SAR EVALUATION REPORT

CLASS II PERMISSIVE CHANGE

FCC 47 CFR § 2.1093
IEEE Std. 1528-2013

For
Single Stream 802.11a/b/g/n/ac + BT 4.1 M.2 Type Card

FCC ID: PPD-QCNFA435
Model Name: QCNFA435

Report Number: 4789114486-SAR-435-2

Issue Date: September 23, 2019

Prepared for
Qualcomm Atheros, Inc.
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Prepared by
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Revision History

Rev.	Date	Revisions	Revised By
V1.0	August 24, 2019	Initial Issue	\
V1.1	September 23, 2019	Updated report in accordance with TCB feedback	Jacky Jiang

Table of Contents

1. Attestation of Test Results

Applicant Name	Qualcomm Atheros, Inc.		
Address	1700 Technology Drive, San Jose, CA 95110		
Manufacturer	Qualcomm Atheros, Inc.		
Address	1700 Technology Drive, San Jose, CA 95110		
EUT Name	Single Stream 802.11a/b/g/n/ac + BT 4.1 M.2 Type Card		
Model Name	QCNFA435		
Sample Status	Normal		
Brand	Qualcomm Atheros		
Host Equipment	Laptop PC		
Band Name	Lenovo		
Host Model	Lenovo IdeaPad S540-13API		
Sample Received Date	July 30, 2019		
Date of Tested	August 7, 2019 to August 15, 2019		
Applicable Standards	FCC 47 CFR § 2.1093 IEEE Std. 1528-2013 KDB publication		
SAR Limits (W/Kg)			
Exposure Category	Peak spatial-average(1g of tissue)	Extremities (hands, wrists, ankles, etc.) (10g of tissue)	
General population / Uncontrolled exposure	1.6	4	
The Highest Reported SAR (W/kg)			
RF Exposure Conditions	**Equipment Class**		
	DTS	**U-NII**	**DSS**
Body (1-g)	0.681	1.175	\
Simultaneous Transmission (1-g)	1.228		
Test Results	Pass		
Tested By: James Qin Engineer Project Associate	Reviewed By: Shawn Wen Laboratory Leader	Approved By: Stephen Guo Laboratory Manager	

2. Test Specification, Methods and Procedures

The tests documented in this report were performed in accordance with IEEE Std. 1528-2013, the following FCC Published RF exposure KDB procedures:

- 248227 D01 802.11 Wi-Fi SAR
- 447498 D01 General RF Exposure Guidance
- 690783 D01 SAR Listings on Grants
- 865664 D01 SAR measurement 100 MHz to 6 GHz
- 865664 D02 RF Exposure Reporting
- 616217 D04 SAR for laptop and tablets

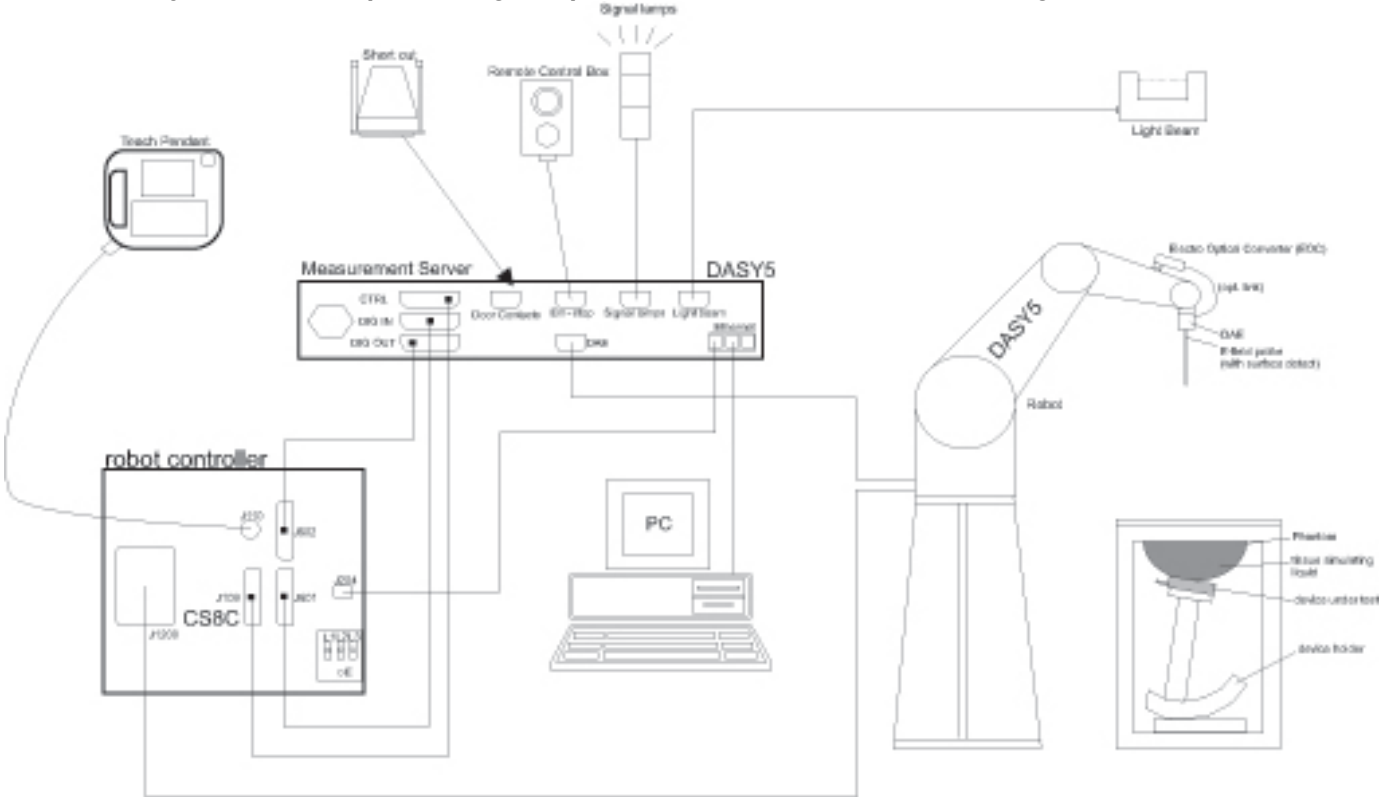
3. Facilities and Accreditation

Test Location	UL Verification Services (Guangzhou) Co., Ltd. Song Shan Lake Branch.
Address	Building 10, Innovation Technology Park, Song Shan Lake Hi tech Development Zone, Dongguan, 523808, China
Accreditation Certificate	**A2LA (Certificate No.: 4102.01)** UL Verification Services (Guangzhou) Co., Ltd. Song Shan Lake Branch has been assessed and proved to be in compliance with A2LA. **FCC (FCC Recognized No.: CN1187)** UL Verification Services (Guangzhou) Co., Ltd. Song Shan Lake Branch has been recognized to perform compliance testing on equipment subject to the Commission's Declaration of Conformity (DoC) and Certification rules **IC(Company No.: 21320)** UL Verification Services (Guangzhou) Co., Ltd. Song Shan Lake Branch has been registered and fully described in a report filed with Industry Canada. The Company Number is 21320. **VCCI (Registration No.: G-20019, R-20004, C-20012 and T-20011)** UL Verification Services (Guangzhou) Co., Ltd. Song Shan Lake Branch has been assessed and proved to be in compliance with VCCI, the Membership No. is 3793. Facility Name: Chamber D, the VCCI registration No. is G-20019 and R-20004 Shielding Room B , the VCCI registration No. is C-20012 and T-20011
Description	All measurement facilities use to collect the measurement data are located at Building 10, Innovation Technology Park, Song Shan Lake Hi tech Development Zone, Dongguan, 523808, China

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 Win7 and the DASY52 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 v01r04 SAR Measurement 100 MHz to 6 GHz

<table>
<tr><td></td><td>≤ 3 GHz</td><td>> 3 GHz</td></tr>
<tr><td>Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface</td><td>5 ± 1 mm</td><td>½·δ·ln(2) ± 0.5 mm</td></tr>
<tr><td>Maximum probe angle from probe axis to phantom surface normal at the measurement location</td><td>30° ± 1°</td><td>20° ± 1°</td></tr>
<tr><td rowspan="2">Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}</td><td>≤ 2 GHz: ≤ 15 mm
2 – 3 GHz: ≤ 12 mm</td><td>3 – 4 GHz: ≤ 12 mm
4 – 6 GHz: ≤ 10 mm</td></tr>
<tr><td colspan="2">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.</td></tr>
</table>

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 v01r04 SAR Measurement 100 MHz to 6 GHz

			≤ 3 GHz	> 3 GHz
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	≤ 1.5·$\Delta z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm

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.

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 greater 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.

	Name of equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
☒	ENA Network Analyzer	Keysight	E5080A	MY55100583	December 10, 2019
☒	Dielectric Assessment Kit	SPEAG	SM DAK 040 SA	1155	NCR
☒	DC power supply	Keysight	E36103A	MY55350020	December 10, 2019
☒	Signal Generator	Rohde & Schwarz	SME06	837633\001	December 10, 2019
☒	BI-Directional Coupler	WERLATONE	C8060-102	3423	December 10, 2019
☒	Peak and Average Power Sensor	Keysight	E9323A	MY55440013	December 10, 2019
☒	Peak and Average Power Sensor	Keysight	E9323A	MY55420006	December 10, 2019
☒	Dual Channel PK Power Meter	Keysight	N1912A	MY55416024	December 10, 2019
☒	Amplifier	CORAD TECHNOLOGY LTD	AMF-4D-00400600-50-30P	1983561	NCR
☐	Base Station Simulator	Rohde & Schwarz	CMW500	155523	December 10, 2019
☒	Dosimetric E-Field Probe	SPEAG	EX3DV4	7383	December 19, 2019
☒	Data Acquisition Electronic	SPEAG	DAE3	427	December 11, 2019
☐	Dipole Kit 750 MHz	SPEAG	D750V3	1153	December 6, 2021
☐	Dipole Kit 835 MHz	SPEAG	D835V2	4d206	December 5, 2021
☐	Dipole Kit 900 MHz	SPEAG	D900V2	1d190	December 5, 2021
☐	Dipole Kit 1800 MHz	SPEAG	D1800V2	2d212	December 6, 2021
☐	Dipole Kit 1900 MHz	SPEAG	D1900V2	5d212	December 7, 2021
☐	Dipole Kit 2300 MHz	SPEAG	D2300V2	1065	December 4, 2021
☒	Dipole Kit 2450 MHz	SPEAG	D2450V2	977	December 4, 2021
☐	Dipole Kit 2600 MHz	SPEAG	D2600V2	1117	December 7, 2021
☒	Dipole Kit 5 GHz	SPEAG	D5GHzV2	1231	December 14, 2021
☐	Software	SPEAG	DASY52	N/A	NCR
☐	Twin Phantom	SPEAG	SAM V5.0	1805	NCR
☒	ELI Phantom	SPEAG	ELI V5.0	1235	NCR
☒	Thermometer	Control Company	4242	150709653	December 6, 2019
☒	Hygrometer	\	GX-138	\	September 5, 2019

Note:

1) As per KDB865664D01 requirements for dipole calibration, the test laboratory has adopted three-year extended calibration interval. Each measured dipole is expected to evaluate with the following criteria at least on annual interval in Appendix C.
   a) There is no physical damage on the dipole;
   b) System check with specific dipole is within 10% of calibrated value;
   c) The most recent return-loss result, measured at least annually, deviates by no more than 20% from the previous measurement.
   d) The most recent measurement of the real or imaginary parts of the impedance, measured at least annually is within 5Ω from the previous measurement.
2) Dielectric assessment kit is calibrated against air, distilled water and a shorting block performed before measuring liquid parameters.
3) NCR is short for “No Calibration Requirement”.

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, the extensive SAR measurement uncertainty analysis described in IEEE Std. 1528-2013 is not required in SAR reports submitted for equipment approval. The equivalent ratio (1.5/1.6) is applied to extremity and occupational exposure conditions.

6. Device Under Test (DUT) Information

6.1. DUT Description

The DUT is a wireless module with IEEE 802.11a/b/g/n/ac, and BT radio.	
DUT Dimension	Overall (Length x Width x Height): 30 mm x 16 mm x 3 mm
Host Dimension	Overall (Length x Width x Height): 280 mm x 207 mm x 20 mm

The Manufacturer claims that only the AUX antenna port is capable of transmitting.

The host antenna is designed for a lower peak gain in the intentional transmit frequency bands and therefore radiated performance in the intentional frequency bands and the spurious emissions out of bands are expected to be lower than that measured in the original modular approval.

6.2. Wireless Technology

Wireless technology	Frequency band
Wi-Fi	2.4 GHz
Wi-Fi	5 GHz
BT	2.4 GHz

7. SAR Test Configuration

As per KDB 616217 D04, when antennas are incorporated in the keyboard section of a laptop computer, SAR is required for the bottom surface of the keyboard. Provided tablet use conditions are not supported by the laptop computer, SAR tests for bystander exposure from the edges of the keyboard and display screen of laptop computers are generally not required.

8. Conducted Output Power Measurement and tune-up tolerance

General note:

1) The manufacturer claims that only the Aux antenna port is capable of transmitting.
2) As per KDB 447498 sec.4.1.d) 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.
3) All the power measurements follow ANSI C63.10 method PM

8.1. Power measurement result of 2.4GHz Wi-Fi for Aux ANT.

Mode	Channel	Frequency (MHz)	Data Rate	Average Power (dBm)	Tune-up Limit (dBm)	SAR Test	Duty Cycle (%)
802.11b	1	2412	1Mbps	20.48	20.5	Required	100.00
	6	2437		20.50	20.5		
	11	2462		20.44	20.5		
802.11g	1	2412	6Mbps	NMR	17.5	Excluded	\
	6	2437		NMR	19.5		
	11	2462		NMR	18.0		
802.11n-HT20	1	2412	MCS0	NMR	17.5	Excluded	\
	6	2437		NMR	19.5		
	11	2462		NMR	17.0		
802.11n-HT40	3	2422	MCS0	NMR	15.5	Excluded	\
	6	2437		NMR	18.5		
	9	2452		NMR	15.0		

Note:
1) NMR is short for “No measurement requirement”.
2) The duty cycle data is come from report No.: RF141008E03 R1

8.2. Power measurement result of 5GHz Wi-Fi for Aux ANT.

Band	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-up Limit (dBm)	SAR Test	Duty Cycle (%)
U-NII-1	802.11a	36	5180	6Mbps	NMR	15.5	Excluded	99.4
		40	5200		NMR	17.0		
		44	5220		NMR	17.0		
		48	5240		NMR	17.0		
	802.11n-HT20	36	5180	MCS0	NMR	15.5	Excluded	\
		40	5200		NMR	17.0		
		44	5220		NMR	17.0		
		48	5240		NMR	17.0		
	802.11n-HT40	38	5190	MCS0	NMR	8.0	Excluded	\
		46	5230		NMR	16.0		
	802.11ac-VHT20	36	5180	MCS0	NMR	15.5	Excluded	\
		40	5200		NMR	17.0		
		44	5220		NMR	17.0		
		48	5240		NMR	17.0		
	802.11ac-VHT40	38	5190	MCS0	NMR	8.5	Excluded	\
		46	5230		NMR	16.0		
	802.11ac-VHT80	42	5210	MCS0	NMR	7.5	Excluded	\
U-NII-2A	802.11a	52	5260	6Mbps	16.92	17.0	Required	99.4
		56	5280		16.82	17.0		
		60	5300		16.93	17.0		
		64	5320		12.42	12.5		
	802.11n-HT20	52	5260	MCS0	NMR	17.0	Excluded	\
		56	5280		NMR	16.0		
		60	5300		NMR	17.0		
		64	5320		NMR	13.0		
	802.11n-HT40	54	5270	MCS0	NMR	16.0	Excluded	\
		62	5310		NMR	8.0		
	802.11ac-VHT20	52	5260	MCS0	NMR	17.0	Excluded	\
		56	5280		NMR	16.0		
		60	5300		NMR	17.0		
		64	5320		NMR	13.0		
	802.11ac-VHT40	54	5270	MCS0	NMR	16.0	Excluded	\
		62	5310		NMR	9.5		
	802.11ac-VHT80	58	5290	MCS0	NMR	9.5	Excluded	\
U-NII-2C	802.11a	100	5500	6Mbps	13.92	14.0	Required	99.4
		104	5520		13.52	14.0		
		108	5540		13.49	14.0		
		112	5560		13.31	14.0		
		116	5580		13.80	14.0		
		120	5600		13.59	14.0		
		124	5620		13.55	14.0		
		128	5640		13.97	14.0		

		132	5660		13.81	14.0		
		136	5680		13.89	14.0		
		140	5700		13.55	14.0		
		144	5720		13.88	14.0		
	802.11n-HT20	100	5500	MCS0	NMR	14.0	Excluded	\
		104	5520		NMR	14.0		
		108	5540		NMR	14.0		
		112	5560		NMR	14.0		
		116	5580		NMR	14.0		
		120	5600		NMR	14.0		
		124	5620		NMR	14.0		
		128	5640		NMR	14.0		
		132	5660		NMR	14.0		
		136	5680		NMR	14.0		
		140	5700		NMR	14.0		
		144	5720		NMR	14.0		
	802.11n-HT40	102	5510	MCS0	NMR	11.5	Excluded	\
		110	5550		NMR	13.0		
		118	5590		NMR	13.0		
		126	5630		NMR	13.0		
		134	5670		NMR	13.0		
		142	5710		NMR	13.0		
	802.11ac-VHT20	100	5500	MCS0	NMR	14.0	Excluded	\
		104	5520		NMR	14.0		
		108	5540		NMR	14.0		
		112	5560		NMR	14.0		
		116	5580		NMR	14.0		
		120	5600		NMR	14.0		
		124	5620		NMR	14.0		
		128	5640		NMR	14.0		
		132	5660		NMR	14.0		
		136	5680		NMR	14.0		
		140	5700		NMR	14.0		
		144	5720		NMR	14.0		
	802.11ac-VHT40	102	5510	MCS0	NMR	11.0	Excluded	\
		110	5550		NMR	13.0		
		118	5590		NMR	13.0		
		126	5630		NMR	13.0		
		134	5670		NMR	13.0		
		142	5710		NMR	13.0		
	802.11ac-VHT80	106	5530	MCS0	NMR	8.5	Excluded	\
		122	5610		NMR	13.0		
		138	5690		NMR	13.0		
U-NII-3	802.11a	149	5745	6Mbps	16.89	17.0	Required	99.4
		153	5765		16.90	17.0		
		157	5785		16.72	17.0		
		161	5805		16.39	17.0		
		165	5825		16.38	17.0		
	802.11n-HT20	149	5745	MCS0	NMR	17.0	Excluded	\
		153	5765		NMR	17.0		

		157	5785		NMR	17.0		
		161	5805		NMR	17.0		
		165	5825		NMR	17.0		
	802.11n-HT40	151	5755	MCS0	NMR	15.0	Excluded	\
		159	5795		NMR	16.0		
	802.11ac-VHT20	149	5745	MCS0	NMR	17.0	Excluded	\
		153	5765		NMR	17.0		
		157	5785		NMR	17.0		
		161	5805		NMR	17.0		
		165	5825		NMR	17.0		
	802.11ac-VHT40	151	5755	MCS0	NMR	15.0	Excluded	\
		159	5795		NMR	16.0		
	802.11ac-VHT80	155	5775	MCS0	NMR	13.5	Excluded	\

Note:
1) NMR is short for “No measurement requirement”.
2) The duty cycle data is come from report No.: RF141008E03-1 R1

8.3. Power measurement result BT

Band	Mode	Antenna	Average Conducted Power (dBm)			Tune-up
			0CH	39CH	78CH	
2.4G	DH5	Aux	NMR	NMR	NMR	6.0
	2DH5	Aux	NMR	NMR	NMR	6.0
	3DH5	Aux	NMR	NMR	NMR	6.0

Band	Mode	Antenna	Average Conducted Power (dBm)			Tune-up
			0CH	19CH	39CH	
2.4G	BLE	Aux	NMR	NMR	NMR	6.0

Note:
1) NMR is short for “No measurement requirement”.

9. RF Exposure Conditions

The antenna location diagram inside the device can be found in App A.

Per FCC KDB 447498D01:
1. The 1-g SAR and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:
[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)]·[√f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for product specific 10-g SAR, where:

- f(GHz) is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

2. The SAR exclusion threshold for distances >50mm is defined by the following equation, as illustrated in KDB 447498 D01 Appendix B:
a) at 100 MHz to 1500 MHz
[Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm)·(f(MHz)/150)] mW
b) at > 1500 MHz and ≤ 6 GHz
[Power allowed at numeric Threshold at 50 mm in step 1) + (test separation distance - 50 mm)·10] mW

3. The test separation distances required for a device to demonstrate SAR or MPE compliance must be sufficiently conservative to support the operational separation distances required by the device and its antennas and radiating structures. For devices such as tablets and transmitters embedded in keyboard sections of laptop computers that are typically used in close proximity to users, the test separation distance is determined by the smallest distance between the outer surface of the device and the user. For larger devices, as the antenna operational separation distance increases to where the SAR characteristics of the device and its antennas are not directly influenced by the user, such as antennas along the top and upper side edges of laptop computer displays or opposite and adjacent edges of tablets, the test separation distance is normally determined by the closest separation between the antenna and the user.

For BT 1-g SAR

Mode	Frequency	Power (dBm)	Power (mW)	Separation Distance (mm)	Calculated Result	Threshold	SAR Test
BT	2480	6.0	3.98	5.00	1.3	3.0	Excluded

Note:
1) Because the calculated result is less than the threshold, so SAR evaluation for BT 1-g SAR is not required.

10. Dielectric Property Measurements & System Check

10.1. Dielectric Property Measurements

The temperature of the tissue-equivalent medium used during measurement must also be within 18°C to 25°C and within ± 2°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.

Tissue Dielectric Parameters
FCC KDB 865664 D01 v01r04 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:

Liquid	Freq.	Liquid Parameters				Deviation(%)		Limit (%)	Temp. (℃)	Test Date
		Measured		Target						
		ϵ_r	σ	ϵ_r	σ	ϵ_r	σ			
Head 2450	2360	40.23	1.67	39.36	1.72	2.21	-3.02	±5	23.1	August 7, 2019
	2450	40.13	1.78	39.20	1.80	2.37	-1.22			
	2540	39.67	1.88	39.09	1.90	1.48	-0.95			
Head 5250	5160	36.07	4.71	36.03	4.61	0.11	2.13	±5	22.1	August 13, 2019
	5250	35.93	4.84	35.93	4.71	0.00	2.82			
	5340	35.74	4.93	35.83	4.80	-0.25	2.77			
Head 5600	5500	36.66	5.15	35.64	4.96	2.86	3.79	±5	22.5	August 14, 2019
	5600	36.34	5.19	35.53	5.07	2.28	2.31			
	5700	36.36	5.25	35.41	5.17	2.68	1.51			
Head 5750	5660	36.70	5.26	35.46	5.13	3.50	2.53	±5	22.7	August 15, 2019
	5750	36.33	5.44	35.36	5.22	2.74	4.18			
	5840	35.87	5.43	35.27	5.30	1.70	2.49			

10.2. 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 ±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 ≥ 15.0 cm for SAR measurements ≤ 3 GHz and ≥ 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 10mm (above 1GHZ) and 15mm (below 1GHz) from dipole center to the simulating liquid surface.
- For area scan, standard grid spacing for head measurements is 15 mm in x- and y- dimension(≤2GHz), 12 mm in x- and y-dimension(2-4 GHz) and 10mm in x- and y- dimension(4-6GHz).
- For zoom scan, Δx_{zoom}, Δy_{zoom}≤ 2GHz - ≤8mm, 2-4GHz - ≤5 mm and 4-6 GHz-≤4mm; Δz_{zoom} ≤3GHz - ≤5 mm, 3-4 GHz- ≤4mm and 4-6GHz-≤2mm.
- Distance between probe sensors and phantom surface was set to 3 mm except for 5 GHz band. For 5GHz band, Distance between probe sensors and phantom surface was set to 2.5 mm
- The dipole input power (forward power) was set to 100 mW or 250 mW depend on the certificate of the dipoles.
- 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.

T.S. Liquid		Measured Results		Target (Ref. value)	Delta (%)	Limit (%)	Temp. (℃)	Test Date
		Zoom Scan (W/Kg)	Normalize to 1W (W/Kg)					
Head 2450	1-g	13.700	54.80	53.70	2.05	±10	23.1	August 7, 2019
	10-g	6.350	25.40	25.00	1.60			
Head 5250	1-g	7.750	77.50	78.60	-1.40	±10	22.1	August 13, 2019
	10-g	2.270	22.70	22.50	0.89			
Head 5600	1-g	8.430	84.30	81.20	3.82	±10	22.5	August 14, 2019
	10-g	2.400	24.00	23.40	2.56			
Head 5750	1-g	8.300	83.00	80.00	3.75	±10	22.7	August 15, 2019
	10-g	2.410	24.10	22.80	5.70			

11. Measured and Reported (Scaled) SAR Results

As per KDB 447498 sec.4.1.e), When SAR or MPE is measured at or scaled to the maximum tune-up tolerance limit, the results are referred to as reported.

Scaled SAR calculation formula:

Scaled SAR = Tune-up in mW / Conducted power in mW * Duty cycle (if available) * SAR value

SAR Test Reduction criteria are as follows:

KDB 447498 D01 General RF Exposure Guidance:
A）Per KDB447498 D01 v06, all SAR measurement results are scaled to the maximum tune-up tolerance limit to demonstrate SAR compliance.
B）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.

Per KDB865664 D01 v01r04:

For each frequency band, repeated SAR measurement is required only when the measured SAR is ≥0.8W/Kg; if the deviation among the repeated measurement is ≤ 20%, and the measured SAR <1.45W/Kg, only one repeated measurement is required.

Per KDB 248227 D01 v02r02:

For Wi-Fi SAR testing, a communication link is set up with the testing software for Wi-Fi mode test. During the test, at the each test frequency channel, the EUT is operated at the RF continuous emission mode. The RF signal utilized in SAR measurement has 100% duty cycle and its crest factor is 1. The test procedures in KDB 248227 D01 v02r02 are applied. (Refer to KDB 248227D01 v02r02 for more details)

Initial Test Position Procedure

For exposure condition with multiple test position, such as handsets operating next to the ear, devices with hotspot mode or UMPC mini-tablet, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all position in an exposure condition. The test position with the highest extrapolated (peak) SAR is used as the initial test position. When reported SAR for the initial test position is ≤ 0.4W/kg, no additional testing for the remaining test position is required. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is ≤ 0.8W/kg or all test position are measured. For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg, SAR is measured for these test positions /configurations on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or all required channels are tested.

Initial Test Configuration Procedure

An initial test configuration is determined for OFDM transmission modes according to the channel bandwidth, modulation and data rate combination(s) with the highest maximum output power specified for production units in each standalone and aggregated frequency band. SAR is measured using the highest measured maximum output power channel. For configurations with the same specified or measured maximum output power, additional transmission mode and test channel selection procedures are required (see section 5.3.2 of KDB 248227D01

v02r02). SAR test reduction of subsequent highest output test channels is based on the reported SAR of the initial test configuration.
For next to the ear, hotspot mode and UMC mini-tablet exposure configurations where multiple test positions are required, the initial test position procedure is applied to minimize the number of test positions required for SAR measurement using the initial test configuration transmission mode. For fixed exposure conditions that do not have multiple SAR test positions, SAR is measured in the transmission mode determined by the initial test configuration. When the reported SAR of the initial test configuration is > 0.8 W/kg, SAR measurement is required for the subsequent next highest measured output power channel(s) in the initial test configuration until the reported SAR is ≤ 1.2 W/kg or all required channels are tested.

Sub Test Configuration Procedure

SAR measurement requirements for the remaining 802.11 transmission mode configurations that have not been tested in the initial test configuration are determined separately for each standalone and aggregated frequency band, in each exposure condition, according to the maximum output power specified for production units.
When the highest reported SAR for the initial test configuration, according to the initial test position or fixed exposure position requirements, is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for that subsequent test configuration.

Note:
1) The same procedure is applied to extremity SAR evaluation, and the corresponding limitation is 2.5 times of 1-g SAR.

11.1. SAR Test Results of 2.4G Wi-Fi with ICT antenna platform

Test Position	Test Mode	Channel/ Frequency	Power (dBm)		Measured SAR Value	Power Drift	Duty Cycle (%)	Scaled (W/Kg)
			Tune-up	Meas.	1-g (W/Kg)			
Aux ANT.								
Bottom surface	802.11b	6/2437	20.50	20.50	0.681	0.16	100.00	0.681

OFDM mode SAR evaluation exclusion analysis for 1-g SAR for aux ANT

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11b	20.5	112.20	0.681	\	\
802.11g	19.5	89.13	\	0.541	Excluded
802.11n HT20	19.5	89.13	\	0.541	Excluded
802.11n HT40	18.5	70.79	\	0.430	Excluded

Note:
1) The highest reported SAR for DSSS adjusted by the ratio of OFDM 802.11g/n to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, so SAR evaluation for 802.11g/n is not required.

11.2. SAR Test Results of 2.4G Wi-Fi with SPD antenna platform

Test Position	Test Mode	Channel/ Frequency	Power (dBm)		Measured SAR Value	Power Drift	Duty Cycle (%)	Scaled (W/Kg)
			Tune-up	Meas.	1-g (W/Kg)			
Aux ANT.								
Bottom surface	802.11b	6/2437	20.50	20.50	0.521	0.13	100.00	0.521

OFDM mode SAR evaluation exclusion analysis for 1-g SAR for aix ANT

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11b	20.5	112.20	0.521	\	\
802.11g	19.5	89.13	\	0.414	Excluded
802.11n HT20	19.5	89.13	\	0.414	Excluded
802.11n HT40	18.5	70.79	\	0.329	Excluded

Note:
1) The highest reported SAR for DSSS adjusted by the ratio of OFDM 802.11g/n to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, so SAR evaluation for 802.11g/n is not required.

11.3. SAR Test Results of 5G Wi-Fi with ICT antenna platform

Test Position	Test Mode	Channel/ Frequency	Power (dBm)		Measured SAR Value	Power Drift	Duty Cycle (%)	Scaled (W/Kg)
			Tune-up	Meas.	1-g (W/Kg)			
Aux ANT.								
5.3GHz band								
Bottom surface	802.11a	60/5300	17.0	16.93	1.020	0.13	99.40	1.043
Bottom surface	802.11a	52/5260	17.0	16.92	1.060	0.03	99.40	1.086
Repeated test at worst measured SAR configuration above								
Bottom surface	802.11a	60/5300	17.0	16.93	1.080	0.19	99.40	1.104
5.5GHz band								
Bottom surface	802.11a	128/5640	14.0	13.97	0.518	-0.06	99.40	0.525
5.8GHz band								
Bottom surface	802.11a	153/5675	17.0	16.90	0.740	0.17	99.40	0.764

Subsequent test configuration SAR evaluation exclusion analysis for 1-g SAR for aux ANT (U-NII-2A)

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11a	17	50.12	1.104	\	\
802.11n HT20	17	50.12	\	1.104	Excluded
802.11n HT40	16	39.81	\	0.877	Excluded
802.11ac VHT20	17	50.12	\	1.104	Excluded
802.11ac VHT40	16	39.81	\	0.877	Excluded
802.11ac VHT80	9.5	8.91	\	0.196	Excluded

Note:
1) The 802.11a mode is selected as Initial Test Configuration for SAR test according to the specified maximum output power. As the highest reported SAR for the initial test configuration is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR test for the other 802.11 modes are not required.

Subsequent test configuration SAR evaluation exclusion analysis for 1-g SAR for aux ANT (U-NII-2C)

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11a	14	25.12	0.525	\	\
802.11n HT20	14	25.12	\	0.525	Excluded
802.11n HT40	13	19.95	\	0.417	Excluded
802.11ac VHT20	14	25.12	\	0.525	Excluded
802.11ac VHT40	13	19.95	\	0.417	Excluded
802.11ac VHT80	12	15.85	\	0.331	Excluded

Note:
1) The 802.11a mode is selected as Initial Test Configuration for SAR test according to the specified maximum output power. As the highest reported SAR for the initial test configuration is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR test for the other 802.11 modes are not required.

Subsequent test configuration SAR evaluation exclusion analysis for 1-g SAR for aux ANT (U-NII-3)

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11a	17	50.12	0.764	\	\
802.11n HT20	17	50.12	\	0.764	Excluded
802.11n HT40	16	39.81	\	0.607	Excluded
802.11ac VHT20	17	50.12	\	0.764	Excluded
802.11ac VHT40	16	39.81	\	0.607	Excluded
802.11ac VHT80	13.5	22.39	\	0.341	Excluded

Note:

1) The 802.11a mode is selected as Initial Test Configuration for SAR test according to the specified maximum output power. As the highest reported SAR for the initial test configuration is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR test for the other 802.11 modes are not required.

11.4. SAR Test Results of 5G Wi-Fi with SPD antenna platform

Test Position	Test Mode	Channel/ Frequency	Power (dBm)		Measured SAR Value	Power Drift	Duty Cycle (%)	Scaled (W/Kg)
			Tune-up	Meas.	1-g (W/Kg)			
Aux ANT.								
5.3GHz band								
Bottom surface	802.11a	60/5300	17.0	16.93	1.060	0.18	99.40	1.084
Bottom surface	802.11a	52/5260	17.0	16.92	0.876	0.14	99.40	0.898
Repeated test at worst measured SAR configuration above								
Bottom surface	802.11a	60/5300	17.0	16.93	1.110	0.16	99.40	1.135
5.5GHz band								
Bottom surface	802.11a	128/5640	14.0	13.97	1.160	-0.05	99.40	1.175
Bottom surface	802.11a	100/5500	14.0	13.92	0.744	0.11	99.40	0.762
Repeated test at worst measured SAR configuration above								
Bottom surface	802.11a	128/5640	14.0	13.97	1.160	0.18	99.40	1.175
5.8GHz band								
Bottom surface	802.11a	153/5765	17.0	16.90	0.835	0.16	99.40	0.860
Bottom surface	802.11a	149/5745	17.0	16.89	0.997	0.17	99.40	1.029
Repeated test at worst measured SAR configuration above								
Bottom surface	802.11a	149/5745	17.0	16.89	1.040	0.17	99.40	1.073

Subsequent test configuration SAR evaluation exclusion analysis for 1-g SAR for aux ANT (U-NII-2A)

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11a	17	50.12	1.135	\	\
802.11n HT20	17	50.12	\	1.135	Excluded
802.11n HT40	16	39.81	\	0.902	Excluded
802.11ac VHT20	17	50.12	\	1.135	Excluded
802.11ac VHT40	16	39.81	\	0.902	Excluded
802.11ac VHT80	9.5	8.91	\	0.202	Excluded

Note:

1) The 802.11a mode is selected as Initial Test Configuration for SAR test according to the specified maximum output power. As the highest reported SAR for the initial test configuration is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR test for the other 802.11 modes are not required.

Subsequent test configuration SAR evaluation exclusion analysis for 1-g SAR for aux ANT (U-NII-2C)

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11a	14	25.12	1.175	\	\
802.11n HT20	14	25.12	\	1.175	Excluded
802.11n HT40	13	19.95	\	0.933	Excluded
802.11ac VHT20	14	25.12	\	1.175	Excluded
802.11ac VHT40	13	19.95	\	0.933	Excluded
802.11ac VHT80	12	15.85	\	0.741	Excluded

Note:
1) The 802.11a mode is selected as Initial Test Configuration for SAR test according to the specified maximum output power. As the highest reported SAR for the initial test configuration is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR test for the other 802.11 modes are not required.

Subsequent test configuration SAR evaluation exclusion analysis for 1-g SAR for aux ANT (U-NII-3)

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11a	17	50.12	1.073	\	\
802.11n HT20	17	50.12	\	1.073	Excluded
802.11n HT40	16	39.81	\	0.852	Excluded
802.11ac VHT20	17	50.12	\	1.073	Excluded
802.11ac VHT40	16	39.81	\	0.852	Excluded
802.11ac VHT80	13.5	22.39	\	0.479	Excluded

Note:
1) The 802.11a mode is selected as Initial Test Configuration for SAR test according to the specified maximum output power. As the highest reported SAR for the initial test configuration is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR test for the other 802.11 modes are not required.

12. Simultaneous Transmission SAR Analysis

Simultaneous transmission SAR test exclusion is determined for each operating configuration and exposure condition according to the reported standalone SAR of each applicable simultaneous transmitting antenna.

Depend on the description of coexistence mode on the module certification report, the 5GH Wi-Fi and BT can transmit simultaneously.

12.1. Estimated SAR

When standalone SAR test exclusion applies to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to following to determine simultaneous transmission SAR test exclusion:
1) (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.
2) 0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR, when the test separation distance is > 50 mm.

When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied.

Estimated 1-g SAR of BT

Position	Frequency (GHz)	Power (dBm)	Power (mW)	Separation Distance (mm)	Estimated 1-g SAR (W/Kg)
Bottom surface	0.248	6.00	3.98	5	0.053

12.2. Simultaneous Transmission calculation for ICT antenna platform

Exposure Position	1	2	3	1+3 Summed 1g SAR(W/kg)	2+3 Summed 1g SAR(W/kg)
	2.4G WLAN ANT(Aux)	5G WLAN ANT(Aux)	Bluetooth ANT (Aux)		
	1g SAR (W/kg)	1g SAR (W/kg)	1g SAR (W/kg)		
ICT antenna platform					
Bottom Surface	0.681	1.104	0.053	0.734	1.157
SPD antenna platform					
Bottom Surface	0.521	1.175	0.053	0.574	1.228

Note:
1) Because the maximum SUM 1-g SAR ≤ 1.6 W/Kg, so the SPLSR analysis is not required.

Appendixes

Refer to separated files for the following appendixes.

4789114486-SAR-435-2_App A Photo

4789114486-SAR-435-2_App B System Check Plots

4789114486-SAR-435-2_App C Highest Test Plots

4789114486-SAR-435-2_App D Cal. Certificates

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