√3	1	1	±2.9%	±2.9%	∞
Power Scaling	±0.0%	R	√3	1	1	±0%	±0%	∞
Phantom and Setup								
Phantom Uncertainty	±6.1%	R	√3	1	1	±3.5%	±3.5%	∞
SAR Correction	±1.9%	R	√3	1	0.84	±1.1%	±0.9%	∞
Liquid Conductivity (mea.)	±2.5%	R	√3	0.78	0.71	±1.1%	±1.0%	∞
Liquid Permittivity(mea.)	±2.5%	R	√3	0.26	0.26	±0.3%	±0.4%	∞
Temp unc. - Conductivity	±3.4%	R	√3	0.78	0.71	±1.5%	±1.4%	∞
Temp unc. - Permittivity	±0.4%	R	√3	0.23	0.26	±0.1%	±0.1%	∞
Combined Standard Uncertainty						±11.2%	±11.1%	361
Expanded STD Uncertainty						±22.3%	±22.2%	

Notes:

Worst Case uncertainty budget for DASY5 assessed according to IEEE 1528-2013. The budget is valid for the frequency range 300 MHz – 3 GHz and represents a worst-case analysis. For specific tests and configurations, the uncertainty could be considerably smaller.



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Error Description	Uncertainty Value	Prob. Dist.	Div.	c_i (1g)	c_i (10g)	Std.Unc. (1g)	Std.Unc. (10g)	$(V_i)_{V_{eff}}$
Measurement System								
Probe Calibration	±6.55%	N	1	1	1	±6.55%	±6.55%	∞
Axial Isotropy	±4.7%	R	√3	0.7	0.7	±1.9%	±1.9%	∞
Hemispherical Isotropy	±9.6%	R	√3	0.7	0.7	±3.9%	±3.9%	∞
Boundary Effect	±2.0%	R	√3	1	1	±1.2%	±1.2%	∞
Linearity	±4.7%	R	√3	1	1	±2.7%	±2.7%	∞
System Detection Limits	±1.0%	R	√3	1	1	±0.6%	±0.6%	∞
Modulation Response	±2.4%	R	√3	1	1	±1.4%	±1.4%	∞
Readout Electronics	±0.3%	N	1	1	1	±0.3%	±0.3%	∞
Response Time	±0.8%	R	√3	1	1	±0.5%	±0.5%	∞
Integration Time	±2.6%	R	√3	1	1	±1.5%	±1.5%	∞
RF Ambient Noise	±3.0%	R	√3	1	1	±1.7%	±1.7%	∞
RF Ambient Reflections	±3.0%	R	√3	1	1	±1.7%	±1.7%	∞
Probe Positioner	±0.8%	R	√3	1	1	±0.5%	±0.5%	∞
Probe Positioning	±6.7%	R	√3	1	1	±3.9%	±3.9%	∞
Max. SAR Eval.	±4.0%	R	√3	1	1	±2.3%	±2.3%	∞
Test sample Related								
Device Positioning	±2.9%	N	1	1	1	±2.9%	±2.9%	145
Device Holder	±3.6%	N	1	1	1	±3.6%	±3.6%	5
Power Drift	±5.0%	R	√3	1	1	±2.9%	±2.9%	∞
Power Scaling	±0.0%	R	√3	1	1	±0%	±0%	∞
Phantom and Setup								
Phantom Uncertainty	±6.6%	R	√3	1	1	±3.8%	±3.8%	∞
SAR Correction	±1.9%	R	√3	1	0.84	±1.1%	±0.9%	∞
Liquid Conductivity (mea.)	±2.5%	R	√3	0.78	0.71	±1.1%	±1.0%	∞
Liquid Permittivity(me.)	±2.5%	R	√3	0.26	0.26	±0.3%	±0.4%	∞
Temp unc. - Conductivity	±3.4%	R	√3	0.78	0.71	±1.5%	±1.4%	∞
Temp unc. - Permittivity	±0.4%	R	√3	0.23	0.26	±0.1%	±0.1%	∞
Combined Standard Uncertainty						±12.3%	±12.2%	748
Expanded STD Uncertainty						±24.6%	±24.5%	

Notes.

Worst Case uncertainty budget for DASY5 assessed according to IEEE 1528-2013. The budget is valid for the frequency range 3 GHz – 6 GHz and represents a worst-case analysis. Probe calibration error reflects uncertainty of the EX3D probe. For specific tests and configurations, the uncertainty could be considerably smaller.



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Error Description	Uncertainty Value	Prob. Dist.	Div.	c_i (1g)	c_i (10g)	Std.Unc. (1g)	Std.Unc. (10g)	$(V_i)_{V_{eff}}$
Measurement System								
Probe Calibration	±6.55%	N	1	1	1	±6.55%	±6.55%	∞
Axial Isotropy	±4.7%	R	√3	0.7	0.7	±1.9%	±1.9%	∞
Hemispherical Isotropy	±9.6%	R	√3	0.7	0.7	±3.9%	±3.9%	∞
Boundary Effect	±2.0%	R	√3	1	1	±1.2%	±1.2%	∞
Linearity	±4.7%	R	√3	1	1	±2.7%	±2.7%	∞
System Detection Limits	±1.0%	R	√3	1	1	±0.6%	±0.6%	∞
Modulation Response	±2.4%	R	√3	1	1	±1.4%	±1.4%	∞
Readout Electronics	±0.3%	N	1	1	1	±0.3%	±0.3%	∞
Response Time	±0.8%	R	√3	1	1	±0.5%	±0.5%	∞
Integration Time	±2.6%	R	√3	1	1	±1.5%	±1.5%	∞
RF Ambient Noise	±3.0%	R	√3	1	1	±1.7%	±1.7%	∞
RF Ambient Reflections	±3.0%	R	√3	1	1	±1.7%	±1.7%	∞
Probe Positioner	±0.8%	R	√3	1	1	±0.5%	±0.5%	∞
Probe Positioning	±6.7%	R	√3	1	1	±3.9%	±3.9%	∞
Post-Processing	±4.0%	R	√3	1	1	±2.3%	±2.3%	∞
Test sample Related								
Device Positioning	±2.9%	N	1	1	1	±2.9%	±2.9%	145
Device Holder	±3.6%	N	1	1	1	±3.6%	±3.6%	5
Power Drift	±5.0%	R	√3	1	1	±2.9%	±2.9%	∞
Power Scaling	±0.0%	R	√3	1	1	±0%	±0%	∞
Phantom and Setup								
Phantom Uncertainty	±7.9%	R	√3	1	1	±4.6%	±4.6%	∞
SAR Correction	±1.9%	R	√3	1	0.84	±1.1%	±0.9%	∞
Liquid Conductivity (mea.)	±2.5%	R	√3	0.78	0.71	±1.1%	±1.0%	∞
Liquid Permittivity(me.)	±2.5%	R	√3	0.26	0.26	±0.3%	±0.4%	∞
Temp unc. - Conductivity	±3.4%	R	√3	0.78	0.71	±1.5%	±1.4%	∞
Temp unc. - Permittivity	±0.4%	R	√3	0.23	0.26	±0.1%	±0.1%	∞
Combined Standard Uncertainty						±12.5%	±12.5%	748
Expanded STD Uncertainty						±25.1%	±25.0%	

Notes.

Worst Case uncertainty budget for DASY5 assessed according to IEC62209-2: 2010. The budget is valid for the frequency range 30MHz – 6 GHz and represents a worst-case analysis. Probe calibration error reflects uncertainty of the EX3D probe. For specific tests and configurations, the uncertainty could be considerably smaller.



3 JOB DESCRIPTION

At the request Vocera Communications, SAR testing was performed on the Communication Badge (Model Number: V5000.) The V5000 was communication badge worn on the body or used against the ear like a phone in a medical environment.

Table 3: Product Information

Test Sample Information	
Manufacturer	Vocera Communications
Product Name	Communication Badge (Model:V5000)
Serial Number	SA3308HR50031B
Receive Date	10/8/2018
Device Received Condition	Good
Test Dates	10/8/2018 to 10/19/2018
Device Category	Portable
RF Exposure Category	General Population/Uncontrolled Environment
Antenna Type	Internal
Test sample Accessories	
Accessory	earbuds

Table 4: Operating Bands

Operating Bands	Technology	Modulation	Frequency Range (MHz)	Max Upper Tolerance Output Power (dBm)	Duty Cycle
2.4GHz WiFi	802.11b, 802.11g, 802.11n	DSS, OFDM	2412 – 2462MHz	18dBm	1:1
5GHz WiFi (U-NII-1, U-NII-2A, U-NII-2C, U-NII-3)	802.11a, 802.11n, 802.11ac	OFDM	5150 – 5250MHz 5250 – 5350MHz 5470 – 5725MHz 5725 – 5850MHz	20dBm	1:1
Bluetooth Low Energy	FHSS	GFSK	2402 – 2480MHz	4.52dBm	1:1



4 SYSTEM VERIFICATION

System Validation

Prior to the assessment, the system was verified to be within $\pm 10\%$ of the specifications by using the system validation kit. The system validation procedure tests the system against reference SAR values and the performance of probe, readout electronics and software. The test setup utilizes a phantom and reference dipole.



Figure 2: System Verification Setup



Table 5: Dipole Validations (1g)

Reference Dipole Validation									
Ambient Temp (°C)	Fluid Temp (°C)	Frequency (MHz)	Dipole	Fluid Type	Dipole Power Input	Cal. Lab SAR (1g)	Measured SAR (1g)	% Error SAR (1g)	Date
23.2	23.1	2450	D2450V2	MSL2450	1W	51.3	50.3	1.95	10/9/2018
23.2	23.1	2450	D2450V2	MSL2450	1W	51.3	52.2	1.75	10/11/2018
23.2	23.1	2450	D2450V2	MSL2450	1W	51.3	51.8	0.97	10/12/2018
23.2	23.1	5200	D5GHzV2	HSL5GHz	1W	79.40	83.3	4.91	10/15/2018
23.2	23.1	5500	D5GHzV2	HSL5GHz	1W	84.70	86.3	1.89	10/15/2018
23.2	23.1	5800	D5GHzV2	HSL5GHz	1W	81.00	84.8	4.69	10/15/2018
23.2	23.1	5200	D5GHzV2	HSL5GHz	1W	79.40	73.8	7.05	10/19/2018
23.2	23.1	5500	D5GHzV2	HSL5GHz	1W	84.70	89.5	5.67	10/19/2018
23.2	23.1	5800	D5GHzV2	HSL5GHz	1W	81.00	85.3	5.31	10/19/2018



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Measurement Uncertainty for System Validation

Source of Uncertainty	Value(dB)	Probability Distribution	Divisor	c_i	$u_i(y)$	$(u_i(y))^2$
Measurement System						
Probe Calibration	5.50	n1	1	1	5.50	30.250
Axial Isotropy	4.70	r	1.732	0.7	2.71	7.364
Hemispherical Isotropy	9.60	r	1.732	0.7	5.54	30.722
Boundary Effect	1.00	r	1.732	1	0.58	0.333
Linearity	4.70	r	1.732	1	2.71	7.364
System Detection Limits	1.00	r	1.732	1	0.58	0.333
Readout Electronics	0.30	n1	1	1	0.30	0.090
Response Time	0.80	r	1.732	1	0.46	0.213
Integration Time	2.60	r	1.732	1	1.50	2.253
RF Ambient Noise	3.00	r	1.732	1	1.73	3.000
RF Ambient Reflections	3.00	r	1.732	1	1.73	3.000
Probe Positioner	0.40	r	1.732	1	0.23	0.053
Probe Positioning	2.90	r	1.732	1	1.67	2.803
Max. SAR Eval.	1.00	r	1.732	1	0.58	0.333
Dipole / Generator / Power Meter Related						
Dipole positioning	2.90	n1	1	1	2.90	8.410
Dipole Calibration Uncertainty	0.68	r	1.732	1	0.39	0.154
Power Meter 1 Uncertainty (+20C to +25C)	0.13	n1	1	2	0.13	0.017
Power Meter 2 Uncertainty (+20C to +25C)	0.04	n1	1	3	0.04	0.002
Sig Gen VSWR Mismatch Error	1.80	n1	1	5	1.80	3.240
Sig Gen Resolution Error	0.01	n1	1	6	0.01	0.000
Sig Gen Level Error	0.90	n1	1	1	0.90	0.810
Phantom and Setup						
Phantom Uncertainty	4.00	r	1.732	1	2.31	5.334
Liquid Conductivity (target)	5.00	r	1.732	0.43	2.89	8.334
Liquid Conductivity (meas.)	2.50	n1	1	0.43	2.50	6.250
Liquid Permittivity (target)	5.00	r	1.732	0.49	2.89	8.334
Liquid Permittivity (meas.)	2.50	n1	1	0.49	2.50	6.250
Combined Standard Uncertainty		N1	1	1	11.63	135.247
Expanded Uncertainty		Normal k=	2		23.26	
Expanded Uncertainty	is	23.3	for	Normal	k=	2



Tissue Simulating Liquid Description and Validation

The dielectric parameters were verified to be within 5% of the target values prior to assessment. The dielectric parameters (ϵ_r, σ) are shown in Table 6. A recipe for the tissue simulating fluid used is shown in Table 7.

Table 6: Dielectric Parameter Validations

Tissue Type	Frequency Measure (MHz)	Dielectric Constant Target	Conductivity Target	Dielectric Constant Measure	Imaginary Part	Conductivity Measure	Dielectric % Deviation	Conductivity % Deviation	Date
2450MSL	2400	52.77	1.95	51.8	14.2	1.89	1.84	2.84	10/12/2018
	2450	52.7	1.95	51.5	14.6	1.99	2.28	1.98	10/12/2018
	2480	52.66	1.95	51.4	14.6	2.01	2.39	3.23	10/12/2018
Tissue Type	Frequency Measure (MHz)	Dielectric Constant Target	Conductivity Target	Dielectric Constant Measure	Imaginary Part	Conductivity Measure	Dielectric % Deviation	Conductivity % Deviation	Date
2450HSL	2400	39.4	1.75	38.8	13.5	1.80	1.52	2.93	10/10/2018
	2450	39.2	1.8	38.6	13.7	1.87	1.53	3.67	10/10/2018
	2480	39.2	1.83	38.2	13.8	1.90	2.55	3.97	10/10/2018
Tissue Type	Frequency Measure (MHz)	Dielectric Constant Target	Conductivity Target	Dielectric Constant Measure	Imaginary Part	Conductivity Measure	Dielectric % Deviation	Conductivity % Deviation	Date
5GHz MSL	5200	49.01	5.30	48.93	18.45	5.33	0.16	0.64	10/18/2018
	5600	48.47	5.77	48.48	18.77	5.84	0.02	1.28	10/18/2018
	5800	48.2	6.00	48.11	19.03	6.14	0.19	2.27	10/18/2018
Tissue Type	Frequency Measure (MHz)	Dielectric Constant Target	Conductivity Target	Dielectric Constant Measure	Imaginary Part	Conductivity Measure	Dielectric % Deviation	Conductivity % Deviation	Date
5GHz HSL	5200	35.99	4.65	35.78	16.54	4.78	0.58	2.83	10/15/2018
	5600	35.53	5.07	35.52	16.66	5.19	0.03	2.30	10/15/2018
	5800	35.3	5.27	35.27	16.74	5.40	0.08	2.43	10/15/2018



Table 7: Tissue Simulating Fluid Recipe

Composition of Ingredients for Liquid Tissue Phantoms (450MHz to 2450 MHz data only)												
Ingredient (% by weight)	f (MHz)											
	450		835		915		1900		2450		5500	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body
Water	38.56	51.16	41.45	52.4	41.05	56	54.9	70.45	62.7	68.64	65.53	78.67
Salt (NaCl)	3.95	1.49	1.45	1.4	1.35	0.76	0.18	0.36	0.5	0	0	0
Sugar	56.32	46.78	56	45	56.5	41.76	0	0	0	0	0	0
HEC	0.98	0.52	1	1	1	1.21	0	0	0	0	0	0
Bactericide	0.19	0.05	0.1	0.1	0.1	0.27	0	0	0	0	0	0
Triton X-100	0	0	0	0	0	0	0	0	36.8	0	17.235	10.665
DGBE	0	0	0	0	0	0	44.92	29.18	0	31.37	0	0
DGHE	0	0	0	0	0	0	0	0	0	0	17.235	10.665
Dielectric Constant	43.42	58	42.54	56.1	42	56.8	39.9	53.3	39.8	52.7		
Conductivity (S/m)	0.85	0.83	0.91	0.95	1	1.07	1.42	1.52	1.88	1.95		

Tissue Simulating Liquid for 5GHz, MBBL3500-5800V5 Manufactured by SPEAG (proprietary mixture)

Ingredients	(% by weight)
Water	78
Mineral oil	11
Emulsifiers	9
Additives and Salt	2



5 EVALUATION PROCEDURES

Prior to any testing, the appropriate fluid was used to fill the phantom to a depth of 15 cm \pm 0.2cm. The fluid parameters were verified and the dipole validation was performed as described in the previous sections.

Test Positions:

The Device was positioned against the SAM and flat phantom using the exact procedure described in IEEE Std 1528:2013, IEC62209-2:2010, and the Office of Engineering and Technology KDB 447498.

Reference Power Measurement:

The measurement probe was positioned at a fixed location above the reference point. A power measurement was made with the probe above this reference position so it could be used for assessing the power drift later in the test procedure.

Area Scan:

A coarse area scan was performed in order to find the approximate location of the peak SAR value. This scan was performed with the measurement probe at a constant height in the simulating fluid. A two dimensional spline interpolation algorithm was then used to determine the peaks and gradients within the scanned area. The area scan resolution conformed to the requirements of KDB 865664 as shown in Table 8.

Zoom Scan:

A zoom scan was performed around the approximate location of the peak SAR as determined from the area scan. On the basis of this data set, the spatial peak SAR value was evaluated with the following procedure. The zoom scan resolution conformed to the requirements of KDB 865664 as shown in Table 8.



Table 8: SAR Area and Zoom Scan Resolutions

		≤ 3 GHz	> 3 GHz	
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface		5 ± 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm	
Maximum probe angle from probe axis to phantom surface normal at the measurement location		30° ± 1°	20° ± 1°	
Maximum area scan spatial resolution: Δx_{Area} , Δy_{Area}		≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm	
		When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.		
Maximum zoom scan spatial resolution: Δx_{Zoom} , Δy_{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: $\Delta z_{Zoom}(n)$	≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm	
	graded grid	$\Delta z_{Zoom}(1)$: 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
		$\Delta z_{Zoom}(n>1)$: between subsequent points	≤ 1.5 · $\Delta z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z	≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm	
<p>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.</p> <p>* 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 ≤ 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.</p>				



Interpolation, Extrapolation and Detection of Maxima:

The probe is calibrated at the center of the dipole sensors which is located 1 to 2.7 mm away from the probe tip. During measurements, the probe stops shortly above the phantom surface, depending on the probe and the surface detecting system. Both distances are included as parameters in the probe configuration file. The software always knows exactly how far away the measured point is from the surface. As the probe cannot directly measure at the surface, the values between the deepest measured point and the surface must be extrapolated.

In DASYS5, the choice of the coordinate system defining the location of the measurement points has no influence on the uncertainty of the interpolation, Maxima Search and extrapolation routines. The interpolation, extrapolation and maximum search routines are all based on the modified Quadratic Shepard's method.

Thereby, the interpolation scheme combines a least-square fitted function method and a weighted average method which are the two basic types of computational interpolation and approximation. The DASYS5 routines construct a once-continuously differentiable function that interpolates the measurement values as follows:

- For each measurement point a trivariate (3-D) / bivariate (2-D) quadratic is computed. It interpolates the measurement values at the data point and forms a least-square fit to neighboring measurement values.
- The spatial location of the quadratic with respect to the measurement values is attenuated by an inverse distance weighting. This is performed since the calculated quadratic will fit measurement values at nearby points more accurate than at points located further away.
- After the quadratics are calculated for at all measurement points, the interpolating function is calculated as a weighted average of the quadratics.

There are two control parameters that govern the behavior of the interpolation method. One specifies the number of measurement points to be used in computing the least-square fits for the local quadratics. These measurement points are the ones nearest the input point for which the quadratic is being computed. The second parameter specifies the number of measurement points that will be used in calculating the weights for the quadratics to produce the final function. The input data points used there are the ones nearest the point at which the interpolation is desired. Appropriate defaults are chosen for each of the control parameters.

The trivariate quadratics that have been previously computed for the 3-D interpolation and whose input data are at the closest distance from the phantom surface, are used in order to extrapolate the fields to the surface of the phantom.

In order to determine all the field maxima in 2-D (Area Scan) and 3-D (Zoom Scan), the measurement grid is refined by a default factor of 10 and the interpolation function is used to evaluate all field values between corresponding measurement points. Subsequently, a linear search is applied to find all the candidate maxima. In a last step, non-physical maxima are removed and only those maxima which are within 2 dB of the global maximum value are retained.



Averaging and Determination of Spatial Peak SAR

The interpolated data is used to average the SAR over the 1g and 10g cubes by spatially discretizing the entire measured volume. The resolution of this spatial grid used to calculate the averaged SAR is 1mm or about 42875 interpolated points. The resulting volumes are defined as cubical volumes containing the appropriate tissue parameters that are centered at the location. The location is defined as the center of the incremental volume.

The spatial-peak SAR must be evaluated in cubical volumes containing a mass that is within 5% of the required mass. The cubical volume centered at each location, as defined above, should be expanded in all directions until the desired value for the mass is reached, with no surface boundaries of the averaging volume extending beyond the outermost surface of the considered region. In addition, the cubical volume should not consist of more than 10% of air. If these conditions are not satisfied then the center of the averaging volume is moved to the next location. Otherwise, the exact size of the final sampling cube is found using an inverse polynomial approximation algorithm, leading to results with improved accuracy. If one boundary of the averaging volume reaches the boundary of the measured volume during its expansion, it will not be evaluated at all. Reference is kept of all locations used and those not used for averaging the SAR. All average SAR values are finally assigned to the centered location in each valid averaging volume.

All locations included in an averaging volume are marked to indicate that they have been used at least once. If a location has been marked as used, but has never been assigned to the center of a cube, the highest averaged SAR value of all other cubical volumes which have used this location for averaging is assigned to this location. Only those locations that are not part of any valid averaging volume should be marked as unused. For the case of an unused location, a new averaging volume must be constructed which will have the unused location centered at one surface of the cube. The remaining five surfaces are expanded evenly in all directions until the required mass is enclosed, regardless of the amount of included air. Of the six possible cubes with one surface centered on the unused location, the smallest cube is used, which still contains the required mass.

If the final cube containing the highest averaged SAR touches the surface of the measured volume, an appropriate warning is issued within the post processing engine.

Power Drift Measurement:

The probe was positioned at precisely the same reference point and the reference power measurement was repeated. The difference between the initial reference power and the final one is referred to as the power drift. This value should not exceed 5%. The power drift measurement was used to assess the output power stability of the test sample throughout the SAR scan.

RF Ambient Activity:

During the entire SAR evaluation, the RF ambient activity was monitored using a spectrum analyzer with an antenna connected to it. The spectrum analyzer was tuned to the frequency of measurement and with one trace set to max hold mode. In this way, it was possible to determine if at any point during the SAR measurement there was an interfering ambient signal. If an ambient signal was detected, then the SAR measurement was repeated.



6 CRITERIA

The following ANSI/IEEE C95.1 – 1992 limits for SAR apply to portable devices operating in the General Population/Uncontrolled Exposure environment. Uncontrolled environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure.

Exposure Type (General Population/Uncontrolled Exposure environment)	SAR Limit (W/kg or mW/g)
Average over the whole body	0.08
Spatial Peak (1g)	1.60
Spatial Peak for hands, wrists, feet and ankles (10g)	4.00

7 TEST CONFIGURATION

The Communication Badge could be used against the head like a phone or worn against the body on a lanyard. Therefore the SAR was measured in both of these exposure configurations.

The device was evaluated according to the specific requirements found in the following KDBs and Standards:

- FCC KDB 447498D01 v06, General RF Exposure Guidance
- FCC KDB 865664D01 v01r04, SAR Measurement Requirements for 100MHz to 6GHz
- FCC KDB 248227D01 v02r02, SAR Guidance for 802.11 (WiFi) Transmitters
- RSS-102 Issue 5, Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)



8 CONDUCTED OUTPUT POWER

Table 9: Bluetooth Conducted Output Power

Frequency Band	Mode	Data Rate	Channel	Freq. (MHz)	Average Power (dBm)
2390 - 2483.5MHz	BT	GFSK	0	2402	2.97
			39	2441	2.38
			78	2480	-1.01
	BT	Pi/4-DQPSK	0	2402	-1.12
			39	2441	-1.09
			78	2480	-4.77
	BT	8DPSK	0	2402	-0.84
			39	2441	-0.81
			78	2480	-4.49
	BLE	GFSK	0	2402	4.52
			39	2441	4.26
			78	2480	1.30

Table 10: 2.4GHz WiFi Conducted Output Power

Frequency Band	Mode	Bandwidth	Channel	Freq. (MHz)	Average Power (dBm)
2390 - 2483.5MHz	802.11b	20MHz	1	2412	17.53
			6	2437	17.76
			11	2463	17.61
	802.11g	20MHz	1	2412	13.11
			6	2437	16.17
			11	2463	13.38
	802.11n20	20MHz	1	2412	13.05
			6	2437	16.12
			11	2463	13.27



Table 11: U-NII-1 WiFi Conducted Output Power

Frequency Band	Mode	Bandwidth	Channel	Freq. (MHz)	Average Power (dBm)
5150 - 5250MHz	802.11a	20MHz	36	5180	13.56
			40	5200	15.31
			44	5220	14.48
			48	5240	14.41
	802.11n (20MHz)	20MHz	36	5180	14.08
			40	5200	15.04
			44	5220	14.63
			48	5240	14.32
	802.11n (40MHz)	40MHz	38	5190	12.22
			46	5230	14.47
802.11ac	80MHz	42	5210	9.08	

Table 12: U-NII-2A WiFi Conducted Output Power

Frequency Band	Mode	Bandwidth	Channel	Freq. (MHz)	Average Power (dBm)
5250 - 5350MHz	802.11a	20MHz	52	5260	15.57
			56	5280	16.54
			60	5300	17.82
			64	5320	14.79
	802.11n (20MHz)	20MHz	52	5260	15.41
			56	5280	15.67
			60	5300	17.11
			64	5320	14.66
	802.11n (40MHz)	40MHz	54	5270	15.56
			62	5310	12.44
	802.11ac	80MHz	58	5290	11.12



Table 13: U-NII-2C WiFi Conducted Output Power

Frequency Band	Mode	Bandwidth	Channel	Freq. (MHz)	Average Power (dBm)
5470 - 5725MHz	802.11a	20MHz	100	5500	15.88
			104	5520	16.27
			108	5540	16.42
			112	5560	16.35
			116	5580	16.72
			120	5600	16.39
			124	5620	16.63
			128	5640	16.48
			132	5660	16.54
			136	5680	16.65
	140	5700	16.71		
	802.11n	20MHz	100	5500	16.41
			104	5520	16.26
			108	5540	16.35
			112	5560	16.22
			116	5580	16.47
			120	5600	16.39
			124	5620	16.06
			128	5640	15.48
			132	5660	15.79
			136	5680	16.11
	140	5700	16.08		
	802.11n	40MHz	102	5510	15.17
			110	5550	16.79
			134	5670	16.58
	802.11ac	80MHz	106	5530	11.12
138			5690	19.34	



Table 14: U-NII-3 WiFi Conducted Output Power

Frequency Band	Mode	Bandwidth	Channel	Freq. (MHz)	Average Power (dBm)
5725 - 5850MHz	802.11a	20MHz	149	5745	19.81
			153	5765	19.78
			157	5785	19.85
			161	5805	19.83
			165	5825	19.79
	802.11n	20MHz	149	5745	19.61
			153	5765	19.55
			157	5785	19.39
			161	5805	19.42
			165	5825	19.54
	802.11n	40MHz	151	5755	19.98
			159	5795	19.86
	802.11ac	80MHz	155	5775	19.63



9 TEST REDUCTIONS

9.1 Bluetooth SAR Reductions

Since the output power of the Bluetooth Low Energy mode was higher than the Bluetooth Classic modes (4.52dBm and 2.97dBm respectively), only the Bluetooth Low Energy mode was tested for SAR.

9.2 2.4GHZ WiFi SAR Reductions

2.4GHz WiFi SAR reduction was applied per KDB248227 D01 v02r02 page 9 as follows:

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.16 The initial test position procedure is described in the following:

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



9.3 5GHz WiFi SAR Reductions

5GHz OFDM SAR reduction was applied per KDB248227 D01 v02r02 Section 5.3.2 Page 11 as follows:

The initial test configuration for 2.4 GHz and 5 GHz OFDM transmission modes is determined by the 802.11 configuration with the highest maximum output power specified for production units, including tune-up tolerance, in each standalone and aggregated frequency band. SAR for the initial test configuration is measured using the highest maximum output power channel determined by the default power measurement procedures (see Clause 4).

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



10 TEST RESULTS

The worst case 1-g SAR value for each exposure configuration was less than the 1.6W/kg limit.

11 SAR DATA:

The results on the following page(s) were obtained when the device was transmitting at maximum output power. The worst case plots, which reveal information about the location of the maximum SAR with respect to the device, are referenced and shown in APPENDIX B – Worst Case SAR Plots. The measured conducted output power was compared to the power declared by the manufacturer and used for scaling the measured SAR values.

Table 15: Body Worn SAR Results, (2.4GHz Band, Bluetooth and 2.4GHz WiFi)

US / Canada Body SAR Results Using 2450MHz MSL							
TX Mode	Spacing	Position	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
DSSS Ch. 6	5mm	Back	0.04	0.3880	0.4100	17.76	18.00
DSSS Ch. 6	5mm	Front	0.05	0.2310	0.2441	17.76	18.00
BLE 2440MHz	5mm	Back	0.01	0.0280	0.0280	4.52	4.52
BLE 2440MHz	5mm	Front	0.05	0.0860	0.0860	4.52	4.52
1g SAR Limit (Head & Body) = 1.6W/kg							

Test Personnel:	Bryan Taylor	Test Date:	10/12/2018
Supervising/Reviewing Engineer:	_____		_____
(Where Applicable)	NA	Tissue Depth:	15cm
Signal Setup:	Test Code	Ambient Temperature:	22.5C
Power Method:	Fully Charged Battery	Relative Humidity:	49.5%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	978.7mbar

Deviations, Additions, or Exclusions: None



Table 16: Body Worn SAR Results, (5GHz WiFi)

US / Canada Body SAR Results Using 5GHz MSL							
TX Mode	Spacing	Position	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
802.11a; Ch 60; 5300MHz	5mm	Back	-0.03	0.0291	0.0481	17.82	20.00
802.11a; Ch 60; 5300MHz	5mm	Front	0.04	0.0295	0.0487	17.82	20.00
802.11a; Ch 116; 5580MHz	5mm	Back	-0.04	0.0369	0.0785	16.72	20.00
802.11a; Ch 116; 5580MHz	5mm	Front	0.02	0.0338	0.0719	16.72	20.00
802.11a; Ch 157; 5785MHz	5mm	Back	0.05	0.1070	0.1108	19.85	20.00
802.11a; Ch 157; 5785MHz	5mm	Front	0.03	0.1730	0.1791	19.85	20.00
802.11ac (80MHz); Ch 138; 5690MHz	5mm	Back	-0.06	0.0980	0.1141	19.34	20.00
802.11ac (80MHz); Ch 138; 5690MHz	5mm	Front	-0.05	0.1080	0.1141	19.34	20.00
802.11ac (80MHz); Ch 155; 5775MHz	5mm	Back	-0.04	0.1850	0.2276	19.10	20.00
802.11ac (80MHz); Ch 155; 5775MHz	5mm	Front	0.02	0.2100	0.2584	19.10	20.00
1g SAR Limit (Head & Body) = 1.6W/kg							

Test Personnel: Bryan Taylor

Test Date: 10/18/2018

Supervising/Reviewing Engineer: _____

(Where Applicable) NA

Tissue Depth: 15cm

Signal Setup: Test Code

Ambient Temperature: 22.1C

Power Method: Fully Charged Battery

Relative Humidity: 50.3%

Pretest Verification w / Ambient Signals or BB Source: Yes

Atmospheric Pressure: 988.5mbar

Deviations, Additions, or Exclusions: None



Table 17: Left Ear / Right Ear (Bluetooth)

US / Canada Left Ear SAR Results Using 2450MHz HSL							
TX Mode	Spacing	Position	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
BLE	0mm	Left Ear (Cheek Touch)	0.02	0.0510	0.0510	4.52	4.52
BLE	0mm	Left Ear (Tilt)	0.03	0.4600	0.4600	4.52	4.52
BLE	0mm	Right Ear (Cheek Touch)	0.04	0.0330	0.0330	4.52	4.52
BLE	0mm	Right Ear (Tilt)	0.02	0.0360	0.0360	4.52	4.52
1g SAR Limit (Head & Body) = 1.6W/kg							

Test Personnel:	Bryan Taylor	Test Date:	10/12/2018
Supervising/Reviewing Engineer:	_____		_____
(Where Applicable)	NA	Tissue Depth:	15cm
Signal Setup:	Test Code	Ambient Temperature:	22.5C
Power Method:	Fully Charged Battery	Relative Humidity:	49.5%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	978.7mbar

Deviations, Additions, or Exclusions: None



Table 18: Left Ear (802.11b)

US / Canada Left Ear SAR Results Using 2450MHz HSL							
TX Mode	Spacing	Position	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
DSSS Ch. 6	0mm	Left Ear (Cheek Touch)	0.05	1.2200	1.2716	17.82	18.00
DSSS Ch. 6 (Repeated)	0mm	Left Ear (Cheek Touch)	0.01	1.2000	1.2508	17.82	18.00
DSSS Ch. 6	0mm	Left Ear (Tilt)	0.10	1.0700	1.1153	17.82	18.00
DSSS Ch. 1	0mm	Left Ear (Cheek Touch)	0.00	1.1500	1.2814	17.53	18.00
DSSS Ch. 1	0mm	Left Ear (Tilt)	-0.08	0.7810	0.8703	17.53	18.00
DSSS Ch. 11	0mm	Left Ear (Cheek Touch)	0.05	0.9630	1.0535	17.61	18.00
DSSS Ch. 11	0mm	Left Ear (Tilt)	0.06	0.7410	0.8106	17.61	18.00
1g SAR Limit (Head & Body) = 1.6W/kg							

Test Personnel:	Bryan Taylor	Test Date:	10/10/2018
Supervising/Reviewing Engineer:	_____		_____
(Where Applicable)	NA	Tissue Depth:	15cm
Signal Setup:	Test Code	Ambient Temperature:	21.8C
Power Method:	Fully Charged Battery	Relative Humidity:	50.2%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	989.4mbar

Deviations, Additions, or Exclusions: None

Note: the worst case SAR was above 0.8W/kg. Therefore the SAR measurement was repeated for that configuration as required by KDB865664D01 Section 2.8.1. Since the repeated measurement was less than 1.45W/kg and varied by less than 20% from the original measurement only one repeated scan was required.



Table 19: Right Ear (802.11b)

US / Canada Right Ear SAR Results Using 2450MHz HSL							
TX Mode	Spacing	Position	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
DSSS Ch. 6	0mm	Right Ear (Cheek Touch)	0.04	0.7780	0.8109	17.82	18.00
DSSS Ch. 6	0mm	Right Ear (Tilt)	0.04	0.6510	0.6785	17.82	18.00
DSSS Ch. 1	0mm	Right Ear (Cheek Touch)	0.03	0.7680	0.8558	17.53	18.00
DSSS Ch. 1	0mm	Right Ear (Tilt)	0.09	0.7230	0.8056	17.53	18.00
DSSS Ch. 11	0mm	Right Ear (Cheek Touch)	0.03	0.7530	0.8237	17.61	18.00
DSSS Ch. 11	0mm	Right Ear (Tilt)	-0.04	0.7500	0.8205	17.61	18.00
1g SAR Limit (Head & Body) = 1.6W/kg							

Test Personnel:	Bryan Taylor	Test Date:	10/11/2018
Supervising/Reviewing Engineer:	_____		_____
(Where Applicable)	NA	Tissue Depth:	15cm
Signal Setup:	Test Code	Ambient Temperature:	23.2C
Power Method:	Fully Charged Battery	Relative Humidity:	50.5%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	992.1mbar

Deviations, Additions, or Exclusions: None



SAR Test Report

Table 20: Left Ear / Right Ear (802.1a, U-NII-2A)

US / Canada Left Ear / Right Ear SAR Results Using 5GHz HSL; UNII-2A							
TX Mode	Spacing	Position	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
802.11a; Ch 60; 5300MHz	0mm	Left Ear (Cheek Touch)	0.04	0.0884	0.0921	17.82	18.00
802.11a; Ch 60; 5300MHz	0mm	Left Ear (Tilt)	0.02	0.1120	0.1167	17.82	18.00
802.11a; Ch 60; 5300MHz	0mm	Right Ear (Cheek Touch)	0.00	0.0347	0.0362	17.82	18.00
802.11a; Ch 60; 5300MHz	0mm	Right Ear (Tilt)	0.04	0.0523	0.0545	17.82	18.00
1g SAR Limit (Head & Body) = 1.6W/kg							

Test Personnel:	Bryan Taylor	Test Date:	10/15/2018
Supervising/Reviewing Engineer:	_____		_____
(Where Applicable)	NA	Tissue Depth:	15cm
Signal Setup:	Test Code	Ambient Temperature:	22.2C
Power Method:	Fully Charged Battery	Relative Humidity:	42.4%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	983.2mbar

Deviations, Additions, or Exclusions: None



SAR Test Report

Table 21: Left Ear / Right Ear (802.1a, U-NII-2C)

US / Canada Left Ear / Right Ear SAR Results Using 5GHz HSL; UNII-2C							
TX Mode	Spacing	Position	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
802.11a; Ch 116; 5580MHz	0mm	Left Ear (Cheek Touch)	-0.02	0.2500	0.2523	16.72	16.76
802.11a; Ch 116; 5580MHz	0mm	Left Ear (Tilt)	-0.03	0.3080	0.3108	16.72	16.76
802.11a; Ch 116; 5580MHz	0mm	Right Ear (Cheek Touch)	0.02	0.2250	0.2271	16.72	16.76
802.11a; Ch 116; 5580MHz	0mm	Right Ear (Tilt)	0.04	0.0523	0.0528	16.72	16.76
1g SAR Limit (Head & Body) = 1.6W/kg							

Test Personnel:	Bryan Taylor	Test Date:	10/16/2018
Supervising/Reviewing Engineer:	_____		_____
(Where Applicable)	NA	Tissue Depth:	15cm
Signal Setup:	Test Code	Ambient Temperature:	21.9
Power Method:	Fully Charged Battery	Relative Humidity:	47.4%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	992.4mbar
	_____		_____

Deviations, Additions, or Exclusions: None



SAR Test Report

Table 22: Left Ear / Right Ear (802.1a, U-NII-3)

US / Canada Left Ear / Right Ear SAR Results Using 5GHz HSL; UNII-3							
TX Mode	Spacing	Position	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
802.11a; Ch 157; 5785MHz	0mm	Left Ear (Cheek Touch)	0.02	0.6360	0.6584	19.85	20.00
802.11a; Ch 157; 5785MHz	0mm	Left Ear (Tilt)	-0.08	0.5890	0.6097	19.85	20.00
802.11a; Ch 157; 5785MHz	0mm	Right Ear (Cheek Touch)	0.03	0.2900	0.3002	19.85	20.00
802.11a; Ch 157; 5785MHz	0mm	Right Ear (Tilt)	-0.08	0.2900	0.3002	19.85	20.00
1g SAR Limit (Head & Body) = 1.6W/kg							

Test Personnel:	Bryan Taylor	Test Date:	10/16/2018
Supervising/Reviewing Engineer:	_____		_____
(Where Applicable)	NA	Tissue Depth:	15cm
Signal Setup:	Test Code	Ambient Temperature:	22.4C
Power Method:	Fully Charged Battery	Relative Humidity:	50.3%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	991.3mbar

Deviations, Additions, or Exclusions: None



SAR Test Report

Table 23: Left Ear / Right Ear (802.ac, U-NII-2C)

US / Canada Left Ear / Right Ear SAR Results Using 5GHz HSL; UNII-2C							
TX Mode	Spacing	Position	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
802.11ac (80MHz); Ch 138; 5690MHz	0mm	Left Ear (Cheek Touch)	0.04	0.2960	0.3446	19.34	20.00
802.11ac (80MHz); Ch 138; 5690MHz	0mm	Left Ear (Tilt)	0.07	0.3520	0.4098	19.34	20.00
802.11ac (80MHz); Ch 138; 5690MHz	0mm	Right Ear (Cheek Touch)	0.02	0.2300	0.2677	19.34	20.00
802.11ac (80MHz); Ch 138; 5690MHz	0mm	Right Ear (Tilt)	-0.05	0.2540	0.2957	19.34	20.00
1g SAR Limit (Head & Body) = 1.6W/kg							

Test Personnel: Bryan Taylor	Test Date: 10/16/2018
Supervising/Reviewing Engineer: _____	_____
(Where Applicable) NA	Tissue Depth: 15cm
Signal Setup: Test Code	Ambient Temperature: 22.4C
Power Method: Fully Charged Battery	Relative Humidity: 50.3%
Pretest Verification w / Ambient Signals or BB Source: Yes	Atmospheric Pressure: 991.3mbar

Deviations, Additions, or Exclusions: None



SAR Test Report

Table 24: Left Ear / Right Ear (802.1ac, U-NII-3)

US / Canada Left Ear / Right Ear SAR Results Using 5GHz HSL; UNII-3							
TX Mode	Spacing	Position	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
802.11ac; Ch 157; 5785MHz	0mm	Left Ear (Cheek Touch)	-0.02	0.5310	0.5782	19.63	20.00
802.11ac; Ch 157; 5785MHz	0mm	Left Ear (Tilt)	0.04	0.4660	0.5074	19.63	20.00
1g SAR Limit (Head & Body) = 1.6W/kg							

Test Personnel: Bryan Taylor	Test Date: 10/16/2018
Supervising/Reviewing Engineer: _____	_____
(Where Applicable) NA	Tissue Depth: 15cm
Signal Setup: Test Code	Ambient Temperature: 22.4C
Power Method: Fully Charged Battery	Relative Humidity: 50.3%
Pretest Verification w / Ambient Signals or BB Source: Yes	Atmospheric Pressure: 991.3mbar

Deviations, Additions, or Exclusions: None



SAR Test Report

Table 25: Left Ear / Right Ear (802.11ac, U-NII-3)

US / Canada Left Ear / Right Ear SAR Results Using 5GHz HSL; UNII-3							
TX Mode	Spacing	Position	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
802.11ac (80MHz); Ch 155; 5775MHz	0mm	Left Ear (Cheek Touch)	0.04	0.4210	0.5179	19.63	20.00
802.11ac (80MHz); Ch 155; 5775MHz	0mm	Left Ear (Tilt)	0.03	0.4340	0.5339	19.63	20.00
802.11ac (80MHz); Ch 155; 5775MHz	0mm	Right Ear (Cheek Touch)	0.05	0.2900	0.3568	19.63	20.00
802.11ac (80MHz); Ch 155; 5775MHz	0mm	Right Ear (Tilt)	0.03	0.3500	0.4306	19.63	20.00
1g SAR Limit (Head & Body) = 1.6W/kg							

Test Personnel:	Bryan Taylor	Test Date:	10/17/2018
Supervising/Reviewing Engineer:	_____		_____
(Where Applicable)	NA	Tissue Depth:	15cm
Signal Setup:	Test Code	Ambient Temperature:	22.6C
Power Method:	Fully Charged Battery	Relative Humidity:	48.5%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	989.6mbar

Deviations, Additions, or Exclusions: None



1.0 REFERENCES

- [1]ANSI, ANSI/IEEE C95.1-1992: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300 GHz, The Institute of electrical and Electronics Engineers, Inc., New York, NY 10017, 1992
- [2]Federal Communications Commission, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01), FCC, Washington, D.C. 20554, 1997
- [3]Thomas Schmid, Oliver Egger, and Niels Kuster, "Automated E-field scanning system for dosimetric assessments", *IEEE Transaction on Microwave Theory and Techniques*, vol. 44, pp. 105-113, Jan. 1996.
- [4]Niels Kuster, Ralph Kastle, and Thomas Schmid, "Dosimetric evaluation of mobile communications equipment with know precision", *IEICE Transactions on Communications*, vol. E80-B, no. 5, pp.645-652, May 1997.
- [5]NIS81, NAMAS, "The treatment of uncertainty in EMC measurement", Tech. Rep., NAMAS Executive, National Physical Laboratory, Teddinton, Middlesex, England, 1994.
- [6]Barry N. Taylor and Chris E. Kuyatt, "Guidelines for evaluating and expressing the uncertainty of NIST measurement results", Tech. Rep., National Institute of Standards and Technology, 1994.
- [7]Federal Communications Commission, KDB 248227 - "SAR Measurement Procedures for 802.11 a/b/g Transmitters"
- [8] Federal Communications Commission, KDB 648474 – "SAR Evaluation Considerations for Handsets with Multiple Transmitters and Antennas".
- [9] Federal Communications Commission, KDB 447498 – "Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies".
- [10] Federal Communications Commission, KDB 616217 – "SAR Evaluation Considerations for Laptop Computers with Antennas Built-in on Display Screens".
- [11] Federal Communications Commission, KDB 450824 – "SAR Probe Calibration and System Verification Considerations for Measurements at 150MHz – 3GHz".
- [12] Federal Communications Commission, KDB 865664 – "SAR Measurement Requirements for 3-6GHz".
- [13] Federal Communications Commission, KDB 941225 – "SAR Measurement Procedures for 3G Devices".
- [14] ANSI, ANSI/IEEE C63.10-2009: American National Standard for Testing Unlicensed Wireless Devices.



APPENDIX A – SYSTEM VALIDATION SUMMARY

Per FCC KDB 865664, a tabulated summary of the system validation status including the validation date(s), measurement frequencies, SAR probes and tissue dielectric parameters have been included in the summary table below. The validation was performed with reference dipoles using the required tissue equivalent media for system validation according to KDB 865664. Each probe calibration point was validated at a frequency within the valid frequency range of the probe calibration point. All measurements were performed using probes calibrated for CW signals. Modulations in the table above represent test configurations for which the SAR system has been validated. The SAR system was also validated with modulated signals per KDB 865664.

Frequency (MHz)	Date	Probe (SN#)	Probe (Model #)	Probe Calibration Point		Dielectric Properties		CW Validation			Modulation Validation		
				Frequency (MHz)	Fluid Type	σ	ϵ_r	Sensitivity	Probe Linearity	Probe Isotropy	Mod. Type	Duty Factor	PAR
2450	1/13/2017	3516	EX3DV3	2450	Body	50.65	2.02	Pass	Pass	Pass	OFDM	N/A	Pass
5200	1/13/2017	3516	EX3DV3	5200	Body	48.71	5.54	Pass	Pass	Pass	OFDM	N/A	Pass
5500	1/13/2017	3516	EX3DV3	5500	Body	47.68	6.29	Pass	Pass	Pass	OFDM	N/A	Pass
5800	1/13/2017	3516	EX3DV3	5800	Body	48.71	5.54	Pass	Pass	Pass	OFDM	N/A	Pass

Frequency (MHz)	Date	Probe (SN#)	Probe (Model #)	Probe Calibration Point		Dielectric Properties		CW Validation			Modulation Validation		
				Frequency (MHz)	Fluid Type	σ	ϵ_r	Sensitivity	Probe Linearity	Probe Isotropy	Mod. Type	Duty Factor	PAR
835	1/14/2017	3516	EX3DV3	835	Body	54.2	0.98	Pass	Pass	Pass	GMSK	Pass	N/A
900	1/14/2017	3516	EX3DV3	900	Body	54	1.02	Pass	Pass	Pass	GMSK	Pass	N/A
1750	1/14/2017	3516	EX3DV3	1800	Body	52.9	1.41	Pass	Pass	Pass	GMSK	Pass	N/A
1900	1/14/2017	3516	EX3DV3	1900	Body	52.7	1.48	Pass	Pass	Pass	GMSK	Pass	N/A

Table 26: SAR System Validation Summary



APPENDIX B – WORST CASE SAR PLOTS

Worst Case Extremity SAR

Test Laboratory: Intertek

File Name: [SAR_DSSS_Body and Extremity Mode.da52:4](#)

11.1.1 SAR_DSSS_Body and Extremity Mode

Procedure Notes:

DUT: Vocera V5000; Sample 1

Communication System: UID 0, Generic 802.11b/g/n (0); Communication System Band: 2.4 GHz Band; Frequency: 2437 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 2437$ MHz; $\sigma = 2.013$ S/m; $\epsilon_r = 50.739$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASYS Configuration:

- Probe: EX3DV3 - SN3516; ConvF(8.43, 8.43, 8.43); Calibrated: 11/15/2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn358; Calibrated: 11/7/2017
- Phantom: SAM 2 with CRP v5.0; Type: QD000P40CD; Serial: TP:1663
- DASYS2 52.8.7(1137); SEMCAD X 14.6.10(7164)

WWAN Flat-Section MSL Testing/DSSS Mid Channel, Extremity 0mm spacing, Back Side/Area Scan 2 (51x71x1):

Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 1.11 W/kg

WWAN Flat-Section MSL Testing/DSSS Mid Channel, Extremity 0mm spacing, Back Side/Zoom Scan

(10x9x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 22.250 V/m; Power Drift = 0.01 dB

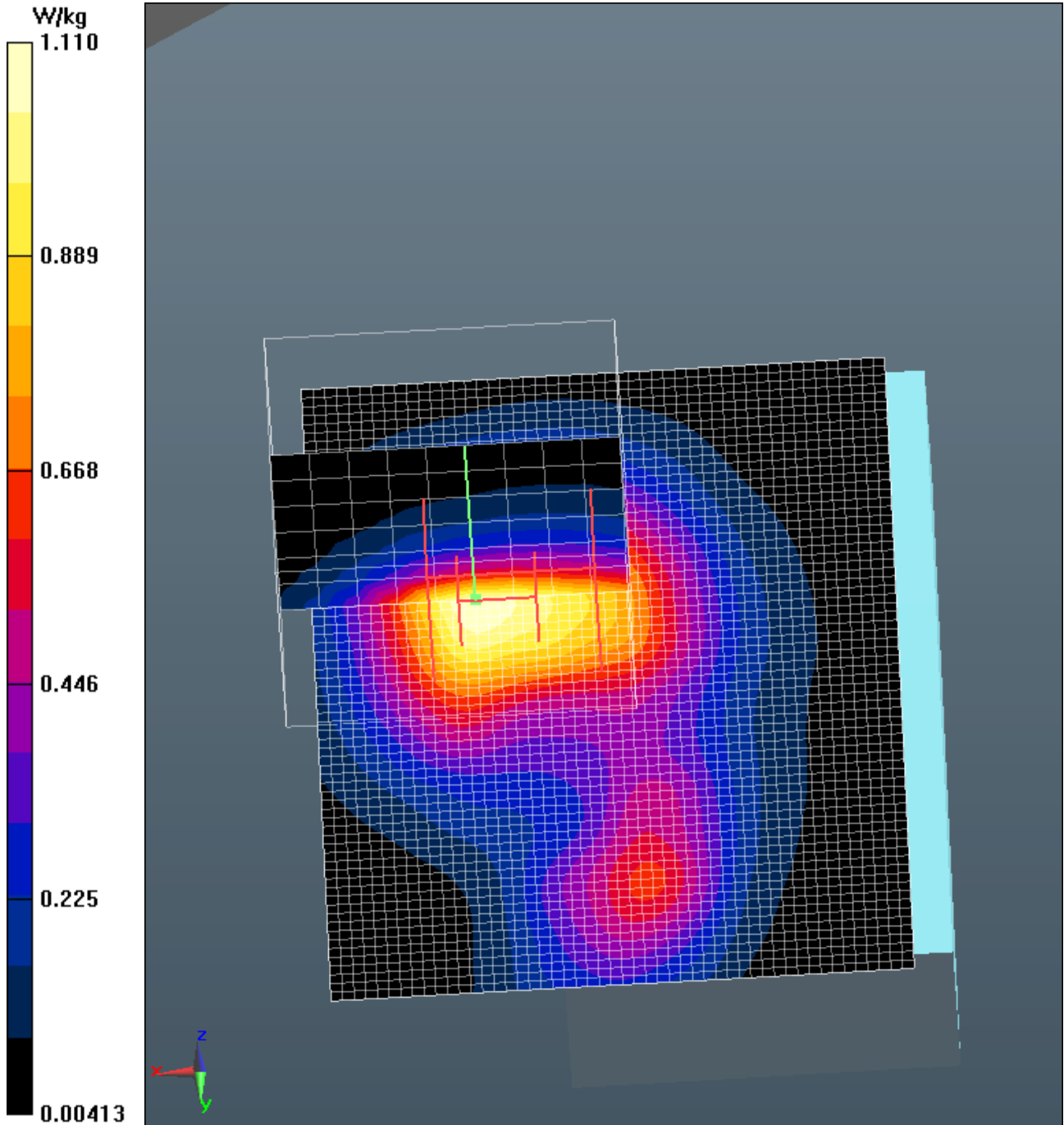
Peak SAR (extrapolated) = 1.37 W/kg

SAR(1 g) = 0.717 W/kg; SAR(10 g) = 0.386 W/kg

Maximum value of SAR (measured) = 1.10 W/kg



SAR Test Report





Worst Case Head SAR (Left Ear, DSSS)

Test Laboratory: Intertek

File Name: [SAR_DSSS_Face_LE_RE.da52:3](#)

11.1.2 SAR_DSSS_Face_LE_RE

Procedure Notes:

DUT: VoceraV5000; Sample 1

Communication System: UID 0, Generic 802.11b/g/n (0); Communication System Band: 2.4 GHz Band; Frequency: 2437 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 2437$ MHz; $\sigma = 1.883$ S/m; $\epsilon_r = 38.021$; $\rho = 1000$ kg/m³

Phantom section: Left Section

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

DASY5 Configuration:

- Probe: EX3DV3 - SN3516; ConvF(8.32, 8.32, 8.32); Calibrated: 11/15/2017;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn358; Calibrated: 11/7/2017
- Phantom: SAM 1 with CRP v5.0; Type: QD000P40CD; Serial: TP: 1243
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

Left-Hand-Side HSL/Touch Position - Mid 2/Area Scan (61x61x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 2.17 W/kg

Left-Hand-Side HSL/Touch Position - Mid 2/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 21.037 V/m; Power Drift = 0.05 dB

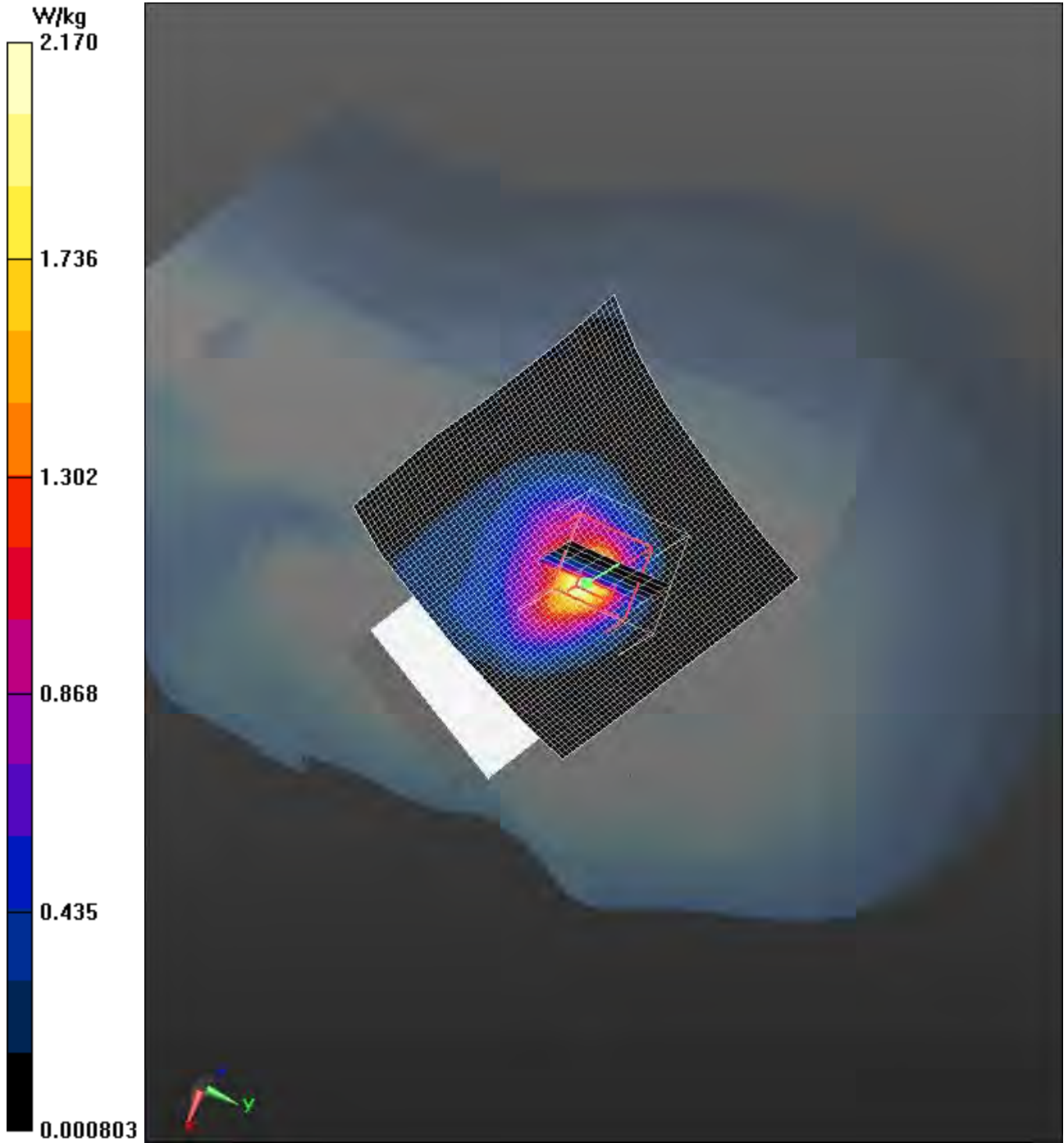
Peak SAR (extrapolated) = 2.67 W/kg

SAR(1 g) = 1.22 W/kg; SAR(10 g) = 0.576 W/kg

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



SAR Test Report





Worst Case Head SAR (Left Ear, OFDM, UNII-3)

Test Laboratory: Intertek

File Name: [SAR_5GHz_Face_LE_RE.da52:3](#)

11.1.3 SAR_5GHz_Face_LE_RE

Procedure Notes:

DUT: VoceraV5000; Sample 1

Communication System: UID 0, Generic 802.11a (0); Frequency: 5782 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 5800$ MHz; $\sigma = 5.12$ S/m; $\epsilon_r = 34.54$; $\rho = 1000$ kg/m³

Phantom section: Left Section

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

DASYS Configuration:

- Probe: EX3DV3 - SN3516; ConvF(4.9, 4.9, 4.9); Calibrated: 11/15/2017;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn358; Calibrated: 11/7/2017
- Phantom: SAM 2 with CRP v5.0; Type: QD000P40CD; Serial: TP:1663
- DASYS2 52.8.7(1137); SEMCAD X 14.6.10(7164)

Left-Hand-Side HSL/Touch Position - Mid 2 2/Area Scan (101x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 1.24 W/kg

Left-Hand-Side HSL/Touch Position - Mid 2 2/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 4.692 V/m; Power Drift = 0.02 dB

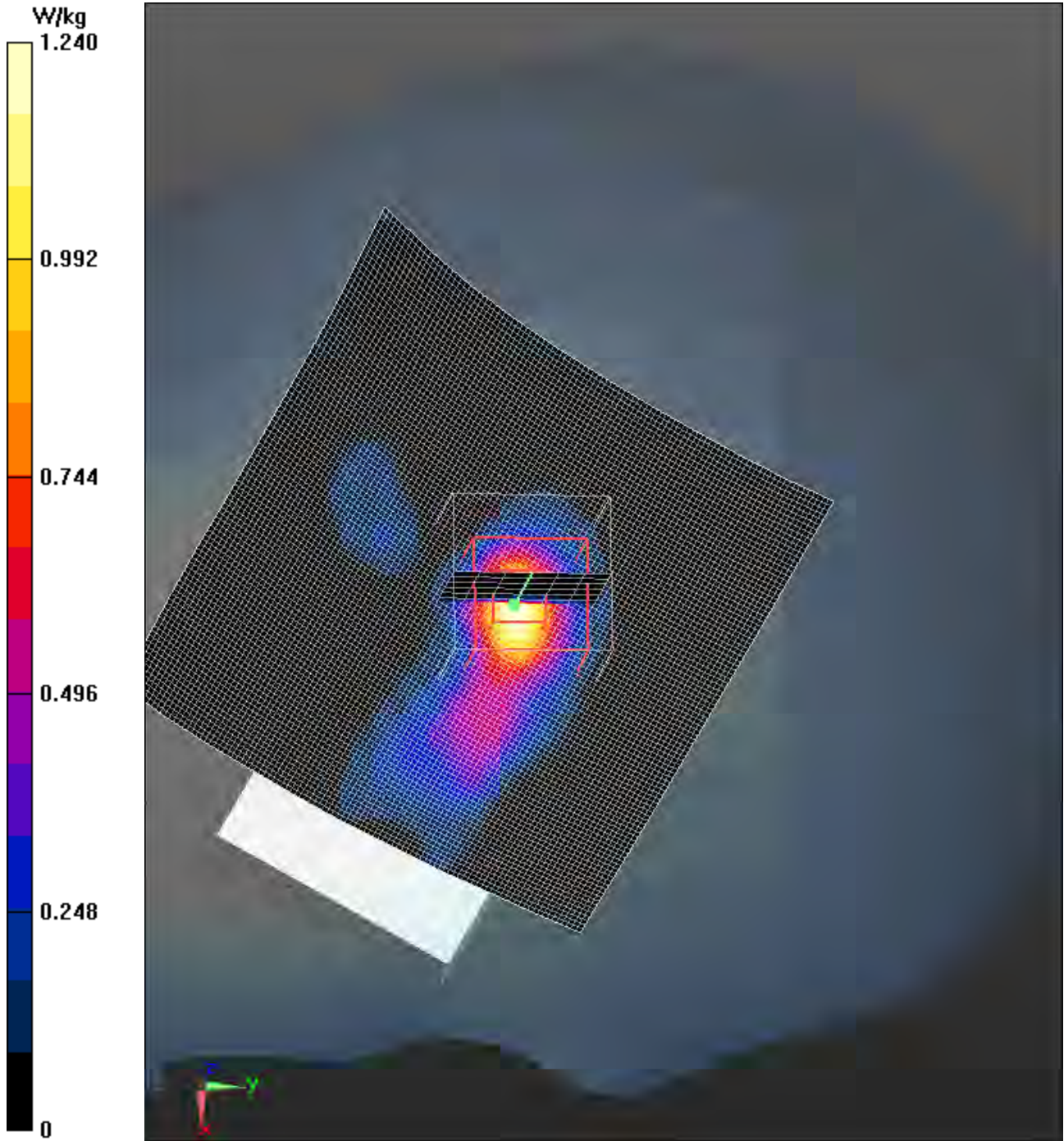
Peak SAR (extrapolated) = 2.70 W/kg

SAR(1 g) = 0.636 W/kg; SAR(10 g) = 0.190 W/kg

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



SAR Test Report





Worst Case Body SAR (DSSS)

Test Laboratory: Intertek

File Name: [SAR_DSSS_Body and Extremity Mode.da52:4](#)

11.1.4 SAR_DSSS_Body and Extremity Mode

Procedure Notes:

DUT: Vocera V5000; Sample 1

Communication System: UID 0, Generic 802.11b/g/n (0); Communication System Band: 2.4 GHz Band; Frequency: 2437 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 2437$ MHz; $\sigma = 2.013$ S/m; $\epsilon_r = 50.739$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY5 Configuration:

- Probe: EX3DV3 - SN3516; ConvF(8.43, 8.43, 8.43); Calibrated: 11/15/2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn358; Calibrated: 11/7/2017
- Phantom: SAM 2 with CRP v5.0; Type: QD000P40CD; Serial: TP:1663
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

WWAN Flat-Section MSL Testing/DSSS Mid Channel, 5mm spacing, Back Side/Area Scan 2 (51x71x1):

Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 0.604 W/kg

WWAN Flat-Section MSL Testing/DSSS Mid Channel, 5mm spacing, Back Side/Zoom Scan (9x8x7)/Cube 0:

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

Reference Value = 16.342 V/m; Power Drift = 0.04 dB

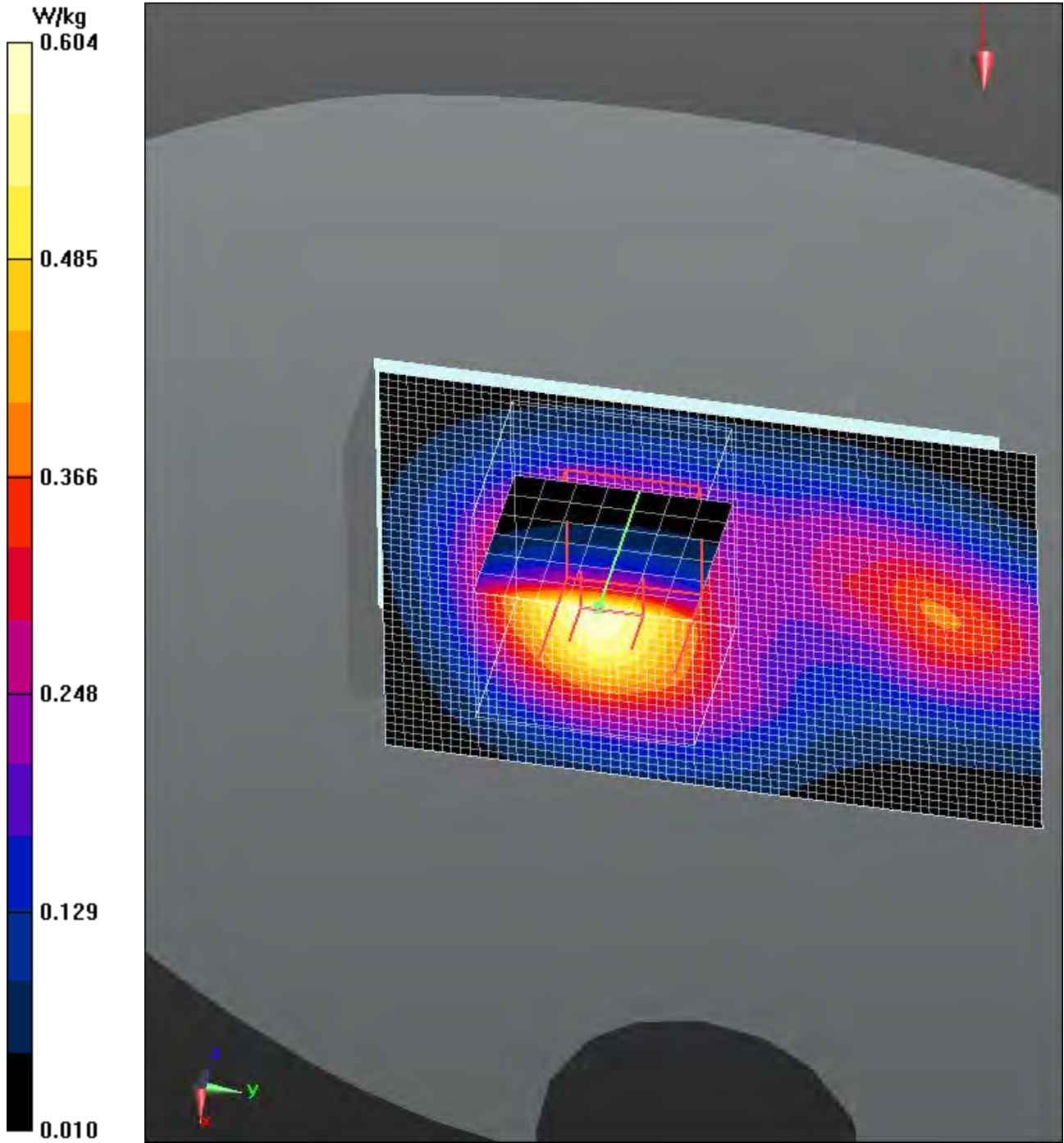
Peak SAR (extrapolated) = 0.735 W/kg

SAR(1 g) = 0.388 W/kg; SAR(10 g) = 0.216 W/kg

Maximum value of SAR (measured) = 0.594 W/kg



SAR Test Report





Worst Case Body SAR (OFDM, UNII-3)

Test Laboratory: Intertek

File Name: [SAR_5GHz_Body and Extremity Mode.da52:4](#)

11.1.5 SAR_5GHz_Body and Extremity Mode

Procedure Notes:

DUT: Vocera V5000; Sample 1

Communication System: UID 0, Generic 802.11a (0); Frequency: 5782 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 5782$ MHz; $\sigma = 6.226$ S/m; $\epsilon_r = 48.309$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY5 Configuration:

- Probe: EX3DV3 - SN3516; ConvF(4.08, 4.08, 4.08); Calibrated: 11/15/2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn358; Calibrated: 11/7/2017
- Phantom: SAM 2 with CRP v5.0; Type: QD000P40CD; Serial: TP:1663
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

WWAN Flat-Section MSL Testing/802.11a ch 157 front side 5mm spacing/Area Scan 2 (51x71x1): Interpolated
grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 0.366 W/kg

WWAN Flat-Section MSL Testing/802.11a ch 157 front side 5mm spacing/Zoom Scan (9x8x7)/Cube 0:

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

Reference Value = 7.865 V/m; Power Drift = 0.03dB

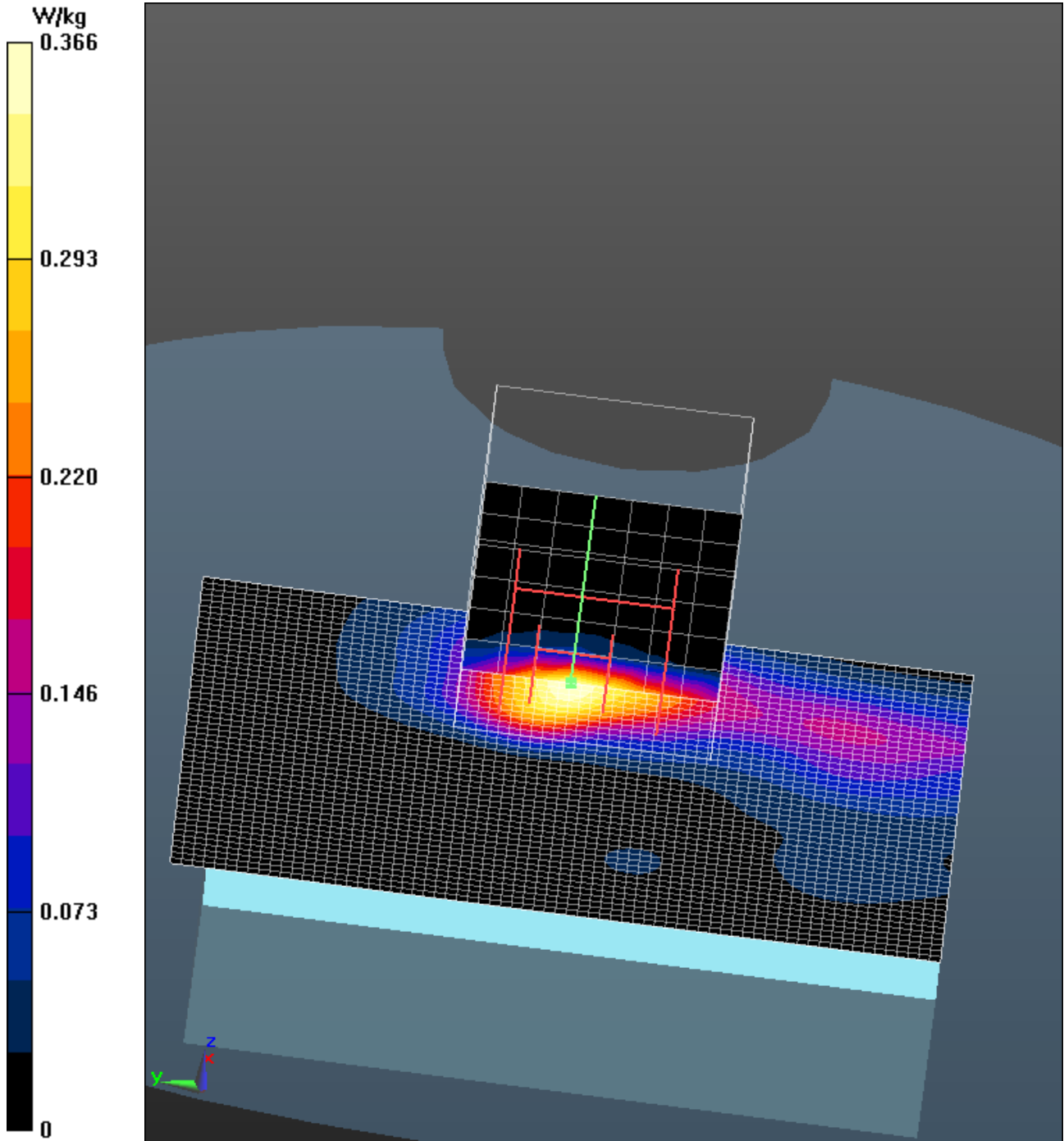
Peak SAR (extrapolated) = 0.907 W/kg

SAR(1 g) = 0.173 W/kg; SAR(10 g) = 0.060 W/kg

Maximum value of SAR (measured) = 0.428 W/kg



SAR Test Report





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 **Intertek**

Certificate No: **EX3-3516_Nov17**

CALIBRATION CERTIFICATE

Object **EX3DV3 - SN:3516**

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 15, 2017**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02525)	Apr-18
Reference 20 dB Attenuator	SN: S5277 (20x)	07-Apr-17 (No. 217-02528)	Apr-18
Reference Probe ES3DV2	SN: 3013	31-Dec-16 (No. ES3-3013_Dec16)	Dec-17
DAE4	SN: 660	7-Dec-16 (No. DAE4-660_Dec16)	Dec-17
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-16)	In house check: Jun-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

Calibrated by:	Name Jeton Kastrati	Function Laboratory Technician	Signature
Approved by:	Name Katja Pokovic	Function Technical Manager	Signature
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			Issued: November 15, 2017



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, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- 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 EX3DV3

SN:3516

Manufactured: March 8, 2004
Calibrated: November 15, 2017

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

DASY/EASY - Parameters of Probe: EX3DV3 - SN:3516

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.83	0.72	0.60	± 10.1 %
DCP (mV) ^B	101.1	101.4	102.2	

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	144.7	±3.0 %
		Y	0.0	0.0	1.0		133.3	
		Z	0.0	0.0	1.0		134.4	

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: EX3DV3 - SN:3516

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	11.21	11.21	11.21	0.36	0.89	± 12.0 %
835	41.5	0.90	10.85	10.85	10.85	0.38	0.84	± 12.0 %
900	41.5	0.97	10.67	10.67	10.67	0.41	0.85	± 12.0 %
1750	40.1	1.37	9.60	9.60	9.60	0.21	0.90	± 12.0 %
1900	40.0	1.40	9.26	9.26	9.26	0.31	0.80	± 12.0 %
2450	39.2	1.80	8.32	8.32	8.32	0.35	0.85	± 12.0 %
2600	39.0	1.96	8.10	8.10	8.10	0.33	0.85	± 12.0 %
4950	36.3	4.40	5.66	5.66	5.66	0.35	1.80	± 13.1 %
5200	36.0	4.66	5.38	5.38	5.38	0.35	1.80	± 13.1 %
5300	35.9	4.76	5.25	5.25	5.25	0.30	1.80	± 13.1 %
5500	35.6	4.96	5.15	5.15	5.15	0.40	1.80	± 13.1 %
5600	35.5	5.07	5.05	5.05	5.05	0.40	1.80	± 13.1 %
5800	35.3	5.27	4.90	4.90	4.90	0.40	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: EX3DV3 - SN:3516

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 ^o (mm)	Unc (k=2)
750	55.5	0.96	11.03	11.03	11.03	0.39	0.85	± 12.0 %
835	55.2	0.97	10.78	10.78	10.78	0.28	1.02	± 12.0 %
900	55.0	1.05	10.94	10.94	10.94	0.42	0.80	± 12.0 %
1750	53.4	1.49	9.21	9.21	9.21	0.31	0.86	± 12.0 %
1900	53.3	1.52	8.84	8.84	8.84	0.35	0.81	± 12.0 %
2450	52.7	1.95	8.43	8.43	8.43	0.33	0.90	± 12.0 %
2600	52.5	2.16	8.16	8.16	8.16	0.29	0.90	± 12.0 %
4950	49.4	5.01	4.90	4.90	4.90	0.35	1.90	± 13.1 %
5200	49.0	5.30	4.86	4.86	4.86	0.35	1.90	± 13.1 %
5300	48.9	5.42	4.85	4.85	4.85	0.35	1.90	± 13.1 %
5500	48.6	5.65	4.39	4.39	4.39	0.40	1.90	± 13.1 %
5600	48.5	5.77	4.30	4.30	4.30	0.40	1.90	± 13.1 %
5800	48.2	6.00	4.08	4.08	4.08	0.40	1.90	± 13.1 %

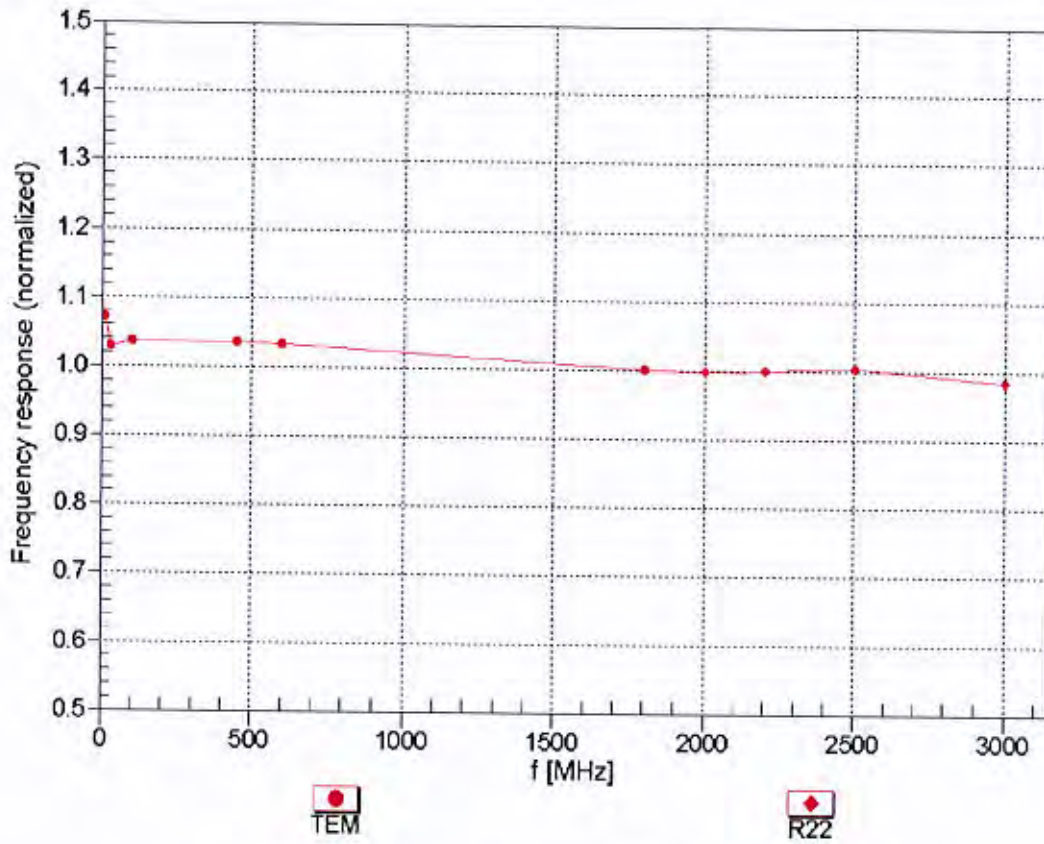
^c Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is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

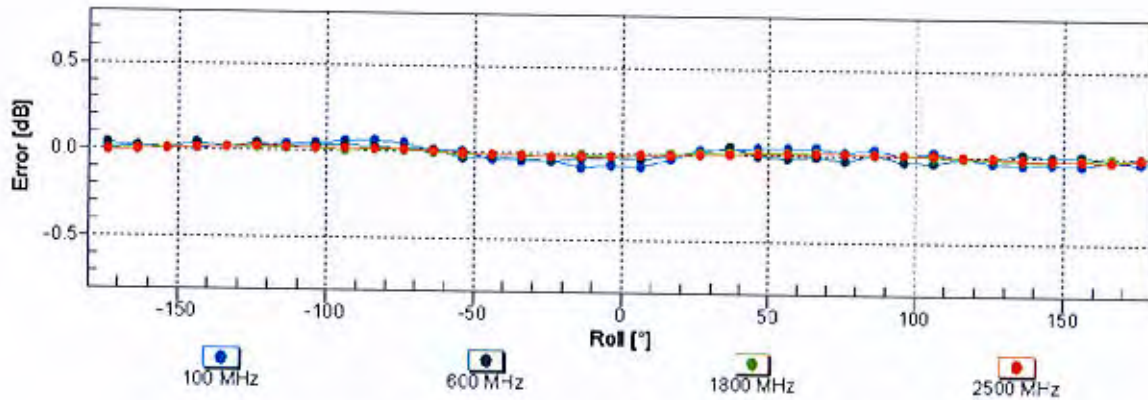
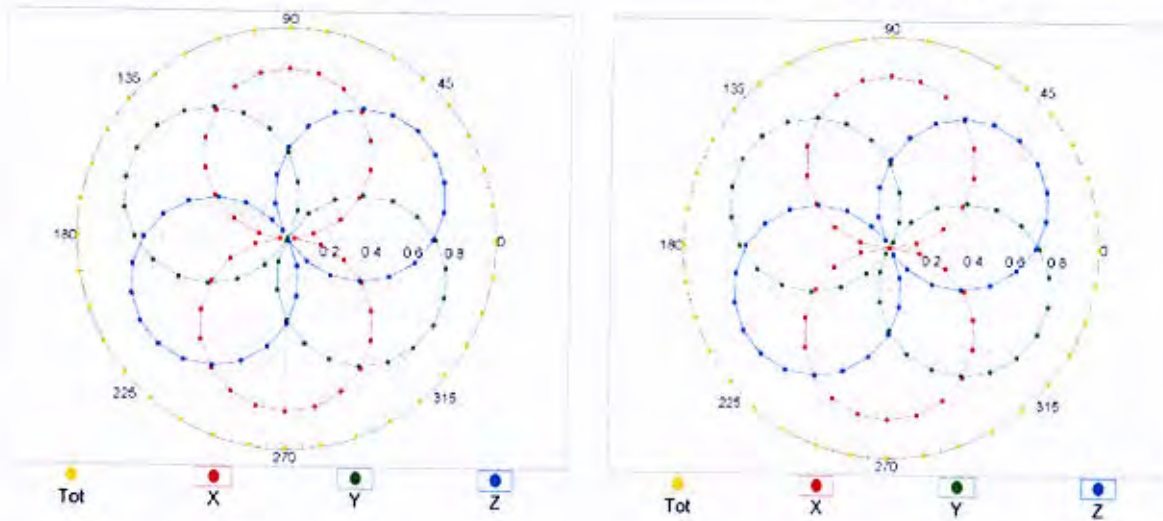


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ (k=2)

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

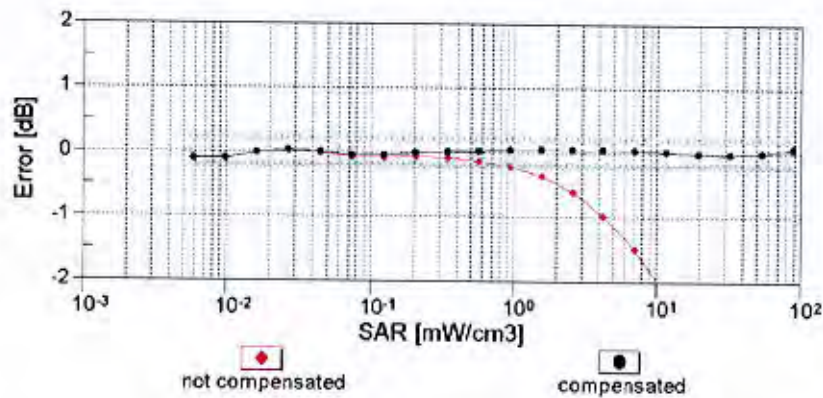
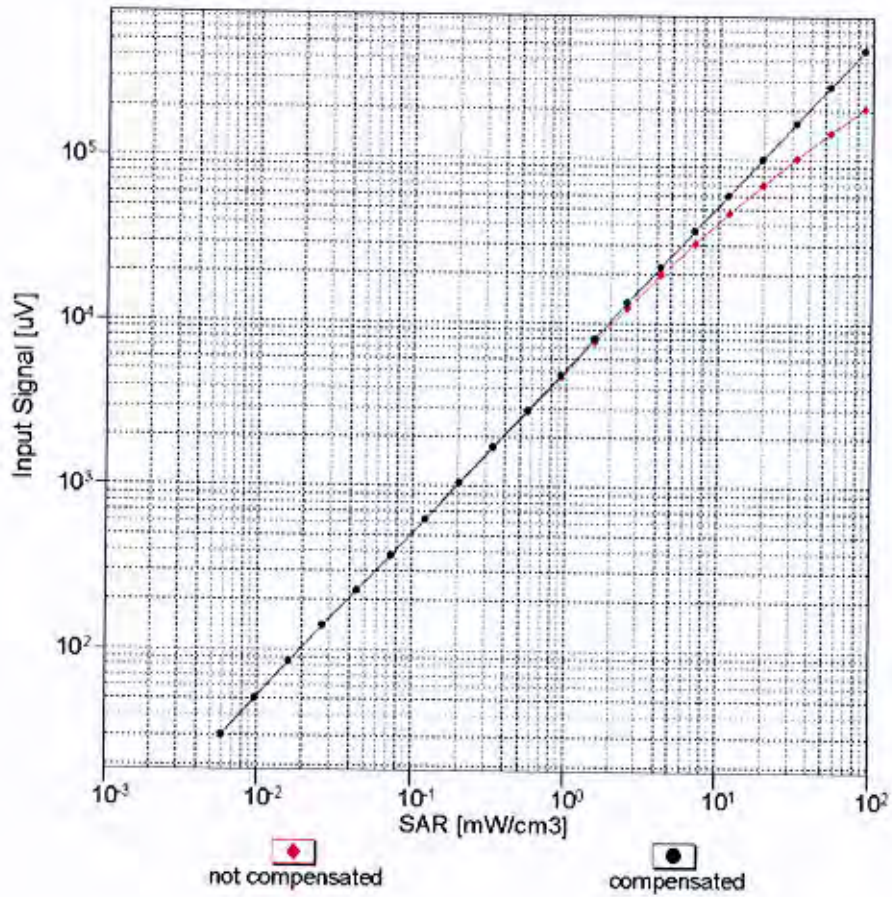
f=600 MHz,TEM

f=1800 MHz,R22



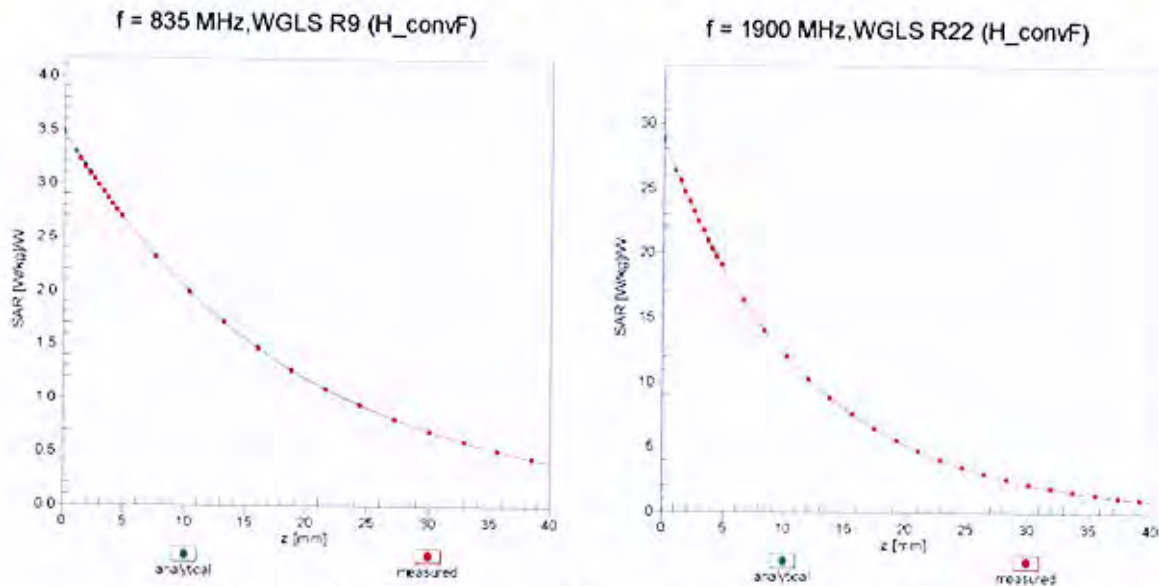
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ (k=2)

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



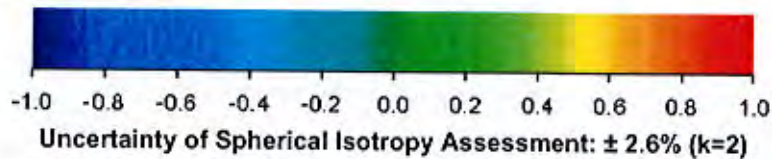
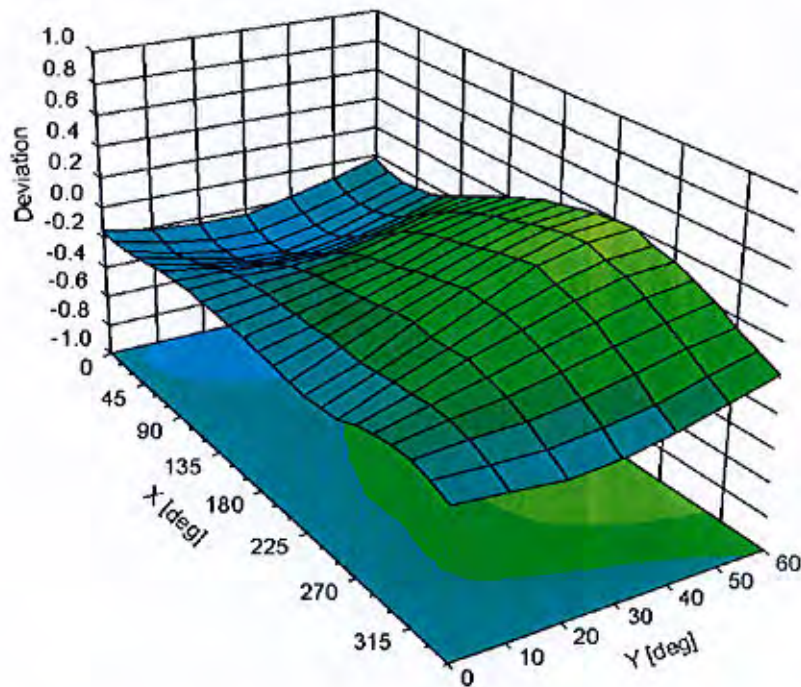
Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz



DASY/EASY - Parameters of Probe: EX3DV3 - SN:3516

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	46.2
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



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Intertek**

Certificate No: **D2450V2-718_Nov17**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN:718**

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

Calibration date: **November 07, 2017**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	31-May-17 (No. EX3-7349_May17)	May-18
DAE4	SN: 601	26-Oct-17 (No. DAE4-601_Oct17)	Oct-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

Calibrated by: **Leif Klysner** Name: **Leif Klysner** Function: **Laboratory Technician**

Signature

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

Issued: November 8, 2017

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
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, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- 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	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz \pm 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 \pm 0.2) °C	37.8 \pm 6 %	1.86 mho/m \pm 6 %
Head TSL temperature change during test	< 0.5 °C	---	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.4 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.3 W/kg \pm 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.22 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	51.5 \pm 6 %	2.02 mho/m \pm 6 %
Body TSL temperature change during test	< 0.5 °C	---	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (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	51.3 W/kg \pm 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.11 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.1 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	54.5 Ω + 3.3 j Ω
Return Loss	- 25.5 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	51.1 Ω + 4.8 j Ω
Return Loss	- 26.3 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.147 ns
----------------------------------	----------

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

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	September 10, 2002

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:718

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.86$ S/m; $\epsilon_r = 37.8$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.12, 8.12, 8.12); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

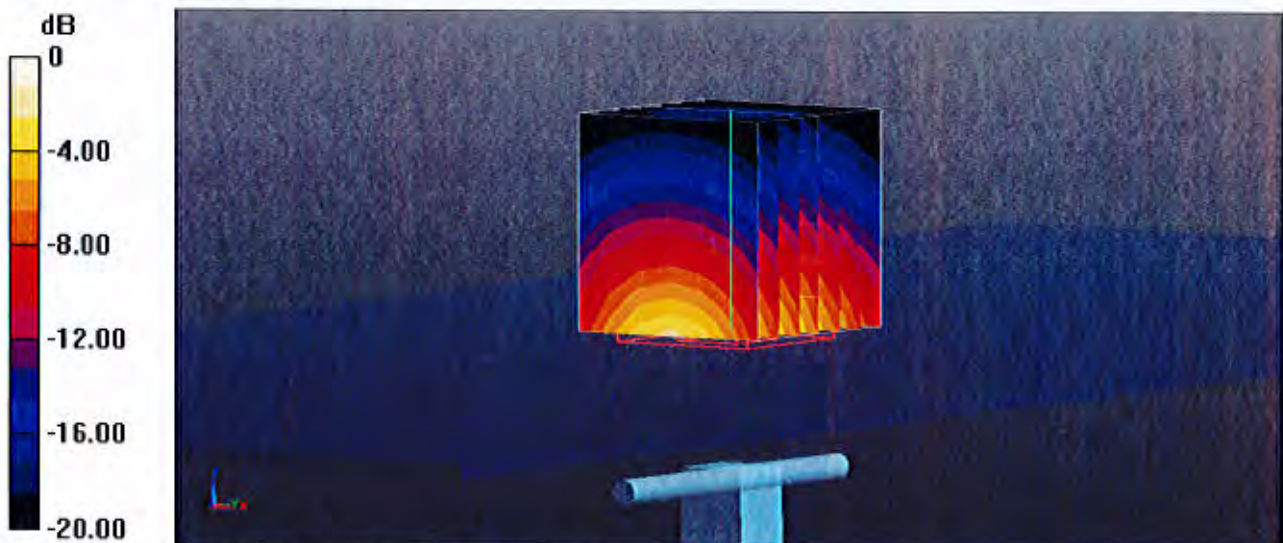
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 116.0 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 27.3 W/kg

SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.22 W/kg

Maximum value of SAR (measured) = 22.3 W/kg



0 dB = 22.3 W/kg = 13.48 dBW/kg

Impedance Measurement Plot for Head TSL

7 Nov 2017 13:53:52

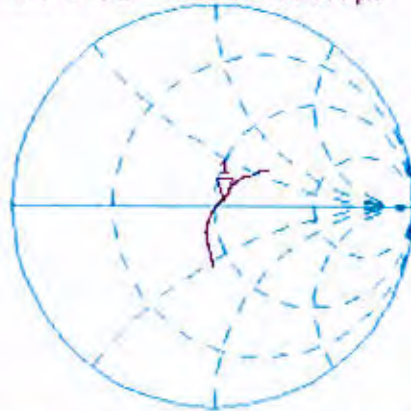
CH1 S11 1 U FS 1: 54.475 Ω 3.3164 Ω 215.44 μH 2 450.000 000 MHz

*
De1

Ca

Avg
16

H1 d

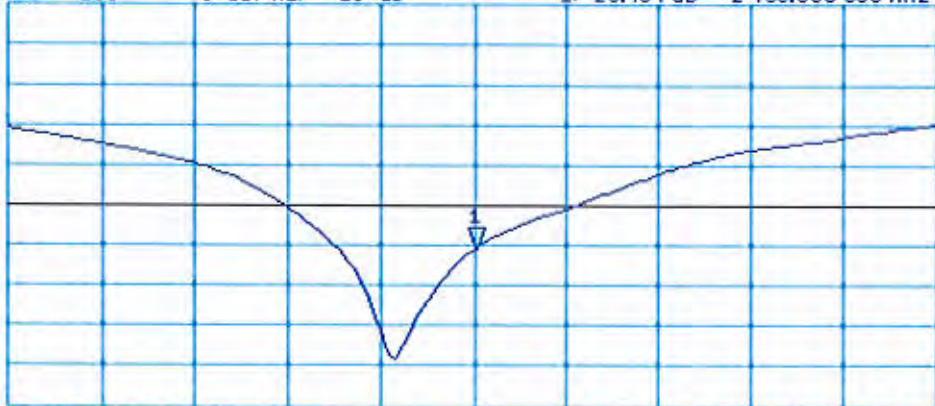


CH2 S11 LOG 5 dB/REF -20 dB 1: -25.464 dB 2 450.000 000 MHz

Ca

Avg
16

H1 d



START 2 250.000 000 MHz

STOP 2 650.000 000 MHz

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:718

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 2.02$ S/m; $\epsilon_r = 51.5$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.1, 8.1, 8.1); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

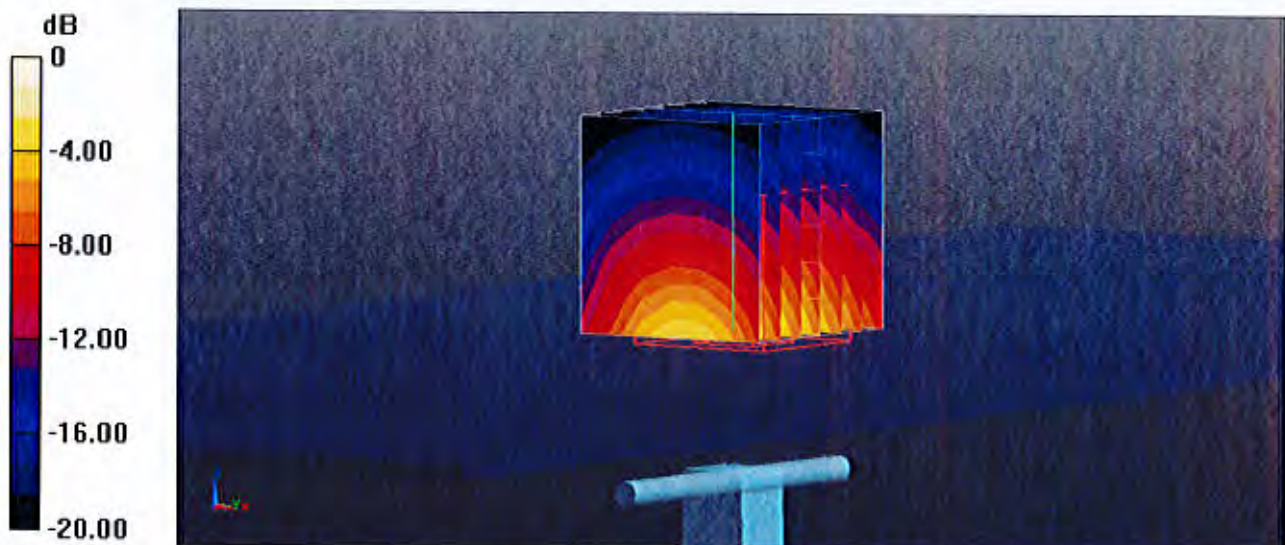
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 106.7 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 26.1 W/kg

SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.11 W/kg

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



0 dB = 20.8 W/kg = 13.18 dBW/kg

Impedance Measurement Plot for Body TSL

7 Nov 2017 13:53:05

CH1 S11 1 U FS

1: 51.129 Ω 4.7539 Ω 308.82 μH

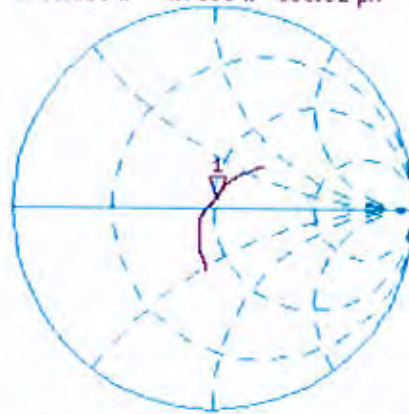
2 450.000 000 MHz

De1

Ca

Avg
16

H1d



CH2 S11 LOG

5 dB/REF -20 dB

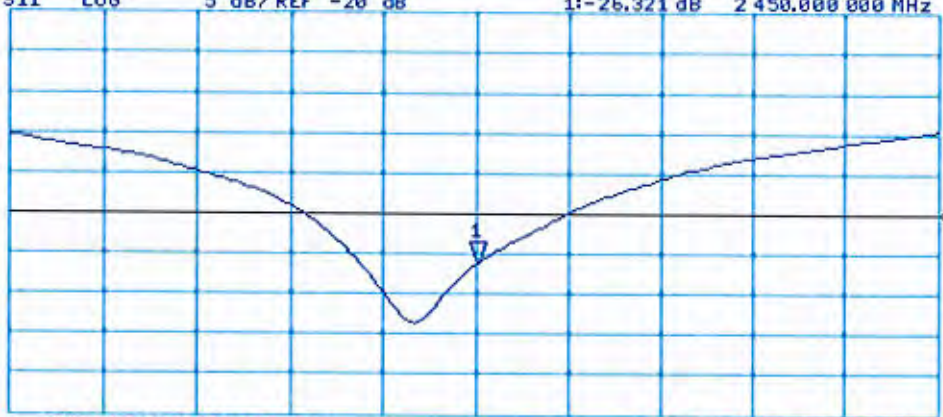
1: -26.321 dB

2 450.000 000 MHz

Ca

Avg
16

H1d



START 2 250.000 000 MHz

STOP 2 650.000 000 MHz



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Intertek**

Certificate No: **D5GHzV2-1025_Nov17**

CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN:1025**

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

Calibration date: **November 06, 2017**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 3503	31-Dec-16 (No. EX3-3503_Dec16)	Dec-17
DAE4	SN: 601	26-Oct-17 (No. DAE4-601_Oct17)	Oct-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-16 (No. 217-02222)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-16 (No. 217-02222)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-16 (No. 217-02223)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

Calibrated by: **Jeton Kastrati** Name: **Jeton Kastrati** Function: **Laboratory Technician**

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

Signature

Issued: November 8, 2017

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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 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- 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	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz ± 1 MHz 5500 MHz ± 1 MHz 5800 MHz ± 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.8 ± 6 %	4.49 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.96 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	79.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.27 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.6 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.4 ± 6 %	4.78 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.49 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	84.7 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.0 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.9 ± 6 %	5.10 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 ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.13 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.0 W/kg ± 19.9 % (k=2)

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

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	47.0 ± 6 %	5.41 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.54 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	74.8 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.10 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.8 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.4 ± 6 %	5.80 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.37 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	83.0 W/kg ± 19.9 % (k=2)

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

Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	45.9 ± 6 %	6.22 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.87 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	78.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.17 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.4 W/kg ± 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	50.1 Ω - 11.9 j Ω
Return Loss	- 18.5 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	47.7 Ω - 3.6 j Ω
Return Loss	- 27.2 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	57.2 Ω + 2.2 j Ω
Return Loss	- 23.0 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	51.8 Ω - 11.3 j Ω
Return Loss	- 19.0 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	47.6 Ω - 2.1 j Ω
Return Loss	- 29.8 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	57.4 Ω + 3.8 j Ω
Return Loss	- 22.2 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.193 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	February 05, 2004

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1025

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

Medium parameters used: $f = 5200$ MHz; $\sigma = 4.49$ S/m; $\epsilon_r = 35.8$; $\rho = 1000$ kg/m³,

Medium parameters used: $f = 5500$ MHz; $\sigma = 4.78$ S/m; $\epsilon_r = 35.4$; $\rho = 1000$ kg/m³,

Medium parameters used: $f = 5800$ MHz; $\sigma = 5.1$ S/m; $\epsilon_r = 34.9$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.76, 5.76, 5.76); Calibrated: 31.12.2016, ConvF(5.2, 5.2, 5.2); Calibrated: 31.12.2016, ConvF(5.01, 5.01, 5.01); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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 = 72.70 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 29.0 W/kg

SAR(1 g) = 7.96 W/kg; SAR(10 g) = 2.27 W/kg

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

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 73.36 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 33.3 W/kg

SAR(1 g) = 8.49 W/kg; SAR(10 g) = 2.41 W/kg

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

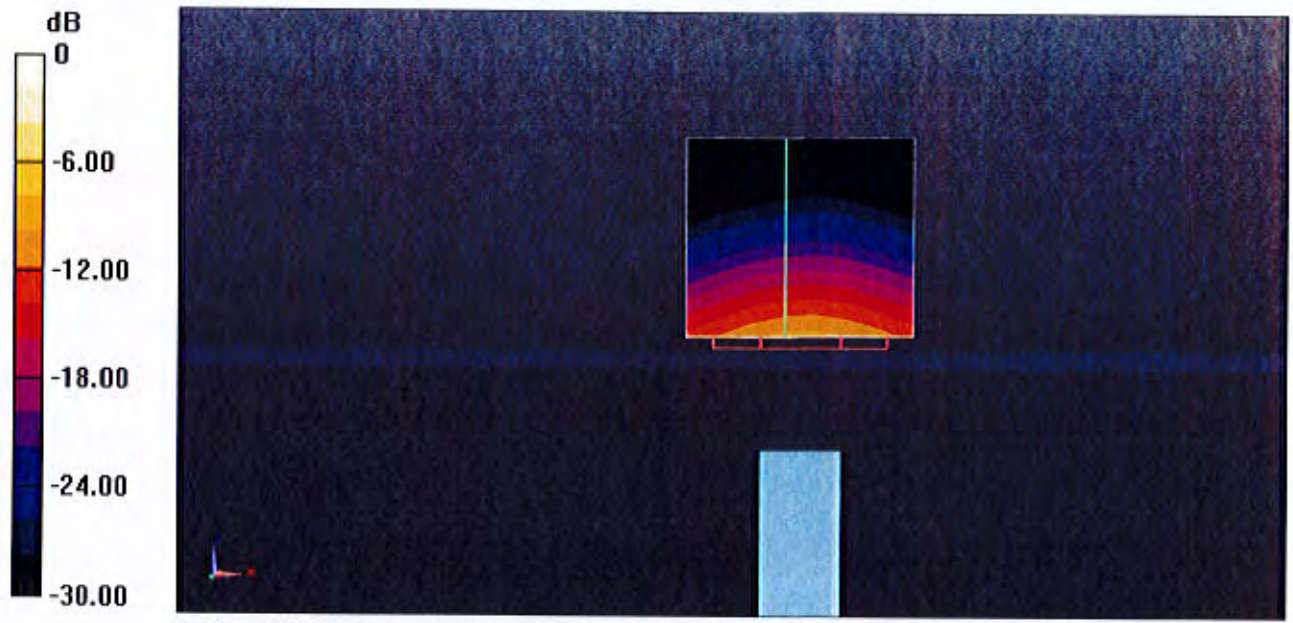
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 71.08 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 32.8 W/kg

SAR(1 g) = 8.13 W/kg; SAR(10 g) = 2.32 W/kg

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



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

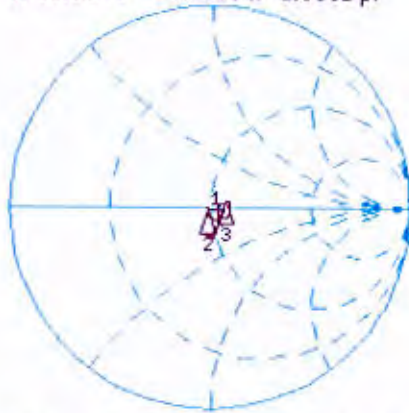
Impedance Measurement Plot for Head TSL

3 Nov 2017 16:20:57

CH1 S11 1 U FS

1: 50.102 Ω -11.918 Ω 2.5681 pF 5 200.000 000 MHz

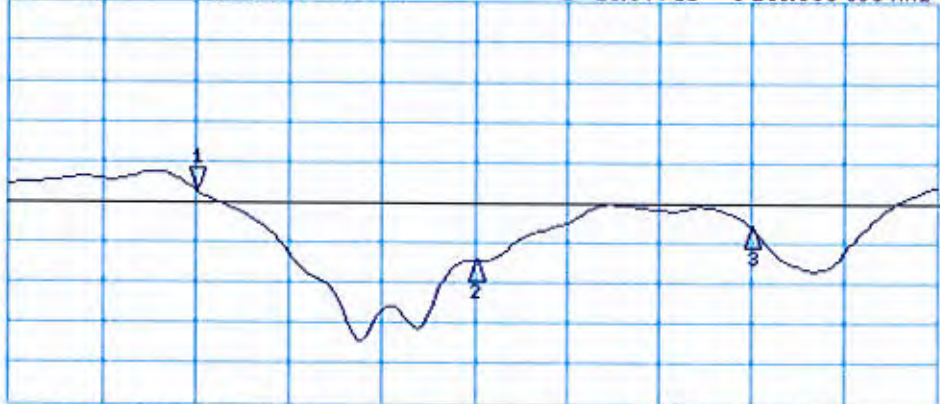
*
De1
Cor
Avg
16
H1d



CH1 Markers
2: 47.652 Ω
-3.5625 Ω
5.50000 GHz
3: 57.223 Ω
2.2129 Ω
5.80000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1:-18.544 dB 5 200.000 000 MHz

Cor
Avg
16
H1d



CH2 Markers
2: -27.194 dB
5.50000 GHz
3: -23.042 dB
5.80000 GHz

START 5 000.000 000 MHz

STOP 6 000.000 000 MHz

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1025

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

Medium parameters used: $f = 5200$ MHz; $\sigma = 5.41$ S/m; $\epsilon_r = 47$; $\rho = 1000$ kg/m³,

Medium parameters used: $f = 5500$ MHz; $\sigma = 5.8$ S/m; $\epsilon_r = 46.4$; $\rho = 1000$ kg/m³,

Medium parameters used: $f = 5800$ MHz; $\sigma = 6.22$ S/m; $\epsilon_r = 45.9$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.29, 5.29, 5.29); Calibrated: 31.12.2016, ConvF(4.62, 4.62, 4.62); Calibrated: 31.12.2016, ConvF(4.48, 4.48, 4.48); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm

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

Reference Value = 64.89 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 29.0 W/kg

SAR(1 g) = 7.54 W/kg; SAR(10 g) = 2.1 W/kg

Maximum value of SAR (measured) = 17.2 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm

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

Reference Value = 67.48 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 34.8 W/kg

SAR(1 g) = 8.37 W/kg; SAR(10 g) = 2.3 W/kg

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

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm

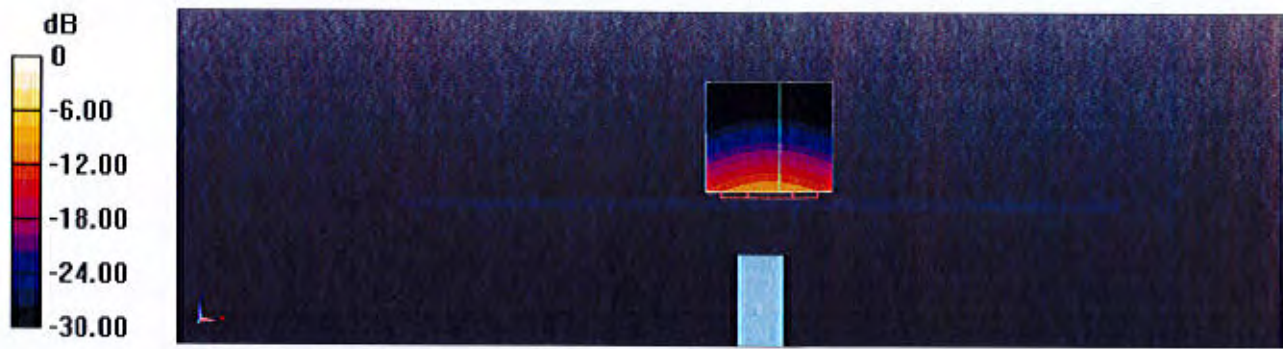
(8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 64.10 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 35.2 W/kg

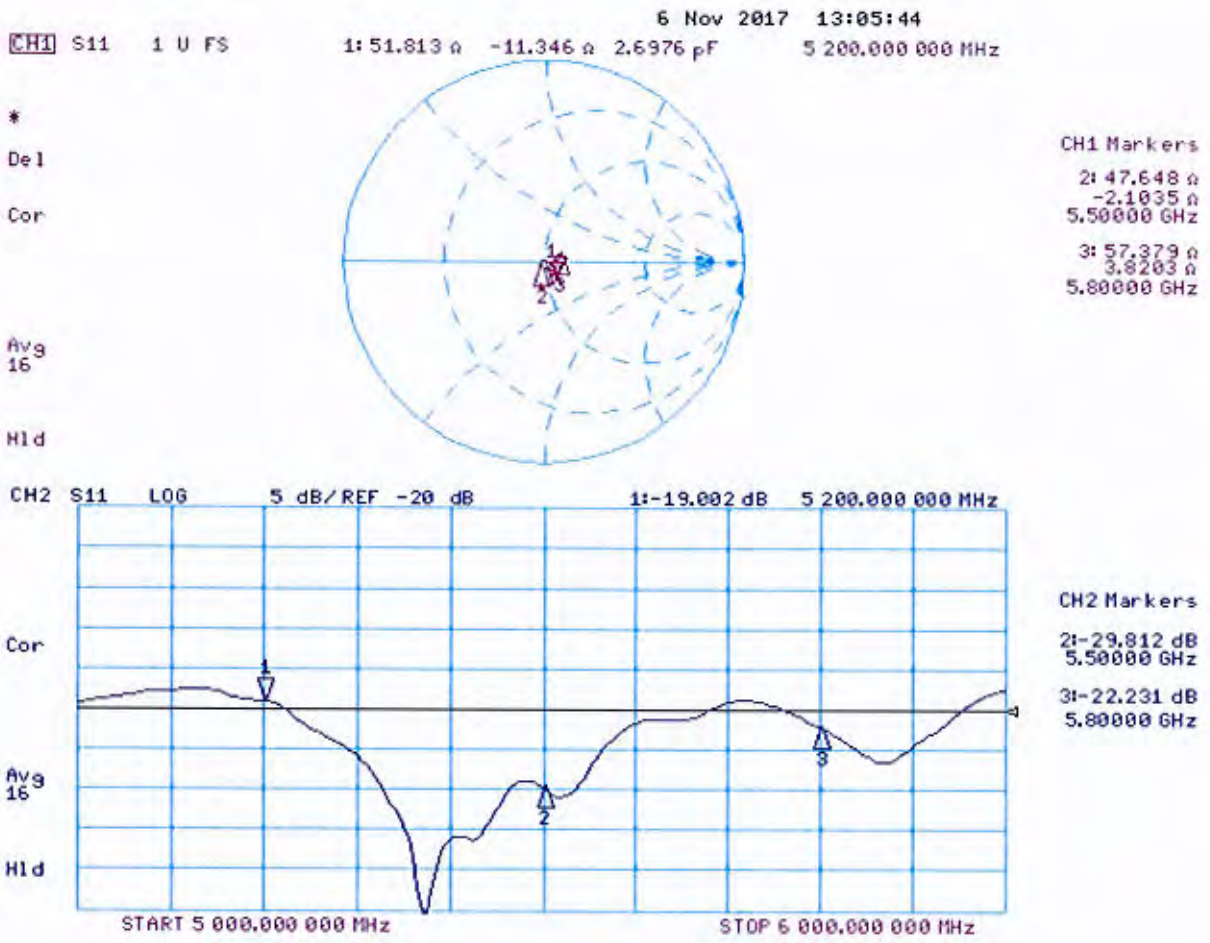
SAR(1 g) = 7.87 W/kg; SAR(10 g) = 2.17 W/kg

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



0 dB = 17.2 W/kg = 12.36 dBW/kg

Impedance Measurement Plot for Body TSL



IMPORTANT NOTICE

USAGE OF THE DAE 4

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

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

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

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

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

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

Important Note:

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

Important Note:

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

Important Note:

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



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Accreditation No.: SCS 0108

Client Intertek

Certificate No: DAE4-358_Nov17

CALIBRATION CERTIFICATE

Object DAE4 - SD 000 D04 BM - SN: 358

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

Calibration date: November 07, 2017

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

All calibrations have been conducted in the closed laboratory facility: environment temperature $(22 \pm 3)^\circ\text{C}$ 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	31-Aug-17 (No:21092)	Aug-18
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	05-Jan-17 (in house check)	In house check: Jan-18
Calibrator Box V2.1	SE UMS 006 AA 1002	05-Jan-17 (in house check)	In house check: Jan-18

Calibrated by: Name Dominique Steffen Function Laboratory Technician

Approved by: Sven Kühn Deputy Manager

Signature

Issued: November 7, 2017

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



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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 = 61nV, full range = -1.....+3mV

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

Calibration Factors	X	Y	Z
High Range	404.142 \pm 0.02% (k=2)	403.791 \pm 0.02% (k=2)	403.656 \pm 0.02% (k=2)
Low Range	3.94100 \pm 1.50% (k=2)	3.96867 \pm 1.50% (k=2)	3.99174 \pm 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	326.0 $^{\circ}$ \pm 1 $^{\circ}$
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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	200034.19	-4.08	-0.00
Channel X + Input	20010.13	4.53	0.02
Channel X - Input	-20000.93	4.50	-0.02
Channel Y + Input	200036.36	-1.67	-0.00
Channel Y + Input	20007.34	1.83	0.01
Channel Y - Input	-20004.60	0.89	-0.00
Channel Z + Input	200036.94	-0.86	-0.00
Channel Z + Input	20005.82	0.36	0.00
Channel Z - Input	-20007.32	-1.69	0.01

Low Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	2001.78	0.07	0.00
Channel X + Input	202.12	0.50	0.25
Channel X - Input	-198.34	0.09	-0.05
Channel Y + Input	2001.70	0.24	0.01
Channel Y + Input	200.66	-0.72	-0.36
Channel Y - Input	-199.27	-0.59	0.30
Channel Z + Input	2001.01	-0.43	-0.02
Channel Z + Input	200.09	-1.30	-0.65
Channel Z - Input	-200.62	-1.93	0.97

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	7.94	6.65
	- 200	-5.62	-7.14
Channel Y	200	-4.31	-4.44
	- 200	3.35	2.93
Channel Z	200	11.41	11.29
	- 200	-13.94	-13.80

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	-	-2.73	-3.25
Channel Y	200	7.99	-	-1.95
Channel Z	200	6.01	5.34	-

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	16030	15287
Channel Y	16126	15647
Channel Z	15843	15805

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	1.29	-0.24	2.28	0.40
Channel Y	0.16	-1.08	1.13	0.41
Channel Z	0.04	-0.72	1.02	0.36

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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Certificate of conformity / First Article Inspection

Item	SAM Twin Phantom V4.0
Type No	QD 000 P40 BA
Series No	TP-1002 and higher
Manufacturer / Origin	Untersee Composites Hauptstr. 69 CH-8559 Fruthwilen Switzerland

Tests

The series production process used allows the limitation to test of first articles. Complete tests were made on the pre-series Type No. QD 000 P40 AA, Serial No. TP-1001 and on the series first article Type No. QD 000 P40 BA, Serial No. TP-1006. Certain parameters have been retested using further series units (called samples).

Test	Requirement	Details	Units tested
Shape	Compliance with the geometry according to the CAD model.	IT'IS CAD File (*)	First article, Samples
Material thickness	Compliant with the requirements according to the standards	2mm +/- 0.2mm in specific areas	First article, Samples
Material parameters	Dielectric parameters for required frequencies	200 MHz – 3 GHz Relative permittivity < 5 Loss tangent < 0.05.	Material sample TP 104-5
Material resistivity	The material has been tested to be compatible with the liquids defined in the standards	Liquid type HSL 1800 and others according to the standard.	Pre-series, First article

Standards

- [1] CENELEC EN 50361
- [2] IEEE P1528-200x draft 6.5
- [3] IEC PT 62209 draft 0.9
- (*) The IT'IS CAD file is derived from [2] and is also within the tolerance requirements of the shapes of [1] and [3].

Conformity

Based on the sample tests above, we certify that this item is in compliance with the uncertainty requirements of SAR measurements specified in standard [1] and draft standards [2] and [3].

Date 18.11.2001

Signature / Stamp

Certificate of Conformity / First Article Inspection

Item	SAM Twin Phantom V4.0 and V5.0
Type No	QD 000 P40 C
Series No	TP-1150 and higher
Manufacturer	Untersee Composites Knebelstrasse 8, CH-8268 Mannenbach, Switzerland

Tests

Complete tests were made on the pre-series QD 000 P40 A, # TP-1001, on the series first article QD 000 P40 B # TP-1006. Certain parameters are retested on series items.

Test	Requirement	Details	Units tested
Dimensions	Compliant with the geometry according to the CAD model.	IT'IS CAD File *	First article, Samples
Material thickness of shell	2mm +/- 0.2mm in flat section, other locations: +/- 0.2mm with respect to CAD file	in flat section, in the cheek area	First article, Samples, TP-1314 ff.
Material thickness at ERP	6mm +/- 0.2mm at ERP		First article, All items
Material parameters	rel. permittivity 2 – 5, loss tangent ≤ 0.05 , at $f \leq 6$ GHz	rel. permittivity 3.5 +/- 0.5 loss tangent ≤ 0.05	Material samples
Material resistivity	Compatibility with tissue simulating liquids .	Compatible with SPEAG liquids. **	Phantoms, Material sample
Sagging	Sagging of the flat section in tolerance when filled with tissue simulating liquid.	< 1% for filling height up to 155 mm	Prototypes, Sample testing

* The IT'IS CAD file is derived from [2] and is also within the tolerance requirements of the shapes of the other documents.

** Note: Compatibility restrictions apply certain liquid components mentioned in the standard, containing e.g. DGBE, DGMHE or Triton X-100. Observe technical note on material compatibility.

Standards

- [1] OET Bulletin 65, Supplement C, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition 01-01
- [2] IEEE 1528-2003, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques, December 2003
- [3] IEC 62209-1 ed1.0, "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", 2005-02-18
- [4] IEC 62209-2 ed1.0, "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 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)", 2010-03-30

Conformity

Based on the sample tests above, we certify that this item is in compliance with the uncertainty requirements of **hand-held** SAR measurements and system performance checks as specified in [1 – 4] and further standards.

Date 25.07.2011

Signature / Stamp

s p e a g

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