



SAR EVALUATION REPORT

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

For
Apple Watch

**FCC ID: BCG-E3104
Model Name: A1757, A1816**

**Report Number: 16U23781-S1V2
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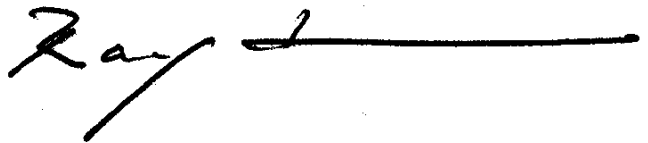
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V1	8/24/2016	Initial Issue	--
V2	8/26/2016	Report revised based on Reviewer's comments: 1. Sec. 6.1.: Updated device information. 2. Appendix A: Updated	Kenneth Mak

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1. Attestation of Test Results

Applicant Name	APPLE INC.			
FCC ID	BCG-E3104			
Model Name	A1757, A1816			
Applicable Standards	FCC 47 CFR § 2.1093 Published RF exposure KDB procedures IEEE Std 1528-2013			
Exposure Category	SAR Limits (W/Kg)			
	Peak spatial-average(1g of tissue)		Extremities (hands, wrists, ankles, etc.) (10g of tissue)	
General population / Uncontrolled exposure	1.6		4	
RF Exposure Conditions	Equipment Class - Highest Reported SAR (W/kg)			
	PCE	DTS	NII	DSS
Extremity	N/A	0.049	NA	0.012
Next-to-Mouth	N/A	0.175	NA	0.062
Date Tested	8/10/2016 to 8/20/2016			
Test Results	Pass			
UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report. Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government (NIST Handbook 150, Annex A). This report is written to support regulatory compliance of the applicable standards stated above.				
Approved & Released By:		Prepared By:		
				
Bobby Bayani Senior Engineer UL Verification Services Inc.		Ray Su Laboratory Engineer UL Verification Services Inc.		

2. Test Specification, Methods and Procedures

The tests documented in this report were performed in accordance with FCC 47 CFR § 2.1093, IEEE STD 1528-2013, the following FCC Published RF exposure [KDB](#) procedures:

- 248227 D01 802.11 Wi-Fi SAR v02r02
- 447498 D01 General RF Exposure Guidance v06
- 447498 D03 Supplement C Cross-Reference v01
- 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04
- 865664 D02 RF Exposure Reporting v01r02

3. Facilities and Accreditation

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

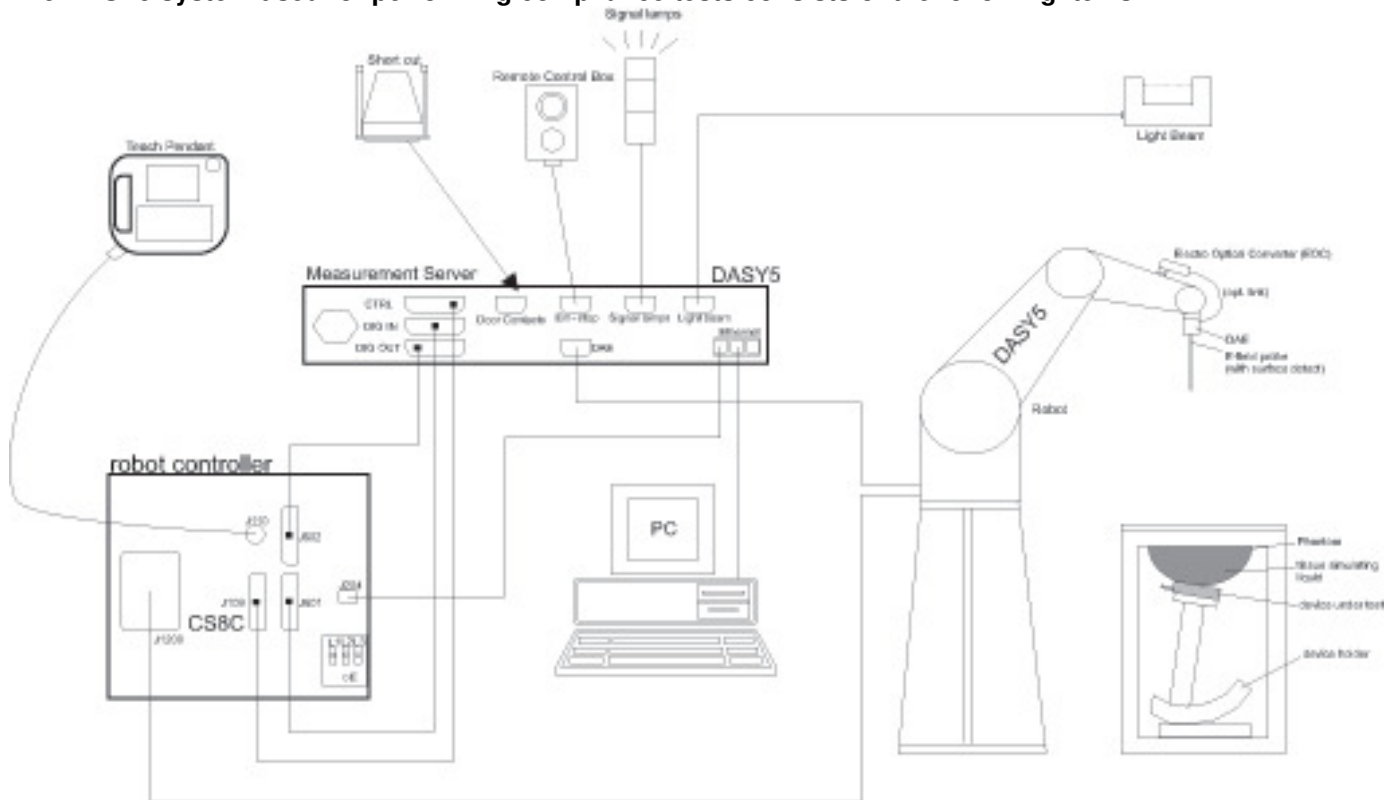
47173 Benicia Street	47266 Benicia Street
SAR Lab A	SAR Lab 1
SAR Lab B	SAR Lab 2
SAR Lab C	SAR Lab 3
SAR Lab D	SAR Lab 4
SAR Lab E	SAR Lab 5
SAR Lab F	
SAR Lab G	
SAR Lab H	

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0.

4. SAR Measurement System & Test Equipment

4.1. SAR Measurement System

The DASY5 system used for performing compliance tests consists of the following items:



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

4.2. SAR Scan Procedures

Step 1: Power Reference Measurement

The Power Reference Measurement and Power Drift Measurements are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. The minimum distance of probe sensors to surface is 2.1 mm. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

Step 2: Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maximal found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE Standard 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan). If only one Zoom Scan follows the Area Scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of Zoom Scans has to be increased accordingly.

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

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$
Maximum area scan spatial resolution: 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.	

Step 3: Zoom Scan

Zoom Scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g of simulated tissue. The Zoom Scan measures points (refer to table below) within a cube whose base faces are centered on the maxima found in a preceding area scan job within the same procedure. When the measurement is done, the Zoom Scan evaluates the averaged SAR for 1 g and 10 g and displays these values next to the job's label.

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

			≤ 3 GHz	> 3 GHz
Maximum zoom scan spatial resolution: $\Delta x_{\text{Zoom}}, \Delta y_{\text{Zoom}}$			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{\text{Zoom}}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{\text{Zoom}}(1)$: between 1 st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{\text{Zoom}}(n>1)$: between subsequent points	$\leq 1.5 \cdot \Delta z_{\text{Zoom}}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm
Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.				
* When zoom scan is required and the <u>reported</u> 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.				

Step 4: Power drift measurement

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

Step 5: Z-Scan (FCC only)

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

4.3. Test Equipment

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

Dielectric Property Measurements

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Network Analyzer	Agilent	8753ES	MY40000980	4/27/2017
Dielectric Probe kit	SPEAG	DAK-3.5	1082	9/15/2016
Shorting block	SPEAG	DAK-3.5 Short	SM DAK 200 BA	N/A
Thermometer	Traceable Calibration Control Co.	4242	140562250	8/24/2016

System Check

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Synthesized Signal Generator	Agilent	N5181A	MY50140610	5/9/2017
Power Meter	Agilent	N1912A	MY50001018	10/19/2016
Power Sensor	Agilent	E9323A	MY53070007	2/27/2017
Power Sensor	Agilent	E9323A	MY53070002	3/22/2017
Amplifier	MITEQ	AMF-4D-00400600-50-30P	1795093	N/A
Directional coupler	Werlatone	C8060-102	2149	N/A
DC Power Supply	AMETEK	XT 15-4	1319A02778	N/A
E-Field Probe (SAR Lab F)	SPEAG	EX3DV4	3749	1/26/2017
E-Field Probe (SAR Lab H)	SPEAG	EX3DV4	3989	2/23/2017
Data Acquisition Electronics (SAR Lab F)	SPEAG	DAE4	1352	11/11/2016
Data Acquisition Electronics (SAR Lab H)	SPEAG	DAE4	1357	2/19/2017
System Validation Dipole	SPEAG	D2450V2	748	2/22/2017

Other

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Power Meter	Agilent	N1912A	MY55196004	7/1/2017
Power Sensor	Agilent	N1921A	MY52270022	12/17/2016
Power Sensor	Agilent	N1921A	MY52270009	12/17/2016

5. Measurement Uncertainty

Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz, when the highest measured 1-g SAR within a frequency band is < 1.5 W/kg and the measured 10-g SAR within a frequency band is < 3.75 W/kg, the extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval.

6. Device Under Test (DUT) Information

6.1. DUT Description

Model A1757 and A1816 have 3 types of enclosure (stainless steel, aluminum, and ceramic) and various kinds of metallic and non-metallic wristbands. There are 2 types of metallic bands: Metal Links and Metal Mesh. SAR testing was performed to determine worst case enclosure for both non-metallic and metallic wristbands.

Intended Use	Wrist-worn
Device Dimension	Model A1757: Overall (Length x Width): 38.6 mm x 35.2 mm (excluding strap) Display Diagonal: 34.03 mm Model A1816: Overall (Length x Width): 39.2 mm x 35.9 mm (excluding strap) Display Diagonal: 34.03 mm
Accessory	Removable wristbands: metallic and non-metallic

6.2. Wireless Technologies

Wireless technologies	Frequency bands	Operating mode	Duty Cycle used for SAR testing
Wi-Fi	2.4 GHz	802.11b 802.11g 802.11n (HT20)	100%
Bluetooth	2.4 GHz	Version 4.2 LE	77.5% (DH5)

6.3. Maximum Output Power from Tune-up Procedure

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

Band (GHz)	Mode	Ch #	Freq. (MHz)	Maximum Output Power (dBm)	SAR Test (Yes/No)
2.4	802.11b	1	2412	19.5	Yes
		2	2417	20.5	
		6	2437	20.5	
		11	2462	20.5	
		12	2467	20.5	
		13	2472	19.0	
	802.11g	1	2412	19.0	No
		2	2417	20.5	
		6	2437	20.5	
		10	2457	20.5	
		11	2462	19.0	
		12	2467	16.5	
		13	2472	6.0	
	802.11n	1	2412	19.0	No
		2	2417	20.5	
		6	2437	20.5	
		10	2457	20.5	
		11	2462	19.0	
		12	2467	16.5	
		13	2472	6.0	
RF Air interface	Mode	Maximum Output Power (dBm)			
Bluetooth (high power)	BDR (GFSK)	17.5			
	EDR (π/4 DQPSK / 8DPSK)	14.5			
	LE	17.5			
Bluetooth (low power)	BDR (GFSK)	11.5			
	EDR (π/4 DQPSK / 8DPSK)	8.5			
	LE	10.0			

7. RF Exposure Conditions (Test Configurations)

Refer to “Antenna Location Exhibit” submission for the specific details of the antenna-to-antenna and antenna-to-edge(s) distances.

Wireless technologies	RF Exposure Conditions	DUT-to-User Separation	Test Position	Antenna-to-edge/surface	SAR Required	Note
WLAN	Extremity (Hand/Wrist/Ankle)	0 mm	Rear	N/A	Yes	
	Next to Mouth	10 mm	Front	N/A	Yes	

8. Dielectric Property Measurements & System Check

8.1. Dielectric Property Measurements

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

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

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

For SAR measurement systems that have implemented the SAR error compensation algorithms documented in IEEE Std 1528-2013, to automatically compensate the measured SAR results for deviations between the measured and required tissue dielectric parameters, the tolerance for ϵ_r and σ may be relaxed to $\pm 10\%$. This is limited to frequencies ≤ 3 GHz.

Tissue Dielectric Parameters

FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

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

IEEE Std 1528-2013

Refer to Table 3 within the IEEE Std 1528-2013

Dielectric Property Measurements Results:

SAR Room	Date	Band (MHz)	Tissue Type	Frequency (MHz)	Relative Permittivity (ϵ_r)			Conductivity (σ)		
					Measured	Target	Delta $\pm 5\%$	Measured	Target	Delta $\pm 5\%$
F	8/8/2016	2450	Head	2450	37.96	39.20	-3.16	1.79	1.80	-0.56
				2400	38.13	39.30	-2.97	1.73	1.75	-1.46
				2480	37.83	39.16	-3.40	1.82	1.83	-0.84
F	8/8/2016	2450	Body	2450	51.15	52.70	-2.94	1.98	1.95	1.49
				2400	51.29	52.77	-2.81	1.90	1.90	0.31
				2480	51.02	52.66	-3.12	2.02	1.99	1.15
F	8/11/2016	2450	Head	2450	37.74	39.20	-3.72	1.75	1.80	-2.83
				2400	37.91	39.30	-3.53	1.69	1.75	-3.41
				2480	37.64	39.16	-3.89	1.78	1.83	-2.75
F	8/11/2016	2450	Body	2450	53.47	52.70	1.46	2.03	1.95	4.21
				2400	53.63	52.77	1.62	1.96	1.90	3.42
				2480	53.32	52.66	1.25	2.08	1.99	4.26
F	8/15/2016	2450	Head	2450	38.13	39.20	-2.73	1.78	1.80	-1.22
				2400	38.34	39.30	-2.43	1.72	1.75	-1.64
				2480	38.00	39.16	-2.97	1.81	1.83	-1.33
F	8/15/2016	2450	Body	2450	51.12	52.70	-3.00	1.87	1.95	-4.05
				2400	51.34	52.77	-2.71	1.81	1.90	-4.85
				2480	51.01	52.66	-3.14	1.91	1.99	-4.38
F	8/18/2016	2450	Head	2450	37.46	39.20	-4.44	1.86	1.80	3.56
				2400	37.64	39.30	-4.22	1.81	1.75	3.05
				2480	37.33	39.16	-4.68	1.89	1.83	3.36
F	8/18/2016	2450	Body	2450	50.64	52.70	-3.91	2.03	1.95	4.15
				2400	50.81	52.77	-3.72	1.96	1.90	3.27
				2480	50.51	52.66	-4.09	2.07	1.99	3.81
H	8/8/2016	2450	Head	2450	38.05	39.20	-2.93	1.88	1.80	4.22
				2400	38.19	39.30	-2.82	1.81	1.75	3.33
				2480	37.93	39.16	-3.15	1.90	1.83	3.74
H	8/11/2016	2450	Head	2450	38.15	39.20	-2.68	1.79	1.80	-0.56
				2400	38.30	39.30	-2.54	1.74	1.75	-0.84
				2480	38.06	39.16	-2.81	1.82	1.83	-0.57
H	8/15/2016	2450	Head	2450	38.69	39.20	-1.30	1.76	1.80	-2.44
				2400	38.86	39.30	-1.11	1.71	1.75	-2.55
				2480	38.56	39.16	-1.54	1.78	1.83	-2.64
H	8/18/2016	2450	Head	2450	39.95	39.20	1.91	1.83	1.80	1.50
				2400	40.10	39.30	2.04	1.77	1.75	1.05
				2480	39.84	39.16	1.73	1.85	1.83	1.12

8.2. System Check

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

System Performance Check Measurement Conditions:

- The measurements were performed in the flat section of the TWIN SAM or ELI phantom, shell thickness: 2.0 $\pm$ 0.2 mm (bottom plate) filled with Body or Head simulating liquid of the following parameters.
- The depth of tissue-equivalent liquid in a phantom must be $\geq$ 15.0 cm for SAR measurements $\leq$ 3 GHz and $\geq$ 10.0 cm for measurements $>$ 3 GHz.
- The DASY system with an E-Field Probe was used for the measurements.
- The dipole was mounted on the small tripod so that the dipole feed point was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10 mm (above 1 GHz) and 15 mm (below 1 GHz) from dipole center to the simulating liquid surface.
- The coarse grid with a grid spacing of 15 mm was aligned with the dipole.
For 5 GHz band - The coarse grid with a grid spacing of 10 mm was aligned with the dipole.
- Special 7x7x7 (below 3 GHz) and/or 8x8x7 (above 3 GHz) fine cube was chosen for the cube.
- Distance between probe sensors and phantom surface was set to 3 mm.
For 5 GHz band - Distance between probe sensors and phantom surface was set to 2.5 mm
- The dipole input power (forward power) was 100 mW.
- The results are normalized to 1 W input power.

System Check Results

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

SAR Room	Date	Tissue Type	Dipole Type _Serial #	Dipole Cal. Due Date	Measured Results for 1g SAR				Measured Results for 10g SAR				Plot No.
					Zoom Scan to 100 mW	Normalize to 1 W	Target (Ref. Value)	Delta $\pm$ 10 %	Zoom Scan to 100 mW	Normalize to 1 W	Target (Ref. Value)	Delta $\pm$ 10 %	
F	8/8/2016	Head	D2450V2 SN:748	2/22/2017	5.440	54.40	50.90	6.88	2.430	24.30	23.70	2.53	1,2
F	8/8/2016	Body	D2450V2 SN:748	2/22/2017	5.020	50.20	49.80	0.80	2.280	22.80	23.20	-1.72	
F	8/11/2016	Head	D2450V2 SN:748	2/22/2017	5.370	53.70	50.90	5.50	2.410	24.10	23.70	1.69	
F	8/11/2016	Body	D2450V2 SN:748	2/22/2017	5.200	52.00	49.80	4.42	2.350	23.50	23.20	1.29	
F	8/15/2016	Head	D2450V2 SN:748	2/22/2017	5.240	52.40	50.90	2.95	2.340	23.40	23.70	-1.27	
F	8/15/2016	Body	D2450V2 SN:748	2/22/2017	4.860	48.60	49.80	-2.41	2.200	22.00	23.20	-5.17	
F	8/18/2016	Head	D2450V2 SN:748	2/22/2017	5.240	52.40	50.90	2.95	2.360	23.60	23.70	-0.42	
F	8/18/2016	Body	D2450V2 SN:748	2/22/2017	5.280	52.80	49.80	6.02	2.410	24.10	23.20	3.88	
H	8/8/2016	Head	D2450V2 SN:748	2/22/2017	5.410	54.10	50.90	6.29	2.440	24.40	23.70	2.95	3,4
H	8/11/2016	Head	D2450V2 SN:748	2/22/2017	5.080	50.80	50.90	-0.20	2.290	22.90	23.70	-3.38	
H	8/15/2016	Head	D2450V2 SN:748	2/22/2017	5.030	50.30	50.90	-1.18	2.260	22.60	23.70	-4.64	
H	8/18/2016	Head	D2450V2 SN:748	2/22/2017	5.020	50.20	50.90	-1.38	2.280	22.80	23.70	-3.80	

9. Conducted Output Power Measurements

9.1. Wi-Fi 2.4GHz (DTS Band)

Measured Results

Band (GHz)	Mode	Data Rate	Ch #	Freq. (MHz)	Avg Pwr (dBm)
2.4	802.11b	1 Mbps	1	2412	19.5
			2	2417	20.5
			6	2437	20.5
			11	2462	20.5
			12	2467	20.5
			13	2472	19.0

Note(s):

- Output Power and SAR are not required for 802.11g/n HT20 channels when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.
- Additionally, SAR is not required for Channels 12 and 13 because the tune-up limit and the measured output power for these two channels are no greater than those for the default test channels.

9.2. Bluetooth

Band (GHz)	Mode	Ch #	Freq. (MHz)	Avg Pwr (dBm)
2.4	BDR (GFSK)	0	2402	17.5
		39	2441	17.5
		78	2480	17.5
	EDR ($\pi/4$ DQPSK / 8DPSK)	0	2402	14.0
		39	2441	14.0
		78	2480	14.0
	LE	0	2402	17.5
		19	2440	17.5
		39	2480	17.5

Note(s):

- Only High Power for BT was evaluated for power measurement and SAR testing. Further evaluation for Low Power is not required.

10. Measured and Reported (Scaled) SAR Results

SAR Test Reduction criteria are as follows:

KDB 447498 D01 General RF Exposure Guidance:

Testing of other required channels within the operating mode of a frequency band is not required when the reported 1-g or 10-g SAR for the mid-band or highest output power channel is:

- ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz
- ≤ 0.6 W/kg or 1.5 W/kg, for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz
- ≤ 0.4 W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≥ 200 MHz

KDB 248227 D01 SAR meas for 802.11:

SAR test reduction for 802.11 Wi-Fi transmission mode configurations are considered separately for DSSS and OFDM. An initial test position is determined to reduce the number of tests required for certain exposure configurations with multiple test positions. An initial test configuration is determined for each frequency band and aggregated band according to maximum output power, channel bandwidth, wireless mode configurations and other operating parameters to streamline the measurement requirements. For 2.4 GHz DSSS, either the initial test position or DSSS procedure is applied to reduce the number of SAR tests; these are mutually exclusive. For OFDM, an initial test position is only applicable to next to the ear, UMPC mini-tablet and hotspot mode configurations, which is tested using the initial test configuration to facilitate test reduction. For other exposure conditions with a fixed test position, SAR test reduction is determined using only the initial test configuration.

The multiple test positions require SAR measurements in head, hotspot mode or UMPC mini-tablet configurations may be reduced according to the highest reported SAR determined using the initial test position(s) by applying the DSSS or OFDM SAR measurement procedures in the required wireless mode test configuration(s). The initial test position(s) is measured using the highest measured maximum output power channel in the required wireless mode test configuration(s). When the reported SAR for the initial test position is:

- ≤ 0.4 W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and wireless mode combination within the frequency band or aggregated band. DSSS and OFDM configurations are considered separately according to the required SAR procedures.
- > 0.4 W/kg, SAR is repeated using the same wireless mode test configuration tested in the initial test position to measure the subsequent next closest/smallest test separation distance and maximum coupling test position, on the highest maximum output power channel, until the reported SAR is ≤ 0.8 W/kg or all required test positions are tested.
 - For subsequent test positions with equivalent test separation distance or when exposure is dominated by coupling conditions, the position for maximum coupling condition should be tested.
 - When it is unclear, all equivalent conditions must be tested.
- For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg, measure the SAR for these positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or all required test channels are considered.
 - The additional power measurements required for this step should be limited to those necessary for identifying subsequent highest output power channels to apply the test reduction.
- When the specified maximum output power is the same for both UNII 1 and UNII 2A, begin SAR measurements in UNII 2A with the channel with the highest measured output power. If the reported SAR for UNII 2A is ≤ 1.2 W/kg, SAR is not required for UNII 1; otherwise treat the remaining bands separately and test them independently for SAR.
- When the specified maximum output power is different between UNII 1 and UNII 2A, begin SAR with the band that has the higher specified maximum output. If the highest reported SAR for the band with the highest specified power is ≤ 1.2 W/kg, testing for the band with the lower specified output power is not required; otherwise test the remaining bands independently for SAR.

To determine the initial test position, Area Scans were performed to determine the position with the *Maximum Value of SAR (measured)*. The position that produced the highest *Maximum Value of SAR* is considered the worst case position; thus used as the initial test position.

10.1. Wi-Fi (DTS Band)

10.1.1. Non-Metallic Wristbands

Frequency Band	Mode	Housing Type	Wristband	RF Exposure Condition	Test Position	Dist. (mm)	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		10-g SAR (W/kg)		Plot No.
									Tune-up limit	Meas.	Meas.	Scaled	Meas.	Scaled	
2.4 GHz	802.11b 1 Mbps	Stainless Steel	None	Extremity	Rear	0	6	2437	20.5	20.5			0.030	0.030	1
		Aluminum					6	2437	20.5	20.5			0.049	0.049	
		Ceramic					6	2437	20.5	20.5			0.039	0.039	
		Stainless Steel	Nylon	Next-to-Mouth	Front	10	6	2437	20.5	20.5	0.175	0.175			2
		Aluminum					6	2437	20.5	20.5	0.150	0.150			
		Ceramic					6	2437	20.5	20.5	0.157	0.157			

Note(s):

SAR Testing was performed on all Housing Types for both RF Exposure Conditions.

10.1.2. Metallic Wristbands

Frequency Band	Mode	Housing Type	Wristband	RF Exposure Condition	Test Position	Dist. (mm)	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		10-g SAR (W/kg)		Plot No.
									Tune-up limit	Meas.	Meas.	Scaled	Meas.	Scaled	
2.4 GHz	802.11b 1 Mbps	Aluminum	Mesh	Extremity	Rear	0	6	2437	20.5	20.5			0.020	0.020	3
			Links				6	2437	20.5	20.5			0.008	0.008	
		Stainless Steel	Mesh				6	2437	20.5	20.5			0.016	0.016	
			Mesh				6	2437	20.5	20.5			0.005	0.005	
		Stainless Steel	Mesh	Next-to-Mouth	Front	10	6	2437	20.5	20.5	0.106	0.106			4
			Links				6	2437	20.5	20.5	0.107	0.107			
		Aluminum	Links				6	2437	20.5	20.5	0.102	0.102			
			Links				6	2437	20.5	20.5	0.104	0.104			

Note(s):

SAR Testing for both Wristbands was performed based on the worst case SAR for each RF Exposure Condition from Sec. 10.1.1.

10.2. Bluetooth

10.2.1. Non-Metallic Wristbands

Frequency Band	Mode	Housing Type	Wristband	RF Exposure Condition	Test Position	Dist. (mm)	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		10-g SAR (W/kg)		Plot No.
									Tune-up limit	Meas.	Meas.	Scaled	Meas.	Scaled	
2.4 GHz	GFSK	Aluminum	None	Extremity	Rear	0	39	2441	17.5	17.5			0.012	0.012	5
		Stainless Steel	Nylon	Next-to-Mouth	Front	10	39	2441	17.5	17.5	0.062	0.062			6

10.2.2. Metallic Wristbands

Frequency Band	Mode	Housing Type	Wristband	RF Exposure Condition	Test Position	Dist. (mm)	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		10-g SAR (W/kg)		Plot No.
									Tune-up limit	Meas.	Meas.	Scaled	Meas.	Scaled	
2.4 GHz	GFSK	Aluminum	Mesh	Extremity	Rear	0	39	2441	17.5	17.5			0.003	0.003	
		Stainless Steel	Links	Next-to-Mouth	Front	10	39	2441	17.5	17.5	0.042	0.042			

Note(s):

Test Justification: Due to similar frequency, BT testing was performed based on the Wi-Fi (DTS Band) worst case SAR result.

11. SAR Measurement Variability

In accordance with published RF Exposure KDB 865664 D01 SAR measurement 100 MHz to 6 GHz. These additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

- 1) Repeated measurement is not required when the original highest measured SAR is < 0.8 or 2 W/kg (1-g or 10-g respectively); steps 2) through 4) do not apply.
- 2) When the original highest measured SAR is ≥ 0.8 or 2 W/kg (1-g or 10-g respectively), repeat that measurement once.
- 3) Perform a second repeated measurement only if the **ratio of largest to smallest SAR** for the original and first repeated measurements is > 1.20 or 3 (1-g or 10-g respectively) or when the original or repeated measurement is ≥ 1.45 or 3.6 W/kg ($\sim 10\%$ from the 1-g or 10-g respective SAR limit).
- 4) Perform a third repeated measurement only if the original, first, or second repeated measurement is ≥ 1.5 or 3.75 W/kg (1-g or 10-g respectively) and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20 or 3 (1-g or 10-g respectively).

Frequency Band (MHz)	Air Interface	RF Exposure Conditions	Test Position	Repeated SAR (Yes/No)	Highest Measured SAR (W/kg)	First Repeated		Second Repeated		Third Repeated
						Measured SAR (W/kg)	Largest to Smallest SAR Ratio	Measured SAR (W/kg)	Largest to Smallest SAR Ratio	Measured SAR (W/kg)
2400	Wi-Fi 802.11b/g/n	Next to Mouth	Front	No	0.175	N/A	N/A	N/A	N/A	N/A
	BT	Next to Mouth	Front	No	0.062	N/A	N/A	N/A	N/A	N/A

Note(s):

Second Repeated Measurement is not required since the ratio of the largest to smallest SAR for the original and first repeated measurement is not > 1.20 or 3 (1-g or 10-g respectively).

12. Simultaneous Transmission SAR Analysis

KDB 447498 D01 General RF Exposure Guidance introduces a new formula for calculating the SAR to Peak Location Ratio (SPLSR) between pairs of simultaneously transmitting antennas:

$$SPLSR = (SAR_1 + SAR_2)^{1.5} / Ri$$

Where:

SAR₁ is the highest measured or estimated SAR for the first of a pair of simultaneous transmitting antennas, in a specific test operating mode and exposure condition

SAR₂ is the highest measured or estimated SAR for the second of a pair of simultaneous transmitting antennas, in the same test operating mode and exposure condition as the first

Ri is the separation distance between the pair of simultaneous transmitting antennas. When the SAR is measured, for both antennas in the pair, it is determined by the actual x, y and z coordinates in the 1-g SAR for each SAR peak location, based on the extrapolated and interpolated result in the zoom scan measurement, using the formula of $[(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2]$

In order for a pair of simultaneous transmitting antennas with the sum of 1-g SAR > 1.6 W/kg to qualify for exemption from Simultaneous Transmission SAR measurements, it has to satisfy the condition of:

$$(SAR_1 + SAR_2)^{1.5} / Ri \leq 0.04$$

Simultaneous Transmission Condition

N/A

Wi-Fi 2.4GHz Radio cannot transmit simultaneously with Bluetooth Radio.

Appendixes

Refer to separated files for the following appendixes.

16U23781-S1V2 SAR_App A Setup Photos

16U23781-S1V1 SAR_App B System Check Plots

16U23781-S1V1 SAR_App C Highest Test Plots

16U23781-S1V1 SAR_App D Tissue Ingredients

16U23781-S1V1 SAR_App E Probe Cal. Certificates

16U23781-S1V1 SAR_App F Dipole Cal. Certificates

END OF REPORT