SAR EVALUATION REPORT

FCC 47 CFR § 2.1093
IEEE Std. 1528-2013

For
UAV Remote Controller

FCC ID: SVNUAV-R1
Model Name: DHI-UAV-R1S-RH

Report Number: 4788322398-2

Issue Date: August 30, 2018

Prepared for
Zhejiang Dahua Vision Technology Co., Ltd.
No.1199, Bin'an Road, Binjiang District, Hangzhou, P.R. China

Prepared by
UL Verification Services (Guangzhou) Co., Ltd, Song Shan Lake Branch
Room 101, Building 10, Innovation Technology Park,
Song Shan Lake Hi tech Development Zone, Dongguan, 523808, China

Tel: +86 769 22038881
Fax: +86 769 33244054
Website: www.ul.com

Revision History

Rev.	Date	Revisions	Revised By
V1.0	July 23, 2018	Initial Issue	
V2.0	August 30, 2018	Report revised based in Reviewer's comments: 1. Section.6: Updated the frequency to 923.35MHz 2. Section.12.1: Corrected the frequency to 2.45GHz 3. Section.12.2: Corrected the conclusion of SPLSR	James Qin

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1. Attestation of Test Results

Applicant Name	Zhejiang Dahua Vision Technology Co., Ltd.
Address	No.1199, Bin'an Road, Binjiang District, Hangzhou, P.R. China
Manufacturer	Zhejiang Dahua Vision Technology Co., Ltd.
Address	No.1199, Bin'an Road, Binjiang District, Hangzhou, P.R. China
EUT Name	UAV Remote Controller
Model Name	DHI-UAV-R1S-RH
Series Models:	UAV-R1S-RH, DH-UAV-R1S-RH, OEM-UAV-R1S-RH, DHI-UAV-R1123, DHI-UAV-R1133, UAV-R1123, UAV-R1133, DH-UAV-R1123, DH-UAV-R1133, OEM-UAV-R1123, OEM-UAV-R1133, DH-UAV-R1S-11, DHI-UAV-R1S-23, DHI-UAV-R1S-33, OEM-UAV-R1S-11, UAV-R1S-23, UAV-R1S-33, DH-UAV-R1S-11-C, DHI-UAV-R1S-23-C, DHI-UAV-R1S-33-C, OEM-UAV-R1S-11-C, UAV-R1S-23-C, UAV-R1S-33-C, DH-UAV-R1S-11CH, OEM-UAV-R1S-11CH, DH-UAV-R1S-11CH-C, OEM-UAV-R1S-11CH-C, DH-UAV-R1S-S-11CH, OEM-UAV-R1S-S-11CH, DH-UAV-R1S-S-11CH-C, OEM-UAV-R1S-S-11CH-C, DHI-UAV-R1S-33CH, UAV-R1S-33CH, DHI-UAV-R1S-33CH-C, UAV-R1S-33CH-C, DHI-UAV-R1S-S-33CH, UAV-R1S-S-33CH, DHI-UAV-R1S-S-33CH-C, UAV-R1S-S-33CH-C, DHI-UAV-R1S-23CH, UAV-R1S-23CH, UAV-R1S-23CH-C, DHI-UAV-R1S-23CH-C, DHI-UAV-R1S-S-23CH, UAV-R1S-S-23CH, DHI-UAV-R1S-S-23CH-C, UAV-R1S-S-23CH-C
Difference:	The difference lies only in the appearance of the different color and graphic pattern.
Sample Status	Normal
Brand	alhua TECHNOLOGY
Date of Tested	June 17, 2018 & July 20, 2018
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			
	915MHz 2GFSK	2.4GHz SRD	DTS	U-NII
Extremities (10g)	1.143	\	1.541	0.125
Simultaneous Transmission	2.698			
Test Results	Passs			

Tested By:	Reviewed By:	Approved By:
James Qin Engineer Project Associate	Shawn Wen Laboratory Leader	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

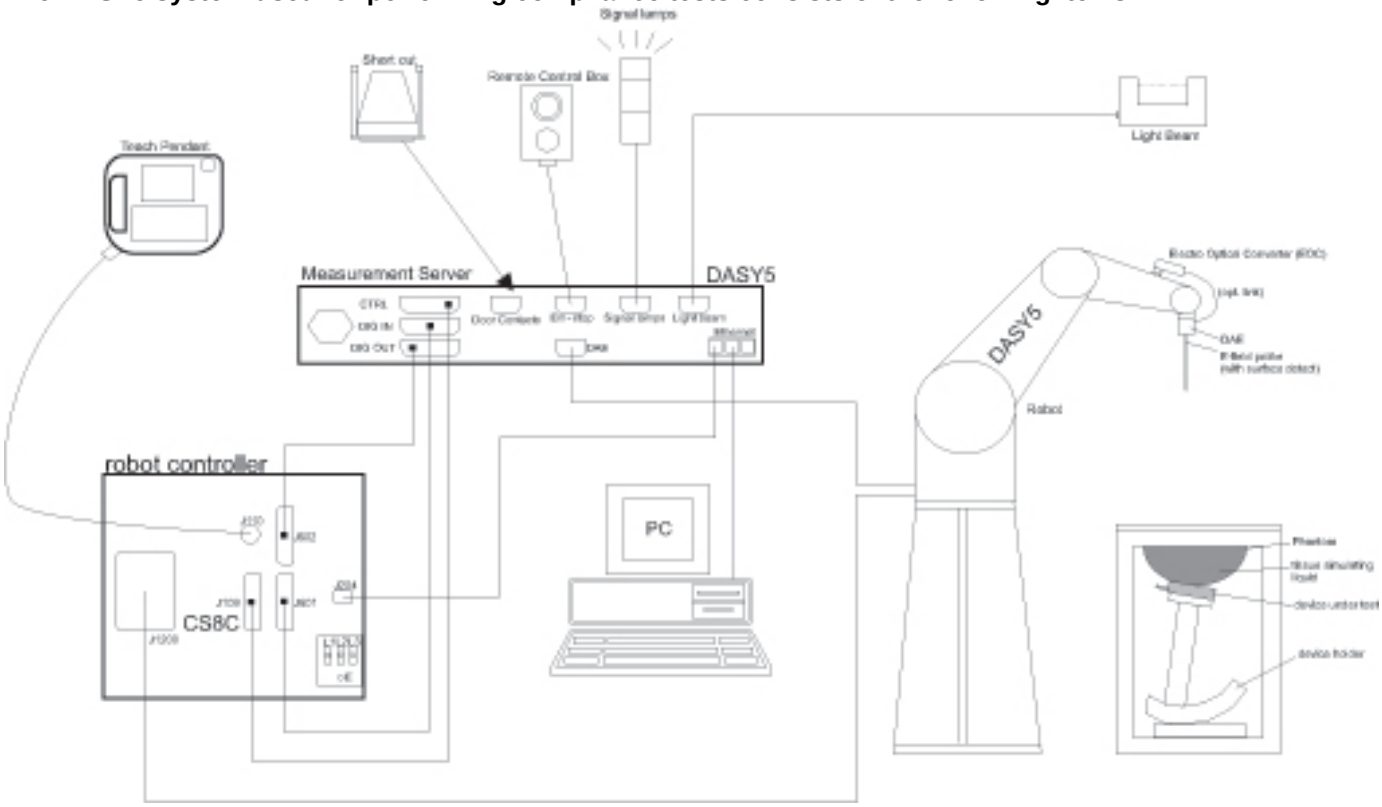
3. Facilities and Accreditation

Test Location	UL Verification Services (Guangzhou) Co., Ltd. Song Shan Lake Branch.
Address	Building 10, Innovation Technology Park, No. 1, Li Bin Road, Song Shan Lake Hi-Tech Development Zone Dongguan, People's Republic of 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, No. 1, Li Bin Road, Song Shan Lake Hi-Tech Development Zone Dongguan, People's Republic of 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

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	½·δ·ln(2) ± 0.5 mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	30° ± 1°	20° ± 1°
Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}	≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm
	When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

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 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.

Name of equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
ENA Network Analyzer	Keysight	E5080A	MY55100583	December 11, 2018
Dielectric Probe kit	SPEAG	SM DAK 040 SA	1155	NCR
DC power supply	Keysight	E36103A	MY55350020	December 11, 2018
Signal Generator	Rohde & Schwarz	SME06	837633\001	March 23, 2019
BI-Directional Coupler	WERLATONE	C8060-102	3423	December 11, 2018
Peak and Average Power Sensor	Keysight	E9323A	MY55440013	December 11, 2018
Peak and Average Power Sensor	Keysight	E9323A	MY55420006	December 11, 2018
Dual Channel PK Power Meter	Keysight	N1912A	MY55416024	December 11, 2018
Amplifier	CORAD TECHNOLOGY LTD	AMF-4D-00400600-50-30P	1983561	NCR
Dosimetric E-Field Probe	SPEAG	EX3DV4	7383	December 13, 2018
Data Acquisition Electronic	SPEAG	DAE3	427	December 3, 2018
Dipole Kit 900 MHz	SPEAG	D900V2	1d190	January 14, 2019
Dipole Kit 2450 MHz	SPEAG	D2450V2	977	January 13, 2019
Dipole Kit 5 GHz	SPEAG	D5GHzV2	1231	January 12, 2019
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 11, 2018
Thermometer	VICTOR	VC230	/	December 11, 2018

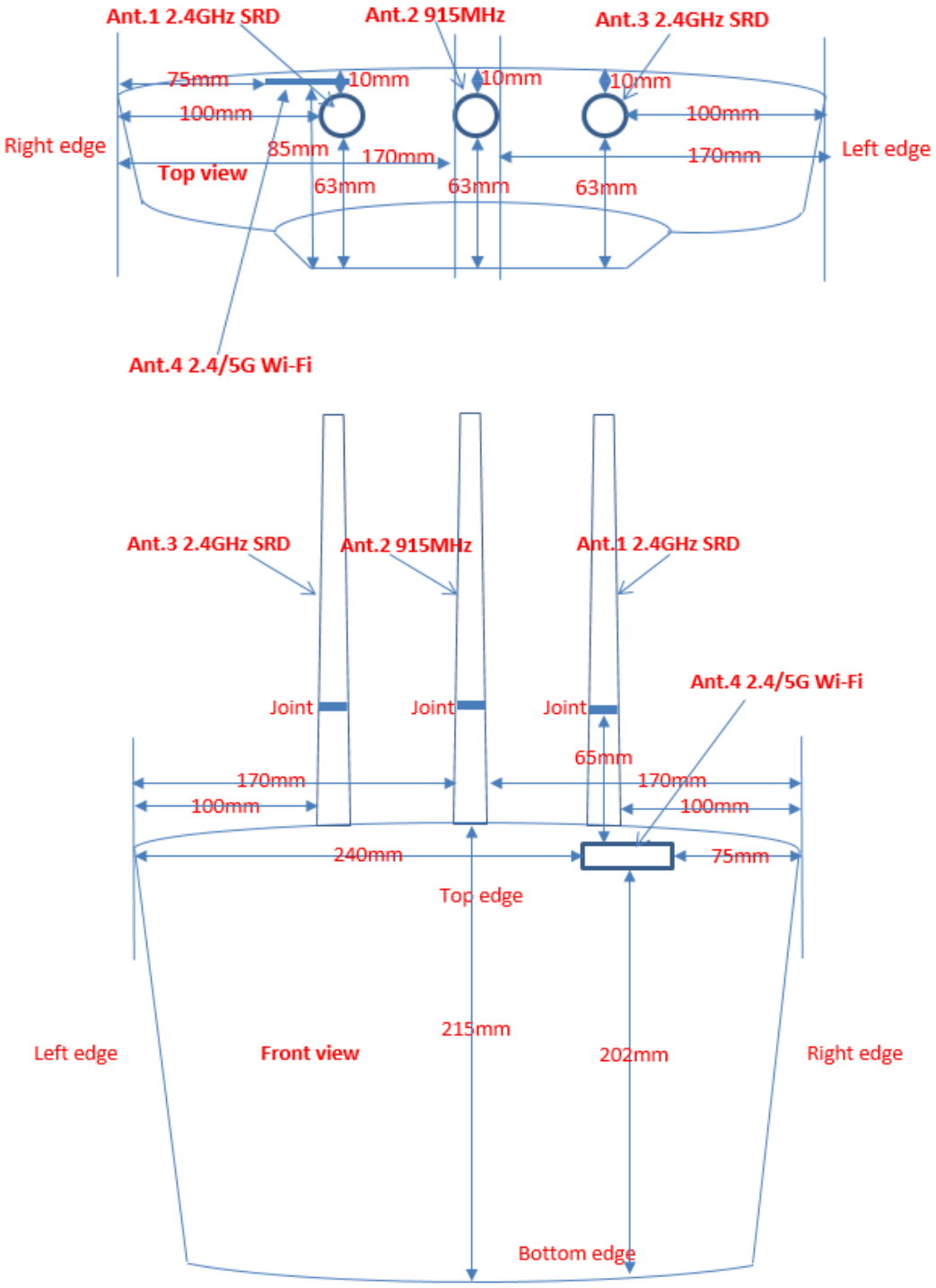
Note:
1) Per KDB865664D01 v01r04 requirements for dipole calibration, the test laboratory has adopted three-year extended calibration interval. Each measured dipole is expected to evaluate with the following criteria at least on annual interval in Appendix C.
a) There is no physical damage on the dipole;
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) Network analyzer probe calibration against air, distilled water and a shorting block performed before measuring liquid parameters.

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. SAR Test Configuration

Refer to the diagram of the device below for the specific details of the antenna-to-surfaces / edges distances.



7. Device Under Test (DUT) Information

7.1. DUT Description

The DUT is a UAV remote controller with IEEE 802.11a/b/g/n/ac, 915MHz 2GFSK and 2.4GHz SRD radio.	
Accessory	None
Rated Power Input	100-240V~,50Hz/60Hz,1.5A max
Battery	7.4V, 7800mAh

7.2. Wireless Technology

Wireless technology	Frequency band	Operating mode
915MHz 2GFSK	915MHz	2GFSK
2.4GHz SRD	2.4 GHz	QPSK OFDMA
Wi-Fi	2.4 GHz	802.11 b 802.11 g 802.11 n(20M) 802.11 n(40M)
Wi-Fi	5.2 GHz	802.11 a 802.11 n(20M) 802.11 n(40M) 802.11 ac(20M) 802.11 ac(40M) 802.11 ac(80M)

8. RF Exposure Conditions (Test Configurations)

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

For 915MHz 2GFSK 1-g SAR (antenna to outer surface separation distance less than 50mm)

Position	Frequency (MHz)	Power (dBm)	Power (mW)	Separation Distance (mm)	Calculation Result	Threshold	SAR Test
Front surface	923.35	21.50	141.25	5.00	27.1	3.0	Required
Back surface	923.35	21.50	141.25	\	\	\	\
Left edge	923.35	21.50	141.25	\	\	\	\
Right edge	923.35	21.50	141.25	\	\	\	\
Top edge	923.35	21.50	141.25	5.00	27.1	3.00	Required
Bottom edge	923.35	21.50	141.25	\	\	\	\

Note:
Because human body won't get close to front surface and top edge when operating the controller, so 1-g body SAR evaluation for front surface and top edge is still excluded even though the calculation result is greater than the corresponding threshold.

For 915MHz 2GFSK 1-g SAR (antenna to outer surface separation distance greater than 50mm)

Position	Frequency (MHz)	Power (dBm)	Power (mW)	Power allowed at 50mm	Separation Distance (mm)	Calculation Result	SAR Test
Front surface	923.35	21.50	141.25	156.10	\	\	\
Back surface	923.35	21.50	141.25	156.10	63.00	236.13	Excluded
Left edge	923.35	21.50	141.25	156.10	170.00	894.78	Excluded
Right edge	923.35	21.50	141.25	156.10	170.00	894.78	Excluded
Top edge	923.35	21.50	141.25	156.10	\	\	\
Bottom edge	923.35	21.50	141.25	156.10	215.00	1171.79	Excluded

For 915MHz 2GFSK 10-g SAR (antenna to outer surface separation distance less than 50mm)

Position	Frequency (MHz)	Power (dBm)	Power (mW)	Separation Distance (mm)	Calculation Result	Threshold	SAR Test
Front surface	923.35	21.50	141.25	5.00	27.1	7.5	Required
Back surface	923.35	21.50	141.25	\	\	\	\
Left edge	923.35	21.50	141.25	\	\	\	\
Right edge	923.35	21.50	141.25	\	\	\	\
Top edge	923.35	21.50	141.25	5.00	27.1	7.5	Required
Bottom edge	923.35	21.50	141.25	\	\	\	\

Note:
Because human extremities won't get close to top edge when operating the controller, so 10-g extremity SAR evaluation for top edge is still excluded even though the calculation result is greater than the corresponding threshold.

For 915MHz 2GFSK 10-g SAR (antenna to outer surface separation distance greater than 50mm)

Position	Frequency (MHz)	Power (dBm)	Power (mW)	Power allowed at 50mm	Separation Distance (mm)	Calculation Result (mW)	SAR Test
Front surface	923.35	21.50	141.25	390.25	\	\	\
Back surface	923.35	21.50	141.25	390.25	63.00	470.28	Excluded
Left edge	923.35	21.50	141.25	390.25	170.00	1128.93	Excluded
Right edge	923.35	21.50	141.25	390.25	170.00	1128.93	Excluded
Top edge	923.35	21.50	141.25	390.25	\	\	\
Bottom edge	923.35	21.50	141.25	390.25	215.00	1405.94	Excluded

For 2.4GHz SRD 1-g SAR

Frequency	Power (dBm)	Power (mW)	Separation Distance (mm)	Calculation Result	Threshold	SAR Test
2450	1.50	1.41	5.00	0.4	3.0	Excluded

For 2.4GHz SRD 10-g SAR

Frequency	Power (dBm)	Power (mW)	Separation Distance (mm)	Calculation Result	Threshold	SAR Test
2450	1.50	1.41	5.00	0.4	7.5	Excluded

For 2.4GHz Wi-Fi 1-g SAR (antenna to outer surface separation distance less than 50mm)

Position	Frequency (MHz)	Power (dBm)	Power (mW)	Separation Distance (mm)	Calculation Result	Threshold	SAR Test
Front surface	2462	22.00	158.49	5.00	49.7	3.0	Required
Back surface	2462	22.00	158.49	\	\	\	\
Left edge	2462	22.00	158.49	\	\	\	\
Right edge	2462	22.00	158.49	\	\	\	\
Top edge	2462	22.00	158.49	\	\	\	\
Bottom edge	2462	22.00	158.49	\	\	\	\

Note:
Because human body won't get close to front surface when operating the controller, so 1-g body SAR evaluation for front surface is still excluded even though the calculation result is greater than the corresponding threshold.

For 2.4GHz Wi-Fi 1-g SAR (antenna to outer surface separation distance greater than 50mm)

Position	Frequency (MHz)	Power (dBm)	Power (mW)	Power allowed at 50mm	Separation Distance (mm)	Calculation Result	SAR Test
Front surface	2462	22.00	158.49	95.60	\	\	\
Back surface	2462	22.00	158.49	95.60	85.00	445.60	Excluded
Left edge	2462	22.00	158.49	95.60	240.00	1995.60	Excluded
Right edge	2462	22.00	158.49	95.60	75.00	345.60	Excluded
Top edge	2462	22.00	158.49	95.60	65.00	245.60	Excluded
Bottom edge	2462	22.00	158.49	95.60	202.00	1615.60	Excluded

For 2.4GHz Wi-Fi 10-g SAR (antenna to outer surface separation distance less than 50mm)

Position	Frequency (MHz)	Power (dBm)	Power (mW)	Separation Distance (mm)	Calculation Result	Threshold	SAR Test
Front surface	2462	22.00	158.49	5.00	49.7	7.5	Required
Back surface	2462	22.00	158.49	\	\	\	\
Left edge	2462	22.00	158.49	\	\	\	\
Right edge	2462	22.00	158.49	\	\	\	\
Top edge	2462	22.00	158.49	\	\	\	\
Bottom edge	2462	22.00	158.49	\	\	\	\

For 2.4GHz Wi-Fi 10-g SAR (antenna to outer surface separation distance greater than 50mm)

Position	Frequency (MHz)	Power (dBm)	Power (mW)	Power allowed at 50mm	Separation Distance (mm)	Calculation Result (mW)	SAR Test
Front surface	2462	22.00	158.49	238.99	\	\	\
Back surface	2462	22.00	158.49	238.99	85	588.99	Excluded
Left edge	2462	22.00	158.49	238.99	240	2138.99	Excluded
Right edge	2462	22.00	158.49	238.99	75	488.99	Excluded
Top edge	2462	22.00	158.49	238.99	65.00	388.99	Excluded
Bottom edge	2462	22.00	158.49	238.99	202	1758.99	Excluded

For 5GHz Wi-Fi 1-g SAR (antenna to outer surface separation distance less than 50mm)

Position	Frequency (MHz)	Power (dBm)	Power (mW)	Separation Distance (mm)	Calculation Result	Threshold	SAR Test
Front surface	5250	14.00	25.12	5.00	11.5	3.0	Required
Back surface	5250	14.00	25.12	\	\	\	\
Left edge	5250	14.00	25.12	\	\	\	\
Right edge	5250	14.00	25.12	\	\	\	\
Top edge	5250	14.00	25.12	\	\	\	\
Bottom edge	5250	14.00	25.12	\	\	\	\

Note:
Because human body won't get close to front surface when operating the controller, so 1-g body SAR evaluation for front surface is still excluded even though the calculation result is greater than the corresponding threshold.

For 5GHz Wi-Fi 1-g SAR (antenna to outer surface separation distance greater than 50mm)

Position	Frequency (MHz)	Power (dBm)	Power (mW)	Power allowed at 50mm	Separation Distance (mm)	Calculation Result	SAR Test
Front surface	5250	14.00	25.12	65.47	\	\	\
Back surface	5250	14.00	25.12	65.47	85.00	415.47	Excluded
Left edge	5250	14.00	25.12	65.47	240.00	1965.47	Excluded
Right edge	5250	14.00	25.12	65.47	75.00	315.47	Excluded
Top edge	5250	14.00	25.12	65.47	65.00	215.47	Excluded
Bottom edge	5250	14.00	25.12	65.47	202.00	1585.47	Excluded

For 5GHz Wi-Fi 10-g SAR (antenna to outer surface separation distance less than 50mm)

Position	Frequency (MHz)	Power (dBm)	Power (mW)	Separation Distance (mm)	Calculation Result	Threshold	SAR Test
Front surface	5250	14.00	25.12	5.00	11.5	7.5	Required
Back surface	5250	14.00	25.12	\	\	\	\
Left edge	5250	14.00	25.12	\	\	\	\
Right edge	5250	14.00	25.12	\	\	\	\
Top edge	5250	14.00	25.12	\	\	\	\
Bottom edge	5250	14.00	25.12	\	\	\	\

For 5GHz Wi-Fi 10-g SAR (antenna to outer surface separation distance greater than 50mm)

Position	Frequency (MHz)	Power (dBm)	Power (mW)	Power allowed at 50mm	Separation Distance (mm)	Calculation Result (mW)	SAR Test
Front surface	5250	14.00	25.12	163.66	\	\	\
Back surface	5250	14.00	25.12	163.66	85.00	513.66	Excluded
Left edge	5250	14.00	25.12	163.66	240	2063.66	Excluded
Right edge	5250	14.00	25.12	163.66	75.00	413.66	Excluded
Top edge	5250	14.00	25.12	163.66	65.00	313.66	Excluded
Bottom edge	5250	14.00	25.12	163.66	202.00	1683.66	Excluded

9. Dielectric Property Measurements & System Check

9.1. 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			
Body 900	850	55.22	1.00	55.15	0.99	0.13	1.41	±5	22.8	July 20, 2018
	900	54.96	1.06	55.00	1.05	-0.07	0.57			
	950	54.36	1.10	51.91	1.07	4.72	2.80			
Body 2450	2360	52.02	1.89	52.82	1.86	-1.51	1.40	±5	23.5	June 17, 2018
	2450	51.69	2.00	52.70	1.95	-1.92	2.36			
	2540	51.50	2.10	52.59	2.08	-2.07	0.72			
Body 5250	5160	48.36	5.28	49.07	5.25	-1.45	0.53	±5	23.1	June 17, 2018
	5250	48.34	5.42	48.95	5.36	-1.25	1.19			
	5340	48.07	5.59	48.96	5.46	-1.82	2.36			

9.2. 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		Messured Results		Target (Ref. value)	Delta (%)	Limit (%)	Temp. (℃)	Test Date
		Zoom Scan (W/Kg)	Normalize to 1W (W/Kg)					
Body 900	1-g	2.680	10.72	11.10	-3.42	±10	22.8	July 20, 2018
	10-g	1.750	7.00	7.20	-2.78			
Body 2450	1-g	12.400	49.60	51.70	-4.06	±10	23.5	June 17, 2018
	10-g	5.860	23.44	24.30	-3.54			
Body 5250	1-g	7.290	72.90	76.10	-4.20	±10	23.1	June 17, 2018
	10-g	2.070	20.70	21.40	-3.27			

10. Conducted Output Power Measurement and tune-up tolerance

10.1. Power measurement result of 915MHz 2GFSK

Band	Freq.(MHz)	Avg. Pwr.(dBm)	Tune-up Limit (dBm)	SAR Test
915MHz	907.15	21.05	21.5	Required
	915.25	20.04	20.5	
	923.35	19.36	20.0	

10.2. Power measurement result of 2.4GHz SRD

Band	Mode		Freq.(MHz)	Avg. Pwr.(dBm)	Tune-up Limit (dBm)	SAR Test
2.4GHz SRD	10M	QPSK	2413	-0.05	1.5	Exclude
			2444	0.35	1.5	
			2475	-0.08	1.5	
		OFDM	2413	0.01	1.5	
			2444	0.06	1.5	
			2475	0.36	1.5	
	20M	QPSK	2413	0.91	1.5	Exclude
			2444	0.48	1.5	
			2475	-0.21	1.5	
		OFDM	2413	0.21	1.5	
			2444	-0.25	1.5	
			2475	0.20	1.5	

10.3. Power measurement result of 2.4GHz Wi-Fi

Mode	Channel	Frequency (MHz)	Data Rate	Average Power (dBm)	Tune-up Limit (dBm)	SAR Test	Duty Cycle %
802.11b	1	2412	1Mbps	21.63	22.0	Required	99.00
	6	2437		21.30	22.0		
	11	2462		21.19	22.0		
802.11g	1	2412	6Mbps	Not required	18.0	Excluded	\
	6	2437		Not required	18.0		
	11	2462		Not required	18.0		
802.11n-HT20	1	2412	MCS0	Not required	18.0	Excluded	\
	6	2437		Not required	18.0		
	11	2462		Not required	18.0		
802.11n-HT40	3	2422	MCS0	Not required	15.0	Excluded	\
	6	2437		Not required	15.0		
	9	2452		Not required	15.0		

10.4. Power measurement result of 5.2 GHz Wi-Fi

Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)	Tune-up Limit (dBm)	SAR Test	Duty Cycle (%)
802.11a	36	5180	6Mbps	13.79	14.0	Required	95.00
	40	5200		13.98	14.0		
	44	5220		13.67	14.0		
	48	5240		13.59	14.0		
802.11n-HT20	36	5180	MCS0	Not required	14.0	Excluded	\
	40	5200		Not required	14.0		
	44	5220		Not required	14.0		
	48	5240		Not required	14.0		
802.11n-HT40	38	5190	MCS0	Not required	12.5	Excluded	\
	46	5230		Not required	12.5		
802.11ac-VHT20	36	5180	MCS0	Not required	14.0	Excluded	\
	40	5200		Not required	14.0		
	44	5220		Not required	14.0		
	48	5240		Not required	14.0		
802.11ac-VHT40	38	5190	MCS0	Not required	12.5	Excluded	\
	46	5230		Not required	12.5		
802.11ac-VHT80	42	5210	MCS0	Not required	12.5	Excluded	\

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

11.1. SAR measurement Results of 915MHz 2GFSK

Test Position (Body 0mm)	Test Mode	Channel/ Frequency	Power (dBm)		SAR Value	Power Drift	Scaled (W/Kg)
			Tune-up	Meas.	10-g (Zoom Scan)		
Front surface	2GFSK	1/907.15	21.50	21.05	1.030	-0.18	1.143

11.2. SAR measurement Results of 2.4GHz Wi-Fi

Test Position (Body 0mm)	Test Mode	Channel/ Frequency	Power (dBm)		SAR Value	Power Drift	Duty Factor (%)	Scaled 10g (W/Kg)
			Tune-up	Meas.	10g (W/Kg)			
Front surface	802.11 b	6/2437	22.00	21.30	1.300	0.16	99.0	1.541

OFDM mode SAR evaluation exclusion analysis.

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11b	22	158.49	1.541	\	\
802.11g	18	63.10	\	0.613	Excluded
802.11n (20M)	18	63.10	\	0.613	Excluded
802.11n (40M)	15	31.62	\	0.307	Excluded

Note:
Because the adjusted 10-g SAR of 802.11g, 802.11n (20M), 802.11n (40M) mode is less than 3 W/Kg, so 10-g SAR evaluation for the 2.4G Wi-Fi OFDM mode is not required.

11.3. SAR measurement Results of 5GHz Wi-Fi

Test Position (Body 0mm)	Test Mode	Channel/ Frequency	Power (dBm)		SAR Value	Power Drift	Duty Factor (%)	Scaled 10g (W/Kg)
			Tune-up	Meas.	10g (W/Kg)			
Front surface	802.11 a	40/5200	14.00	13.98	0.118	0.15	95.0	0.125

OFDM mode SAR evaluation exclusion analysis.

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11a	14	25.12	0.125	\	\
802.11n 20M	14	25.12	\	0.125	Excluded
802.11n 40M	12.5	17.78	\	0.088	Excluded
802.11ac 20M	14	25.12	\	0.125	Excluded
802.11ac 40M	12.5	17.78	\	0.088	Excluded
802.11ac 80M	12.5	17.78	\	0.088	Excluded

Note:
Because the adjusted 10-g SAR of 802.11n (20M), 802.11n (40M), 802.11ac (20M), 802.11ac (40M), 802.11ac (80M) mode is less than 3 W/Kg, so 10-g SAR evaluation for the 5GHz Wi-Fi OFDM mode is not required.

12. Simultaneous Transmission SAR Analysis

The 2.4/5G Wi-Fi antenna can transmit simultaneously with the 915MHz antenna and the 2.4GHz SRD antenna (Ant.3), the 2.4GHz SRD antenna (Ant.1) just support receive function.

Combination NO.	Mode
1	2.4GHz Wi-Fi + 915MHz
2	5GHz Wi-Fi + 915MHz
3	2.4GHz Wi-Fi + 2.4GHz SRD
4	5GHz Wi-Fi + 2.4GHz SRD
5	915MHz + 2.4GHz SRD
6	2.4GHz Wi-Fi + 2.4GHz SRD + 915MHz
7	5GHz Wi-Fi + 2.4GHz SRD + 915MHz

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

Frequency (GHz)	Power (dBm)	Power (mW)	Separation Distance (mm)	Estimate 10g SAR (W/Kg)
2.45	1.50	1.41	5	0.014

12.2. Simultaneous Transmission calculation

For Combination NO.1

Test Position	2.4G Wi-Fi (W/Kg)	915MHz (W/Kg)	SUM 10-g SAR (W/Kg)	SPLSR (Yes / No)
Front Surface	1.541	1.143	2.684	No
Back Surface	0.000	0.000	0.000	No
Top Edge	0.000	0.000	0.000	No
Bottom Edge	0.000	0.000	0.000	No
Left Edge	0.000	0.000	0.000	No
Right Edge	0.000	0.000	0.000	No

Note: because the maximum SUM 10-g SAR ≤ 4.0 W/Kg, so the SPLSR analysis is not required.

For Combination NO.2

Test Position	5G Wi-Fi (W/Kg)	915MHz (W/Kg)	SUM 10-g SAR (W/Kg)	SPLSR (Yes / No)
Front Surface	0.125	1.143	1.268	No
Back Surface	0.000	0.000	0.000	No
Top Edge	0.000	0.000	0.000	No
Bottom Edge	0.000	0.000	0.000	No
Left Edge	0.000	0.000	0.000	No
Right Edge	0.000	0.000	0.000	No

Note: because the maximum SUM 10-g SAR ≤ 4.0 W/Kg, so the SPLSR analysis is not required.

For Combination NO.3

Test Position	2.4G Wi-Fi (W/Kg)	2.4GHz SRD (W/Kg)	SUM 10-g SAR (W/Kg)	SPLSR (Yes / No)
Front Surface	1.541	0.014	1.555	No
Back Surface	0.000	0.000	0.000	No
Top Edge	0.000	0.000	0.000	No
Bottom Edge	0.000	0.000	0.000	No
Left Edge	0.000	0.000	0.000	No
Right Edge	0.000	0.000	0.000	No

Note: because the maximum SUM 10-g SAR ≤ 4.0 W/Kg, so the SPLSR analysis is not required.

For Combination NO.4

Test Position	5G Wi-Fi (W/Kg)	2.4GHz SRD (W/Kg)	SUM 10-g SAR (W/Kg)	SPLSR (Yes / No)
Front Surface	0.125	0.014	0.139	No
Back Surface	0.000	0.000	0.000	No
Top Edge	0.000	0.000	0.000	No
Bottom Edge	0.000	0.000	0.000	No
Left Edge	0.000	0.000	0.000	No
Right Edge	0.000	0.000	0.000	No

Note:
Because the maximum sum 10-g SAR is < 4.0 W/Kg, so the SPLSR is not required.

For Combination NO.5

Test Position	915MHz (W/Kg)	2.4GHz SRD (W/Kg)	SUM 10-g SAR (W/Kg)	SPLSR (Yes / No)
Front Surface	1.143	0.014	1.157	No
Back Surface	0.000	0.000	0.000	No
Top Edge	0.000	0.000	0.000	No
Bottom Edge	0.000	0.000	0.000	No
Left Edge	0.000	0.000	0.000	No
Right Edge	0.000	0.000	0.000	No

Note:
Because the maximum sum 10-g SAR is < 4.0 W/Kg, so the SPLSR is not required.

For Combination NO.6

Test Position	2.4G Wi-Fi (W/Kg)	915MHz (W/Kg)	2.4GHz SRD (W/Kg)	SUM 10-g SAR (W/Kg)	SPLSR (Yes / No)
Front Surface	1.541	1.143	0.014	2.698	No
Back Surface	0.000	0.000	0.000	0.000	No
Top Edge	0.000	0.000	0.000	0.000	No
Bottom Edge	0.000	0.000	0.000	0.000	No
Left Edge	0.000	0.000	0.000	0.000	No
Right Edge	0.000	0.000	0.000	0.000	No

Note:
Because the maximum sum 10-g SAR is < 4.0 W/Kg, so the SPLSR is not required.

For Combination NO.7

Test Position	5G Wi-Fi (W/Kg)	915MHz (W/Kg)	2.4GHz SRD (W/Kg)	SUM 10-g SAR (W/Kg)	SPLSR (Yes / No)
Front Surface	0.125	1.143	0.014	1.282	No
Back Surface	0.000	0.000	0.000	0.000	No
Top Edge	0.000	0.000	0.000	0.000	No
Bottom Edge	0.000	0.000	0.000	0.000	No
Left Edge	0.000	0.000	0.000	0.000	No
Right Edge	0.000	0.000	0.000	0.000	No

Note:
Because the maximum sum 10-g SAR is < 4.0 W/Kg, so the SPLSR is not required.

Appendixes

Refer to separated files for the following appendixes.

4788322398-2_App A Photo

4788322398-2_App B System Check Plot

4788322398-2_App C Highest Test Plot

4788322398-2_App D Cal. Certificates

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