



RADIO TEST REPORT

Test Report No. : 12899681H-A-R1

Applicant : DENSO CORPORATION
Type of Equipment : PHONE AS KEY MODULE (PAKM)
Model No. : S2NF0
FCC ID : HYQS2NF0
Test regulation : FCC Part 15 Subpart C: 2019
Test Result : Complied (Refer to SECTION 3.2)

1. This test report shall not be reproduced in full or partial, without the written approval of UL Japan, Inc.
2. The results in this report apply only to the sample tested.
3. This sample tested is in compliance with the above regulation.
4. The test results in this report are traceable to the national or international standards.
5. This test report covers Radio technical requirements. It does not cover administrative issues such as Manual or non-Radio test related Requirements. (if applicable)
6. The all test items in this test report are conducted by UL Japan, Inc. Ise EMC Lab.
7. This test report must not be used by the customer to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.
8. The information provided from the customer for this report is identified in SECTION 1.
9. This report is a revised version of 12899681H-A. 12899681H-A is replaced with this report.

Date of test: June 10 to 19, 2019

Representative test engineer:


Takafumi Noguchi

Engineer

Consumer Technology Division

Approved by:


Motoya Imura

Leader

Consumer Technology Division



This laboratory is accredited by the NVLAP LAB CODE 200572-0, U.S.A. The tests reported herein have been performed in accordance with its terms of accreditation.
*As for the range of Accreditation in NVLAP, you may refer to the WEB address,
http://japan.ul.com/resources/emc_accredited/

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

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REVISION HISTORY

Original Test Report No.: 12899681H-A

[illegible]

CONTENTS	PAGE
SECTION 1: Customer information.....	4
SECTION 2: Equipment under test (E.U.T.).....	4
SECTION 3: Test specification, procedures & results.....	5
SECTION 4: Operation of E.U.T. during testing.....	8
SECTION 5: Radiated Spurious Emission	10
SECTION 6: Antenna Terminal Conducted Tests.....	13
APPENDIX 1: Test data	14
6 dB Bandwidth and 99 % Occupied Bandwidth.....	14
Average Output Power.....	18
Radiated Spurious Emission	20
Conducted Spurious Emission	26
Power Density	29
APPENDIX 2: Test instruments	31
APPENDIX 3: Photographs of test setup	32
Radiated Spurious Emission	32
Worst Case Position	33

SECTION 1: Customer information

Company Name	:	DENSO CORPORATION
Address	:	1-1, Showa-cho, Kariya-shi, Aichi-ken, 448-8661, Japan
Telephone Number	:	+81-566-61-5209
Facsimile Number	:	+81-566-25-4837
Contact Person	:	Kazunari Nakamura

The information provided from the customer is as follows;

- Applicant, Type of Equipment, Model No., FCC ID on the cover and other relevant pages
- Operating/Test Mode(s) (Mode(s)) on all the relevant pages
- SECTION 1: Customer information
- SECTION 2: Equipment under test (E.U.T.)
- SECTION 4: Operation of E.U.T. during testing

* 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 (E.U.T.)

2.1 Identification of E.U.T.

Type of Equipment	:	PHONE AS KEY MODULE (PAKM)
Model No.	:	S2NF0
Serial No.	:	Refer to SECTION 4.2
Rating	:	DC 12 V (S2NF0) DC 3.3 V (Bluetooth IC)
Receipt Date of Sample (Information from test lab.)	:	June 6, 2019
Country of Mass-production	:	Japan
Condition of EUT	:	Production prototype (Not for Sale: This sample is equivalent to mass-produced items.)
Modification of EUT	:	No Modification by the test lab

2.2 Product Description

Model: S2NF0 (referred to as the EUT in this report) is a PHONE AS KEY MODULE (PAKM).

Radio Specification

Radio Type	:	Transceiver
Frequency of Operation	:	2402 MHz - 2480 MHz
Modulation	:	GFSK
Antenna type	:	Inverted F Antenna
Antenna Gain	:	3.3 dBi (max)
Clock frequency (Maximum)	:	48 MHz (Crystal)

SECTION 3: Test specification, procedures & results

3.1 Test Specification

Test Specification : FCC Part 15 Subpart C
FCC Part 15 final revised on July 19, 2019 and effective August 19, 2019 except 15.258

Title : FCC 47CFR Part15 Radio Frequency Device Subpart C Intentional Radiators
Section 15.207 Conducted limits
Section 15.247 Operation within the bands 902-928MHz,
2400-2483.5MHz, and 5725-5850MHz

* The revision on July 19, 2019, does not affect the test specification applied to the EUT.

3.2 Procedures and results

Item	Test Procedure	Specification	Worst margin	Results	Remarks
Conducted Emission	FCC: ANSI C63.10-2013 6. Standard test methods	FCC: Section 15.207	N/A	N/A	*1)
	IC: RSS-Gen 8.8	IC: RSS-Gen 8.8			
6dB Bandwidth	FCC: KDB 558074 D01 15.247 Meas Guidance v05r02	FCC: Section 15.247(a)(2)	See data.	Complied a)	Conducted
	IC: -	IC: RSS-247 5.2(a)			
Maximum Peak Output Power	FCC: KDB 558074 D01 15.247 Meas Guidance v05r02	FCC: Section 15.247(b)(3)		Complied b)	Conducted
	IC: RSS-Gen 6.12	IC: RSS-247 5.4(d)			
Power Density	FCC: KDB 558074 D01 15.247 Meas Guidance v05r02	FCC: Section 15.247(e)		Complied c)	Conducted
	IC: -	IC: RSS-247 5.2(b)			
Spurious Emission Restricted Band Edges	FCC: KDB 558074 D01 15.247 Meas Guidance v05r02	FCC: Section 15.247(d)	1.1 dB 192.004 MHz, QP, Vertical	Complied# d), e)	Conducted (below 30 MHz)/ Radiated (above 30 MHz) *2)
	IC: RSS-Gen 6.13	IC: RSS-247 5.5 RSS-Gen 8.9 RSS-Gen 8.10			

Note: UL Japan, Inc.'s EMI Work Procedures No. 13-EM-W0420 and 13-EM-W0422.

*1) The test is not applicable since the EUT is not the device that is designed to be connected to the public utility (AC) power line.

*2) Radiated test was selected over 30 MHz based on section 15.247(d) and KDB 558074 D01 15.247 Meas Guidance v05r02 8.5 and 8.6.

a) Refer to APPENDIX 1 (data of 6 dB Bandwidth and 99 % Occupied Bandwidth)

b) Refer to APPENDIX 1 (data of Maximum Peak Output Power)

c) Refer to APPENDIX 1 (data of Power Density)

d) Refer to APPENDIX 1 (data of Conducted Spurious Emission)

e) Refer to APPENDIX 1 (data of Radiated Spurious Emission)

Symbols:

Complied The data of this test item has enough margin, more than the measurement uncertainty.

Complied# The data of this test item meets the limits unless the measurement uncertainty is taken into consideration.

* In case any questions arise about test procedure, ANSI C63.10: 2013 is also referred.

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FCC Part 15.31 (e)

The test was performed with the New Battery and the EUT constantly provides the stable voltage to RF part through the regulator regardless of input voltage from New Battery. Therefore, this EUT complies with the requirement.

FCC Part 15.203 Antenna requirement

It is impossible for end users to replace the antenna, because the antenna is mounted inside of the EUT. Therefore, the equipment complies with the antenna requirement of Section 15.203.

3.3 Addition to standard

Item	Test Procedure	Specification	Worst margin	Results	Remarks
99% Occupied Bandwidth	RSS-Gen 6.7	IC: -	N/A	-	Conducted

Other than above, no addition, exclusion nor deviation has been made from the standard.

3.4 Uncertainty

EMI

There is no applicable rule of uncertainty in this applied standard. Therefore, the results are derived depending on whether or not laboratory uncertainty is applied.

The following uncertainties have been calculated to provide a confidence level of 95 % using a coverage factor $k=2$.
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Antenna Terminal test

Test Item	Uncertainty (+/-)
20 dB Bandwidth / 99 % Occupied Bandwidth	0.96 %
Maximum Peak Output Power / Average Output Power	1.3 dB
Carrier Frequency Separation	0.42 %
Dwell time / Burst rate	0.10 %
Conducted Spurious Emission	2.7 dB

Radiated emission

Measurement distance	Frequency range	Uncertainty (+/-)
3 m	9 kHz to 30 MHz	3.3 dB
10 m		3.2 dB
3 m	30 MHz to 200 MHz (Horizontal)	4.8 dB
	(Vertical)	5.0 dB
	200 MHz to 1000 MHz (Horizontal)	5.2 dB
	(Vertical)	6.3 dB
10 m	30 MHz to 200 MHz (Horizontal)	4.8 dB
	(Vertical)	4.9 dB
	200 MHz to 1000 MHz (Horizontal)	5.0 dB
	(Vertical)	5.0 dB
3 m	1 GHz to 6 GHz	5.0 dB
	6 GHz to 18 GHz	5.3 dB
1 m	10 GHz to 26.5 GHz	5.8 dB
	26.5 GHz to 40 GHz	5.8 dB
10 m	1 GHz to 18 GHz	5.2 dB

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3.5 Test Location

UL Japan, Inc. Ise EMC Lab.

*NVLAP Lab. code: 200572-0 / FCC Test Firm Registration Number: 199967 / ISED Lab Company Number: 2973C

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Test site	Width x Depth x Height (m)	Size of reference ground plane (m) / horizontal conducting plane	Other rooms	Maximum measurement distance
No.1 semi-anechoic chamber	19.2 x 11.2 x 7.7	7.0 x 6.0	No.1 Power source room	10 m
No.2 semi-anechoic chamber	7.5 x 5.8 x 5.2	4.0 x 4.0	-	3 m
No.3 semi-anechoic chamber	12.0 x 8.5 x 5.9	6.8 x 5.75	No.3 Preparation room	3 m
No.3 shielded room	4.0 x 6.0 x 2.7	N/A	-	-
No.4 semi-anechoic chamber	12.0 x 8.5 x 5.9	6.8 x 5.75	No.4 Preparation room	3 m
No.4 shielded room	4.0 x 6.0 x 2.7	N/A	-	-
No.5 semi-anechoic chamber	6.0 x 6.0 x 3.9	6.0 x 6.0	-	-
No.5 measurement room	6.4 x 6.4 x 3.0	6.4 x 6.4	-	-
No.6 shielded room	4.0 x 4.5 x 2.7	4.0 x 4.5	-	-
No.6 measurement room	4.75 x 5.4 x 3.0	4.75 x 4.15	-	-
No.7 shielded room	4.7 x 7.5 x 2.7	4.7 x 7.5	-	-
No.8 measurement room	3.1 x 5.0 x 2.7	3.1 x 5.0	-	-
No.9 measurement room	8.8 x 4.6 x 2.8	2.4 x 2.4	-	-
No.11 measurement room	6.2 x 4.7 x 3.0	4.8 x 4.6	-	-

* Size of vertical conducting plane (for Conducted Emission test) : 2.0 x 2.0 m for No.1, No.2, No.3, and No.4 semi-anechoic chambers and No.3 and No.4 shielded rooms.

3.6 Test data, Test instruments, and Test set up

Refer to APPENDIX.

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SECTION 4: Operation of E.U.T. during testing

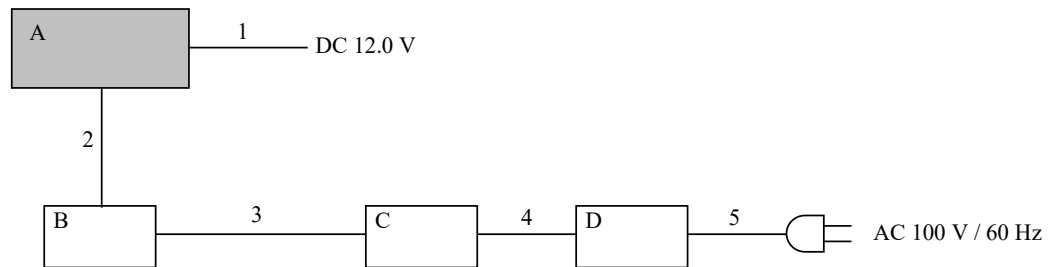
4.1 Operating Mode(s)

Bluetooth (BT) Low Energy (LE): Transmitting mode (Tx)

Test Item	Operating Mode	Tested Frequency
Spurious Emission 6dB Bandwidth Maximum Peak Output Power Power Density 99% Occupied Bandwidth	Tx BT LE	2402 MHz 2440 MHz 2480 MHz
*Power of the EUT was set by the software as follows; - Power settings: 5 - Software: Smart RF studio 7 Ver 2.12.0 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.		

4.2 Configuration and peripherals

[Radiated Emission test]



* Cabling and setup(s) were taken into consideration and test data was taken under worse case conditions.

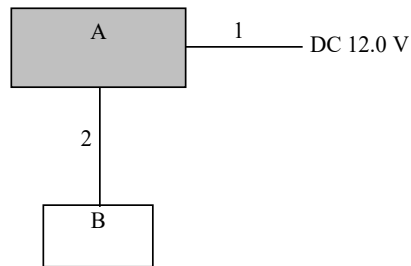
Description of EUT and Support equipment

No.	Item	Model number	Serial number	Manufacturer	Remark
A	PHONE AS KEY MODULE (PAKM)	S2NF0	4	DENSO CORPORATION	EUT
B	JIG	-	-	-	-
C	Laptop PC	HSN-Q07C	5CD8384BC4	Hewlett-Packard Company	-
D	AC Adapter	HSTNN-CA41	WFULP0CGC83 HBG 0C	Hewlett-Packard Company	-

List of cables used

No.	Name	Length (m)	Shield		Remark
			Cable	Connector	
1	DC Power Cable	4.8	Unshielded	Unshielded	-
2	Signal Cable	0.9	Unshielded	Unshielded	-
3	USB Cable	6.8	Shielded	Shielded	-
4	DC Power Cable	1.7	Unshielded	Unshielded	-
5	AC Power Cable	0.9	Unshielded	Unshielded	-

[Antenna Terminal Conducted test]



* Cabling and setup(s) were taken into consideration and test data was taken under worse case conditions.

Description of EUT and Support equipment

No.	Item	Model number	Serial number	Manufacturer	Remark
A	PHONE AS KEY MODULE (PAKM)	S2NF0	12	DENSO CORPORATION	EUT
B	JIG	-	-	-	-

List of cables used

No.	Name	Length (m)	Shield		Remark
			Cable	Connector	
1	DC Power Cable	4.8	Unshielded	Unshielded	-
2	Signal Cable	0.9	Unshielded	Unshielded	-

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SECTION 5: Radiated Spurious Emission

Test Procedure

It was measured based on "8.5 and 8.6 of KDB 558074 D01 15.247 Meas Guidance v05r02".

[For below 1 GHz]

EUT was placed on a urethane platform of nominal size, 1.0 m by 1.5 m, raised 0.8 m above the conducting ground plane. The Radiated Electric Field Strength has been measured in a Semi Anechoic Chamber with a ground plane.

[For above 1 GHz]

EUT was placed on a urethane platform of nominal size, 0.5 m by 0.5 m, raised 1.5 m above the conducting ground plane.

The Radiated Electric Field Strength has been measured in a Semi Anechoic Chamber with absorbent materials lined on a ground plane.

The height of the measuring antenna varied between 1 and 4 m and EUT was rotated a full revolution in order to obtain the maximum value of the electric field strength.

Test antenna was aimed at the EUT for receiving the maximum signal and always kept within the illumination area of the 3 dB beamwidth of the antenna.

The measurements were performed for both vertical and horizontal antenna polarization with the Test Receiver, or the Spectrum Analyzer.

The measurements were made with the following detector function of the test receiver and the Spectrum analyzer (in linear mode).

The test was made with the detector (RBW/VBW) in the following table.

When using Spectrum analyzer, the test was made with adjusting span to zero by using peak hold.

Test Antennas are used as below;

Frequency	30 MHz to 200 MHz	200 MHz to 1 GHz	Above 1 GHz
Antenna Type	Biconical	Logperiodic	Horn

In any 100 kHz bandwidth outside the restricted band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator confirmed 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on a radiated measurement.

20 dBc was applied to the frequency over the limit of FCC 15.209 / Table 4 of RSS-Gen 8.9(ISED) and outside the restricted band of FCC15.205 / Table 6 of RSS-Gen 8.10 (ISED).

Frequency	Below 1 GHz	Above 1 GHz		20 dBc
Instrument used	Test Receiver	Spectrum Analyzer		Spectrum Analyzer
Detector	QP	PK	AV *1)	PK
IF Bandwidth	BW 120 kHz	RBW: 1 MHz VBW: 3 MHz	11.12.2.5.1 RBW: 1 MHz VBW: 3 MHz Detector: Power Averaging (RMS) Trace: 100 traces 11.12.2.5.2 The duty cycle was less than 98% for detected noise, a duty factor was added to the 11.12.2.5.1 results.	RBW: 100 kHz VBW: 300 kHz

*1) Average Power Measurement was performed based on ANSI C63.10-2013.

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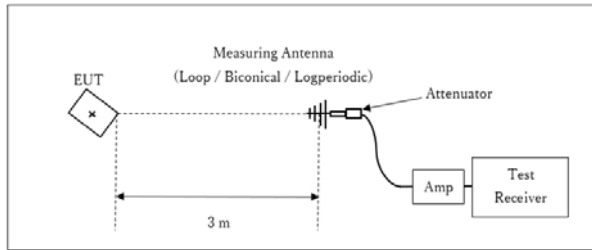
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Figure 2: Test Setup

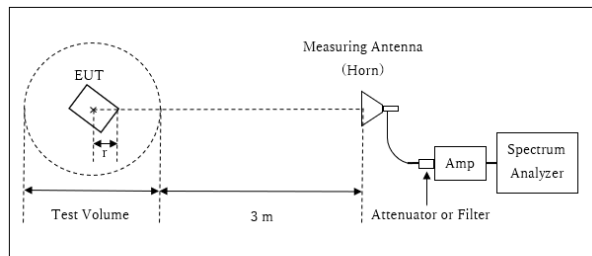
Below 1 GHz



x : Center of turn table

Test Distance: 3 m

1 GHz - 10 GHz



r : Radius of an outer periphery of EUT

x : Center of turn table

Distance Factor: $20 \times \log (3.9 \text{ m} / 3.0 \text{ m}) = 2.28 \text{ dB}$

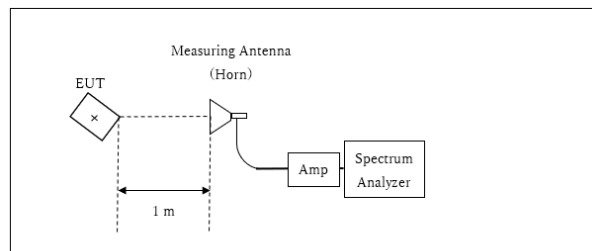
* Test Distance: $(3 + \text{Test Volume} / 2) - r = 3.9 \text{ m}$

Test Volume : 2.0 m

(Test Volume has been calibrated based on CISPR 16-1-4.)

$r = 0.1 \text{ m}$

10 GHz - 26.5 GHz



x : Center of turn table

Distance Factor: $20 \times \log (1.0 \text{ m} / 3.0 \text{ m}) = -9.5 \text{ dB}$

*Test Distance: 1 m

- The noise levels were confirmed at each position of X, Y and Z axes of EUT to see the position of maximum noise, and the test was made at the position that has the maximum noise.

The test results and limit are rounded off to one decimal place, so some differences might be observed.

Measurement range : 30 MHz - 26.5 GHz

Test data : APPENDIX

Test result : Pass

SECTION 6: Antenna Terminal Conducted Tests

Test Procedure

The tests were made with below setting connected to the antenna port.

Test	Span	RBW	VBW	Sweep time	Detector	Trace	Instrument used
6dB Bandwidth	3 MHz	100 kHz	300 kHz	Auto	Peak	Max Hold	Spectrum Analyzer
99% Occupied Bandwidth *1)	Enough width to display emission skirts	1 to 5 % of OBW	Three times of RBW	Auto	Peak	Max Hold	Spectrum Analyzer
Maximum Peak Output Power	-	-	-	Auto	Peak/ Average *2)	-	Power Meter (Sensor: 50 MHz BW)
Peak Power Density	1.5 times the 6dB Bandwidth	3 kHz	10 kHz	Auto	Peak	Max Hold	Spectrum Analyzer *3)
Conducted Spurious Emission *4)	9kHz to 150kHz	200 Hz	620 Hz	Auto	Peak	Max Hold	Spectrum Analyzer
	150kHz to 30MHz	9.1 kHz	27 kHz				
*1) Peak hold was applied as Worst-case measurement. *2) Reference data *3) Section 11.10.2 Method PKPSD (peak PSD) of "ANSI C63.10-2013". *4) In the frequency range below 30MHz, RBW was narrowed to separate the noise contents. Then, wide-band noise near the limit was checked separately, however the noise was not detected as shown in the chart. (9 kHz - 150 kHz: RBW = 200 Hz, 150 kHz - 30 MHz: RBW = 9.1 kHz)							

The test results and limit are rounded off to two decimals place, so some differences might be observed.
 The equipment and cables were not used for factor 0 dB of the data sheets.

Test data : APPENDIX
Test result : Pass

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APPENDIX 1: Test data

6 dB Bandwidth and 99 % Occupied Bandwidth

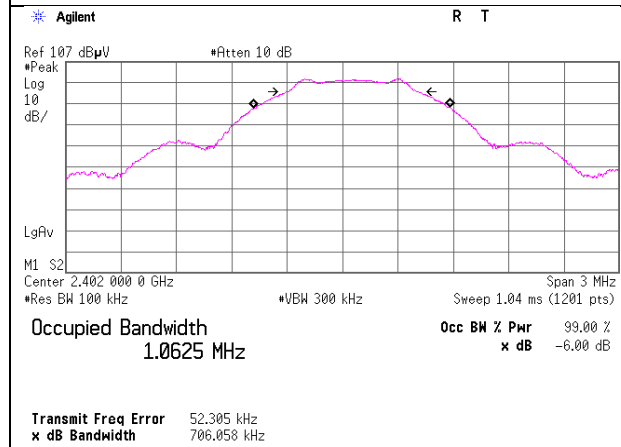
Report No. 12899681H
Test place Ise EMC Lab. No.8 Measurement Room
Date June 10, 2019
Temperature / Humidity 22 deg. C / 65 % RH
Engineer Takafumi Noguchi
Mode Tx BT LE

Mode	Frequency [MHz]	99% Occupied Bandwidth [kHz]	6dB Bandwidth [MHz]	Limit for 6dB Bandwidth [MHz]
BT LE	2402	1045.8	0.706	> 0.5000
	2440	1070.2	0.710	> 0.5000
	2480	1065.5	0.722	> 0.5000

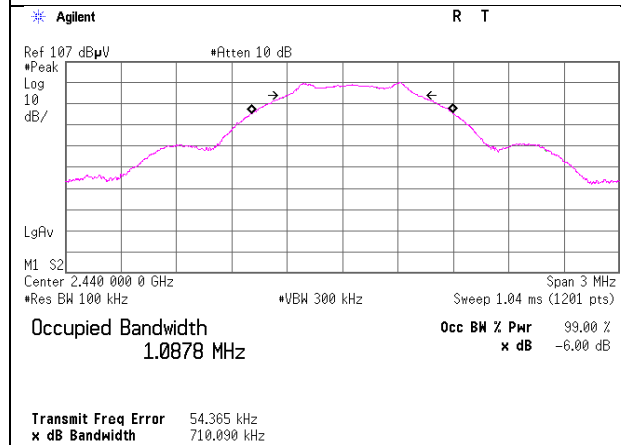
6 dB Bandwidth

BT LE

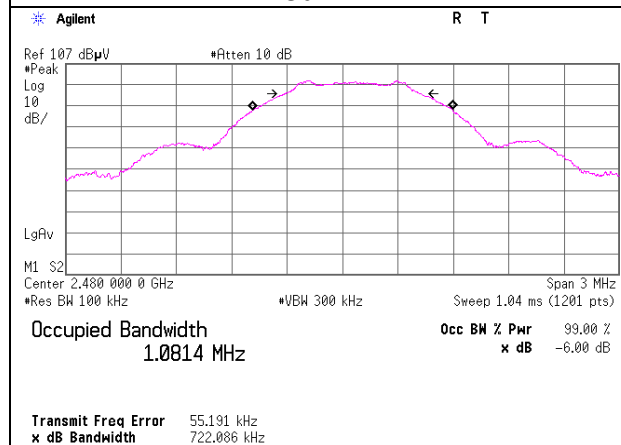
2402 MHz



2440 MHz



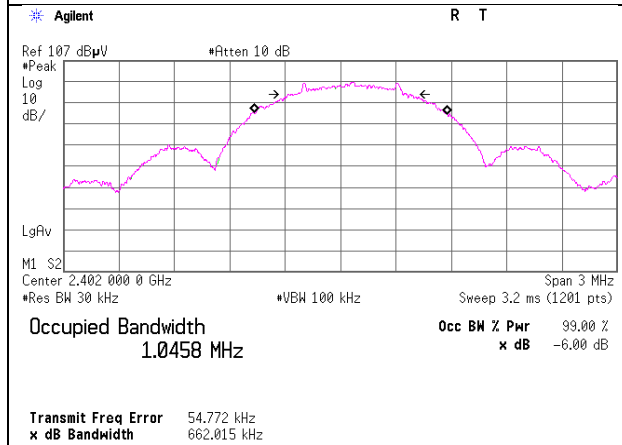
2480 MHz



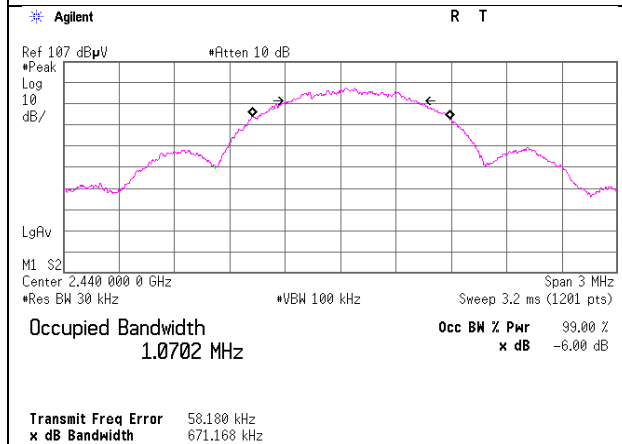
99% Occupied Bandwidth

BT LE

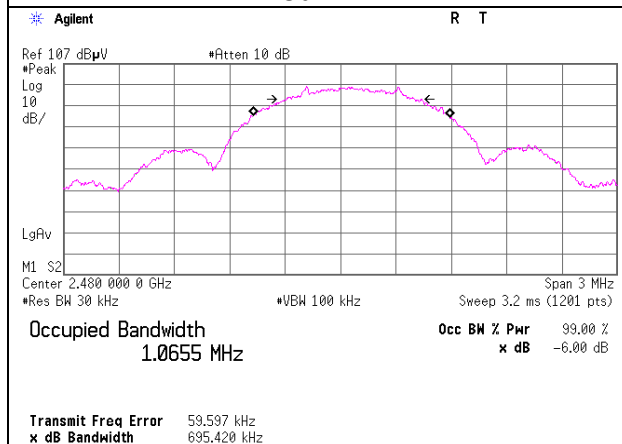
2402 MHz



2440 MHz



2480 MHz



Maximum Peak Output Power

Report No. 12899681H
Test place Ise EMC Lab. No.8 Measurement Room
Date June 10, 2019
Temperature / Humidity 22 deg. C / 65 % RH
Engineer Takafumi Noguchi
Mode Tx BT LE

Freq. [MHz]	Reading [dBm]	Cable Loss [dB]	Atten. Loss [dB]	Conducted Power					e.i.r.p. for RSS-247					
				Result		Limit		Margin [dB]	Antenna Gain [dBi]	Result		Limit		Margin [dB]
				[dBm]	[mW]	[dBm]	[mW]			[dBm]	[mW]	[dBm]	[mW]	
2402	-7.64	1.00	10.10	3.46	2.22	30.00	1000	26.54	3.30	6.76	4.74	36.02	4000	29.26
2440	-9.80	1.00	10.10	1.30	1.35	30.00	1000	28.70	3.30	4.60	2.88	36.02	4000	31.42
2480	-7.63	1.00	10.10	3.47	2.22	30.00	1000	26.53	3.30	6.77	4.75	36.02	4000	29.25

Sample Calculation:

Result = Reading + Cable Loss (customer supplied) + Attenuator Loss

e.i.r.p. Result = Conducted Power Result + Antenna Gain

All comparison were carried out on same frequency and measurement factors.

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Average Output Power
(Reference data for RF Exposure)

Report No. 12899681H
Test place Ise EMC Lab. No.8 Measurement Room
Date June 10, 2019
Temperature / Humidity 22 deg. C / 65 % RH
Engineer Takafumi Noguchi
Mode Tx BT LE

Freq. [MHz]	Reading [dBm]	Cable Loss [dB]	Atten. Loss [dB]	Result (Time average)		Duty factor [dB]	Result (Burst power average)	
				[dBm]	[mW]		[dBm]	[mW]
2402	-7.78	1.00	10.10	3.32	2.15	0.00	3.32	2.15
2440	-10.01	1.00	10.10	1.09	1.29	0.00	1.09	1.29
2480	-7.77	1.00	10.10	3.33	2.15	0.00	3.33	2.15

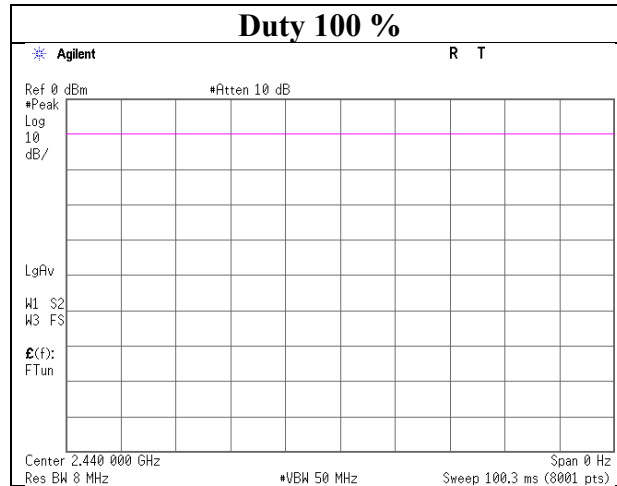
Sample Calculation:

Result (Time average) = Reading + Cable Loss (customer supplied) + Attenuator Loss

Result (Burst power average) = Time average + Duty factor

Burst rate confirmation

Report No. 12899681H
Test place Ise EMC Lab. No.8 Measurement Room
Date June 10, 2019
Temperature / Humidity 22 deg. C / 65 % RH
Engineer Takafumi Noguchi
Mode Tx BT LE



* Since the burst rate is not different between the channels, the data has been obtained on the representative channel.

Radiated Spurious Emission

Report No. 12899681H
Test place Ise EMC Lab.
Semi Anechoic Chamber No.3
Date June 14, 2019 June 19, 2019
Temperature / Humidity 23 deg. C / 65 % RH 24 deg. C / 53 % RH
Engineer Junya Okuno Takafumi Noguchi
(Above 1 GHz) (Below 1 GHz)
Mode Tx BT LE 2402 MHz

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Duty Factor [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori.	115.924	QP	22.5	12.3	8.5	32.1	-	11.1	43.5	32.4	
Hori.	120.002	QP	31.2	12.8	8.5	32.1	-	20.4	43.5	23.2	
Hori.	166.665	QP	34.7	15.7	9.0	32.1	-	27.3	43.5	16.2	
Hori.	182.869	QP	37.6	16.2	9.2	32.1	-	30.9	43.5	12.6	
Hori.	186.518	QP	39.3	16.5	9.2	32.1	-	32.9	43.5	10.6	
Hori.	192.003	QP	36.6	16.5	9.2	32.1	-	30.3	43.5	13.2	
Hori.	2390.000	PK	43.3	27.8	5.3	32.8	-	43.7	73.9	30.2	
Hori.	4804.000	PK	40.5	31.7	7.5	31.8	-	47.8	73.9	26.1	Floor noise
Hori.	7206.000	PK	44.9	35.7	8.7	32.7	-	56.6	73.9	17.3	
Hori.	9608.000	PK	43.1	38.6	9.2	33.3	-	57.7	73.9	16.3	
Hori.	2390.000	AV	34.4	27.8	5.3	32.8	-	34.7	53.9	19.2	
Hori.	4804.000	AV	29.8	31.7	7.5	31.8	-	37.2	53.9	16.8	Floor noise
Hori.	7206.000	AV	36.0	35.7	8.7	32.7	-	47.7	53.9	6.2	
Hori.	9608.000	AV	34.5	38.6	9.2	33.3	-	49.0	53.9	4.9	
Vert.	115.924	QP	34.7	12.3	8.5	32.1	-	23.3	43.5	20.2	
Vert.	120.002	QP	42.4	12.8	8.5	32.1	-	31.6	43.5	12.0	
Vert.	166.665	QP	35.9	15.7	9.0	32.1	-	28.5	43.5	15.0	
Vert.	182.869	QP	44.5	16.2	9.2	32.1	-	37.8	43.5	5.7	
Vert.	186.518	QP	47.4	16.5	9.2	32.1	-	41.0	43.5	2.5	
Vert.	192.003	QP	48.3	16.5	9.2	32.1	-	42.0	43.5	1.5	
Vert.	2390.000	PK	44.2	27.8	5.3	32.8	-	44.5	73.9	29.4	
Vert.	4804.000	PK	44.0	31.7	7.5	31.8	-	51.3	73.9	22.6	Floor noise
Vert.	7206.000	PK	43.7	35.7	8.7	32.7	-	55.4	73.9	18.5	
Vert.	9608.000	PK	43.2	38.6	9.2	33.3	-	57.7	73.9	16.2	Floor noise
Vert.	2390.000	AV	34.2	27.8	5.3	32.8	-	34.6	53.9	19.3	
Vert.	4804.000	AV	33.6	31.7	7.5	31.8	-	40.9	53.9	13.0	Floor noise
Vert.	7206.000	AV	36.1	35.7	8.7	32.7	-	47.8	53.9	6.1	
Vert.	9608.000	AV	32.5	38.6	9.2	33.3	-	47.0	53.9	6.9	Floor noise

Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter+Distance factor(above 1 GHz)) - Gain(Amplifier)

*Other frequency noises omitted in this report were not seen or had enough margin (more than 20 dB).

Distance factor: 1 GHz - 10 GHz $20\log(3.9\text{ m} / 3.0\text{ m}) = 2.28\text{ dB}$
10 GHz - 26.5 GHz $20\log(1.0\text{ m} / 3.0\text{ m}) = -9.5\text{ dB}$

20dBc Data Sheet

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant Factor [dB/m]	Loss [dB]	Gain [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori	2402.000	PK	99.9	27.8	5.3	32.7	100.2	-	-	Carrier
Hori	2400.000	PK	51.1	27.8	5.3	32.7	51.5	80.2	28.7	
Vert	2402.000	PK	96.9	27.8	5.3	32.7	97.2	-	-	Carrier
Vert	2400.000	PK	47.8	27.8	5.3	32.7	48.2	77.2	29.0	

Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter+Distance factor(above 1 GHz)) - Gain(Amplifier)

Distance factor: 1 GHz - 10 GHz $20\log(3.9\text{ m} / 3.0\text{ m}) = 2.28\text{ dB}$
10 GHz - 26.5 GHz $20\log(1.0\text{ m} / 3.0\text{ m}) = -9.5\text{ dB}$

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Ise EMC Lab.

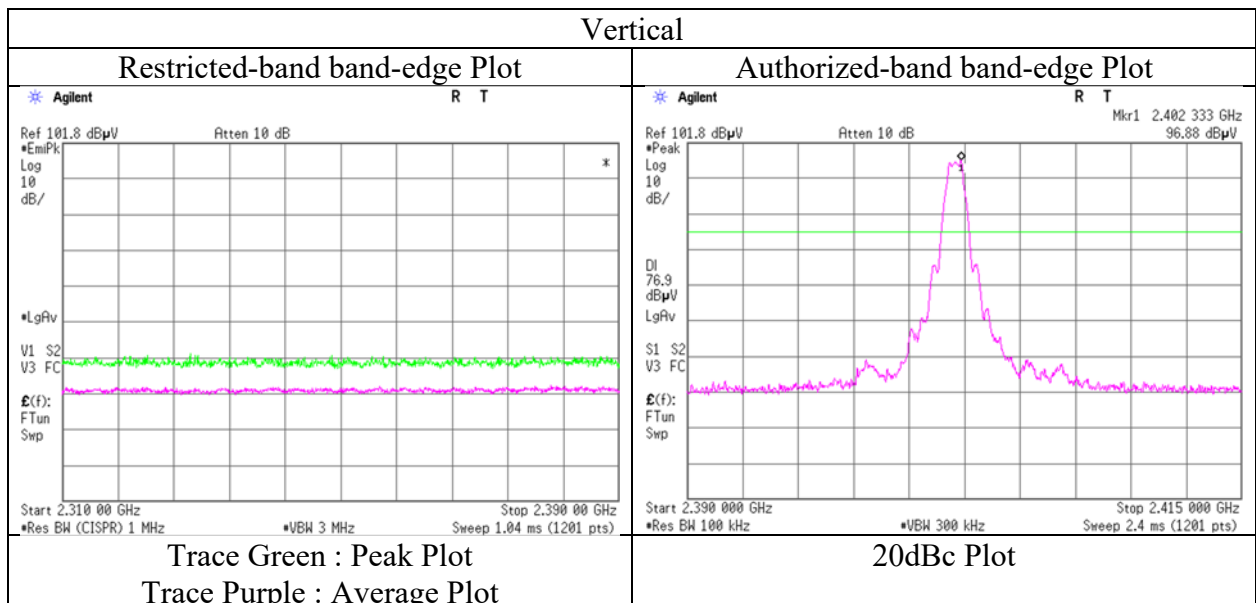
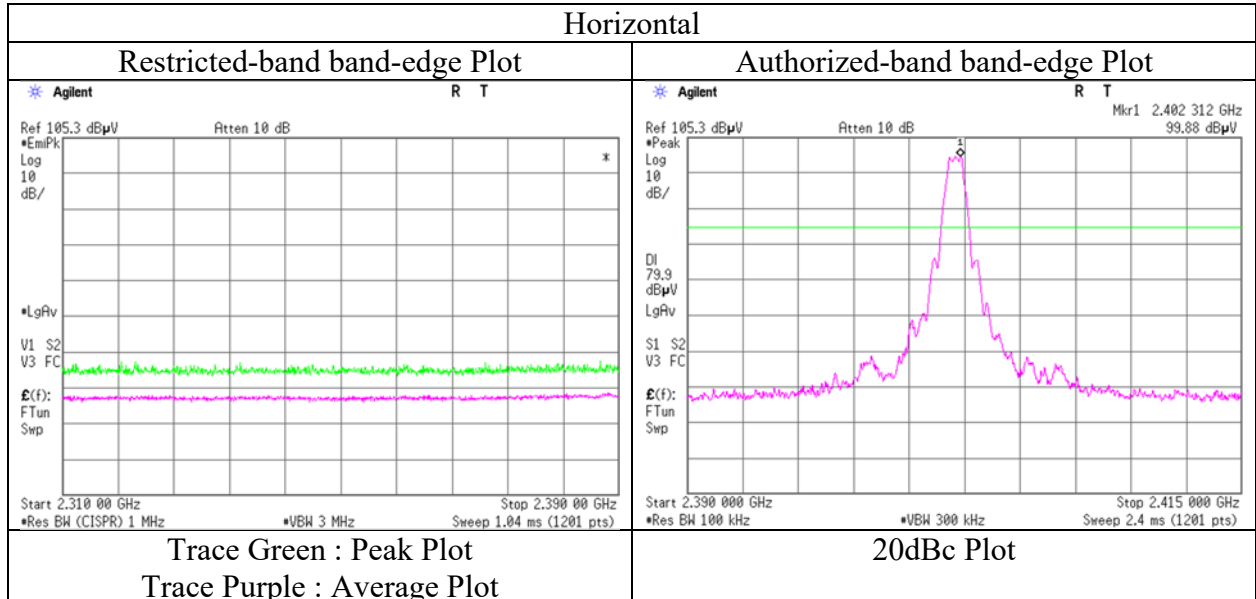
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Facsimile : +81 596 24 8124

Radiated Spurious Emission (Reference Plot for band-edge)

Report No.	12899681H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.3
Date	June 14, 2019
Temperature / Humidity	23 deg. C / 65 % RH
Engineer	Junya Okuno
	(Above 1 GHz)
Mode	Tx BT LE 2402 MHz



* The measurement was conducted for a sufficiently long enough time to detect any possible spurious emissions.

Final result of restricted band edge was shown in tabular data.

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Ise EMC Lab.

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Facsimile : +81 596 24 8124

Radiated Spurious Emission

Report No.	12899681H	
Test place	Ise EMC Lab.	
Semi Anechoic Chamber	No.3	No.3
Date	June 14, 2019	June 19, 2019
Temperature / Humidity	23 deg. C / 65 % RH	24 deg. C / 53 % RH
Engineer	Junya Okuno (Above 1 GHz)	Takafumi Noguchi (Below 1 GHz)
Mode	Tx BT LE 2440 MHz	

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Duty Factor [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori.	115.904	QP	22.3	12.3	8.5	32.1	-	10.9	43.5	32.6	
Hori.	120.001	QP	30.7	12.8	8.5	32.1	-	19.9	43.5	23.7	
Hori.	166.641	QP	34.6	15.7	9.0	32.1	-	27.2	43.5	16.3	
Hori.	182.837	QP	36.8	16.2	9.2	32.1	-	30.1	43.5	13.4	
Hori.	186.534	QP	38.9	16.5	9.2	32.1	-	32.5	43.5	11.0	
Hori.	192.008	QP	37.1	16.5	9.2	32.1	-	30.8	43.5	12.7	
Hori.	4880.000	PK	42.7	31.7	7.5	31.8	-	50.1	73.9	23.8	
Hori.	7320.000	PK	45.2	36.3	8.7	32.7	-	57.5	73.9	16.4	
Hori.	9760.000	PK	42.1	39.1	9.2	33.4	-	57.1	73.9	16.9	Floor noise
Hori.	4880.000	AV	36.0	31.7	7.5	31.8	-	43.4	53.9	10.5	
Hori.	7320.000	AV	38.6	36.3	8.7	32.7	-	50.9	53.9	3.0	
Hori.	9760.000	AV	32.3	39.1	9.2	33.4	-	47.2	53.9	6.7	Floor noise
Vert.	115.904	QP	35.0	12.3	8.5	32.1	-	23.6	43.5	19.9	
Vert.	120.001	QP	43.3	12.8	8.5	32.1	-	32.5	43.5	11.1	
Vert.	166.641	QP	36.7	15.7	9.0	32.1	-	29.3	43.5	14.2	
Vert.	182.837	QP	43.5	16.2	9.2	32.1	-	36.8	43.5	6.7	
Vert.	186.534	QP	46.4	16.5	9.2	32.1	-	40.0	43.5	3.5	
Vert.	192.008	QP	47.5	16.5	9.2	32.1	-	41.2	43.5	2.3	
Vert.	4880.000	PK	42.0	31.7	7.5	31.8	-	49.4	73.9	24.5	
Vert.	7320.000	PK	44.3	36.3	8.7	32.7	-	56.6	73.9	17.3	
Vert.	9760.000	PK	42.4	39.1	9.2	33.4	-	57.4	73.9	16.6	Floor noise
Vert.	4880.000	AV	34.8	31.7	7.5	31.8	-	42.2	53.9	11.7	
Vert.	7320.000	AV	37.4	36.3	8.7	32.7	-	49.7	53.9	4.2	
Vert.	9760.000	AV	32.4	39.1	9.2	33.4	-	47.3	53.9	6.6	Floor noise

Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter+Distance factor(above 1 GHz)) - Gain(Amplifier)

*Other frequency noises omitted in this report were not seen or had enough margin (more than 20 dB).

Distance factor: 1 GHz - 10 GHz 20log (3.9 m / 3.0 m) = 2.28 dB
 10 GHz - 26.5 GHz 20log (1.0 m / 3.0 m) = -9.5 dB

Radiated Spurious Emission

Report No.	12899681H	
Test place	Ise EMC Lab.	
Semi Anechoic Chamber	No.3	No.3
Date	June 14, 2019	June 19, 2019
Temperature / Humidity	23 deg. C / 65 % RH	24 deg. C / 53 % RH
Engineer	Junya Okuno (Above 1 GHz)	Takafumi Noguchi (Below 1 GHz)
Mode	Tx BT LE 2480 MHz	

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Duty Factor [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori.	115.928	QP	22.5	12.3	8.5	32.1	-	11.1	43.5	32.4	
Hori.	120.001	QP	30.8	12.8	8.5	32.1	-	20.0	43.5	23.6	
Hori.	166.649	QP	35.6	15.7	9.0	32.1	-	28.2	43.5	15.3	
Hori.	182.873	QP	37.6	16.2	9.2	32.1	-	30.9	43.5	12.6	
Hori.	186.534	QP	39.9	16.5	9.2	32.1	-	33.5	43.5	10.0	
Hori.	192.004	QP	39.9	16.5	9.2	32.1	-	33.6	43.5	9.9	
Hori.	2483.500	PK	47.8	27.5	5.4	32.7	-	47.9	73.9	26.0	
Hori.	4960.000	PK	42.3	31.8	7.5	31.8	-	49.8	73.9	24.1	
Hori.	7440.000	PK	43.8	36.6	8.7	32.7	-	56.4	73.9	17.5	
Hori.	9920.000	PK	42.5	39.1	9.2	33.4	-	57.3	73.9	16.6	
Hori.	2483.500	AV	36.1	27.5	5.4	32.7	-	36.3	53.9	17.6	
Hori.	4960.000	AV	34.5	31.8	7.5	31.8	-	42.0	53.9	11.9	
Hori.	7440.000	AV	34.4	36.6	8.7	32.7	-	47.0	53.9	6.9	
Hori.	9920.000	AV	33.0	39.1	9.2	33.4	-	47.8	53.9	6.1	
Vert.	115.928	QP	35.3	12.3	8.5	32.1	-	23.9	43.5	19.6	
Vert.	120.001	QP	42.3	12.8	8.5	32.1	-	31.5	43.5	12.1	
Vert.	166.649	QP	37.8	15.7	9.0	32.1	-	30.4	43.5	13.1	
Vert.	182.873	QP	43.8	16.2	9.2	32.1	-	37.1	43.5	6.4	
Vert.	186.534	QP	46.8	16.5	9.2	32.1	-	40.4	43.5	3.1	
Vert.	192.004	QP	48.7	16.5	9.2	32.1	-	42.4	43.5	1.1	
Vert.	2483.500	PK	48.5	27.5	5.4	32.7	-	48.6	73.9	25.3	
Vert.	4960.000	PK	42.9	31.8	7.5	31.8	-	50.5	73.9	23.5	Floor noise
Vert.	7440.000	PK	43.2	36.6	8.7	32.7	-	55.8	73.9	18.1	Floor noise
Vert.	9920.000	PK	42.2	39.1	9.2	33.4	-	57.1	73.9	16.8	Floor noise
Vert.	2483.500	AV	36.4	27.5	5.4	32.7	-	36.6	53.9	17.3	
Vert.	4960.000	AV	32.9	31.8	7.5	31.8	-	40.4	53.9	13.5	Floor noise
Vert.	7440.000	AV	32.0	36.6	8.7	32.7	-	44.6	53.9	9.3	Floor noise
Vert.	9920.000	AV	31.3	39.1	9.2	33.4	-	46.1	53.9	7.8	Floor noise

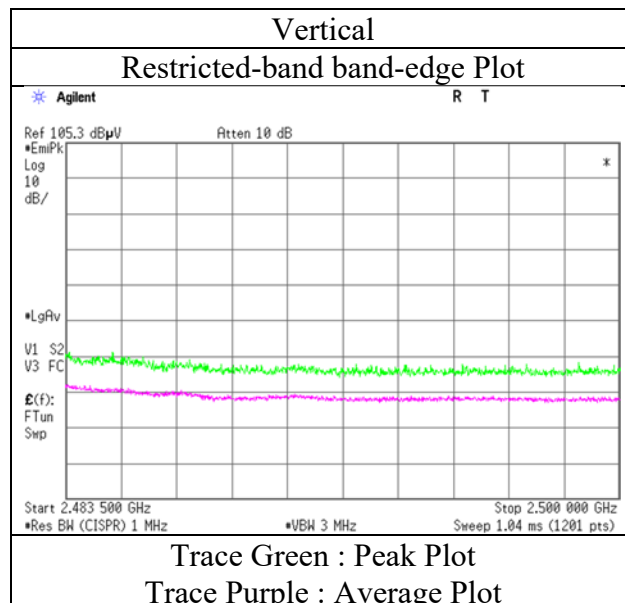
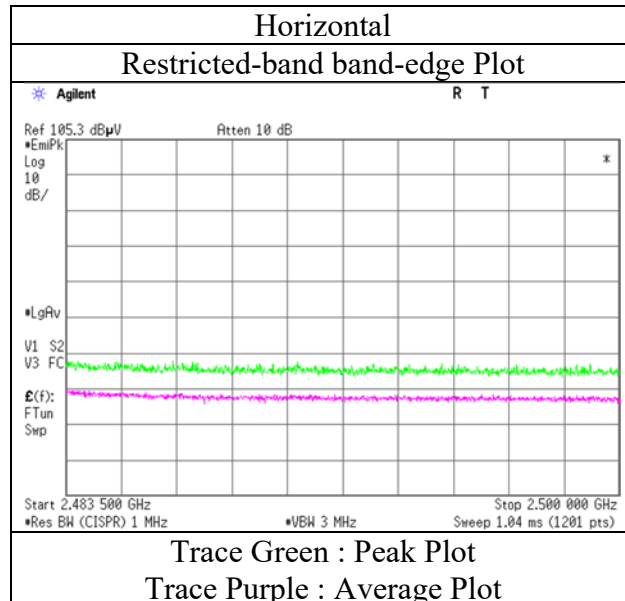
Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter+Distance factor(above 1 GHz)) - Gain(Amplifier)

*Other frequency noises omitted in this report were not seen or had enough margin (more than 20 dB).

Distance factor: 1 GHz - 10 GHz $20\log(3.9\text{ m} / 3.0\text{ m}) = 2.28\text{ dB}$
10 GHz - 26.5 GHz $20\log(1.0\text{ m} / 3.0\text{ m}) = -9.5\text{ dB}$

Radiated Spurious Emission (Reference Plot for band-edge)

Report No.	12899681H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.3
Date	June 14, 2019
Temperature / Humidity	23 deg. C / 65 % RH
Engineer	Junya Okuno (Above 1 GHz)
Mode	Tx BT LE 2480 MHz



* The measurement was conducted for a sufficiently long enough time to detect any possible spurious emissions.

Final result of restricted band edge was shown in tabular data.

UL Japan, Inc.

Ise EMC Lab.

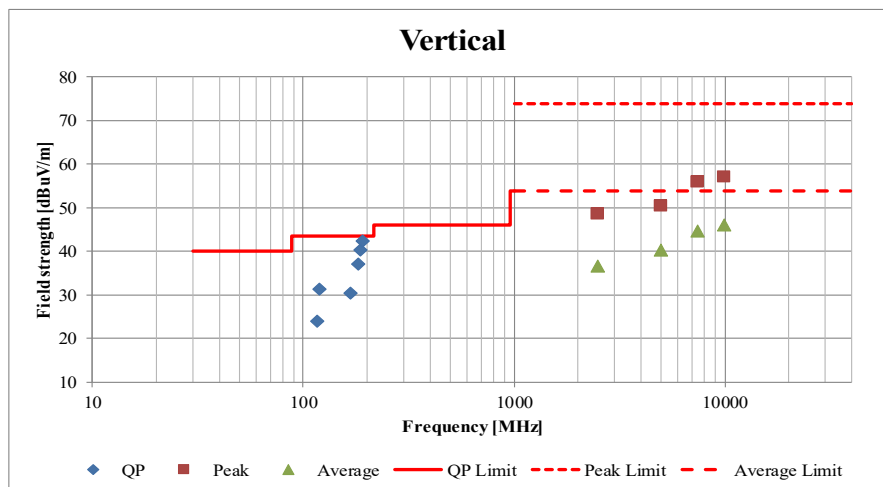
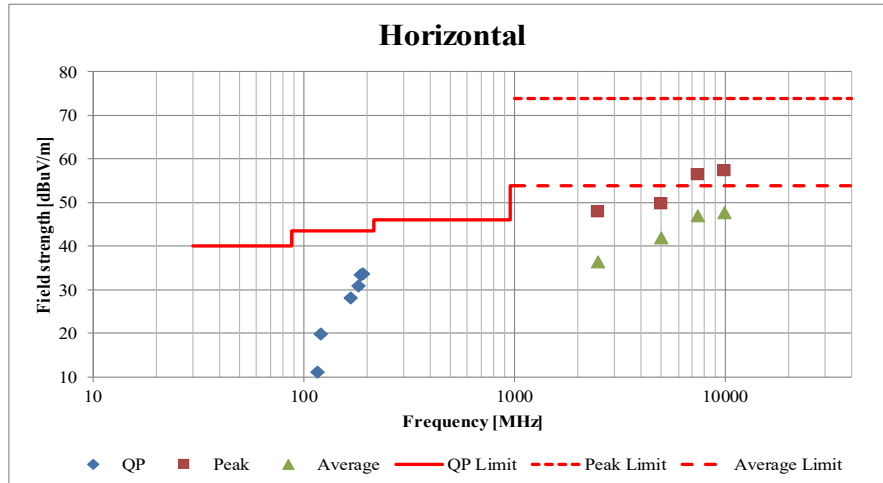
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Radiated Spurious Emission **(Plot data, Worst case)**

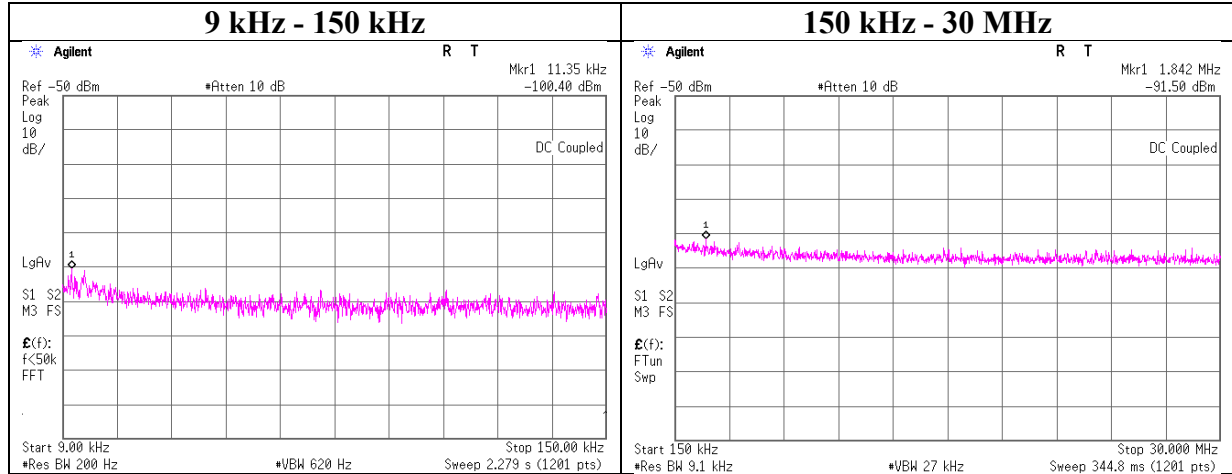
Report No.	12899681H	
Test place	Ise EMC Lab.	No.3
Semi Anechoic Chamber		
Date	June 14, 2019	June 19, 2019
Temperature / Humidity	23 deg. C / 65 % RH	24 deg. C / 53 % RH
Engineer	Junya Okuno (Above 1 GHz)	Takafumi Noguchi (Below 1 GHz)
Mode	Tx BT LE 2480 MHz	



*These plots data contains sufficient number to show the trend of characteristic features for EUT.

Conducted Spurious Emission

Report No.	12899681H
Test place	Ise EMC Lab. No.8 Measurement Room
Date	June 10, 2019
Temperature / Humidity	22 deg. C / 65 % RH
Engineer	Takafumi Noguchi
Mode	Tx BT LE 2402 MHz



Frequency	Reading	Cable Loss	Attenuator Loss	Antenna Gain	N (Number of Output)	EIRP	Distance	Ground bounce	E (field strength)	Limit	Margin	Remark
[kHz]	[dBm]	[dB]	[dB]	[dBi]		[dBm]	[m]	[dB]	[dBuV/m]	[dBuV/m]	[dB]	
11.35	-100.40	1.00	9.84	3.3	1	-86.3	300	6.0	-25.0	46.5	71.5	
1842.00	-91.50	1.00	9.81	3.3	1	-77.4	30	6.0	3.9	29.5	25.7	

$E [dBuV/m] = EIRP [dBm] - 20 \log (Distance [m]) + Ground\ bounce [dB] + 104.8 [dBuV/m]$

$EIRP [dBm] = Reading [dBm] + Cable\ loss [dB] + Attenuator\ Loss [dB] + Antenna\ gain [dBi] + 10 * \log (N)$

N: Number of output

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Ise EMC Lab.

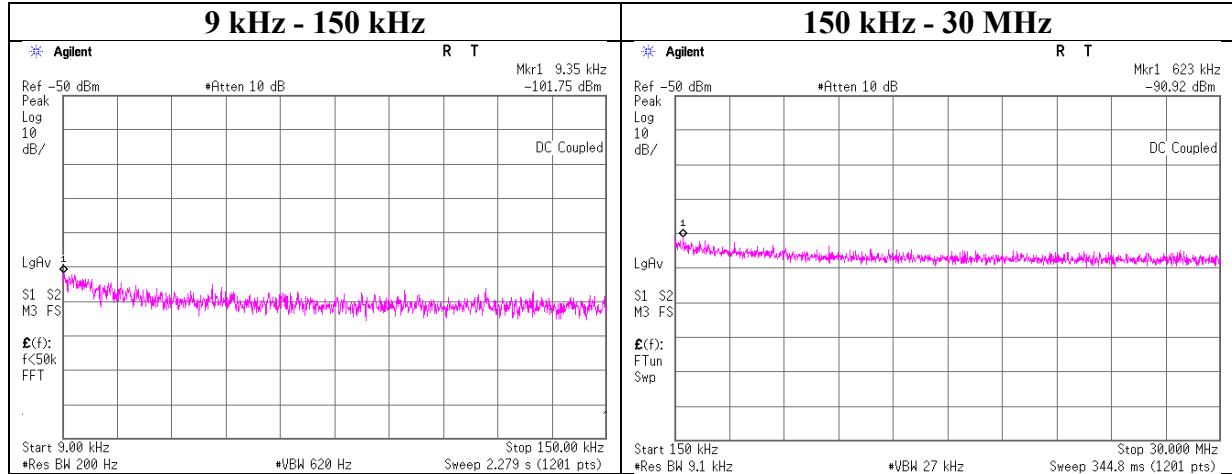
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Conducted Spurious Emission

Report No.	12899681H
Test place	Ise EMC Lab. No.8 Measurement Room
Date	June 10, 2019
Temperature / Humidity	22 deg. C / 65 % RH
Engineer	Takafumi Noguchi
Mode	Tx BT LE 2440 MHz



Frequency	Reading	Cable Loss	Attenuator Loss	Antenna Gain	N (Number of Output)	EIRP	Distance	Ground bounce	E (field strength)	Limit	Margin	Remark
[kHz]	[dBm]	[dB]	[dB]	[dBi]		[dBm]	[m]	[dB]	[dBuV/m]	[dBuV/m]	[dB]	
9.35	-101.75	1.00	9.84	3.3	1	-87.6	300	6.0	-26.4	48.1	74.5	
623.00	-90.92	1.00	9.81	3.3	1	-76.8	30	6.0	4.4	31.7	27.3	

$E [dBuV/m] = EIRP [dBm] - 20 \log (Distance [m]) + Ground\ bounce [dB] + 104.8 [dBuV/m]$

$EIRP [dBm] = Reading [dBm] + Cable\ loss [dB] + Attenuator\ Loss [dB] + Antenna\ gain [dBi] + 10 * \log (N)$

N: Number of output

UL Japan, Inc.

Ise EMC Lab.

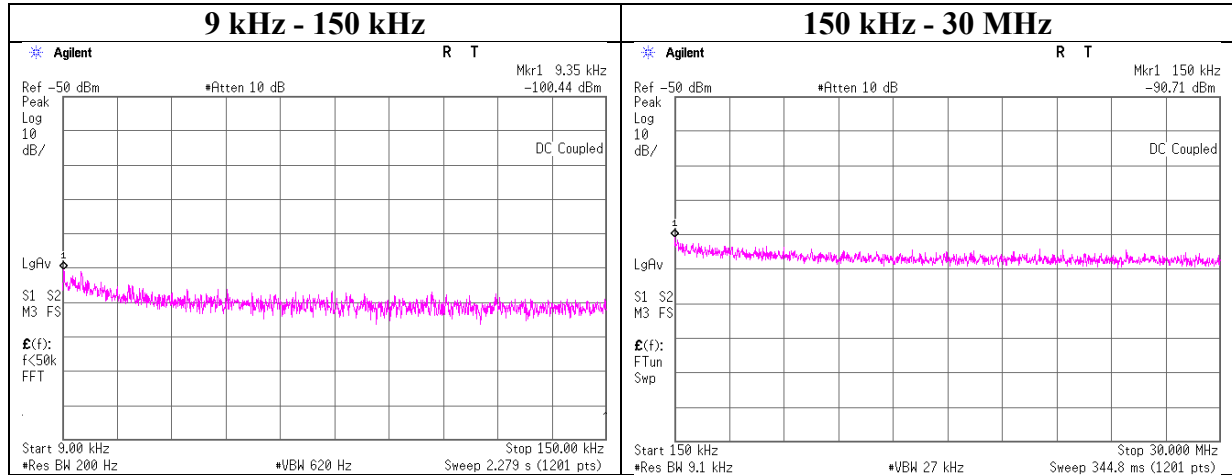
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Conducted Spurious Emission

Report No.	12899681H
Test place	Ise EMC Lab. No.8 Measurement Room
Date	June 10, 2019
Temperature / Humidity	22 deg. C / 65 % RH
Engineer	Takafumi Noguchi
Mode	Tx BT LE 2480 MHz



Frequency [kHz]	Reading [dBm]	Cable Loss [dB]	Attenuator Loss [dB]	Antenna Gain [dBi]	N (Number of Output)	EIRP [dBm]	Distance [m]	Ground bounce [dB]	E (field strength) [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
9.35	-100.44	1.00	9.84	3.3	1	-86.3	300	6.0	-25.0	48.1	73.1	
150.00	-90.71	1.00	9.81	3.3	1	-76.6	300	6.0	-15.3	24.0	39.3	

$E [dBuV/m] = EIRP [dBm] - 20 \log (Distance [m]) + Ground\ bounce [dB] + 104.8 [dBuV/m]$

$EIRP [dBm] = Reading [dBm] + Cable\ loss [dB] + Attenuator\ Loss [dB] + Antenna\ gain [dBi] + 10 * \log (N)$

N: Number of output

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Power Density

Report No. 12899681H
Test place Ise EMC Lab. No.8 Measurement Room
Date June 10, 2019
Temperature / Humidity 22 deg. C / 65 % RH
Engineer Takafumi Noguchi
Mode Tx BT LE

Freq.	Reading	Cable Loss	Atten. Loss	Result	Limit	Margin
[MHz]	[dBm]	[dB]	[dB]	[dBm]	[dBm]	[dB]
2402	-17.86	1.00	10.10	-6.76	8.00	14.76
2440	-18.26	1.00	10.10	-7.16	8.00	15.16
2480	-18.88	1.00	10.10	-7.78	8.00	15.78

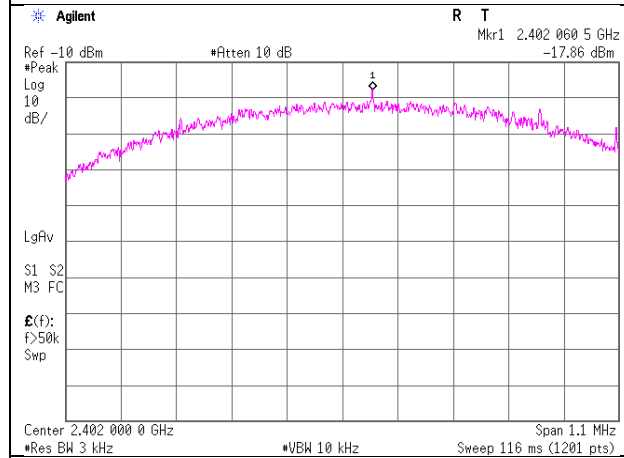
Sample Calculation:

Result = Reading + Cable Loss (customer supplied) + Attenuator Loss

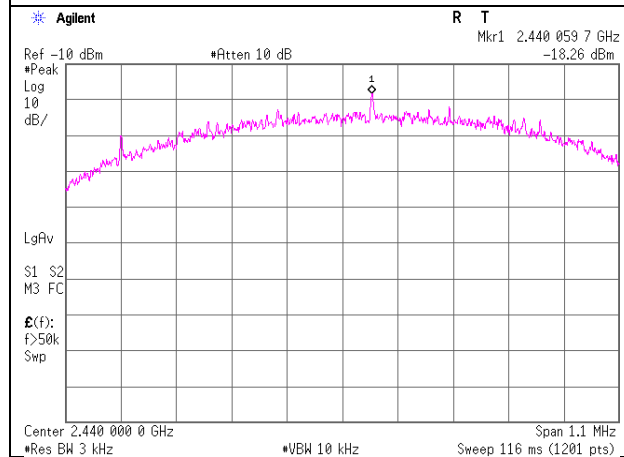
Power Density

BT LE

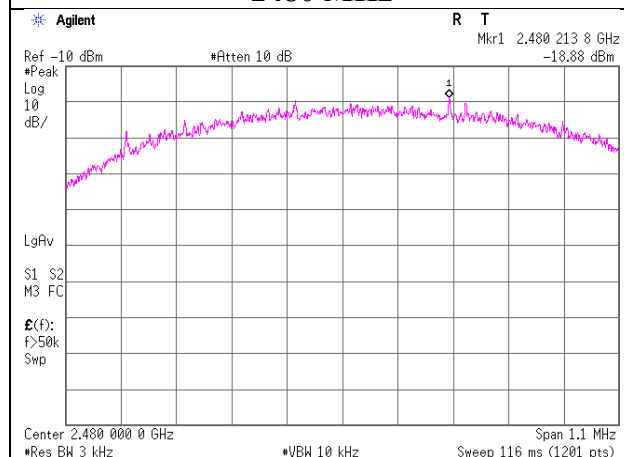
2402 MHz



2440 MHz



2480 MHz



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APPENDIX 2: Test instruments

Test Instruments

Test item	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Calibration Due Date	Cal Int
RE	177964	Microwave Cable	Junkosha INC.	MMX221	1901S329(1m)/ 1902S579(5m)	3/5/2019	3/31/2020	12
RE	141884	Spectrum Analyzer	AGILENT	E4448A	MY44020357	3/13/2019	3/31/2020	12
RE	141580	MicroWave System Amplifier	AGILENT	83017A	MY39500779	3/5/2019	3/31/2020	12
RE	141513	Horn Antenna 15-40GHz	Schwarzbeck	BBHA9170	BBHA9170306	5/10/2019	5/31/2020	12
RE	141507	Horn Antenna 1-18GHz	Schwarzbeck	BBHA9120D	258	5/10/2019	5/31/2020	12
RE	142013	AC3_Semi Anechoic Chamber(SVSWR)	TDK	Semi Anechoic Chamber 3m	DA-10005	4/8/2019	4/30/2021	24
RE	148897	Attenuator	KEYSIGHT	8491A	MY52462349	12/20/2018	12/31/2019	12
RE	141949	Test Receiver	Rohde & Schwarz	ESCI	100767	8/6/2018	8/31/2019	12
RE	141152	EMI measurement program	TSJ	TEPTO-DV	-	-	-	-
RE	142008	AC3_Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 3m	DA-10005	6/26/2018	6/30/2020	24
RE	141942	Test Receiver	Rohde & Schwarz	ESCI	100300	8/8/2018	8/31/2019	12
RE	141554	Thermo-Hygrometer	CUSTOM	CTH-180	1301	1/11/2019	1/31/2020	12
RE	141582	Pre Amplifier	SONOMA INSTRUMENT	310	260834	2/8/2019	2/29/2020	12
RE	142183	Measure	KOMELON	KMC-36	-	-	-	-
RE	141266	Logperiodic Antenna(200-1000MHz)	Schwarzbeck	VUSLP9111B	911B-191	3/25/2019	3/31/2020	12
RE	178648	EMI measurement program	TSJ	TEPTO-DV	-	-	-	-
RE	141331	Attenuator(6dB)	TME	UFA-01	-	2/5/2019	2/29/2020	12
RE	141424	Biconical Antenna	Schwarzbeck	BBA9106	1915	5/24/2019	5/31/2020	12
RE	141532	DIGITAL HiTESTER	HIOKI	3805	51201197	1/29/2019	1/31/2020	12
RE	141323	Coaxial cable	UL Japan	-	-	7/3/2018	7/31/2019	12
AT	141156	Attenuator(10dB)	Weinschel Corp	2	BL1173	11/2/2018	11/30/2019	12
AT	141901	Spectrum Analyzer	AGILENT	E4440A	MY48250080	10/4/2018	10/31/2019	12
AT	141567	Thermo-Hygrometer	CUSTOM	CTH-201	0008	1/11/2019	1/31/2020	12
AT	141557	DIGITAL HiTESTER	HIOKI	3805	70900530	1/29/2019	1/31/2020	12
AT	141809	Power Meter	ANRITSU	ML2495A	825002	5/16/2019	5/31/2020	12
AT	141830	Power sensor	ANRITSU	MA2411B	738285	5/16/2019	5/31/2020	12
AT	141361	Attenuator(10dB) 1-18GHz	Orient Microwave	BX10-0476-00	-	3/4/2019	3/31/2020	12

*Hyphens for Last Calibration Date, Calibration Due Date and Cal Int (month) are instruments that Calibration is not required (e.g. software), or instruments checked in advance before use.

The expiration date of the calibration is the end of the expired month.

All equipment is calibrated with valid calibrations. Each measurement data is traceable to the national or international standards.

As for some calibrations performed after the tested dates, those test equipment have been controlled by means of an unbroken chains of calibrations.

Test item:

RE: Radiated Emission test

AT: Antenna Terminal Conducted test

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