SAR TEST REPORT

Test Report No.: 12429783S-A-R1

Applicant : **RICOH COMPANY, LTD.**

Type of Equipment : **Digital Camera**

Model No. : **R02020**

FCC ID : **BBP-R02020**

Test Standard : **FCC 47CFR §2.1093**

Test Result : **Complied**

Highest Reported SAR(1g) [W/kg]				Remarks (DTS band)				Remarks (UNII band)			
DTS band	UNII band	Type	Limit	Frequency [MHz]	Mode	Output power (average) [dBm]		Frequency [MHz]	Mode	Output power (average) [dBm]	
						Measured	Max.			Measured	Max
1.49	1.41	Body-worn	1.6	2412	11g(6Mbps)	12.11	13	5180	11n(20HT)(MCS0)	12.91	14

*. **Highest reported SAR of this device for body-worn and simultaneous transmission (Bluetooth + Wi-Fi(U-NII-1); 0.13 (estimated) + 1.41 = 1.54 W/kg) are "1.49 W/kg" and "1.54 W/kg".**

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7. The all test items in this test report are conducted by UL Japan, Inc. Shonan EMC Lab.
8. The opinions and the interpretations to the result of the description in this report are outside scopes where UL Japan has been accredited.
9. This report (-R1) is a revised version of 12429783-A. 12429783-A report is replaced with this report.

Date of test: August 29, September 5 and 6, 2018

Test engineer: H. Naka
Hiroshi Naka
Engineer, Consumer Technology Division

Approved by: T. Imamura
Toyokazu Imamura
Leader, Consumer Technology Division

☐ The testing in which "Non-accreditation" is displayed is outside the accreditation scopes in UL Japan.
☒ There is no testing item of "Non-accreditation".

RTL02610

REVISION HISTORY

Revision	Test report No.	Date	Page revised	Contents
Original	12429783S-A	October 10, 2018	-	-
-R1	12429783S-A-R1	February 8, 2019	p2,3	p2; add revised information, p3; power speacification (lower) was changed.

*. By issue of new revision report, the report of an old revision becomes invalid.

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Contents of appendixes

SECTION 1: Customer information

Company Name	RICOH COMPANY, LTD.
Brand Name	RICOH
Address	1-3-6 Nakamagome, Ohta-ku, Tokyo 143-8555, Japan
Telephone Number	+81-50-3534-5213
Contact Person	Kenji Daigo

SECTION 2: Equipment under test (EUT)

2.1 Identification of EUT and platform

Type of Equipment	Digital Camera
Model Number	R02020
Serial Number	YN100001060
Condition of EUT	Production prototype (Not for sale: This samples is equivalent to mass-produced items.)
Receipt Date of Sample	July 31, 2018 *. No modification by the Lab. (*. After power measurement, the RF wiring was changed to the original antenna line from the antenna conducted power measurement line for SAR test.)
Country of Mass-production	China
Category Identified	Portable device *.Since EUT may contact and/or very close to a human body during Wi-Fi operation, the partial-body SAR (1g) shall be observed.
Rating	DC 3.6V (Built-in Li-ion battery), DC 5V (USB BUS power operation) *. The EUT was operated by either the build-in re-chargeable Li-ion battery or USB BUS power via USB adaptor.
Feature of EUT	The EUT is a Digital Camera which support wireless LAN and Bluetooth 4.2.
SAR Accessory	None

2.2 Product Description (Wireless Module)

	Mode		channel	Operation frequency [MHz]	Data rate [Mbps]	Modulation	Channel spacing [MHz]	Band width [MHz]	Average power [dBm] Min.	Typical	Max.
Transmit average power (*. The measured Tx output power (antenna terminal conducted) refers to section 6 in this report.)	**Bluetooth (Ver.4.2)**	**BDR/EDR**	0~78	2402~2480	1~3	FHSS	1	1	**-3**	**0.2**	**4**
		Low energy	0~39	2402~2480	1	FHSS	2	2	**-3**	**0.2**	**4**
	IEEE 802.11b		1~11	2412~2462	1~11	DSSS	5	20	**8**	**11**	**13**
	IEEE 802.11g		1~11	2412~2462	6~54	OFDM	5	20	**8**	**11**	**13**
	IEEE 802.11n(20HT)		1~11	2412~2462	MCS0~7	OFDM	5	20	**8**	**11**	**13**
	IEEE 802.11a		36,40,44,48	5180~5240	6~54	OFDM	20	20	**9**	**12**	**14**
	IEEE 802.11n(20HT)		36,40,44,48	5180~5240	MCS0~7	OFDM	20	20	**9**	**12**	**14**
	IEEE 802.11ac(20VHT)		36,40,44,48	5180~5240	MCS0~8	OFDM	20	20	**9**	**12**	**14**
	IEEE 802.11n(40HT)		38,46	5190 5230	MCS0~7	OFDM	20	40	**9**	**12**	**14**
	IEEE 802.11ac(40VHT)		38,46	5190 5230	MCS0~9	OFDM	20	40	**9**	**12**	**14**
	IEEE 802.11ac(80VHT)		42	5210	MCS0~9	OFDM	20	80	**9**	**12**	**14**

Equipment type		Transceiver
Type of modulation	Bluetooth	FHSS: GFSK (*. EDR: GFSK+ π/4-DQPSK, GFSK+ 8DPSK)
	Wi-Fi	DSSS: DBPSK, DQPSK, CCK / OFDM: BPSK, QPSK, 16QAM, 64QAM, 256QAM (*.256QAM is supported by 11ac mode.)
Power supply		DC 1.3V, DC 1.8V, DC 3.0V (*. These power are supplied via constant voltage circuit.)

Quantity of Antenna	1 set (*1)		
Antenna type	Pattern antenna (λ/2 dipole antenna) + Parasitic element (Cu sheet)	Antenna connector type	MM5829-2700 <manufactured by Murata>
Antenna gain (Peak)	3.52 dBi (2.4GHz band), 2.87 dBi (5GHz band) (*.including cable loss)		

*. BLE: Bluetooth Low Energy; BDR: Basic Data Rate; EDR: Enhanced Data Rate.
*. The EUT do not use the special transmitting technique such as "beam-forming" and "time-space code diversity."
*. This Wireless module supports both Wi-Fi and Bluetooth. Wi-Fi of 2.4GHz and Bluetooth were not transmitted simultaneously. Wi-Fi of 5GHz and Bluetooth were transmitted simultaneously at same antenna. Therefore, simultaneously transmitted SAR was only considered for Wi-Fi of 5GHz band operation.
*1. The antenna is the combination of a pattern antenna and a parasitic element. SAR was measured when a pattern antenna and a parasitic element were normally functioning. Worst SAR was observed on a parasitic element near the exterior of the product.

SECTION 3: Test specification, procedures and results

3.1 Test specification

FCC47CFR 2.1093: Radiofrequency radiation exposure evaluation: portable devices.

The US Federal Communications Commission has released the report and order "Guidelines for Evaluating the Environmental Effects of RF Radiation", ET Docket No. 93-62 in August 1996. The order requires routine SAR evaluation prior to equipment authorization of portable transmitter devices, including portable telephones. For consumer products, the applicable limit is 1.6 mW/g for an uncontrolled environment and 8.0 mW/g for an occupational/controlled environment as recommended by the ANSI/IEEE standard C95.1-1992. The device should be evaluated at maximum output power (radiated from the antenna) under "worst-case" conditions for normal or intended use, incorporating normal antenna operating positions, device peak performance frequencies and positions for maximum RF energy coupling in accordance with the following measurement procedures.

KDB 447498 D01 (v06):	General RF exposure guidance
KDB 248227 D01 (v02r02):	SAR Guidance for IEEE 802.11 (Wi-Fi) transmitters
KDB 865664 D01 (v01r04):	SAR measurement 100MHz to 6GHz
IEEE Std. 1528-2013:	IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques.

3.2 Exposure limit

Environments of exposure limit	Whole-Body (averaged over the entire body)	Partial-Body (averaged over any 1g of tissue)	Hands, Wrists, Feet and Ankles (averaged over any 10g of tissue)
(A) Limits for Occupational /Controlled Exposure (W/kg)	0.4	8.0	20.0
(B) Limits for General population /Uncontrolled Exposure (W/kg)	0.08	**1.6**	4.0

***. Occupational/Controlled Environments:** are defined as locations where there is exposure that may be incurred by people who are aware of the potential for exposure, (i.e. as a result of employment or occupation).

***. General Population/Uncontrolled Environments:** are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure.

The limit applied in this test report is;

General population / uncontrolled exposure, Partial-Body (averaged over any 1g of tissue) limit: 1.6 W/kg

3.3 Procedures and Results

Test Procedure	SAR measurement; KDB 447498, KDB 248227, KDB 865664, IEEE Std.1528			
Category	FCC 47CFR §2.1093 (Portable device)		**SAR type**	Body touch

Band (Operation frequency [MHz])	**Bluetooth (BT)** (2402-2480)	**Wi-Fi (DTS)** (2412-2462)	**Wi-Fi (U-NII-1)** (5180~5240)	**Simultaneous transmission** (Bluetooth+Wi-Fi(U-NII-1)(*1)
Results (Reported SAR(1g))	SAR test: Not required (lower power)	**Complied**	**Complied**	**Complied**
SAR (1g) Limit [W/kg]	**1.6**	**1.6**	**1.6**	**1.6**
Reported SAR(1g) value	n/a	**1.49 W/kg**	**1.41 W/kg**	**1.54 W/kg** (BT: 0.13 W/kg (Estimated)+ Wi-Fi(U-NII-1): 1.41 W/kg)
Measured SAR value	n/a	1.20 W/kg	1.08 W/kg	(Refer to left column)
Mode, frequency[MHz]	(BLE, BDR, EDR)	g(6Mbps), 2412	n20(MCS0), 5180	(Refer to left column)
Duty cycle [%] (scaled factor)	-	99.5 (×1.01)	99.4 (×1.01)	(Refer to left column)
Output average power [dBm] (max. power, scaled factor)	max.power: 4 dBm (3mW)	12.11 (max.13, ×1.23)	12.91 (max.14, ×1.29)	(Refer to left column)

Note: UL Japan's SAR Work Procedures No.13-EM-W0429 and 13-EM-W0430. No addition, deviation nor exclusion has been made from standards

*. BLE: Bluetooth Low Energy; BDR: Basic Data Rate; EDR: Enhanced Data Rate; b: IEEE 802.11b, g: IEEE 802.11g, a: IEEE 802.11a, n20: IEEE 802.11n(20HT), n40: IEEE 802.11n(40HT), ac20: IEEE 802.11ac(20VHT), ac40: IEEE 802.11n(40VHT), ac80: IEEE 802.11ac(80VHT), n/a: not applied.

*1. This Wireless module supports both Wi-Fi and Bluetooth. Wi-Fi of 2.4GHz and Bluetooth were not transmitted simultaneously. Wi-Fi of 5GHz and Bluetooth were transmitted simultaneously at same antenna. Therefore, simultaneously transmitted SAR was only considered for Wi-Fi of 5GHz band operation.

*. (Calculating formula) Corrected SAR to max.power (W/kg) = (Measured SAR (W/kg)) × (Duty scaled) × (Tune-up factor)
where; Tune-up factor [-] = 1 / (10 ^ ("Δmax (max.power - burst average power), dB" / 10)), Duty scaled factor [-] = 100(%) / (duty cycle, %)

3.4 Test Location

UL Japan, Inc., Shonan EMC Lab.
1-22-3 Megumigaoka, Hiratsuka-shi, Kanagawa-ken 259-1220 JAPAN
Telephone number: +81 463 50 6400 / Facsimile number: +81 463 50 6401
JAB Accreditation No. RTL02610
FCC Test Firm Registration Number: 839876
*. Refers to next page for the test room which was used.

Used?	Place	IC Registration No.	Width x Depth x Height (m)	Size of reference ground plane (m) / horizontal conducting plane	Maximum measurement distance
☐	No.1 Semi-anechoic chamber	2973D-1	20.6 × 11.3 × 7.65	20.6 × 11.3	10 m
☐	No.2 Semi-anechoic chamber	2973D-2	20.6 × 11.3 × 7.65	20.6 × 11.3	10 m
☐	No.3 Semi-anechoic chamber	2973D-3	12.7 × 7.7 × 5.35	12.7 × 7.7	5 m
☐	No.4 Semi-anechoic chamber	-	8.1 × 5.1 × 3.55	8.1 × 5.1	-
☐	No.1 Shielded room	-	6.8 × 4.1 × 2.7	6.8 × 4.1	-
☐	No.2 Shielded room	-	6.8 × 4.1 × 2.7	6.8 × 4.1	-
☐	No.3 Shielded room	-	6.3 × 4.7 × 2.7	6.3 × 4.7	-
☐	No.4 Shielded room	-	4.4 × 4.7 × 2.7	4.4 × 4.7	-
☐	No.5 Shielded room	-	7.8 × 6.4 × 2.7	7.8 × 6.4	-
☐	No.6 Shielded room	-	7.8 × 6.4 × 2.7	7.8 × 6.4	-
☒	**No.7 Shielded room**	2973D-4	**2.76 × 3.76 × 2.4**	**2.76 × 3.76**	-
☐	No.8 Shielded room	-	3.45 × 5.5 × 2.4	3.45 × 5.5	-
☐	No.1 Measurement room	-	2.55 × 4.1 × 2.5	2.55 × 4.1	-

3.5 Confirmation before SAR testing

Average power for SAR tests

Before SAR test, the RF wiring for the sample had been switched to the antenna conducted power measurement line from the antenna line and the average power was measured. The result is shown in Section 6.

*. The EUT transmission power was verified that it was within 2dB lower than the maximum tune-up tolerance limit when it was set the rated power. (Clause 4.1, KDB447498 D01 (v06))

Step.1 Data rate check (*. The power measurement was applied to the following data rate in each operation mode.)

802.11b		802.11g		802.11a		802.11n(20HT) (1×SS)			802.11n(40HT) (1×SS)			Bluetooth		
Modulation	Data rate	Modulation	Data rate	Modulation	Data rate	MCS Index	Data rate	Modulation	MCS Index	Data rate	Modulation	Type	Modulation	Packet type
DBPSK/DSSS	1	BPSK/OFDM	6	BPSK/OFDM	6	0	6.5	BPSK/OFDM	0	13.5	BPSK/OFDM	BLE	GFSK/FHSS	BLE (1Mbps)
DQPSK/DSSS	2	BPSK/OFDM	9	BPSK/OFDM	9	1	13	QPSK/OFDM	1	27	QPSK/OFDM	BDR	GFSK/FHSS	DH5 (1Mbps)
CCK/DSSS	5.5	QPSK/OFDM	12	QPSK/OFDM	12	2	19.5	QPSK/OFDM	2	40.5	QPSK/OFDM	EDR2	π/4-DQPSK/FHSS	2-DH5 (2Mbps)
CCK/DSSS	11	QPSK/OFDM	18	QPSK/OFDM	18	3	26	16QAM/OFDM	3	54	16QAM/OFDM	EDR3	8DPSK/FSSS	3-DH5 (3Mbps)
Data rate: [Mbps]		16QAM/OFDM	24	16QAM/OFDM	24	4	39	16QAM/OFDM	4	81	16QAM/OFDM			
SS: Spatial Stream		16QAM/OFDM	36	16QAM/OFDM	36	5	52	64QAM/OFDM	5	108	64QAM/OFDM			
		64QAM/OFDM	48	64QAM/OFDM	48	6	58.5	64QAM/OFDM	6	121.5	64QAM/OFDM			
		64QAM/OFDM	54	64QAM/OFDM	54	7	65	64QAM/OFDM	7	135	64QAM/OFDM			

802.11ac(VHT20) (1×SS)				802.11ac(VHT40) (1×SS)				802.11ac(VHT80) (1×SS)			
MCS	Modulation	MCS	Modulation	MCS	Modulation	MCS	Modulation	MCS	Modulation	MCS	Modulation
0	BPSK/OFDM	5	64QAM/OFDM	0	BPSK/OFDM	5	64QAM/OFDM	0	BPSK/OFDM	5	64QAM/OFDM
1	QPSK/OFDM	6	64QAM/OFDM	1	QPSK/OFDM	6	64QAM/OFDM	1	QPSK/OFDM	6	64QAM/OFDM
2	QPSK/OFDM	7	64QAM/OFDM	2	QPSK/OFDM	7	64QAM/OFDM	2	QPSK/OFDM	7	64QAM/OFDM
3	16QAM/OFDM	8	256QAM/OFDM	3	16QAM/OFDM	8	256QAM/OFDM	3	16QAM/OFDM	8	256QAM/OFDM
4	16QAM/OFDM			4	16QAM/OFDM	9	256QAM/OFDM	4	16QAM/OFDM	9	256QAM/OFDM

Step.2 Consideration of SAR test channel

For the SAR test reference, on each operation band, the average output power was measured on the lower/middle/upper and specified channels with the worst data rate condition.

3.6 Confirmation after SAR testing

It was checked that the power drift [W] is within ±5% in the evaluation procedure of SAR testing. The verification of power drift during the SAR test is that DASY5 system calculates the power drift by measuring the e-filed at the same location at beginning and the end of the scan measurement for each test position.
The result is shown in APPENDIX 2.

*. DASY5 system calculation Power drift value[dB] =20log(Ea)/(Eb) (where, Before SAR testing: Eb[V/m] / After SAR testing: Ea[V/m])
Limit of power drift[W] = ±5%
Power drift limit (X) [dB] = 10log(P_drift)=10log(1.05/1)=10log(1.05)-10log(1)=0.21dB
from E-filed relations with power.
S=E×H=E^2/η=P/(4×π×r^2) (η: Space impedance) → P=(E^2×4×π×r^2)/η
Therefore, The correlation of power and the E-filed
Power drift limit (X) dB=10log(P_drift)=10log(E_drift)^2=20log(E_drift)
From the above mentioned, **the calculated power drift of DASY5 system must be the less than ±0.21dB.**

3.7 Test setup of EUT and SAR measurement procedure

Antenna separation distances in each test setup plan are shown as follows.

	Mode:	Wi-Fi (*1)		Bluetooth (*2)		
Setup plan	**Explanation of SAR test setup plan** (*. Refer to Appendix 1 for test setup photographs which had been tested.)	**D [mm]**	**SAR Tested /Reduced**	**D [mm]**	**SAR Tested /Reduced**	**SAR type**
Top	A center of top surface on a camera is touched to the Flat phantom.	**1.42**	**Tested**	**1.42**	*Reduced*	Body-touch
Top-left	A left portion of top surface on a camera is touched to the Flat phantom.	**1.42**	**Tested**	**1.42**	*Reduced*	
Front-top	A top portion of front surface on a camera is touched to the Flat phantom.	**4.8**	**Tested**	**4.8**	*Reduced*	
Back-top	A top portion of back surface on a camera is touched to the Flat phantom.	**4.8**	**Tested**	**4.8**	*Reduced*	
Right	A right surface of camera is touched to the Flat phantom.	**5.77**	**Tested**	**5.77**	*Reduced*	
Left	A left surface of camera is touched to the Flat phantom.	**5.77**	**Tested**	**5.77**	*Reduced*	
Front	A height (lens) in the front surface on a camera is touched to the Flat phantom.	**≈10**	**Tested**	**≈10**	*Reduced*	
Back	A height (lens) in the back surface on a camera is touched to the Flat phantom.	**≈10**	**Tested**	**≈10**	*Reduced*	
Bottom	A bottom surface of camera is touched to the Flat phantom.	**>50**	*Reduced*	**>50**	*Reduced*	

*. **D:** Antenna separation distance. It is the distance from the antenna to the outer surface of platform which an operator may touch.
*. Size of EUT: 48.0 mm (width) × 132.9 mm (height) × 29.644 mm (thickness)

<u>*. Consideration for SAR evaluation exemption</u>

SAR test exclusion considerations according to KDB447498 D01
The following is based on KDB447498D01.

Step 1) The 1-g 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 SAR(1g)), 7.5(for SAR(10g)) ··· formula (1)
If power is calculated from the upper formula (1);
[SAR(1g) test exclusion thresholds, mW] = 3 × [test separation distance, mm] / [√f (GHz)]··························· formula (2)

1. The upper frequency of the frequency band was used in order to calculate standalone SAR test exclusion considerations.
2. Power and distance are rounded to the nearest mW and mm before calculation
3. The result is rounded to one decimal place for comparison
4. The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

When the calculated threshold value by a numerical formula above-mentioned in the following table is 3.0 or less, SAR test can be excluded.

Step 2) At 1500 MHz to 6 GHz and for test separation distances > 50 mm, the SAR test exclusion threshold is determined according to the following,
[test exclusion thresholds, mW] = [(Power allowed at numeric threshold for 50mm in formula (1))] + [(test separation distance, mm) - (50mm)] × 10 · formula (3)

1. The upper frequency of the frequency band was used in order to calculate standalone SAR test exclusion considerations.
2. Power and distance are rounded to the nearest mW and mm before calculation

When output power is less than the calculated threshold value by a numerical formula above-mentioned in the following table, SAR test is excluded.

[SAR exclusion calculations for step 1) antenna ≤50mm from the user, and for step 2) antenna > 50mm from the user.]

					Step 1) SAR exclusion calculations for antenna ≤50mm from the user.					Step 2) > 50mm from the user
					Calculated threshold value					
Band	Tx mode	Upper Frequency [MHz]	Maximum output power		Setup	Top, Top-left	Front-top, Back-top	Right, Left	Front, Back	Bottom
			[dBm]	[mW]	D[mm]	≤5 (1.42)	5	6	10	>50
2.4GHz	BLE	2480	4	3	Judge	0.9, Reduce	0.9, Reduce	0.8, Reduce	0.5, Reduce	≥96mW (50mm), Reduce
2.4GHz	b,g,n20	2462	13	20	Judge	**<u>6.3, Measure</u>**	**<u>6.3, Measure</u>**	**<u>5.2, Measure</u>**	**<u>3.1, Measure</u>**	≥96mW (50mm), Reduce
U-NII-1	a,n20/40,ac20/40/80	5240	14	25	Judge	**<u>11.4, Measure</u>**	**<u>11.4, Measure</u>**	**<u>9.5, Measure</u>**	**<u>5.7, Measure</u>**	≥96mW (50mm), Reduce

*. D: Antenna separation distance, BLE: Bluetooth Low Energy, b: IEEE 802.11b, g: IEEE 802.11g, a: IEEE 802.11a, n20: IEEE 802.11n(20HT), n40: IEEE 802.11n(40HT), ac20: IEEE 802.11ac(20VHT), ac40: IEEE 802.11n(40VHT), ac80: IEEE 802.11ac(80VHT)

<u><Conclusion for consideration for SAR test reduction></u>

1) For Wi-Fi operation, near an antenna section ("Top", "Top-left", "Front-top", "Back-top", "Right", "Left", "Front" and "Back" setup) is applied the SAR test in body-liquid. The SAR test of "Bottom" setup is reduced because the SAR test exclusion judge value are smaller than "3" and they have enough antenna separation distance (more than 100 mm).
2) For Bluetooth operation, the SAR test is reduced for all SAR setups, because the SAR test exclusion judge value are smaller than "3."
3) The SAR test of front-of-face (tested by head liquid) wasn't considered, because this EUT does not use with touching the human head.
4) The all SAR tests were conservatively performed with test separation distance 0mm.

By the determined test setup shown above, the SAR test was applied in the following procedures.

Step 1	On 2.4GHz band, in body liquid, worst SAR search by DSSS mode with a highest measurement output power channel. Add test for OFDM mode, if it's necessary.
Step 2	On U-NII-2A band, in body liquid, worst SAR search by largest channel bandwidth mode with a highest measurement output power channel. Add test for other bandwidth mode, if it's necessary.

*. During SAR test, the radiated power is always monitored by Spectrum Analyzer.

SECTION 4: Operation of EUT during testing

4.1 Operation mode for SAR testing

The EUT has Bluetooth (BDR, EDR, Low energy) and IEEE 802.11b, g, a, n(20HT), n(40HT), ac(20VHT), ac(40VHT) and ac(80VHT) continuous transmitting modes. The frequency and the modulation used in the SAR testing are shown as a following.

Operation mode	BDR	EDR	LE	b		g	n20	a	n20	ac20	n40	ac40	ac80
band	Bluetooth			2.4GHz band				U-NII-1					
Tx band [MHz]	2402~2480			2412~2462				5180~5240			5190, 5230		5210
Bandwidth [MHz]	1	1	2	20		20	20	20	20	20	40	40	80
Max.power [dBm]	4	4	4	13		13	13	14	14	14	14	14	14
Modulation	FHSS	FHSS	FHSS	DSSS		OFDM	OFDM	OFDM	OFDM	OFDM	OFDM	OFDM	OFDM
Data rate [Mbps]	1	2,3	1	1	5.5Short	6	MCS0	MCS0	6	MCS0	MCS0	MCS0	MCS0
Frequency tested [MHz]	n/a (*.SAR reduction applied.)	n/a (*.SAR reduction applied.)	n/a (*.SAR reduction applied.)	2412, 2437, 2462 (*1)	2462 (*2)	2412, 2437, 2462 (*1)	2412, 2437, 2462 (*1)	5180, 5220, 5240 (*3)	5180, 5200, 5220, 5240 (*3)	5180, 5220, 5240 (*3)	5190, 5230 (*3)	5190, 5230 (*3)	5210 (*3)

Control software		
	Power measurement	BLE/BDR/EDR: R02020 BT RF TEST Version 1 (test 6), Wi-Fi: R02020 WLAN RF TEST Version 1 (test 8)
	SAR	R02020 Camera firmware version: 07020018(0803)

SAR test reduction consideration

[Table 1. Output power and Body-SAR test channel selection and Reported SAR(1g) [W/kg] (Results) and test reduction plan]

802.11 Modes	b	g	n20)	a	n20	ac20	n40	ac40	ac80
Data rate [Mbps]	1	6	MCS0	6	MCS0	MCS0	MCS0	MCS0	MCS0
2.4GHz, Ch.	*1* / *6* / *11*	*1* / *6* / *11*	*1* / *6* / *11*						
Max. power [mW]	20 / 20 / 20	20 / 20 / 20	20 / 20 / 20						
Measured Ave. [mW]	16 / 16 / 16	17 / 17 / 17	16 / 17 / 17						
Reported SAR 1g	**1.45 / 1.36 / 1.30**	**1.49 / 1.39 / 1.35**	**1.44 / 1.38 / 1.36**						
U-NII-1, Ch.				*36* / *40* / *44* / *48*	*36* / *40* / *44* / *48*	*36* / *40* / *44* / *48*	*38* / *46*	*38* / *46*	*42*
Max. power [mW]				25 / 25 / 25 / 25	25 / 25 / 25 / 25	25 / 25 / 25 / 25	25 / 25	25 / 25	25
Measured Ave. [mW]				20 / 20 / 19 / 19	20 / 19 / 19 / 19	20 / 20 / 19 / 19	17 / 17	17 / 17	19
Reported SAR 1g				**1.40 / 1.35 / 1.39**	**1.41 / 1.38 / 1.30 / 1.38**	**1.39 / 1.34 / 1.41**	**1.39 / 1.34**	**1.37 / 1.35**	**1.37**

*. D/R: Data rate, n/a: not applied; BLE: Bluetooth Low Energy; BDR: Basic Data Rate; EDR: Enhanced Data Rate; b: IEEE 802.11b, g: IEEE 802.11g, a: IEEE 802.11a, n20: IEEE 802.11n(20HT), n40: IEEE 802.11n(40HT), ac20: IEEE 802.11ac(20VHT), ac40: IEEE 802.11n(40VHT), ac80: IEEE 802.11ac(80VHT)

*1. For 2.4GHz band, since reported SAR1g value of DSSS mode was over than 1.2W/kg in the "Initial test position", SAR test was applied to all mode with all required SAR test channel.

*2. This channel has the maximum measured time-average power of DSSS mode. However, the reported SAR1g of lowest data rate was higher than this data rate. The SAR test of DSSS mode was applied to the lowest data rate.

*3. For 5GHz band, since reported SAR1g value of largest bandwidth mode was over than 1.2W/kg in the "Initial test position", SAR test was applied to all mode with all required SAR test channel.

SECTION 5: Uncertainty Assessment (SAR measurement)

Uncertainty of SAR measurement (2.4-6GHz) (*.ε&σ: ≤ ± 5%, DAK3.5, Tx: ≈100% duty cycle) (v08)	1g SAR	10g SAR
Combined measurement uncertainty of the measurement system (k=1)	± 13.7%	± 13.6%
Expanded uncertainty (k=2)	± 27.4%	± 27.2%

	Error Description (2.4-6GHz) (v08)	Uncertainty Value	Probability distribution	Divisor	ci (1g)	ci (10g)	ui (1g)	ui (10g)	Vi, veff
A	**Measurement System** (DASY5)						(std. uncertainty)	(std. uncertainty)	
1	Probe Calibration Error	±6.55 %	Normal	1	1	1	±6.55 %	±6.55 %	∞
2	Axial isotropy Error	±4.7 %	Rectangular	√3	√0.5	√0.5	±1.9 %	±1.9 %	∞
3	Hemispherical isotropy Error	±9.6 %	Rectangular	√3	√0.5	√0.5	±3.9 %	±3.9 %	∞
4	Linearity Error	±4.7 %	Rectangular	√3	1	1	±2.7 %	±2.7 %	∞
5	Probe modulation response	±2.4 %	Rectangular	√3	1	1	±1.4 %	±1.4 %	∞
6	Sensitivity Error (detection limit)	±1.0 %	Rectangular	√3	1	1	±0.6 %	±0.6 %	∞
7	Boundary effects Error	±4.3%	Rectangular	√3	1	1	±2.5 %	±2.5 %	∞
8	Readout Electronics Error(DAE)	±0.3 %	Rectangular	√3	1	1	±0.3 %	±0.3 %	∞
9	Response Time Error	±0.8 %	Normal	1	1	1	±0.8 %	±0.8 %	∞
10	Integration Time Error (≈100% duty cycle)	±0 %	Rectangular	√3	1	1	0 %	0 %	∞
11	RF ambient conditions-noise	±3.0 %	Rectangular	√3	1	1	±1.7 %	±1.7 %	∞
12	RF ambient conditions-reflections	±3.0 %	Rectangular	√3	1	1	±1.7 %	±1.7 %	∞
13	Probe positioner mechanical tolerance	±3.3 %	Rectangular	√3	1	1	±1.9 %	±1.9 %	∞
14	Probe Positioning with respect to phantom shell	±6.7 %	Rectangular	√3	1	1	±3.9 %	±3.9 %	∞
15	Max. SAR evaluation (Post-processing)	±4.0 %	Rectangular	√3	1	1	±2.3 %	±2.3 %	∞
B	**Test Sample Related**								
16	Device Holder or Positioner Tolerance	±3.6 %	Normal	1	1	1	±3.6 %	±3.6 %	5
17	Test Sample Positioning Error	±5.0 %	Normal	1	1	1	±5.0 %	±5.0 %	145
18	Power scaling	±0%	Rectangular	√3	1	1	±0 %	±0 %	∞
19	Drift of output power (measured, <0.2dB)	±2.3%	Rectangular	√3	1	1	±2.9 %	±2.9 %	∞
C	**Phantom and Setup**								
20	Phantom uncertainty (shape, thickness tolerances)	±7.5 %	Rectangular	√3	1	1	±4.3 %	±4.3 %	∞
21	Algorithm for correcting SAR (e',σ: ≤5%)	±1.2 %	Normal	1	1	0.84	±1.2 %	±0.97 %	∞
22	Measurement Liquid Conductivity Error (DAK3.5)	±3.0 %	Normal	1	0.78	0.71	±2.3 %	±2.1 %	7
23	Measurement Liquid Permittivity Error (DAK3.5)	±3.1 %	Normal	1	0.23	0.26	±0.7 %	±0.8 %	7
24	Liquid Conductivity-temp.uncertainty (≤2deg.C.)	±5.3 %	Rectangular	√3	0.78	0.71	±2.4 %	±2.2 %	∞
25	Liquid Permittivity-temp.uncertainty (≤2deg.C.)	±0.9 %	Rectangular	√3	0.23	0.26	±0.1 %	±0.1 %	∞
	Combined Standard Uncertainty						**±13.7** %	**±13.6** %	733
	Expanded Uncertainty (k=2)						**±27.4 %**	**±27.2 %**	

*. Table of uncertainties are listed for ISO/IEC 17025.
*. This measurement uncertainty budget is suggested by IEEE Std.1528(2013) and determined by Schmid & Partner Engineering AG (DASY5 Uncertainty Budget). Per KDB 865664 D01 (v01r04) SAR Measurement 100 MHz to 6 GHz Section 2.8.1., when the highest measured SAR(1g) within a frequency band is < 1.5W/kg, the extensive SAR measurement uncertainty analysis described in IEEE Std.1528 (2013) is not required in SAR reports submitted for equipment approval.

SECTION 6: Confirmation before testing

6.1 SAR reference power measurement (*. Antenna terminal conducted average power of EUT)

*. Antenna gain (peak): +3.52 dBi (2.4GHz band), +2.87 dBi (5GHz band)

Mode	Frequency		Data rate	Power Setting (software)	Duty cycle	Duty factor	Duty scaled factor	Measurement Result				Power correction			Power Tune-up?	Remarks
								Time average power		Burst power		Max. power	Δ from max.	Tune-up factor		
	[MHz]	CH	[Mbps]	[-]	[%]	[dB]	[-]	[dBm]	[mW]	[dBm]	[mW]	[dBm]	[dB]	[-]		
BLE	2402	0	1	Mid,-2.4	66.1	1.80	×1.51	1.45	1.40	**3.25**	2.11	4	-0.75	×1.19	tuning	(*1)
	2440	19		Mid,-2.4	66.1	1.80	×1.51	2.10	1.62	**3.90**	2.45	4	-0.10	×1.02	tuning	(*1)
	2480	39		Mid,-2.4	66.1	1.80	×1.51	-1.01	0.79	**0.79**	1.20	4	-3.21	×2.09	tuning	(*1)
BDR	2402	0	1 (DH5)	SAR,-2.4	77.7	1.10	×1.29	2.39	1.73	**3.49**	2.23	4	-0.51	×1.12	tuning	(*1)
	2441	39		SAR,-2.4	77.7	1.10	×1.29	2.89	1.95	**3.99**	2.51	4	-0.01	×1.00	tuning	(*1)
	2480	78		SAR,-2.4	77.7	1.10	×1.29	-0.15	0.97	**0.95**	1.24	4	-3.05	×2.02	tuning	(*1)
EDR	2402	0	2 (2-DH5)	SAR,-0.8	77.7	1.10	×1.29	1.84	1.53	**2.94**	1.97	4	-1.06	×1.28	tuning	(*1)
	2441	39		SAR,-0.8	77.7	1.10	×1.29	2.47	1.77	**3.57**	2.28	4	-0.43	×1.10	tuning	(*1)
	2480	78		SAR,-0.8	77.7	1.10	×1.29	-0.69	0.85	**0.41**	1.10	4	-3.59	×2.29	tuning	(*1)
EDR	2402	0	3 (3-DH5)	SAR,-0.8	77.7	1.10	×1.29	1.91	1.55	**3.01**	2.00	4	-0.99	×1.26	tuning	(*1)
	2441	39		SAR,-0.8	77.7	1.10	×1.29	2.36	1.72	**3.46**	2.22	4	-0.54	×1.13	tuning	(*1)
	2480	78		SAR,-0.8	77.7	1.10	×1.29	-0.57	0.88	**0.53**	1.13	4	-3.47	×2.22	tuning	(*1)
b	2412	1	1	EMC,13	99.95	0.00	×1.00	12.01	15.89	**12.01**	15.89	13	-0.99	×1.26	tuning	*.Payload=756
	2437	6	1	EMC,13	99.95	0.00	×1.00	12.03	15.96	**12.03**	15.96	13	-0.97	×1.25	tuning	*.Payload=756
	2462	11	1	EMC,13	99.95	0.00	×1.00	12.06	16.07	**12.06**	16.07	13	-0.94	×1.24	tuning	*.Payload=756
b	2412	1	5.5short	EMC,13	99.6	0.02	×1.00	12.26	16.83	**12.28**	16.90	13	-0.72	×1.18	tuning	*.Payload=756
	2437	6	5.5short	EMC,13	99.6	0.02	×1.00	12.30	16.98	**12.32**	17.06	13	-0.68	×1.17	tuning	*.Payload=756
	2462	11	5.5short	EMC,13	99.6	0.02	×1.00	12.36	17.22	**12.38**	17.30	13	-0.62	×1.15	tuning	*.Payload=756
g	2412	1	6	EMC,13	99.5	0.02	×1.01	12.09	16.18	**12.11**	16.26	13	-0.89	×1.23	tuning	*.Payload=756
	2437	6	6	EMC,13	99.5	0.02	×1.01	12.09	16.18	**12.11**	16.26	13	-0.89	×1.23	tuning	*.Payload=756
	2462	11	6	EMC,13	99.5	0.02	×1.01	12.21	16.63	**12.23**	16.71	13	-0.77	×1.19	tuning	*.Payload=756
n20	2412	1	MCS0	EMC,13	99.4	0.03	×1.01	12.13	16.33	**12.16**	16.44	13	-0.84	×1.21	tuning	*.Payload=756
	2437	6	MCS0	EMC,13	99.4	0.03	×1.01	12.17	16.48	**12.20**	16.60	13	-0.80	×1.20	tuning	*.Payload=756
	2462	11	MCS0	EMC,13	99.4	0.03	×1.01	12.24	16.75	**12.27**	16.87	13	-0.73	×1.18	tuning	*.Payload=756
a	5180	36	6	SAR,13	99.5	0.02	×1.00	12.93	19.63	**12.95**	19.72	14	-1.05	×1.27	tuning	*.Payload=756
	5200	40	6	SAR,13	99.5	0.02	×1.00	12.93	19.63	**12.95**	19.72	14	-1.05	×1.27	tuning	*.Payload=756
	5220	44	6	SAR,13	99.5	0.02	×1.00	12.82	19.14	**12.84**	19.23	14	-1.16	×1.31	tuning	*.Payload=756
	5240	48	6	SAR,13	99.5	0.02	×1.00	12.81	19.10	**12.83**	19.19	14	-1.17	×1.31	tuning	*.Payload=756
n20	5180	36	MCS0	SAR,13	99.4	0.03	×1.01	12.88	19.41	**12.91**	19.54	14	-1.09	×1.29	tuning	*.Payload=756
	5200	40	MCS0	SAR,13	99.4	0.03	×1.01	12.86	19.32	**12.89**	19.45	14	-1.11	×1.29	tuning	*.Payload=756
	5220	44	MCS0	SAR,13	99.4	0.03	×1.01	12.86	19.32	**12.89**	19.45	14	-1.11	×1.29	tuning	*.Payload=756
	5240	48	MCS0	SAR,13	99.4	0.03	×1.01	12.84	19.23	**12.87**	19.36	14	-1.13	×1.30	tuning	*.Payload=756
ac20	5180	36	MCS0	SAR,13	99.5	0.02	×1.01	12.96	19.77	**12.98**	19.86	14	-1.02	×1.26	tuning	*.Payload=756
	5200	40	MCS0	SAR,13	99.5	0.02	×1.01	12.92	19.59	**12.94**	19.68	14	-1.06	×1.28	tuning	*.Payload=756
	5220	44	MCS0	SAR,13	99.5	0.02	×1.01	12.86	19.32	**12.88**	19.41	14	-1.12	×1.29	tuning	*.Payload=756
	5240	48	MCS0	SAR,13	99.5	0.02	×1.01	12.84	19.23	**12.86**	19.32	14	-1.14	×1.30	tuning	*.Payload=756
n40	5190	38	MCS0	SAR,14	98.6	0.06	×1.01	12.26	16.83	**12.32**	17.06	14	-1.68	×1.47	tuning	*.Payload=756
	5230	46	MCS0	SAR,14	98.6	0.06	×1.01	12.30	16.98	**12.36**	17.22	14	-1.64	×1.46	tuning	*.Payload=756
ac40	5190	38	MCS0	SAR,14	98.7	0.06	×1.01	12.28	16.90	**12.34**	17.14	14	-1.66	×1.47	tuning	*.Payload=756
	5230	46	MCS0	SAR,14	98.7	0.06	×1.01	12.29	16.94	**12.35**	17.18	14	-1.65	×1.46	tuning	*.Payload=756
ac80	5210	42	MCS0	SAR,14	97.1	0.13	×1.03	12.64	18.37	**12.77**	18.92	14	-1.23	×1.33	tuning	*.Payload=756

*. : SAR test was applied. *. xx.xx highlight is shown the higher measured output power in each operation mode, in each band. n/a: not applied.

*1. The measured duty cycle number of BLE, BDR and EDR was nearly equal to highest theory duty cycle.

*. The SAR test power of Wi-Fi mode was adjusted to not more than 2dB lower than maximum tune-up power (KDB 447498 D01 (v06) requirement).

*. Preliminary tests were performed in different data rate and data rate associated with the highest power were chosen for full test in following tables.

Data rate (D/R) vs Time average power (dBm) (*.The bold character shows the data rate which has the highest measured power.)

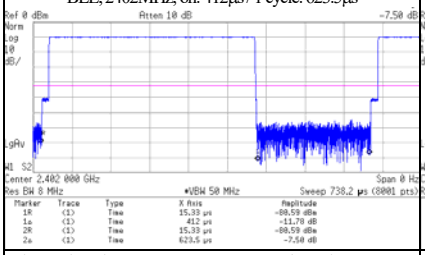
11b		11g		11n(20HT)		11a		11n(20HT)		11ac(20VHT)		11n(40HT)		11ac(40VHT)		11ac(80VHT)	
2412MHz		2412MHz		2412MHz		5180MHz		5180MHz		5180MHz		5190MHz		5190MHz		5210MHz	
D/R	Power	D/R	Power	D/R	Power	D/R	Power	D/R	Power	D/R	Power	D/R	Power	D/R	Power	D/R	Power
[Mbps]	**13**max	[Mbps]	**13**max	[Mbps]	**13**max	[Mbps]	**14**max	[Mbps]	**14**max	[Mbps]	**14**max	[Mbps]	**14**max	[Mbps]	**14**max	[Mbps]	**14**max
1	12.01	**6**	**12.09**	**MCS0**	**12.13**	**6**	**12.93**	**MCS0**	**12.88**	**MCS0**	**12.96**	**MCS0**	**12.26**	**MCS0**	**12.28**	**MCS0**	**12.64**
2 Long	11.93	9	12.03	MCS1	12.09	9	12.88	MCS1	12.85	MCS1	12.92	MCS1	12.25	MCS1	12.25	MCS1	12.49
5.5 Long	12.03	12	12.04	MCS2	12.08	12	12.87	MCS2	12.82	MCS2	12.87	MCS2	12.23	MCS2	12.20	MCS2	12.43
11 Long	11.98	18	11.99	MCS3	12.02	18	12.84	MCS3	12.77	MCS3	12.82	MCS3	12.20	MCS3	12.07	MCS3	12.28
2 Short	12.17	24	11.97	MCS4	11.98	24	12.73	MCS4	12.67	MCS4	12.64	MCS4	12.15	MCS4	12.05	MCS4	12.22
5.5 Short	**12.26**	36	11.92	MCS5	11.96	36	12.65	MCS5	12.63	MCS5	12.62	MCS5	12.07	MCS5	12.02	MCS5	12.12
11 Short	12.22	48	11.89	MCS6	11.92	48	12.60	MCS6	12.61	MCS6	12.61	MCS6	11.94	MCS6	11.94	MCS6	12.10
*. SAR test was applied to 11b mode with lowest data rate.		56	11.86	MCS7	11.89	56	12.57	MCS7	12.60	MCS7	12.58	MCS7	11.92	MCS7	11.89	MCS7	12.08
										MCS8	12.52			MCS8	11.83	MCS8	12.06
														MCS9	11.83	MCS9	12.04

*. CH: channel, Max: Maximum. D/R: Data Rate.

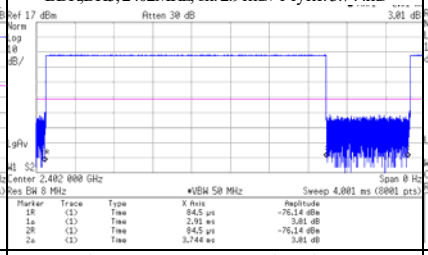
*.Calculating formula: Result-Time average power (dBm) = (P/M Reading, dBm)+(Cable loss, dB)+(Attenuator, dB)
Result-Burst power (dBm) (*.equal to 100% duty cycle) = (P/M Reading, dBm)+(Cable loss, dB)+(Attenuator, dB)+(duty factor, dB)
Duty factor (dBm) = 10 × log (100/(duty cycle, %))
Δ form max. (dB) = (Results-Burst power (average, dBm)) - (Max.-specification output power (average, dBm))
Duty scaled factor (Duty cycle correction factor for obtained SAR value) (unit: (-)) = 100(%) / (duty cycle, %)
Tune-up factor (Power tune-up factor for obtained SAR value) (unit: (-)) = 1 / (10 ^ ("Deviation from max., dB" / 10))

*. Date measured: August 1~3 and 21, 2018 / Measured by: Hiroshi Naka / Place: preparation room of No. 7 shielded room. ((24~25) deg.C. / (50~60) %RH)
*. Uncertainty of antenna port conducted test; Power measurement uncertainty above 1GHz for this test was: (±) 0.48 dB(Average)/(±) 0.66 dB(Peak).
*. Uncertainty of antenna port conducted test; Duty cycle and time measurement: (±) 0.012 %.
*. Chart of the worst duty cycle for each operation mode.

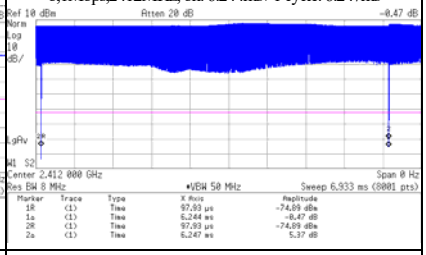
BLE, 2402MHz; on: 412µs / 1 cycle: 623.5µs



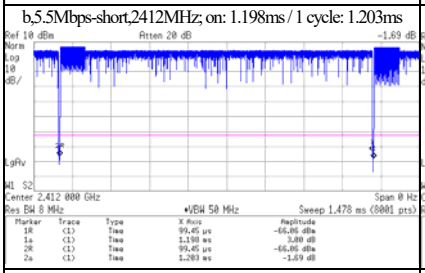
BDR,DH5, 2402MHz; on: 2.91ms / 1 cycle: 3.744ms



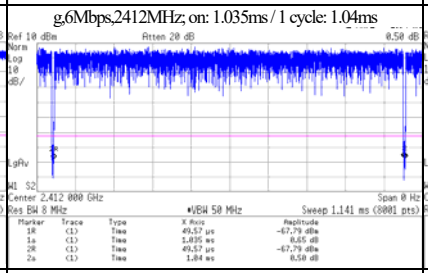
b,1Mbps,2412MHz; on: 6.244ms / 1 cycle: 6.247ms



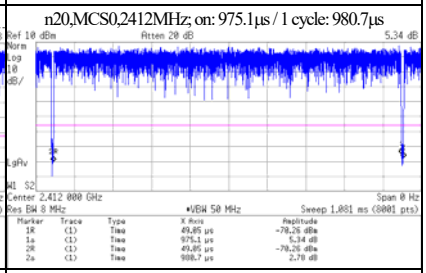
b,5.5Mbps-short,2412MHz; on: 1.198ms / 1 cycle: 1.203ms



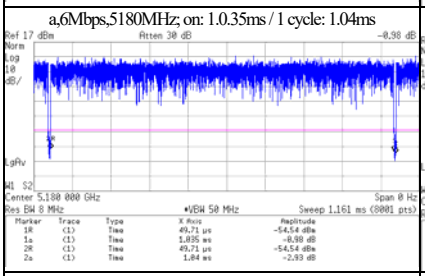
g,6Mbps,2412MHz; on: 1.035ms / 1 cycle: 1.04ms



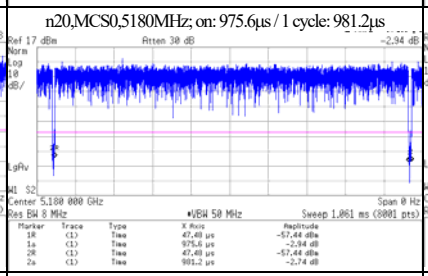
n20,MCS0,2412MHz; on: 975.1µs / 1 cycle: 980.7µs



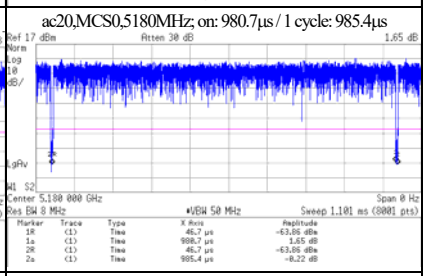
a,6Mbps,5180MHz; on: 1.0.35ms / 1 cycle: 1.04ms



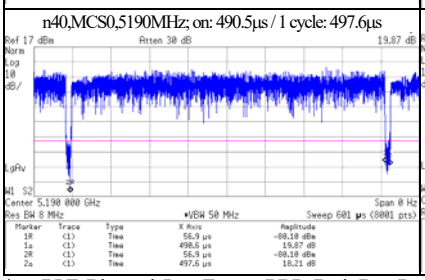
n20,MCS0,5180MHz; on: 975.6µs / 1 cycle: 981.2µs



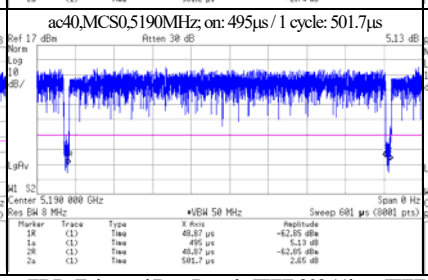
ac20,MCS0,5180MHz; on: 980.7µs / 1 cycle: 985.4µs



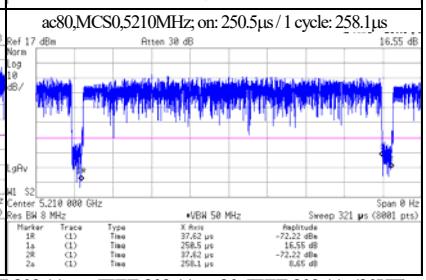
n40,MCS0,5190MHz; on: 490.5µs / 1 cycle: 497.6µs



ac40,MCS0,5190MHz; on: 495µs / 1 cycle: 501.7µs



ac80,MCS0,5210MHz; on: 250.5µs / 1 cycle: 258.1µs



*. BLE: Bluetooth Low Energy; BDR: Basic Data Rate; EDR: Enhanced Data Rate; b: IEEE 802.11b, g: IEEE 802.11g, a: IEEE 802.11a, n20: IEEE 802.11n(20HT), n40: IEEE 802.11n(40HT), ac20: IEEE 802.11ac(20VHT), ac40: IEEE 802.11n(40VHT), ac80: IEEE 802.11ac(80VHT)

SECTION 7: SAR Measurement results

Measurement date: August 29, September 5 and 6, 2018 Measurement by: Hiroshi Naka

[Measured and Reported (Scaled) SAR results]

SAR measurement results										Reported SAR (1g) [W/kg]						
Mode	Frequency [MHz] (Channel)	Data rate [Mbps]	EUT setup: Position	EUT setup: Gap [mm]	EUT setup: Source power	SAR (1g) [W/kg] Max. value of multi-peak: Meas.	SAR (1g) [W/kg] Max. value of multi-peak: ΔSAR [%]	SAR (1g) [W/kg] Max. value of multi-peak: ΔSAR corrected	SAR plot # in Appendix 2-2	Duty cycle correction: Duty [%]	Duty cycle correction: Duty scaled	Output average power correction: Meas. [dBm].	Output average power correction: Max. [dBm]	Output average power correction: Tune-up factor	SAR Corrected (Scaled) (*d)	Remarks
Step 1a: 2.4GHz Band (Initial position) (*. Initial position was defined by the preliminary SAR test on July 31, 2018.)																
b	2462(11)	1	**Top**	0	Adaptor	**1.05**	+1.80	n/a (*c)	Plot 1-2	99.95	×1.00	12.06	13	×1.24	**1.302**	-
b	2462(11)	5.5	**Top**	0	Adaptor	**1.11**	+1.80	n/a (*c)	Plot 1-3	99.6	×1.00	12.38	13	×1.15	**1.277**	SAR: 1Mbps > 5.5Mbps
b	2437(6)	1	**Top**	0	Adaptor	**1.09**	+1.72	n/a (*c)	Plot 1-4	99.95	×1.00	12.03	13	×1.25	**1.363**	-
b	2412(1)	1	**Top**	0	Adaptor	**1.15**	+1.45	n/a (*c)	Plot 1-5	99.95	×1.00	12.01	13	×1.26	**1.449**	-
g	2412(1)	6	**Top**	0	Adaptor	**1.20**	+1.45	n/a (*c)	Plot 1-1	99.5	×1.01	12.11	13	×1.23	**1.491**	*.Highest Report SAR1g. *.Maximum measured.
g	2437(6)	6	**Top**	0	Adaptor	**1.12**	+1.72	n/a (*c)	Plot 1-6	99.5	×1.01	12.11	13	×1.23	**1.391**	-
g	2462(11)	6	**Top**	0	Adaptor	**1.12**	+1.80	n/a (*c)	Plot 1-7	99.5	×1.01	12.23	13	×1.19	**1.346**	-
n20	2412(1)	MCS0	**Top**	0	Adaptor	**1.17**	+1.45	n/a (*c)	Plot 1-8	99.4	×1.01	12.15	13	×1.22	**1.442**	-
n20	2437(6)	MCS0	**Top**	0	Adaptor	**1.13**	+1.72	n/a (*c)	Plot 1-9	99.4	×1.01	12.19	13	×1.21	**1.381**	-
n20	2462(11)	MCS0	**Top**	0	Adaptor	**1.13**	+1.80	n/a (*c)	Plot 1-10	99.4	×1.01	12.26	13	×1.19	**1.358**	-
g	2412(1)	6	**Top**	0	Battery	**1.15**	+1.45	n/a (*c)	Plot 1-11	99.5	×1.01	12.11	13	×1.23	**1.429**	*. Battery operation.
Step 1b: 2.4GHz Band (Other position)																
b	2412(1)	1	**Front-top**	0	Adaptor	**0.985**	+1.45	n/a (*c)	Plot 1-12	99.95	×1.00	12.01	13	×1.26	**1.241**	-
b	2437(6)	1	**Front-top**	0	Adaptor	**1.05**	+1.72	n/a (*c)	Plot 1-13	99.95	×1.00	12.03	13	×1.25	**1.313**	-
b	2462(11)	1	**Front-top**	0	Adaptor	**1.03**	+1.80	n/a (*c)	Plot 1-14	99.95	×1.00	12.06	13	×1.24	**1.277**	-
b	2412(1)	1	**Back-top**	0	Adaptor	**0.948**	+1.45	n/a (*c)	Plot 1-15	99.95	×1.00	12.01	13	×1.26	**1.194**	-
b	2437(6)	1	**Back-top**	0	Adaptor	**0.980**	+1.72	n/a (*c)	Plot 1-16	99.95	×1.00	12.03	13	×1.25	**1.225**	-
b	2462(11)	1	**Back-top**	0	Adaptor	**0.952**	+1.80	n/a (*c)	Plot 1-17	99.95	×1.00	12.06	13	×1.24	**1.180**	-
b	2412(1)	1	**Right**	0	Adaptor	**0.085**	+1.45	n/a (*c)	Plot 1-18	99.95	×1.00	12.01	13	×1.26	**0.107**	-
b	2412(1)	1	**Left**	0	Adaptor	**0.101**	+1.45	n/a (*c)	Plot 1-19	99.95	×1.00	12.01	13	×1.26	**0.127**	-
b	2412(1)	1	**Front**	0	Adaptor	**n/a**	+1.45	n/a (*c)	Plot 1-20	*. Since SAR peak location has enough air					**n/a**	*.Refer to "Front-top" result.
b	2412(1)	1	**Back**	0	Adaptor	**n/a**	+1.45	n/a (*c)	Plot 1-21	gap, zoom scan was not performed.					**n/a**	*.Refer to "Back-top" result.
Step 2a: U-NII-1 Band (Initial position) (*. Initial position was defined by the preliminary SAR test on July 31, 2018.)																
ac80	5210(42)	MCS0	**Top-left**	0	Adaptor	**0.998**	+0.66	n/a (*c)	Plot 2-2	97.1	×1.03	12.77	14	×1.33	**1.367**	-
n40	5190(38)	MCS0	**Top-left**	0	Adaptor	**0.938**	+0.72	n/a (*c)	Plot 2-3	98.6	×1.01	12.32	14	×1.47	**1.393**	-
n40	5230(46)	MCS0	**Top-left**	0	Adaptor	**0.908**	+0.74	n/a (*c)	Plot 2-4	98.6	×1.01	12.36	14	×1.46	**1.339**	-
ac40	5190(38)	MCS0	**Top-left**	0	Adaptor	**0.923**	+0.72	n/a (*c)	Plot 2-5	98.7	×1.01	12.34	14	×1.47	**1.370**	-
ac40	5230(46)	MCS0	**Top-left**	0	Adaptor	**0.917**	+0.74	n/a (*c)	Plot 2-6	98.7	×1.01	12.35	14	×1.46	**1.352**	-
a	5180(36)	6	**Top-left**	0	Adaptor	**1.09**	+0.73	n/a (*c)	Plot 2-7	99.5	×1.01	12.95	14	×1.27	**1.398**	*.Maximum measured.
a	5220(44)	6	**Top-left**	0	Adaptor	**1.02**	+0.73	n/a (*c)	Plot 2-8	99.5	×1.01	12.84	14	×1.31	**1.350**	-
a	5240(48)	6	**Top-left**	0	Adaptor	**1.05**	+0.75	n/a (*c)	Plot 2-9	99.5	×1.01	12.83	14	×1.31	**1.389**	-
n20	5180(36)	MCS0	**Top-left**	0	Adaptor	**1.08**	+0.73	n/a (*c)	Plot 2-1	99.4	×1.01	12.91	14	×1.29	**1.407**	*.Highest Report SAR1g.
n20	5220(44)	MCS0	**Top-left**	0	Adaptor	**1**	+0.73	n/a (*c)	Plot 2-10	99.4	×1.01	12.89	14	×1.29	**1.303**	-
n20	5240(48)	MCS0	**Top-left**	0	Adaptor	**1.05**	+0.75	n/a (*c)	Plot 2-11	99.4	×1.01	12.87	14	×1.30	**1.379**	-
ac20	5180(36)	MCS0	**Top-left**	0	Adaptor	**1.09**	+0.73	n/a (*c)	Plot 2-12	99.5	×1.01	12.98	14	×1.26	**1.387**	-
ac20	5220(44)	MCS0	**Top-left**	0	Adaptor	**1.03**	+0.73	n/a (*c)	Plot 2-13	99.5	×1.01	12.88	14	×1.29	**1.342**	-
ac20	5240(48)	MCS0	**Top-left**	0	Battery	**1.07**	+0.75	n/a (*c)	Plot 2-14	99.5	×1.01	12.86	14	×1.30	**1.405**	-
n20	5200(40)	MCS0	**Top-left**	0	Adaptor	**1.06**	+0.74	n/a (*c)	Plot 2-15	99.4	×1.01	12.89	14	×1.29	**1.381**	-
n20	5180(36)	MCS0	**Top-left**	0	Adaptor	**1.05**	+0.73	n/a (*c)	Plot 2-16	99.4	×1.01	12.91	14	×1.29	**1.368**	*. Battery operation.
Step 2b: U-NII-1 Band (Other position)																
ac80	5210(42)	MCS0	**Top**	0	Adaptor	**0.499**	+0.66	n/a (*c)	Plot 2-17	97.1	×1.03	12.77	14	×1.33	**0.684**	-
ac80	5210(42)	MCS0	**Right**	0	Adaptor	**0.357**	+0.66	n/a (*c)	Plot 2-18	97.1	×1.03	12.77	14	×1.33	**0.489**	-
ac80	5210(42)	MCS0	**Left**	0	Adaptor	**0.444**	+0.66	n/a (*c)	Plot 2-19	97.1	×1.03	12.77	14	×1.33	**0.608**	-
ac80	5210(42)	MCS0	**Front**	0	Adaptor	**0.425**	+0.66	n/a (*c)	Plot 2-20	97.1	×1.03	12.77	14	×1.33	**0.582**	-
ac80	5210(42)	MCS0	**Front-top**	0	Adaptor	**0.380**	+0.66	n/a (*c)	Plot 2-21	97.1	×1.03	12.77	14	×1.33	**0.521**	-
ac80	5210(42)	MCS0	**Back**	0	Adaptor	**0.207**	+0.66	n/a (*c)	Plot 2-22	97.1	×1.03	12.77	14	×1.33	**0.284**	-
ac80	5210(42)	MCS0	**Back-top**	0	Adaptor	**0.240**	+0.66	n/a (*c)	Plot 2-23	97.1	×1.03	12.77	14	×1.33	**0.329**	-

Notes: *. Gap: It is the separation distance between the outer surface of product and the bottom outer surface of phantom; Max.: Maximum; Meas.: Measured value; n/a: not applied; b: IEEE 802.11b, g: IEEE 802.11g, a: IEEE 802.11a, n20: IEEE 802.11n(20HT), n40: IEEE 802.11n(40HT), ac20: IEEE 802.11ac(20VHT), ac40: IEEE 802.11n(40VHT), ac80: IEEE 802.11ac(80VHT)
*. During test, the EUT was operated by either USB adaptor or a full-charged built-in Li-ion battery.
*. Calibration frequency of the SAR measurement probe (and used conversion factors)

Liquid	SAR test frequency	Probe calibration frequency	Validity	Conversion factor	Uncertainty
Body	2412, 2437, 2462 MHz	2450 MHz	within ±50 MHz of calibration frequency	7.32	±12.0 %
Body	5180, 5190, 5210, 5220, 5230, 5240 MHz	5250 MHz	within ±110 MHz of calibration frequency	4.49	±13.1 %

*. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

[Liquid measurement]

Frequency [MHz] (Channel)	Liquid type	Liquid parameters (*a)								Temp. [deg.C.]	Depth [mm]	ΔSAR Coefficients(*b)		Date measured
		Permittivity (εr) [-]				Conductivity [S/m]						ΔSAR	Correction required?	
		Target	Measured		Limit	Target	Measured		Limit			1g {%}		
			Meas.	Δεr [%]			Meas.	Δσ [%]						
2412 (1)	Body	***52.75***	50.59	-4.1	-5% ≤ εr-meas. ≤ 0%	***1.914***	1.934	+1.1	0% ≤ σ-meas. ≤ +5%	22.5	151	+1.45	not required.	August 29, 2018, before SAR test
2437 (6)		***52.72***	50.49	-4.2		***1.938***	1.969	+1.6				+1.72	not required.	
2462 (11)		***52.68***	50.37	-4.4		***1.967***	2.001	+1.7				+1.80	not required.	
5180 (36)	Body	***49.04***	47.08	-4.0	-5% ≤ εr-meas. ≤ 0%	***5.276***	5.455	+3.4	0% ≤ σ-meas. ≤ +5%	24.0	150	+0.73	not required.	September 5~6, 2018 (*1), before SAR test
5190 (38)		***49.03***	47.06	-4.0		***5.288***	5.473	+3.5				+0.72	not required.	
5200(40)		***49.01***	47.01	-4.1		***5.299***	5.472	+3.3				+0.74	not required.	
5210 (42)		***49.00***	47.01	-4.1		***5.311***	5.489	+3.4				+0.66	not required.	
5220 (44)		***48.99***	46.99	-4.1		***5.323***	5.491	+3.2				+0.73	not required.	
5230 (46)		***48.97***	46.96	-4.1		***5.334***	5.506	+3.2				+0.74	not required.	
5240 (48)		***48.96***	46.91	-4.2		***5.346***	5.525	+3.4				+0.75	not required.	

*1. On September 6, it was within 24 hours from measurement on September 5 and same liquid temperature, so parameters of September 5 were used continuously.

Memo

*a. The target value is a parameter defined in Appendix A of KDB865664 D01 (v01r04), the dielectric parameters suggested are given at 2000, 2450, 3000 and 5800MHz. Parameters for the frequencies between 2000 MHz and 5800 MHz were obtained using linear interpolation.

*b. Calculating formula: $\Delta SAR(1g) = C\varepsilon r \times \Delta\varepsilon r + C\sigma \times \Delta\sigma$, $C\varepsilon r = -7.854E\text{-}4 \times f^3 + 9.402E\text{-}3 \times f^2 - 2.742E\text{-}2 \times f - 0.2026$ / $C\sigma = 9.804E\text{-}3 \times f^3 - 8.661E\text{-}2 \times f^2 + 2.981E\text{-}2 \times f + 0.7829$

*c. Since the calculated ΔSAR values of the tested liquid had shown positive correction, the measured SAR was not converted by ΔSAR correction.
Calculating formula: ΔSAR corrected SAR (W/kg) = (Meas. SAR (W/kg)) × (100 - (ΔSAR(%)) / 100

*d. Calculating formula: Reported SAR (W/kg) = (Measured SAR (W/kg)) × (Duty scaled) × (Tune-up factor)
Duty scaled = Duty scaled factor: Duty cycle correction factor for obtained SAR value, Duty scaled factor [-] = 100(%) / (duty cycle, %)
Tune-up factor: Power tune-up factor for obtained SAR value, Tune-up factor [-] = 1 / (10 ^ ("Deviation from max., dB" / 10))

(Clause 5, SAR TEST PROCEDURES, in KDB248227 D01 (v02r02))

5.1.1 Initial Test Position SAR Test Reduction Procedure

DSSS and OFDM configurations are considered separately according to the required SAR procedures. SAR is measured in the initial test position using the 802.11 transmission mode configuration required by the DSSS procedure or initial test configuration and subsequent test configuration(s) according to the OFDM procedures. The initial test position procedure is described in the following:

c) 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. Additional power measurements may be required for this step, which should be limited to those necessary for identifying the subsequent highest output power channels.

5.2.1 802.11b DSSS SAR Test Requirements

SAR is measured for 2.4 GHz 802.11b DSSS using either a fixed test position or, when applicable, the initial test position procedure. SAR test reduction is determined according to the following:

2) When the reported SAR is > 0.8 W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.

5.2.2 2.4 GHz 802.11g/n OFDM SAR Test Exclusion Requirements

When SAR measurement is required for 2.4 GHz 802.11g/n OFDM configurations, the measurement and test reduction procedures for OFDM are applied (section 5.3, including sub-sections). SAR is not required for the following 2.4 GHz OFDM conditions.

1) When KDB Publication 447498 SAR test exclusion applies to the OFDM configuration.
2) When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.

5.3.2 OFDM Transmission Mode SAR Test Configuration and Channel Selection Requirements

The initial test configuration for 2.4 GHz and 5 GHz OFDM transmission modes is determined by the 802.11 configuration with the highest maximum output power specified for production units, including tune-up tolerance, in each standalone and aggregated frequency band. SAR for the initial test configuration is measured using the highest maximum output power channel determined by the default power measurement procedures.

a) When multiple channel bandwidth configurations in a frequency band have the same specified maximum output power, the initial test configuration is determined by applying the following steps sequentially.
   1) The largest channel bandwidth configuration is selected among the multiple configurations in a frequency band with the same specified maximum output power.
   2) If multiple configurations have the same specified maximum output power and largest channel bandwidth, the lowest order modulation among the largest channel bandwidth configurations is selected.
   3) If multiple configurations have the same specified maximum output power, largest channel bandwidth and lowest order modulation, the lowest data rate configuration among these configurations is selected.
   4) When multiple transmission modes (802.11a/g/n/ac) have the same specified maximum output power, largest channel bandwidth, lowest order modulation and lowest data rate, the lowest order 802.11 mode is selected; i.e., 802.11a is chosen over 802.11n then 802.11ac or 802.11g is chosen over 802.11n.
b) After an initial test configuration is determined, if multiple test channels have the same measured maximum output power, the channel chosen for SAR measurement is determined according to the following. These channel selection procedures apply to both the initial test configuration and subsequent test configuration(s), with respect to the default power measurement procedures or additional power measurements required for further SAR test reduction. The same procedures also apply to subsequent highest output power channel(s) selection.
   1) The channel closest to mid-band frequency is selected for SAR measurement.
   2) For channels with equal separation from mid-band frequency; for example, high and low channels or two mid-band channels, the higher frequency (number) channel is selected for SAR measurement.

7.2 SAR Measurement Variability

In accordance with published RF Exposure KDB procedure 865664 D01 (v01r04) 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 < 0.80 W/kg; steps 2) through 4) do not apply.
2) When the original highest measured SAR is ≥ 0.80 W/kg, 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 W/kg (~ 10% from the 1-g SAR limit).
4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

Mode	Frequency [MHz] (Channel)	Data rate [Mbps]	EUT setup position	Measured SAR (1g) [W/kg]		Largest to Smallest SAR Ratio	SAR plot # in Appendix 2-2	Remarks
				Original	Repeated			
g	2412 (1)	6	Top	1.20	1.16	1.034	Original: Plot 1-1 Repeated: Plot 3-1	*. 2nd repeated measurement is not required since the ratio of the largest to smallest SAR for the original and 1st repeated measurement is not > 1.20.
a	5180 (36)	6	Top-left	1.09	1.06	1.028	Original: Plot 2-7 Repeated: Plot 3-2	*. 2nd repeated measurement is not required since the ratio of the largest to smallest SAR for the original and 1st repeated measurement is not > 1.20.

7.3 Simultaneous transmission evaluation

This Wireless module supports both Wi-Fi and Bluetooth. Wi-Fi of 2.4GHz and Bluetooth were not transmitted simultaneously. Wi-Fi of5GHz and Bluetooth were transmitted simultaneously at same antenna. Therefore, simultaneously transmitted SAR was only considered for Wi-Fi of 5GHz band operation.

Simultaneous transmission scenario				Σ1g SAR [W/kg] (≤1.6)	SPLSR (Yes / No)	Calculated distance [mm]	SPLSR (≤ 0.04)	Volume Scan (Yes/No)	Figure	Remarks
Test position	Highest Reported SAR(1g) [W/kg] (Standalone base)									
	Wi-Fi: DTS Band	Wi-Fi: UNII band	Bluetooth							
Top-left	-	1.41	0.13 (*.Estimated)	1.54	No	-	-	-	-	Wi-Fi(5GHz)+BT

General Note:

1) Bluetooth and Wi-Fi share the same antenna, and cannot transmit simultaneously on 2.4GHz band.
2) EUT will choose either Wi-Fi of 2.4GHz or 5GHz according to the network signal condition, therefore, Wi-Fi of 2.4GHz and 5GHz will not operate simultaneously.
3) The Reported SAR simulation is calculated based on the same configuration and test position.
4) Per KDB447498 D01(v06), simultaneously transmission SAR is compliant if;
   (1) Reported SAR summation < 1.6 W/kg
   (2) "SPLSR = (SAR1 + SAR2)^1.5 / (minimum antenna separation distance, mm)", and the peak separation distance is determined form the square root of [(x1-x2)^2 + (y1-y2)^2 + (z1-z2^2)], where (x1, y1, z1) and (x2, y2, z2) are the coordinates of the extrapolated peak SAR location in the zoom scan.
   (where; "SAR1" is simulated SAR(1g) of Bluetooth, "SAR2" is highest reported SAR(1g) on antenna when it is 5GHz Wi-Fi operated.)
   (3) if SPLSR ≤ 0.04, simultaneously transmission SAR measurement is not necessary.
   (4) Simultaneously transmission SAR, and the reported multi-band SAR < 1.6 W/kg.
5) For simultaneously transmission analysis, Bluetooth SAR is estimated per KDB447498 D01(v06) based on the formula below.
   (1) [(max. power of channel, including tune-up tolerance, mW) / (minimum 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) When the minimum separation distance is < 5mm, the distance is used 5mm to determine SAR test exclusion.
   (3) Bluetooth estimated SAR is conservatively determined by 5mm separation, for all applicable exposure positions.

Maximum power	Exposure Position	Minimum separation distance	Estimated SAR(BT)	Remarks
4 dBm (3 mW)	Near antenna	≤ 5mm	0.126 W/kg	-

Estimated SAR (Bluetooth) = (3mW) / (5mm) × (√2.480GHz) / (7.5) = 0.126 W/kg, where "5mm" is the minimum test separation distance.

7.4 Device holder perturbation verification

When the highest reported SAR of an antenna is > 1.2 W/kg, holder perturbation verification is required for each antenna, using the highest SAR configuration among all applicable frequency bands.

[Device holder perturbation verification; Measured and Reported (Scaled) SAR results]

SAR measurement results									Reported SAR (1g) [W/kg]						
Mode	Frequency [MHz] (Channel)	Data rate [Mbps]	EUT setup		SAR (1g) [W/kg]			SAR plot # in Appendix 2-2	Duty cycle correction		Output average power correction			SAR Corrected (Scaled) (*d)	Remarks
			Position	Gap [mm]	Max. value of multi-peak				Duty [%]	Duty scaled	Meas. [dBm].	Max. [dBm]	Tune-up factor		
					Meas.	ΔSAR [%]	ΔSAR corrected								
With device holder															
g	2412(1)	6	Top	0	1.20	+1.45	n/a (*c)	Plot 1-1	99.5	×1.01	12.11	13	×1.23	1.491	Higher Report SAR1g.
n20	5180(36)	MCS0	Top-left	0	1.08	+0.70	n/a (*c)	Plot 2-1	99.4	×1.01	12.91	14	×1.29	1.407	Higher Report SAR1g.
No device holder															
g	2412(1)	6	Top	0	1.17	+1.45	n/a (*c)	Plot 4-1	99.5	×1.01	12.11	13	×1.23	1.453	-
n20	5180(36)	MCS0	Top-left	0	1.04	+0.70	n/a (*c)	Plot 4-2	99.4	×1.01	12.91	14	×1.29	1.355	-

[Device holder perturbation verification]

Mode	Frequency [MHz] (Channel)	Data rate [Mbps]	EUT setup		Reported SAR (1g) [W/kg]		Device holder perturbation SAR Ratio	Remarks
			Position	Gap [mm]	Device holder			
					Exist	None		
g	2412(1)	6	Top	0	1.491	1.453	-2.5 %	*.It was smaller than 5% of uncertainty of the setup, so influence of a device holder was judged to be no problem.
n20	5180(36)	MCS0	Top-left	0	1.407	1.355	-3.7 %	

*. Calculating formula: Device holder perturbation SAR Ratio (%) = {{((Reported SAR-none (W/kg)) / Reported SAR-exist (W/kg))} - 1}*100