SAR TEST REPORT

Test Report No.: 12212638S-A

Applicant : **RICOH IMAGING COMPANY, LTD.**

Type of Equipment : **Digital Camera**

Model No. : **R02010**

FCC ID : **2ACZS-R02010**

Test Standard : **FCC 47CFR §2.1093**

Test Result : **Complied**

Highest Reported SAR(1g) Value			Remarks			Output power (average)	
Tune-up value	Type	Limit	Band	Frequency	Mode	Measured	Maximum
1.20 W/kg	**Body-worn**	**1.6**	DTS	2462 MHz	11n(20HT)(MCS0)	11.63 dBm	12.5 dBm

*. **Highest reported SAR (1g) across all exposure conditions (body worn) of this device is "1.20 W/kg".**

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Date of test: April 23~25, 2018

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

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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".

JAB Testing RTL02610

REVISION HISTORY

Revision	Test report No.	Date	Page revised	Contents
Original	12212638S-A	May 31, 2018	-	-
-r01	12212638S-A	October 30, 2018	p1,2,3,8	(p1,2,3,8) Error correcting, (p2) Revision history up-dated

*. 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 IMAGING COMPANY, LTD.
Brand Name	RICOH
Address	1-3-6 Nakamagome, Ohta-ku, Tokyo 143-8555, Japan
Telephone Number	+81-50-3534-5408
Contact Person	Takafumi Ohkuma

SECTION 2: Equipment under test (EUT)

2.1 Identification of EUT

Type of Equipment	Digital Camera
Model Number	R02010
Serial Number	0000028
Condition of EUT	Production prototype (Not for sale: This samples is equivalent to mass-produced items.)
Receipt Date of Sample	April 23, 2018 *. No modification by the Lab. (*. After power measurement, the RF wiring of digital camera was changed to the original antenna line from the antenna conducted power measurement line for SAR test.)
Country of Mass-production	Vietnam
Category Identified	Portable device *. Since the digital camera may contact a human body during Wi-Fi operation, the partial-body SAR (1g) shall be observed.
Rating	DC 3.6V (Li-ion battery operation), 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 cable.
Feature of EUT	Model: R02010 (referred to as the EUT in this report) is a Digital Camera which support wireless LAN (Wi-Fi) and Bluetooth version 4.2 (Low Energy).
SAR Accessory	None

2.2 Product Description (Wireless LAN + Bluetooth Combo Module)

Equipment type		Transceiver									
Transmit average power (*. The measured Tx output power (antenna terminal conducted) refers to section 6 in this report.)		Mode		channel	Operation frequency [MHz]	Data rate [Mbps]	Modulation	Channel spacing [MHz]	Band width [MHz]	Average power [dBm]	
										Min.	Typical	Max.
		Bluetooth v4.2	**Low Energy**	0~39	2402~2480	1	FHSS	2	2	**3.5**	**6.5**	**8.5**
		11b		1~11	2412~2462	1~11	DSSS	5	20	**6.5**	**9.5**	**12.5**
		11g		1~11	2412~2462	6~54	OFDM	5	20	**6.5**	**9.5**	**12.5**
		11n(20HT)		1~11	2412~2462	MCS0~7	OFDM	5	20	**6.5**	**9.5**	**12.5**
Type of modulation	Bluetooth	FHSS: GFSK									
	Wi-Fi	DSSS: DBPSK, DQPSK, CCK / OFDM: BPSK, QPSK, 16QAM, 64QAM									
Power supply		DC 1.8V and DC 3.3V (*. These power are supplied via constant voltage circuit.)									
Quantity of Antenna		1 piece									
Antenna type		λ/4 Monopole Antenna (Model: Embedded antenna)		Antenna connector type		Wireless LAN + Bluetooth Combo Module side: JSC, Antenna side: JSC					
Antenna gain (Peak)		-2.1 dBi									

*. The EUT do not use the special transmitting technique such as "beam-forming" and "time-space code diversity."
*. Wi-Fi and Bluetooth Low Energy were not transmitted simultaneously. Therefore simultaneously transmitted SAR was not considered.

SECTION 3: Test specification, procedures and results

3.1 Test specification

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
General population / uncontrolled exposure, Hands (averaged over any 10g of tissue) limit: 4 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 worn (body touch)

Band (Operation frequency [MHz])	Bluetooth (Low Energy) (2402-2480)	Wi-Fi (DTS) (2412-2462)	Simultaneous transmission (Bluetooth Low Energy +Wi-Fi (*1)
Results (Reported SAR(1g))	Complied (*. lower power, SAR test was exempt.)	Complied	N/A (This device is not supported the simultaneously transmission.)
SAR (1g) Limit [W/kg]	1.6	1.6	-
Reported SAR(1g) value	N/A	1.20 W/kg	-
Measured SAR value	N/A	0.921 W/kg	-
Mode, frequency[MHz]	-	11n(20HT)(MCS0), 2462	-
Duty cycle [%] (duty scaled factor)	-	93.5 (×1.07)	-
Output average power [dBm] (max. power, Tune-up factor)	(Max. 8.0 dBm)	11.63 (12.5, ×1.22)	-

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
*. N/A: Not applied, max. power: maximum output power.
*. (Calculating formula) Corrected SAR to max.power (W/kg) = (Measured SAR (W/kg)) × (Duty scaled factor) × (Tune-up factor)
where; Tune-up factor [-] = 1 / (10 ^ ("Δmax (max.power - burst average power), dB" / 10)), Duty scaled factor [-] = 100(%) / (duty cycle, %)
*1. Wi-Fi and Bluetooth Low Energy were not transmitted simultaneously. Therefore simultaneously transmitted SAR was not considered.

3.4 Test Location

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JAB Accreditation No. RTL02610
FCC Test Firm Registration Number: 839876

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

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.

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

802.11b		802.11g				802.11n(20HT) (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	Data rate
DBPSK/DSSS	1	BPSK/OFDM	6	16QAM/OFDM	24	0	6.5	BPSK/OFDM	4	39	16QAM/OFDM	LE	GFSK/FHSS	-	1
DQPSK/DSSS	2	BPSK/OFDM	9	16QAM/OFDM	36	1	13	QPSK/OFDM	5	52	64QAM/OFDM				
CCK/DSSS	5.5	QPSK/OFDM	12	64QAM/OFDM	48	2	19.5	QPSK/OFDM	6	58.5	64QAM/OFDM				
CCK/DSSS	11	QPSK/OFDM	18	64QAM/OFDM	54	3	26	16QAM/OFDM	7	65	64QAM/OFDM				

*. Data rate: [Mbps], SS: Spatial Stream

Step.2 Consideration of SAR test channel

For the SAR test reference, on each operation band, the average output power was measured on the low/middle/upper channels with the worst data rate condition in step 1 in the above.

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.

Setup plan	Explanation of SAR test setup plan (*. Refer to Appendix 1 for test setup photographs which had been tested.)	Wi-Fi D [mm]	Wi-Fi SAR Tested /Reduced	Bluetooth (Low Energy) D [mm]	Bluetooth (Low Energy) SAR Tested /Reduced	SAR type
Right-front	A front edge of right surface of a camera is touched to the Flat phantom.	**2.2**	**Tested**	**2.2**	*Reduced*	Body-touch
Front-right	A right portion (hand grip) of camera is touched to the Flat phantom.	**2.7**	**Tested**	**2.7**	*Reduced*	
Front	A front of camera is touched to the Flat phantom.	**≈3**	**Tested**	**≈3**	*Reduced*	
Right	A right surface of camera is touched to the Flat phantom.	**4.2**	**Tested**	**4.2**	*Reduced*	
Top-front	A right-front portion of top surface of a camera is touched to the Flat phantom.	**≈10**	**Tested**	**≈10**	*Reduced*	
Top	A top surface of camera is touched to the Flat phantom.	**16.4**	**Tested**	**16.4**	*Reduced*	
Bottom	A bottom surface of camera is touched to the Flat phantom.	**17.9**	**Tested**	**17.9**	*Reduced*	
Rear	A rear of camera (LCD side) is touched to the Flat phantom.	**27**	*Reduced*	**27**	*Reduced*	
Left	A left surface of camera is touched to the Flat phantom.	**≈98**	*Reduced*	**≈98**	*Reduced*	

*. **D:** Antenna separation distance. It is the distance from the antenna inside EUT to the outer surface of EUT which an operator may touch.
. Size of EUT (digital camera): 109.4 mm (width) × 61.9 mm (height) × 33.2 mm (depth) (. nominal size)

<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)] × [$\sqrt{f}$ (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] / [$\sqrt{f}$ (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									
Antenna	Tx mode	Upper Freq. [MHz]	Maximum output power [dBm]	Maximum output power [mW]	Setup D[mm]	Right-front ≤5 (2.2)	Front-right ≤5 (2.7)	Front ≤5 (≈3)	Right ≤5 (4.2)	Top-front ≈10	Top 16.4	Bottom 18	Rear 27	Left ≈98
Main	b	2462	12.5	18	Judge	<u>5.6, Measure</u>				2.8, Reduce	1.8, Reduce	1.6, Reduce	0.8, Reduce	576mW, Reduce
Main	g	2462	12.5	18	Judge	<u>5.6, Measure</u>				2.8, Reduce	1.8, Reduce	1.6, Reduce	0.8, Reduce	576mW, Reduce
Main	n20	2462	12.5	18	Judge	<u>5.6, Measure</u>				2.8, Reduce	1.8, Reduce	1.6, Reduce	0.8, Reduce	576mW, Reduce
Main	BLE	2480	8.5	7	Judge	2.2, Reduce				1.1, Reduce	0.7, Reduce	0.6, Reduce	0.4, Reduce	576mW, Reduce

*. Freq: Frequency, D: Antenna separation distance, BLE: Bluetooth Low Energy, b: IEEE 802.11b, g: IEEE 802.11g, n20: IEEE 802.11n(20HT); N/A: not applied..

<u><Conclusion for consideration for SAR test reduction></u>
1) The test was conservatively performed with test separation distance 0mm.
2) For Wi-Fi operation, setup of "Right-front", "Front-right", "Front" and "Right" are applied the SAR test in body-liquid. The SAR test of "Top-front", "Top", "Bottom" and "Rear" setups are also applied because the digital camera (EUT) is small device. The SAR test of "Left" setup is reduced because the SAR test exclusion judge value are smaller than "3." and they have enough antenna separation distance (as the threshold power value).
3) For Bluetooth operation, the SAR test is reduced for all setups, because the SAR test exclusion judge value are smaller than "3."
4) The EUT (digital camera) didn't have view finder, so SAR test of front-of-face condition wasn't considered.

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

Worst SAR search by DSSS mode;
1) Determine the highest reported SAR(1g) of DSSS mode by SAR test. (*. Change the channel, if it is required.)
2) Check the SAR of OFDM mode by SAR test, if it is required.

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

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SECTION 4: Operation of EUT during testing

4.1 Operating modes for SAR testing

This EUT has IEEE.802.11b, 11g and 11n(20HT) and Bluetooth Low Energy (BLE) continuous transmitting modes.
The frequency and the modulation used in the SAR testing are shown as a following.

Operation mode		BLE (Bluetooth Low Energy)	b	g	n20
Tx frequency band		2402-2480MHz	2412-2462MHz		
Maximum power [dBm]		8.5	12.5	12.5	12.5
SAR tested condition	Frequency [MHz]	-	2412, 2437, 2462	2412, 2437, 2462	2412, 2437, 2462
	Modulation	FHSS	DSSS	OFDM	OFDM
	Data rate [Mbps]	1	1, 2	6	6.5(MCS0)
SAR tested/reduced?		Reduced	Tested	Tested	Tested
Controlled software		RICOH WLAN CONDUCTED TEST MODE (Version; CPU: Ver 00.20.02.02, DSP: Ver 00.90.20.05) This software was used for both power measurement and SAR test. For Wi-Fi operation, it set Tx parameters which includes; "channel", and "data rate" via LCD of camera. The Wi-Fi power was set and saved in the SD card which inserted the camera during test. For BLE operation, it set Tx parameters which includes; "channel". The BLE power was fixed by the firmware of camera.			
Power setting	Power measurement	fix	11 (*. tuned up)	11 (*. tuned up)	11 (*. tuned up)
	SAR	fix	11 (*. tuned up)	11 (*. tuned up)	11 (*. tuned up)

*. BLE: Bluetooth Low Energy, b: IEEE 802.11b, g: IEEE 802.11g, n20: IEEE 802.11n(20HT); n/a: not applied.
*. Any output power reducing for channel 1 and 11 to meet restricted band requirements was not observed.

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) (std. uncertainty)	ui (10g) (std. uncertainty)	Vi, veff
A	**Measurement System** (DASY5)								
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) - Worst data rate/channel determination

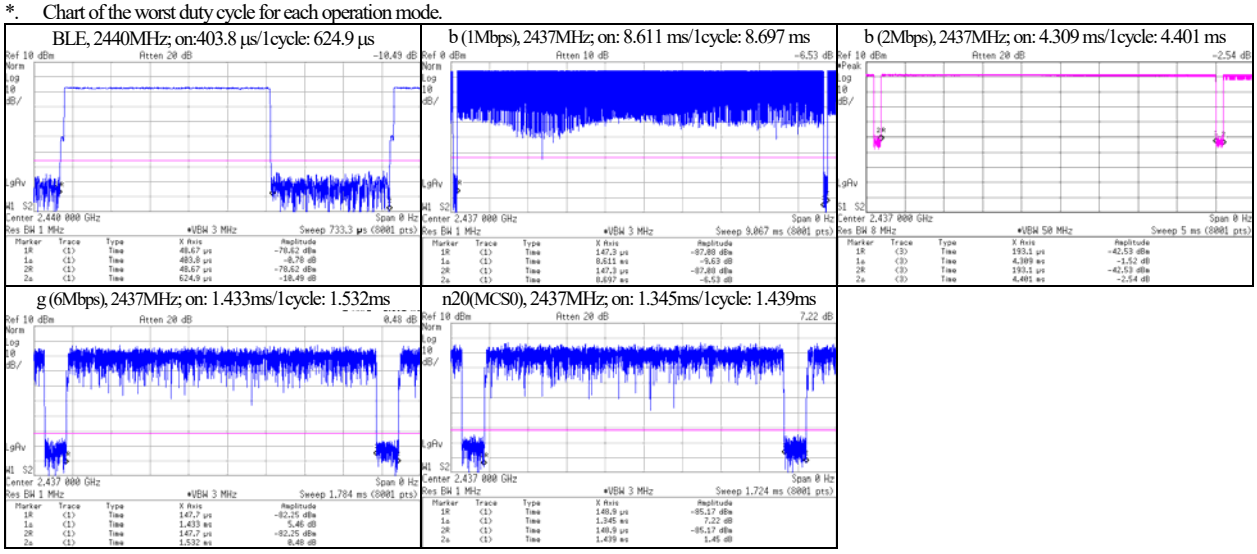
Mode	Frequency		Data rate	Power Setting (software)	Duty cycle	Duty factor	Duty scaled factor	Measurement Result				Power correction			Was power tuning applied?	Remarks *. Antenna gain (peak): -2.1 dBi
								Time average power		Burst power		Max. power	Δ from max.	Tune-up factor		
	[MHz]	CH	[Mbps]	[-]	[%]	[dB]	[-]	[dBm]	[mW]	[dBm]	[mW]	[dBm]	[dB]	[-]		
BLE	2402	Low	1	fix	64.6	1.90	×1.55	4.23	2.65	**6.13**	4.10	8.5	-2.37	×1.73	n/a (fix)	-
	2440	Middle	1	fix	64.6	1.90	×1.55	4.35	2.72	**6.25**	4.22	8.5	-2.25	×1.68	n/a (fix)	-
	2480	High	1	fix	64.6	1.90	×1.55	3.34	2.16	**5.24**	3.34	8.5	-3.26	×2.12	n/a (fix)	-
b	2412	1	1	11(*1)	99.0	0.04	×1.01	11.35	13.65	**11.39**	13.77	12.5	-1.11	×1.29	tuned-up(*1)	-
	2437	6	1	11(*1)	99.0	0.04	×1.01	11.55	14.29	**11.59**	14.42	12.5	-0.91	×1.23	tuned-up(*1)	-
	2462	11	1	11(*1)	99.0	0.04	×1.01	11.34	13.61	**11.38**	13.74	12.5	-1.12	×1.29	tuned-up(*1)	-
	2412	1	2	11(*1)	97.9	0.09	×1.02	11.69	14.76	**11.78**	15.07	12.5	-0.72	×1.18	tuned-up(*1)	-
	2437	6	2	11(*1)	97.9	0.09	×1.02	11.75	14.96	**11.84**	15.28	12.5	-0.66	×1.16	tuned-up(*1)	-
	2462	11	2	11(*1)	97.9	0.09	×1.02	11.68	14.72	**11.77**	15.03	12.5	-0.73	×1.18	tuned-up(*1)	-
g	2412	1	6	11(*1)	93.5	0.29	×1.07	12.07	16.11	**12.36**	17.22	12.5	-0.14	×1.03	tuned-up(*1)	-
	2437	6	6	11(*1)	93.5	0.29	×1.07	12.14	16.37	**12.43**	17.50	12.5	-0.07	×1.02	tuned-up(*1)	-
	2462	11	6	11(*1)	93.5	0.29	×1.07	12.09	16.18	**12.38**	17.30	12.5	-0.12	×1.03	tuned-up(*1)	-
n20	2412	1	MCS0	11(*1)	93.5	0.29	×1.07	11.59	14.42	**11.88**	15.42	12.5	-0.62	×1.15	tuned-up(*1)	-
	2437	6	MCS0	11(*1)	93.5	0.29	×1.07	11.75	14.96	**12.04**	16.00	12.5	-0.46	×1.11	tuned-up(*1)	-
	2462	11	MCS0	11(*1)	93.5	0.29	×1.07	11.34	13.61	**11.63**	14.55	12.5	-0.87	×1.22	tuned-up(*1)	-

*. : SAR test was applied.; *. xx.xx highlight is shown the maximum measured output power.; CH: channel, max: maximum, n/a: not applied.

*1. The SAR test power of Wi-Fi was tuned-up (adjusted) to not more than 2dB lower than maximum tune-up power (KDB 447498 D01 (v06) requirement).
*. BLE: Bluetooth Low Energy, b: IEEE 802.11b, g: IEEE 802.11g, n20: IEEE 802.11n(20HT); n/a: not applicable.
*. For DSSS mode, the lowest data rate (lowest modulation) mode (1Mbps) was selected for the SAR test.
*. The measured duty cycle number of BLE was nearly equal to highest theory duty cycle.
*. 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, [Mbps]) vs Time average power (dBm)																		
11b (2437MHz)				11g (2437MHz)								11n(20HT) (2437MHz)						
D/R	Duty cycle (%)	Duty factor (dB)	Power	D/R	Duty cycle (%)	Duty factor (dB)	Power	D/R	Duty cycle (%)	Duty factor (dB)	Power	D/R	Duty cycle (%)	Duty factor (dB)	Power	D/R	Duty cycle (%)	Duty factor (dB)	Power
1	99.0	0.04	11.50	**6**	93.5	0.29	**12.11**	24	79.4	1.00	11.20	**MCS0**	93.5	0.29	**11.71**	MCS4	72.2	1.41	10.57
2	97.9	0.09	**11.74**	9	91.0	0.41	11.90	36	72.8	1.38	10.86	MCS1	87.7	0.57	11.35	MCS5	67.6	1.70	10.11
5.5	94.8	0.23	11.59	12	88.1	0.55	11.78	48	67.2	1.73	10.66	MCS2	83.1	0.80	11.16	MCS6	65.5	1.84	10.00
11	91.0	0.41	11.32	18	83.9	0.76	11.61	56	65.6	1.83	10.52	MCS3	79.8	0.98	11.01	MCS7	63.6	1.97	9.71

*. Chart of the worst duty cycle for each operation mode.



*. 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: April 23, 2018 / Measured by: Hiroshi Naka / Place: preparation room of No. 7 shielded room. (23 deg.C. / 50 %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 %.

SECTION 7: SAR Measurement results

Measurement date: April 24~25, 2018 Measurement by: Hiroshi Naka

[Liquid measurement]

Target Frequency [MHz]	Liquid type	Liquid parameters (*a)								Temp. [deg.C.]	Depth [mm]	ΔSAR Coefficients(*c)		Date measured
		Permittivity (εr) [-]				Conductivity [S/m]								
		Target	Measured		Limit (*b)	Target	Measured		Limit (*b)			ΔSAR (1g) [%]	Correction required?	
			Meas.	Δεr [%]			Meas.	Δσ [%]						
2412	Body	*52.75*	50.63	-4.0	-5% ≤ εr-meas. ≤ 0%	*1.914*	1.943	+1.5	0% ≤ σ-meas. ≤ +5%	22.5	152	+1.65	not required.	April 24, 2018, before SAR test (April 25, 2018 (*1))
2437		*52.72*	50.56	-4.1		*1.938*	1.979	+2.1				+1.95	not required.	
2462		*52.68*	50.46	-4.2		*1.967*	2.019	+2.7				+2.22	not required.	

*1. On April 25, it was within 24 hours from measurement on April 24 and same liquid temperature, so measured parameters of April 24 were used continuously

[SAR measurement results]

SAR measurement results											Reported SAR (1g) [W/kg]						Remarks
Mode	Frequency [MHz] (Channel)	Data rate [Mbps]	EUT setup				SAR (1g) [W/kg]			SAR plot # in Appendix 2-2	Duty cycle correction		Output burst average power correction			SAR Corrected (*d)	
			Position	Gap [mm]	Battery ID	LCD position	Max.value of multi-peak				Duty [%]	Duty scaled	Meas. [dBm].	Max. [dBm]	Tune-up factor		
							Meas.	ΔSAR [%]	ΔSAR corrected								
b	2437(6)	1	Front-right	0	#1	fix	**0.807**	+1.95	n/a (*c)	Plot 1-2	99.0	×1.01	11.59	12.5	×1.23	**1.003**	-
	2412(1)			0	#1	fix	**0.743**	+1.65	n/a (*c)	Plot 1-3	99.0	×1.01	11.39	12.5	×1.29	**0.968**	-
	2462(11)			0	#1	fix	**0.800**	+2.22	n/a (*c)	Plot 1-4	99.0	×1.01	11.38	12.5	×1.29	**1.042**	-
	2437(6)	2		0	#1	fix	**0.866**	+1.95	n/a (*c)	Plot 1-5	97.9	×1.02	11.84	12.5	×1.16	**1.025**	*.Data rate: 2Mbps
g	2437(6)	6		0	#3	fix	**1.04**	+1.95	n/a (*c)	Plot 1-6	93.5	×1.07	12.43	12.5	×1.02	**1.135**	-
	2412(1)			0	#3	fix	**0.934**	+1.65	n/a (*c)	Plot 1-7	93.5	×1.07	12.36	12.5	×1.03	**1.029**	-
	2462(11)			0	#3	fix	**1.03**	+2.22	n/a (*c)	Plot 1-8	93.5	×1.07	12.38	12.5	×1.03	**1.135**	-
	2437(6)			0	USB	fix	**1.01**	+1.95	n/a (*c)	Plot 1-9	93.5	×1.07	12.43	12.5	×1.02	**1.102**	*.USB operation.
n20	2437(6)	MCS0		0	#2	fix	**0.931**	+1.95	n/a (*c)	Plot 1-10	93.5	×1.07	12.04	12.5	×1.11	**1.106**	-
	2412(1)			0	#2	fix	**0.918**	+1.65	n/a (*c)	Plot 1-11	93.5	×1.07	11.88	12.5	×1.15	**1.130**	-
	2462(11)			0	#2	fix	**0.921**	+2.22	n/a (*c)	**Plot 1-1**	93.5	×1.07	11.63	12.5	×1.22	**1.202**	*. Higher reported.
b	2437(6)	1	Right-front	0	#1	fix	**0.747**	+1.95	n/a (*c)	Plot 1-12	99.0	×1.01	11.59	12.5	×1.23	**0.928**	-
	2412(1)			0	#1	fix	**0.704**	+1.65	n/a (*c)	Plot 1-13	99.0	×1.01	11.39	12.5	×1.29	**0.917**	-
	2462(11)			0	#1	fix	**0.661**	+2.22	n/a (*c)	Plot 1-14	99.0	×1.01	11.38	12.5	×1.29	**0.861**	-
	2437(6)		Front	0	#3	fix	**0.743**	+1.95	n/a (*c)	Plot 1-15	99.0	×1.01	11.59	12.5	×1.23	**0.923**	-
	2412(1)			0	#3	fix	**0.754**	+1.65	n/a (*c)	Plot 1-16	99.0	×1.01	11.39	12.5	×1.29	**0.982**	-
	2462(11)			0	#3	fix	**0.721**	+2.22	n/a (*c)	Plot 1-17	99.0	×1.01	11.38	12.5	×1.29	**0.939**	-
	2437(6)		Right	0	#1	fix	**0.501**	+1.95	n/a (*c)	Plot 1-18	99.0	×1.01	11.59	12.5	×1.23	**0.622**	-
			Top-front	0	#2	fix	**0.112**	+1.95	n/a (*c)	Plot 1-19	99.0	×1.01	11.59	12.5	×1.23	**0.139**	-
			Top	0	#2	fix	**n/a**	+1.95	n/a (*c)	Plot 1-20	*. Zoom scan was not performed, because of the measured interpolated maximum value of area scan was small enough.					**n/a**	-
			Bottom	0	#1	fix	**n/a**	+1.95	n/a (*c)	Plot 1-21						**n/a**	-
			Rear	0	#1	fix	**n/a**	+1.95	n/a (*c)	Plot 1-22						**n/a**	-

Notes:

*****. b: IEEE 802.11b, g: IEEE 802.11g, n20: IEEE 802.11n(20HT); Max.: maximum.; Meas.: Measured.; n/a: not applied.

*. Gap: It is the separation distance between the nearest position of camera outer surface and the bottom outer surface of phantom.
Battery ID: Battery ID No.#1, #2 and #3 are same. Refer to Appendix 1 for more detail.

. During test, the EUT was operated with full charged battery and without all interface cables. (.Except USB bus power operation.)

*. Calibration frequency of the SAR measurement probe (and used conversion factors)

SAR test frequency	Probe calibration frequency	Validity	Conversion factor	Uncertainty
2412, 2437, 2462 MHz	2450MHz	within ±50MHz of calibration frequency	7.45	±12.0%

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

*a. The target value is a parameter defined in Appendix A of KDB865664 D01 (v01r04), the dielectric parameters suggested for head and body tissue simulating liquid are given at 2000 and 2450MHz. Parameters for the frequencies 2000-2450MHz were obtained using linear interpolation. (Refer to appendix 3-4.)

*b. Refer to KDB865664 D01 (v01r04), item 2), Clause 2.6; "When nominal tissue dielectric parameters are recorded in the probe calibration data; for example, only target values and tolerance are reported, the measured εr and σ of the liquid used in routine measurements must be: ≤ the target εr and ≥ the target σ values and also within 5% of the required target dielectric parameters."

*c. Calculating formula: $\Delta SAR(1g) = C\varepsilon r \times \Delta\varepsilon r + C\sigma \times \Delta\sigma$, $C\varepsilon r = -7.854E\text{-}4 \times f^3 + 9.402E\text{-}3 \times f^2 - 2.742E\text{-}2 \times f - 0.2026$ / $C\sigma = 9.804E\text{-}3 \times f^3 - 8.661E\text{-}2 \times f^2 + 2.981E\text{-}2 \times f + 0.7829$
ΔSAR corrected SAR (1g) (W/kg) = (Meas. SAR(1g) (W/kg)) × (100 - (ΔSAR(%)) / 100

*d. Calculating formula: Reported SAR (1g) (W/kg) = (Measured SAR (1g) (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 5.2, 2.4GHz SAR Procedures, in KDB248227 D01 (v02r02))

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:

1) When the reported SAR of the highest measured maximum output power channel (section 3.1) for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.
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.

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]	Data rate	EUT setup position	Measured SAR (1g) [W/kg]		Largest to Smallest SAR Ratio	SAR plot # in Appendix 2-2	Remarks
				Original	Repeated			
11g	2437 (6ch)	6Mbps	**Front-right**	**1.04**	**1.04**	**1.000**	Original: Plot 1-6 Repeated: Plot 2-1	*. 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.

7.3 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]

Mode	Frequency [MHz]	Data rate	EUT setup position	Measured SAR (1g) [W/kg] Device holder		Device holder perturbation SAR Ratio	SAR plot # in Appendix 2-2	Remarks
				Exist	None			
n(20HT)	2462 (11ch)	MCS0	**Front-right**	**0.921**	**0.955**	**+3.7 %**	Holder exist:: Plot 1-1 Holder none: Plot 3-1	*.It was smaller than 5% of uncertainty of the setup, so influence of a device holder was judged to be no problem.

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