



SAR EVALUATION REPORT

IEEE Std 1528-2013

For
Dolphin CT50

FCC ID: HD5-CT50LFN
Model Name: CT50LFN

Report Number: 12441959-S1V1
Issue Date: 10/5/2018

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Revision History

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V1	10/5/2018	Initial Issue	--

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1. Attestation of Test Results

Applicant Name	HONEYWELL INTERNATIONAL INC			
FCC ID	HD5-CT50LFN			
Model Name	CT50LFN			
Applicable Standards	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
Head	0.941	0.454	0.243	N/A
Body-worn	0.918	0.089	0.251	N/A
Product specific 10g SAR	3.397	0.321	0.509	N/A
Simultaneous TX	1.395	1.395	1.184	1.002
Simultaneous TX Product Specific 10g	3.906	3.577	3.906	3.498
Date Tested	9/6/2018 to 9/11/2018			
Test Results	Pass			
Note: WLAN and Bluetooth SAR test results from the original filling FCC ID: HD5-CT50LFN were used in this report for Simultaneous Tx SAR analysis. This report only contains SAR test data for CDMA200 bands BC0 and BC1. WLAN and Bluetooth SAR test results can be found in the original SAR Report: 15U20259-S1A. The WLAN and Bluetooth SAR results from the original filling are reproduced above for reference.				
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:		
				
Dave Weaver Operations Leader UL Verification Services Inc.		AJ Newcomer 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:

- o 447498 D01 General RF Exposure Guidance v06
- o 447498 D03 Supplement C Cross-Reference v01
- o 648474 D04 Handset SAR v01r03
- o 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04
- o 865664 D02 RF Exposure Reporting v01r02
- o 941225 D06 Hotspot Mode v02r01
- o 941225 D07 UMPC Mini Tablet v01r02

In addition to the above, the following information was used:

- o [TCB workshop](#) October 2015; RF Exposure Procedures (KDB 941225 D05A)
- o [TCB workshop](#) April 2016; Page 22, RF Exposure Procedures (Phablet Procedures)
- o [TCB workshop](#) October 2016; RF Exposure Procedures (DUT Holder Perturbations)
- o [TCB workshop](#) May 2017; Page 9, Broadband Liquid Above 3 GHz

3. Facilities and Accreditation

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

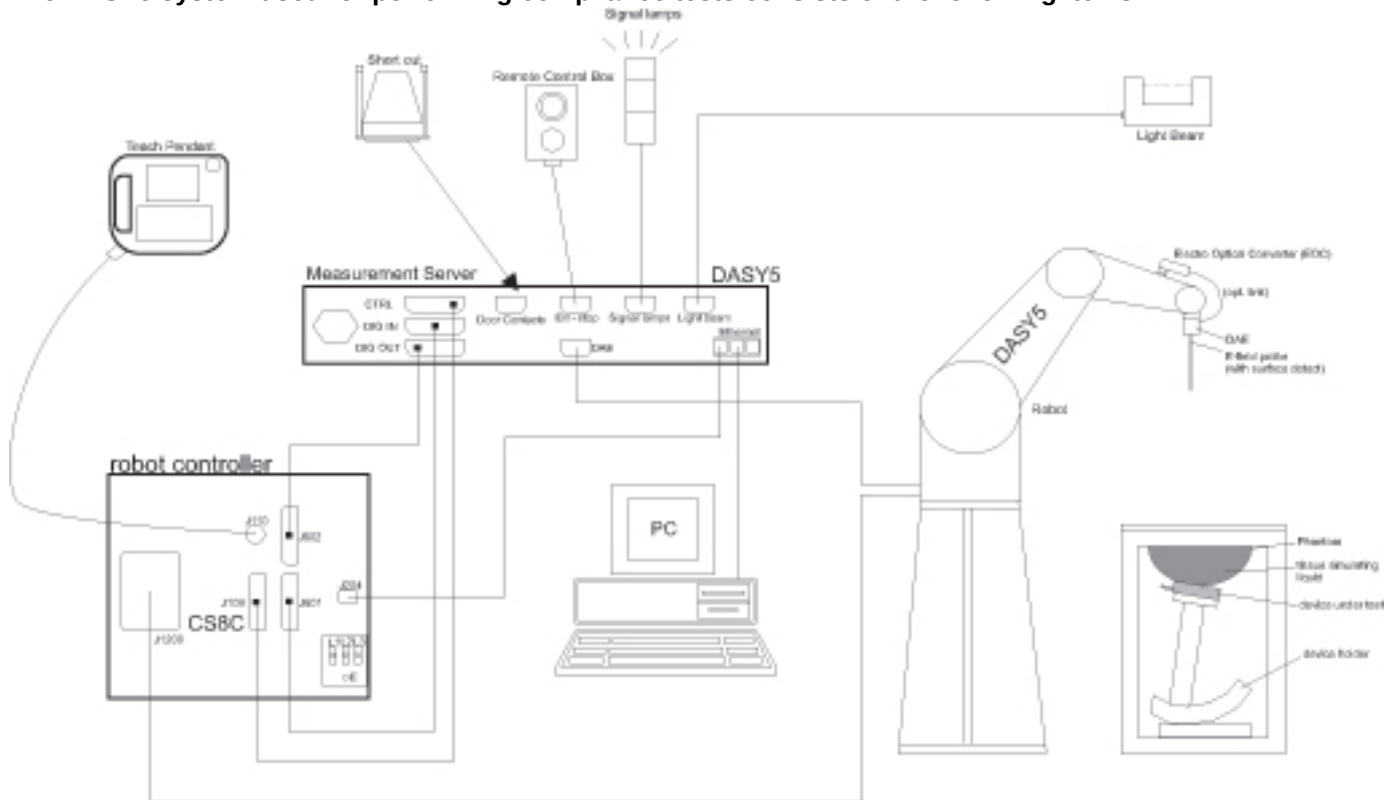
47173 Benicia Street	47266 Benicia Street
SAR Lab A	SAR Lab 1
SAR Lab B	SAR Lab 2
SAR Lab C	SAR Lab 3
SAR Lab D	SAR Lab 4
SAR Lab E	SAR Lab 5
SAR Lab F	SAR Lab 6
SAR Lab G	SAR Lab 7
SAR Lab H	SAR Lab 8

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: $\Delta x_{\text{Area}}, \Delta y_{\text{Area}}$	≤ 2 GHz: ≤ 15 mm $2 - 3$ GHz: ≤ 12 mm	$3 - 4$ GHz: ≤ 12 mm $4 - 6$ GHz: ≤ 10 mm
	When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

Step 3: Zoom Scan

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

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

			≤ 3 GHz	> 3 GHz
Maximum zoom scan spatial resolution: $\Delta x_{\text{Zoom}}, \Delta y_{\text{Zoom}}$			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{\text{Zoom}}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{\text{Zoom}}(1)$: between 1 st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{\text{Zoom}}(n>1)$: between subsequent points	$\leq 1.5 \cdot \Delta z_{\text{Zoom}}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm
Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.				
* When zoom scan is required and the <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
Vector Network Analyzer	R&S	ZNLE6	101274-MN	7/16/2019
Dielectric Probe kit	SPEAG	DAK-3.5	1082	10/17/2018
Shorting Block	SPEAG	DAK-3.5 Short	SM DAK 200 BA	10/17/2018
Thermometer	Fisher Scientific	Traceable	140562250	11/7/2018

System Check

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Signal Generator	Agilent	N5181A	MY50140610	6/7/2019
Power Meter	Keysight	N1912A	MY55196007	7/23/2019
Power Sensor	Agilent	N1921A	MY53020038	4/23/2019
Power Sensor	Agilent	N1921A	MY5226009	1/8/2019
Amplifier	MITEQ	AMF-4D-00400600-50-30P	1795093	N/A
Bi-directional coupler	Werlatone, Inc.	C8060-102	2149	N/A
DC Power Supply	HP	6296A	2841A-05955	N/A

Lab Equipment

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
E-Field Probe (SAR Lab 8)	SPEAG	EX3DV4	7501	5/4/2019
Data Acquisition Electronics (SAR Lab 8)	SPEAG	DAE4	1258	5/22/2019
System Validation Dipole	SPEAG	D835V2	4d117	5/16/2019
System Validation Dipole	SPEAG	D1900V2	5d163	10/5/2018
Thermometer (SAR Lab 8)	Fisher Scientific	Traceable	181062300	2/26/2019

Other

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Base Station Simulator	R & S	R & S	104245-JZ	6/21/2019

Note(s):

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 expanded SAR measurement uncertainty must be $\leq 30\%$, for a confidence interval of $k = 2$. If these conditions are met, extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval.

Therefore, the measurement uncertainty is not required.

6. Device Under Test (DUT) Information

6.1. DUT Description

Device Dimension	Refer to Appendix A		
Battery Options	Standard – Lithium-ion battery, Rating 3.6 Vdc, 14.5 Wh		
Accessory	Headset		
Bluetooth Tethering	BT Tethering mode permits the device to share its cellular data connection with other devices. ☒ BT Tethering (Bluetooth 2.4 GHz)		
Test sample information	S/N	IMEI	Notes
	1629940712	99000621056091	Conducted
	16299407C7	990006210562616	Radiated

6.2. Wireless Technologies

Wireless technologies	Frequency bands	Operating Mode		Duty Cycle used for SAR testing
GSM	850 1900	Voice (GMSK) GPRS (GMSK) EDGE (8PSK)	GSM Class : B Multi-Slot Class: Class 12 - 4 Up, 4 Down	GSM Voice: 12.5% (E)GPRS: 1 Slot: 12.5% 2 Slots: 25% 3 Slots: 37.5% 4 Slots: 50%
	Does this device support DTM (Dual Transfer Mode)? ☐ Yes ☒ No			
CDMA (CDMA2000)	BC0 BC1	1xRTT (Voice & Data) 1xEV-DO Rel. 0 1xEV-DO Rev. A 1xAdvanced		100%
	Does this device support SV-DO (1xRTT-1xEVDO)? ☐ Yes ☒ No			
W-CDMA (UMTS)	Band II Band V	UMTS Rel. 99 (Voice & Data) HSDPA (Rel. 5) HSUPA (Rel. 6) HSPA+ (Rel. 7)		100%
LTE	FDD Band 2 FDD Band 4 FDD Band 5 FDD Band 17	QPSK 16QAM Rel. 10 Does not support Carrier Aggregation (CA)		100% (FDD)
	Does this device support SV-LTE (1xRTT-LTE)? ☐ Yes ☒ No			
Wi-Fi	2.4 GHz	802.11b 802.11g 802.11n (HT20)		100% ¹
	5 GHz	802.11a 802.11n (HT20) 802.11n (HT40) 802.11ac (VHT20) 802.11ac (VHT40) 802.11ac (VHT80) 802.11ac (VHT160)		100% ¹
	Does this device support bands 5.60 ~ 5.65 GHz? ☒ Yes ☐ No			
	Does this device support Band gap channel(s)? ☐ Yes ☒ No			
Bluetooth	2.4 GHz	Version 4.0 LE		(DH5) 77.5% ¹

Notes:

1. Duty cycle for Wi-Fi and Bluetooth is referenced from the original SAR Report 15U20259-S1A
2. This report only contains SAR test results for CDMA 2000 Bands BC0 and BC1. For the SAR test results for all other technologies, refer to the original filling SAR Report: 15U20259-S1A.

6.3. General LTE SAR Test and Reporting Considerations

Item	Description																																																																				
Frequency range, Channel Bandwidth, Numbers and Frequencies	Band 2	Frequency range: 1850 - 1910 MHz (BW = 60 MHz)																																																																			
		Channel Bandwidth																																																																			
		20 MHz	15 MHz	10 MHz	5 MHz	3 MHz	1.4 MHz																																																														
	Low	18700 /1860	18675/ 1857.5	18650/ 1855	18625/ 1852.5	18615/ 1851.5	18607/ 1850.7																																																														
	Mid	18900/ 1880	18900/ 1880	18900/ 1880	18900/ 1880	18900/ 1880	18900/ 1880																																																														
	High	19100/ 1900	19125/ 1902.5	19150/ 1905	19175/ 1907.5	19185/ 1908.5	19193/ 1909.3																																																														
	Band 4	Frequency range: 1710 - 1755 MHz (BW = 45 MHz)																																																																			
		Channel Bandwidth																																																																			
		20 MHz ¹	15 MHz	10 MHz	5 MHz	3 MHz	1.4 MHz																																																														
	Low	20050/ 1720	20025/ 1717.5	20000/ 1715	19975/ 1712.5	19965/ 1711.5	19957/ 1710.7																																																														
	Mid	20175/ 1732.5	20175/ 1732.5	20175/ 1732.5	20175/ 1732.5	20175/ 1732.5	20175/ 1732.5																																																														
	High	20300/ 1745	20325/ 1747.5	20350/ 1750	20375/ 1752.5	20385/ 1753.5	20393/ 1754.3																																																														
	Band 5	Frequency range: 824 - 849 MHz (BW = 25 MHz)																																																																			
		Channel Bandwidth																																																																			
		20 MHz	15 MHz	10 MHz ¹	5 MHz	3 MHz	1.4 MHz																																																														
	Low			20450/ 829	20425/ 826.5	20415/ 825.5	20407/ 824.7																																																														
	Mid			20525/ 836.5	20525/ 836.5	20525/ 836.5	20525/ 836.5																																																														
	High			20600/ 844	20625/ 846.5	20635/ 847.5	20643/ 848.3																																																														
	Band 17	Frequency range: 704 - 716 MHz (BW = 12 MHz)																																																																			
		Channel Bandwidth																																																																			
		20 MHz	15 MHz	10 MHz ¹	5 MHz ¹	3 MHz	1.4 MHz																																																														
	Low			23780/ 709	23755/ 706.5																																																																
	Mid			23790/ 710	23790/ 710																																																																
	High			23800/ 711	23825/ 713.5																																																																
LTE transmitter and antenna implementation	Refer to Appendix A.																																																																				
Maximum power reduction (MPR)	Table 6.2.3-1: Maximum Power Reduction (MPR) for Power Class 1, 2 and 3 <table> <tr> <th rowspan="2">Modulation</th><th colspan="6">Channel bandwidth / Transmission bandwidth (N_{RB})</th><th rowspan="2">MPR (dB)</th></tr> <tr> <th>1.4 MHz</th><th>3.0 MHz</th><th>5 MHz</th><th>10 MHz</th><th>15 MHz</th><th>20 MHz</th></tr> <tr> <td>QPSK</td><td>> 5</td><td>> 4</td><td>> 8</td><td>> 12</td><td>> 16</td><td>> 18</td><td>≤ 1</td></tr> <tr> <td>16 QAM</td><td>≤ 5</td><td>≤ 4</td><td>≤ 8</td><td>≤ 12</td><td>≤ 16</td><td>≤ 18</td><td>≤ 1</td></tr> <tr> <td>16 QAM</td><td>> 5</td><td>> 4</td><td>> 8</td><td>> 12</td><td>> 16</td><td>> 18</td><td>≤ 2</td></tr> <tr> <td>64 QAM</td><td>≤ 5</td><td>≤ 4</td><td>≤ 8</td><td>≤ 12</td><td>≤ 16</td><td>≤ 18</td><td>≤ 2</td></tr> <tr> <td>64 QAM</td><td>> 5</td><td>> 4</td><td>> 8</td><td>> 12</td><td>> 16</td><td>> 18</td><td>≤ 3</td></tr> <tr> <td>256 QAM</td><td colspan="6">≥ 1</td><td>≤ 5</td></tr> </table> MPR Built-in by design The manufacturer MPR values are always within the 3GPP maximum MPR allowance but may not follow the default MPR values. A-MPR (additional MPR) was disabled during SAR testing							Modulation	Channel bandwidth / Transmission bandwidth (N _{RB})						MPR (dB)	1.4 MHz	3.0 MHz	5 MHz	10 MHz	15 MHz	20 MHz	QPSK	> 5	> 4	> 8	> 12	> 16	> 18	≤ 1	16 QAM	≤ 5	≤ 4	≤ 8	≤ 12	≤ 16	≤ 18	≤ 1	16 QAM	> 5	> 4	> 8	> 12	> 16	> 18	≤ 2	64 QAM	≤ 5	≤ 4	≤ 8	≤ 12	≤ 16	≤ 18	≤ 2	64 QAM	> 5	> 4	> 8	> 12	> 16	> 18	≤ 3	256 QAM	≥ 1						≤ 5
Modulation	Channel bandwidth / Transmission bandwidth (N _{RB})						MPR (dB)																																																														
	1.4 MHz	3.0 MHz	5 MHz	10 MHz	15 MHz	20 MHz																																																															
QPSK	> 5	> 4	> 8	> 12	> 16	> 18	≤ 1																																																														
16 QAM	≤ 5	≤ 4	≤ 8	≤ 12	≤ 16	≤ 18	≤ 1																																																														
16 QAM	> 5	> 4	> 8	> 12	> 16	> 18	≤ 2																																																														
64 QAM	≤ 5	≤ 4	≤ 8	≤ 12	≤ 16	≤ 18	≤ 2																																																														
64 QAM	> 5	> 4	> 8	> 12	> 16	> 18	≤ 3																																																														
256 QAM	≥ 1						≤ 5																																																														
Power reduction	No																																																																				
Spectrum plots for RB configurations	A properly configured base station simulator was used for the SAR and power measurements; therefore, spectrum plots for each RB allocation and offset configuration are not included in the SAR report.																																																																				

Notes:

- Maximum bandwidth does not support at least three non-overlapping channels in certain channel bandwidths. When a device supports overlapping channel assignment in a channel bandwidth configuration, the middle channel of the group of overlapping channels should be selected for testing per KDB 941225 D05 SAR for LTE Devices.

7. RF Exposure Conditions (Test Configurations)

Refer to Appendix A for the specific details of the antenna-to-antenna and antenna-to-edge(s) distances. This product is a phone supporting next to ear operations with diagonal dimensions greater than 20 cm. As such, it is categorized as a phablet and requires testing in accordance with the phablet procedures described in both KDB 648474 and 616217 in order to, respectively, demonstrate compliance for head SAR and body SAR exposure conditions. The usual body-worn accessory and hotspot mode testing required for phones are however not performed as they are effectively covered by the more conservative test procedures for tablets.

Wireless technologies	RF Exposure Conditions	DUT-to-User Separation	Test Position	Antenna-to-edge/surface	SAR Required	Note
WWAN	Head	0 mm	Left Touch	N/A	Yes	
			Left Tilt (15°)	N/A	Yes	
			Right Touch	N/A	Yes	
			Right Tilt (15°)	N/A	Yes	
	Body	15 mm	Rear	N/A	Yes	
			Front	N/A	Yes	
WLAN	Head	0 mm	Left Touch	N/A	Yes	
			Left Tilt (15°)	N/A	Yes	
			Right Touch	N/A	Yes	
			Right Tilt (15°)	N/A	Yes	
	Body	15 mm	Rear	N/A	Yes	
			Front	N/A	Yes	

Product Specific 10g SAR:

Wireless technologies	RF Exposure Conditions	DUT-to-User Separation	Test Position	Antenna-to-edge/surface	SAR Required	Note
WWAN (Main)	Product Specific 10g	0 mm	Rear	< 25 mm	Yes	2
			Edge 1	> 25 mm	No	1
			Edge 2	< 25 mm	Yes	2
			Edge 3	< 25 mm	Yes	2
			Edge 4	< 25 mm	Yes	2
WLAN	Product Specific 10g	0 mm	Rear	< 25 mm	Yes	2
			Edge 1	< 25 mm	Yes	2
			Edge 2	> 25 mm	No	1
			Edge 3	> 25 mm	No	1
			Edge 4	< 25 mm	Yes	2

Notes:

- SAR is not required because the distance from the antenna to the edge is > 25 mm as per KDB 941225 D06 Hot Spot SAR.
- For Phablet devices: when Hotspot Mode is not supported, Product Specific 10-g SAR is required for all surfaces and edges with an antenna located at ≤ 25 mm from that surface or edge in direct contact with a flat phantom, to address interactive hand use exposure conditions.

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.

The dielectric constant (ϵ_r) and conductivity (σ) of typical tissue-equivalent media recipes are expected to be within $\pm 5\%$ of the required target values; but 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 Lab	Date	Band (MHz)	Tissue Type	Frequency (MHz)	Relative Permittivity (ϵ_r)			Conductivity (σ)		
					Measured	Target	Delta (%)	Measured	Target	Delta (%)
8	9/6/2018	1900	Head	1900	40.07	40.00	0.18	1.42	1.40	1.57
				1850	40.13	40.00	0.33	1.40	1.40	-0.29
				1920	40.10	40.00	0.25	1.43	1.40	2.29
8	9/6/2018	1900	Body	1900	52.62	53.30	-1.28	1.58	1.52	3.68
				1850	52.68	53.30	-1.16	1.55	1.52	1.71
				1920	52.66	53.30	-1.20	1.59	1.52	4.41
8	9/10/2018	835	Head	835	41.69	41.50	0.46	0.90	0.90	0.21
				805	41.78	41.68	0.24	0.89	0.90	-0.69
				905	41.39	41.50	-0.27	0.93	0.97	-4.85
8	9/10/2018	835	Body	835	54.31	55.20	-1.61	1.01	0.97	4.12
				805	54.35	55.33	-1.78	1.00	0.97	2.99
				905	53.99	55.00	-1.84	1.03	1.05	-2.42
8	9/10/2018	1900	Body	1900	54.50	53.30	2.25	1.58	1.52	3.68
				1850	54.59	53.30	2.42	1.55	1.52	1.64
				1920	54.48	53.30	2.21	1.59	1.52	4.67

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 $\pm 10\%$ of the manufacturer calibrated dipole SAR target. Refer to Appendix B for the SAR System Check Plots.

SAR Lab	Date	Tissue Type	Dipole Type _Serial #	Dipole Cal. Due Data	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 $\pm 10\%$	
8	9/6/2018	Head	D1900V2 SN:5d163	10/5/2018	3.850	38.50	38.77	-0.70	1.990	19.90	20.10	-1.00	
8	9/6/2018	Body	D1900V2 SN:5d163	10/5/2018	3.920	39.20	42.99	-8.82	2.040	20.40	21.97	-7.15	1,2
8	9/10/2018	Head	D835V2 SN:4d117	5/16/2019	0.986	9.86	9.87	-0.10	0.641	6.41	6.40	0.16	
8	9/10/2018	Body	D835V2 SN:4d117	5/16/2019	0.978	9.78	10.31	-5.14	0.641	6.41	6.84	-6.29	3,4
8	9/10/2018	Body	D1900V2 SN:5d163	10/5/2018	4.150	41.50	42.99	-3.47	2.160	21.60	21.97	-1.68	

9. Conducted Output Power Measurements

9.1. CDMA

1x Advanced Setup Procedures used to establish the test signals

Call box setup procedure

- Protocol Rev > 6 (IS-2000-0)
- System ID: 331; NID: 65535, Reg. Ch. #.:
- Radio Config (RC) > Fwd11, Rvs8
- Service Option (SO) Setup > SO75 (Loopback)
- Traffic Data Rate > Full
- Rvs Power Ctrl > All Up bits (Maximum Tx Pout)
- Reverse Power Control Mode: 00-200 to 400 bps
- Smart blanking was disabled.

SAR for next to the ear head exposure is measured in RC3 with the handset configured to transmit at full rate in SO55. The 3G SAR test reduction procedure is applied to RC1 with RC3 as the primary mode

Body-worn accessory SAR is measured in RC3 with the handset configured in TDSO/SO32 to transmit at full rate on FCH only with all other code channels disabled. The body-worn accessory procedures in KDB Publication 447498 D01 are applied. The 3G SAR test reduction procedure is applied to the multiple code channel configuration (FCH+SCHn), with FCH only as the primary mode.

When VOIP is supported by Ev-Do devices for next to the ear use, head exposure SAR is required.

SAR measurement is not required for the 1xEVDO Rev. A, Rev. B and 1x-Advanced. When primary mode and the adjusted SAR is ≤ 1.2 W/kg and secondary mode is $\leq \frac{1}{4}$ dB higher than the primary mode

CDMA BC0 Measured Results

Mode		Channel	Freq. (MHz)	Maximum Average Power (dBm)	
				Measured Pwr	Tune-up Limit
1xRTT	RC1, SO55 (Loopback)	1013	824.70	23.48	24.50
		384	836.52	23.44	
		777	848.31	23.42	
	RC3, SO55 (Loopback)	1013	824.70	23.46	
		384	836.52	23.42	
		777	848.31	23.40	
	RC3, SO32 (+F-SCH)	1013	824.70	23.45	
		384	836.52	23.43	
		777	848.31	23.41	
1xAdvanced	Fwd11/Rvs8 SO75 (Loopback)	1013	824.70	23.47	24.50
		384	836.52	23.43	
		777	848.31	23.39	
1xEv-Do Rel. 0	307.2 kbps (2 slot, QPSK)	1013	824.70	23.52	24.50
		384	836.52	23.49	
		777	848.31	23.46	
1xEv-Do Rev. A	307.2K, QPSK/ ACK channel is transmitted at all the slots	1013	824.70	23.48	24.50
		384	836.52	23.44	
		777	848.31	23.43	

CDMA BC1 Measured Results

Mode		Channel	Freq. (MHz)	Maximum Average Power (dBm)	
				Measured Pwr	Tune-up Limit
1xRTT	RC1, SO55 (Loopback)	25	1851.25	23.93	24.00
		600	1880.00	23.88	
		1175	1908.75	24.00	
	RC3, SO55 (Loopback)	25	1851.25	23.90	
		600	1880.00	23.87	
		1175	1908.75	24.00	
	RC3, SO32 (+F-SCH)	25	1851.25	23.90	
		600	1880.00	23.87	
		1175	1908.75	24.00	
1xAdvanced	Fwd11/Rvs8 SO75 (Loopback)	25	1851.25	23.90	24.00
		600	1880	23.86	
		1175	1908.75	24.00	
1xEv-Do Rel. 0	307.2 kbps (2 slot, QPSK)	25	1851.25	24.00	24.00
		600	1880.00	24.00	
		1175	1908.75	24.00	
1xEv-Do Rev. A	307.2K, QPSK/ ACK channel is transmitted at all the slots	25	1851.25	24.00	24.00
		600	1880	24.00	
		1175	1908.75	24.00	

10. Measured and Reported (Scaled) SAR Results

SAR Test Reduction criteria are as follows:

- Reported SAR(W/kg) for WWAN = Measured SAR *Tune-up Scaling Factor
- Reported SAR(W/kg) for Wi-Fi and Bluetooth = Measured SAR * Tune-up scaling factor * Duty Cycle scaling factor
- Duty Cycle scaling factor = 1 / Duty cycle (%)

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 648474 D04 Handset SAR:

With headset attached, when the reported SAR for body-worn accessory, measured without a headset connected to the handset, is > 1.2 W/kg, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for that body-worn accessory with a headset attached to the handset.

KDB 648474 D04 Handset SAR (Phablet Only):

When hotspot mode does not apply, 10-g Extremity SAR is required for all surfaces and edges with an antenna located at ≤ 25 mm from that surface or edge in direct contact with a flat phantom, to address interactive hand use exposure conditions.

When hotspot mode applies, 10-g extremity SAR is required only for the surfaces and edges with hotspot mode 1-g reported SAR > 1.2 W/kg.

Per TCB workshop April 2016; Page 22, RF Exposure Procedures (Phablet Procedures): phablet 10-g SAR should not be identified as hand or extremity SAR; this should be reported as product specific 10-g SAR in reports and grants.

10.1. CDMA BC0

RF Exposure Conditions	Mode	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Head	1xRTT RC3 SO55	0	Left Touch	384	836.52	24.50	23.42	0.606	0.777	
			Left Tilt	384	836.52	24.50	23.42	0.543	0.696	
			Right Touch	1013	824.70	24.50	23.46	0.736	0.935	
				384	836.52	24.50	23.42	0.732	0.939	
				777	848.31	24.50	23.40	0.678	0.873	
			Right Tilt	384	836.52	24.50	23.42	0.523	0.671	
Head	1xEVDO Rel. 0	0	Left Touch	384	836.52	24.50	23.49	0.618	0.780	
			Left Tilt	384	836.52	24.50	23.49	0.469	0.592	
			Right Touch	1013	824.70	24.50	23.52	0.739	0.926	
				384	836.52	24.50	23.49	0.746	0.941	1
				777	848.31	24.50	23.46	0.683	0.868	
			Right Tilt	384	836.52	24.50	23.49	0.470	0.593	
Body-worn	1xRTT RC3 SO32	15	Rear	384	836.52	24.50	23.43	0.510	0.652	
			Front	384	836.52	24.50	23.43	0.548	0.701	2

Product Specific 10g SAR:

RF Exposure Conditions	Mode	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Power (dBm)		10-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Product Specific 10g	1xRTT RC3 SO32	0	Rear	384	836.52	24.50	23.43	1.010	1.292	
			Front	384	836.52	24.50	23.43	1.410	1.804	3
			Edge 2	384	836.52	24.50	23.43	0.302	0.386	
			Edge 3	384	836.52	24.50	23.43	0.336	0.430	
			Edge 4	384	836.52	24.50	23.43	0.504	0.645	

10.2. CDMA BC1

RF Exposure Conditions	Mode	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Head	1xRTT RC3 SO55	0	Left Touch	600	1880.00	24.00	23.87	0.256	0.264	4
			Left Tilt	600	1880.00	24.00	23.87	0.046	0.047	
			Right Touch	600	1880.00	24.00	23.87	0.138	0.142	
			Right Tilt	600	1880.00	24.00	23.87	0.076	0.079	
Head	1xEVDO Rel. 0	0	Left Touch	600	1880.00	24.00	24.00	0.256	0.256	
			Left Tilt	600	1880.00	24.00	24.00	0.054	0.054	
			Right Touch	600	1880.00	24.00	24.00	0.136	0.136	
			Right Tilt	600	1880.00	24.00	24.00	0.082	0.082	
Body-worn	1xRTT RC3 SO32	15	Rear	25	1851.30	24.00	23.90	0.897	0.918	5
				600	1880.00	24.00	23.87	0.787	0.811	
				1175	1908.75	24.00	24.00	0.762	0.762	
			Front	600	1880.00	24.00	23.87	0.362	0.373	

Product Specific 10g SAR:

RF Exposure Conditions	Mode	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Power (dBm)		10-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
Product Specific 10g	1xRTT RC3 SO32	0	Rear	25	1851.30	24.00	23.90	3.320	3.397	6
				600	1880.00	24.00	23.87	3.030	3.122	
				1175	1908.75	24.00	24.00	3.070	3.070	
			Front	600	1880.00	24.00	23.87	1.330	1.370	
			Edge 2	600	1880.00	24.00	23.87	0.117	0.121	
			Edge 3	600	1880.00	24.00	23.87	1.640	1.690	
			Edge 4	600	1880.00	24.00	23.87	0.283	0.292	
Product Specific 10g	1xEVDO Rel. 0	0	Rear	25	1851.30	24.00	24.00	3.350	3.350	
				600	1880.00	24.00	24.00	3.070	3.070	
				1175	1908.75	24.00	24.00	3.120	3.120	

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 when the original or repeated measurement is ≥ 1.45 or 3.6 W/kg (~ 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 .

Frequency Band (MHz)	Air Interface	RF Exposure Conditions	Test Position	Repeated SAR (Yes/No)	Highest Measured SAR (W/kg)	First Repeated	
						Measured SAR (W/kg)	Largest to Smallest SAR Ratio
850MHz	CDMA BC0	Head	Right Touch	No	0.746	N/A	N/A
1900MHz	CDMA BC1	Body	Rear	Yes	0.897	0.889	1.01

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 < 1.20 .

Product Specific 10g SAR:

Frequency Band (MHz)	Air Interface	RF Exposure Conditions	Test Position	Repeated SAR (Yes/No)	Highest Measured SAR (W/kg)	First Repeated	
						Measured SAR (W/kg)	Largest to Smallest SAR Ratio
850 MHz	CDMA BC0	Product Specific 10g	Front	No	1.410	N/A	N/A
1900 MHz	CDMA BC1	Product Specific 10g	Rear	Yes	3.350	3.340	1.00

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 < 1.20 .

12. Simultaneous Transmission Conditions

RF Exposure Condition	Item	Capable Transmit Configurations	
Head	1	GSM(Voice)	+ DTS
	2	GSM(Voice)	+ U-NII
	3	GSM(GPRS/EDGE)	+ DTS
	4	GSM(GPRS/EDGE)	+ U-NII
	5	CDMA 2000	+ DTS
	6	CDMA 2000	+ U-NII
	7	W-CDMA	+ DTS
	8	W-CDMA	+ U-NII
	9	LTE	+ DTS
	10	LTE	+ U-NII
Body-worn	11	GSM(Voice)	+ DTS
	12	GSM(Voice)	+ U-NII
	13	GSM(Voice)	+ BT
	14	GSM(GPRS/EDGE)	+ DTS
	15	GSM(GPRS/EDGE)	+ U-NII
	16	GSM(GPRS/EDGE)	+ BT
	17	W-CDMA	+ DTS
	18	W-CDMA	+ U-NII
	19	W-CDMA	+ BT
	20	W-CDMA	+ DTS
	21	W-CDMA	+ U-NII
	22	W-CDMA	+ BT
	23	LTE	+ DTS
	24	LTE	+ U-NII
	25	LTE	+ BT
Product Specific 10g	26	GSM(Voice)	+ DTS
	27	GSM(Voice)	+ U-NII
	28	GSM(Voice)	+ BT
	29	GSM(GPRS/EDGE)	+ DTS
	30	GSM(GPRS/EDGE)	+ U-NII
	31	GSM(GPRS/EDGE)	+ BT
	32	W-CDMA	+ DTS
	33	W-CDMA	+ U-NII
	34	W-CDMA	+ BT
	35	W-CDMA	+ DTS
	36	W-CDMA	+ U-NII
	37	W-CDMA	+ BT
	38	LTE	+ DTS
	39	LTE	+ U-NII
	40	LTE	+ BT
Notes: 1. Wi-Fi does not support Wi-Fi Hotspot or Wi-Fi Direct. 2. VoIP is supported in GPRS/EDGE, CDMA2000, W-CDMA, and LTE. 3. DTS Radio cannot transmit simultaneously with Bluetooth Radio. 4. U-NII Radio cannot transmit simultaneously with Bluetooth Radio.			

12.1. Sum of SAR

To qualify for simultaneous transmission SAR test exclusion based upon Sum of SAR the sum of the reported standalone SARs for all simultaneously transmitting antennas shall be below the applicable standalone SAR limit. If the sum of the SARs is above the applicable limit then simultaneous transmission SAR test exclusion may still apply if the requirements of the SAR to Peak Location Ratio (SPLSR) evaluation are met.

12.2. Sum of the SAR for WWAN & Wi-Fi & BT

RF Exposure conditions	Test Position	Standalone SAR (W/kg)				Σ 1-g SAR (W/kg)		
		WWAN ①	DTS ②	U-NII ③	BT	WWAN + DTS +	WWAN + U-NII +	WWAN + BT +
Head	Left Touch	0.780	0.269	0.243		1.049	1.023	
	Left Tilt	0.696	0.269	0.243		0.965	0.939	
	Right Touch	0.941	0.454	0.243		1.395	1.184	
	Right Tilt	0.671	0.269	0.243		0.940	0.914	
Body-worn	Rear	0.918	0.089	0.251	0.084	1.007	1.169	1.002
	Front	0.701	0.089	0.251	0.084	0.790	0.952	0.785

Conclusion:

Simultaneous transmission SAR measurement (Volume Scan) is not required because the sum of the 1-g SAR is < 1.6 W/kg.

Product Specific 10g SAR:

RF Exposure conditions	Test Position	Standalone SAR (W/kg)				Σ 10-g SAR (W/kg)		
		WWAN ①	DTS ②	U-NII ③	BT	WWAN + DTS +	WWAN + U-NII +	WWAN + BT +
Extremity	Rear	3.397	0.180	0.509	0.101	3.577	3.906	3.498
	Edge 1		0.321	0.031	0.101			
	Edge 2	0.386			0.101	0.386	0.386	0.487
	Edge 3	1.690			0.100	1.690	1.690	1.790
	Edge 4	0.645	0.030	0.361	0.101	0.675	1.006	0.746

Conclusion:

Simultaneous transmission SAR measurement (Volume Scan) is not required because the sum of the 10-g SAR is < 4.0 W/kg.

Appendixes

Refer to separated files for the following appendixes.

12441959-S1V1 Appendix A: SAR Setup Photos

12441959-S1V1 Appendix B: SAR System Check Plots

12441959-S1V1 Appendix C: Highest SAR Test Plots

12441959-S1V1 Appendix D: SAR Liquid Tissue Ingredients

12441959-S1V1 Appendix E: SAR Probe Calibration Certificates

12441959-S1V1 Appendix F: SAR Dipole Calibration Certificates

END OF REPORT