RADIO TEST REPORT

Test Report No. : 12405756H-A-R2

Applicant	:	**MITSUBISHI ELECTRIC CORPORATION ITAMI WORKS**
Type of Equipment	:	**K band RF front-end module**
Model No.	:	**IPS-280**
FCC ID	:	**2ARCVIPS280**
Test regulation	:	**FCC Part 15 Subpart C: 2018**
Test Result	:	**Complied (Refer to SECTION 3.2)**

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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 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 12405756H-A-R1. 12405756H-A-R1 is replaced with this report.

Date of test: December 2, 2018 to February 22, 2019

Representative test engineer:
Ryota Yamanaka
Engineer
Consumer Technology Division

Approved by:
Motoya Imura
Leader
Consumer Technology Division

NVLAP TESTING
NVLAP LAB CODE: 200572-0

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

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

REVISION HISTORY

Original Test Report No.: 12405756H-A

Revision	Test report No.	Date	Page revised	Contents
- (Original)	12405756H-A	March 13, 2019	-	-
1	12405756H-A-R1	March 20, 2019	P.5	Correction of FCC Part 15.31 (e)
1	12405756H-A-R1	March 20, 2019	P.15 to 21	Correction of mode name
1	12405756H-A-R1	March 20, 2019	P.18	Correction of the title (upper); From Restricted band-edge Plot to Authorized-band band-edge Plot
1	12405756H-A-R1	March 20, 2019	P.18	Addition of description of Trace under the Plot data
1	12405756H-A-R1	March 20, 2019	P.20	Addition of Reference Plot
1	12405756H-A-R1	March 20, 2019	P.20	Correction of frequency on the data From 24.1275932 GHz to 24.12805 GHz
1	12405756H-A-R1	March 20, 2019	P.21	Correction of Duty Cycle data
1	12405756H-A-R1	March 20, 2019	P.21	Correction of frequency on the data From 24.127000 GHz to 24.12805 GHz
1	12405756H-A-R1	March 20, 2019	P.23	Correction of content related to traceability
1	12405756H-A-R1	March 20, 2019	P.24	Correction of setup photo of Conducted emission
2	12405756H-A-R2	April 12, 2019	P.5	Correction of FCC Part 15.31 (e) in Clause 3.2

CONTENTS **PAGE**

SECTION 1: Customer information

Company Name	:	MITSUBISHI ELECTRIC CORPORATION ITAMI WORKS*1)
Address	:	8-1-1, Tsukaguchi-Honmachi, Amagasaki City, Hyogo 661-8661, Japan
Telephone Number	:	+81-6-6497-8904
Facsimile Number	:	+81-6-6497-9327
Contact Person	:	SEIYA NAGASHIMA

*1) Remarks:
MITSUBISHI ELECTRIC CORPORATION ITAMI WORKS designates InnoSenT GmbH as manufacturer of the product (K band Transceiver Module).

The information provided from the customer is as follows;
- Applicant, Type of Equipment, Model No. on the cover and other 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	:	K band RF front-end module
Model No.	:	IPS-280
Serial No.	:	Refer to Section 4, Clause 4.2
Rating	:	DC 3.3 V (typ.)
Receipt Date of Sample	:	August 23, 2018
Country of Mass-production	:	Germany
Condition of EUT	:	Production model
Modification of EUT	:	No Modification by the test lab

2.2 Product Description

Model: IPS-280 (referred to as the EUT in this report) is a K band RF front-end module.

Radio Specification

Radio Type	:	Transceiver
Frequency of Operation	:	24.16 GHz
Modulation	:	Unmodulation
Antenna Type	:	λ/2 Patch Antenna
Antenna Connector	:	Built-In
Antenna Gain	:	13.5 dBi
Usage location	:	Vehicles (including Train vehicle)
Clock frequency (maximum)	:	- (Direct oscillation by the SiGe transistor built-in MMIC)

SECTION 3: Test specification, procedures & results

3.1 Test Specification

Test Specification : FCC Part 15 Subpart C
FCC Part 15 final revised on March 12, 2018 and effective April 11, 2018

Title : FCC 47CFR Part15 Radio Frequency Device Subpart C Intentional Radiators
Section 15.207 Conducted limits
Section 15.245 Operation within the bands 902 - 928 MHz, 2435 - 2465 MHz, 5785 - 5815 MHz, 10500 - 10550 MHz, and 24075 - 24175 MHz.

3.2 Procedures and results

Item	Test Procedure	Specification	Deviation	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	[QP] 24.4 dB 29.53687 MHz, L [AV] 14.4 dB 29.53687 MHz, L	Complied a)	-
Electric Field Strength of Fundamental Emission	**FCC:** ANSI C63.10-2013 6. Standard test methods **IC:** RSS-Gen 6.12	**FCC:** Section 15.245(b) **IC:** RSS-210	N/A	14.9 dB 24160.000 MHz, Horizontal, AV / Vertical, AV	Complied b)	Radiated
Electric Field Strength of Spurious Emission	**FCC:** ANSI C63.10-2013 6. Standard test methods 9. Procedures for testing millimeter-wave systems **IC:** RSS-Gen 6.13	**FCC:** Section 15.205(a)(b)(d) Section 15.209(a) Section 15.245(b) **IC:** RSS-210 RSS-Gen 8.9	N/A	17.1 dB 106.027MHz, Vertical, QP	Complied b)	Radiated
20 dB Bandwidth	**FCC:** ANSI C63.10-2013 6. Standard test methods **IC:** -	**FCC:** Section 15.215 **IC:** Reference data	N/A	See data.	Complied c)	Radiated
99 % Occupied Bandwidth	**FCC:** - **IC:** RSS-Gen 6.6	**FCC:** Reference data **IC:** -	N/A	See data.	Complied c)	Radiated

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

a) Refer to APPENDIX 1 (data of Conducted emission)
b) Refer to APPENDIX 1 (data of Radiated Emission (Electric Field Strength of Fundamental and Spurious Emission))
c) Refer to APPENDIX 1 (data of 20dB Bandwidth, 99% Occupied Bandwidth)

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.

FCC Part 15.31 (e)
The stable voltage is provided constantly to the RF Module through the regulator of the hosts. 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

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 following 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 $k = 2$.

Ise EMC Lab.

Test distance	Radiated emission (+/-) 9 kHz - 30 MHz
3 m	3.3 dB
10 m	3.2 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	4.8 dB	5.2 dB	4.8 dB	5.0 dB
Vertical	4.9 dB	6.3 dB	4.9 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	5.9 dB	5.9 dB	5.5 dB

*Measurement distance

Radiated emission (+/-)	
40 GHz - 50 GHz	4.1 dB
50 GHz - 75 GHz	5.5 dB
75 GHz - 110 GHz	5.8 dB
110 GHz - 170 GHz	5.0 dB
170 GHz - 260 GHz	5.0 dB

Radiated emission (+/-) With Block downconverter	
75 GHz - 83 GHz	4.6 dB

3.5 Test Location

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
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	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 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.

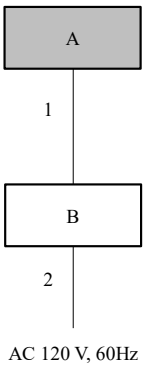
Refer to APPENDIX.

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

4.1 Operating Modes

Test Item	Mode	Tested frequency
Conducted Emission Electric Field Strength of Fundamental Emission Electric Field Strength of Spurious Emission 20 dB Bandwidth 99 % Occupied Bandwidth	Transmitting mode (Tx)	24.16 GHz
The system was configured in typical fashion (as a customer would normally use it) for testing. *EUT has the power settings by the software as follows; Power Settings: 4dBm Software: RF setting tool *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	Remarks
A	K band RF front-end module	IPS-280	00001011	InnoSenT GmbH	EUT
B	DC Power Supply	PMC-35-2A	RM000298	KIKUSUI	

List of cables used

No.	Name	Length (m)	Shield		Remarks
			Cable	Connector	
1	DC Cable	2.1	Unshielded	Unshielded	-
2	AC Cable	2.0	Unshielded	Unshielded	-

SECTION 5: Conducted Emission

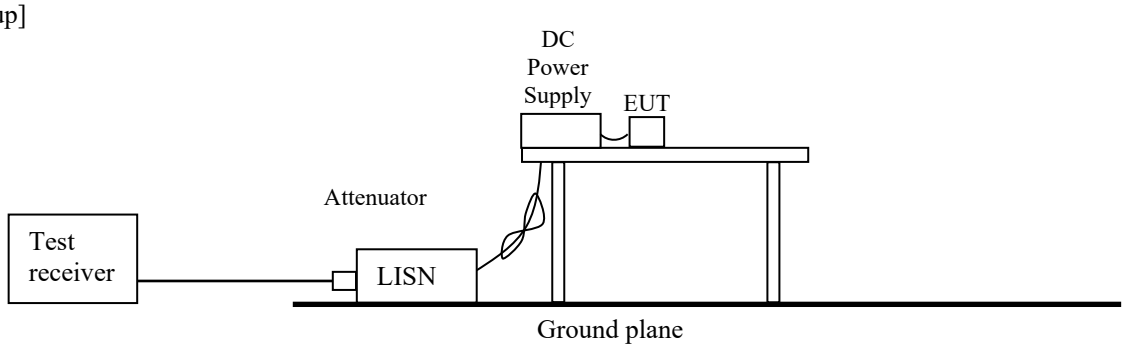
Test Procedure and conditions

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 rear of tabletop was located 40 cm to the vertical conducting plane. The rear of EUT, including peripherals aligned and flushed with rear of tabletop. All other surfaces of tabletop were at least 80 cm from any other grounded conducting surface. EUT was located 80 cm from a Line Impedance Stabilization Network (LISN)/ Artificial mains Network (AMN) and excess AC cable was bundled in center.

For the tests on EUT with other peripherals (as a whole system)
I/O cable and AC cables that were connected to the peripherals were bundled in center. They were folded back and forth forming a bundle 30 cm to 40 cm long and were hanged at a 40 cm height to the ground plane. All unused 50 ohm connectors of the LISN(AMN) were resistivity terminated in 50 ohm when not connected to the measuring equipment.

The AC Mains Terminal Continuous disturbance Voltage has been measured with the EUT in a Semi Anechoic Chamber or a Measurement Room.
The EUT was connected to a LISN (AMN) through the DC power supply.
An overview sweep with peak detection has been performed.

[Test Setup]



Detector **: CISPR quasi-peak and average detector (IF BW 9 kHz)**
Measurement range **: 0.15 MHz - 30 MHz**
Test data **: APPENDIX 1**
Test result **: Pass**

SECTION 6: Radiated emission (Electric Field Strength of Fundamental and Spurious Emission)

Test Procedure and conditions

[For below 1 GHz]
EUT was placed on a urethane platform of nominal size, 1.5 m by 1.0 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, up to 40 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 (frequency range 9 kHz – 30 MHz: loop antenna was fixed height at 1.0 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 voltage average 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.

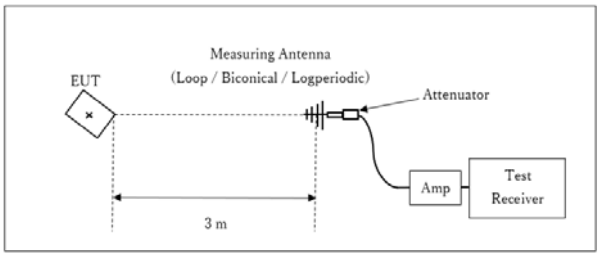
Test Antennas are used as below;

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

Frequency	9 kHz - 150 kHz	150 kHz - 30 MHz	30 MHz - 1 GHz	1 GHz - 40 GHz	
Instrument used	Test Receiver	Test Receiver	Test Receiver	Spectrum Analyzer	
Detector	QP, Average	QP, Average	QP	Peak	Average
IF Bandwidth	BW 200 Hz	BW 9 kHz	BW 120 kHz	RBW: 1 MHz VBW: 3 MHz	RBW: 1 MHz VBW: 10 Hz

[Test setup]

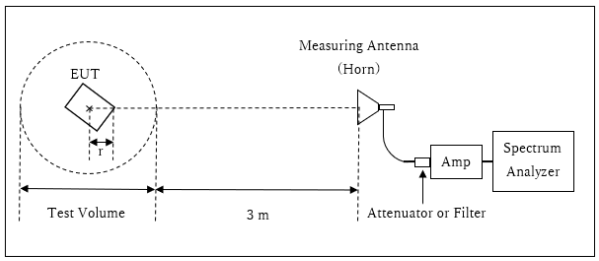
Below 1 GHz



× : Center of turn table

Test Distance: 3 m

1 GHz - 10 GHz



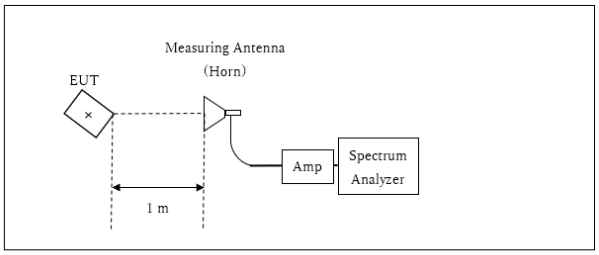
r : Radius of an outer periphery of EUT
× : Center of turn table

Distance Factor: 20 x log (3.75 m*/3.0 m) = 1.94 dB
* Test Distance: (3 + Test Volume /2) - r = 3.75 m

Test Volume: 1.5 m
(Test Volume has been calibrated based on CISPR 16-1-4.)
r = 0 m

* The test was performed with r = 0.0 m since EUT is small and it was the rather conservative condition.

10 GHz - 40 GHz



× : Center of turn table

Distance Factor: 20 x log (1.0 m* / 3.0 m) = -9.54 dB
*Test Distance: 1 m

[About fundamental measurement]
The carrier levels were confirmed at maximum direction of transmission. The maximum direction was searched under carefully since beam-widths are narrow.

The carrier levels were measured in the far field. The distance of the far field was calculated from follow equation.

$$r = \frac{2D^2}{\lambda}$$

where

r is the distance from the radiating element of the EUT to the edge of the far field, in m
D is the largest dimension of both the radiating element and the test antenna (horn), in m
(The antenna aperture size of test antenna was used for this caluculation.)
Lambda is the wavelength of the emission under investigation [300 / *f* (MHz) * 10^3], in millimeter

Frequency	Wavelength	Maximum Dimention			Far Field
		EUT	Test Antenna LIMS ID 141503	Maximum	Boundary
	Lambda			*D*	*r*
[GHz]	[mm]	[m]	[m]	[m]	[m]
24.175	12.4	0.070	0.039	0.070	0.790

[Above 40 GHz]
The test was performed based on "Procedures for testing millimeter-wave systems" of ANSI C63.10-2013. The EUT was placed on an urethane platform, raised 1.5 m above the conducting ground plane. The measurements were performed on handheld method.

Set spectrum analyzer RBW, VBW, span, etc., to the proper values. Note these values. Enable two traces—one set to "clear write," and the other set to "max hold." Begin hand-held measurements with the test antenna (horn) at a distance of 1 m from the EUT in a horizontally polarized position. Slowly adjust its position, entirely covering the plane 1 m from the EUT. Observation of the two active traces on the spectrum analyzer will allow refined horn positioning at the point(s) of maximum field intensity. Repeat with the horn in a vertically polarized position. If the emission cannot be detected at 1 m, reduce the RBW to increase system sensitivity. Note the value. If the emission still cannot be detected, move the horn closer to the EUT, noting the distance at which a measurement is made.

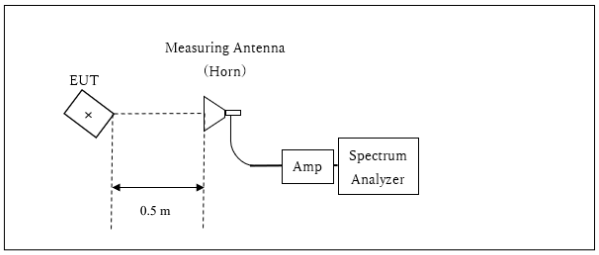
Note the maximum level indicated on the spectrum analyzer. Adjust this level, if necessary, by the antenna gain, conversion loss of the external mixer and gain of LNA used, at the frequency under investigation. Calculate the field strength of the emission at the measurement distance from the Friis' transmission equation.

Frequency	40 GHz - 50 GHz	50 GHz - 75 GHz	75 GHz - 100 GHz
Final measurement distance with 1 MHz Peak detector	0.5 m	0.25 m	0.25 m

Detector	Peak	Average
IF Bandwidth	RBW: 1 MHz VBW: 3 MHz	RBW: 1 MHz VBW: 10 Hz

[Test setup]

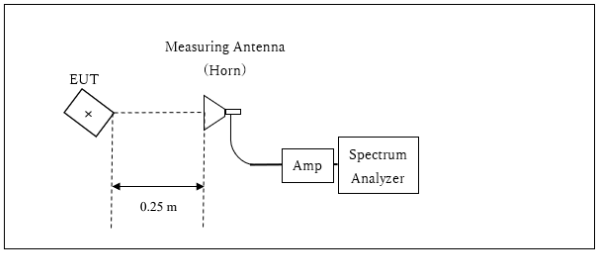
40 GHz - 50 GHz



× : Center of turn table

Distance Factor: 20 x log (0.5 m* / 3.0 m) = -15.6 dB
*Test Distance: 0.5 m

50 GHz - 100 GHz



× : Center of turn table

Distance Factor: 20 x log (0.25 m* / 3.0 m) = -21.6 dB
*Test Distance: 0.25 m

- The carrier level and noise levels were confirmed at each position of X and Y 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 : 9 kHz – 100 GHz
Test data : APPENDIX
Test result : Pass

SECTION 7: 20 dB Bandwidth, 99 % Occupied Bandwidth and Duty Cycle

Test Procedure

The measurement was performed in the antenna height to gain the maximum of Electric field strength.

Test	Span	RBW	VBW	Sweep	Detector	Trace	Instrument used
20 dB Bandwidth	500 kHz	5.1 kHz 1 % to 5 % of OBW	15 kHz Three times of RBW	Auto	Peak	Max Hold	Spectrum Analyzer
99 % Occupied Bandwidth	500 kHz, Enough width to display emission skirts	5.1 kHz, 1 % to 5 % of OBW	15 kHz, Three times of RBW	Auto	Peak *1)	Max Hold	Spectrum Analyzer
Duty Cycle	-	-	-	100 msec	-	Single	Spectrum Analyzer
*1) Peak detector was applied as Worst-case measurement.							

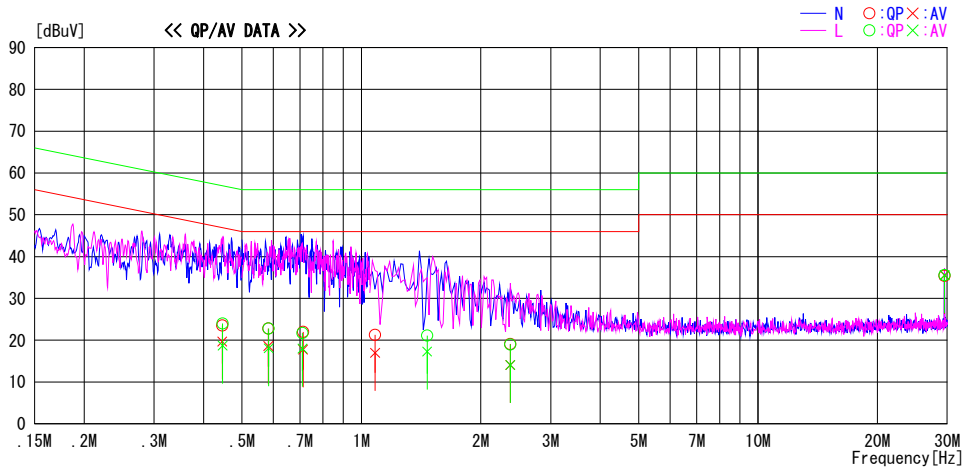
Test data : APPENDIX
Test result : Pass

APPENDIX 1: Test data

Conducted Emission

Report No.	12405756H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.4
Date	February 4, 2019
Temperature / Humidity	24 deg. C / 41% RH
Engineer	Ryota Yamanaka
Mode	Transmitting mode (Tx)

LIMIT : FCC15.207 QP ClassB
FCC15.207 AV ClassB



Frequency	Reading Level		Corr.	Results		Limit		Margin		Phase	Comment
	QP	AV	Factor	QP	AV	QP	AV	QP	AV		
[MHz]	[dBuV]	[dBuV]	[dB]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	[dB]	[dB]		
0.44599	10.1	6.3	13.4	23.5	19.7	56.9	46.9	33.4	27.2	N	
0.58267	9.3	5.1	13.5	22.8	18.6	56.0	46.0	33.2	27.4	N	
0.71273	8.5	4.3	13.5	22.0	17.8	56.0	46.0	34.0	28.2	N	
1.08287	7.8	3.5	13.5	21.3	17.0	56.0	46.0	34.7	29.0	N	
2.37234	5.5	0.5	13.6	19.1	14.1	56.0	46.0	36.9	31.9	N	
29.53687	20.7	20.8	14.7	35.4	35.5	60.0	50.0	24.6	14.5	N	
0.44669	10.6	5.3	13.4	24.0	18.7	56.9	46.9	32.9	28.2	L	
0.58377	9.3	4.6	13.5	22.8	18.1	56.0	46.0	33.2	27.9	L	
0.71052	8.2	4.5	13.5	21.7	18.0	56.0	46.0	34.3	28.0	L	
1.46423	7.6	3.8	13.5	21.1	17.3	56.0	46.0	34.9	28.7	L	
2.37481	5.4	0.5	13.6	19.0	14.1	56.0	46.0	37.0	31.9	L	
29.53687	20.9	20.9	14.7	35.6	35.6	60.0	50.0	24.4	14.4	L	

CHART: WITH FACTOR Peak hold data. CALCULATION : RESULT = READING + C.F (LISN + CABLE + ATT)
Except for the above table: adequate margin data below the limits.

*The test result is rounded off to one or two decimal places, so some differences might be observed.

Radiated Emission (Electric Field Strength of Fundamental and Spurious Emission)

Report No.	12405756H				
Test place	Ise EMC Lab.				
Semi Anechoic Chamber	No.2	No.1	No.4	No.3	No.3
Date	December 2, 2018	February 4, 2019	February 7, 2019	February 10, 2019	February 22, 2019
Temperature / Humidity	22 deg. C / 42 % RH	22 deg. C / 36 % RH	21 deg. C / 41 % RH	20 deg. C / 30 % RH	22 deg. C / 37 % RH
	1 GHz - 18 GHz 26.5 GHz - 50 GHz	30 MHz -1 GHz	9 kHz -30 MHz	50 GHz - 100 GHz	18 GHz - 26.5 GHz
Engineer	Ryota Yamanaka				
Mode	Transmitting mode (Tx)				

[Fundamental]

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori	24160.000	PK	105.7	39.8	-0.2	32.1	113.2	147.9	34.7	
Hori	24160.000	AV	105.5	39.8	-0.2	32.1	113.0	127.9	14.9	VBW:10Hz Voltage Avg
Vert	24160.000	PK	105.6	39.8	-0.2	32.1	113.1	147.9	34.8	
Vert	24160.000	AV	105.5	39.8	-0.2	32.1	113.0	127.9	14.9	VBW:10Hz Voltage Avg

Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter+Mixer(above 50 GHz)+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).

*NS: No signal detected.

Distance factor: 18 GHz - 26.5 GHz 20log (1.0 m / 3.0 m) = -9.5 dB

[Band-edge]

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori	24000.000	PK	46.9	40.0	-0.2	32.2	54.5	73.9	19.4	NS
Hori	24075.000	PK	47.2	39.9	-0.2	32.2	54.7	73.9	19.2	NS
Hori	24175.000	PK	47.8	39.7	-0.2	32.1	55.2	73.9	18.7	NS
Hori	24000.000	AV	32.8	40.0	-0.2	32.2	40.4	53.9	13.5	NS VBW:10Hz Voltage Avg
Hori	24075.000	AV	33.8	39.9	-0.2	32.2	41.3	53.9	12.6	NS VBW:10Hz Voltage Avg
Hori	24175.000	AV	34.4	39.7	-0.2	32.1	41.8	53.9	12.1	NS VBW:10Hz Voltage Avg
Vert	24000.000	PK	46.6	40.0	-0.2	32.2	54.2	73.9	19.7	NS
Vert	24075.000	PK	47.5	39.9	-0.2	32.2	55.0	73.9	18.9	NS
Vert	24175.000	PK	48.0	39.7	-0.2	32.1	55.4	73.9	18.5	NS
Vert	24000.000	AV	32.5	40.0	-0.2	32.2	40.1	53.9	13.8	NS VBW:10Hz Voltage Avg
Vert	24075.000	AV	33.4	39.9	-0.2	32.2	40.9	53.9	13.0	NS VBW:10Hz Voltage Avg
Vert	24175.000	AV	34.0	39.7	-0.2	32.1	41.4	53.9	12.5	NS VBW:10Hz Voltage Avg

Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter+Mixer(above 50 GHz)+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).

*NS: No signal detected.

Distance factor: 18 GHz - 26.5 GHz 20log (1.0 m / 3.0 m) = -9.5 dB

Radiated Emission (Electric Field Strength of Fundamental and Spurious Emission)

Report No.	12405756H				
Test place	Ise EMC Lab.				
Semi Anechoic Chamber	No.2	No.1	No.4	No.3	No.3
Date	December 2, 2018	February 4, 2019	February 7, 2019	February 10, 2019	February 22, 2019
Temperature / Humidity	22 deg. C / 42 % RH	22 deg. C / 36 % RH	21 deg. C / 41 % RH	20 deg. C / 30 % RH	22 deg. C / 37 % RH
	1 GHz - 18 GHz 26.5 GHz - 50 GHz	30 MHz -1 GHz	9 kHz -30 MHz	50 GHz - 100 GHz	18 GHz - 26.5 GHz
Engineer	Ryota Yamanaka				
Mode	Transmitting mode (Tx)				

[Spurious emissions other than above]

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori	88.357	QP	28.8	8.1	8.4	38.9	6.4	43.5	37.1	NS
Hori	94.389	QP	29.4	9.0	8.5	38.9	8.0	43.5	35.5	NS
Hori	100.181	QP	28.6	10.1	8.6	39.0	8.3	43.5	35.2	NS
Hori	106.027	QP	28.6	10.9	8.7	39.0	9.2	43.5	34.3	NS
Hori	111.916	QP	28.6	11.8	8.7	39.0	10.1	43.5	33.4	NS
Hori	117.811	QP	29.5	12.4	8.8	39.0	11.7	43.5	31.8	NS
Hori	48320.000	PK	50.2	41.7	-6.5	23.4	62.0	97.5	35.5	NS
Hori	72478.000	PK	37.5	41.7	-3.9	20.8	54.5	97.5	43.0	NS
Hori	96640.000	PK	44.7	45.6	-8.8	28.9	52.6	73.9	21.4	NS
Hori	48320.000	AV	37.3	41.7	-6.5	23.4	49.1	77.5	28.4	NS VBW:10Hz Voltage Avg
Hori	72478.000	AV	25.2	41.7	-3.9	20.8	42.2	77.5	35.3	NS VBW:10Hz Voltage Avg
Hori	96640.000	AV	32.2	45.6	-8.8	28.9	40.1	53.9	13.8	NS VBW:10Hz Voltage Avg
Vert	88.357	QP	40.6	8.1	8.4	38.9	18.2	43.5	25.3	
Vert	94.389	QP	44.3	9.0	8.5	38.9	22.9	43.5	20.6	
Vert	100.181	QP	46.2	10.1	8.6	39.0	25.9	43.5	17.6	
Vert	106.027	QP	45.8	10.9	8.7	39.0	26.4	43.5	17.1	
Vert	111.916	QP	42.2	11.8	8.7	39.0	23.7	43.5	19.8	
Vert	117.811	QP	39.1	12.4	8.8	39.0	21.3	43.5	22.2	
Vert	48320.000	PK	50.2	41.7	-6.5	23.4	62.0	97.5	35.5	NS
Vert	72478.000	PK	37.4	41.7	-3.9	20.8	54.4	97.5	43.1	NS
Vert	96640.000	PK	45.8	45.6	-8.8	28.9	53.7	73.9	20.2	NS
Vert	48320.000	AV	37.3	41.7	-6.5	23.4	49.1	77.5	28.4	NS VBW:10Hz Voltage Avg
Vert	72478.000	AV	25.1	41.7	-3.9	20.8	42.1	77.5	35.4	NS VBW:10Hz Voltage Avg
Vert	96640.000	AV	32.2	45.6	-8.8	28.9	40.1	53.9	13.8	NS VBW:10Hz Voltage Avg

Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter+Mixer(above 50 GHz)+Distance factor(above 1 GHz)) - Gain(Amplifier)

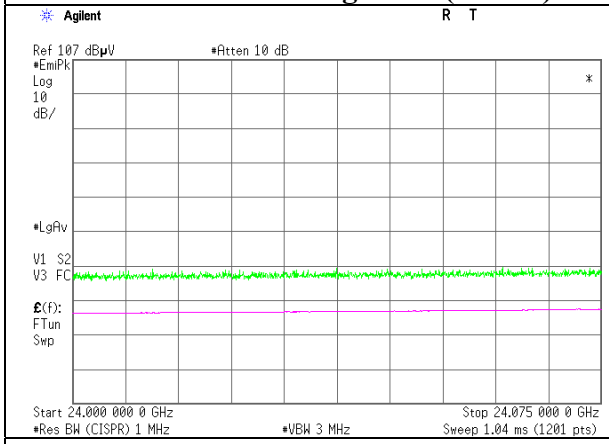
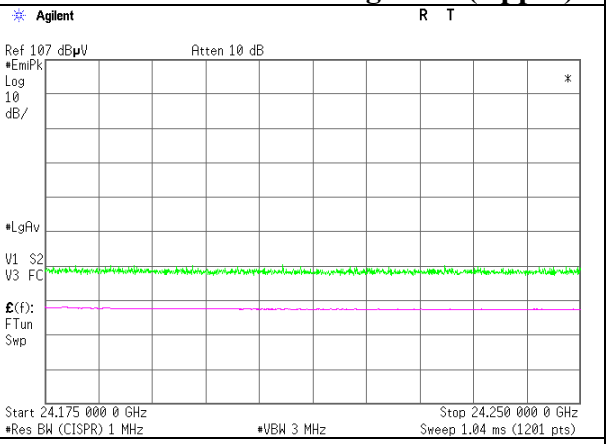
*Other frequency noises omitted in this report were not seen or had enough margin (more than 20 dB).

*NS: No signal detected.

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) = -9.5 dB
26.5 GHz - 50 GHz 20log (0.5 m / 3.0 m) = -15.6 dB
50 GHz - 100 GHz 20log (0.25 m / 3.0 m) = -21.6 dB

Radiated Spurious Emission
(Reference Plot for band-edge)

Report No.	12405756H
Test place	Ise EMC Lab. No. 3 Semi Anechoic Chamber
Date	February 22, 2019
Temperature / Humidity	22 deg. C / 37 % RH
Engineer	Ryota Yamanaka
Mode	Transmitting mode (Tx)

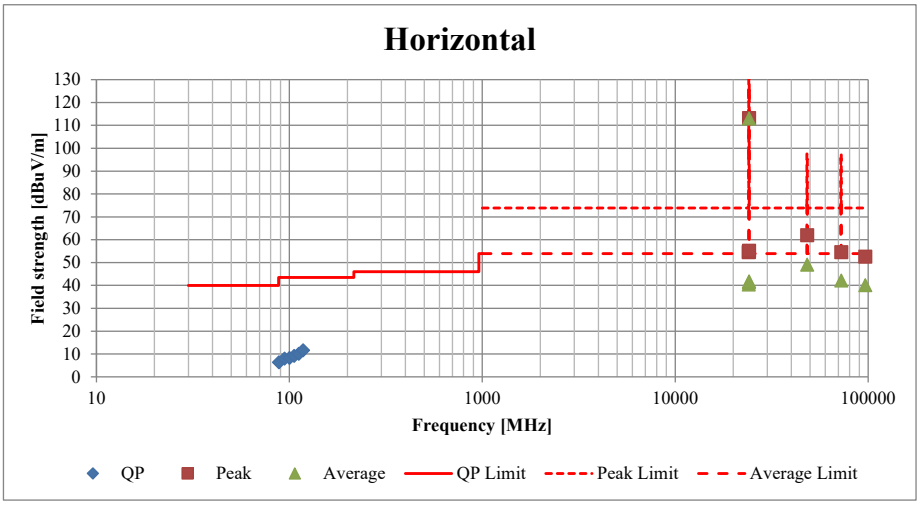
Restricted band-edge Plot (Lower)	Authorized-band band-edge Plot (Upper)
	
Trace Green : Peak Plot Trace Purple : Average Plot	Trace Green : Peak Plot Trace Purple : Average Plot

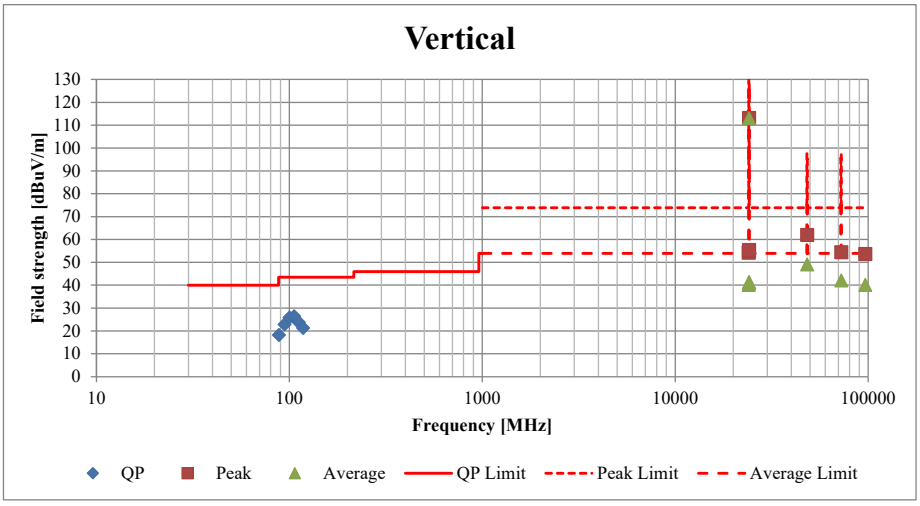
* Final result of restricted band edge was shown in tabular data.

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 Emission (Electric Field Strength of Fundamental and Spurious Emission)

Report No.	12405756H				
Test place	Ise EMC Lab.				
Semi Anechoic Chamber	No.2	No.1	No.4	No.3	No.3
Date	December 2, 2018	February 4, 2019	February 7, 2019	February 10, 2019	February 22, 2019
Temperature / Humidity	22 deg. C / 42 % RH	22 deg. C / 36 % RH	21 deg. C / 41 % RH	20 deg. C / 30 % RH	22 deg. C / 37 % RH
	1 GHz - 18 GHz 26.5 GHz - 50 GHz	30 MHz -1 GHz	9 kHz -30 MHz	50 GHz - 100 GHz	18 GHz - 26.5 GHz
Engineer	Ryota Yamanaka				
Mode	Transmitting mode (Tx)				

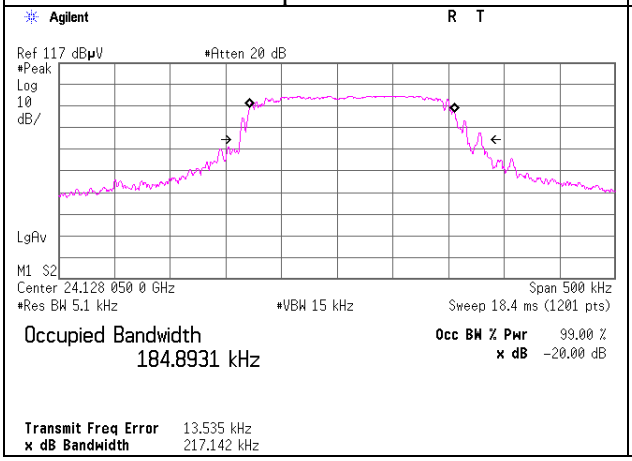
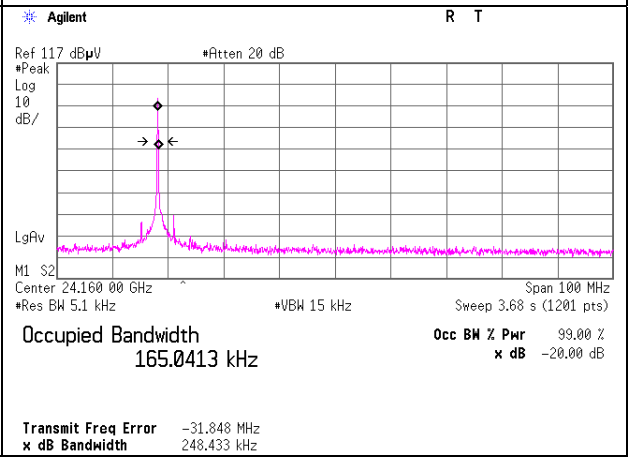




20dB Bandwidth, 99% Occupied Bandwidth

Report No.	12405756H
Test place	Ise EMC Lab. No. 2 Semi Anechoic Chamber
Date	February 2, 2019
Temperature / Humidity	22 deg. C / 33 % RH
Engineer	Ryota Yamanaka
Mode	Transmitting mode (Tx)

Frequency [GHz]	20 dB Bandwidth [kHz]	99% Occupied Bandwidth [kHz]
24.12805	217.142	184.893

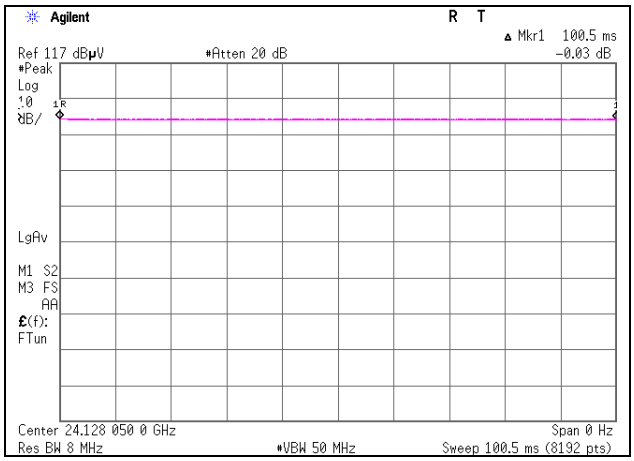
20dB Bandwidth, 99% Occupied Bandwidth	Reference Plot
	

Duty Cycle

Report No.	12405756H
Test place	Ise EMC Lab. No. 2 Semi Anechoic Chamber
Date	February 2, 2019
Temperature / Humidity	22 deg. C / 33 % RH
Engineer	Ryota Yamanaka
Mode	Transmitting mode (Tx)

Mode	Tx On time [ms]	Tx On + Off time [ms]	Duty factor [dB]
Tx Normal	100.500	100.500	0.00

Duty factor = 20 * log (Tx On time / Tx On + Off time)



APPENDIX 2: Test Instruments

Test equipment (1/2)

Test item	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Calibration Due Date	Cal Int
CE/RE	141949	Test Receiver	Rohde & Schwarz	ESCI	100767	8/6/2018	8/31/2019	12
CE/RE	141152	EMI measurement program	TSJ	TEPTO-DV	-	-	-	-
CE/RE	141217	Coaxial cable	Fujikura/Suhner/ TSJ	5D-2W/ SFM141/ 421-010/ sucoform141-P	-/04178	6/13/2018	6/30/2019	12
CE	141248	Attenuator	JFW Industries, Inc.	50FP-013H2 N	-	12/6/2018	12/31/2019	12
CE	141925	Terminator	TME	CT-01	-	11/07/2018	11/30/2019	12
CE/RE	142011	AC4_Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 3m	DA-10005	6/28/2018	6/30/2020	24
CE/RE	141562	Thermo-Hygrometer	CUSTOM	CTH-201	0010	1/11/2019	1/31/2020	12
CE/RE	142227	Measure	KOMELON	KMC-36	-	-	-	-
CE	141357	LISN(AMN)	Schwarzbeck	NSLK8127	8127-729	7/24/2018	7/31/2019	12
CE/RE	141545	DIGITAL HiTESTER	HIOKI	3805	51201148	1/29/2019	1/31/2020	12
RE	141532	DIGITAL HiTESTER	HIOKI	3805	51201197	1/29/2019	1/31/2020	12
RE	142013	AC3_Semi Anechoic Chamber(SVSWR)	TDK	Semi Anechoic Chamber 3m	DA-10005	4/6/2018	4/30/2019	12
RE	142008	AC3_Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 3m	DA-10005	6/26/2018	6/30/2020	24
RE	141899	Spectrum Analyzer	AGILENT	E4448A	MY46180655	8/10/2018	8/31/2019	12
RE	142183	Measure	KOMELON	KMC-36	-	-	-	-
RE	141580	MicroWave System Amplifier	AGILENT	83017A	MY39500779	3/13/2018	3/31/2019	12
RE	141417	Microwave Cable	Junkosha	MWX221	1404S374(1m) / 1405S074(5m)	2/4/2019	2/29/2020-	12
RE	141503	Horn Antenna 18-26.5GHz	EMCO	3160-09	1265	6/6/2018	6/30/2019	12
RE	141554	Thermo-Hygrometer	CUSTOM	CTH-180	1301	1/11/2019	1/31/2020	12
RE	141427	Biconical Antenna	Schwarzbeck	VHA9103B	8031	5/31/2018	5/31/2019	12
RE	141505	Horn Antenna 26.5-40GHz	EMCO	Oct-60	1140	6/7/2018	6/30/2019	12
RE	151897	Microwave Cable	RINEI SEIKI	SF101EA/11PC2 4/11PC24/2.5M	SN MY1726/1EA	4/19/2018	4/30/2019	12
RE	141577	Microwave System Power Amplifier	AGILENT	83050A	MY39500610	10/4/2018	10/31/2019	12
RE	142041	Horn Antenna	Oshima Prototype Engineering Co.	A16-187	1	9/11/2018	9/30/2019	12
RE	141579	Pre Amplifier	AGILENT	8449B	3008A02142	1/21/2019	1/31/2020	12
RE	142006	AC2_Semi Anechoic Chamber(SVSWR)	TDK	Semi Anechoic Chamber 3m	DA-06902	4/1/2018	4/29/2019	12
RE	142004	AC2_Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 3m	DA-06902	6/29/2018	6/30/2020	24
RE	141203	Attenuator(6dB)	Weinschel Corp	2	BK7970	11/5/2018	11/30/2019	12
RE	141317	Coaxial Cable	Fujikura/Agilent	-	-	2/23/2018	2/28/2019	12
RE	141578	Pre Amplifier	AGILENT	8447D	2944A10845	9/19/2018	9/30/2019	12
RE	141265	Logperiodic Antenna (200-1000MHz)	Schwarzbeck	VUSLP9111B	911B-190	5/31/2018	5/31/2019	12
RE	141392	Microwave Cable	Junkosha	MWX221	1604S253(1 m) / 1608S087(5 m)	8/8/2018	8/31/2019	12
RE	141542	Digital Tester	Fluke Corporation	FLUKE 26-3	78030611	8/21/2018	8/31/2019	12
RE	142029	Horn Antenna	WiseWave	ARH1523-02	10766-01	10/29/2018	10/31/2019	12
RE	141512	Horn Antenna 1-18GHz	Schwarzbeck	BBHA9120D	254	6/6/2018	6/30/2019	12
RE	141566	Thermo-Hygrometer	CUSTOM	CTH-201	A08Q26	1/11/2019	1/31/2020	12
RE	142031	Horn Antenna	WiseWave	ARH1023-02	10766-01	10/29/2018	10/31/2019	12

Test equipment (2/2)

Test item	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Calibration Due Date	Cal Int
RE	141583	Pre Amplifier	SONOMA INSTRUMENT	310	260833	2/8/2019	2/29/2020	12
RE	141222	Coaxial Cable	FUJIKURA	3D-2W(12m)/ 5D-2W(5m)/ 5D-2W(0.8m)/5	-	2/23/2018	2/28/2019	12
RE	141413	Coaxial Cable	UL Japan	-	-	6/12/2018	6/30/2019	12
RE	141254	Loop Antenna	Rohde & Schwarz	HFH2-Z2	100017	10/11/2018	10/31/2019	12
RE	142048	Harmonic Mixer	AGILENT	11970W	2521 A01909	7/9/2018	7/31/2019	12
RE	142054	Pre Amplifier	AmTechs Corporation	LNA-7511025	9601	8/22/2018	8/31/2019	12
RE	141227	Microwave Cable	Junkosha	MMX221-00500DMSDMS	1502S305	3/12/2018	3/31/2019	12
RE	142055	Power Amplifier	SAGE Millimeter, Inc.	SBP-5037532015-1515-N1	11599-01	12/17/2018	12/31/2019	12
RE	142047	Preselected Millimeter Mixer	AGILENT	11974V-E01	3001A00412	7/13/2018	7/31/2019	12
RE	148898	Attenuator	KEYSIGHT	8491A	MY52462282	10/3/2018	10/31/2019	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.**

[Below 40 GHz]
All equipment is calibrated with valid calibrations. Each measurement data is traceable to the national or international standards.

[Above 40 GHz]
Acceptance criteria for untraceable equipment was formulated according to ISO/IEC 17025 5.6.2.2.2, and the regular inspection was performed based on it annually.
For 40 GHz – 110 GHz, power sensor is calibrated by manufacturer, and the measured calibration data is used as in-house reference. The calibration data by manufacturer is checked for acceptance by a calorie meter except for some frequency bands. Electric power is checked with the calorie meter by measuring resistance and voltage of reference resistor.

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:
CE: Conducted Emission test
RE: Radiated Emission test, Bandwidth and Duty cycle tests