



RADIO TEST REPORT


Test Report No. : 12985473H-R2

Applicant : Panasonic Corporation
Type of Equipment : Magi'c Box
Model No. : ZERS1901
FCC ID : 2AM4XZERS01
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 12985473H-R.12985473H-R1 replaced with this report.

Date of test: September 29 and 30, 2019

Representative test engineer:


Akihiko Maeda
Engineer
Consumer Technology Division

Approved by:


Takayuki Shimada
Leader
Consumer Technology Division



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REVISION HISTORY

Original Test Report No.: 12985473H

Revision	Test report No.	Date	Page revised	Contents
- (Original)	12985473H	October 9, 2019	-	-
1	12985473H-R1	October 21, 2019	P 11	Correction of explanatory note *1)
1	12985473H-R1	October 21, 2019	P 15	Deletion of explanatory note
1	12985473H-R1	October 21, 2019	P 18	Correction of explanatory note for duty factor
1	12985473H-R1	October 21, 2019	P 22	Correction of test data
2	12985473H-R2	October 23, 2019	P22	Correction of explanatory note *2) Addition of reference chart

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Reference: Abbreviations (Including words undescribed in this report)

A2LA	The American Association for Laboratory Accreditation	MCS	Modulation and Coding Scheme
AC	Alternating Current	MRA	Mutual Recognition Arrangement
AFH	Adaptive Frequency Hopping	N/A	Not Applicable
AM	Amplitude Modulation	NIST	National Institute of Standards and Technology
Amp, AMP	Amplifier	NS	No signal detect.
ANSI	American National Standards Institute	NSA	Normalized Site Attenuation
Ant, ANT	Antenna	NVLAP	National Voluntary Laboratory Accreditation Program
AP	Access Point	OBW	Occupied Band Width
ASK	Amplitude Shift Keying	OFDM	Orthogonal Frequency Division Multiplexing
Atten., ATT	Attenuator	P/M	Power meter
AV	Average	PCB	Printed Circuit Board
BPSK	Binary Phase-Shift Keying	PER	Packet Error Rate
BR	Bluetooth Basic Rate	PHY	Physical Layer
BT	Bluetooth	PK	Peak
BT LE	Bluetooth Low Energy	PN	Pseudo random Noise
BW	BandWidth	PRBS	Pseudo-Random Bit Sequence
Cal Int	Calibration Interval	PSD	Power Spectral Density
CCK	Complementary Code Keying	QAM	Quadrature Amplitude Modulation
Ch., CH	Channel	QP	Quasi-Peak
CISPR	Comite International Special des Perturbations Radioelectriques	QPSK	Quadri-Phase Shift Keying
CW	Continuous Wave	RBW	Resolution Band Width
DBPSK	Differential BPSK	RDS	Radio Data System
DC	Direct Current	RE	Radio Equipment
D-factor	Distance factor	RF	Radio Frequency
DFS	Dynamic Frequency Selection	RMS	Root Mean Square
DQPSK	Differential QPSK	RSS	Radio Standards Specifications
DSSS	Direct Sequence Spread Spectrum	Rx	Receiving
EDR	Enhanced Data Rate	SA, S/A	Spectrum Analyzer
EIRP, e.i.r.p.	Equivalent Isotropically Radiated Power	SG	Signal Generator
EMC	ElectroMagnetic Compatibility	SVSWR	Site-Voltage Standing Wave Ratio
EMI	ElectroMagnetic Interference	TR	Test Receiver
EN	European Norm	Tx	Transmitting
ERP, e.r.p.	Effective Radiated Power	VBW	Video BandWidth
EU	European Union	Vert.	Vertical
EUT	Equipment Under Test	WLAN	Wireless LAN
Fac.	Factor		
FCC	Federal Communications Commission		
FHSS	Frequency Hopping Spread Spectrum		
FM	Frequency Modulation		
Freq.	Frequency		
FSK	Frequency Shift Keying		
GFSK	Gaussian Frequency-Shift Keying		
GNSS	Global Navigation Satellite System		
GPS	Global Positioning System		
Hori.	Horizontal		
ICES	Interference-Causing Equipment Standard		
IEC	International Electrotechnical Commission		
IEEE	Institute of Electrical and Electronics Engineers		
IF	Intermediate Frequency		
ILAC	International Laboratory Accreditation Conference		
ISED	Innovation, Science and Economic Development Canada		
ISO	International Organization for Standardization		
JAB	Japan Accreditation Board		
LAN	Local Area Network		
LIMS	Laboratory Information Management System		

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SECTION 1: Customer information

Company Name	:	Panasonic Corporation
Address	:	1006 Kadoma, Kadoma City, Osaka, 571-8506 Japan
Telephone Number	:	+81-50-3487-8129
Contact Person	:	Masaaki Noda

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	:	Magi'c Box
Model No.	:	ZERS1901
Serial No.	:	Refer to SECTION 4.2
Rating	:	DC 3 V to DC 15 V
Receipt Date of Sample (Information from test lab.)	:	September 12, 2019
Country of Mass-production	:	Japan
Condition of EUT	:	Engineering 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: ZERS1901 (referred to as the EUT in this report) is a Magi'c Box.

Radio Specification

Radio Type	:	Transceiver
Frequency of Operation	:	2478 MHz
Modulation	:	2-GFSK, 2Mbps
Antenna type	:	Chip Antenna
Antenna Gain	:	-6 dBi
Clock frequency (Maximum)	:	RF: 24 MHz, MPU: 16 MHz

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 47 CFR Part 15 Radio Frequency Device Subpart C Intentional Radiators
Section 15.207 Conducted limits
Section 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz,
and 5725-5850 MHz

* Also the EUT complies with FCC Part 15 Subpart B.

3.2 Procedures and results

Item	Test Procedure	Specification	Worst margin	Results	Remarks
Conducted Emission	FCC: ANSI C63.10-2013 6. Standard test methods ISED: RSS-Gen 8.8	FCC: Section 15.207 ISED: RSS-Gen 8.8	N/A	N/A	*1)
6dB Bandwidth	FCC: KDB 558074 D01 15.247 Meas Guidance v05r02 ISED: -	FCC: Section 15.247(a)(2) ISED: RSS-247 5.2(a)	See data.	Complied a)	Conducted
Maximum Peak Output Power	FCC: KDB 558074 D01 15.247 Meas Guidance v05r02 ISED: RSS-Gen 6.12	FCC: Section 15.247(b)(3) ISED: RSS-247 5.4(d)		Complied b)	Conducted
Power Density	FCC: KDB 558074 D01 15.247 Meas Guidance v05r02 ISED: -	FCC: Section 15.247(e) ISED: RSS-247 5.2(b)		Complied c)	Conducted
Spurious Emission Restricted Band Edges	FCC: KDB 558074 D01 15.247 Meas Guidance v05r02 ISED: RSS-Gen 6.13	FCC: Section 15.247(d) ISED: RSS-247 5.5 RSS-Gen 8.9 RSS-Gen 8.10	3.1 dB 14868.000 MHz, PK, Horizontal	Complied# d), e)	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 was not performed on since the EUT does not have AC Power ports.

*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.

FCC Part 15.31 (e)

This EUT provides stable voltage constantly to RF Part 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	RSS-Gen 6.7	ISED: -	N/A	- a)	Conducted
a) Refer to APPENDIX 1 (data of 6 dB Bandwidth and 99 % Occupied Bandwidth)					

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

3.4 Uncertainty

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) (Vertical)	4.8 dB
		5.0 dB
	200 MHz to 1000 MHz (Horizontal) (Vertical)	5.2 dB
		6.3 dB
10 m	30 MHz to 200 MHz (Horizontal) (Vertical)	4.8 dB
		4.9 dB
	200 MHz to 1000 MHz (Horizontal) (Vertical)	5.0 dB
		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

3.5 Test Location

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*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.

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

4.1 Operating Mode(s)

Mode	Remarks*
Transmitting (Tx)	PN9
*All tests except for Duty confirmation test was performed with transmitting duty was 100 %.	
*Power of the EUT was set by the software as follows; Power settings: 0x3f00 *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.	

*The details of Operating mode(s)

Test Item	Operating Mode	Tested frequency
6dB Bandwidth 99% Occupied Bandwidth Spurious Emission (Radiated /Conducted) Maximum Peak Output Power Power Density	Transmitting (Tx)	2478 MHz

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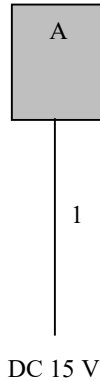
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4.2 Configuration and peripherals



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

Description of EUT and Support equipment

No.	Item	Model number	Serial number	Manufacturer	Remarks
A	Magi'c Box	ZERS1901	FFFF370F0001: for AT* FFFF370F0002: for other tests	Panasonic Corporation	EUT

*AT: Antenna Terminal conducted test

List of cables used

No.	Name	Length (m)	Shield		Remarks
			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 "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 m 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	PK
IF Bandwidth	BW 120 kHz	RBW: 1 MHz VBW: 3 MHz	Peak with Duty Factor *1)	RBW: 100 kHz VBW: 300 kHz

*1) For Pulse emission: The Average value was calculated by reducing Duty factor from PK (PK value – Duty factor).
For Duty factor, please refer to Page 22.

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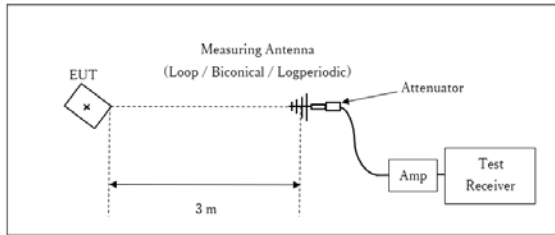
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Figure 2: Test Setup

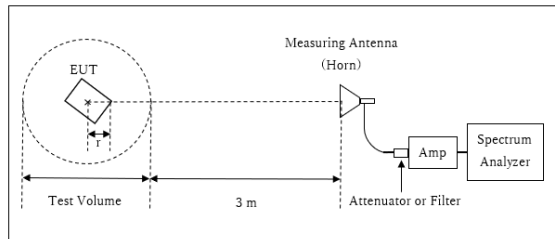
Below 1 GHz



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: $20 \times \log (3.75 \text{ m} / 3.0 \text{ m}) = 1.94 \text{ dB}$

* Test Distance: $(3 + \text{Test Volume} / 2) - r = 3.75 \text{ m}$

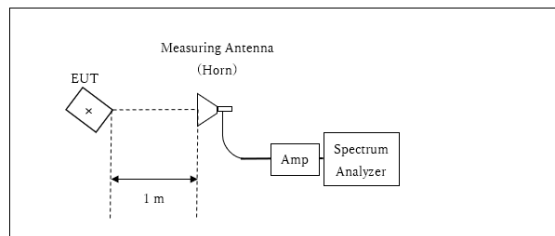
Test Volume : 1.5 m

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

r = 0.0 m

*The test was performed with r = 0.0 m since test was performed severer condition.

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 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.

Measurement range	: 30 MHz - 26.5 GHz
Test data	: APPENDIX
Test result	: Pass

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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	5 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.

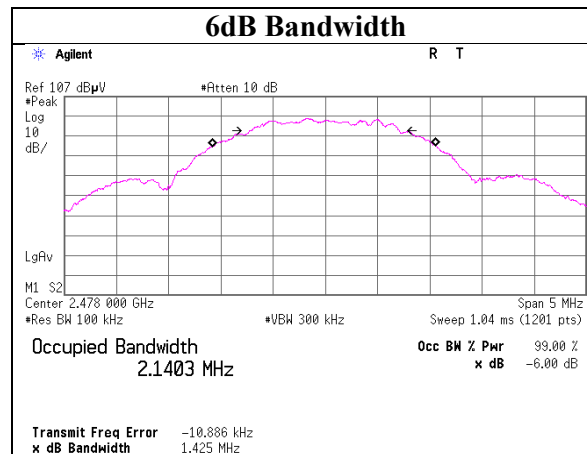
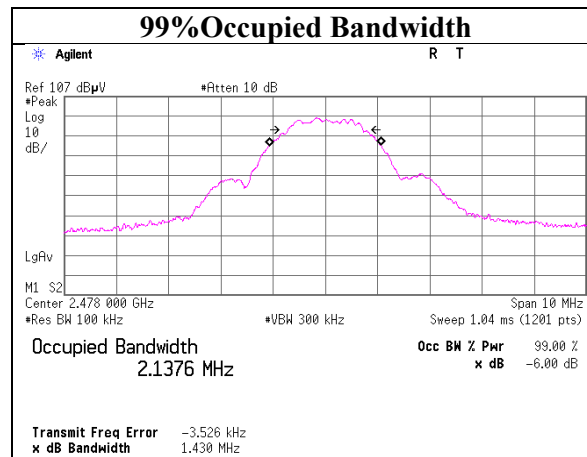
Test data : APPENDIX
 Test result : Pass

APPENDIX 1: Test data

6 dB Bandwidth and 99 % Occupied Bandwidth

Report No.	12985473H
Test place	Ise EMC Lab. No.4 Measurement Room
Date	September 30, 2019
Temperature / Humidity	24 deg. C / 56 % RH
Engineer	Akihiko Maeda
Mode	Tx

Frequency [MHz]	99% Occupied Bandwidth [kHz]	6dB Bandwidth [MHz]	Limit for 6dB Bandwidth [MHz]
2478	2137.6	1.425	> 0.5000



Maximum Peak Output Power

Report No. 12985473H
Test place Ise EMC Lab. No.4 Measurement Room
Date September 30, 2019
Temperature / Humidity 24 deg. C / 56 % RH
Engineer Akihiko Maeda
Mode Tx

Freq.	Reading	Cable Loss	Atten. Loss	Conducted Power					e.i.r.p. for RSS-247					
				Result		Limit		Margin	Antenna Gain	Result		Limit		Margin
				[dBm]	[mW]	[dBm]	[mW]	[dB]		[dBm]	[mW]	[dBm]	[mW]	[dB]
2478	-8.55	1.00	10.10	2.55	1.80	30.00	1000	27.45	-6	-3.45	0.45	36.02	4000	39.47

Sample Calculation:

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

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

*The equipment and cables were not used for factor 0 dB of the data sheets.

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Average Output Power
(Reference data)

Report No. 12985473H
Test place Ise EMC Lab. No.4 Measurement Room
Date September 30, 2019
Temperature / Humidity 24 deg. C / 56 % RH
Engineer Akihiko Maeda
Mode Tx

Freq. [MHz]	Reading [dBm]	Cable Loss [dB]	Atten. Loss [dB]	Result (Time average)		Duty factor [dB]	Result (Burst power average)	
				[dBm]	[mW]		[dBm]	[mW]
2478	-8.83	1.00	10.10	2.27	1.69	0.00	2.27	1.69

Sample Calculation:

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

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

*The equipment and cables were not used for factor 0 dB of the data sheets.

Radiated Spurious Emission

Report No.	12985473H	
Test place	Ise EMC Lab.	
Semi Anechoic Chamber	No.2	No.4
Date	September 29, 2019	September 29, 2019
Temperature / Humidity	26 deg. C / 54 % RH	23 deg. C / 67 % RH
Engineer	Akihiko Maeda (Above 1 GHz)	Akihiko Maeda (Below 1 GHz)
Mode	Tx 2478 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.	63.749	QP	21.7	7.0	8.0	32.2	-	4.5	40.0	35.5	
Hori.	71.130	QP	21.5	6.3	8.1	32.1	-	3.7	40.0	36.3	
Hori.	75.462	QP	21.7	6.5	8.1	32.1	-	4.2	40.0	35.8	
Hori.	79.075	QP	21.6	6.7	8.2	32.1	-	4.4	40.0	35.6	
Hori.	82.875	QP	21.6	7.3	8.2	32.1	-	5.0	40.0	35.0	
Hori.	96.015	QP	21.9	9.6	8.4	32.1	-	7.7	43.5	35.8	
Hori.	2390.000	PK	43.2	27.3	5.3	34.3	-	41.5	73.9	32.4	
Hori.	2483.500	PK	44.3	28.1	5.4	34.2	-	43.6	73.9	30.3	
Hori.	4956.000	PK	51.4	31.9	7.6	33.5	-	57.4	73.9	16.5	
Hori.	7434.000	PK	50.1	36.3	8.9	33.5	-	61.8	73.9	12.1	
Hori.	9912.000	PK	51.4	38.8	9.8	33.8	-	66.1	73.9	7.8	
Hori.	12390.000	PK	55.2	38.6	-0.8	32.8	-	60.2	73.9	13.7	
Hori.	14868.000	PK	62.2	40.7	0.2	32.3	-	70.8	73.9	3.1	
Hori.	17346.000	PK	56.9	41.1	1.3	32.1	-	67.1	73.9	6.8	
Hori.	19824.000	PK	51.6	40.3	-1.3	32.3	-	58.4	73.9	15.5	
Hori.	24780.000	PK	52.6	40.5	0.0	32.2	-	60.9	73.9	13.0	
Vert.	63.749	QP	22.7	7.0	8.0	32.2	-	5.5	40.0	34.5	
Vert.	71.130	QP	25.1	6.3	8.1	32.1	-	7.3	40.0	32.7	
Vert.	75.462	QP	27.5	6.5	8.1	32.1	-	10.0	40.0	30.0	
Vert.	79.075	QP	29.1	6.7	8.2	32.1	-	11.9	40.0	28.1	
Vert.	82.875	QP	26.1	7.3	8.2	32.1	-	9.5	40.0	30.5	
Vert.	96.015	QP	27.4	9.6	8.4	32.1	-	13.2	43.5	30.3	
Vert.	2390.000	PK	43.6	27.3	5.3	34.3	-	41.9	73.9	32.0	
Vert.	2483.500	PK	43.9	28.1	5.4	34.2	-	43.2	73.9	30.7	
Vert.	4956.000	PK	52.6	31.9	7.6	33.5	-	58.6	73.9	15.3	
Vert.	7434.000	PK	48.8	36.3	8.9	33.5	-	60.5	73.9	13.4	
Vert.	9912.000	PK	52.0	38.8	9.8	33.8	-	66.7	73.9	7.2	
Vert.	12390.000	PK	56.7	38.6	-0.8	32.8	-	61.7	73.9	12.2	
Vert.	14868.000	PK	60.3	40.7	0.2	32.3	-	68.9	73.9	5.0	
Vert.	17346.000	PK	59.5	41.1	1.3	32.1	-	69.7	73.9	4.2	
Vert.	19824.000	PK	52.7	40.3	-1.3	32.3	-	59.5	73.9	14.4	
Vert.	24780.000	PK	55.1	40.5	0.0	32.2	-	63.4	73.9	10.5	

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 $20\log(3.75\text{ m} / 3.0\text{ m}) = 1.94\text{ dB}$
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.	2478.000	PK	81.4	28.0	5.4	34.2	80.6	-	-	Carrier
Hori.	2400.000	PK	35.2	27.0	5.3	34.3	33.3	60.6	27.3	
Vert.	2478.000	PK	81.6	28.0	5.4	34.2	80.8	-	-	Carrier
Vert.	2400.000	PK	34.5	27.0	5.3	34.3	32.6	60.8	28.2	

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

Distance factor: 1 GHz - 10 GHz $20\log(3.75\text{ m} / 3.0\text{ m}) = 1.94\text{ dB}$
10 GHz - 26.5 GHz $20\log(1.0\text{ m} / 3.0\text{ m}) = -9.5\text{ dB}$

PK with Duty factor

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant Factor [dB/m]	Loss [dB]	Gain [dB]	Duty Factor [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori.	2390.000	PK	43.2	27.3	5.3	34.3	-20.5	21.0	53.9	32.9	*
Hori.	2483.500	PK	44.3	28.1	5.4	34.2	-20.5	23.1	53.9	30.8	*
Hori.	4956.000	PK	51.4	31.9	7.6	33.5	-20.5	36.9	53.9	17.0	*
Hori.	7434.000	PK	50.1	36.3	8.9	33.5	-20.5	41.3	53.9	12.6	*
Hori.	9912.000	PK	51.4	38.8	9.8	33.8	-20.5	45.6	53.9	8.3	*
Hori.	12390.000	PK	55.2	38.6	-0.8	32.8	-20.5	39.7	53.9	14.2	*
Hori.	14868.000	PK	62.2	40.7	0.2	32.3	-20.5	50.3	53.9	3.6	*
Hori.	17346.000	PK	56.9	41.1	1.3	32.1	-20.5	46.6	53.9	7.3	*
Hori.	19824.000	PK	51.6	40.3	-1.3	32.3	-20.5	37.9	53.9	16.0	*
Hori.	24780.000	PK	52.6	40.5	0.0	32.2	-20.5	40.4	53.9	13.5	*
Vert.	2390.000	PK	43.6	27.3	5.3	34.3	-20.5	21.4	53.9	32.5	*
Vert.	2483.500	PK	43.9	28.1	5.4	34.2	-20.5	22.7	53.9	31.2	*
Vert.	4956.000	PK	52.6	31.9	7.6	33.5	-20.5	38.1	53.9	15.8	*
Vert.	7434.000	PK	48.8	36.3	8.9	33.5	-20.5	40.0	53.9	13.9	*
Vert.	9912.000	PK	52.0	38.8	9.8	33.8	-20.5	46.2	53.9	7.7	*
Vert.	12390.000	PK	56.7	38.6	-0.8	32.8	-20.5	41.2	53.9	12.7	*
Vert.	14868.000	PK	60.3	40.7	0.2	32.3	-20.5	48.4	53.9	5.5	*
Vert.	17346.000	PK	59.5	41.1	1.3	32.1	-20.5	49.2	53.9	4.7	*
Vert.	19824.000	PK	52.7	40.3	-1.3	32.3	-20.5	39.0	53.9	14.9	*
Vert.	24780.000	PK	55.1	40.5	0.0	32.2	-20.5	42.9	53.9	11.0	*

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

- Gain(Amplifier) + Duty factor (Refer to Duty confirmation data sheet)

*Above noise was synchronized with carrier frequency.

Distance factor: 1 GHz - 10 GHz 20log (3.75 m / 3.0 m) = 1.94 dB
10 GHz - 26.5 GHz 20log (1.0 m / 3.0 m) = -9.5dB

* Duty Factor was calculated with the 1 Data transmission period.

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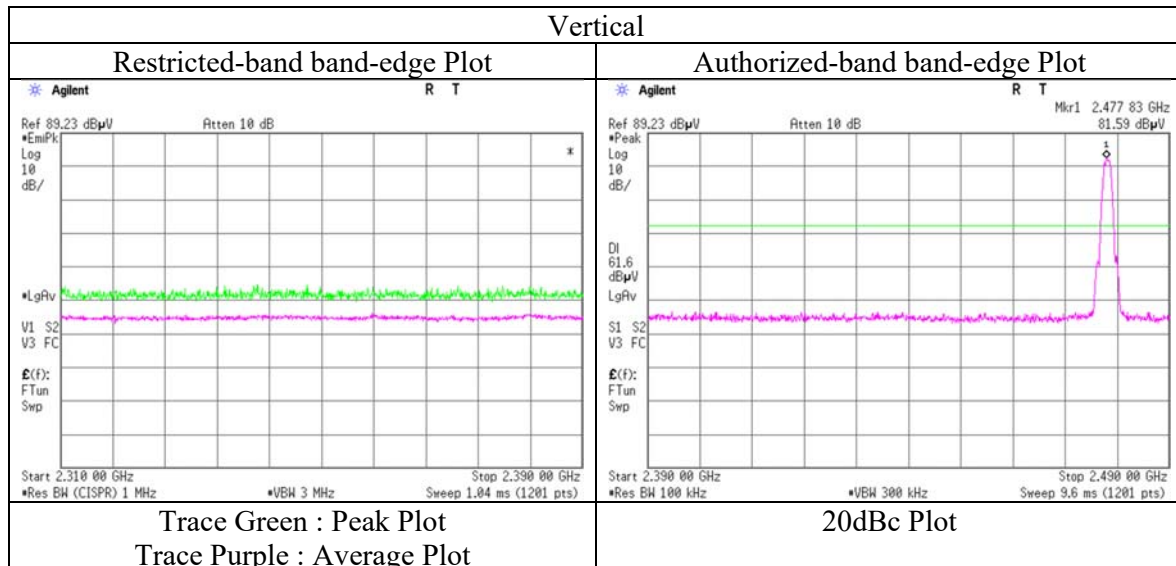
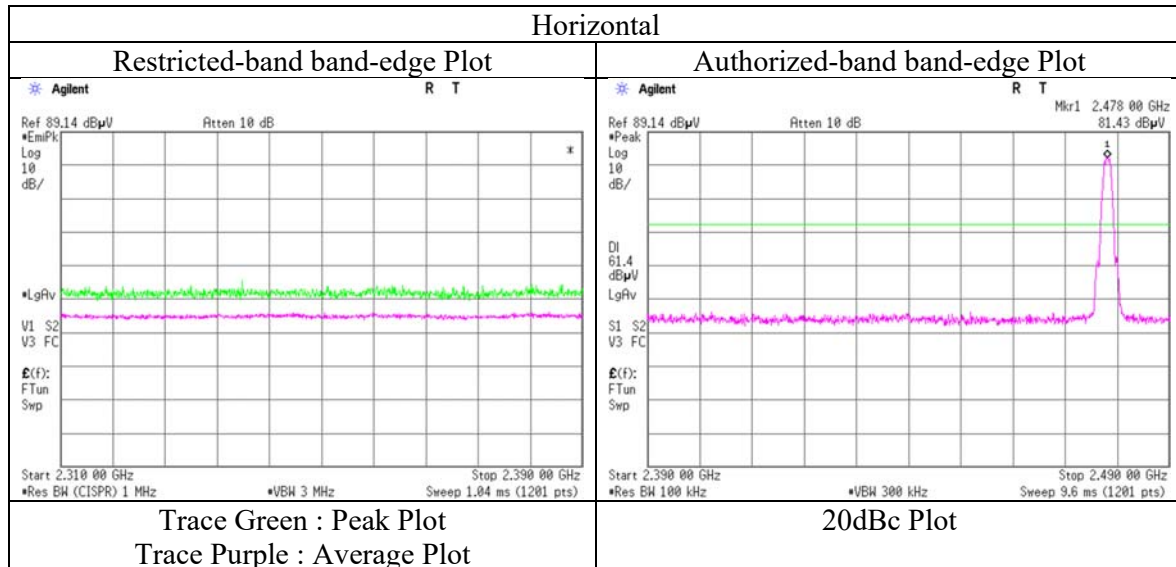
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN

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Radiated Spurious Emission (Reference Plot for band-edge)

Report No.	12985473H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.2
Date	September 29, 2019
Temperature / Humidity	26 deg. C / 54 % RH
Engineer	Akihiko Maeda (Above 1 GHz)
Mode	Tx 2478 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.

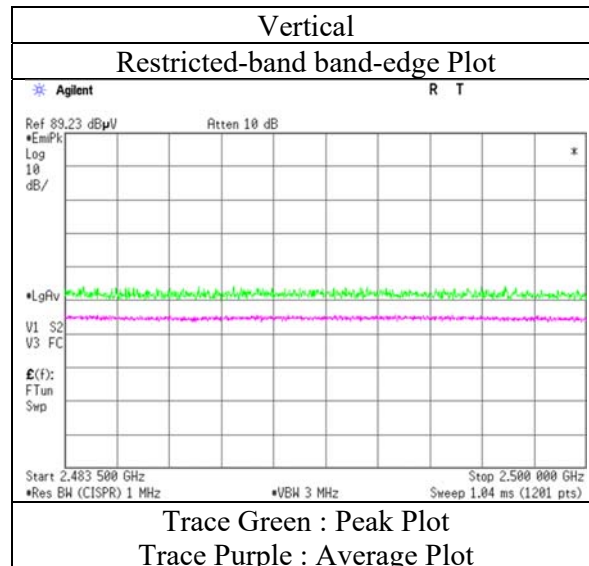
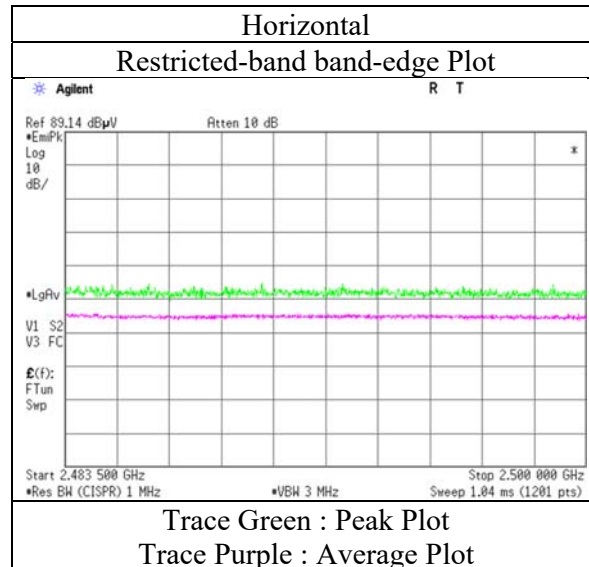
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN

Telephone : +81 596 24 8999

Facsimile : +81 596 24 8124

Radiated Spurious Emission (Reference Plot for band-edge)

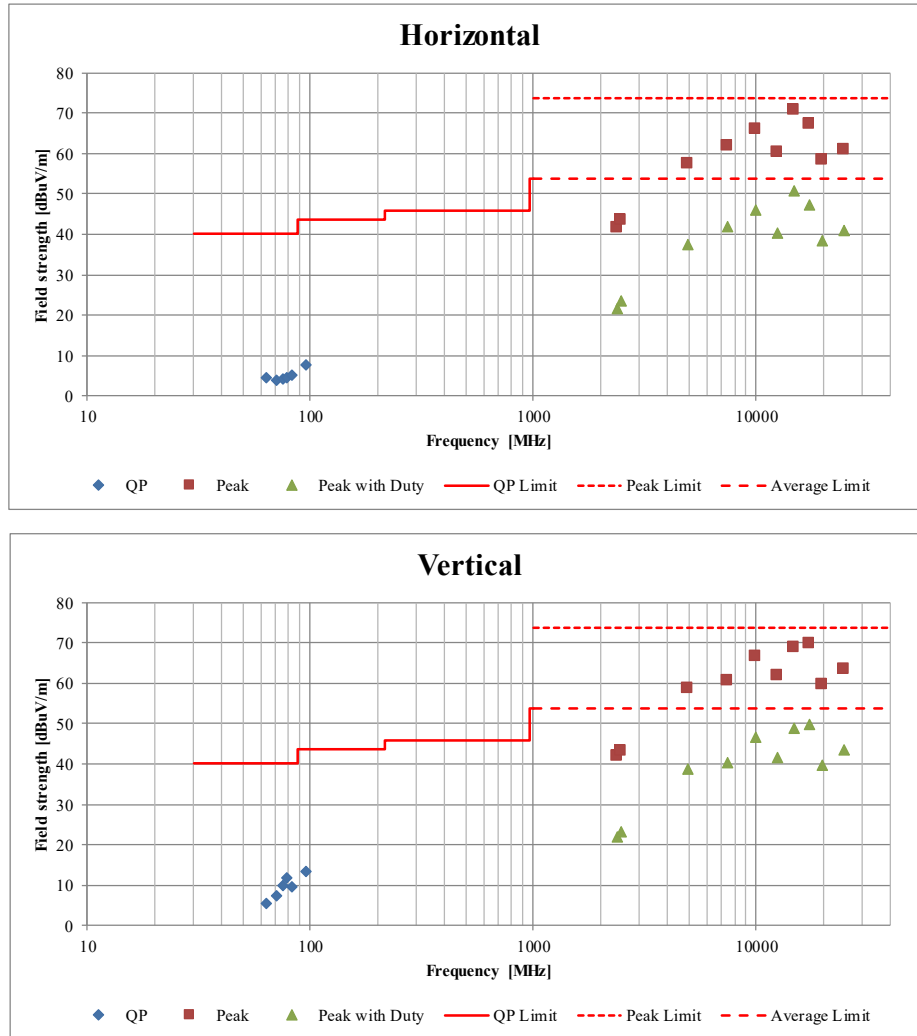
Report No.	12985473H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.2
Date	September 29, 2019
Temperature / Humidity	26 deg. C / 54 % RH
Engineer	Akihiko Maeda (Above 1 GHz)
Mode	Tx 2478 MHz



* 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.

Radiated Spurious Emission (Plot data, Worst case)

Report No.	12985473H	
Test place	Ise EMC Lab.	
Semi Anechoic Chamber	No.2	No.4
Date	September 29, 2019	September 29, 2019
Temperature / Humidity	26 deg. C / 54 % RH	23 deg. C / 67 % RH
Engineer	Akihiko Maeda (Above 1 GHz)	Akihiko Maeda (Below 1 GHz)
Mode	Tx 2478 MHz	



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

Duty confirmation

Report No.	12985473H
Test place	Ise EMC Lab. No.4 Measurement Room
Date	September 30, 2019
Temperature / Humidity	24 deg. C / 56 % RH
Engineer	Akihiko Maeda
Mode	Tx

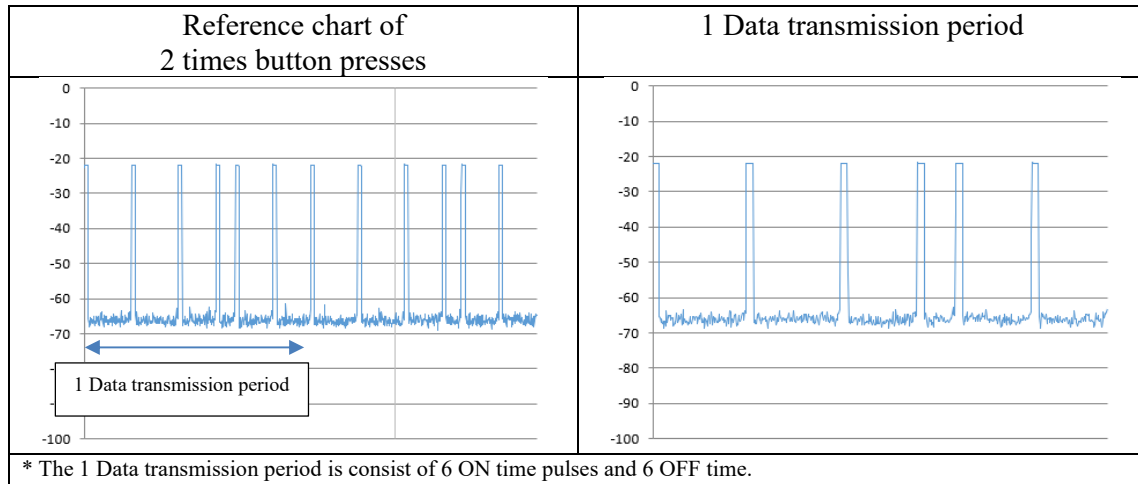
Measured ON time *1) [ms]	1 Data Transmission period *2) [ms]	Duty cycle *3)	Duty factor *4) [dB]
0.69	7.27	0.095	-20.5

*1) Measured ON Time = (Number of analyzer bins showing transmission) * (dwell time per bin)

*2) 1 Data Transmission period = (Number of analyzer bins showing ON and OFF time at the worst case) * (dwell time per bin)

*3) Duty cycle = Measured ON time / 1 Data transmission period

*4) Duty factor = $20\log_{10}(\text{Duty Cycle})$



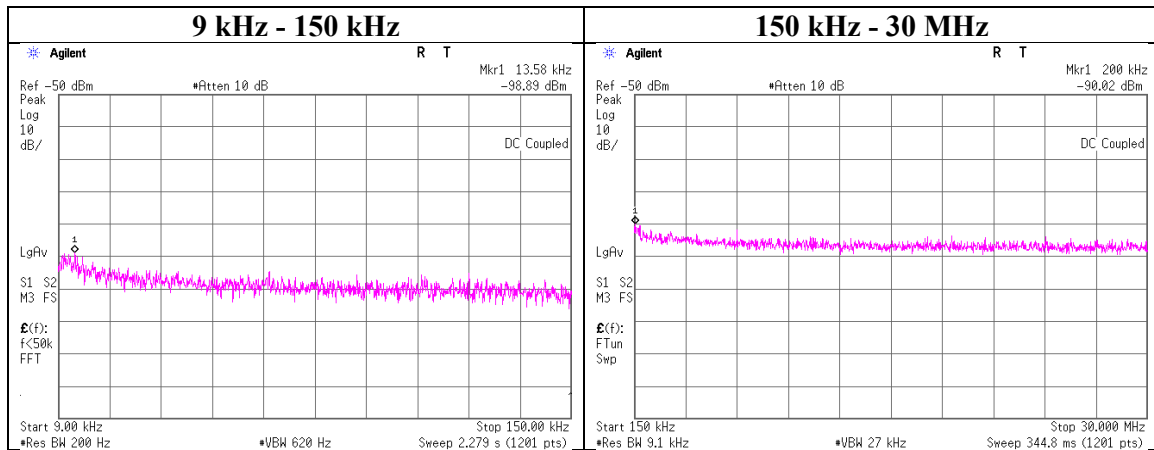
* The signal monitoring equipment consists of a spectrum analyzer with the capacity to display 8001 bins on the horizontal axis.

* A time-domain resolution of 0.00125 msec/bin is achievable with a 10 msec sweep time

* Measured ON time is calculated by multiplying the number of bins during an observation period by the dwell time per bin, with the analyzer set to peak detection.

Conducted Spurious Emission

Report No.	12985473H
Test place	Ise EMC Lab. No.4 Measurement Room
Date	September 30, 2019
Temperature / Humidity	24 deg. C / 56 % RH
Engineer	Akihiko Maeda
Mode	Tx 2478 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
13.58	-98.9	1.00	9.8	2.0	1	-86.1	300	6.0	-24.8	44.9	69.7	
200.00	-90.0	1.00	9.8	2.0	1	-77.2	300	6.0	-16.0	21.5	37.5	

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

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

N: Number of output

*2.0 dBi was applied to the test result based on ANSI C63.10 since antenna gain was less than 2.0 dBi.

Power Density

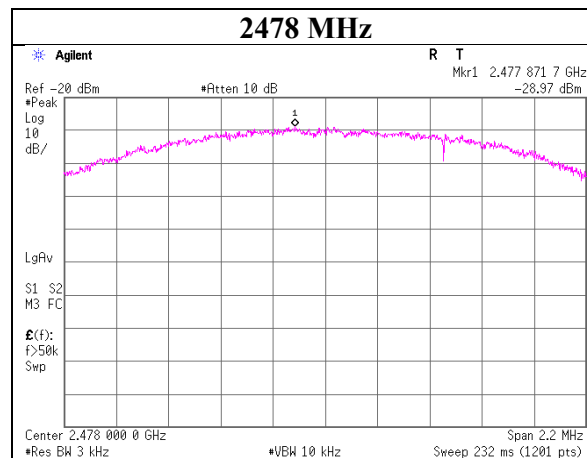
Report No.	12985473H
Test place	Ise EMC Lab. No.4 Measurement Room
Date	September 30, 2019
Temperature / Humidity	24 deg. C / 56 % RH
Engineer	Akihiko Maeda
Mode	Tx

Freq.	Reading	Cable Loss	Atten. Loss	Result	Limit	Margin
[MHz]	[dBm]	[dB]	[dB]	[dBm]	[dBm]	[dB]
2478	-28.97	1.00	10.10	-17.87	8.00	25.87

Sample Calculation:

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

*The equipment and cables were not used for factor 0 dB of the data sheets.



APPENDIX 2: Test instruments

Test Instruments

Test Item	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Calibration Due Date	Cal Int
RE	142006	AC2_Semi Anechoic Chamber(SVSWR)	TDK	Semi Anechoic Chamber 3m	DA-06902	04/01/2019	04/30/2021	24
RE	178648	EMI measurement program	TSJ	TEPTO-DV	-	-	-	-
RE	141542	Digital Tester	Fluke Corporation	FLUKE 26-3	78030611	08/20/2019	08/31/2020	12
RE	142226	Measure	KOMELON	KMC-36	-	-	-	-
RE/AT	141900	Spectrum Analyzer	AGILENT	E4440A	MY46185823	11/15/2018	11/30/2019	12
RE	141950	EMI Test Receiver	Rohde & Schwarz	ESU26	100412	06/27/2019	06/30/2020	12
RE	141512	Horn Antenna 1-18GHz	Schwarzbeck	BBHA9120D	254	05/09/2019	05/31/2020	12
RE	141392	Microwave Cable	Junkosha	MWX221	1604S253(1 m) / 1608S087(5 m)	08/06/2019	08/31/2020	12
RE	141579	Pre Amplifier	AGILENT	8449B	3008A02142	01/21/2019	01/31/2020	12
RE	141296	High Pass Filter 3.5-18.0GHz	UL Japan	HPF SELECTOR	002	09/11/2019	09/30/2020	12
RE	141503	Horn Antenna 18-26.5GHz	EMCO	3160-09	1265	04/12/2019	04/30/2020	12
RE	142011	AC4_Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 3m	DA-10005	06/28/2018	06/30/2020	24
RE	141562	Thermo-Hygrometer	CUSTOM	CTH-201	0010	01/11/2019	01/31/2020	12
RE	141547	DIGITAL HiTESTER	HIOKI	3805	60500120	02/25/2019	02/29/2020	12
RE	142227	Measure	KOMELON	KMC-36	-	-	-	-
RE	141899	Spectrum Analyzer	AGILENT	E4448A	MY46180655	08/07/2019	08/31/2020	12
RE	141425	Biconical Antenna	Schwarzbeck	VHA9103+BBA9106	1302	08/24/2019	08/31/2020	12
RE	141267	Logperiodic Antenna (200-1000MHz)	Schwarzbeck	VUSLP9111B	9111B-192	08/24/2019	08/31/2020	12
RE	141331	Attenuator(6dB)	TME	UFA-01	-	02/05/2019	02/29/2020	12
RE	141397	Coaxial Cable	UL Japan	-	-	06/18/2019	06/30/2020	12
RE	141583	Pre Amplifier	SONOMA INSTRUMENT	310	260833	02/08/2019	02/29/2020	12
RE	141556	Thermo-Hygrometer	CUSTOM	CTH-201	0003	12/05/2018	12/31/2019	12
AT	141810	Power Meter	ANRITSU	ML2495A	824014	10/09/2018	10/31/2019	12
AT	141832	Power sensor	ANRITSU	MA2411B	738174	10/09/2018	10/31/2019	12
AT	141532	DIGITAL HiTESTER	HIOKI	3805	51201197	01/29/2019	01/31/2020	12
AT	141568	Thermo-Hygrometer	CUSTOM	CTH-201	2901	01/11/2019	01/31/2020	12
AT	141361	Attenuator(10dB) 1-18GHz	Orient Microwave	BX10-0476-00	-	03/04/2019	03/31/2020	12
AT	141156	Attenuator(10dB)	Weinschel Corp	2	BL1173	11/02/2018	11/30/2019	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

UL Japan, Inc.

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