SAR TEST REPORT

Test Report No.: 12669313S-A-R1

Applicant : **CASIO COMPUTER CO., LTD.**

Type of Equipment : **RF Module**

Model No. : **WSD-F21** (*. It was installed into a limited host: WSD-F21 (Smart Outdoor Watch).)

FCC ID : **BBQ-WSDF21**

Test Standard : **FCC 47CFR §2.1093**

Test Result : **Complied (Refer to Section 3.3)**

RF Exposure Condition	Platform		Highest Reported SAR Value			Remarks			Output power (average)	
	Type	Model	Type	Tune-up value	Limit	Band	Frequency	Mode	Measured	Maximum
Extremity (Wrist)	Smart Outdoor Watch	WSD-F21	SAR (10g)	< 0.10 W/kg	4	DTS	2462 MHz	11b(1Mbps)	16.28 dBm	18 dBm
Next-to-Mouth			SAR (1g)	< 0.10 W/kg	1.6	DTS	2437 MHz	11b(1Mbps)	16.38 dBm	18 dBm

*. 11b: IEEE 802.11b

***. Highest reported SAR (1g) across all exposure conditions and on this platform is "<0.10 W/kg (10g, Wrist)" and "<0.10 W/kg (1g, Next-of-mouth)".**

*. This RF Module: WSD-F21 was only installed into the Smart Outdoor Watch which were listed in above.

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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. The information provided from the customer for this report is identified in SECTION 1.

Date of test: March 4 and 5, 2019

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

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

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☒ There is no testing item of "Non-accreditation".

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CERTIFICATE 1266.03

REVISION HISTORY

Revision	Test report No.	Date	Page revised	Contents
Original	12669313S-A	March 14, 2019	-	-
-R1	12669313S-A-R1	March 19, 2019	all pages	*.EUT was changed to the module (WSD-F21) from platform (WSD-F21). SAR test procedure was changed to module approval.

*. 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	CASIO COMPUTER CO., LTD.
Address	2-1, Sakaecho 3-chome, Hamura-shi, Tokyo, 205-8555 Japan
Telephone Number	+81-42-579-7249
Contact Person	Munetaka Seo

The information provided from the customer is as follows;
- Applicant, Type of Equipment, Model No., FCC IDon the cover and other relevant pages
- SECTION 1: Customer information
- SECTION 2: Equipment under test (EUT)
- SECTION 4: Operation of EUT during testing
- Appendix 1: The part of Antenna location information, Description of EUT and Support Equipment

* The laboratory is exempted from liability of any test results affected from the above information in SECTION 2 and 4.

SECTION 2: Equipment under test (EUT)

2.1 Identification of EUT

	EUT	Platform
Type of Equipment	RF Module	Smart Outdoor Watch
Model Number	WSD-F21	WSD-F21
Serial Number	6	6
Condition of EUT	Production prototype	Production prototype
	*. Not for sale: These samples are equivalent to mass-produced items.	
Receipt Date of Sample	February 4, 2019 (*. EUT for power measurement.) *. No modification by the Lab. March 1, 2019 (*. EUT for SAR test.) *. No modification by the Lab. (*. After power measurement, the EUT was returned to the customer, and the RF wiring was changed to the original antenna line from the antenna conducted power measurement line by the customer.)	
Country of Mass-production	Japan, Thailand	
Category Identified	Portable device	
Feature of EUT	Model: WSD-F21 (referred to as the EUT in this report) is a RF Module which installs into the Smart Outdoor Watch (Wristwatch , Model: WSD-F21). The platform: WSD-F21 supports some operations and functions (e.g. responding to mail and SMS messages, etc.) by using the voice command.	
SAR Accessory (Platform)	Removable wrist band: non-metallic. *. For the SAR test, the wrist band holder was cut off and also removed the wrist band to make the back of wristwatch touch to the flat phantom directly. (Refer to Appendix 1-1 for more detail.)	

2.2 Product Description (RF Module)

Model	WSD-F21	FCC ID	BBQ-F21	ISED certification number	2388B-WSDF21	
Equipment type	Transceiver					
Operation mode	Wi-Fi			Bluetooth (Ver. 4.2 with EDR function)		
Frequency of operation	2412-2462 MHz (b, g, n20)			2402-2480 MHz (BDR (Basic Data Rate), EDR (Enhanced Data Rate), BLE (Low Energy mode))		
Channel spacing	5 MHz			1MHz (BDR, EDR), 2MHz (BLE)		
Bandwidth	20 MHz (b, g, n20)			79MHz		
Type of modulation	(b) DSSS: DBPSK, DQPSK, CCK (g, n20)) OFDM: BPSK, QPSK, 16QAM, 64QAM			FHSS: GFSK (*. EDR: GFSK+π/4-DQPSK, GFSK+8DPSK)		

Transmit typical power and maximum tune-up tolerance limit	Mode	b	g	n(20HT)	BDR	EDR	BLE
	Typical	15.0 dBm	11.0 dBm	10.0 dBm	7.5 dBm	4.5 dBm	5.5 dBm
	Maximum	18.0 dBm	14.0 dBm	13.0 dBm	9.5 dBm	6.5 dBm	7.5 dBm
	Remarks	-	-	-	-	-	-
	*. The measured Tx output power (conducted) refers to section 6 in this report.						

Quantity of Antenna	1 piece	Antenna model	1019-046A	Antenna connector type	Soldering
Antenna gain (peak)	-6.90 dBi			Antenna type	Inverted L Type

*. b: IEEE 802.11b, g: IEEE 802.11g, n20: IEEE 802.11n(20HT); BLE: Bluetooth Low Energy; BDR: Basic Data Rate; EDR: Enhanced Data Rate; n/a: not applied.
*. The EUT do not use the special transmitting technique such as "beam-forming" and "time-space code diversity."
*. Since Wi-Fi and Bluetooth are used a same antenna, Wi-Fi and Bluetooth do not transmit simultaneously.

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, Extremity (averaged over any 10g of tissue) limit: 4 W/kg (Wrist)
General population / uncontrolled exposure, Partial-Body (averaged over any 1g of tissue) limit: 1.6 W/kg (Next-to-Mouth)

***. Tested platform is a wristwatch which support the voice command.**

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)			
Platform / model	Smart Outdoor Watch (Model: WSD-F21)			
RF Exposure condition	Extremity (Wrist)		Partial-body (Next-to-Mouth)	
Limit	4 W/kg (SAR(10g))		1.6 W/kg (SAR(1g))	
Results	Bluetooth	Wi-Fi	Bluetooth	Wi-Fi
	Complied (*. lower power, SAR test was exempt.)	Complied (*. Refer to Section 7 and Appendix 2)	Complied (*. lower power, SAR test was exempt.)	Complied (*. Refer to Section 7 and Appendix 2)
Reported SAR value (*. Scaled)	N/A	0.056 W/kg	N/A	0.088 W/kg
Measured SAR value	N/A	0.037 W/kg	N/A	0.060 W/kg
Operation mode, channel	-	11b (1Mbps, DSSS), 2462 MHz (11ch)	-	11b (1Mbps, DSSS), 2437 MHz (6ch)
Duty cycle (duty cycle factor)	-	99.0 % (×1.01)	-	99.0 % (×1.01)
Power measured/max. (scaled factor)	-	16.28 dBm / max.18 dBm (×1.49)	-	16.38 dBm / max.18dBm (×1.45)

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
*. b: IEEE 802.11b, max.:maximum, n/a: not applied.
*. Since Bluetooth and Wii-Fi are used a same antenna, Bluetooth and Wi-Fi do not transmit simultaneously.
*. (Calculating formula) (Reported SAR value) 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, %)

Test outline: Where the EUT is built into a platform, it was verified whether multi-platform conditions can be suited in according with section 2) of 5.2.2 in KDB447498 D01 (v06).

Consideration of the test results:	**The highest reported SAR (1g) and SAR (10g) of this platform was kept; ≤ 0.4 W/kg.** Since highest reported SAR (1g) on this EUT's platform obtained in accordance with KDB447498 D01 (v06) was kept under 0.4 W/kg, this EUT was approved to operate multi-platform (limited to the wristwatch type).

3.4 Addition, deviation and exclusion to the test procedure

No addition, exclusion nor deviation has been made from the test procedure.

3.5 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
A2LA Certificate Number: 1266.03 (FCC Test Firm Registration Number: 626366)

Used?	Place	ISED 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	-

3.6 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.

*. The platform 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.**)**

b		g				n20 (SS×1)						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	BLE	GFSK/FHSS	-	1
DQPSK/DSSS	2	BPSK/OFDM	9	16QAM/OFDM	36	1	13	QPSK/OFDM	5	52	64QAM/OFDM	BDR	GFSK/FHSS	DH5	1
CCK/DSSS	5.5	QPSK/OFDM	12	64QAM/OFDM	48	2	19.5	QPSK/OFDM	6	58.5	64QAM/OFDM	EDR2	π/4-DQPSK/FHSS	2DH	2
CCK/DSSS	11	QPSK/OFDM	18	64QAM/OFDM	54	3	26	16QAM/OFDM	7	65	64QAM/OFDM	EDR3	8DPSK/FSSS	3DH5	3

*. Data rate: [Mbps]; SS: Spatial Stream; b: IEEE 802.11b, g: IEEE 802.11g, n20: IEEE 802.11n(20HT); BLE: Bluetooth Low Energy; BDR: Basic Data Rate; EDR: Enhanced Data Rate.

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 and specified channels with the worst data rate condition in step 1 in the above.

3.7 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.**

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 (BDR/EDR/BLE) continuous transmitting modes.
The frequency and the modulation used in the SAR testing are shown as a following.

Operation mode		BDR	EDR		BLE	b	g	n20
Tx frequency band		2402-2480MHz				2412-2462MHz		
Maximum power [dBm]		9.5	6.5	6.5	7.5	18.0	14.0	13.0
			(*. lower power than BDR.)				(*. lower power than 11b mode)	
SAR tested condition	Frequency [MHz]	n/a	n/a (lower power)			2412, 2437, 2462	n/a	n/a
	Modulation	GFSK	GFSK+π/4-DQPSK	GFSK+8DPSK	GFSK	DSSS	OFDM	OFDM
	Data rate [Mbps]	1	2	3	1	1	6	6.5(MCS0)
SAR tested/reduced?		Reduced	Reduced	Reduced	Reduced	Tested	Reduce	Reduce
Controlled software		WSD-F21-radio ver1.0 *. This setting of software is the worst case. Any conditions under the normal use do not exceed the condition of setting. In addition, end users cannot change the settings of the output power of the product.						
Power setting	Power measurement	fix	fix	fix	fix	fix	fix	fix
	SAR	fix	n/a	n/a	n/a	fix	fix	fix

*. b: IEEE 802.11b, g: IEEE 802.11g, n20: IEEE 802.11n(20HT); BLE: Bluetooth Low Energy; BDR: Basic Data Rate; EDR: Enhanced Data Rate; n/a: not applied.
*. Any output power reducing for channel 1 and 11 to meet restricted band requirements was not observed.
*. (KDB248227 D01 (v02r02)) Since the reported SAR of the highest measured maximum output power channel is ≤ 0.8 W/kg, the SAR testing for other channels were omitted. However, the SAR testing was applied to lower, middle and upper channels for the worst SAR condition.

4.2 Test setup and SAR measurement procedure

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

Mode		Wi-Fi		Bluetooth		
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 (*1, *2)	D [mm]	SAR Tested /Reduced (*1, *2)	SAR type (*1, *2)
Back	The back flat-surface of watch is touched to the Flat phantom.	**7.35**	**Tested**	**7.35**	**Tested**	Wrist-touch
Front	The front surface of watch is set parallel to the Flat phantom with 10mm separation gap.	**7.72**	**Tested**	**7.72**	**Tested**	Next-to-Mouth
Bezel-left	The left side of bezel of watch is touched to the Flat phantom.	**9.5**	Reduced	**9.5**	Reduced	Not applied
Near side	The near side of bezel of watch is touched to the Flat phantom.	**21.564**	Reduced	**21.564**	Reduced	
Far side	The far side of bezel of watch is touched to the Flat phantom.	**26.214**	Reduced	**26.214**	Reduced	
Bezel-right	The right side of bezel of watch is touched to the Flat phantom.	**43.658**	Reduced	**43.658**	Reduced	

*. **D:** Antenna separation distance. It is the distance from the EUT antenna inside a platform to the outer surface of platform which an operator may touch.
. Size of platform: round shape, 60 mm (length) × 60 mm (width) × 20 mm (thickness) (. excluding wrist band.)

***. Consideration for SAR evaluation exemption**

***1. It was applied the SAR test procedure "KDB447498 D01 (v06), Clause 6.2. Wrist watch and wrist-worn transmitters", because this platform which has EUT built-in is a wristwatch and the voice command is supported.**

According to KDB447498 D01 (v06), Clause 6.2. Wrist watch and wrist-worn transmitters;

Transmitters that are built-in within a wrist watch or similar wrist-worn devices typically operate in speaker mode for voice communication, with the device worn on the wrist and positioned next to the mouth. Next to the mouth exposure requires 1-g SAR and the wrist-worn condition requires 10-g extremity SAR. The 10-g extremity and 1-g SAR test exclusions may be applied to the wrist and face exposure conditions. When SAR evaluation is required, next to the mouth use is evaluated with the front of the device positioned at 10 mm from a flat phantom filled with head tissue-equivalent medium. The wrist bands should be strapped together to represent normal use conditions. SAR for wrist exposure is evaluated with the back of the device positioned in direct contact against a flat phantom filled with body tissue-equivalent medium. The wrist bands should be unstrapped and touching the phantom. The space introduced by the watch or wrist bands and the phantom must be representative of actual use conditions; otherwise, if applicable, the neck or a curved head region of the SAM phantom may be used, provided the device positioning and SAR probe access issues have been addressed through a KDB inquiry. When other device positioning and SAR measurement considerations are necessary, a KDB inquiry is also required for the test results to be acceptable; for example, devices with rigid wrist bands or electronic circuitry and/or antenna(s) incorporated in the wrist bands. These test configurations are applicable only to devices that are worn on the wrist and cannot support other use conditions; therefore, the operating restrictions must be fully demonstrated in both the test reports and user manuals.

*2. SAR test exclusion considerations according to KDB447498 D01

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) for SAR 1g (next-to-mouth), nor 7.5 (of less) for SAR 10g (wrist-touch), SAR test can be excluded.

[SAR exclusion calculations for step 1) antenna ≤50mm from the user]

Antenna	Tx mode	Upper Freq. [MHz]	Maximum output power		Step 1) SAR exclusion calculations for antenna ≤50mm from the user.						
					Calculated threshold value						
					Setup	Back (SAR 10g)	Front (SAR 1g)	Bezel-right	Near-side	Far-side	Bezel-right
			[dBm]	[mW]	D[mm]	7	8	10	22	26	44
Main	b	2462	18.0	**63**	Judge	**14.1, Measure**	**12.4, Measure**	Reduce, KDB 447498 D01, Clause 6.2			
Main	g	2462	14.0	**25**	Judge	5.6, Reduce	**6.3, Measure**	Reduce, KDB 447498 D01, Clause 6.2			
Main	n20	2462	13.0	**20**	Judge	4.5, Reduce	**4.9, Measure**	Reduce, KDB 447498 D01, Clause 6.2			
Main	BDR	2480	9.5	**9**	Judge	2.0, Reduce	2.8, Reduce	Reduce, KDB 447498 D01, Clause 6.2			
Main	BLE	2480	7.5	**6**	Judge	1.3, Reduce	1.6, Reduce	Reduce, KDB 447498 D01, Clause 6.2			
Main	EDR	2480	6.5	**4**	Judge	0.9, Reduce	1.2, Reduce	Reduce, KDB 447498 D01, Clause 6.2			

*. Freq: Frequency, D: Antenna separation distance, b: IEEE 802.11b, g: IEEE 802.11g, n20: IEEE 802.11n(20HT); BLE: Bluetooth Low Energy; BDR: Basic Data Rate; EDR: Enhanced Data Rate.

<Conclusion for consideration for SAR test reduction>

1) Tested platform is a wristwatch with the watch-wristband which can't be removed easily. This platform is usually worn on the wrist. Since the platform has sound responsive function, the platform is used in front of the mouth when a voice input is operated.
2) So, the "Back" setup is considered extremity (wrist) SAR (touch) and is applied the SAR test in body-liquid.
3) So, the "Front" setup is considered partial body SAR (next-to-mouth, 10 mm separation gap) and is applied the SAR test in head-liquid.

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

Step 1	Worst extremity SAR(10g) (wrist) search of DSSS mode; Determine the highest reported SAR(10g) of DSSS mode. (*. Change the channel and mode, if it is necessary.)
Step 2	Worst partial body SAR(1g) (next-to-mouth) search of DSSS mode; Determine the highest reported SAR(1g) of DSSS mode. (*. Change the channel and mode, if it is necessary.)

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

SECTION 5: Uncertainty Assessment (SAR measurement)

Although this standard determines only the limit value of uncertainty, there is no applicable rule of uncertainty in this. Therefore, the following results are derived depending on whether or not laboratory uncertainty is applied.

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 (ε',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

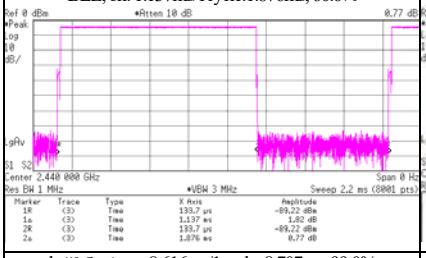
Mode	Frequency		Data rate	Power Setting (software)	Duty cycle	Duty factor	Duty scaled factor	Measurement Result				Power correction			Was power tuning applied?	Remarks *. Antenna gain (peak): -6.90 dBi
								Time average power		Burst power		Max. power	Δ from max.	Tune-up factor		
	[MHz]	CH	[Mbps]	[-]	[%]	[dB]	[-]	[dBm]	[mW]	[dBm]	[mW]	[dBm]	[dB]	[-]		
BDR	2402	0	1(DH5)	fix	77.8	1.09	×1.29	7.67	5.85	**8.76**	7.52	9.5	-0.74	×1.19	n/a (fix)	-
	2441	39	1(DH5)	fix	77.8	1.09	×1.29	7.73	5.93	**8.82**	7.62	9.5	-0.68	×1.17	n/a (fix)	-
	2480	78	1(DH5)	fix	77.8	1.09	×1.29	7.71	5.90	**8.80**	7.59	9.5	-0.70	×1.17	n/a (fix)	-
EDR	2402	0	2(2DH5)	fix	77.8	1.09	×1.29	4.00	2.51	**5.09**	3.23	6.5	-1.41	×1.38	n/a (fix)	-
	2441	39	2(2DH5)	fix	77.8	1.09	×1.29	4.08	2.56	**5.17**	3.29	6.5	-1.33	×1.36	n/a (fix)	-
	2480	78	2(2DH5)	fix	77.8	1.09	×1.29	4.80	3.02	**5.89**	3.88	6.5	-0.61	×1.15	n/a (fix)	-
EDR	2402	0	3(3DH5)	fix	77.8	1.09	×1.29	4.02	2.52	**5.11**	3.24	6.5	-1.39	×1.38	n/a (fix)	-
	2441	39	3(3DH5)	fix	77.8	1.09	×1.29	4.12	2.58	**5.21**	3.32	6.5	-1.29	×1.35	n/a (fix)	-
	2480	78	3(3DH5)	fix	77.8	1.09	×1.29	4.82	3.03	**5.91**	3.90	6.5	-0.59	×1.15	n/a (fix)	-
BLE	2402	0	1	fix	60.6	2.18	×1.65	4.81	3.03	**6.99**	5.00	7.5	-0.51	×1.12	n/a (fix)	-
	2440	19	1	fix	60.6	2.18	×1.65	4.69	2.94	**6.87**	4.86	7.5	-0.63	×1.16	n/a (fix)	-
	2480	39	1	fix	60.6	2.18	×1.65	4.51	2.82	**6.69**	4.67	7.5	-0.81	×1.21	n/a (fix)	-
b	2412	1	1	fix	99.0	0.04	×1.01	16.42	43.85	**16.46**	44.26	18.0	-1.54	×1.43	n/a (fix)	-
	2437	6	1	fix	99.0	0.04	×1.01	16.34	43.05	**16.38**	43.45	18.0	-1.62	×1.45	n/a (fix)	-
	2462	11	1	fix	99.0	0.04	×1.01	16.24	42.07	**16.28**	42.46	18.0	-1.72	×1.49	n/a (fix)	-
g	2412	1	6	fix	93.7	0.28	×1.07	12.44	17.54	**12.72**	18.71	14.0	-1.28	×1.34	n/a (fix)	-
	2437	6	6	fix	93.7	0.28	×1.07	12.35	17.18	**12.63**	18.32	14.0	-1.37	×1.37	n/a (fix)	-
	2462	11	6	fix	93.7	0.28	×1.07	12.31	17.02	**12.59**	18.16	14.0	-1.41	×1.38	n/a (fix)	-
n20	2412	1	MCS0	fix	93.1	0.31	×1.07	11.19	13.15	**11.50**	14.13	13.0	-1.50	×1.41	n/a (fix)	-
	2437	6	MCS0	fix	93.1	0.31	×1.07	11.00	12.59	**11.31**	13.52	13.0	-1.69	×1.48	n/a (fix)	-
	2462	11	MCS0	fix	93.1	0.31	×1.07	11.04	12.71	**11.35**	13.65	13.0	-1.65	×1.46	n/a (fix)	-

*. : SAR test was applied.; *. xx.xx highlight is shown the maximum measured output power in each mode.; CH: channel, max: maximum, n/a: not applied.
*. The SAR test power was not more than 2dB lower than maximum tune-up power by the default power setting. (KDB 447498 D01 (v06) requirement).
*. b: IEEE 802.11b, g: IEEE 802.11g, n20: IEEE 802.11n(20HT); BLE: Bluetooth Low Energy; BDR: Basic Data Rate; EDR: Enhanced Data Rate; n/a: not applied.
*. For Wi-Fi mode, the lowest data rate (lowest modulation) mode was selected for the SAR test which had the highest time-based measured average power.
*. The measured duty cycle number of BDR/EDR/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.

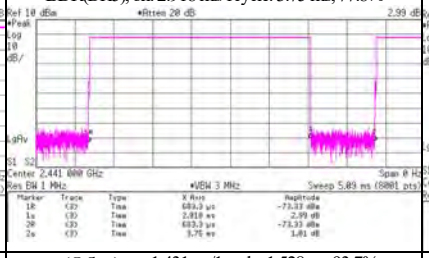
Data rate (D/R, [Mbps]) vs Time average power (dBm)																			
11b (2412MHz)				11g (2412MHz)								11n(20HT) (2412MHz)							
D/R	Duty cycle (%)	Duty factor (dB)	Power	D/R	Duty cycle (%)	Duty factor (dB)	Power	D/R	Duty cycle (%)	Duty factor (dB)	Power	D/R	Duty cycle (%)	Duty factor (dB)	Power	D/R	Duty cycle (%)	Duty factor (dB)	Power
1	99.0	0.04	**16.42**	**6**	93.7	0.28	**12.44**	24	78.9	1.03	n/a (*1)	**MCS0**	93.1	0.31	**11.19**	MCS4	72.0	1.43	n/a (*1)
2	98.0	0.09	16.39	9	90.8	0.42	12.43	36	72.1	1.42	n/a (*1)	MCS1	87.4	0.58	10.91	MCS5	66.9	1.75	n/a (*1)
5.5	94.7	0.24	16.34	12	88.0	0.56	12.35	48	66.5	1.77	n/a (*1)	MCS2	82.7	0.82	n/a (*1)	MCS6	65.2	1.86	n/a (*1)
11	90.4	0.44	16.08	18	83.4	0.79	n/a (*1)	56	64.6	1.90	n/a (*1)	MCS3	78.6	1.05	n/a (*1)	MCS7	62.9	2.01	n/a (*1)

*. Since the duty cycle is lower than 85%, this data rate (as higher modulation mode) is not selected the SAR test. (KDB 248227, clause 2.2)

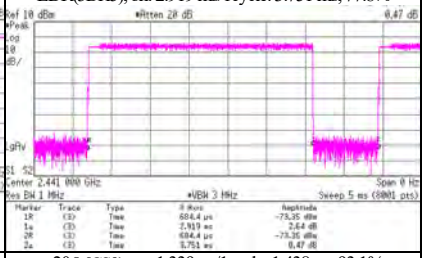
BLE, on: 1.137ms/1cycle:1.876ms, 60.6%



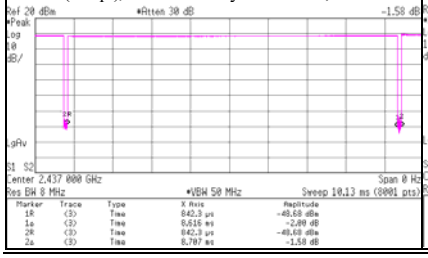
BDR(DH5), on: 2.918 ms/1cycle: 3.75 ms, 77.8%



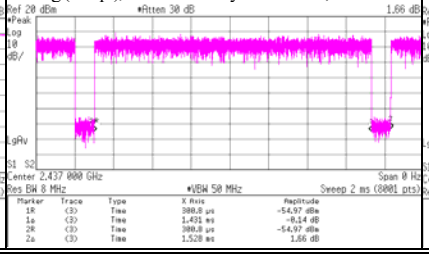
EDR(3DH5), on: 2.919 ms/1cycle: 3.751 ms, 77.8%



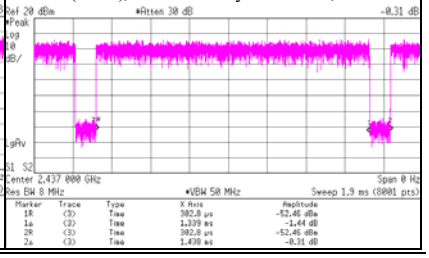
b (1Mbps), on: 8.616ms/1cycle: 8.707ms, 99.0%



g (6Mbps), on: 1.431ms/1cycle: 1.528ms, 93.7%



n20(MCS0), on: 1.339ms/1cycle: 1.438ms, 93.1%



*. 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, %)), where Duty cycle (%) = (on-time) / (1 cycle time) × 100
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: February 26, 2019 / Measured by: Hiroshi Naka / Place: preparation room of No. 7 shielded room. (23 deg.C. / 44 %RH)
*. Uncertainty of antenna port conducted test; Power measurement uncertainty above 1GHz for this test was: (±) 0.81 dB(Average).
*. Uncertainty of antenna port conducted test; Duty cycle and time measurement: (±) 0.012 %.

6.2 Comparison of power of EMC sample

	WSD-F21's platform model	WSD-F21 serial No.	Date power measured	Reference report#	Tx mode	Data rate [Mbps]	Average power (burst) [dBm] ("*": Highest)			
							Max. power	Frequency [MHz]		
								2412	2437	2462
EMC (Ref.)	WSD-F21	1	June 22, 2018	12669310S-A	11b	11	18.0	16.40*	16.37	16.28
SAR test	WSD-F21	6	February 26, 2019	*.This report	11b	1	18.0	16.49*	16.38	16.28

*. The power data above-mentioned diverted a result of measurement of EMC test of report identifier: 12669310S-A tested and published by UL Japan, Inc.

SECTION 7: SAR Measured results

Measurement date: March 4 and 5, 2019 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]						ΔSAR [%]		Correction required?	
		Target	Measured Meas.	Measured Δεr [%]	Limit (*b)	Target	Measured Meas.	Measured Δσ [%]	Limit (*b)						
2412	Body	52.75	50.84	-3.6	-5% ≤ εr-meas. ≤ 0%	1.914	1.966	+2.8	0% ≤ σ-meas. ≤ +5%	22.0	151	+1.31	10g	not required.	March 5, 2019 before SAR test
2437		52.72	50.75	-3.7		1.938	1.999	+3.2				+1.42	10g	not required.	
2462		52.68	50.65	-3.9		1.967	2.037	+3.5				+1.53	10g	not required.	
2412	Head	39.27	38.25	-2.6	-5% ≤ εr-meas. ≤ 0%	1.766	1.826	+3.4	0% ≤ σ-meas. ≤ +5%	23.9	150	+2.24	1g	not required.	March 4, 2019 before SAR test
2437		39.22	38.16	-2.7		1.788	1.857	+3.9				+2.46	1g	not required.	
2462		39.18	38.05	-2.9		1.813	1.884	+3.7				+2.52	1g	not required.	

[SAR measurement results]

Mode	Frequency [MHz] (Channel)	Data rate [Mbps]	Setup Position	Setup Source power	Setup Gap [mm]	SAR [W/kg] Max. value of multi-peak Type	SAR [W/kg] Max. value of multi-peak Meas.	SAR [W/kg] Max. value of multi-peak ΔSAR [%]	SAR [W/kg] Max. value of multi-peak ΔSAR corrected	SAR plot # in Appendix 2-2	Reported SAR [W/kg] Duty cycle correction Duty [%]	Duty cycle correction Duty scaled	Output burst average power correction Meas. [dBm].	Output burst average power correction Max. [dBm]	Output burst average power correction Tune-up factor	SAR Corrected (*d)	Limit [W/kg]	Remarks
Step 1: Worst extremity SAR(10g) (wrist) in Body liquid																		
11b	2437(6)	1	Back	Battery	0	10g	0.035	+1.42	n/a (*c)	Plot 1-2	99.0	×1.01	16.38	18.0	×1.45	0.051	4	-
11b	2412(1)	1	Back	Battery	0	10g	0.035	+1.31	n/a (*c)	Plot 1-3	99.0	×1.01	16.46	18.0	×1.43	0.051	4	-
11b	2462(11)	1	Back	Battery	0	10g	0.037	+1.53	n/a (*c)	Plot 1-1	99.0	×1.01	16.28	18.0	×1.49	0.056	4	Higher
Step 2: Worst partial body SAR(1g) (next-to-mouth) in Head liquid																		
11b	2437(6)	1	Front	Battery	10	1g	0.060	+2.46	n/a (*c)	Plot 2-1	99.0	×1.01	16.38	18.0	×1.45	0.088	1.6	Higher
11b	2412(1)	1	Front	Battery	10	1g	0.060	+2.24	n/a (*c)	Plot 2-2	99.0	×1.01	16.46	18.0	×1.43	0.087	1.6	-
11b	2462(11)	1	Front	Battery	10	1g	0.048	+2.52	n/a (*c)	Plot 2-3	99.0	×1.01	16.28	18.0	×1.49	0.072	1.6	-

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; n/a: not applied.
*. During test, the platform was operated by build-in rechargeable Li-ion battery with USB bus power by connecting I/F cable.
*. 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	2450MHz	within ±50MHz of calibration frequency	7.32	±12.0%
Head	2412, 2437, 2462 MHz	2450MHz	within ±50MHz of calibration frequency	7.31	±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 KDB 865664 D01 (v01r04), the dielectric parameters suggested are given at 2000, 2450, 3000MHz. Parameters for the frequencies between 2000 and 3000 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 5.2, 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 for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.

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.

*. SAR test of OFDM mode was reduced, because the estimate reported SAR of OFDM mode was ≤ 1.2 W/kg by using the highest reported SAR of DSSS mode.

OFDM mode	Maximum tune-up tolerance limit DSSS [dBm]	DSSS [mW] (a)	OFDM [dBm]	OFDM [mW] (b)	OFDM scaled factor [-] (b)/(a)×100	DSSS reported SAR value SAR type		Setup	[W/kg]	Estimated SAR value: OFDM [W/kg]	Exclusion limit [W/kg]	Standalone SAR test require?
11g	18.0	63	14.0	25	0.397	10g	Wrist	Back	0.056	**0.022**	**≤ 1.2**	**No**
n(20HT)	18.0	63	13.0	20	0.317	10g		Back	0.056	**0.018**	**≤ 1.2**	**No**
11g	18.0	63	14.0	25	0.397	1g	Next-to-mouse	Front	0.088	**0.035**	**≤ 1.2**	**No**
n(20HT)	18.0	63	13.0	20	0.317	1g		Front	0.088	**0.028**	**≤ 1.2**	**No**