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TEST REPORT

Report Number: 102780674LEX-001
Project Number: G102780674

Evaluation of the: GoTenna Mesh (Model: 80085)

Tested to the SAR Criteria in

FCC Part 2.1093 and RSS-102 Issue 5 per KDB447498 D01 v06

For

GOTENNA

Test Performed by:	Test Authorized by:
Intertek 731 Enterprise Drive Lexington, KY 40510	GOTENNA 81 Willoughby Street, Suite 302 Brooklyn, NY 19805

Prepared By:____________________ **Date:** 12/12/2016

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Approved By:____________________ **Date:** 12/12/2016

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DOCUMENT HISTORY

Revision/ Project Number	Writer Initials	Date	Change
1.0 /G102780674	BCT	12/12/2016	Original document

1.0 INTRODUCTION

At the request of GOTENNA, the GoTenna Mesh 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 ±22.3%.

The 80085 was tested at the maximum output power measured by Intertek. Maximum output power measurements are tabulated under Section 8.0 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) was found to be:

Transmit Band (MHz)	Device Position	Frequency (MHz)	Conducted Output Power (dBm)	Reported SAR_{1g} – Body Mode (W/kg)	Limit (W/kg)
902.5 – 927.5MHz	USB Edge, Direct Contact with Phantom	915MHz	29.03dBm	0.2931	1.6W/kg

Table 1: Maximum Measured SAR

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

2.0 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.

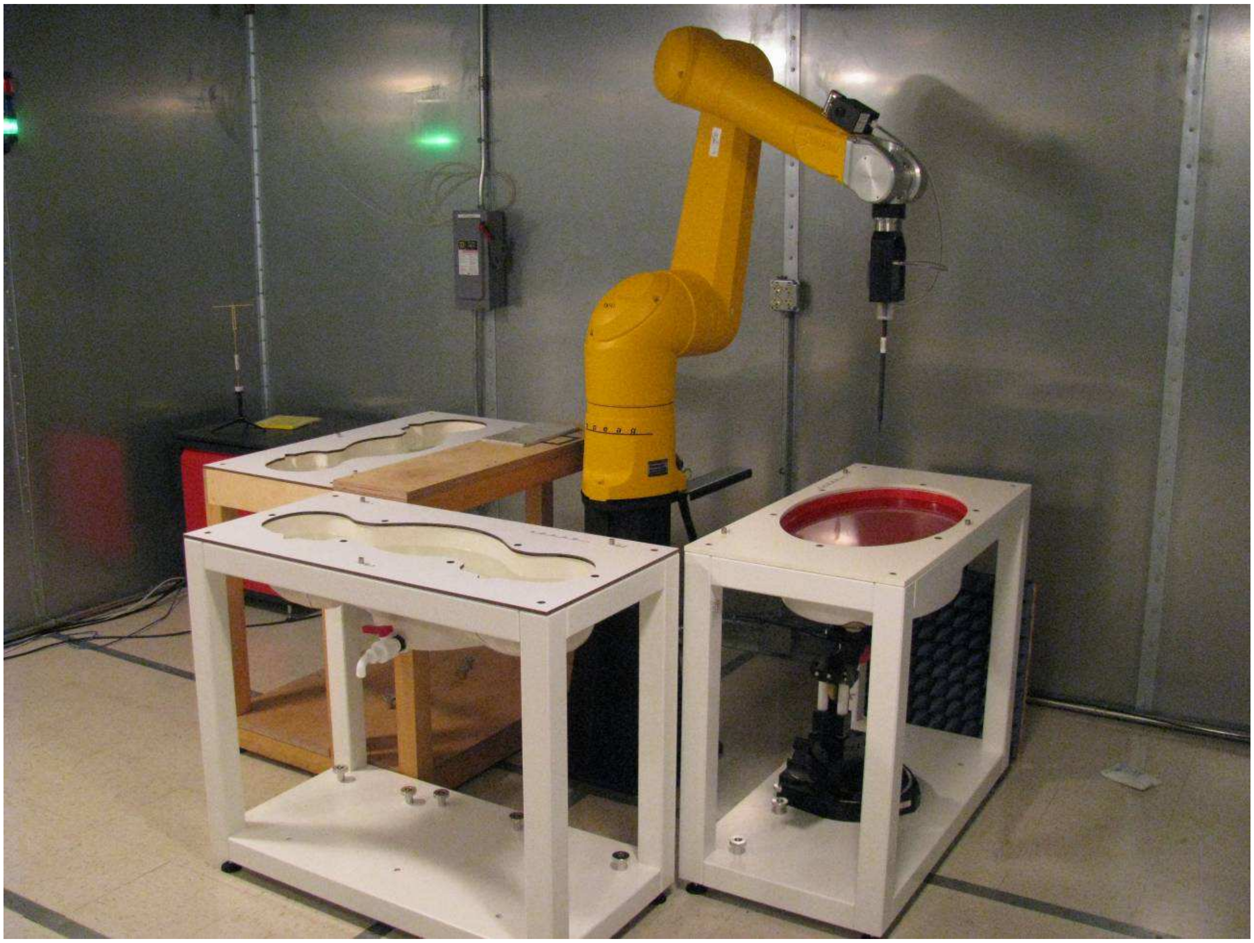

Figure 1: Intertek SAR Test Site

Measurement Equipment

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

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
SAR Probe	3516	Speag	EXDV3	10/26/2016	10/26/2017
System Verification Dipole	013	Speag	D900V2	12/9/2015	12/9/2016
DAE	358	Speag	DAE4	10/24/2016	10/24/2017
Vector Signal Generator	257708	Rohde & Schwarz	SMBV100A	9/21/2016	9/21/2017
Network Analyzer	US39173983	Agilent	8753ES	3/17/2016	3/17/2017
USB Power Sensor	100155	Rohde & Schwarz	NRP-Z81	9/22/2016	9/22/2017
USB Power Sensor	100705	Rohde & Schwarz	NRP-Z51	9/22/2016	9/22/2017
Dielectric Probe Kit	1111	Speag	DAK-3.5	NCR	NCR
Spectrum Analyzer	3099	Rohde & Schwarz	FSP7	9/20/2016	9/20/2017
Base Station Simulator	119981	Rohde & Schwarz	CMU200	9/25/2016	9/25/2017
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
Tape Measure	3629	Tajima	10m Tape	10/4/2016	10/4/2017
Thermometer	3181	Fluke	53II	3/31/2016	3/31/2017

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 1528-2013 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	±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.

1. 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.

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(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						±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.

3.0 JOB DESCRIPTION

At the request of GOTENNA, SAR testing was performed on the 80085. This is a portable device that can pair with a smart phone and use the GoTenna app to communicate off-grid using a proprietary mesh network.

Test sample	
Manufacturer	GOTENNA
Product Name	GoTenna Mesh (Model:80085)
Serial Number	MPK1610261216-005
Receive Date	11/22/2016
Device Received Condition	Good
Test Dates	11/22/2016 to 11/22/2016
Device Category	Portable
RF Exposure Category	General Population/Uncontrolled Environment
Antenna Type	Internal
Test sample Accessories	
Accessory	None

Table 3: Product Information

Operating Bands	**Frequency Range (MHz)**	**Maximum Output Power (declared by Manufacturer)**	**Duty Cycle**
Mesh network (FHSS)	902.5 – 927.5MHz	30dBm	1:1
Bluetooth (FHSS)	2402 – 2480MHz	7.73dBm	1:1

Table 4: Operating Bands

4.0 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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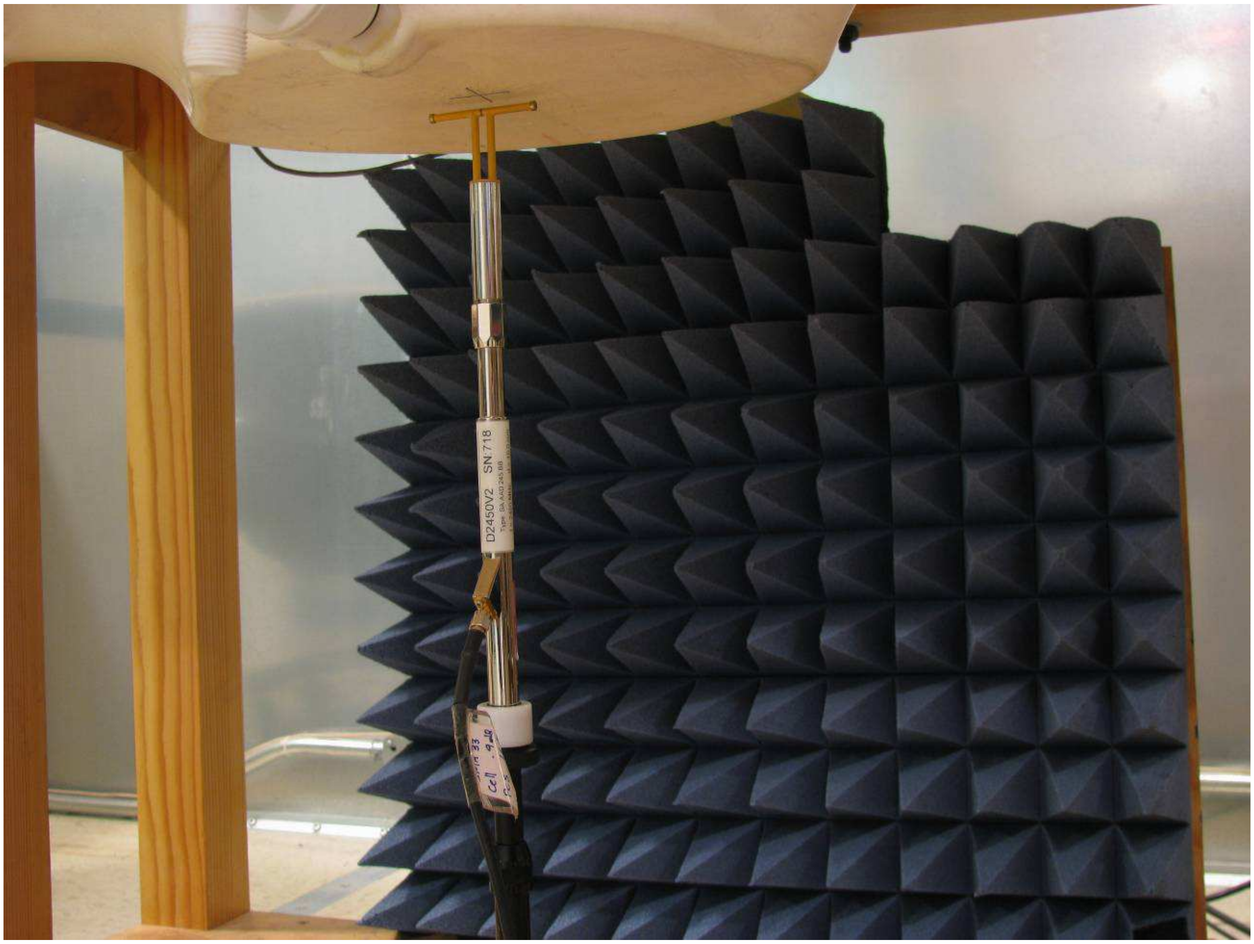


Figure 2: System Verification Setup

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	900	D900V2	MSL900	1W	11.4	10.5	7.89	11/22/2016

Table 5: Dipole Validations

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 (**$\varepsilon_{r,}$ 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)**	**Permittivity Target**	**Conductivity Target**	**Permittivity Measure**	**Complex Permittivity**	**Conductivity Measure**	**Dielectric % Deviation**	**Conductivity % Deviation**	**Date**
MSL900	900	55	1.05	54.3	20.4	1.02	1.27	2.79	11/22/2016
	915	55	1.06	54.7	20.6	1.05	0.55	1.14	
	930	55	1.07	54.9	20.8	1.08	0.18	0.51	

Table 6: Dielectric Parameter Validations

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		

Table 7: Tissue Simulating Fluid Recipe

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

5.0 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 1528:2013, 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 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	½·δ·ln(2) ± 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 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	$\le 1.5 \cdot \Delta z_{Zoom}(n-1)$	
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. 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.

6.0 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

7.0 TEST CONFIGURATION

The GoTenna Mesh could be mounted in such a way that it comes into direct contact with the users skin. Therefore when performing the SAR tests, the sample was mounted in direct contact with the SAR phantom.

According to the manufacturer, the actual feature code's Tx duty cycle is 8ms every 4 seconds frequency hopping across 51 channels, which yields 0.2% duty cycle per channel, or 10.2% duty cycle if measured across entire 902 to 928 MHz spectrum. Therefore the measured SAR values were adjusted by a factor of 0.0102 to account for the low transmission duty cycle.

Testing was performed on the middle channel of each operating band first. When the 1g SAR exceeded 0.8W/kg on the middle channel, the low and high channels were also scanned.

Test Setup

8.0 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]. The worst case 1-g SAR value was less than the 1.6W/kg limit.

Standalone SAR Measurements

	US / Canada Body SAR Results Using 900MHz MSL.								
Date	TX Mode	Position	Position	Power Drift (dB)	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Duty Cycle Adjustment	Measured Conducted Output Power (dBm)	Maximum Conducted Output Power (dBm)
11/22/2016	915MHz, Mesh	Direct	Label Side	-0.13	1.9700	0.2468	0.1002	29.03	30.00
11/22/2016	915MHz, Mesh	Direct	LED Side	0.11	2.2100	0.2769	0.1002	29.03	30.00
11/22/2016	915MHz, Mesh	Direct	Blank Edge	0.16	2.2100	0.2769	0.1002	29.03	30.00
11/22/2016	915MHz, Mesh	Direct	USB Edge	-0.18	2.3400	0.2931	0.1002	29.03	30.00
1g SAR Limit (Head & Body) = 1.6W/kg									

Table 9: SAR Results

Conducted Output Power Measurements:

Table 10: Conducted Power Measurements

Mode	Frequency (MHz)	Power (dBm)	Power (W)
Mesh	902.5	29.03	0.801W
Mesh	915.0	29.00	0.796W
Mesh	927.5	29.14	0.822W

Table 11: Conducted Power Measurements (Bluetooth)

Mode	Frequency (MHz)	Power (dBm)	Power (mW)
Bluetooth	2402	-1.99	0.633mW
Bluetooth	2440	-2.06	0.623mW
Bluetooth	2480	-1.57	0.697mW

*Note that the Bluetooth radio is exempt from SAR testing due to the low output power

Simultaneous Transmission Calculations:

The Bluetooth and mesh network radio can transmit simultaneously. The FCC exemption threshold for 2.45GHz radios with less than 5mm separation distance to the user is 10mW. The RSS-102 exemption threshold for 2.45GHz is 4mW. The maximum output power measured for Bluetooth was 0.697mW, well under both exclusion thresholds.

In order to consider the simultaneous transmission for Bluetooth and Mesh together, the Bluetooth SAR must be estimated per 4.3.2b (KDB447498) using the following formula:

[(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)]·[√f(GHz)/x] W/kg, for test separation distances ≤ 50 mm; where x = 7.5 for 1-g SAR and x = 18.75 for 10-g SAR

- **Max power: 0.7mW**
- **Min separation distance: 0mm (5mm used in calculation)**
- **f(GHz): 2.402**

The maximum estimated Bluetooth SAR for this device is 0.03W/kg using the values above.

Per 4.3.2 of KDB447498, when the sum of all the simultaneous transmitting SAR values is less than the stand alone SAR limit then simultaneous transmission SAR exclusion applies. For this product, the worst case mesh network SAR (0.0031W/kg) summed with the worst case estimated Bluetooth SAR (0.03W/kg) is less than the standalone SAR limit. Therefore simultaneous SAR is excluded.

(0.2931 + 0.03)W/kg) = 0.3231W/kg

9.0 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.

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
835	12/20/2015	3516	EX3DV3	835	Body	54.2	0.98	Pass	Pass	Pass	GMSK	Pass	N/A
900	12/20/2015	3516	EX3DV3	900	Body	54	1.02	Pass	Pass	Pass	GMSK	Pass	N/A
1750	12/20/2015	3516	EX3DV3	1800	Body	52.9	1.41	Pass	Pass	Pass	GMSK	Pass	N/A
1900	12/20/2015	3516	EX3DV3	1900	Body	52.7	1.48	Pass	Pass	Pass	GMSK	Pass	N/A

				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	12/22/2015	3516	EX3DV3	2450	Body	50.65	2.02	Pass	Pass	Pass	OFDM	N/A	Pass
5200	12/21/2015	3516	EX3DV3	5200	Body	48.71	5.54	Pass	Pass	Pass	OFDM	N/A	Pass
5500	12/21/2015	3516	EX3DV3	5500	Body	47.68	6.29	Pass	Pass	Pass	OFDM	N/A	Pass
5800	12/21/2015	3516	EX3DV3	5800	Body	48.71	5.54	Pass	Pass	Pass	OFDM	N/A	Pass

Table 12: SAR System Validation Summary

Mid Channel LED Side_Direct Contact Date/Time: 11/22/2016 12:11:18 PM

Test Laboratory: Intertek
File Name: SAR_NA.da52:4

SAR_NA

Procedure Notes:

DUT: Gotenna; Serial:

Communication System: UID 0, CW (0); Communication System Band: D900 (900.0 MHz);
Frequency: 900 MHz;Duty Cycle: 1:1

Medium parameters used: f = 900 MHz; σ = 1.02 S/m; ε_r = 57.98; ρ = 1000 kg/m^3

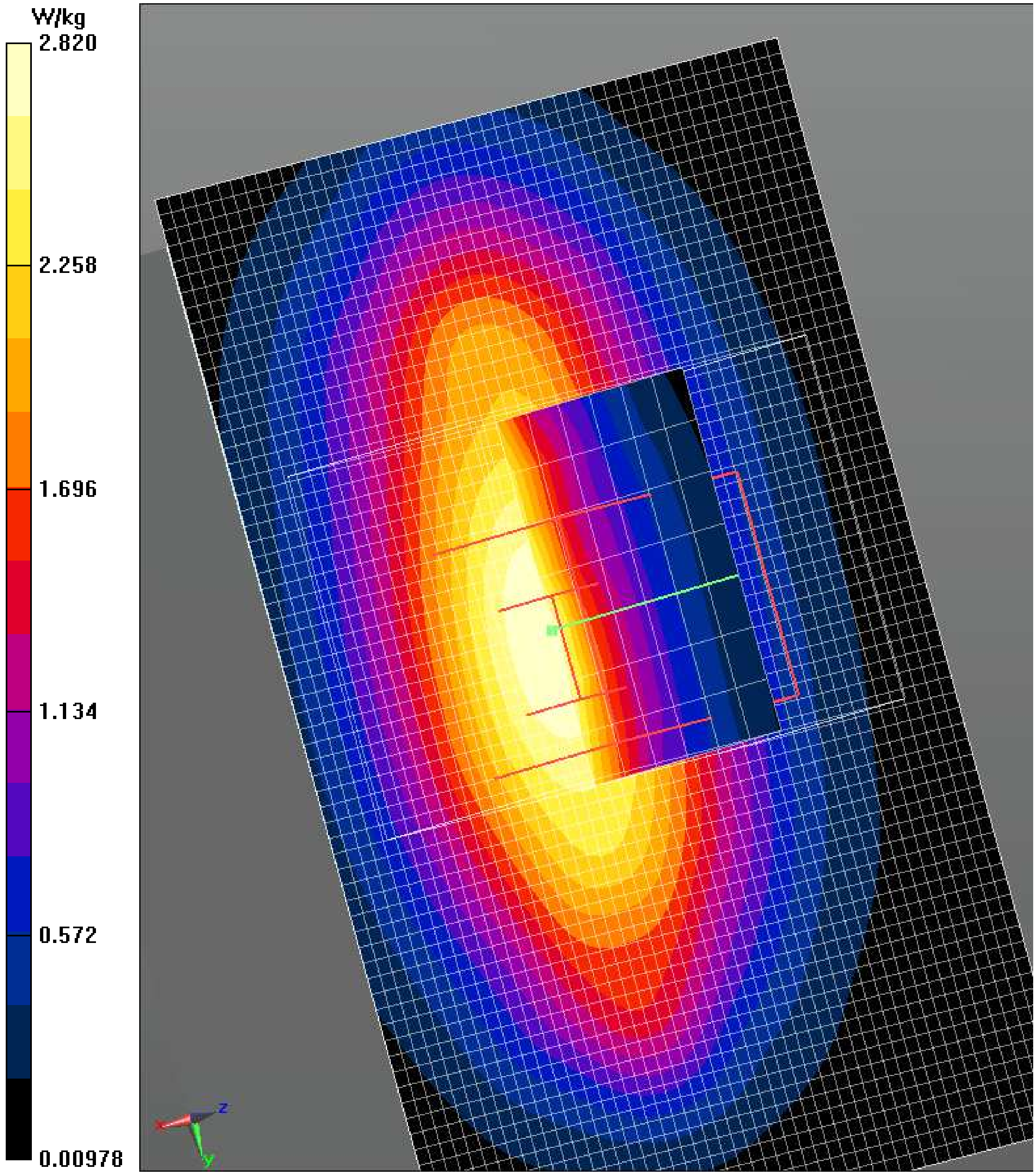
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV3 - SN3516; ConvF(10.87, 10.87, 10.87); Calibrated: 10/26/2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn358; Calibrated: 10/19/2016
- 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/Mid Channel LED Side_Direct Contact/Area Scan 2 (51x71x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 2.82 W/kg

WWAN Flat-Section MSL Testing/Mid Channel LED Side_Direct Contact/Zoom Scan (9x8x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 51.636 V/m; Power Drift = 0.11 dB
Peak SAR (extrapolated) = 3.37 W/kg
SAR(1 g) = 2.21 W/kg; SAR(10 g) = 1.43 W/kg
Maximum value of SAR (measured) = 2.97 W/kg



W/kg
2.820
2.258
1.696
1.134
0.572
0.00978

Mid Channel Label Side_Direct Contact Date/Time: 11/22/2016 1:34:01 PM

Test Laboratory: Intertek
File Name: SAR_NA.da52:4

SAR_NA

Procedure Notes:

DUT: Gotenna; Serial:

Communication System: UID 0, CW (0); Communication System Band: D900 (900.0 MHz); Frequency: 900 MHz;Duty Cycle: 1:1

Medium parameters used: f = 900 MHz; σ = 1.02 S/m; ε_r = 57.98; ρ = 1000 kg/m^3

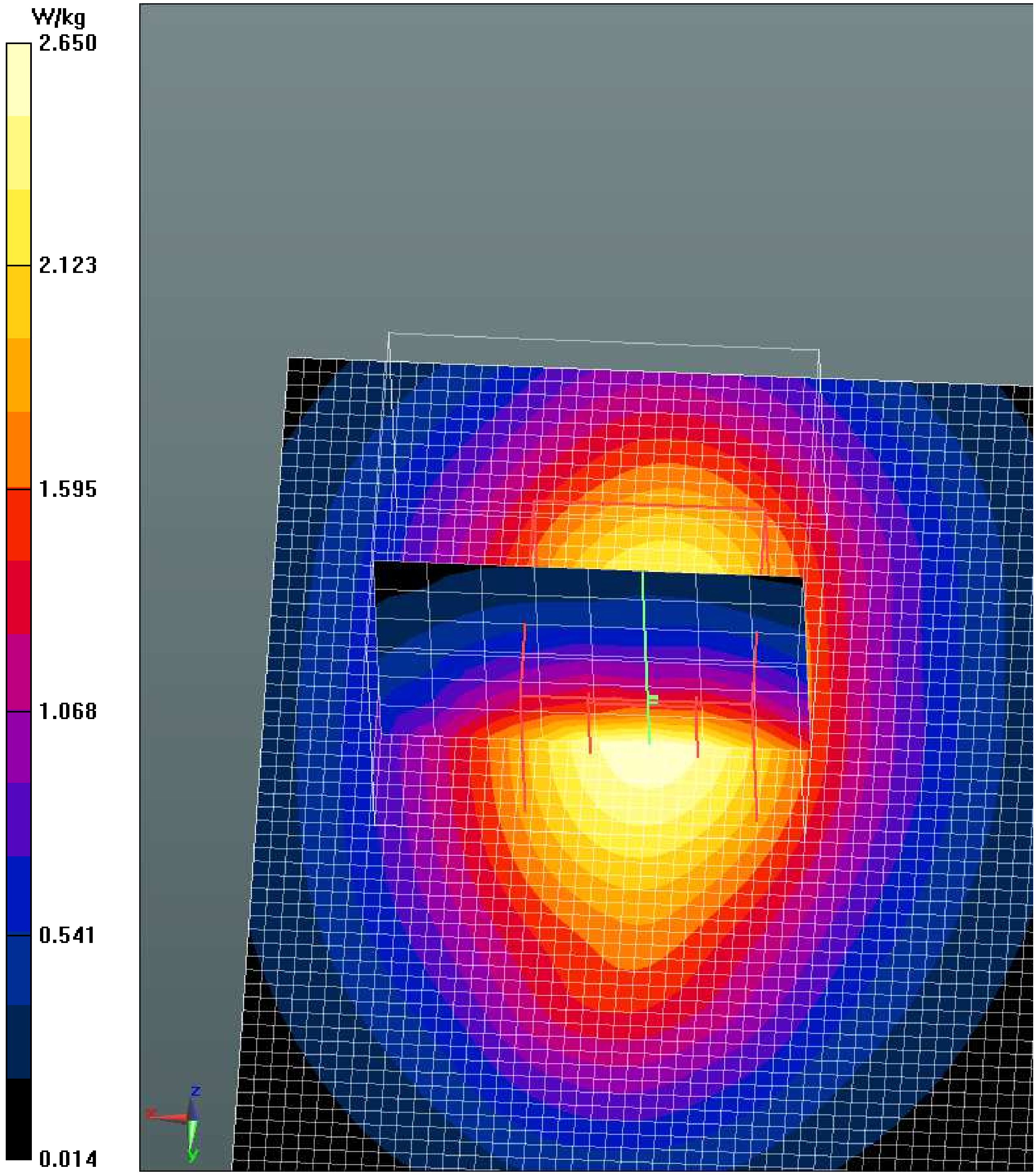
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV3 - SN3516; ConvF(10.87, 10.87, 10.87); Calibrated: 10/26/2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn358; Calibrated: 10/19/2016
- 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/Mid Channel Label Side_Direct Contact/Area Scan 2 (51x71x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 2.65 W/kg

WWAN Flat-Section MSL Testing/Mid Channel Label Side_Direct Contact/Zoom Scan (9x8x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 50.526 V/m; Power Drift = -0.13 dB
Peak SAR (extrapolated) = 2.91 W/kg
SAR(1 g) = 1.97 W/kg; SAR(10 g) = 1.33 W/kg
Maximum value of SAR (measured) = 2.58 W/kg


W/kg
2.650
2.123
1.595
1.068
0.541
0.014

Mid Channel USB Edge Direct Contact Date/Time: 11/22/2016 2:25:14 PM

Test Laboratory: Intertek
File Name: SAR_NA.da52:4

SAR_NA

Procedure Notes:

DUT: Gotenna; Serial:

Communication System: UID 0, CW (0); Communication System Band: D900 (900.0 MHz);
Frequency: 900 MHz;Duty Cycle: 1:1

Medium parameters used: f = 900 MHz; σ = 1.02 S/m; ε_r = 57.98; ρ = 1000 kg/m^3

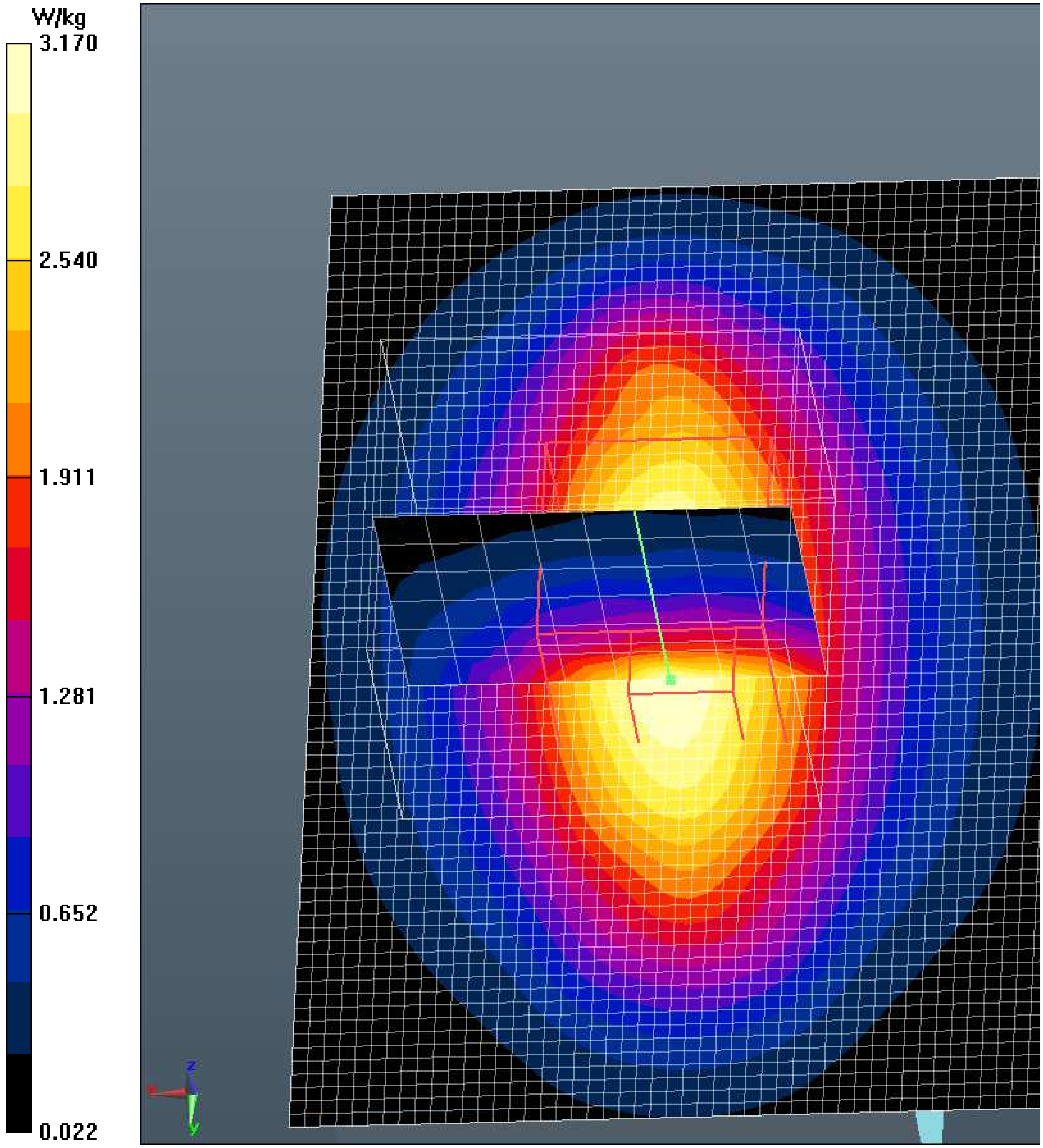
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV3 - SN3516; ConvF(10.87, 10.87, 10.87); Calibrated: 10/26/2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn358; Calibrated: 10/19/2016
- 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/Mid Channel USB Edge_Direct Contact 2/Area Scan 2 (51x71x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 3.17 W/kg

WWAN Flat-Section MSL Testing/Mid Channel USB Edge_Direct Contact 2/Zoom Scan (9x8x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 56.869 V/m; Power Drift = -0.18 dB
Peak SAR (extrapolated) = 3.80 W/kg
SAR(1 g) = 2.34 W/kg; SAR(10 g) = 1.5 W/kg
Maximum value of SAR (measured) = 3.28 W/kg


W/kg
3.170
2.540
1.911
1.281
0.652
0.022

Mid Channel Blank Edge Direct Contact Date/Time: 11/22/2016 10:33:54 AM

Test Laboratory: Intertek
File Name: SAR_NA.da52:4

SAR_NA

Procedure Notes:

DUT: Gotenna; Serial:

Communication System: UID 0, CW (0); Communication System Band: D900 (900.0 MHz);
Frequency: 900 MHz;Duty Cycle: 1:1

Medium parameters used: f = 900 MHz; σ = 1.02 S/m; ε_r = 57.98; ρ = 1000 kg/m^3

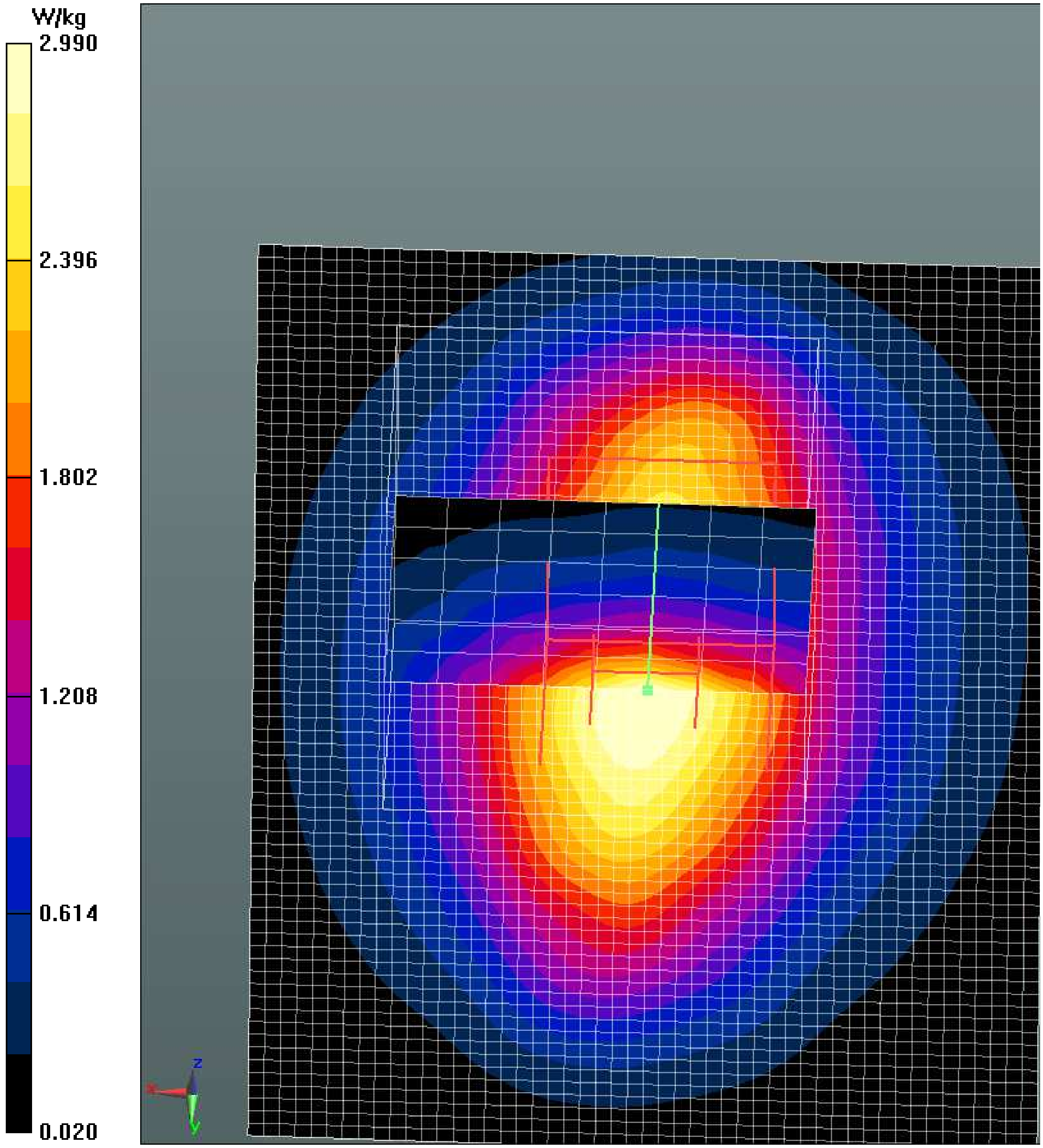
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV3 - SN3516; ConvF(10.87, 10.87, 10.87); Calibrated: 10/26/2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn358; Calibrated: 10/19/2016
- 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/Mid Channel Blank Edge_Direct Contact 2 2/Area Scan 2 (51x71x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 2.99 W/kg

WWAN Flat-Section MSL Testing/Mid Channel Blank Edge_Direct Contact 2 2/Zoom Scan (9x8x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 53.131 V/m; Power Drift = 0.16 dB
Peak SAR (extrapolated) = 3.55 W/kg
SAR(1 g) = 2.21 W/kg; SAR(10 g) = 1.4 W/kg
Maximum value of SAR (measured) = 3.09 W/kg



W/kg
2.990
2.396
1.802
1.208
0.614
0.020