



RADIO TEST REPORT

Test Report No. : 14093012H-A-R2

Applicant : Hitachi Astemo, Ltd.
Type of EUT : MILLIMETER WAVE RADAR (POSITION2)
Model Number of EUT : MRS3754-018
FCC ID : 2A3Y7MRS3754-00A-00
Test regulation : FCC Part 95 Subpart M
Test Result : Complied (Refer to SECTION 3)

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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 limits of the above regulation.
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7. The all test items in this test report are conducted by UL Japan, Inc. Ise EMC Lab.
8. The opinions and the interpretations to the result of the description in this report are outside scopes where UL Japan, Inc. has been accredited.
9. The information provided from the customer for this report is identified in Section 1.
10. This report is a revised version of 14093012H-A-R1. 14093012H-A-R1 is replaced with this report.

Date of test: November 15 to December 1, 2021

Representative test engineer:


Yuichiro Yamazaki
Engineer

Approved by:


Tsubasa Takayama
Leader



CERTIFICATE 5107.02

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

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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.: 14093012H-A

Revision	Test report No.	Date	Page revised	Contents
- (Original)	14093012H-A	January 25, 2022	-	-
1	14093012H-A-R1	July 12, 2022	P.6	Correction of the date of of final revision in Section 3.1. From "November 2, 2017" To "October 20, 2021"
1	14093012H-A-R1	July 12, 2022	P.15	Correction of erroneous description in <i>T_s</i> . From "Fs and B were used the actual measurement value, and Ts was referred to the values in the specifications. " To "Fs, Ts and B were used the actual measurement value."
1	14093012H-A-R1	July 12, 2022	P.19, 20	Correction of erroneous description in calculating formula From "FCMW" To "FMCW"
2	14093012H-A-R2	August 17, 2022	P.19	Correction of erroneous description for Peak value of Radiated Power test (DC 12V). -Measured Power From "-15.92" To "-15.47" - FMCW desensitization Factor From "-8.35" To "-8.34" - EIRP From "27.83 dBm / 606.74 mW" To "28.27 dBm / 671.43 mW"

Reference: Abbreviations (Including words undescribed in this report)

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

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Ise EMC Lab.

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

Telephone : +81 596 24 8999

Facsimile : +81 596 24 8124

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SECTION 1: Customer information

Company Name	:	Hitachi Astemo, Ltd.
Address	:	2520 Oaza-takaba, Hitachinaka-shi, Ibaraki-ken, 312-8503 Japan
Telephone Number	:	+81-70-7486-0720
Contact Person	:	Masayuki Sato

The information provided from the customer is as follows;

- Applicant, Type of EUT, Model Number of EUT, 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 (EUT) other than the Receipt Date
- SECTION 4: Operation of EUT 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 (EUT)

2.1 Identification of EUT

Type	:	MILLIMETER WAVE RADAR (POSITION2)
Model Number	:	MRS3754-018
Serial Number	:	Refer to SECTION 4.2
Receipt Date	:	November 11, 2021
Condition	:	Pre-production
		(Not for Sale: This sample is equivalent to production version.)
Modification	:	No Modification by the test lab

2.2 Product Description

Model: MRS3754-018 (referred to as the EUT in this report) is a MILLIMETER WAVE RADAR (POSITION2).

General Specification

Rating	:	DC 12 V / 24 V
Clock frequency (ies) in the system	:	40 MHz

Radio Specification

Radio Type	:	Transceiver
Frequency of Operation	:	76.5 GHz
Frequency of Operation (Band)	:	76 GHz - 77 GHz
Modulation	:	FMCW
Antenna Type	:	Microstrip Array Antenna
Antenna Connector	:	None (Internal Antenna)
Antenna Gain	:	11 dBi
Steerable Antenna	:	Electronically (Receiving Part only)
Usage location	:	Vehicle-mounted

Variant model

EUT has the following variant models;

- MILLIMETER WAVE RADAR (POSITION1): MRS3754-017
- MILLIMETER WAVE RADAR (POSITION3): MRS3754-019

The parts composition of each model is the same, the differences are only the M5 bolt mounting position and label contents. These differences cause no influence on radio specification. There was no also degradation of EMC characteristic. Therefore, they are completely identical in Radio and EMC characteristics

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SECTION 3: Test specification, procedures & results

3.1 Test Specification

Test Specification : FCC Part 95 Subpart M
FCC Part 95 final revised on October 20, 2021

Title : FCC 47CFR Part95 – PERSONAL RADIO SERVICES
Subpart M – The 76-81 GHz Band Radar Service

3.2 Procedures and results

Item	Test Procedure	Specification	Worst margin	Results	Remarks
Conducted emission	FCC: N/A	FCC: N/A	N/A	N/A	*1)
Occupied bandwidth	FCC: ANSI C63.26-2015 5.4 Occupied bandwidth	FCC: Section 2.1049	See data.	Complied a)	Radiated
Radiated Power	FCC: ANSI C63.26-2015 5.5 Radiated emissions testing	FCC: Section 95.3367 Section 2.1046 Section 2.1047		Complied b)	Radiated
Modulation characteristics	ANSI C63.10-2013 6. Standard test methods 9. Procedures for testing millimeter-wave systems				
Field strength of spurious radiation	FCC: ANSI C63.26-2015 5.5 Radiated emissions testing	FCC: Section 95.3379 (a) Section 2.1053 Section 2.1057	45.35 dB 75.736 GHz, Average detected	Complied c)	Radiated
Frequency stability	FCC: ANSI C63.26-2015 5.6 Frequency stability testing	FCC: Section 95.3379 (b) Section 2.1055	See data.	Complied d)	Radiated
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.					
a) Refer to APPENDIX 1 (data of Occupied bandwidth)					
b) Refer to APPENDIX 1 (data of Radiated Power and Modulation characteristics)					
c) Refer to APPENDIX 1 (data of Field strength of spurious radiation)					
d) Refer to APPENDIX 1 (data of Frequency Stability)					
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 C63.26-2015 and C63.10-2013 are also referred.

Supplied Voltage Information

This EUT provides stable voltage constantly to RF Module regardless of input voltage.

Antenna Information

The antenna is not removable from the EUT.

3.3 Addition to standard

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

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3.4 Uncertainty

EMI

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

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

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Frequency range	Conducted emission using AMN(LISN) (+/-)
0.009 MHz - 0.15 MHz	2.9 dB
0.15 MHz - 30 MHz	3.4 dB

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	5.0 dB	6.3 dB	4.8 dB	5.0 dB

Radiated emission (Above 1 GHz)					
(3 m*) (+/-)		(1 m*) (+/-)		(0.5 m*) (+/-)	(10 m*) (+/-)
1 GHz - 6 GHz	6 GHz - 18 GHz	10 GHz - 26.5 GHz	26.5 GHz - 40 GHz	26.5 GHz - 40 GHz	1 GHz - 18 GHz
4.9 dB	5.2 dB	5.5 dB	5.5 dB	5.5 dB	5.2 dB

*Measurement distance

Radiated emission	Uncertainty [+/- dB]	Distance
40 GHz - 50 GHz	4.1	>= 0.5 m
50 GHz - 75 GHz	5.1	>= 0.5 m
75 GHz - 110 GHz	5.4	>= 0.5 m
110 GHz - 170 GHz	5.2	>= 3.8 cm*
170 GHz - 260 GHz	5.0	>= 2.5 cm*

*under consideration about Uncertainty for testing at 1 cm distance

Radiated Emission (with Block downconverter)	Uncertainty [+/- dB]	Distance
75 GHz - 83 GHz	4.4*	>= 0.5 m

* This value was used for 75 GHz - 83 GHz in this report.

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3.5 Test Location

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*A2LA Certificate Number: 5107.02 / FCC Test Firm Registration Number: 884919

ISED Lab Company Number: 2973C / CAB identifier: JP0002

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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.10 shielded room	3.8 x 2.8 x 2.8	3.8 x 2.8	-	-
No.11 measurement room	4.0 x 3.4 x 2.5	N/A	-	-
No.12 measurement room	2.6 x 3.4 x 2.5	N/A	-	-

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

3.6 Test data, Test instruments, and Test set up

Refer to APPENDIX.

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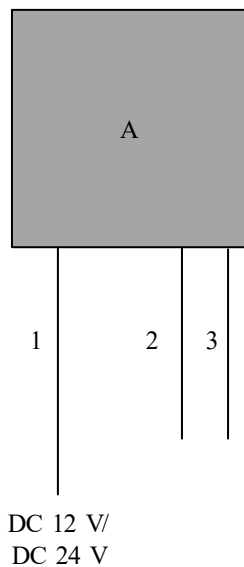
Facsimile : +81 596 24 8124

SECTION 4: Operation of EUT during testing

4.1 Operating Mode(s)

Mode	Test Item
Normal operating mode	Occupied bandwidth Power density Field strength of spurious radiation Frequency stability
Power of the EUT was set by the software as follows; Power settings: 21 dBm Software: Core0 : MRR.00.02.02.02.01.03.03.00.FE Core1 : MRR.00.02.02.02.11.03.03.00.FE *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	MILLIMETER WAVE RADAR (POSITION2)	MRS3754-018	213110031S	Hitachi Astemo, Ltd.	EUT

List of cables used

No.	Name	Length (m)	Shield		Remark
			Cable	Connector	
1	DC Cable	3.1	Unshielded	Unshielded	-
2	Signal Cable	3.1	Unshielded	Unshielded	-
3	Signal Cable	3.1	Unshielded	Unshielded	-

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SECTION 5: Radiated Spurious Emission

Test Procedure

[For below 30 MHz]

The 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 EUT was rotated a full revolution in order to obtain the maximum value of the electric field intensity.

The measurements were performed for vertical polarization (antenna angle: 0 deg., 45 deg., 90 deg., 135 deg., and 180 deg.) and horizontal polarization.

*Refer to Figure 1 about Direction of the Loop Antenna.

[For above 30 MHz, up to 1 GHz]

The 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, up to 40 GHz]

The 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.

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

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

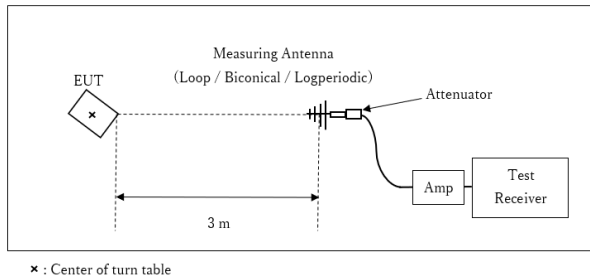
Frequency	9 kHz to 150 kHz	150 kHz to 30 MHz	30 MHz to 1 GHz	1 GHz to 40 GHz
Instrument used	Test Receiver	Test Receiver	Test Receiver	Spectrum Analyzer
Detector	CISPR QP, Average	CISPR QP, Average	CISPR QP	Average *1)
IF Bandwidth	200 Hz	9 kHz	120 kHz	RBW: 1 MHz VBW: 3 MHz

*1) A RMS average mode was used with the following settings:

Sweep time is set higher than EUT cycle time multiply the number of sweep points.

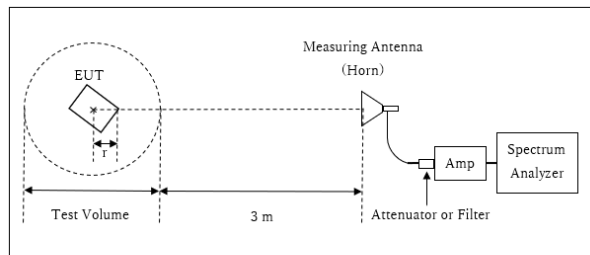
The number of sweep points are set be higher than the span of the spectrum analyzer divided by the RBW.

[Test setup]
Below 1 GHz



Test Distance: 3 m

1 GHz - 10 GHz



Distance Factor: $20 \times \log (4.0 \text{ m}^* / 3.0 \text{ m}) = 2.5 \text{ dB}$

* Test Distance: $(3 + \text{Test Volume} / 2) - r = 4.0 \text{ m}$

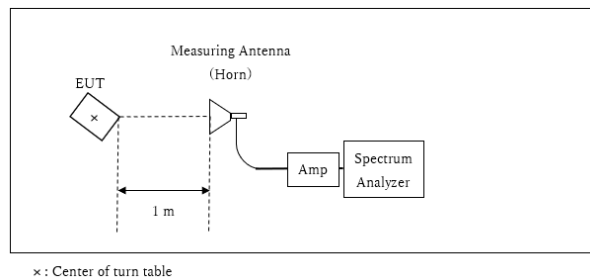
Test Volume: 2 m

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

$r = 0.0 \text{ m}$

* The test was performed with $r = 0.0 \text{ m}$ since that yielded the worst emission levels from the EUT.

10 GHz - 40 GHz

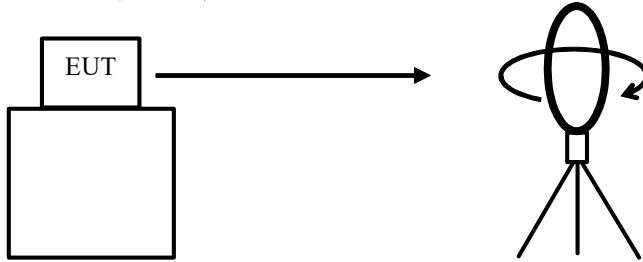


Distance Factor: $20 \times \log (1.0 \text{ m}^* / 3.0 \text{ m}) = -9.5 \text{ dB}$

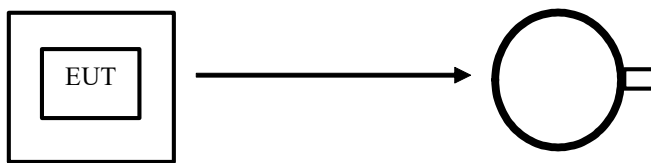
* Test Distance: 1 m

Figure 1: Direction of the Loop Antenna

Side View (Vertical)

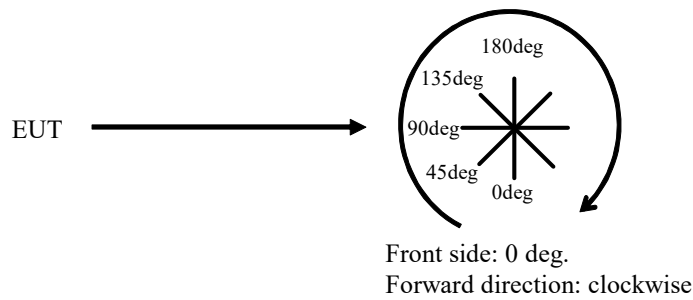


Top View (Horizontal)



Antenna was not rotated.

Top View (Vertical)



[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 a urethane platform, raised 1.5 m above the conducting ground plane. The measurements were performed on handheld method.

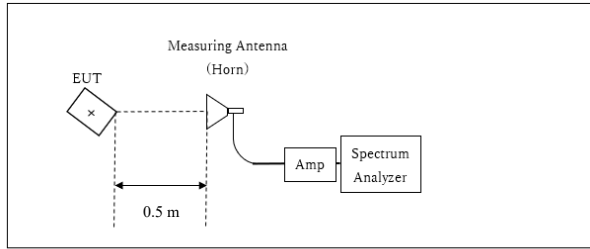
Set spectrum analyzer RBW, VBW, span, etc., to the proper values. Note these values. Enable two traces—one set to “clear write,” and the other set to “max hold.” Begin hand-held measurements with the test antenna (horn) at a distance of 1 m from the EUT in a horizontally polarized position. Slowly adjust 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, filter loss, 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 to 50 GHz	50 GHz to 75 GHz	75 GHz to 76 GHz	81 GHz to 83 GHz	83 GHz to 110 GHz	110 GHz to 231 GHz
Final measurement distance with 1 MHz RMS detector	0.5 m	1.0 m	1.2 m	1.2 m	0.5 m	0.01 m

[Test setup]

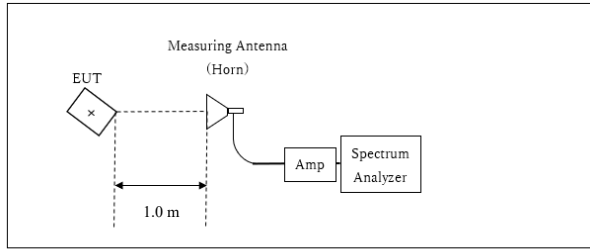
40 GHz - 50 GHz, 83 GHz - 110 GHz



× : Center of turn table

*Test Distance: 0.5 m

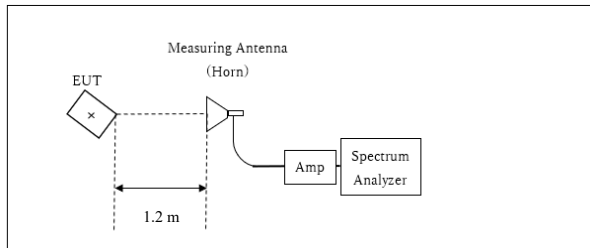
50 GHz - 75 GHz



× : Center of turn table

*Test Distance: 1.0 m

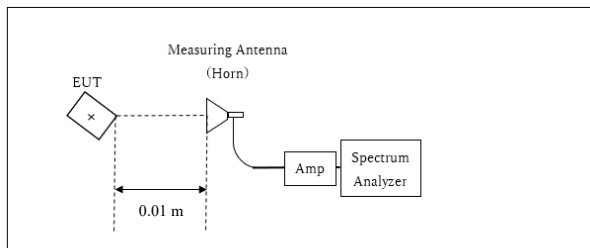
75 GHz - 76 GHz, 81 GHz - 83 GHz,



× : Center of turn table

*Test Distance: 1.2 m

110 GHz - 231 GHz



× : Center of turn table

*Test Distance: 0.01 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 extremely 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 calculation.)
 λ is the wavelength of the emission under investigation [300/f (MHz)], in m

Frequency [GHz]	Wavelength λ [mm]	Maximum Dimention			Far Field Boundary r [m]	Tested Distance [m]
		EUT [m]	Test Antenna [m]	Maximum D [m]		
76.475	3.9	0.024400	0.026162	0.026162	0.349	1.2

- The carrier level and noise levels were confirmed at each position of X, 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.

The Peak Power results was applied to the desensitization correction factor by KDB653005 4.(c).

The derivation of the FMCW Desensitization Factor is given in Keysight Application Note 5952 1039 Appendix B.

Desensitization factor was calculated from follow equation.

$$\alpha = \frac{1}{\sqrt[4]{1 + \left(\frac{2\ln(2)}{\pi}\right)^2 \left(\frac{F_s}{T_s B^2}\right)^2}}$$

And

FMCW Desensitization factor = 20 Log (α)

Where

F_s is FMCW Sweep Width or Chirp Width

T_s is FMCW Sweep Time

B is -3dB Bandwidth of Gaussian RBW Filter

Rating	F_s	T_s	B	α	FMCW Desensitization factor
[V]	[MHz]	[us]	[MHz]		[dB]
12	859.4607	56.1	1.0	0.383	-8.34
24	860.4641	56.1	1.0	0.382	-8.35

F_s , T_s and B were used the actual measurement value.

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

Measurement range : 9 kHz - 231 GHz

Test data : APPENDIX

Test result : Pass

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Facsimile : +81 596 24 8124

SECTION 6: Frequency Stability

Test Procedure

The block downconverter was placed in side of the temperature chamber's drain hole.

The power supply was set to nominal operating voltage (100 %), and the spectrum mask was measured at 20 deg. C. After that, EUT power supply was varied between 85 % and 115 % of nominal voltage and the frequency excursion of the EUT emission mask was recorded.

The EUT operating temperature was raised to 50 deg. C, and the frequency excursion of the EUT emission mask was recorded. Measurements were repeated at each 10 deg. C decrement down to -20 deg. C.

Both lower and upper frequencies of the 20 dB Bandwidth were recorded.

Test data : APPENDIX

Test result : Pass

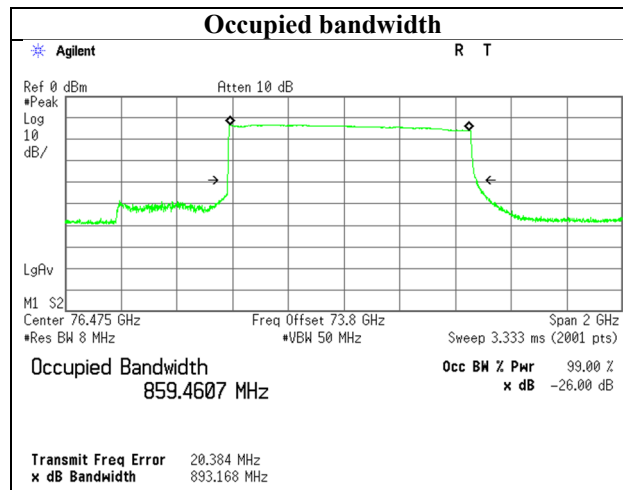
APPENDIX 1: Test data

Occupied bandwidth

Rating: DC 12 V

Report No.	14093012H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.1
Date	November 29, 2021
Temperature / Humidity	21 deg. C / 38 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode

Frequency	99 % Occupied bandwidth
[GHz]	[MHz]
76.475	859.4607



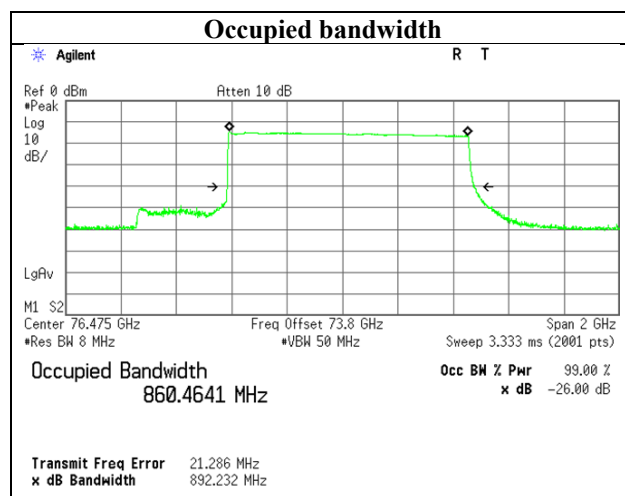
The measurement was performed with Peak detector and Max Hold since the duty cycle was not 100 %.

Occupied bandwidth

Rating: DC 24 V

Report No.	14093012H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.1
Date	November 29, 2021
Temperature / Humidity	21 deg. C / 38 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode

Frequency	99 % Occupied bandwidth
[GHz]	[MHz]
76.475	860.4641



The measurement was performed with Peak detector and Max Hold since the duty cycle was not 100 %.

Radiated Power

Rating: DC 12 V

Report No.	14093012H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.1
Date	November 29, 2021
Temperature / Humidity	21 deg. C / 38 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode

Power	Freq.	Measured Power	Rx Ant. Gain	Down Converter Gain	IF Cable Loss	Tested Distance	FSL	Duty Factor	FMCW desensitization Factor	EIRP		Lmit	Margin
	[GHz]	[dBm]	[dBi]	[dB]	[dB]	[m]	[dB]	[dB]	[dB]	[dBm]	[mW]	[dBm]	[dB]
Average	76.475	-24.03	23.05	14.68	1.43	1.2	71.70	8.43	-	19.79	95.28	50	30.21
Peak	76.475	-15.47	23.05	14.68	1.43	1.2	71.70	-	-8.34	28.27	671.43	55	26.73

Calculating formula:

$FSL (\text{Free Space path Loss}) = 10 * \log_{10}((4 * \pi * \text{Tested Distance} / \text{Lambda})^2)$

Average EIRP = Measured Power - Rx Ant. Gain - Down Converter Gain + IF Cable Loss + FSL + Duty Factor

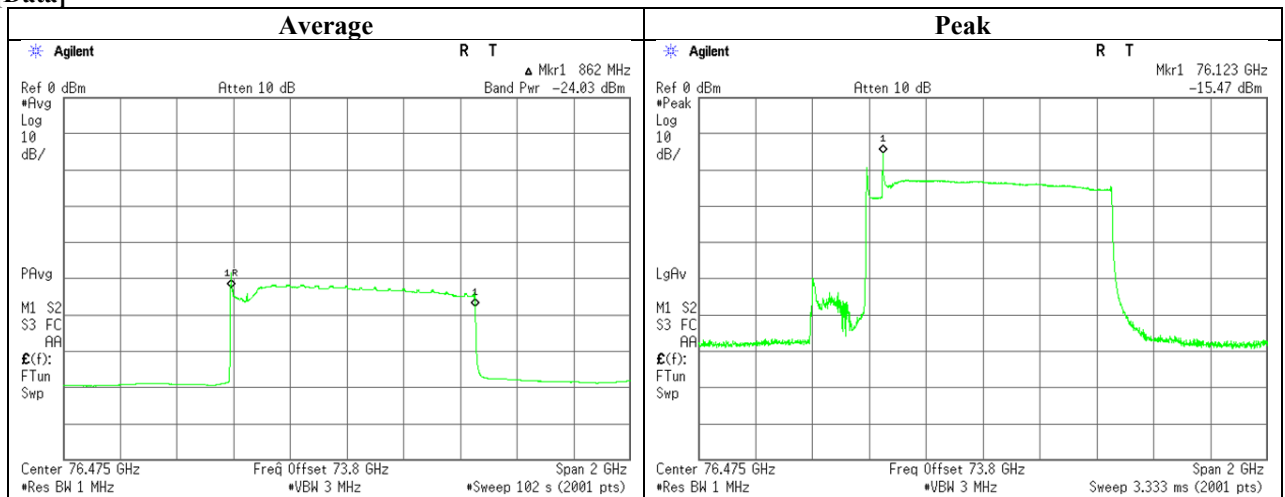
Peak EIRP = Measured Power - Rx Ant. Gain - Down Converter Gain + IF Cable Loss + FSL - FMCW desensitization factor

The test method referred to KDB653005 4.(c).

The derivation of the Duty Factor is given in next page (Modulation characteristics).

The derivation of the FMCW Desensitization Factor is given in Keysight Application Note 5952 1039 Appendix B. (Refer Section 5)

[Data]



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Facsimile : +81 596 24 8124

Radiated Power

Rating: DC 24 V

Report No.	14093012H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.1
Date	November 29, 2021
Temperature / Humidity	21 deg. C / 38 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode

Power	Freq.	Measured Power	Rx Ant. Gain	Down Converter Gain	IF Cable Loss	Tested Distance	FSL	Duty Factor	FMCW desensitization Factor	EIRP		Lmit	Margin
	[GHz]	[dBm]	[dBi]	[dB]	[dB]	[m]	[dB]	[dB]	[dB]	[dBm]	[mW]	[dBm]	[dB]
Average	76.475	-24.32	23.05	14.68	1.43	1.2	71.70	8.43	-	19.50	89.13	50	30.50
Peak	76.475	-15.92	23.05	14.68	1.43	1.2	71.70	-	-8.35	27.83	606.74	55	27.17

Calculating formula:

FSL (Free Space path Loss) = $10 * \log_{10}((4 * \pi * \text{Tested Distance} / \text{Lambda})^2)$

Average EIRP = Measured Power - Rx Ant. Gain - Down Converter Gain + IF Cable Loss + FSL + Duty Factor

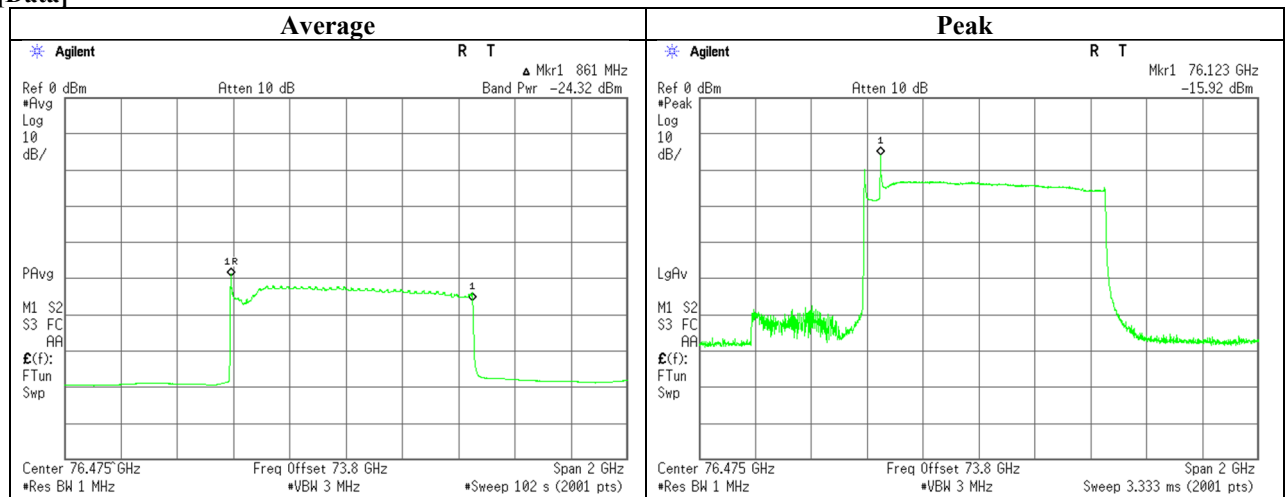
Peak EIRP = Measured Power - Rx Ant. Gain - Down Converter Gain + IF Cable Loss + FSL - FMCW desensitization factor

The test method referred to KDB653005 4.(c).

The derivation of the Duty Factor is given in next page (Modulation characteristics).

The derivation of the FMCW Desensitization Factor is given in Keysight Application Note 5952 1039 Appendix B. (Refer Section 5)

[Data]



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Modulation characteristics

Report No.	14093012H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.4
Date	November 15, 2021
Temperature / Humidity	21 deg. C / 42 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode (Rating: DC 24 V)

[Duty Factor]

	Tx On time [ms]	Tx On + Off time [ms]	Chirp time [us]	Chirp time + Idle time [us]	Number of Chirp*	Chirp time (Total) [ms]	Duty factor [dB]
Measured	7.930	50.015	56.134	62.056	128	7.185	8.43
Declared *	7.940	-	-	62.000	128	-	-

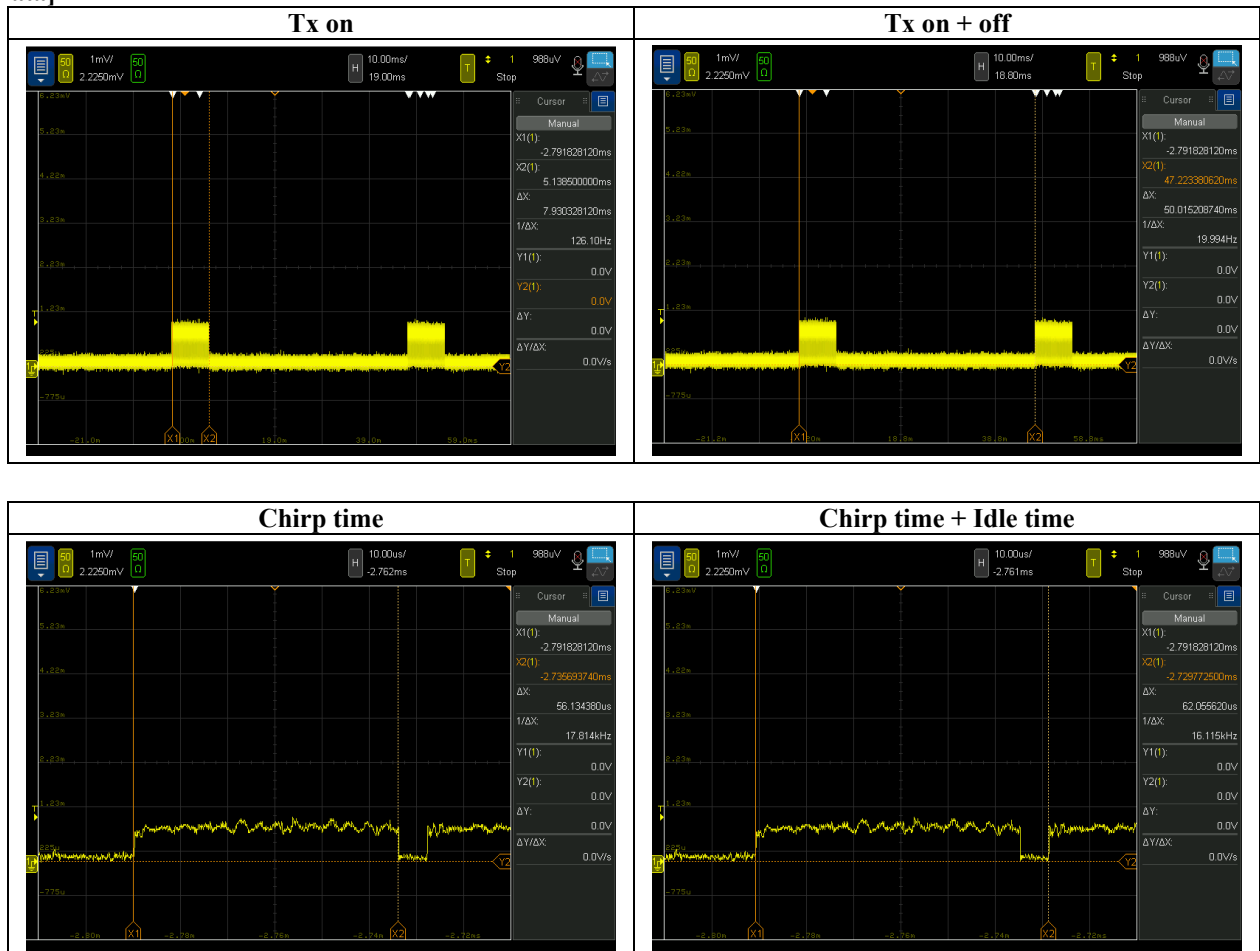
Calculating formula:

Chirp time (Total) = Chirp time * Number of Chirp

Duty factor = $10 * \log (\text{Chirp time (Total)} / \text{Tx On + Off time})$

* See the application document.

[Data]



* This Duty Cycle is the worst case. Transmitting time does not exceed it.

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Facsimile : +81 596 24 8124

Field strength of spurious radiation (below 40 GHz)

Report No. 14093012H
Test place Ise EMC Lab.
Semi Anechoic Chamber No.1 No. 1 No.4
Date November 29, 2021 November 30, 2021 December 1, 2021
Temperature / Humidity 21 deg. C / 38 % RH 22 deg. C / 35 % RH 22 deg. C / 32 % RH
Engineer Yuichiro Yamazaki Yuichiro Yamazaki Yuichiro Yamazaki
(26.5 GHz - 40 GHz) (9 kHz - 30 MHz) (30 MHz - 26.5 GHz)
Mode Normal operating mode (Rating: DC 12 V)

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori.	44.836	QP	22.4	13.1	7.4	32.0	10.8	40.0	29.2	NS
Hori.	80.012	QP	24.3	6.9	7.8	32.0	7.0	40.0	33.0	NS
Hori.	190.403	QP	21.5	16.5	8.8	31.9	14.8	43.5	28.8	NS
Hori.	306.000	QP	20.9	13.8	9.6	31.9	12.5	46.0	33.6	NS
Hori.	570.053	QP	21.5	18.6	11.1	32.1	19.1	46.0	26.9	NS
Hori.	964.766	QP	20.9	22.3	12.6	30.9	25.0	54.0	29.0	NS
Vert.	44.836	QP	22.3	13.1	7.4	32.0	10.7	40.0	29.3	NS
Vert.	80.012	QP	24.7	6.9	7.8	32.0	7.4	40.0	32.6	NS
Vert.	190.403	QP	21.5	16.5	8.8	31.9	14.8	43.5	28.8	NS
Vert.	306.000	QP	21.0	13.8	9.6	31.9	12.6	46.0	33.5	NS
Vert.	570.053	QP	21.5	18.6	11.1	32.1	19.1	46.0	26.9	NS
Vert.	964.766	QP	20.8	22.3	12.6	30.9	24.9	54.0	29.1	NS

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

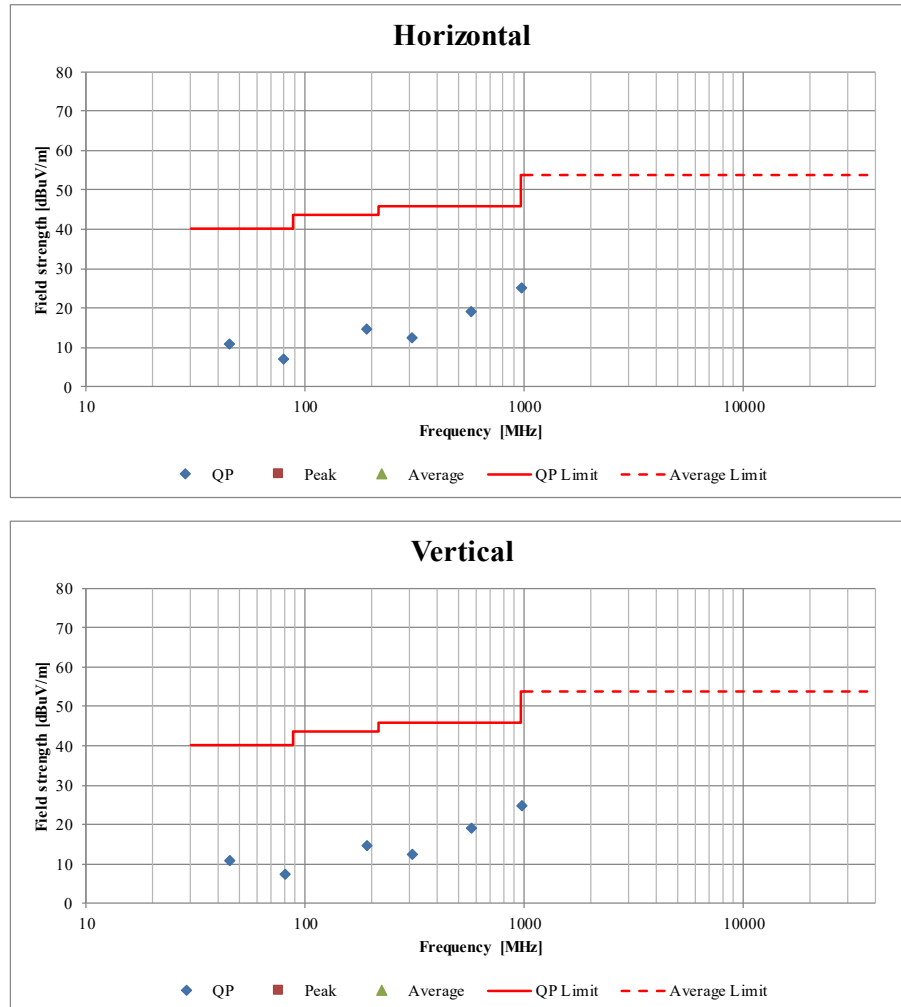
*Other frequency noises omitted in this report were not seen or had enough margin (more than 20 dB).

Distance factor: 1 GHz - 10 GHz $20\log(4.0\text{ m} / 3.0\text{ m}) = 2.5\text{ dB}$
10 GHz - 40 GHz $20\log(1.0\text{ m} / 3.0\text{ m}) = -9.5\text{ dB}$

NS: No Signal detected.

Field strength of spurious radiation
(Plot data, Worst case)

Report No.	14093012H		
Test place	Ise EMC Lab.		
Semi Anechoic Chamber	No.1	No. 1	No.4
Date	November 29, 2021	November 30, 2021	December 1, 2021
Temperature / Humidity	21 deg. C / 38 % RH	22 deg. C / 35 % RH	22 deg. C / 32 % RH
Engineer	Yuichiro Yamazaki	Yuichiro Yamazaki	Yuichiro Yamazaki
	(26.5 GHz - 40 GHz)	(9 kHz - 30 MHz)	(30 MHz - 26.5 GHz)
Mode	Normal operating mode (Rating: DC 12 V)		



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

Field strength of spurious radiation (above 40 GHz)

Report No. 14093012H
Test place Ise EMC Lab.
Semi Anechoic Chamber No. 4 No. 1
Date November 19, 2021 November 30, 2021
Temperature / Humidity 21 deg. C / 40 % RH 22 deg. C / 35 % RH
Engineer Yuichiro Yamazaki Yuichiro Yamazaki
40 GHz - 83 GHz 83 GHz - 231 GHz
Mode Normal operating mode (Rating: DC 12 V)

Freq. [GHz]	Reading [dBm]	Rx Ant. gain [dBi]	Filter loss [dB]	LNA gain [dB]	Mixer loss [dB]	IF cable loss [dB]	Meas. range D [m]	FSL [dB]	EIRP		Power density at 3 m			Remarks
									[dBm]	[mW]	Result [pW/cm ²]	Limit [pW/cm ²]	Margin [dB]	
48.749	-51.50	22.17	0.00	32.50	0.00	8.94	0.5	60.18	-37.05	0.000197	0.17	600	35.36	NS
54.641	-69.89	23.27	0.22	26.69	0.00	0.00	1.0	67.19	-52.44	0.000006	0.01	600	50.75	NS
69.857	-68.95	24.29	0.47	20.90	0.00	0.00	1.0	69.33	-44.34	0.000037	0.03	600	42.66	NS
74.747	-65.58	24.49	1.53	20.45	0.00	0.00	1.0	69.91	-39.07	0.000124	0.11	600	37.39	NS
75.736	-81.93	23.02	0.00	0.00	-14.91	1.21	1.2	71.61	-47.03	0.000020	0.02	600	45.35	Average detected
81.605	-76.34	23.45	0.00	0.00	-12.27	2.50	1.2	72.26	-37.30	0.000186	0.16	600	35.61	NS
89.517	-53.31	23.88	0.60	33.36	0.00	0.00	0.5	65.46	-44.49	0.000036	0.03	600	42.80	NS
99.559	-46.94	24.45	0.45	33.65	0.00	0.00	0.5	66.38	-38.21	0.000151	0.13	600	36.52	NS
102.571	-44.52	24.58	0.39	31.94	0.00	0.00	0.5	66.64	-34.01	0.000398	0.35	600	32.32	NS
117.035	-87.73	22.54	0.00	18.19	55.46	0.00	0.01	33.81	-39.20	0.000120	0.11	600	37.51	NS
120.809	-88.12	22.67	0.00	19.58	53.22	0.00	0.01	34.08	-43.07	0.000049	0.04	600	41.38	NS
128.232	-88.00	22.90	0.00	20.64	52.65	0.00	0.01	34.60	-44.29	0.000037	0.03	600	42.61	NS
139.191	-89.97	23.17	0.00	18.94	53.72	0.00	0.01	35.31	-43.05	0.000050	0.04	600	41.37	NS
142.234	-90.88	23.23	0.00	19.04	55.40	0.00	0.01	35.50	-42.25	0.000060	0.05	600	40.56	NS
150.053	-92.08	23.33	0.00	18.19	58.60	0.00	0.01	35.97	-39.03	0.000125	0.11	600	37.35	NS
162.022	-93.00	23.40	0.00	16.05	59.42	0.00	0.01	36.63	-36.40	0.000229	0.20	600	34.71	NS
166.205	-93.76	23.41	0.00	14.01	61.64	0.00	0.01	36.85	-32.69	0.000539	0.48	600	31.00	NS
171.378	-87.87	22.43	0.00	0.00	59.72	0.00	0.01	37.12	-13.46	0.045122	39.90	600	11.77	NS
178.548	-89.12	22.60	0.00	0.00	57.39	0.00	0.01	37.48	-16.86	0.020629	18.24	600	15.17	NS
186.418	-88.31	22.77	0.00	0.00	57.71	0.00	0.01	37.85	-15.51	0.028097	24.84	600	13.83	NS
199.484	-90.22	23.01	0.00	0.00	56.40	0.00	0.01	38.44	-18.39	0.014501	12.82	600	16.70	NS
204.247	-89.91	23.08	0.00	0.00	59.28	0.00	0.01	38.64	-15.06	0.031174	27.56	1000	15.60	NS
208.183	-90.40	23.14	0.00	0.00	57.00	0.00	0.01	38.81	-17.73	0.016864	14.91	1000	18.26	NS
217.260	-91.08	23.24	0.00	0.00	57.25	0.00	0.01	39.18	-17.88	0.016279	14.39	1000	18.42	NS
224.032	-91.83	23.30	0.00	0.00	63.74	0.00	0.01	39.45	-11.94	0.063914	56.51	1000	12.48	NS

Calculation: FSL (Free Space path Loss) = $10 * \log((4 * \pi * D / \lambda)^2)$
EIRP = Reading - Rx Ant. gain + Filter loss - LNA gain + Mixer loss + IF cable loss + FSL
Power density Result at 3 m = EIRP / (4 * π * 300²)

These calculation results are same as results which were calculated with formulas described in the Section 9 of ANSI C63.10-2013.

The equipment were not used for factor 0 dB of the data sheets.
The conversion loss is automatically corrected in the mixer, so the factor of data sheet were 0 dB.

NS: No signal detected.

The peak density is less than the average limit (except Average Detected).

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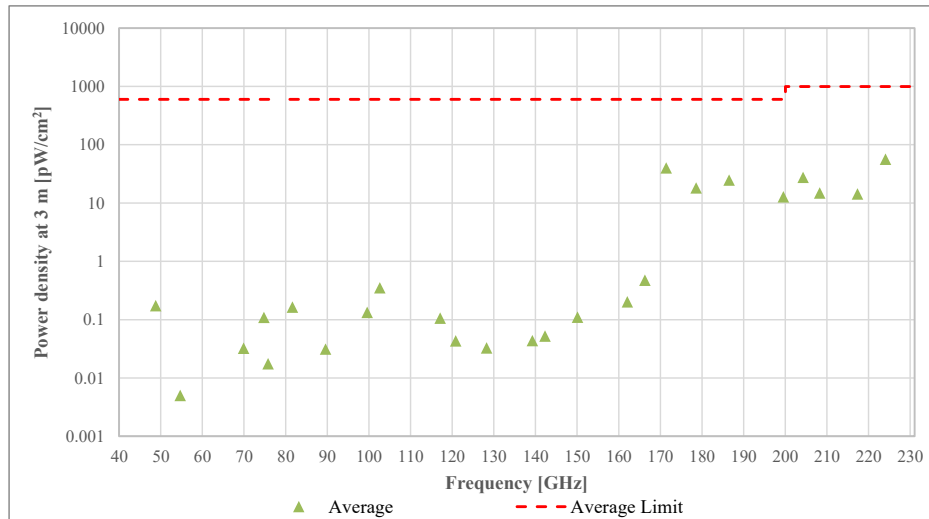
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Facsimile : +81 596 24 8124

Field strength of spurious radiation (above 40 GHz)
(Plot data, Worst case)

Report No.	14093012H	
Test place	Ise EMC Lab.	
Semi Anechoic Chamber	No. 4	No. 1
Date	November 19, 2021	November 30, 2021
Temperature / Humidity	21 deg. C / 40 % RH	22 deg. C / 35 % RH
Engineer	Yuichiro Yamazaki	Yuichiro Yamazaki
	(40 GHz - 83 GHz)	(83 GHz - 231 GHz)
Mode	Normal operating mode (Rating: DC 12 V)	



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

Frequency Stability

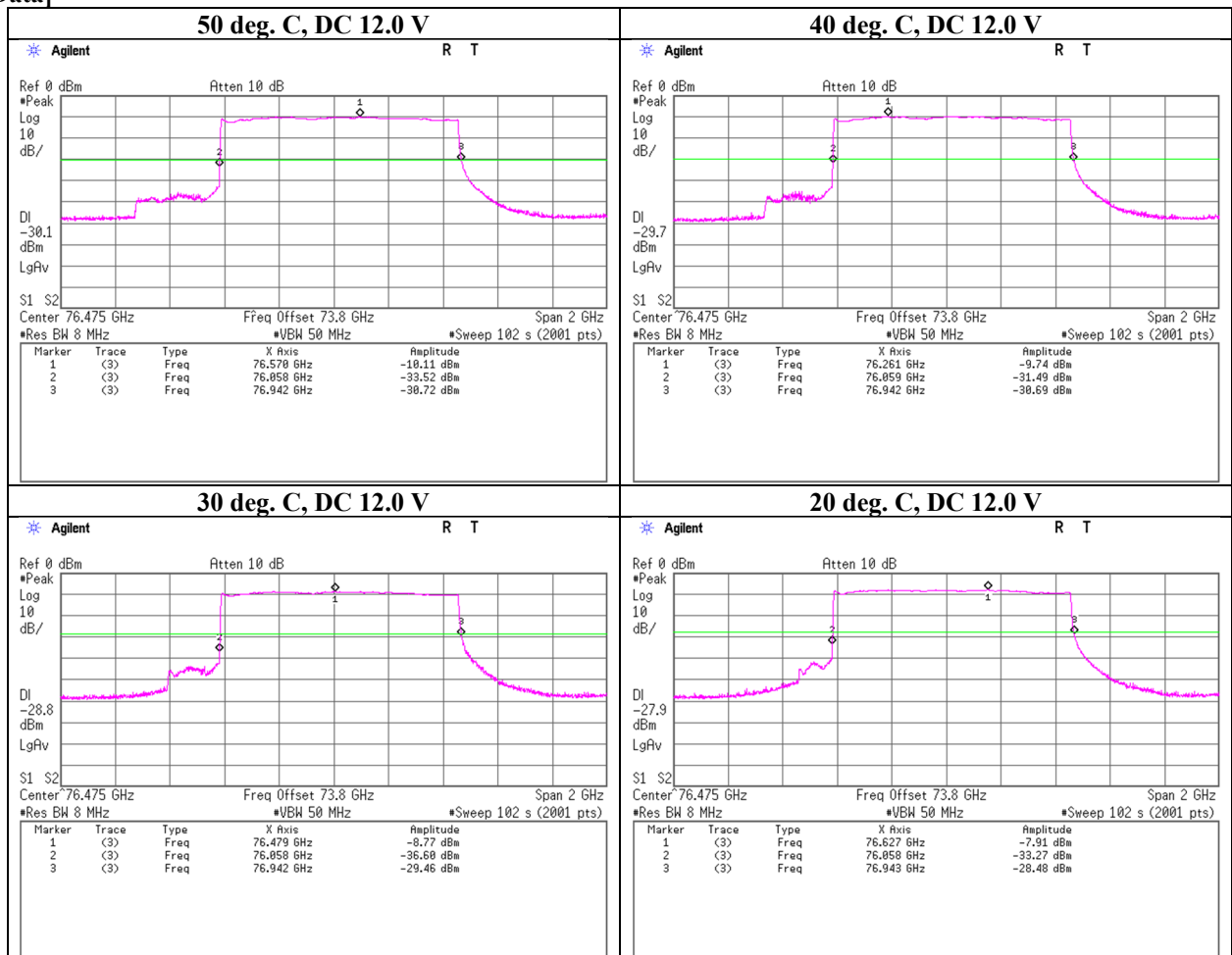
Rating: DC 12 V

Report No. 14093012H
Test place Ise EMC Lab. No.6 Measurement Room
Date November 25, 2021
Temperature / Humidity 25 deg. C / 38 % RH
Engineer Yuichiro Yamazaki
Mode Normal operating mode

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
50	12.0	76.058	76.942	
40	12.0	76.059	76.942	
30	12.0	76.058	76.942	
20	12.0	76.058	76.943	
20	10.2	76.058	76.943	85 % of the minimum operating voltage, DC 12 V * 0.85
20	13.8	76.059	76.942	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.052	76.943	
0	12.0	76.058	76.944	
-10	12.0	76.060	76.944	
-20	12.0	76.062	76.944	

Fundamental emissions were contained within the frequency band 76 GHz - 81 GHz during all conditions of operation.

[Data]



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Ise EMC Lab.

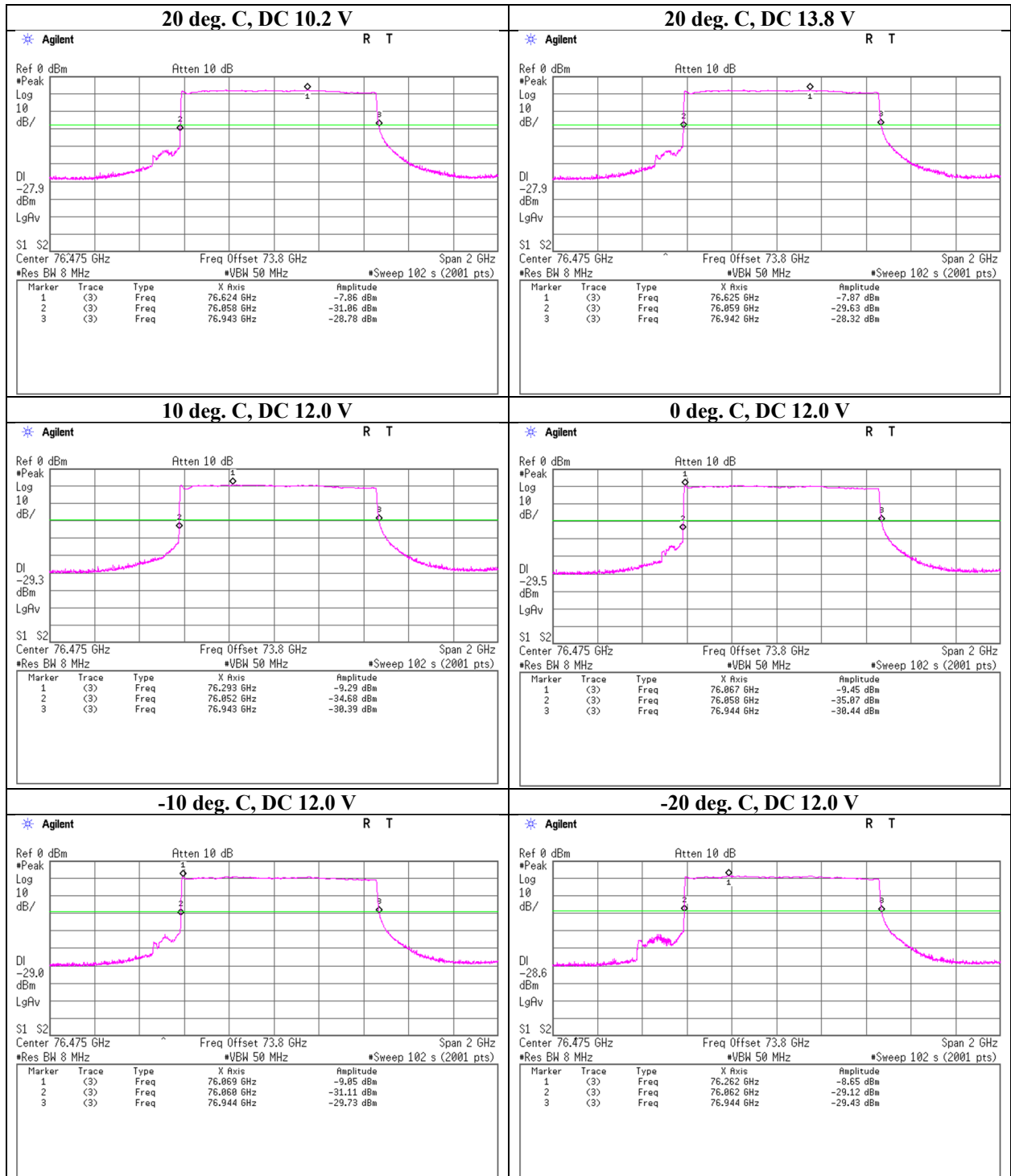
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Frequency Stability

Rating: DC 12 V



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Frequency Stability

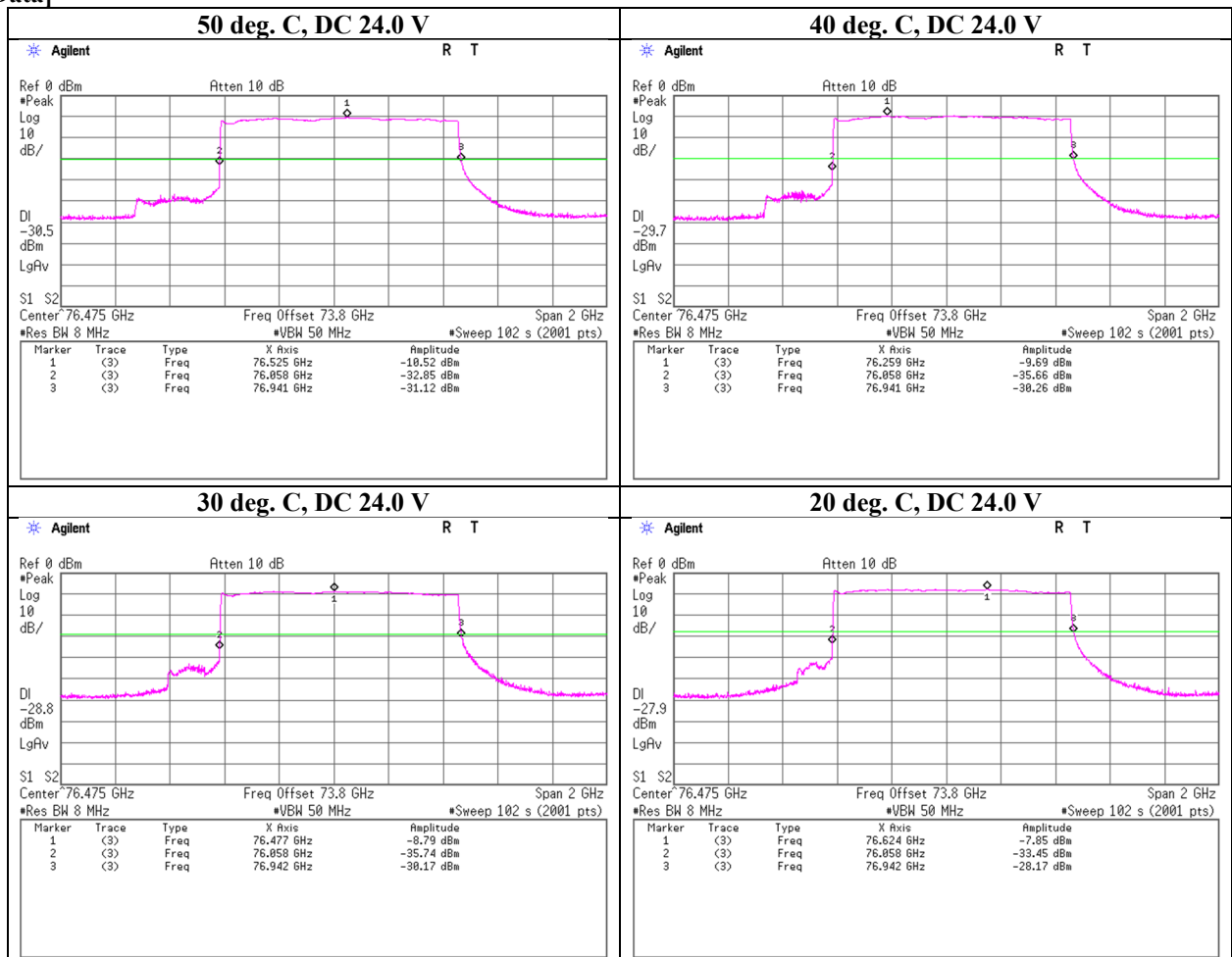
Rating: DC 24 V

Report No. 14093012H
Test place Ise EMC Lab. No.6 Measurement Room
Date November 25, 2021
Temperature / Humidity 25 deg. C / 38 % RH
Engineer Yuichiro Yamazaki
Mode Normal operating mode

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
50	24.0	76.058	76.941	
40	24.0	76.058	76.941	
30	24.0	76.058	76.942	
20	24.0	76.058	76.942	
20	20.4	76.058	76.942	85 % of the minimum operating voltage, DC 24 V * 0.85
20	27.6	76.058	76.942	115 % of the maximum operating voltage, DC 24 V * 1.15
10	24.0	76.052	76.943	
0	24.0	76.059	76.943	
-10	24.0	76.060	76.944	
-20	24.0	76.062	76.944	

Fundamental emissions were contained within the frequency band 76 GHz - 81 GHz during all conditions of operation.

[Data]



UL Japan, Inc.

Ise EMC Lab.

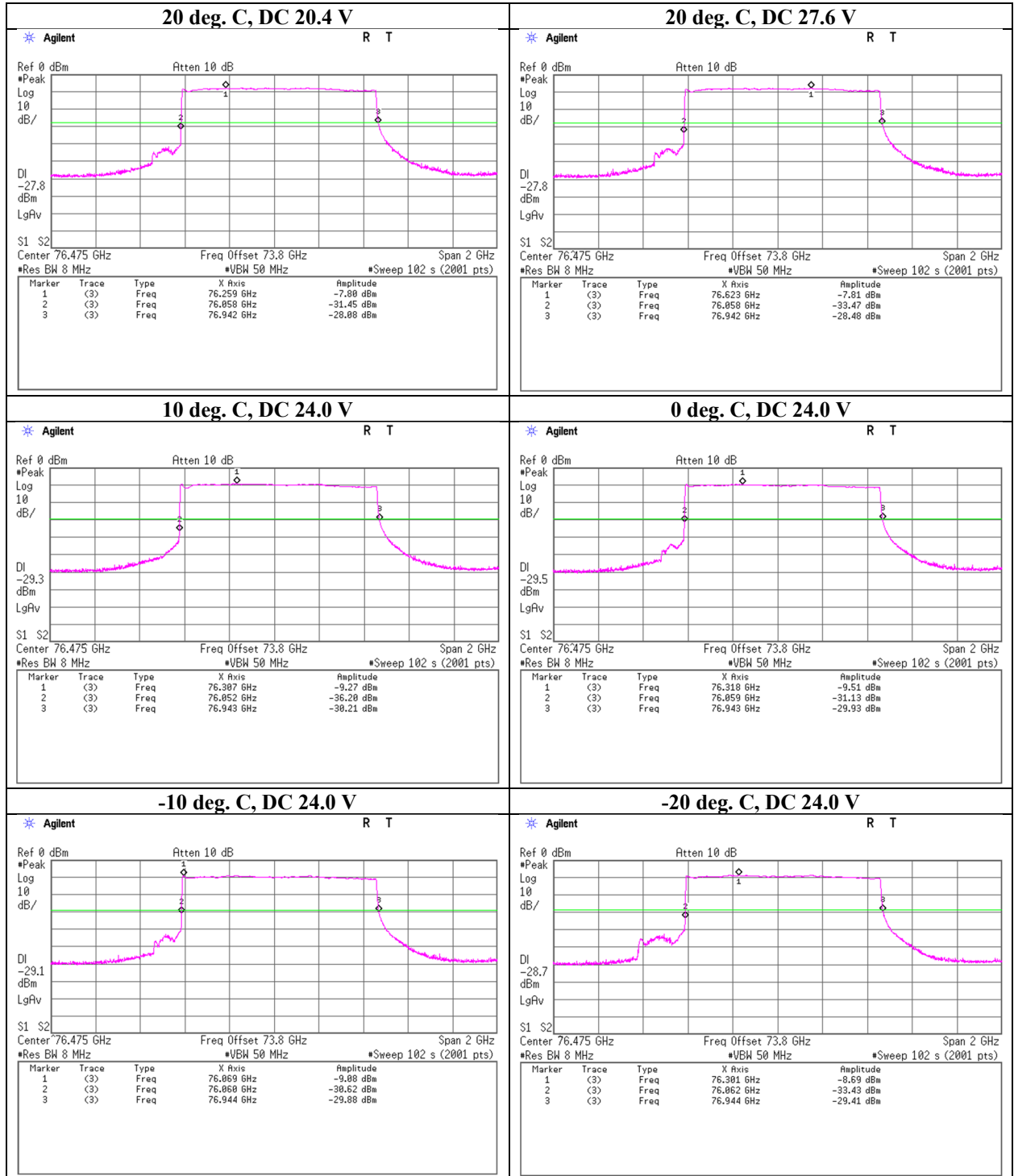
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Telephone : +81 596 24 8999

Facsimile : +81 596 24 8124

Frequency Stability

Rating: DC 24 V



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APPENDIX 2: Test instruments

Test equipment (1/2)

Test Item	Local ID	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Cal Int
RE	MOS-15	141562	Thermo-Hygrometer	CUSTOM. Inc	CTH-201	0010	01/15/2021	12
RE	MMM-10	141545	DIGITAL HiTESTER	HIOKI E.E. CORPORATION	3805	51201148	01/07/2021	12
RE	MJM-29	142230	Measure	KOMELON	KMC-36	-	-	-
RE	COTS-ME MI-02	178648	EMI measurement program	TSJ (Techno Science Japan)	TEPTO-DV	-	-	-
RE	MAEC-04-SVSWR	142017	AC4_Semi Anechoic Chamber(SVSWR)	TDK	Semi Anechoic Chamber 3m	DA-10005	04/12/2021	24
RE	MSA-03	141884	Spectrum Analyzer	Keysight Technologies Inc	E4448A	MY44020357	03/10/2021	12
RE	MCC-66	141328	Microwave Cable 1G-40GHz	Suhner	SUCOFLEX102	28636/2	04/16/2021	12
RE	MMX-05	142050	Block Downconverter	EMC Instruments Corporation	PS-X30-W10117A	13715	03/02/2021	12
RE	MHA-35	180544	Horn Antenna	SAGE Millimeter, Inc.	SAZ-2410-10-S1	17343-01	06/24/2021	12
RE	MDO-10	211944	Digital Storage Oscilloscope	Keysight Technologies Inc	DSOX6002A	MY59380318	10/07/2021	12
RE	MDT-05	142529	Detector	HEROTEK, INC.	DT1840P	484823	-	-
RE	MAEC-04	142011	AC4_Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 3m	DA-10005	05/25/2020	24
RE	MAT-34	141331	Attenuator(6dB)	TME	UFA-01	-	02/02/2021	12
RE	MBA-05	141425	Biconical Antenna	Schwarzbeck Mess-Elektronik OHG	VHA9103+BBA9106	VHA 91031302	08/28/2021	12
RE	MCC-50	141397	Coaxial Cable	UL Japan	-	-	11/03/2021	12
RE	MLA-23	141267	Logperiodic Antenna (200-1000MHz)	Schwarzbeck Mess-Elektronik OHG	VUSLP9111B	9111B-192	08/28/2021	12
RE	MPA-14	141583	Pre Amplifier	SONOMA INSTRUMENT	310	260833	02/18/2021	12
RE	MTR-08	141949	Test Receiver	Rohde & Schwarz	ESCI	100767	08/05/2021	12
RE	MSA-14	141901	Spectrum Analyzer	Keysight Technologies Inc	E4440A	MY48250080	12/18/2020	12
RE	MPA-12	141581	MicroWave System Amplifier	Keysight Technologies Inc	83017A	00650	10/07/2021	12
RE	MHA-21	141508	Horn Antenna 1-18GHz	Schwarzbeck Mess-Elektronik OHG	BBHA9120D	557	05/10/2021	12
RE	MCC-257	208936	Microwave Cable	Huber+Suhner	SF126E/11PC35/11PC35/1000M,5000M	537061/126E / 537076/126E	07/18/2021	12
RE	MOS-14	141561	Thermo-Hygrometer	CUSTOM. Inc	CTH-201	1401	01/15/2021	12
RE	MMM-18	141558	Digital Tester(TRUE RMS MULTIMETER)	Fluke Corporation	115	17930030	05/24/2021	12
RE	MJM-24	142225	Measure	ASKUL	-	-	-	-
RE	MCH-04	141429	Temperature and Humidity Chamber	Espec	PL-2KP	14015723	08/05/2021	12
RE	MSA-04	141885	Spectrum Analyzer	Keysight Technologies Inc	E4448A	US44300523	11/10/2021	12
RE	MAEC-01	141998	AC1_Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 10m	DA-06881	06/08/2020	24
RE	MOS-27	141566	Thermo-Hygrometer	CUSTOM. Inc	CTH-201	A08Q26	01/15/2021	12
RE	MMM-03	141530	Digital Tester	Fluke Corporation	FLUKE 26-3	78030621	08/10/2021	12
RE	MJM-25	142226	Measure	KOMELON	KMC-36	-	-	-
RE	MAEC-01-SVSWR	141994	AC1_Semi Anechoic Chamber(SVSWR)	TDK	Semi Anechoic Chamber 10m	DA-06881	04/05/2021	24
RE	MAT-08	141213	Attenuator(6dB)	Weinschel Corp	2	BK7971	11/09/2021	12
RE	MTR-10	141951	EMI Test Receiver	Rohde & Schwarz	ESR26	101408	03/09/2021	12
RE	MCC-03	141215	Coaxial Cable	Fujikura/Suhner/TSJ	5D-2W/3D-2W/RG400u/RFM-E421(SW)	-/01068 (Switcher)	06/02/2021	12
RE	MLPA-01	141254	Loop Antenna	Rohde & Schwarz	HFH2-Z2	100017	04/17/2021	12
RE	MCC-255	207745	Coaxial Cable	UL Japan Inc.	-	-	05/17/2021	12
RE	MPA-13	141582	Pre Amplifier	SONOMA INSTRUMENT	310	260834	02/18/2021	12

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

Test equipment (2/2)

Test Item	Local ID	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Cal Int
RE	MHA-24	142036	Horn Antenna	Custom Microwave Inc.	HO6R	-	09/30/2021	12
RE	MPA-29	176027	D-Band Low Noise Amplifier	SAGE Millimeter, Inc.	SBL-1141741860-0606-EI	15235-01	07/08/2021	12
RE	MMX-03	142049	Harmonic Mixer	OML INC.	M06HWD	D100709-1	11/17/2021	12
RE	MDPLX-01	142026	Diplexer	OML INC.	DPL26	-	11/25/2021	12
RE	MCC-135	142032	Microwave Cable	Huber+Suhner	SUCOFLEX102	37511/2	09/18/2021	12
RE	MHA-27	142039	Horn Antenna	Custom Microwave Inc.	HO4R	-	09/30/2021	12
RE	MMX-04	142053	Harmonic Mixer	OML INC.	M04HWD	Y100709-1	12/07/2021	12
RE	MMX-08	186077	Wave guide Harmonic Mixer	Keysight Technologies Inc	M1971W	MY56390146	05/18/2021	12
RE	MPA-31	180607	Power Amplifier	SAGE Millimeter, Inc.	SBP-7531142515-1010-E1	17343-01	10/18/2021	12
RE	MHF-29	154635	High Pass Filter 83 GHz - 110 GHz	Oshima Prototype Engineering Co.	A17-016	1	05/18/2021	12
RE	MSA-19	182484	Signal Analyzer	Keysight Technologies Inc	N9030B	MY57143159	06/18/2021	12
RE	MCC-246	199563	Microwave Cable	Huber+Suhner	SF126E/11PC35/11PC35/1000M,5000M	537061/126E / 537072/126E	-	-
RE	MHA-31	142041	Horn Antenna	Oshima Prototype Engineering Co.	A16-187	1	09/30/2021	12
RE	MPA-25	159919	Power Amplifier	SAGE Millimeter, Inc.	SBP-4035033018-2F2F-S1	12559-01	06/02/2021	12
RE	MCC-220	151897	Microwave Cable	Huber+Suhner	SF101EA/11PC24/11PC24/2.5M	SN MY1726/1EA	04/12/2021	12
RE	MHA-33	180634	Horn Antenna	SAGE Millimeter, Inc.	SAZ-2410-15-S1	17343-01	06/24/2021	12
RE	MMX-07	186076	Wave guide Harmonic Mixer	Keysight Technologies Inc	M1971V	MY56390208	05/18/2021	12
RE	MHA-23	147261	Horn Antenna	Schwarzbeck Mess-Elektronik OHG	BBHA9170	BBHA9170136	-	-

*Hyphens for Last Calibration 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.

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

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

Test Item: RE: Radiated Emission

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Facsimile : +81 596 24 8124