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TEST REPORT

Report Number: G101112064LEX-003.3
Project Number: G101112064

Evaluation of Model Number: CSI 2140

FCCID: NL5-CSI2410M1
ICID: 3434A-CSI2140M1

Tested to the SAR Criteria in

FCC Part 2.1093

Industry Canada RSS-102 Issue 4

For

Computational systems Inc.

Test Performed by:	Test Authorized by:
Intertek 731 Enterprise Drive Lexington, KY 40510	Computational systems Inc. 835 Innovation Drive Knoxville, TN 37932

Prepared By:________________ **Date:** 1-6-2014

Bryan Taylor, Team Leader

Approved By:________________ **Date:** 1-6-2014

Jason Centers, Senior Project Engineer

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1.0 DOCUMENT HISTORY

Revision/ Project Number	Writer Initials	Date	Change
1.0 /G101112064	BT	12/1/2013	Original document
2.0 /G101112064	BT	1/2/2014	Included SAR results for the top and left edges. Included justification for exempting SAR tests on the right and bottom edges. Included SAR data to address the low/mid/high channel requirements from IC Notice 2012-DRS1203. Due to the large number of SAR scans the plots are now presented as separate exhibits.
3.0 /G101112064	BT	1/6/2014	Corrected output power for 802.11b mode / 1Mbps / Ch. 11. Also corrected the SAR scaling using the updated output power and the simultaneous transmission calculation. Added references to IEC62209-2 and IEEE Std. 1528.

2.0 INTRODUCTION

At the request of Computational Systems Inc., the Machinery Health Analyzer was evaluated for SAR in accordance with the requirements for FCC Part 2.1093 and RSS-102. Testing was performed in accordance with IEEE Std 1528, IEC62209-2, 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 ±21.4%.

The CSI 2140 was tested at the maximum output power measured by Intertek. Maximum output power measurements are tabulated under Section 9.0 Test Results.

The maximum spatial peak SAR value for the sample device averaged over 1g was found to be:

Transmit Band (MHz)	Mode	Channel	Frequency (MHz)	Conducted Output Power (dBm)	Reported SAR_{1g} – Body Mode (W/kg)	Limit (W/kg)
2.4GHz Band	802.11b, 1Mbps, Back Side	11	2462MHz	15.26dBm	0.63W/kg	1.6W/kg

Table 1: Maximum Measured SAR

Based on the worst-case data presented above, the Machinery Health Analyzer was found to be **compliant** with the 1.6 W/kg requirement for general population / uncontrolled exposure.

Modifications made to test sample

Intertek implemented no modifications.

3.0 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 $\pm 2^{O}$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.

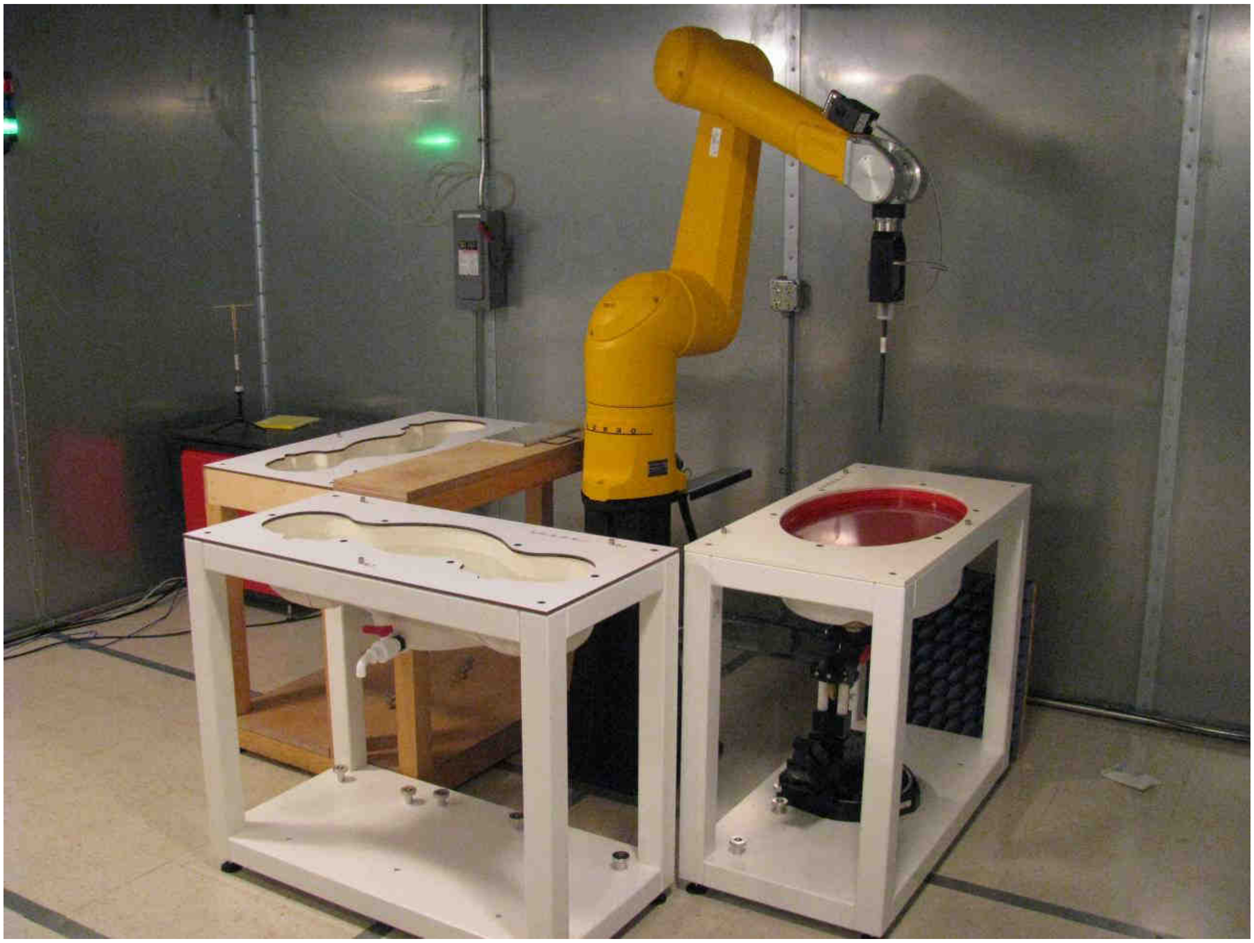

Figure 1: Intertek SAR Test Site

Measurement Equipment

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

Description	Serial Number	Manufacture	Model	Cal. Date	Cal. Due	Eq. Used
SAR Probe	3516	Speag	EXDV3	12/10/12	12/10/13	☒
System Verification Dipole	718	Speag	D2450V2	12/4/2012	12/4/2013	☒
SAR Probe	3516	Speag	EXDV3	12/13/13	12/13/14	☒
System Verification Dipole	718	Speag	D2450V2	12/13/13	12/13/14	☒
DAE	358	Speag	DAE4	9/13/13	9/13/14	☒
Vector Signal Generator	257708	Rohde & Schwarz	SMBV100A	5/30/13	5/30/14	☒
Network Analyzer	US391739 83	Agilent	8753ES	3/20/13	3/20/14	☒
Power Meter	1838538	Gigatronics	8542C	7/18/13	7/18/14	☒
Power Sensor	1830320	Gigatronics	80601A	7/18/13	7/18/14	☒
USB Power Sensor	100705	Rohde & Schwarz	NRP-Z51	9/11/13	9/11/14	☒
Spectrum Analyzer	3900	Rohde & Schwarz	ESU40	9/11/13	9/11/14	☒
Dielectric Probe Kit	1111	Speag	DAK-3.5	NCR	NCR	☒
Twin SAM Phantom	1243	Speag	QD000P40CA	NCR	NCR	☒
6-axis robot	F11/5H1Y A/A/01	Staubli	RX-90	NCR	NCR	☒

NCR – No Calibration Required

Table 2: Test Equipment Used for SAR Evaluation

Measurement Uncertainty

The Table below includes the uncertainty budget suggested by the IEEE Std 1528-2003 and 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	±5.5%	N	1	1	1	±5.5%	±5.5%	∞
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%	∞
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.	±1.0%	R	√3	1	1	±0.6%	±0.6%	∞
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%	∞
Phantom and Setup								
Phantom Uncertainty	±4.0%	R	√3	1	1	±2.3%	±2.3%	∞
Liquid Conductivity (target)	±5.0%	R	√3	0.64	0.43	±1.8%	±1.2%	∞
Liquid Conductivity (meas.)	±2.5%	N	1	0.64	0.43	±1.6%	±1.1%	∞
Liquid Permittivity (target)	±5.0%	R	√3	0.6	0.49	±1.7%	±1.4%	∞
Liquid Permittivity (meas.)	±2.5%	N	1	0.6	0.49	±1.5%	±1.2%	∞
Combined Standard Uncertainty						±10.7%	±10.5%	387
Expanded STD Uncertainty						**±21.4%**	**±21.0%**	

Notes.

1. Worst Case uncertainty budget for DASY5 assessed according to IEEE 1528-2003. 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.

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%	∞
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	±9.9%	R	√3	1	1	±5.7%	±5.7%	∞
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%	∞
Phantom and Setup								
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Liquid Conductivity (target)	±5.0%	R	√3	0.64	0.43	±1.8%	±1.2%	∞
Liquid Conductivity (meas.)	±2.5%	N	1	0.64	0.43	±1.6%	±1.1%	∞
Liquid Permittivity (target)	±5.0%	R	√3	0.6	0.49	±1.7%	±1.4%	∞
Liquid Permittivity (meas.)	±2.5%	N	1	0.6	0.49	±1.5%	±1.2%	∞
Combined Standard Uncertainty						±12.8%	±12.8%	330
Expanded STD Uncertainty						**±25.6%**	**±25.2%**	

Notes.

Worst Case uncertainty budget for DASY5 assessed according to IEEE 1528-2003. 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.

4.0 JOB DESCRIPTION

At the request of Computational systems Inc., SAR testing was performed on the CSI 2140.

Test sample	
Manufacturer	Computational systems Inc.
Model Number	CSI 2140
Serial Number	BETA 001020
Receive Date	10/31/2013
Device Received Condition	Good
Device Category	Portable
RF Exposure Category	General Population/Uncontrolled Environment
Antenna Type	Internal
Test sample Accessories	
Power Supply	15VDC ITE Power Supply Part Number TR9CG4000LCP-F

Table 3: Product Information

Operating Bands	**Frequency Range (MHz)**	**Modulation**	**Duty Cycle**
2.4GHz	2412 – 2462MHz	802.11b/g	1:1
2.4GHz	2402 – 2480MHz	Bluetooth	1:1

Table 4: Operating Bands

Figure 2: Test Sample (Front)

Figure 3: Test Sample (Back)

5.0 SYSTEM VERIFICATION

System Validation

Prior to the assessment, the system was verified to be within ±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. The results from the system verifications with a dipole are shown in *Table 5*.

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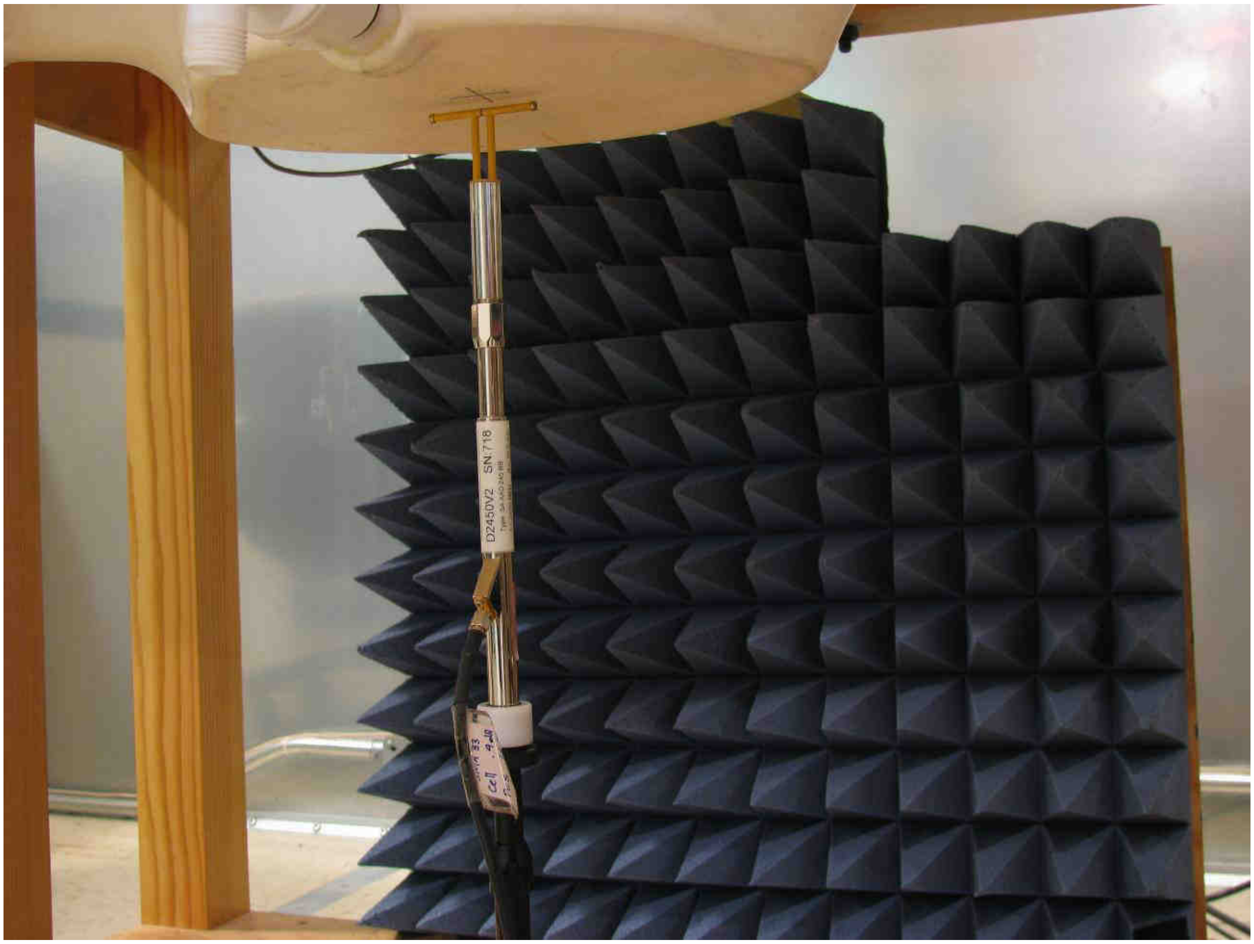

Figure 4: System Verification Setup

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
23.1	22.1	2450	D2450V2	MSL2450	1W	51.5	51.2	0.58	11/18/2013
22.9	23.3	2450	D2450V2	MSL2450	1W	51.5	50.1	2.72	11/20/2013
22.9	21.4	2450	D2450V2	MSL2450	1W	49.6	51.9	4.64	12/28/2013
22.9	21.4	2450	D2450V2	MSL2450	1W	49.6	51.7	4.23	12/31/2013

Table 5: Dipole Validation

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.

Measured Tissue Properties									
Tissue Type	Frequency Measure (MHz)	Dielectric Constant Target	Conductivity Target	Dielectric Constant Measure	Imaginary Part	Conductivity Measure	Dielectric % Deviation	Conductivity % Deviation	Date
2.4GHZ MSL	2400	52.77	1.95	50.59	14.8	1.97	4.13	1.27	11/18/2013
	2450	52.7	1.95	50.39	14.89	2.03	4.38	4.01	11/18/2013
	2462	52.66	1.95	50.39	14.91	2.04	4.31	4.66	11/18/2013

Measured Tissue Properties									
Tissue Type	Frequency Measure (MHz)	Dielectric Constant Target	Conductivity Target	Dielectric Constant Measure	Imaginary Part	Conductivity Measure	Dielectric % Deviation	Conductivity % Deviation	Date
2.4GHZ MSL	2400	52.77	1.95	50.21	14.4	1.92	4.85	1.47	11/20/2013
	2450	52.7	1.95	50.2	14.48	1.97	4.74	1.14	11/20/2013
	2462	52.66	1.95	50.11	14.4	1.97	4.84	1.08	11/20/2013

Measured Tissue Properties									
Tissue Type	Frequency Measure (MHz)	Dielectric Constant Target	Conductivity Target	Dielectric Constant Measure	Imaginary Part	Conductivity Measure	Dielectric % Deviation	Conductivity % Deviation	Date
2.4GHZ MSL	2400	52.77	1.95	54.53	14.32	1.91	3.34	2.01	12/28/2013
	2450	52.7	1.95	54.22	14.44	1.97	2.88	0.86	12/28/2013
	2462	52.66	1.95	54.15	14.61	2.00	2.83	2.55	12/28/2013

Measured Tissue Properties									
Tissue Type	Frequency Measure (MHz)	Dielectric Constant Target	Conductivity Target	Dielectric Constant Measure	Imaginary Part	Conductivity Measure	Dielectric % Deviation	Conductivity % Deviation	Date
2.4GHZ MSL	2400	52.77	1.95	53.88	14.21	1.90	2.10	2.77	12/30/2013
	2450	52.7	1.95	53.72	14.38	1.96	1.94	0.45	12/30/2013
	2462	52.66	1.95	53.57	14.56	1.99	1.73	2.20	12/30/2013

Table 6: Dielectric Parameter Validation

Table 7: Tissue Simulating Fluid Recipe

TYPICAL 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

6.0 EVALUATION PROCEDURES

Prior to any testing, the appropriate fluid was used to fill the phantom to a depth of 15 cm ±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, IEC62209-2, 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 used for the 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.

			≤ 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			$30° \pm 1°$	$20° \pm 1°$
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 $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	
Maximum zoom scan spatial resolution: 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 1st 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	$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	$3 - 4$ GHz: ≥ 28 mm $4 - 5$ GHz: ≥ 25 mm $5 - 6$ GHz: ≥ 22 mm

Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.

* When zoom scan is required and the *reported* SAR from the *area scan based 1-g SAR estimation* 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.

Table 8: SAR Area and Zoom Scan Resolutions

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 DASY5, 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 DASY5 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. 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.

7.0 CRITERIA

The following FCC limits for SAR apply to portable devices operating in the General Population/Uncontrolled Exposure environment:

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

8.0 TEST CONFIGURATION

For the purpose of this evaluation, the CSI 2140 was considered to be a device that could be operated against the body. Therefore SAR scans were performed on both the front, back, left, and top sides of the device while in direct contact with the phantom surface. The right and bottom edges were excluded due to the large distance to the transmitting antenna. The test positions are shown in Figure 5 through Figure 8.

The test channels and operating modes were selected using software based test commands that enabled transmission at 100% duty cycle in each modulation mode. All SAR scans were performed with a freshly charged battery installed. In accordance with KDB248227 the lowest channel and lowest data rate were measured in addition to the default test channels (1, 6, and 11) as well as that which produced the highest output power in 802.11b mode. The same rationale was used for 802.11g mode if the measured output powers were more than 1/4dB higher than the corresponding output power for 802.11b mode.

No standalone SAR testing was performed on the Bluetooth radio since its output power was below the level necessary for exemption. The calculation for simultaneous transmission exclusion from section 4.3.2 of KDB447498 was used to show that the estimated Bluetooth radio SAR summed with the measured WiFi SAR was less than the 1.6W/kg limit. See the test result section for this calculation.

Figure 5: Front Test Position

Figure 6: Left Side Test Position

Figure 7: Top Side Test Position

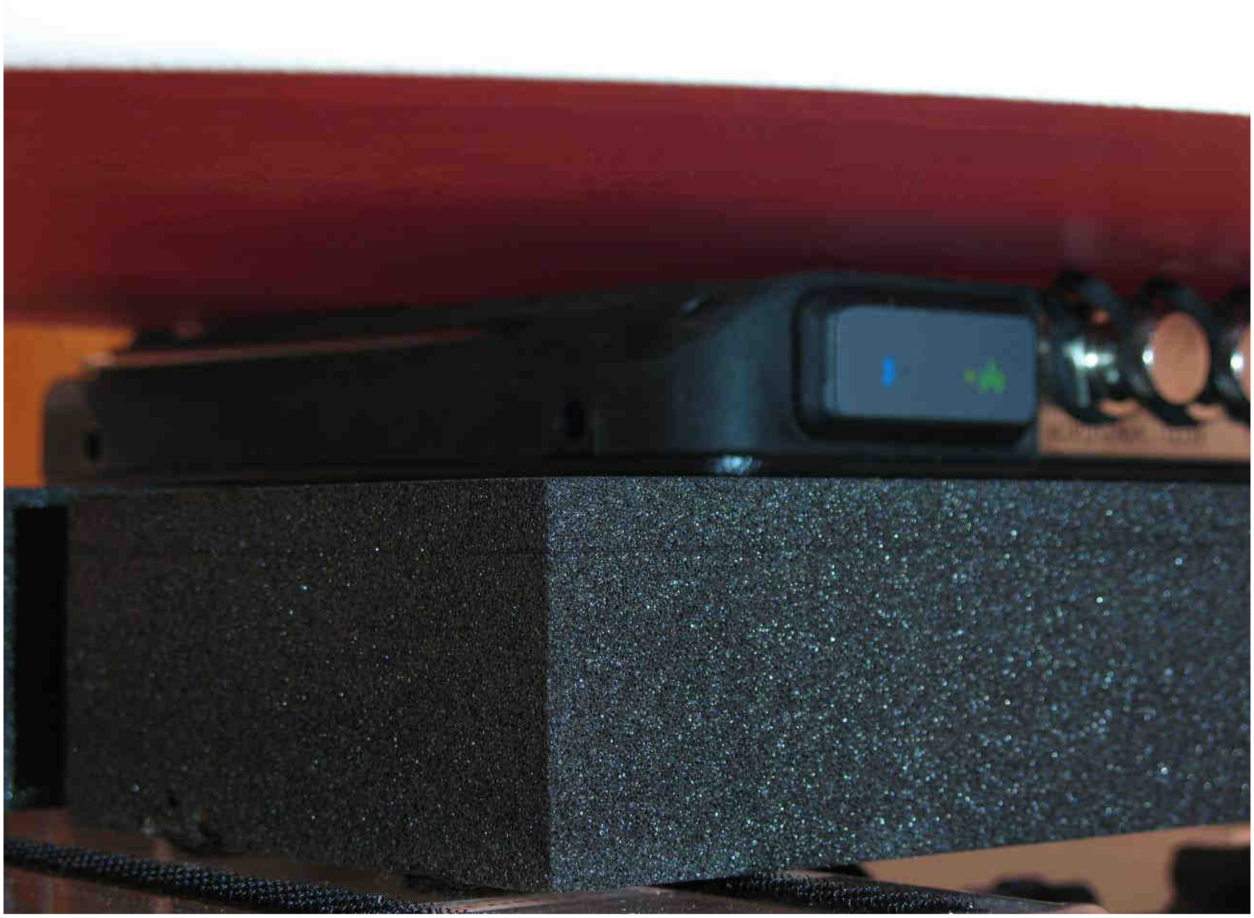

Figure 8: Back Test Position

9.0 TEST RESULTS

The results on the following page(s) were obtained when the device was transmitting at maximum output power. Detailed measurement data and plots, which reveal information about the location of the maximum SAR with respect to the device, are referenced are shown in separate exhibits presented with this application. The measured conducted output power was compared to the power declared by the manufacturer and used for scaling the measured SAR values.

The device was evaluated according to the specific requirements found in FCC KDB 447498[9] 248227. The worst case 1-g SAR value for the WiFi transmitter was less than the 1.6mW/g limit. Repeatability measurements were not required since the Reported SAR was <0.8W/kg.

No standalone SAR testing was performed on the Bluetooth radio since its output power was below the level necessary for exemption.

Conducted Output Power Measurements:

Mode	Frequency (MHz)	Channel Number	Conducted Power (dBm)			
			Data Rate (Mbps)			
			1	2	5.5	11
802.11b	2412	1	15.14	16.25	16.52	17.11
	2437	6	16.2	17.02	16.88	16.94
	2462	11	15.26	15.33	16.12	16.14

Table 9: 802.11b Conducted Power Measurements

Mode	Frequency (MHz)	Channel Number	Conducted Power (dBm)							
			Data Rate (Mbps)							
			6	9	12	18	24	36	48	54
802.11g	2412	1	17.07	17.13	16.88	16.85	17.43	16.57	16.83	16.8
	2437	6	15.86	15.92	15.65	15.45	16.72	16.45	16.69	16.71
	2462	11	14.63	14.82	14.92	15.26	15.91	15.33	15.54	15.92

Table 10: 802.11g Conducted Power Measurements

Channel	Frequency (MHz)	Data Rate	Output Power (dBm)	Limit (dBm)	Pass / Fail
Low	2402	1Mbps	-1.59dBm	30dBm	Pass
Mid	2441	1Mbps	-2.70dBm	30dBm	Pass
High	2480	1Mbps	-3.35dBm	30dBm	Pass
Low	2402	2Mbps	1.56dBm	30dBm	Pass
Mid	2441	2Mbps	0.48dBm	30dBm	Pass
High	2480	2Mbps	0.16dBm	30dBm	Pass
Low	2402	3Mbps	1.69dBm	30dBm	Pass
Mid	2441	3Mbps	0.6dBm	30dBm	Pass
High	2480	3Mbps	0.23dBm	30dBm	Pass

Table 11: Bluetooth Conducted Power Measurements

Standalone SAR Measurements:

SAR Measurement Results at the Body									
Position	Channel	Frequency (MHz)	Mode	Seperation Distance (mm)	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
Front	1	2412MHz	802.11b, 1Mbps	0	0.02	0.01	0.02	15.14	18.10
Front	1	2412MHz	802.11b, 11Mbps	0	0.00	0.01	0.02	17.11	18.10
Front	6	2437MHz	802.11b, 1Mbps	0	-0.12	0.02	0.02	16.20	18.10
Front	6	2437MHz	802.11b, 2Mbps	0	-0.02	0.01	0.02	17.02	18.10
Front	11	2462MHz	802.11b, 11Mbps	0	0.12	0.01	0.02	16.14	18.10
Front	1	2412MHz	802.11g, 6Mbps	0	-0.02	0.02	0.03	17.07	18.10
Front	1	2412MHz	802.11g, 24Mbps	0	-0.15	0.02	0.03	17.43	18.10

Table 12: Front Side SAR Results

SAR Measurement Results at the Body									
Position	Channel	Frequency (MHz)	Mode	Seperation Distance (mm)	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
Back	1	2412MHz	802.11b, 1Mbps	0	-0.05	0.23	0.45	15.14	18.10
Back	1	2412MHz	802.11b, 11Mbps	0	-0.01	0.24	0.30	17.11	18.10
Back	6	2437MHz	802.11b, 1Mbps	0	0.16	0.29	**0.45**	16.20	18.10
Back	6	2437MHz	802.11b, 2Mbps	0	-0.01	0.34	0.44	17.02	18.10
Back	11	2462MHz	802.11b, 11Mbps	0	0.01	0.29	0.45	16.14	18.10
Back	1	2412MHz	802.11g, 6Mbps	0	-0.03	0.30	0.38	17.07	18.10
Back	1	2412MHz	802.11g, 24Mbps	0	0.01	0.36	0.42	17.43	18.10
Low and High Channels Measured in the Configuration that Produced the Highest SAR Value (per IC Notice 2012-DRS1203)									
Back	1	2412MHz	802.11b, 1Mbps	0	-0.05	0.23	0.45	15.14	18.10
Back	11	2462MHz	802.11b, 1Mbps	0	0.09	0.33	**0.63**	15.26	18.10

Table 13: Back Side SAR Results

SAR Measurement Results at the Body									
Position	Channel	Frequency (MHz)	Mode	Seperation Distance (mm)	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
Left Edge	1	2412MHz	802.11b, 1Mbps	0	0.12	0.01	0.01	15.14	18.10
Left Edge	1	2412MHz	802.11b, 11Mbps	0	-0.15	0.01	0.01	17.11	18.10
Left Edge	6	2437MHz	802.11b, 1Mbps	0	0.20	0.01	0.02	16.20	18.10
Left Edge	6	2437MHz	802.11b, 2Mbps	0	-0.16	0.01	0.01	17.02	18.10
Left Edge	11	2462MHz	802.11b, 11Mbps	0	0.33	0.01	0.02	16.14	18.10
Left Edge	1	2412MHz	802.11g, 6Mbps	0	-0.14	0.01	0.02	17.07	18.10
Left Edge	1	2412MHz	802.11g, 24Mbps	0	-0.18	0.01	0.01	17.43	18.10

Table 14: Left Side SAR Results

SAR Measurement Results at the Body									
Position	Channel	Frequency (MHz)	Mode	Seperation Distance (mm)	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
Top Edge	1	2412MHz	802.11b, 1Mbps	0	0.26	0.16	0.31	15.14	18.10
Top Edge	1	2412MHz	802.11b, 11Mbps	0	-0.14	0.18	0.22	17.11	18.10
Top Edge	6	2437MHz	802.11b, 1Mbps	0	0.12	0.19	0.29	16.20	18.10
Top Edge	6	2437MHz	802.11b, 2Mbps	0	-0.12	0.20	0.25	17.02	18.10
Top Edge	11	2462MHz	802.11b, 11Mbps	0	0.23	0.22	0.35	16.14	18.10
Top Edge	1	2412MHz	802.11g, 6Mbps	0	-0.17	0.31	0.39	17.07	18.10
Top Edge	1	2412MHz	802.11g, 24Mbps	0	-0.12	0.27	0.32	17.43	18.10

Table 15: Top Side SAR Results

Simultaneous Transmission Calculations (Bluetooth and WiFi Radio):

Highest Bluetooth output power = 1.69dBm = 1.48mW

Estimated Bluetooth 1-g SAR = (1.48mW / 5mm) * (Sqrt [2.48Ghz]/7.5)

Estimated Bluetooth 1-g SAR = 0.062W/kg

Worst case measured WiFi 1-g SAR = 0.63W/kg

Worst case simultaneous TX 1-g SAR = 0.062W/kg + 0.63W/kg = 0.692W/kg

Since the sum of the estimated Bluetooth 1-g SAR and worst case WiFi 1-g SAR is less than the 1.6W/kg limit, the device qualifies for the simultaneous TX exclusion outlined in 4.3.2 of KDB447498.

SAR Test Exclusions:

No standalone SAR testing was performed on the Bluetooth radio since its output power was below the level necessary for exemption.

The following formulas from KDB 447498 section 4.3 were used to exclude certain edge configurations from testing based on output power and distance from the closest part of the antenna to the tablet edge as described in KDB 616217 section 4.3 for determination of exclusion with the edges. The diagram in Figure 9 shows the antenna spacing from the two edges that were excluded from the WiFi SAR testing (170mm and 220mm respectively).

Edges ≤ 50 mm

[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)]*[$\sqrt{f_{(GHz)}}$] ≤ 3.0

Edges > 50mm

[(Power allowed at numeric threshold for 50mm) + (test separation distance -50mm)*10] mW

Antenna	Back Side	Front Side	Top Edge	Bottom Edge	Right Edge	Left Edge
2.4GHz (WLAN)	Tested	Tested	Tested	Excluded	Excluded	Tested
2.4GHz (Bluetooth)	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded

Table 16: Tablet Edges Evaluated for SAR

Figure 9: Antenna Spacing from Edges

10.0 REFERENCES

[1] ANSI, *ANSI/IEEE C95.1-1991: 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, "Dosimetic 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. Tayor 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, KDG 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.

11.0 APPENDIX – 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.

				Probe Calibration Point		Dielectric Properties		CW Validation			Modulation Validation		
Frequency (MHz)	Date	Probe (SN#)	Probe (Model #)	Frequency (MHz)	Fluid Type	σ	ϵ_r	Sensitivity	Probe Linearity	Probe Isotropy	Mod. Type	Duty Factor	PAR
2450	1/7/2013	3516	EX3DV3	2450	Body	50.65	2.02	Pass	Pass	Pass	OFDM	N/A	Pass
5200	1/8/2013	3516	EX3DV3	5200	Body	48.71	5.54	Pass	Pass	Pass	OFDM	N/A	Pass
5500	1/8/2013	3516	EX3DV3	5500	Body	47.68	6.29	Pass	Pass	Pass	OFDM	N/A	Pass
5800	1/8/2013	3516	EX3DV3	5800	Body	48.71	5.54	Pass	Pass	Pass	OFDM	N/A	Pass

Table 17: SAR System Validation Summary

12.0 APPENDIX – DESCRIPTION OF THE FLAT PHANTOM USED FOR TESTING

Schmid & Partner Engineering AG **s p e a g**

Zeughausstrasse 43, 8004 Zurich, Switzerland
Phone +41 44 245 9700, Fax +41 44 245 9779
info@speag.com, http://www.speag.com

Certificate of Conformity / First Article Inspection

Item	Oval Flat Phantom ELI 5.0
Type No	QD OVA 002 A
Series No	1108 and higher
Manufacturer	Untersee Composites Knebelstrasse 8, CH-8268 Mannenbach, Switzerland

Tests

Complete tests were made on the prototype units QD OVA 001 A, pre-series units QD OVA 001 B as well as on some series units QD OVA 001 B. Some tests are made on all series units QD OVA 002 A.

Test	Requirement	Details	Units tested
Shape	Internal dimensions, depth and sagging are compatible with standards	Bottom elliptical 600 x 400 mm, Depth 190 mm, dimension compliant with [1] for f > 375 MHz	Prototypes
Material thickness	Bottom: 2.0mm +/- 0.2mm	dimension compliant with [3] for f > 800 MHz	all
Material parameters	rel. permittivity 2 – 5, loss tangent ≤ 0.05, at f ≤ 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.	within tolerance for filling height up to 155 mm	Prototypes, samples

** 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 **body-worn** SAR measurements and system performance checks as specified in [1 – 4] and further standards.

Date 25.7.2011

Signature / Stamp

s p e a g
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