



RADIO TEST REPORT

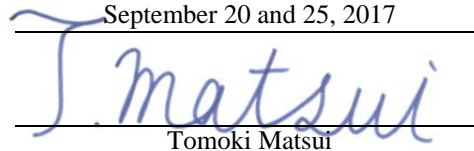
Test Report No. : 11927987H-A

Applicant : ALPS ELECTRIC CO., LTD.
Type of Equipment : Virtual key module (VKM)
Model No. : TFWD5E0010
FCC ID : CWTWD5E0010
Test regulation : FCC Part 15 Subpart C: 2017
Test Result : Complied

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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 must not be used by the customer to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.
6. This test report covers Radio technical requirements. It does not cover administrative issues such as Manual or non-Radio test related Requirements. (if applicable)

Date of test: September 20 and 25, 2017

Representative test engineer:

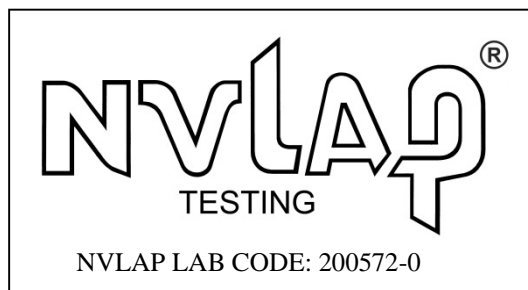

Tomoki Matsui

Engineer
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Approved by:


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UL Japan, Inc.

Ise EMC Lab.

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13-EM-F0429

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SECTION 1: Customer information

Company Name : ALPS ELECTRIC CO., LTD.
Address : 6-3-36, Furukawanakazato, Osaki-city, Miyagi-pref. 989-6181 JAPAN
Telephone Number : +81-229-23-5111
Facsimile Number : +81-229-22-6290
Contact Person : Yasuhiro Yabe

SECTION 2: Equipment under test (E.U.T.)

2.1 Identification of E.U.T.

Type of Equipment : Virtual key module (VKM)
Model No. : TFWD5E0010
Serial No. : Refer to Clause 4.2
Rating : DC 12 V
Receipt Date of Sample : September 19, 2016
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: TFWD5E0010 (referred to as the EUT in this report) is a Virtual key module (VKM).

General Specification

Clock frequency(ies) in the system : 32.768 kHz(Crystal) at BLE Block , 26 MHz(Crystal) at BLE Block ,
20 MHz(Crystal) at CPU Block

Radio Specification

Bluetooth Low Energy (Ver.4.2)

Equipment Type : Transceiver
Frequency of Operation : 2402 MHz - 2480 MHz
Type of Modulation : GFSK
Power Supply (inner) : DC 3.3 V
Antenna Type : Pattern Antenna
Antenna Gain : 2.0 dBi

Variant model

Model; TFWD5E0010 has variant models as follows;

	Model Number (Parts No.)	Customer parts No.
Tested model	TFWD5E0010	84394613
Variant model	TFWD5E0020	84394613
Variant model	TFWD5E0027	84425478

Variant models are same shape as a tested model, and same hardware.
Only Model Number different.

These differences cause no influence to radio specification.
There was no degradation of EMC characteristic.
They are identical in electronic characteristics.

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SECTION 3: Test specification, procedures & results

3.1 Test Specification

Test Specification : FCC Part 15 Subpart C
FCC Part 15 final revised on September 20, 2017 and effective October 20, 2017

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 September 20, 2017, 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 IC: RSS-Gen 8.8	FCC: Section 15.207 IC: RSS-Gen 8.8	N/A *1)	N/A	N/A
6dB Bandwidth	FCC: KDB 558074 D01 DTS Meas Guidance v04 IC: -	FCC: Section 15.247(a)(2) IC: RSS-247 5.2(a)	See data.	Complied	Conducted
Maximum Peak Output Power	FCC: KDB 558074 D01 DTS Meas Guidance v04 IC: RSS-Gen 6.12	FCC: Section 15.247(b)(3) IC: RSS-247 5.4(d)		Complied	Conducted
Power Density	FCC: KDB 558074 D01 DTS Meas Guidance v04 IC: -	FCC: Section 15.247(e) IC: RSS-247 5.2(b)		Complied	Conducted
Spurious Emission Restricted Band Edges	FCC: KDB 558074 D01 DTS Meas Guidance v04 IC: RSS-Gen 6.13	FCC: Section15.247(d) IC: RSS-247 5.5 RSS-Gen 8.9 RSS-Gen 8.10	11.2 dB 178.467 MHz, QP, Horizontal	Complied	Conducted (below 30 MHz)/ Radiated (above 30 MHz) *2)

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 DTS Meas Guidance v04 12.2.7.

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

FCC Part 15.31 (e)

This EUT provides stable voltage (DC 3.3 V) constantly to RF Module regardless of input voltage. 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.

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3.3 Addition to standard

Item	Test Procedure	Specification	Worst margin	Results	Remarks
99% Occupied Bandwidth	IC: RSS-Gen 6.6	IC: -	N/A	-	Conducted

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

3.4 Uncertainty

EMI

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		Uncertainty (+/-)
RF output power		1.2 dB
Antenna terminal conducted emission / Power density / Burst power		3.1 dB
Adjacent channel power / Channel power		
Below 3 GHz		1.8 dB
3 GHz to 6 GHz		2.7 dB

Polarity	Radiated emission (Below 1 GHz)			
	(3 m*) (+/-)		(10 m*) (+/-)	
	30 MHz - 200 MHz	200 MHz - 1000 MHz	30 MHz - 200 MHz	200 MHz - 1000 MHz
Horizontal	5.0 dB	5.3 dB	5.0 dB	5.0 dB
Vertical	5.2 dB	6.3 dB	5.0 dB	5.0 dB

Radiated emission (Above 1 GHz)				
(3 m*) (+/-)		(1 m*) (+/-)		(10 m*) (+/-)
1 GHz - 6 GHz	6 GHz - 18 GHz	10 GHz - 26.5 GHz	26.5 GHz - 40 GHz	1 GHz - 18 GHz
5.2 dB	5.5 dB	5.5 dB	5.4 dB	5.5 dB

*Measurement distance

Radiated emission test

The data listed in this test report has enough margin, more than the site margin.

3.5 Test Location

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NVLAP Lab. code: 200572-0 / FCC Test Firm Registration Number: 199967

Test site	IC Registration Number	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	2973C-1	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	2973C-2	7.5 x 5.8 x 5.2	4.0 x 4.0	-	3 m
No.3 semi-anechoic chamber	2973C-3	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	2973C-4	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.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	N/A	-	-
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 m x 2.0m 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.

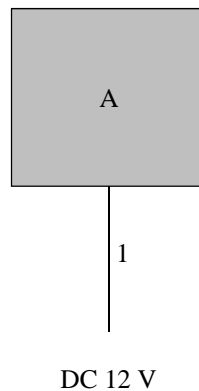
SECTION 4: Operation of E.U.T. during testing

4.1 Operating Mode(s)

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

Test Item	Operating Mode	Tested Frequency
Spurious Emission 6dB Bandwidth Maximum Peak Output Power Power Density 99% Occupied Bandwidth	Tx BT LE	2402MHz 2440MHz 2480MHz
*Power of the EUT was set by the software as follows; Power settings: 0 dBm Software: HCI tester 1.00 (TOSHIBA) 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



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

Description of EUT

No.	Item	Model number	Serial number	Manufacturer	Remark
A	Virtual key module (VKM)	TFWD5E0010	17091501	ALPS ELECTRIC CO., LTD.	EUT

List of cables used

No.	Name	Length (m)	Shield		Remark
			Cable	Connector	
1	DC Cable	3.0	Unshielded	Unshielded	-

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SECTION 5: Radiated Spurious Emission

Test Procedure

It was measured based on "11.0 Emissions in non-restricted frequency bands" of "KDB 558074 D01 DTS Meas Guidance v04".

[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.

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(IC) and outside the restricted band of FCC15.205 / Table 6 of RSS-Gen 8.10 (IC).

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	Average Power Method: RBW: 1 MHz VBW: 3 MHz Detector: Power Averaging (RMS) Trace: 100 traces If duty cycle was less than 98%, a duty factor was added to the results.	RBW: 100 kHz VBW: 300kHz
Test Distance	3 m	4.5 m *2) (1 GHz – 10 GHz), 1 m *3) (10 GHz – 26.5 GHz)		4.5 m *2) (1 GHz – 10 GHz), 1 m *3) (10 GHz – 26.5 GHz)

*1) Average Power Measurement was performed based on 6.0 & 12.2.5 of "KDB 558074 D01 DTS Meas Guidance v04".

*2) Distance Factor: $20 \times \log(4.5 \text{ m} / 3.0 \text{ m}) = 3.53 \text{ dB}$

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

- The carrier level and 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.

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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 10.2 Method PKPSD (peak PSD) of "KDB 558074 D01 DTS Meas Guidance v04".							
*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.							

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

Test data : APPENDIX
Test result : Pass

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APPENDIX 1: Test data

6dB Bandwidth

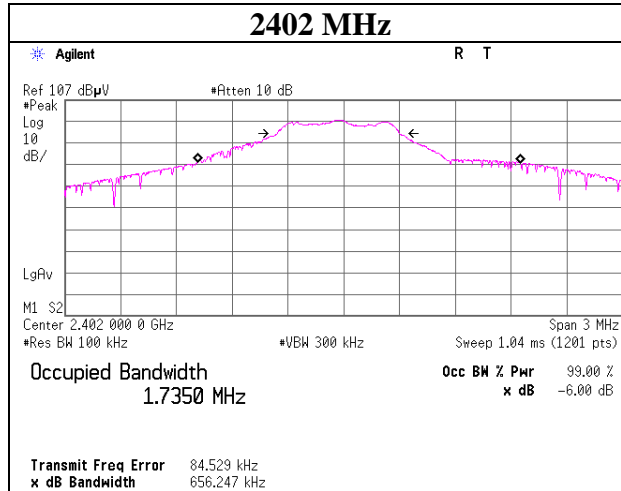
Test place Ise EMC Lab. No.11 Measurement Room
Report No. 11927987H
Date September 25, 2017
Temperature / Humidity 23 deg. C / 64 % RH
Engineer Tomoki Matsui
Mode Tx BT LE

Mode	Frequency [MHz]	6dB Bandwidth [MHz]	Limit [kHz]
BT LE	2402	0.656	> 500
	2440	0.666	> 500
	2480	0.661	> 500

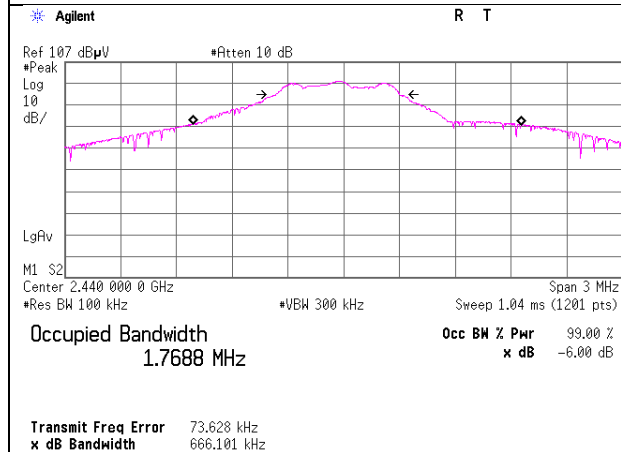
6dB Bandwidth

BT LE

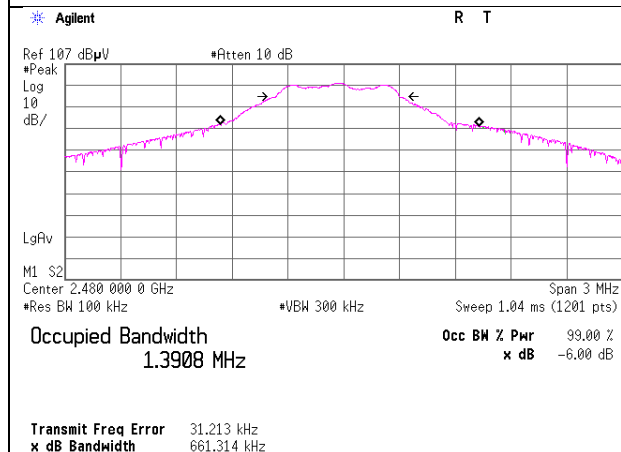
2402 MHz



2440 MHz



2480 MHz



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Maximum Peak Output Power

Test place Ise EMC Lab. No.11 Measurement Room
Report No. 11927987H
Date September 25, 2017
Temperature / Humidity 23 deg. C / 64 % RH
Engineer Tomoki Matsui
Mode Tx BT LE

BT LE

Freq. [MHz]	Reading [dBm]	Cable Loss [dB]	Atten. Loss [dB]	Result		Limit		Margin [dB]
				[dBm]	[mW]	[dBm]	[mW]	
2402	-9.49	1.50	6.17	-1.82	0.66	30.00	1000	31.82
2440	-9.07	1.50	6.17	-1.40	0.72	30.00	1000	31.40
2480	-8.90	1.50	6.17	-1.23	0.75	30.00	1000	31.23

Sample Calculation:

Result = Reading + Cable Loss (including the cable(s) customer supplied) + Attenuator Loss

Average Output Power
(Reference data for RF Exposure)

Test place : Ise EMC Lab. No.11 Measurement Room
Report No. : 11927987H
Date : September 25, 2017
Temperature / Humidity : 23 deg. C / 64 % RH
Engineer : Tomoki Matsui
Mode : Tx BT LE

BTLE

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	-11.41	1.50	6.17	-3.74	0.42	1.15	-2.59	0.55
2440	-10.98	1.50	6.17	-3.31	0.47	1.15	-2.16	0.61
2480	-10.81	1.50	6.17	-3.14	0.49	1.15	-1.99	0.63

Sample Calculation:

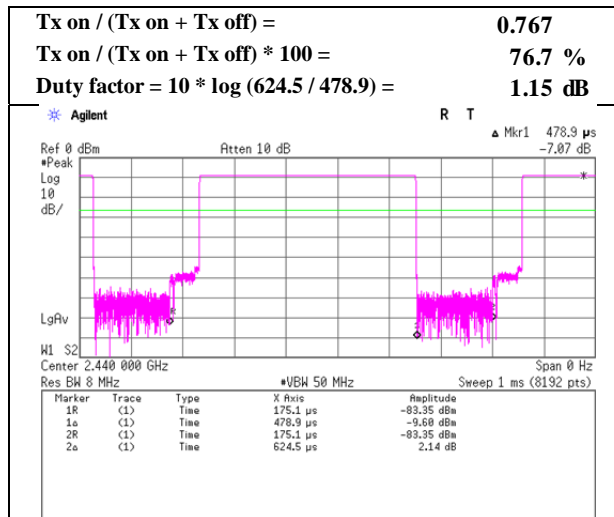
Result (Time average) = Reading + Cable Loss (including the cable(s) customer supplied) + Attenuator

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

Burst rate confirmation

Test place	Ise EMC Lab. No.11 Measurement Room
Report No.	11927987H
Date	September 25, 2017
Temperature / Humidity	23 deg. C / 64 % RH
Engineer	Tomoki Matsui
Mode	Tx BT LE

BTLE



Radiated Spurious Emission

Test place : Ise EMC Lab. No.4 Semi Anechoic Chamber
Report No. : 11927987H
Date : September 20, 2017 September 20, 2017 September 20, 2017
Temperature / Humidity : 24 deg. C / 62 % RH 23 deg. C / 61 % RH 23 deg. C / 61 % RH
Engineer : Hiroyuki Furutaka Ryota Yamanaka Ryota Yamanaka
 (1 GHz – 10 GHz) Below 1GHz (10 GHz – 26.5 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	95.081	QP	33.2	9.1	8.1	32.1	-	18.3	43.5	25.2	
Hori	149.713	QP	30.1	14.9	8.7	32.0	-	21.7	43.5	21.8	
Hori	172.353	QP	34.9	16.0	8.9	32.0	-	27.8	43.5	15.7	
Hori	194.162	QP	33.8	16.4	9.1	31.9	-	27.4	43.5	16.1	
Hori	247.200	QP	39.0	11.7	9.5	31.9	-	28.3	46.0	17.7	
Hori	356.400	QP	30.4	14.8	10.3	31.9	-	23.6	46.0	22.4	
Hori	2390.000	PK	52.1	27.0	6.7	32.1	-	53.7	73.9	20.2	
Hori	4804.000	PK	40.4	31.3	9.3	31.2	-	49.8	73.9	24.1	Floor noise
Hori	7206.000	PK	41.5	35.6	10.2	32.4	-	54.9	73.9	19.0	Floor noise
Hori	9608.000	PK	42.1	38.2	11.2	32.7	-	58.8	73.9	15.1	Floor noise
Hori	2390.000	AV	37.4	27.0	6.7	32.1	1.2	40.2	53.9	13.8	*1)
Hori	4804.000	AV	32.7	31.3	9.3	31.2	-	42.1	53.9	11.8	Floor noise
Hori	7206.000	AV	33.3	35.6	10.2	32.4	-	46.7	53.9	7.2	Floor noise
Hori	9608.000	AV	30.7	38.2	11.2	32.7	-	47.4	53.9	6.5	Floor noise
Vert	44.447	QP	37.2	12.7	7.4	32.1	-	25.2	40.0	14.8	
Vert	60.321	QP	44.3	7.7	7.6	32.1	-	27.5	40.0	12.5	
Vert	97.110	QP	40.5	9.4	8.1	32.1	-	25.9	43.5	17.6	
Vert	172.002	QP	33.7	16.0	8.9	32.0	-	26.6	43.5	16.9	
Vert	195.601	QP	30.0	16.5	9.1	31.9	-	23.7	43.5	19.8	
Vert	234.400	QP	34.6	11.6	9.4	31.9	-	23.7	46.0	22.3	
Vert	2390.000	PK	49.6	27.0	6.7	32.1	-	51.2	73.9	22.7	
Vert	4804.000	PK	40.4	31.3	9.3	31.2	-	49.8	73.9	24.1	Floor noise
Vert	7206.000	PK	41.5	35.6	10.2	32.4	-	54.9	73.9	19.0	Floor noise
Vert	9608.000	PK	42.1	38.2	11.2	32.7	-	58.8	73.9	15.1	Floor noise
Vert	2390.000	AV	34.9	27.0	6.7	32.1	1.2	37.7	53.9	16.3	*1)
Vert	4804.000	AV	32.7	31.3	9.3	31.2	-	42.1	53.9	11.8	Floor noise
Vert	7206.000	AV	33.3	35.6	10.2	32.4	-	46.7	53.9	7.2	Floor noise
Vert	9608.000	AV	30.7	38.2	11.2	32.7	-	47.4	53.9	6.5	Floor noise

Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter+Distance factor(above 1 GHz)) - Gain(Amplifier) + Duty factor
*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 (4.5 m / 3.0 m) = 3.53 dB
10 GHz - 26.5 GHz 20log (1.0 m / 3.0 m) = -9.5 dB

*1) Not Out of Band emission(Leakage Power)

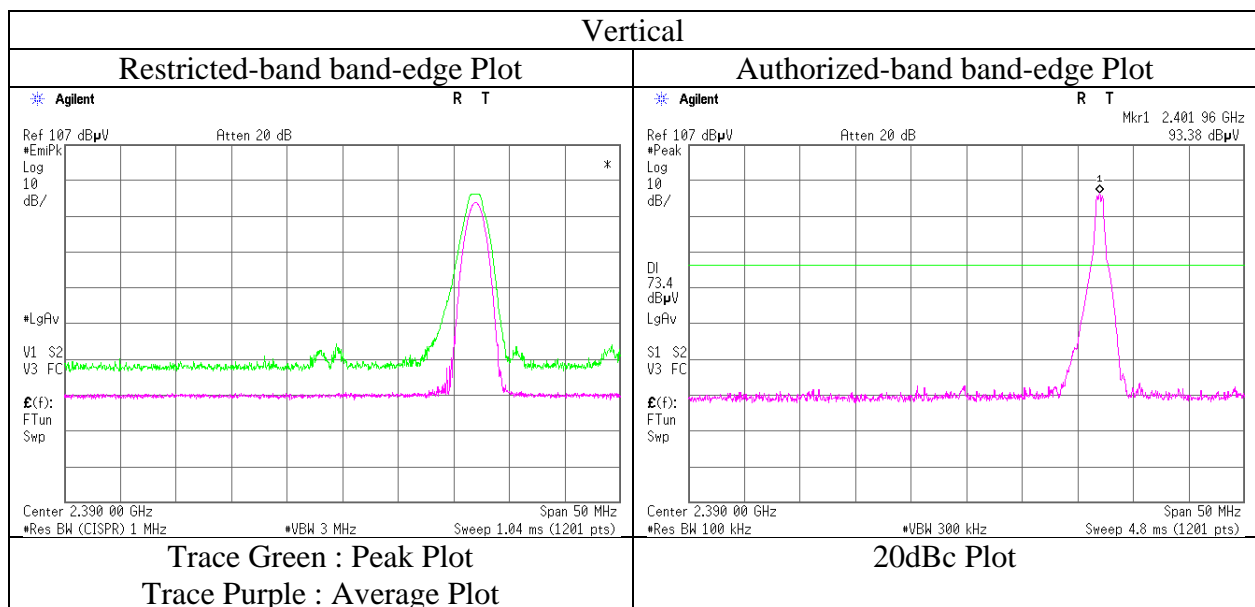
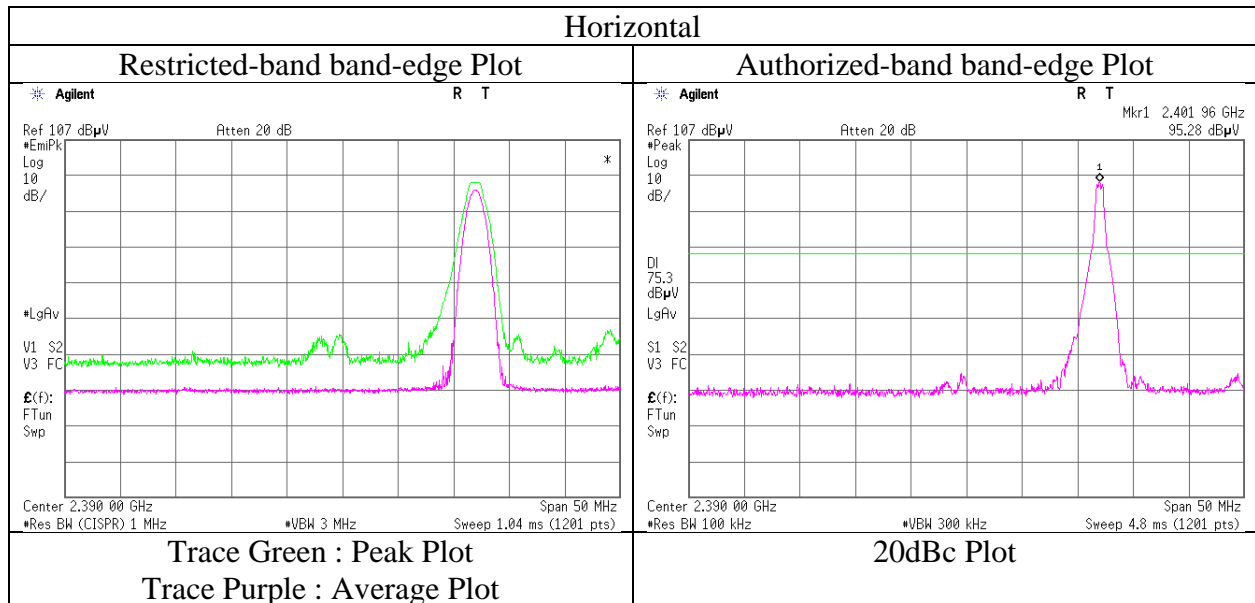
20dBc Data Sheet

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori	2402.000	PK	95.3	27.0	6.7	32.1	96.9	-	-	Carrier
Hori	2400.000	PK	52.8	27.0	6.7	32.1	54.4	76.9	22.5	
Vert	2402.000	PK	93.4	27.0	6.7	32.1	95.0	-	-	Carrier
Vert	2400.000	PK	56.6	27.0	6.7	32.1	58.2	75.0	16.8	

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

Radiated Spurious Emission (Reference Plot for band-edge)

Test place	Ise EMC Lab. No.4 Semi Anechoic Chamber
Report No.	11927987H
Date	September 20, 2017
Temperature / Humidity	24 deg. C / 62 % RH
Engineer	Hiroyuki Furutaka
Mode	Tx BT LE 2402MHz



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

Radiated Spurious Emission

Test place	Ise EMC Lab. No.4 Semi Anechoic Chamber		
Report No.	11927987H		
Date	September 20, 2017	September 20, 2017	September 20, 2017
Temperature / Humidity	24 deg. C / 62 % RH	23 deg. C / 61 % RH	23 deg. C / 61 % RH
Engineer	Hiroyuki Furutaka	Ryota Yamanaka	Ryota Yamanaka
	(1 GHz – 10 GHz)	Below 1GHz	(10 GHz – 26.5 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	59.800	QP	33.4	7.9	7.6	32.1	-	16.8	40.0	23.2	
Hori	152.016	QP	29.4	15.0	8.7	32.0	-	21.1	43.5	22.4	
Hori	178.467	QP	39.0	16.3	9.0	32.0	-	32.3	43.5	11.2	
Hori	198.242	QP	30.1	16.5	9.1	31.9	-	23.8	43.5	19.7	
Hori	249.515	QP	37.7	11.7	9.5	31.9	-	27.0	46.0	19.0	
Hori	364.880	QP	32.7	15.0	10.4	32.0	-	26.1	46.0	19.9	
Hori	4880.000	PK	40.2	31.4	9.3	31.2	-	49.7	73.9	24.2	Floor noise
Hori	7320.000	PK	41.8	35.8	10.2	32.5	-	55.3	73.9	18.6	Floor noise
Hori	9760.000	PK	41.8	38.2	11.2	32.8	-	58.4	73.9	15.5	Floor noise
Hori	4880.000	AV	32.4	31.4	9.3	31.2	-	41.9	53.9	12.0	Floor noise
Hori	7320.000	AV	34.0	35.8	10.2	32.5	-	47.5	53.9	6.4	Floor noise
Hori	9760.000	AV	30.9	38.2	11.2	32.8	-	47.5	53.9	6.4	Floor noise
Vert	44.659	QP	38.6	12.6	7.4	32.1	-	26.5	40.0	13.5	
Vert	59.681	QP	44.3	7.9	7.6	32.1	-	27.7	40.0	12.3	
Vert	98.547	QP	40.5	9.7	8.1	32.1	-	26.2	43.5	17.3	
Vert	176.491	QP	33.7	16.2	8.9	32.0	-	26.8	43.5	16.7	
Vert	272.880	QP	29.5	18.5	9.7	31.9	-	25.8	46.0	20.2	
Vert	302.555	QP	32.8	13.6	10.0	31.8	-	24.6	46.0	21.4	
Vert	4880.000	PK	40.2	31.4	9.3	31.2	-	49.7	73.9	24.2	Floor noise
Vert	7320.000	PK	41.8	35.8	10.2	32.5	-	55.3	73.9	18.6	Floor noise
Vert	9760.000	PK	41.8	38.2	11.2	32.8	-	58.4	73.9	15.5	Floor noise
Vert	4880.000	AV	32.4	31.4	9.3	31.2	-	41.9	53.9	12.0	Floor noise
Vert	7320.000	AV	34.0	35.8	10.2	32.5	-	47.5	53.9	6.4	Floor noise
Vert	9760.000	AV	30.9	38.2	11.2	32.8	-	47.5	53.9	6.4	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(4.5 m / 3.0 m) = 3.53 dB
 10 GHz - 26.5 GHz 20log(1.0 m / 3.0 m) = -9.5 dB

Radiated Spurious Emission

Test place	Ise EMC Lab. No.4 Semi Anechoic Chamber		
Report No.	11927987H		
Date	September 20, 2017	September 20, 2017	September 20, 2017
Temperature / Humidity	24 deg. C / 62 % RH	23 deg. C / 61 % RH	23 deg. C / 61 % RH
Engineer	Hiroyuki Furutaka	Ryota Yamanaka	Ryota Yamanaka
	(1 GHz – 10 GHz)	Below 1GHz	(10 GHz – 26.5 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	99.840	QP	35.3	9.9	8.1	32.1	-	21.2	43.5	22.3	
Hori	111.200	QP	31.6	11.7	8.3	32.0	-	19.6	43.5	23.9	
Hori	178.958	QP	38.3	16.3	9.0	32.0	-	31.6	43.5	11.9	
Hori	197.960	QP	30.5	16.5	9.1	31.9	-	24.2	43.5	19.3	
Hori	232.798	QP	37.1	11.6	9.4	31.9	-	26.2	46.0	19.8	
Hori	365.918	QP	33.1	15.0	10.4	32.0	-	26.5	46.0	19.5	
Hori	2483.500	PK	52.9	27.0	6.8	32.0	-	54.7	73.9	19.2	
Hori	2493.770	PK	52.6	27.0	6.8	32.0	-	54.4	73.9	19.5	
Hori	4960.000	PK	41.3	31.6	9.3	31.1	-	51.1	73.9	22.8	Floor noise
Hori	7440.000	PK	41.9	35.9	10.3	32.5	-	55.6	73.9	18.3	Floor noise
Hori	9920.000	PK	42.5	38.2	11.2	32.9	-	59.0	73.9	14.9	Floor noise
Hori	2483.500	AV	37.6	27.0	6.8	32.0	1.2	40.6	53.9	13.4	*1)
Hori	2493.770	AV	37.1	27.0	6.8	32.0	1.2	40.1	53.9	13.9	*1)
Hori	4960.000	AV	32.5	31.6	9.3	31.1	-	42.3	53.9	11.6	Floor noise
Hori	7440.000	AV	33.8	35.9	10.3	32.5	-	47.5	53.9	6.4	Floor noise
Hori	9920.000	AV	31.0	38.2	11.2	32.9	-	47.5	53.9	6.4	Floor noise
Vert	44.878	QP	38.6	12.6	7.4	32.1	-	26.5	40.0	13.5	
Vert	58.960	QP	43.2	8.1	7.6	32.1	-	26.8	40.0	13.2	
Vert	101.513	QP	39.6	10.2	8.2	32.1	-	25.9	43.5	17.6	
Vert	176.998	QP	34.6	16.2	8.9	32.0	-	27.7	43.5	15.8	
Vert	235.122	QP	31.3	17.1	9.4	31.9	-	25.9	46.0	20.1	
Vert	361.034	QP	25.1	14.9	10.4	31.9	-	18.5	46.0	27.5	
Vert	2483.500	PK	49.2	27.0	6.8	32.0	-	51.0	73.9	22.9	
Vert	2493.770	PK	50.4	27.0	6.8	32.0	-	52.2	73.9	21.7	
Vert	4960.000	PK	41.3	31.6	9.3	31.1	-	51.1	73.9	22.8	Floor noise
Vert	7440.000	PK	41.9	35.9	10.3	32.5	-	55.6	73.9	18.3	Floor noise
Vert	9920.000	PK	42.5	38.2	11.2	32.9	-	59.0	73.9	14.9	Floor noise
Vert	2483.500	AV	37.0	27.0	6.8	32.0	1.2	40.0	53.9	14.0	*1)
Vert	2493.770	AV	36.4	27.0	6.8	32.0	1.2	39.4	53.9	14.6	*1)
Vert	4960.000	AV	32.5	31.6	9.3	31.1	-	42.3	53.9	11.6	Floor noise
Vert	7440.000	AV	33.8	35.9	10.3	32.5	-	47.5	53.9	6.4	Floor noise
Vert	9920.000	AV	31.0	38.2	11.2	32.9	-	47.5	53.9	6.4	Floor noise

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

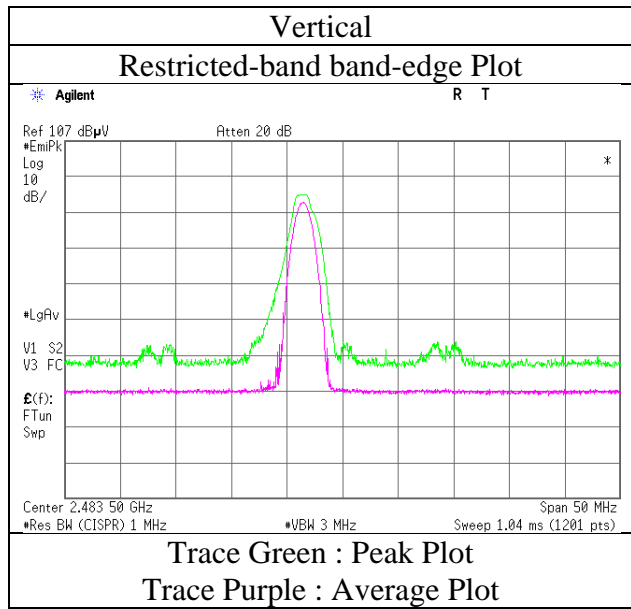
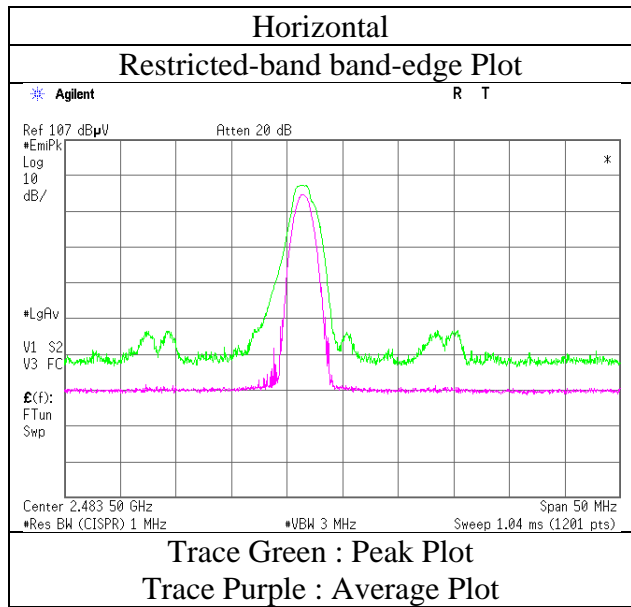
*Other frequency noises omitted in this report were not seen or had enough margin (more than 20 dB).

Distance factor: 1 GHz - 10 GHz $20\log(4.5\text{ m} / 3.0\text{ m}) = 3.53\text{ dB}$
10 GHz - 26.5 GHz $20\log(1.0\text{ m} / 3.0\text{ m}) = -9.5\text{ dB}$

*1) Not Out of Band emission(Leakage Power)

Radiated Spurious Emission
(Reference Plot for band-edge)

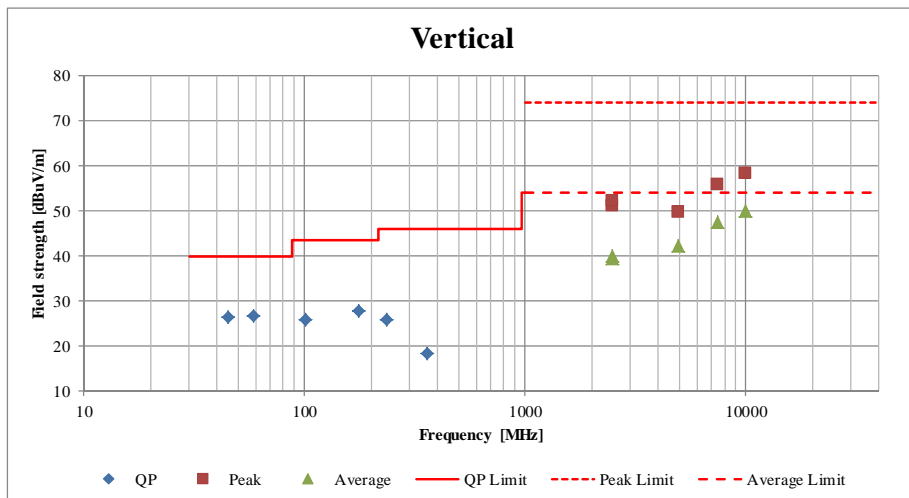
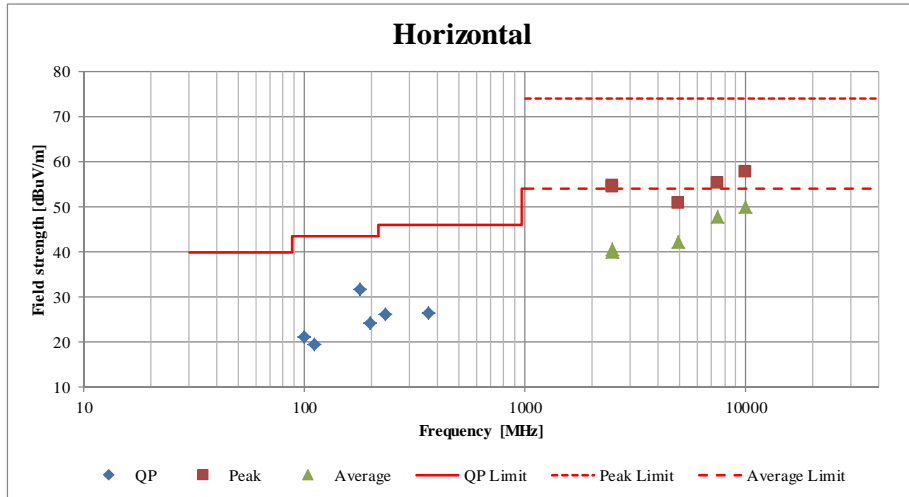
Test place	Ise EMC Lab. No.4 Semi Anechoic Chamber
Report No.	11927987H
Date	September 20, 2017
Temperature / Humidity	24 deg. C / 62 % RH
Engineer	Hiroyuki Furutaka
Mode	Tx BT LE 2480 MHz



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

Radiated Spurious Emission
(Plot data, Worst case)

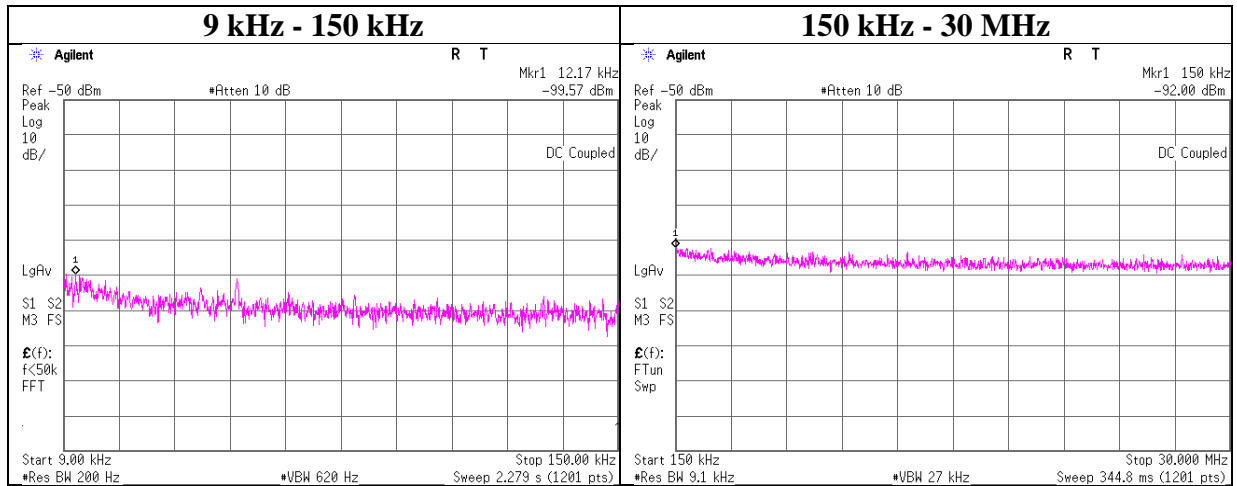
Test place	Ise EMC Lab. No.4 Semi Anechoic Chamber		
Report No.	11927987H		
Date	September 20, 2017	September 20, 2017	September 20, 2017
Temperature / Humidity	24 deg. C / 62 % RH	23 deg. C / 61 % RH	23 deg. C / 61 % RH
Engineer	Hiroyuki Furutaka (1 GHz – 10 GHz)	Ryota Yamanaka Below 1GHz	Ryota Yamanaka (10 GHz – 26.5 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

Test place	Ise EMC Lab. No.11 Measurement Room
Report No.	11927987H
Date	September 25, 2017
Temperature / Humidity	23 deg. C / 64 % RH
Engineer	Tomoki Matsui
Mode	Tx BT LE 2402MHz



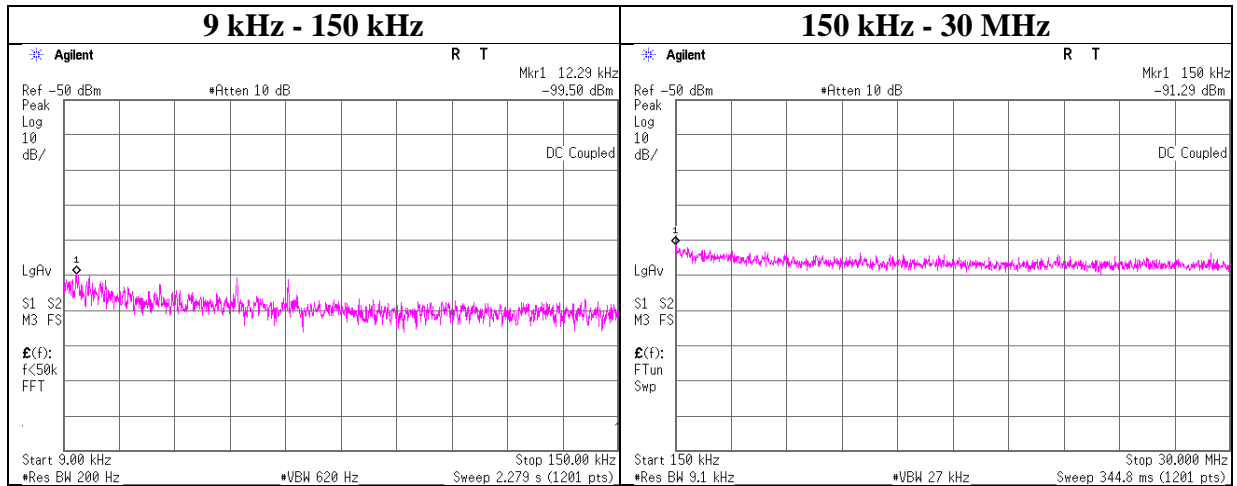
Frequency [kHz]	Reading [dBm]	Cable Loss [dB]	Attenuator Loss [dB]	Antenna Gain [dBi]	EIRP [dBm]	Distance [m]	Ground bounce [dB]	E (field strength) [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
12.17	-99.6	1.50	6.2	2.0	-89.9	300	6.0	-28.6	45.8	74.4	
150.00	-92.0	1.50	6.2	2.0	-82.3	300	6.0	-21.1	24.0	45.1	

$$E = \text{EIRP} - 20 \log(D) + \text{Ground bounce} + 104.8 \text{ [dBuV/m]}$$

$$\text{EIRP} = \text{Reading} + \text{Cable Loss} + \text{Attenuator Loss} + \text{Antenna Gain} + 10 * \log(N)$$

Conducted Spurious Emission

Test place	Ise EMC Lab. No.11 Measurement Room
Report No.	11927987H
Date	September 25, 2017
Temperature / Humidity	23 deg. C / 64 % RH
Engineer	Tomoki Matsui
Mode	Tx BT LE 2440MHz



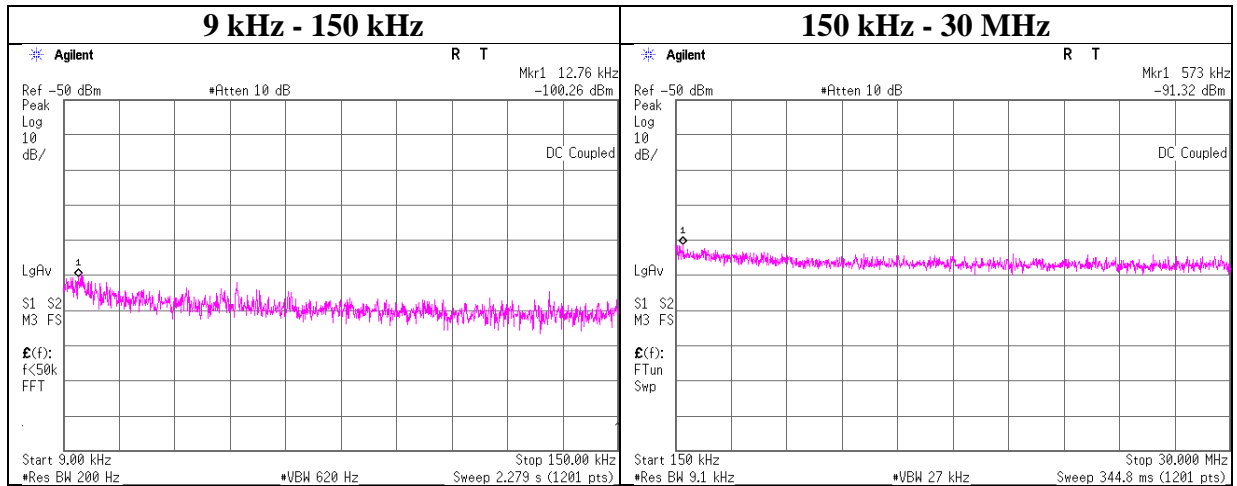
Frequency [kHz]	Reading [dBm]	Cable Loss [dB]	Attenuator Loss [dB]	Antenna Gain [dBi]	EIRP [dBm]	Distance [m]	Ground bounce [dB]	E (field strength) [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
12.29	-99.5	1.50	6.2	2.0	-89.8	300	6.0	-28.6	45.8	74.4	
150.00	-91.3	1.50	6.2	2.0	-81.6	300	6.0	-20.4	24.0	44.4	

$E = \text{EIRP} - 20 \log(D) + \text{Ground bounce} + 104.8 \text{ [dBuV/m]}$

$\text{EIRP} = \text{Reading} + \text{Cable Loss} + \text{Attenuator Loss} + \text{Antenna Gain} + 10 * \log(N)$

Conducted Spurious Emission

Test place	Ise EMC Lab. No.11 Measurement Room
Report No.	11927987H
Date	September 25, 2017
Temperature / Humidity	23 deg. C / 64 % RH
Engineer	Tomoki Matsui
Mode	Tx BT LE 2480MHz



Frequency [kHz]	Reading [dBm]	Cable Loss [dB]	Attenuator Loss [dB]	Antenna Gain [dBi]	EIRP [dBm]	Distance [m]	Ground bounce [dB]	E (field strength) [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
12.76	-100.3	1.50	6.2	2.0	-90.6	300	6.0	-29.3	45.4	74.7	
573.00	-91.3	1.50	6.2	2.0	-81.7	30	6.0	-0.4	32.4	32.8	

$E = \text{EIRP} - 20 \log(D) + \text{Ground bounce} + 104.8 \text{ [dBuV/m]}$

$\text{EIRP} = \text{Reading} + \text{Cable Loss} + \text{Attenuator Loss} + \text{Antenna Gain} + 10 * \log(N)$

Power Density

Test place Ise EMC Lab. No.11 Measurement Room
Report No. 11927987H
Date September 25, 2017
Temperature / Humidity 23 deg. C / 64 % RH
Engineer Tomoki Matsui
Mode Tx BT LE

BT LE

Freq. [MHz]	Reading [dBm]	Cable Loss [dB]	Atten. Loss [dB]	Result [dBm]	Limit [dBm]	Margin [dB]
2402.00	-22.33	1.50	6.17	-14.66	8.00	22.66
2440.00	-22.20	1.50	6.17	-14.53	8.00	22.53
2480.00	-22.00	1.50	6.17	-14.33	8.00	22.33

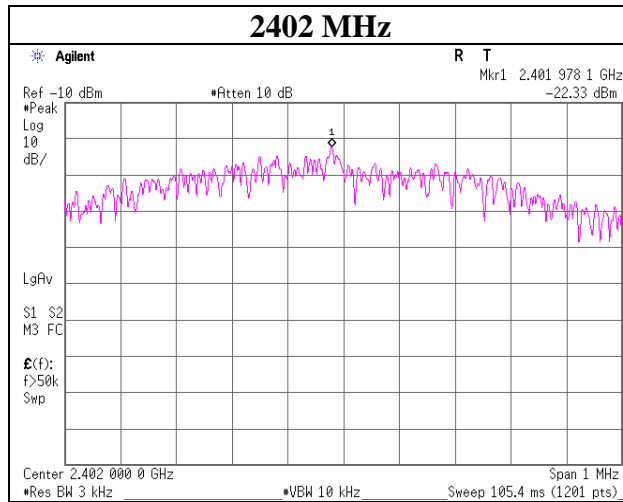
Sample Calculation:

Result = Reading + Cable Loss (including the cable(s) customer supplied) + Attenuator

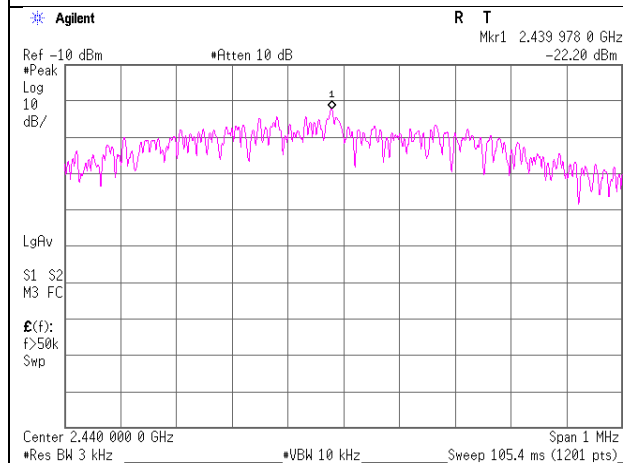
Power Density

BL TE

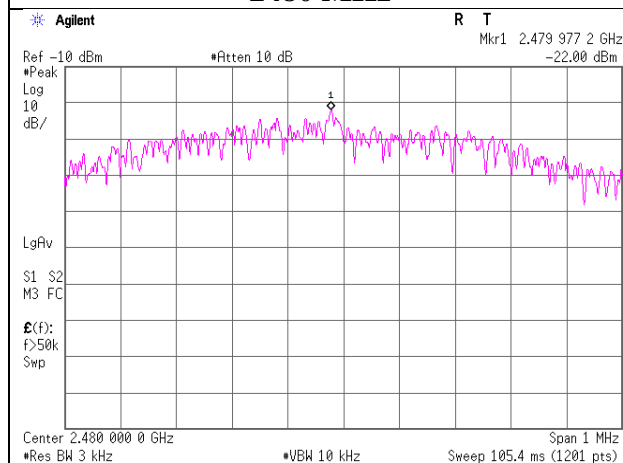
2402 MHz



2440 MHz



2480 MHz



UL Japan, Inc.

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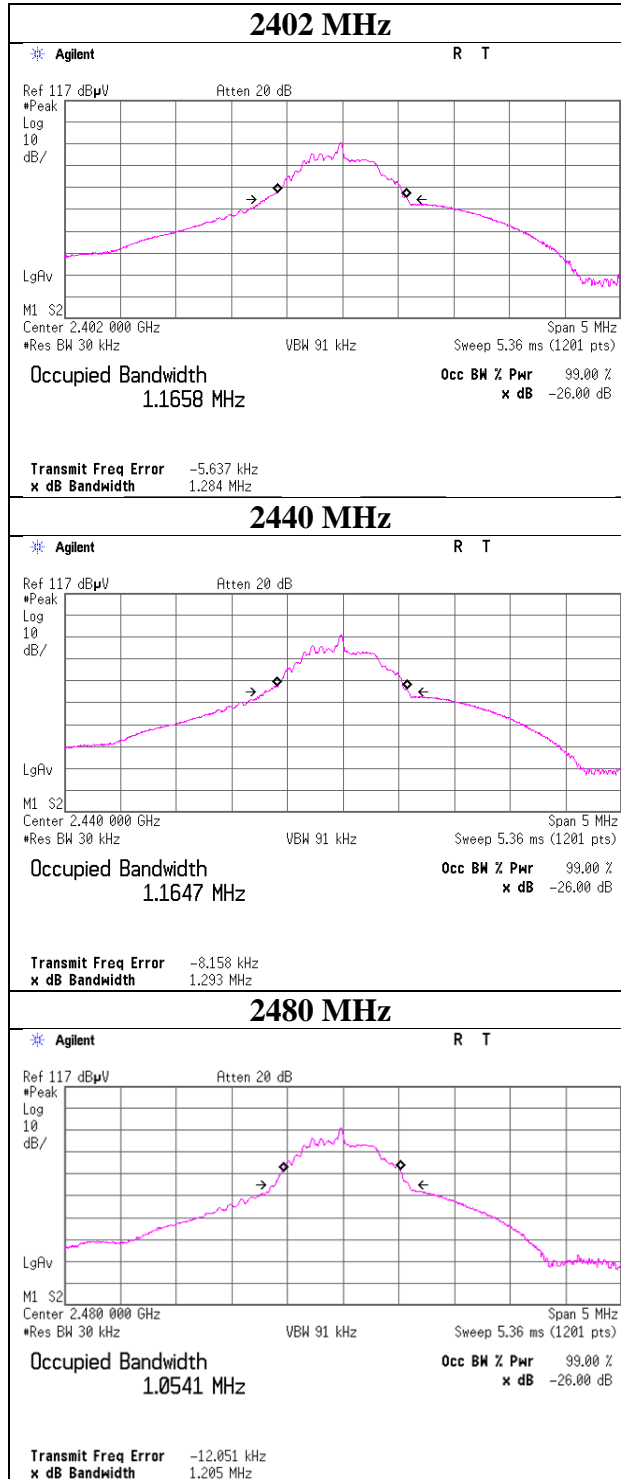
Telephone : +81 596 24 8999

Facsimile : +81 596 24 8124

99% Occupied Bandwidth

Test place	Ise EMC Lab. No.11 Measurement Room
Report No.	11927987H
Date	September 25, 2017
Temperature / Humidity	23 deg. C / 64 % RH
Engineer	Tomoki Matsui
Mode	Tx BT LE

BT LE



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Ise EMC Lab.

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Facsimile : +81 596 24 8124

APPENDIX 2: Test instruments

Test equipment

Control No.	Instrument	Manufacturer	Model No	Serial No	Test Item	Calibration Date * Interval(month)
MAEC-04	Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 3m	DA-10005	RE	2016/10/19 * 12
MOS-15	Thermo-Hygrometer	Custom	CTH-180	1501	RE	2017/01/20 * 12
MJM-26	Measure	KOMELON	KMC-36	-	RE	-
COTS-MEMI	EMI measurement program	TSJ	TEPTO-DV	-	RE	-
MSA-03	Spectrum Analyzer	Agilent	E4448A	MY44020357	RE	2017/05/29 * 12
MHA-06	Horn Antenna 1-18GHz	Schwarzbeck	BBHA9120D	254	RE	2017/02/24 * 12
MCC-141	Microwave Cable	Junkosha	MWX221	1305S002R(1m) / 1405S146(5m)	RE	2017/06/23 * 12
MPA-12	MicroWave System Amplifier	Agilent	83017A	00650	RE	2016/10/21 * 12
MHF-26	High Pass Filter 3.5-18.0GHz	UL Japan	HPF SELECTOR	002	RE	2017/09/11 * 12
MMM-10	DIGITAL HiTESTER	Hioki	3805	051201148	RE	2017/01/19 * 12
MTR-10	EMI Test Receiver	Rohde & Schwarz	ESR26	101408	RE	2017/01/12 * 12
MBA-05	Biconical Antenna	Schwarzbeck	BBA9106	1302	RE	2016/11/23 * 12
MLA-23	Logperiodic Antenna(200-1000MHz)	Schwarzbeck	VUSLP9111B	911B-192	RE	2017/01/26 * 12
MCC-50	Coaxial Cable	UL Japan	-	-	RE	2017/06/26 * 12
MAT-97	Attenuator	KEYSIGHT	8491A	MY52462282	RE	2016/10/31 * 12
MPA-14	Pre Amplifier	SONOMA INSTRUMENT	310	260833	RE	2017/03/27 * 12
MHA-21	Horn Antenna 1-18GHz	Schwarzbeck	BBHA9120D	9120D-557	RE	2016/09/28 * 12
MHA-17	Horn Antenna 15-40GHz	Schwarzbeck	BBHA9170	BBHA9170307	RE	2017/06/30 * 12
MRENT-130	Spectrum Analyzer	Agilent	E4440A	MY46187750	AT	2017/06/20 * 12
MPM-13	Power Meter	Anritsu	ML2495A	0824014	AT	2016/11/02 * 12
MPSE-18	Power sensor	Anritsu	MA2411B	0738174	AT	2016/11/02 * 12
MAT-19	Attenuator(6dB)(above 1 GHz)	HIROSE ELECTRIC CO.,LTD.	AT-106	-	AT	2016/12/14 * 12
MOS-19	Thermo-Hygrometer	Custom	CTH-201	0001	AT	2016/12/13 * 12
MMM-17	DIGITAL HiTESTER	Hioki	3805	070900530	AT	2017/01/19 * 12

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,
AT: Antenna terminal disturbance voltage**

UL Japan, Inc.

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