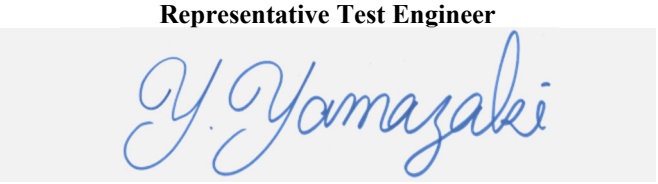
RADIO TEST REPORT

Test Report No. 14202169H-A-R1

Customer	**TOYODA GOSEI CO., LTD.**
Description of EUT	**Millimeter Wave Radar with Emblem with Emblem**
Model Number of EUT	**TGMWR011**
FCC ID	**2A6DFTGMWR011**
Test Regulation	**FCC Part 95 Subpart M**
Test Result	**Complied (Refer to SECTION 3)**
Issue Date	**May 27, 2022**
Remarks	**-**

Representative Test Engineer



Yuichiro Yamazaki
Engineer

Approved By

Ryota Yamanaka
Engineer

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".

Report Cover Page - Form-ULID-003532 (DCS:13-EM-F0429) Issue# 20.0

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- The all test items in this test report are conducted by UL Japan, Inc. Ise EMC Lab.
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- The information provided from the applicant for this report is identified in Section 1.
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REVISION HISTORY

Original Test Report No.: 14202169H-A

This report is a revised version of 14202169H-A. 14202169H-A is replaced with this report.

Revision	Test Report No.	Date	Page Revised Contents
- (Original)	14202169H-A	April 25, 2022	-
1	14202169H-A-R1	May 27, 2022	Deletion of ": 2017" from Test Regulation of cover page.
1	14202169H-A-R1	May 25, 2022	Deletion of all parts corresponding to Conducted emission
1	14202169H-A-R1	May 27, 2022	Correction of the EUT Condition in Clause 2.2 From "Engineering prototype" to "Pre-production"
1	14202169H-A-R1	May 27, 2022	Correction of the following items in Clause 2.2; - From "Steerable Antenna: Electoronically (Digital Besan Firming)" to "Scanning Antenna(Transmit):Fixed beam" - From "Unmanned Ground Vehicle-mounted" to "Vehicle-mounted" for Usage location
1	14202169H-A-R1	May 27, 2022	Correction of Configuration and peripherals diagram and list in Section 4.2; - Deletion of the diagram for Conducted emission - Description separately for below 1GHz and above 1GHz of Radiated emission - Correction of the list due to the above modification
1	14202169H-A-R1	May 27, 2022	Correction of the horizontal axis unit of Plot data (Above 40 GHz) from [MHz] to [GHz] (page. 34)
1	14202169H-A-R1	May 27, 2022	Addition of the following Local ID in Test equipment; MDO-10 / MDT-05 / MSA-19

Reference: Abbreviations (Including words undescribed in this report)

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

CONTENTS **PAGE**

SECTION 1: Customer Information

Company Name	TOYODA GOSEI CO., LTD.*1)
Address	30 Nishinomachi, Kitajima, Inazawa, Aichi, 492-8540 Japan
Telephone Number	+81-90-6394-5824
Contact Person	Atsushi Kumo

*1) Remarks:
TOYODA GOSEI CO., LTD. designates DENSO CORPORATION as manufacturer of the product (Millimeter Wave Radar with Emblem with Emblem).

The information provided from the customer is as follows;
- Customer, Description 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 and Test 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

Description	Millimeter Wave Radar with Emblem with Emblem
Model Number	TGMWR011
Serial Number	Refer to SECTION 4.2
Condition	Pre-production (Not for Sale: This sample is equivalent to mass-produced items.)
Modification	No Modification by the test lab
Receipt Date	March 3, 2022
Test Date	March 6 to 15, 2022

2.2 Product Description

General Specification

Rating	DC 12 V
Operating temperature	-30 deg. C to +51.3 deg. C

Radio Specification

Equipment Type	Transceiver
Bandwidth	FCM: 900 MHz
Scanning Antenna (transmit)	Fixed beam
Usage location	Vehicle-mounted

Mode	Frequency of Operation	Modulation	Emission Classification	Antenna gain
FCM1	76.3 GHz, 76.5 GHz, 76.7 GHz	FCM	QXN	18.8 dBi
FCM2	76.5 GHz	FCM	QXN	14.1 dBi
CW	76.5 GHz	N/A	N0N	14.1 dBi

SECTION 3: Test specification, procedures & results

3.1 Test Specification

Test Specification	FCC Part 95 Subpart M FCC Part 95 final revised on November 2, 2017
Title	FCC 47CFR Part95 – PERSONAL RADIO SERVICES Subpart M – The 76-81 GHz Band Radar Service

* 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:** 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 Modulation characteristics	**FCC:** ANSI C63.26-2015 5.5 Radiated emissions testing ANSI C63.10-2013 6. Standard test methods 9. Procedures for testing millimeter-wave systems	**FCC:** Section 95.3367 Section 2.1046 Section 2.1047		Complied b)	Radiated
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	19.0 dB 33.1 MHz, Vertical / 38.9 MHz, Vertical	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: Work Instructions-ULID-003591 and Work Instructions-ULID-003593.
*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.

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 $k = 2$.

Radiated emission

Measurement distance	Frequency range		Uncertainty (+/-)
3 m	9 kHz to 30 MHz		3.2 dB
10 m			3.0 dB
3 m	30 MHz to 200 MHz	Horizontal	4.8 dB
		Vertical	5.0 dB
	200 MHz to 1000 MHz	Horizontal	5.1 dB
		Vertical	6.2 dB
10 m	30 MHz to 200 MHz	Horizontal	4.8 dB
		Vertical	4.8 dB
	200 MHz to 1000 MHz	Horizontal	5.0 dB
		Vertical	5.0 dB
3 m	1 GHz to 6 GHz		4.9 dB
	6 GHz to 18 GHz		5.2 dB
1 m	10 GHz to 26.5 GHz		5.4 dB
	26.5 GHz to 40 GHz		5.4 dB
0.5 m	26.5 GHz to 40 GHz		5.4 dB
10 m	1 GHz to 18 GHz		5.4 dB
>= 0.5 m	40 GHz to 50 GHz		4.1 dB
>= 0.5 m	50 GHz to 75 GHz		5.1 dB
>= 0.5 m	75 GHz to 110 GHz		5.4 dB
>= 3.8 cm*	110 GHz to 170 GHz		5.2 dB
>= 2.5 cm*	170 GHz to 260 GHz		5.0 dB

*under consideration about Uncertainty for testing at 1 cm distance

Radiated emission (with Block downconverter)

Measurement distance	Frequency range	Uncertainty (+/-)
>= 0.5 m	75 GHz - 83 GHz	4.4 dB*

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

3.5 Test Location

UL Japan, Inc. Ise EMC Lab.
*A2LA Certificate Number: 5107.02 / FCC Test Firm Registration Number: 884919
ISED Lab Company Number: 2973C / CAB identifier: JP0002
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN
Telephone: +81 596 24 8999, Facsimile: +81 596 24 8124

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.

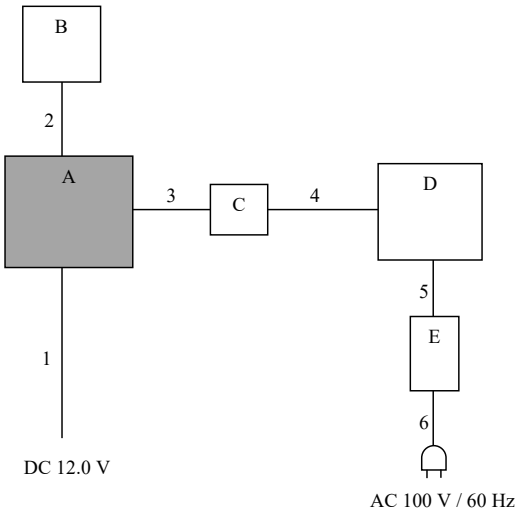
SECTION 4: Operation of EUT during testing

4.1 Operating Mode(s)

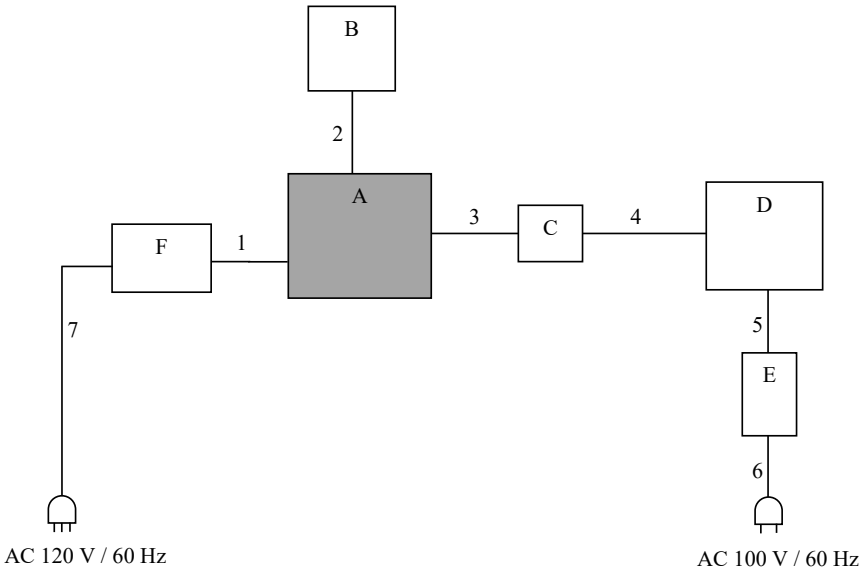
Mode	Test Item
Transmitting mode (Tx) - FCM 1 Low (76.3 GHz) - FCM 1 Mid (76.5 GHz) - FCM 1 High (76.7 GHz) - FCM 2 ch 1 - FCM 2 ch 2 - FCM 2 ch 3 - CW ch 1 - CW ch 2 - CW ch 3	Occupied bandwidth, Radiated Power, Duty, Frequency Stability
Normal operating mode	Modulation characteristics, Field strength of spurious radiation
*Power of the EUT was set by the software as follows; Power Setting: Same as production model Software: mwr_gen6_0064_3420 (Date: 2022.03.06, Storage location: EUT memory)	
*This setting of software is the worst case. Any conditions under the normal use do not exceed the condition of setting. In addition, end users cannot change the settings of the output power of the product.	

4.2 Configuration and peripherals

[Radiated emission test (Below 1 GHz)]



[Radiated emission test (above 1 GHz)]



* 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	Millimeter Wave Radar with Emblem with Emblem	TGMWR011	0365244780002169080022000	DENSO CORPORATION	EUT
B	Dummy Load	-	-	-	-
C	CAN Interface	VN1610	007150-043653	vector	-
D	Laptop PC	20KG-S3DT00	PF-1MEGDN 19/02	Lenovo	-
E	AC Adaptor	ADLX45YLC2A	L1CZ8CC07M1	Lenovo	-
F	DC Power Supply	PAK35-10A	LF002313	ikusui Electronics Corp.	*1)

List of cables used

No.	Name	Length (m)	Shield		Remarks
			Cable	Connector	
1	DC Cable	4.0	Unshielded	Unshielded	-
2	DC Cable	1.5	Unshielded	Unshielded	-
3	CAN Cable	4.0	Unshielded	Unshielded	-
4	USB Cable	1.0	Shielded	Shielded	-
5	DC Cable	1.7	Unshielded	Unshielded	-
6	AC Cable	0.9	Unshielded	Unshielded	-
7	AC Cable	2.0	Unshielded	Unshielded	*1)

*1) Used for other tests except for Radiated Emission (Below 1GHz) test.

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 to 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.

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

Test Antennas are used as below;

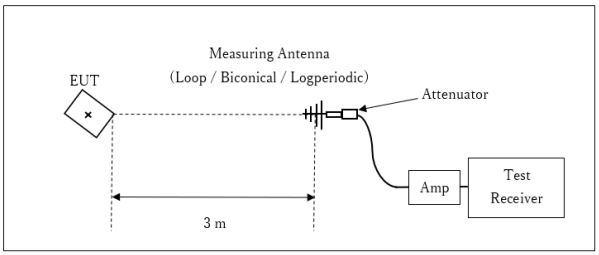
Frequency	Below 30 MHz	30 MHz to 200 MHz	200 MHz to 1 GHz	Above 1 GHz
Antenna Type	Loop	Biconical	Logperiodic	Horn

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]

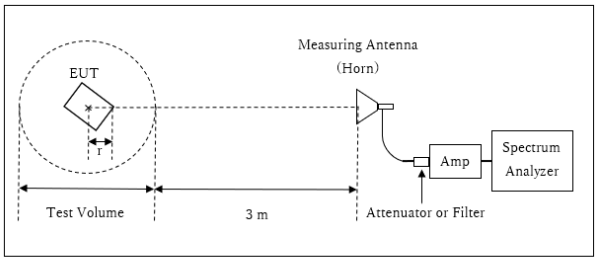
Below 1 GHz



× : Center of turn table

Test Distance: 3 m

1 GHz to 10 GHz

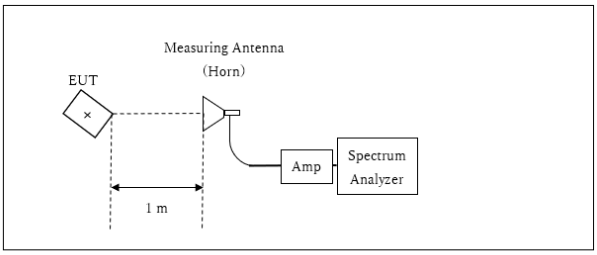


r : Radius of an outer periphery of EUT
× : Center of turn table

Distance Factor: 20 x log (3.67 m*/3.0 m) = 1.76 dB
* Test Distance: (3 + Test Volume /2) - r = 3.67 m

Test Volume: 1.5 m
(Test Volume has been calibrated based on CISPR 16-1-4.)
r = 0.08 m

10 GHz to 40 GHz

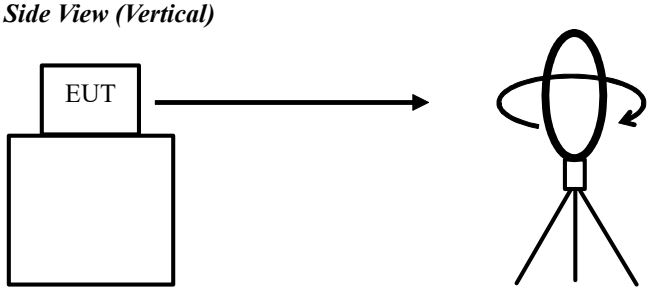


× : Center of turn table

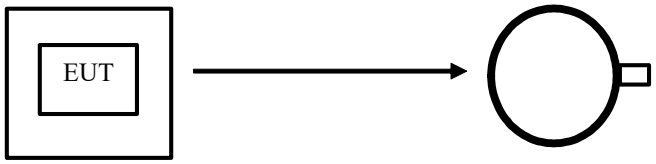
Distance Factor: 20 x log (1.0 m* / 3.0 m) = -9.5 dB
*Test Distance: 1 m

Figure 1: Direction of the Loop Antenna

Side View (Vertical)

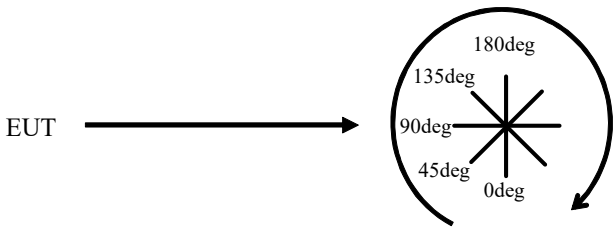


Top View (Horizontal)



Antenna was not rotated.

Top View (Vertical)



Front side: 0 deg.
Forward direction: clockwise

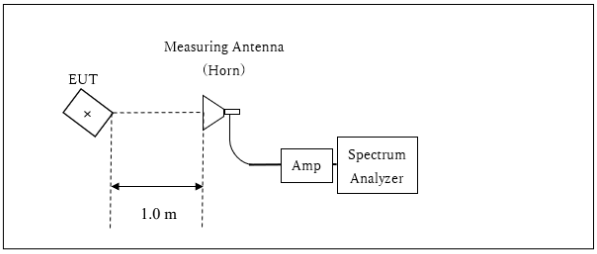
[Above 40 GHz (except for fundamental measurement)]
The test was performed based on "Procedures for testing millimeter-wave systems" of ANSI C63.10-2013.
The EUT was placed on a urethane platform, raised 1.5 m above the conducting ground plane. The measurements were performed on handheld method.

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 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	1.0 m	0.5 m	0.01 m

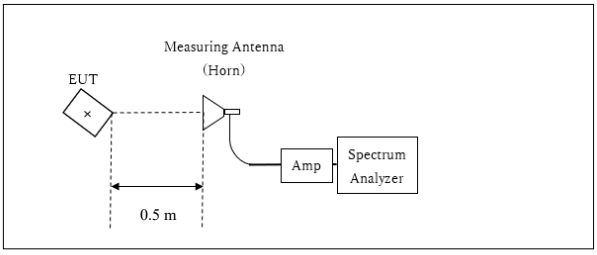
[Test setup]
40 GHz to 76 GHz, 81 GHz to 83 GHz



× : Center of turn table

*Test Distance: 1.0 m

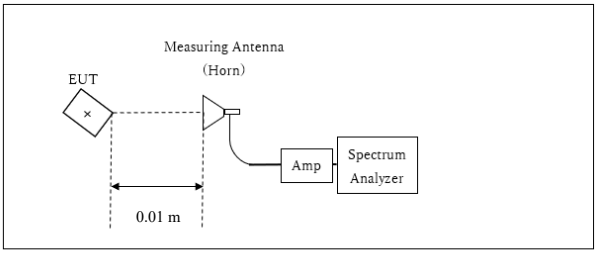
83 GHz to 110 GHz



× : Center of turn table

*Test Distance: 0.5 m

110 GHz to 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 caluculation.)
Lambda is the wavelength of the emission under investigation [300/f (MHz)], in m

Frequency	Wavelength	Maximum Dimention			Far Field Boundary	Tested Distance
		EUT	Test Antenna	Maximum		
	Lambda			*D*	*r*	
[GHz]	[mm]	[m]	[m]	[m]	[m]	[m]
77.000	3.9	0.018500	0.026162	0.026162	0.352	1.5

- 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.

$$\alpha = \frac{1}{\sqrt[4]{1 + \left(\frac{2In(2)}{\pi}\right)^2 \left(\frac{Fs}{Ts\,B^2}\right)^2}}$$

And
FMCW Desensitization factor = 20 Log (α)

Where
*F*s is FMCW Sweep Width or Chirp Width (Use the measured 99% OBW value)
*T*s is FMCW Sweep Time (Use the declared 1 chirp value)
B is -3dB Bandwidth of Gaussian RBW Filter

Mode	F_s	T_s	B	α	FMCW Desensitization factor
	[MHz]	[us]	[MHz]		[dB]
FCM 1 Low	376.4210	66.0	1.0	0.608	-4.33
FCM 1 Mid	375.9792	66.0	1.0	0.608	-4.32
FCM 1 High	376.3674	66.0	1.0	0.608	-4.33
FCM 2 ch 1	894.5179	120.0	1.0	0.539	-5.36
FCM 2 ch 2	894.3576	120.0	1.0	0.539	-5.36
FCM 2 ch 3	894.7242	120.0	1.0	0.539	-5.36

*F*s and *B* were used the actual measurement value, and *T*s was referred to the values in the specifications.

Measurement range : 9 kHz to 231 GHz
Test data : APPENDIX
Test result : Pass

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.

In addition, additional tests were performed with some temperatures according to the customer's request.

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

Test data : APPENDIX
Test result : Pass

APPENDIX 1: Test data

Occupied bandwidth

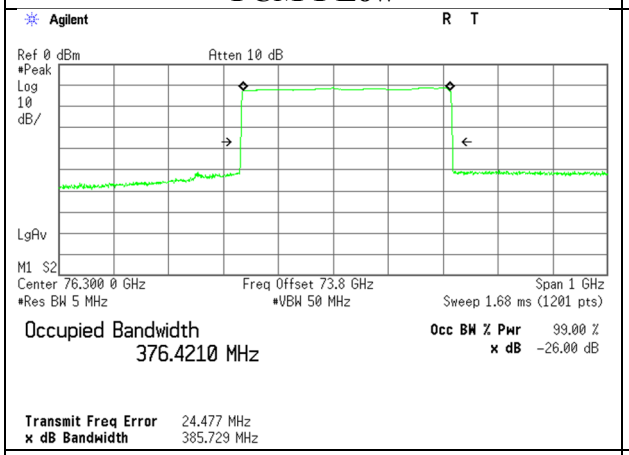
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No. 2
Date	March 7, 2022
Temperature / Humidity	22 deg. C / 38 % RH
Engineer	Yuichiro Yamazaki
Mode	Tx

Mode	Frequency [GHz]	99 % Occupied bandwidth [MHz]
FCM 1 Low	76.3	376.4210
FCM 1 Mid	76.5	375.9792
FCM 1 High	76.7	376.3674
FCM 2 ch 1	76.5	894.5179
FCM 2 ch 2	76.5	894.3576
FCM 2 ch 3	76.5	894.7242
CW ch 1	76.5	25.0235
CW ch 2	76.5	14.3900
CW ch 3	76.5	9.7591

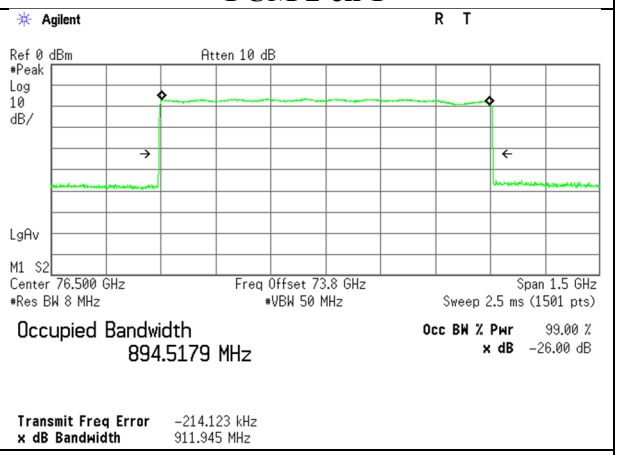
*Since the transmitter signal is CW it is impractical to use a RBW setting of 1 % to 5 % of the emission bandwidth since the emission bandwidth will be proportional to the RBW.

Occupied bandwidth

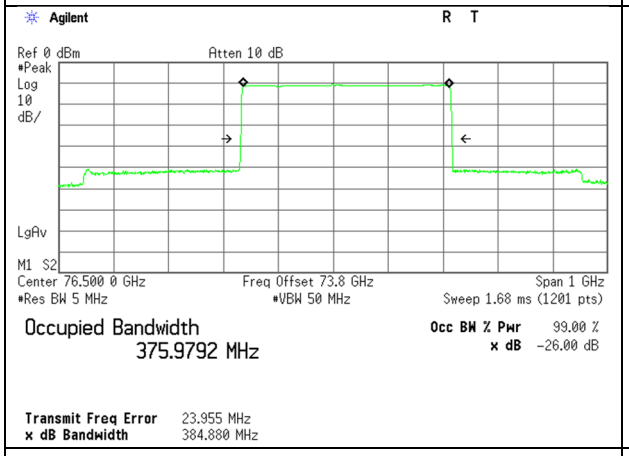
FCM 1 Low



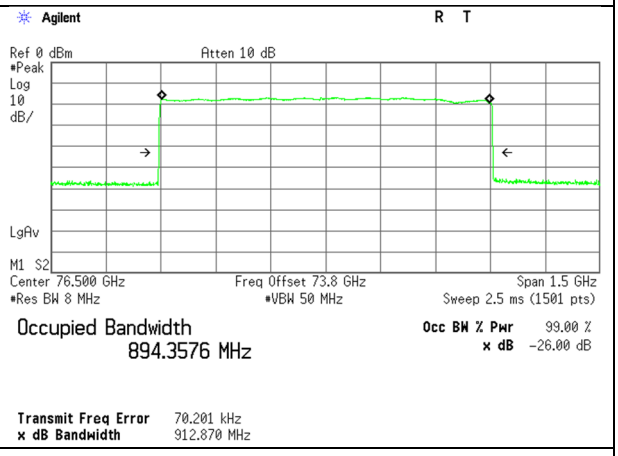
FCM 2 ch 1



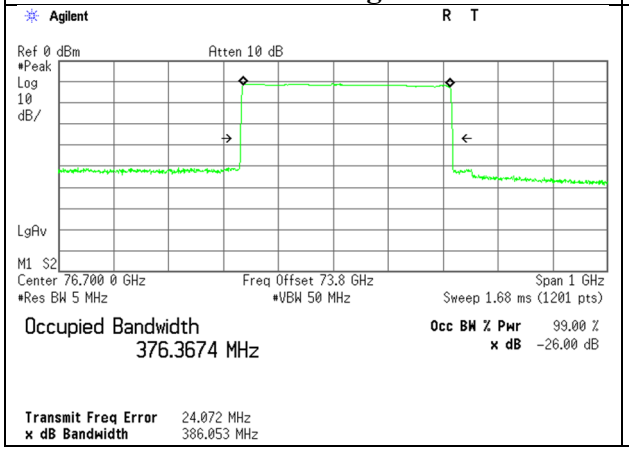
FCM 1 Mid



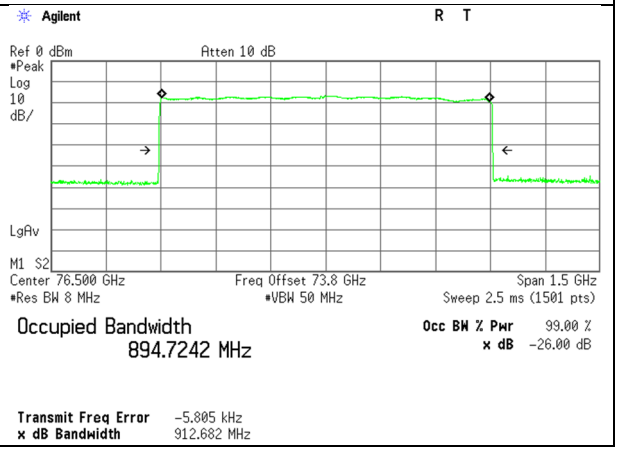
FCM 2 ch 2



FCM 1 High



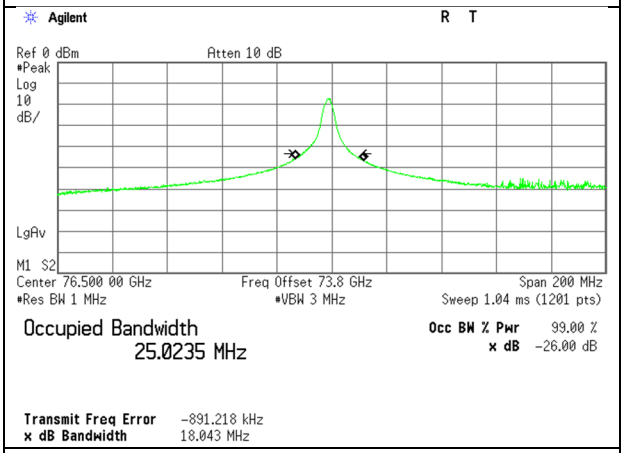
FCM 2 ch 3



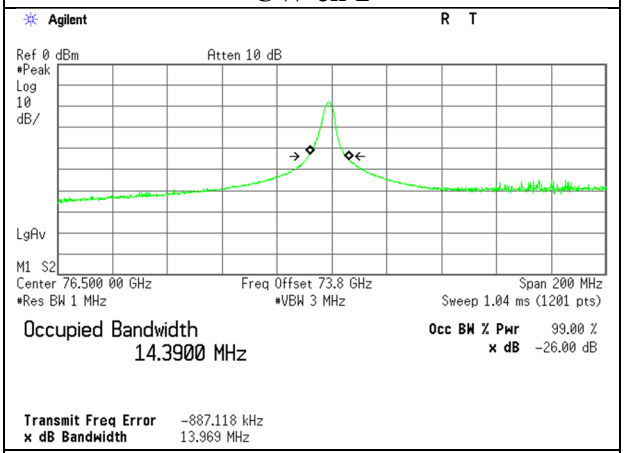
The measurement was performed with Peak detector and Max Hold since the duty cycle was not 100 %.

Occupied bandwidth

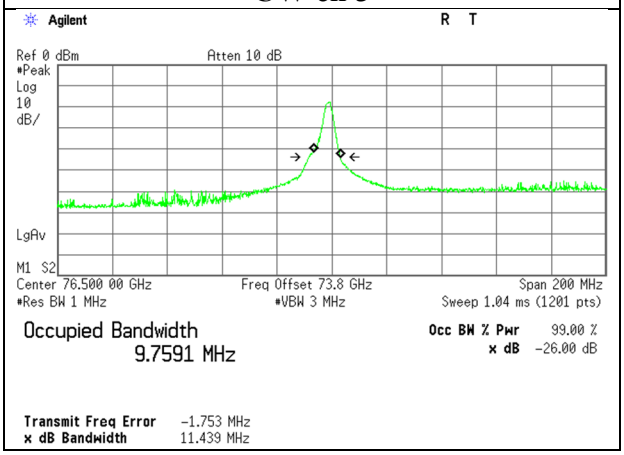
CW ch 1



CW ch 2



CW ch 3



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

Radiated Power

Test place	Ise EMC Lab.	
Semi Anechoic Chamber	No. 2	No. 2
Date	March 7, 2022	March 8, 2022
Temperature / Humidity	22 deg. C / 38 % RH	22 deg. C / 36 % RH
Engineer	Yuichiro Yamazaki	Yuichiro Yamazaki
Mode	Tx	

Mode	Power	Freq.	Measured Power	Tested Distance	Rx Antenna Gain	Down Converter Gain	IF Cable Loss	FSL	Duty Factor	FMCW desensitization Factor	EIRP		Limit	Margin
		[GHz]	[dBm]	[m]	[dBi]	[dB]	[dB]	[dB]	[dB]	[dB]	[mW]	[dBm]	[dBm]	[dB]
FCM 1	Average	76.3	-18.23	1.5	23.05	14.65	1.39	73.61	4.44	-	224.39	23.51	50	26.49
Low	Peak	76.3	-11.58	1.5	23.05	14.65	1.39	73.61	-	-4.33	1011.58	30.05	55	24.95
FCM 1	Average	76.5	-17.74	1.5	23.06	14.73	1.44	73.64	4.44	-	250.61	23.99	50	26.01
Mid	Peak	76.5	-11.00	1.5	23.06	14.73	1.44	73.64	-	-4.32	1150.80	30.61	55	24.39
FCM 1	Average	76.7	-18.08	1.5	23.06	14.81	1.49	73.66	4.44	-	231.21	23.64	50	26.36
High	Peak	76.7	-10.73	1.5	23.06	14.81	1.49	73.66	-	-4.33	1224.62	30.88	55	24.12
FCM 2	Average	76.5	-43.58	1.5	23.06	14.65	1.39	73.64	25.77	-	89.33	19.51	50	30.49
ch 1	Peak	76.5	-19.89	1.5	23.06	14.65	1.39	73.64	-	-5.36	190.11	22.79	55	32.21
FCM 2	Average	76.5	-43.50	1.5	23.06	14.65	1.39	73.64	25.76	-	90.78	19.58	50	30.42
ch 2	Peak	76.5	-19.90	1.5	23.06	14.65	1.39	73.64	-	-5.36	189.67	22.78	55	32.22
FCM 2	Average	76.5	-43.18	1.5	23.06	14.65	1.39	73.64	25.76	-	97.72	19.90	50	30.10
ch 3	Peak	76.5	-19.00	1.5	23.06	14.65	1.39	73.64	-	-5.36	233.35	23.68	55	31.32
CW	Average	76.5	-22.57	1.5	23.06	14.65	1.39	73.64	4.95	-	93.33	19.70	50	30.30
ch 1	Peak	76.5	-16.52	1.5	23.06	14.65	1.39	73.64	-	-	120.23	20.80	55	34.20
CW	Average	76.5	-24.24	1.5	23.06	14.65	1.39	73.64	4.89	-	62.66	17.97	50	32.03
ch 2	Peak	76.5	-18.29	1.5	23.06	14.65	1.39	73.64	-	-	79.98	19.03	55	35.97
CW	Average	76.5	-23.32	1.5	23.06	14.65	1.39	73.64	4.83	-	76.38	18.83	50	31.17
ch 3	Peak	76.5	-17.63	1.5	23.06	14.65	1.39	73.64	-	-	93.11	19.69	55	35.31

Calculating formula:

FSL (Free Space path Loss) = 10 * log10((4 * Pi * Tested Distance / 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 - FCMW desensitization factor

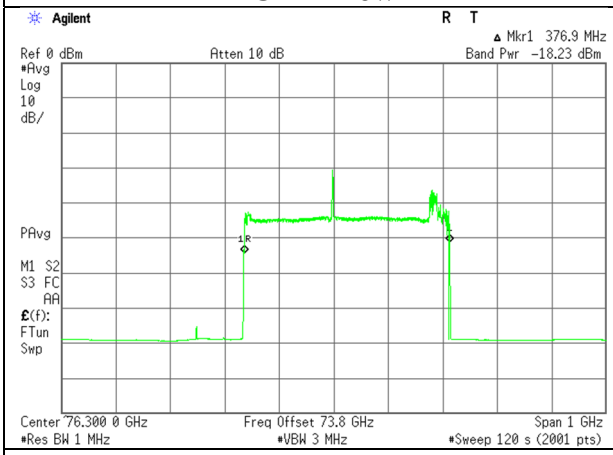
These calculation results are same as results which were calculated with formulas described in the Section 9 of ANSI C63.10-2013.

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)

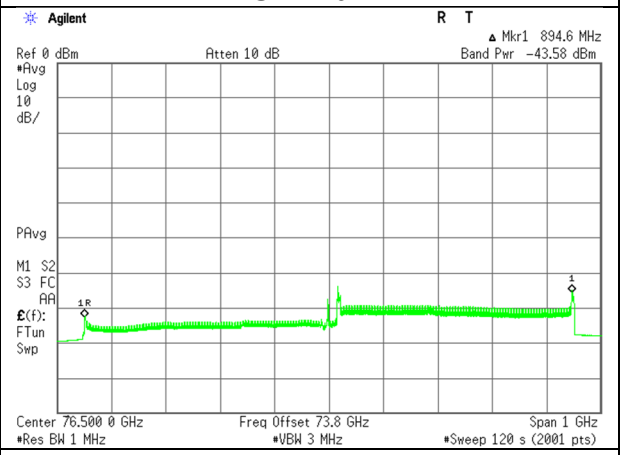
Radiated Power

Average

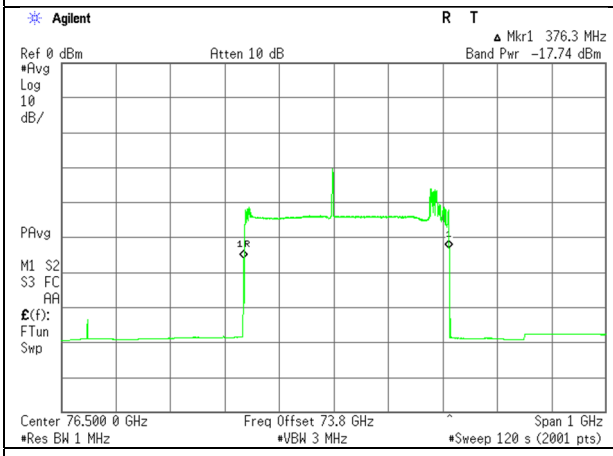
FCM 1 Low



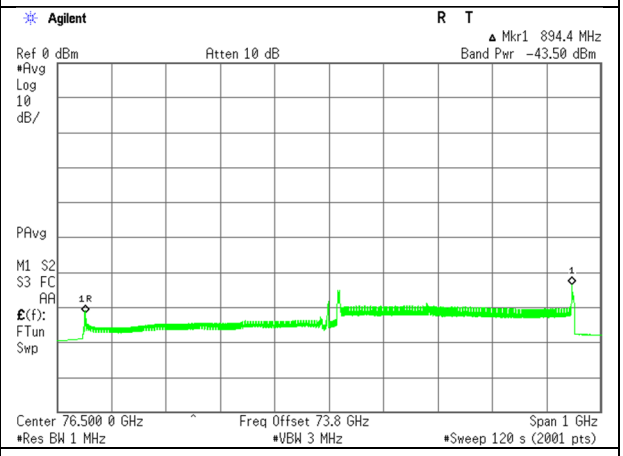
FCM 2 ch 1



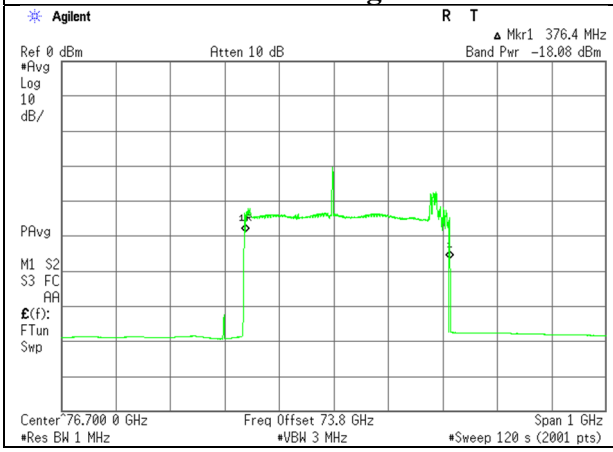
FCM 1 Mid



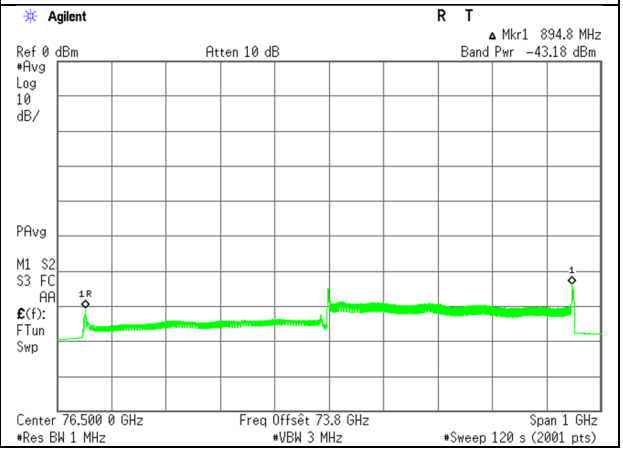
FCM 2 ch 2



FCM 1 High



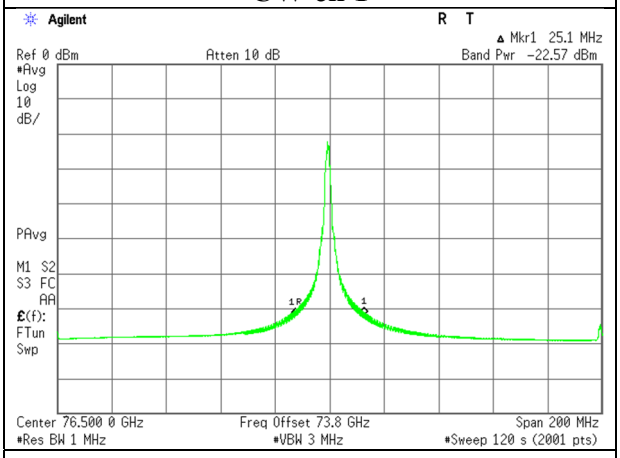
FCM 2 ch 3



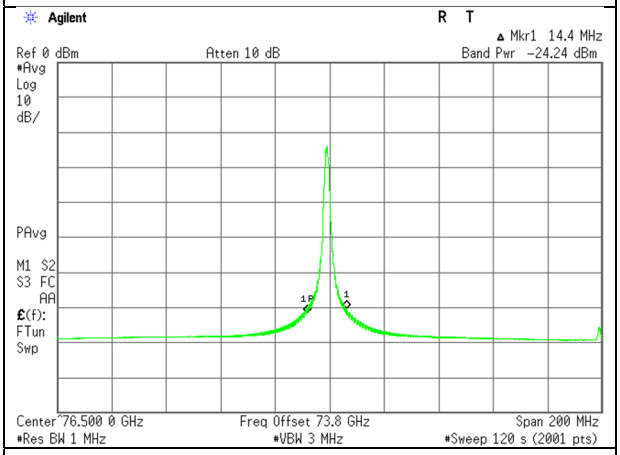
Radiated Power

Average

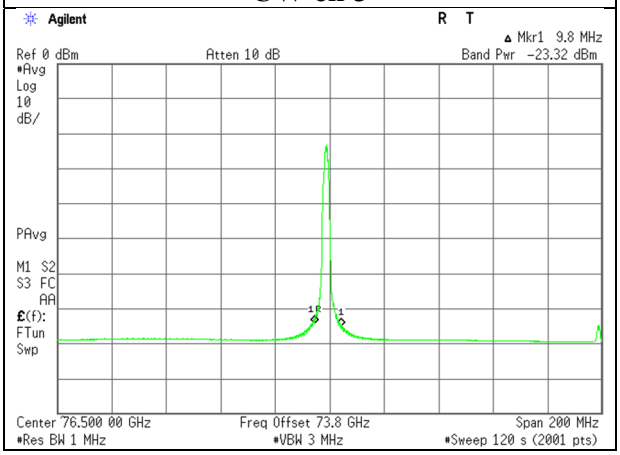
CW ch 1



CW ch 2



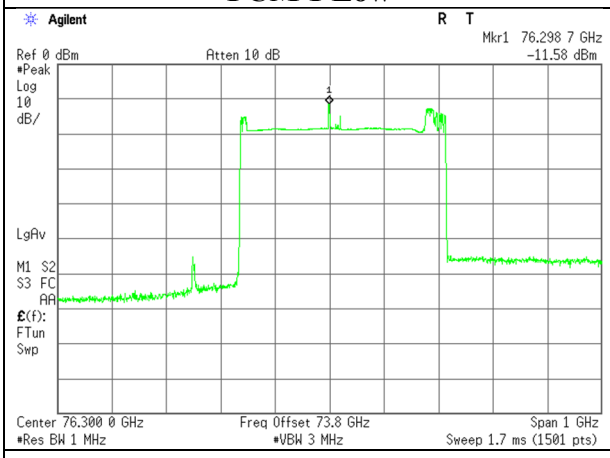
CW ch 3



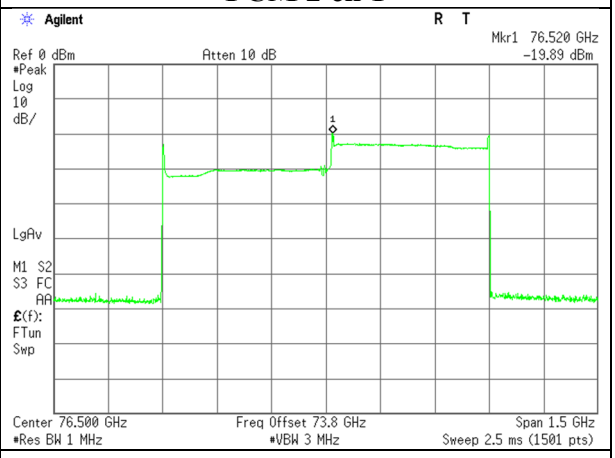
Radiated Power

Peak

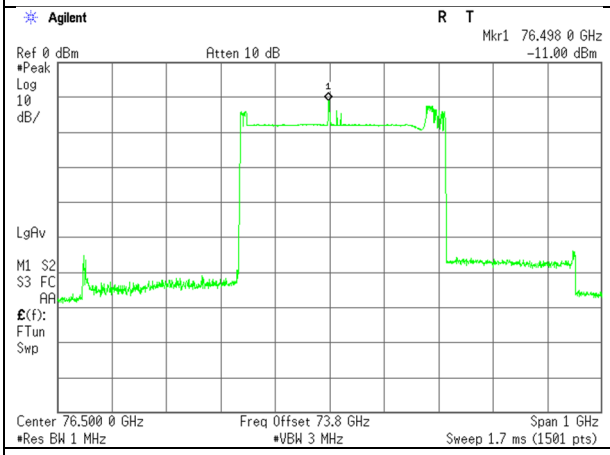
FCM 1 Low



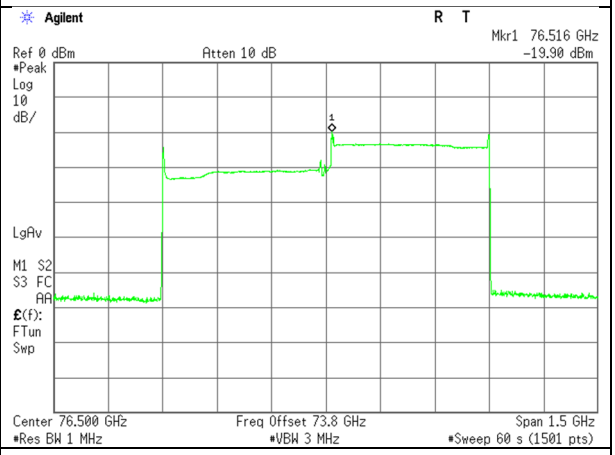
FCM 2 ch 1



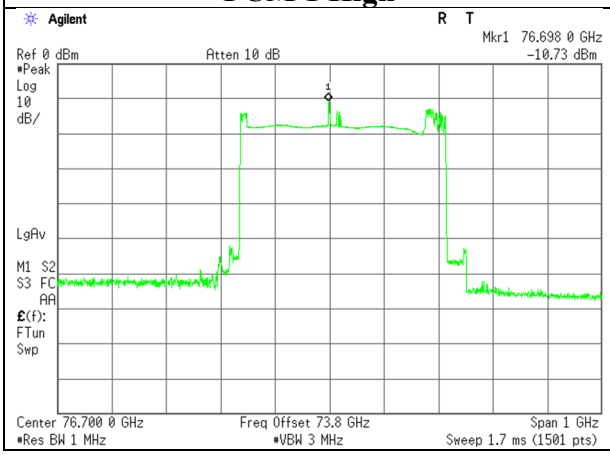
FCM 1 Mid



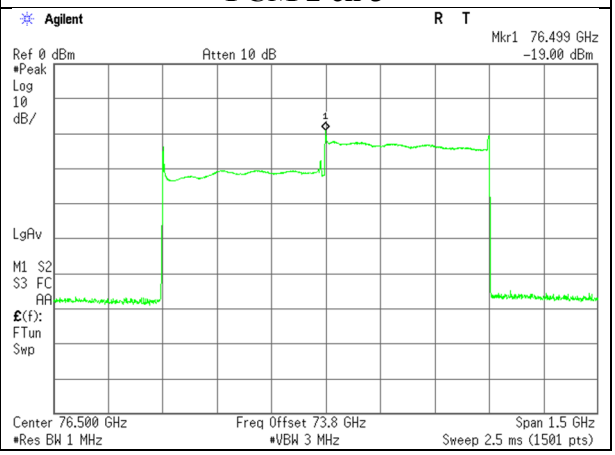
FCM 2 ch 2



FCM 1 High



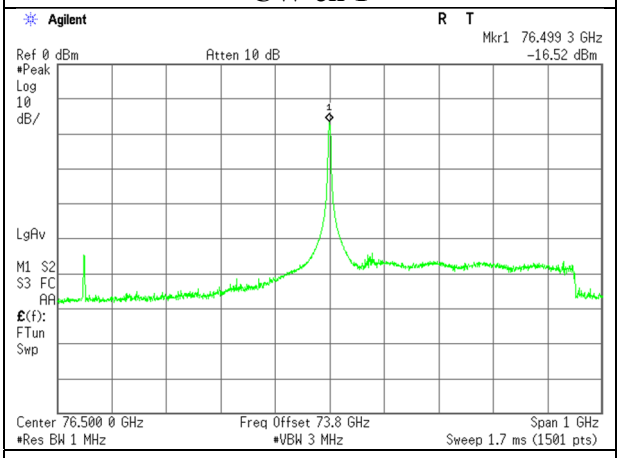
FCM 2 ch 3



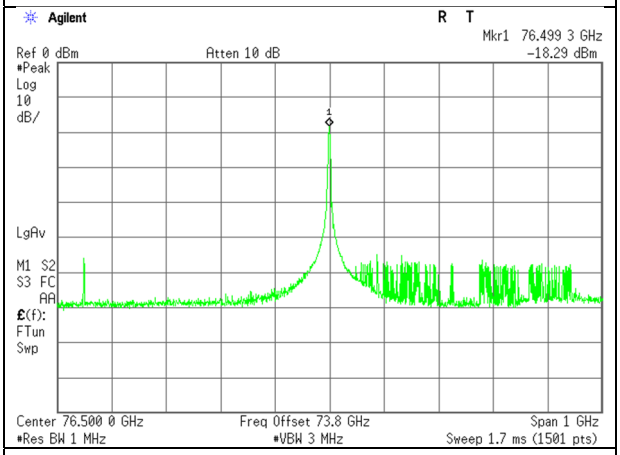
Radiated Power

Peak

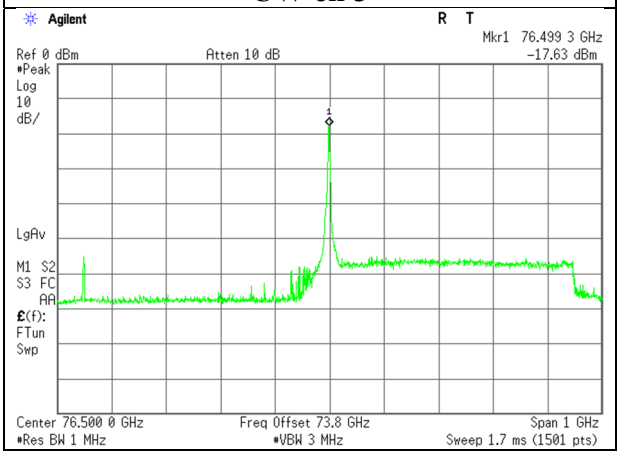
CW ch 1



CW ch 2



CW ch 3



Duty

Test place	Ise EMC Lab.
Semi Anechoic Chamber	No. 2
Date	March 8, 2022
Temperature / Humidity	22 deg. C / 36 % RH
Engineer	Yuichiro Yamazaki
Mode	Tx

Mode	Tx On time [ms]	Tx On + Tx Off time [ms]	Duty Factor [dB]
FCM 1 Low	17.99	50.00	-4.44
FCM 1 Mid	17.99	50.00	-4.44
FCM 1 High	17.99	50.00	-4.44
FCM 2 ch 1	0.135	51.10	-25.77
FCM 2 ch 2	0.135	51.09	-25.76
FCM 2 ch 3	0.135	51.10	-25.76
CW ch 1	15.99	50.00	-4.95
CW ch 2	16.22	50.00	-4.89
CW ch 3	16.45	50.00	-4.83

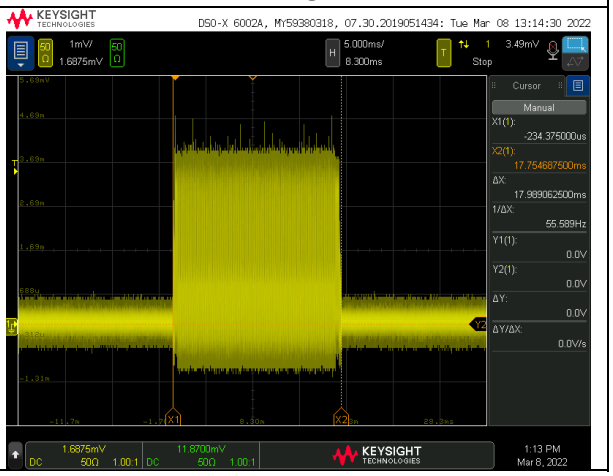
Calculation: Duty Factor = 10 * log(Tx On time / Tx On + Tx Off time)

Duty

FCM 1 Low

Tx On + Tx Off

Tx On



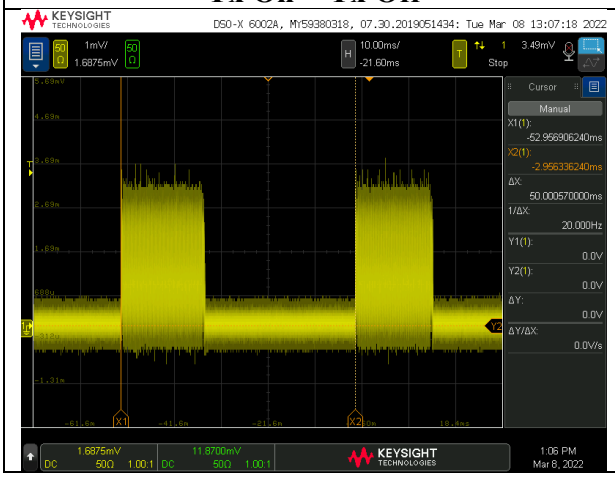
FCM 1 Mid

Tx On + Tx Off

Tx On

FCM 1 High

Tx On + Tx Off

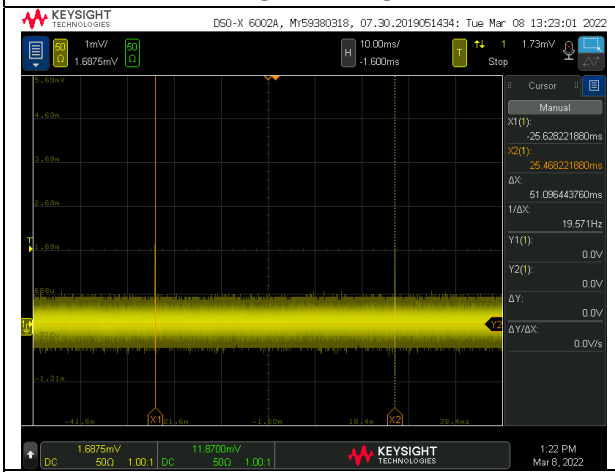


Tx On

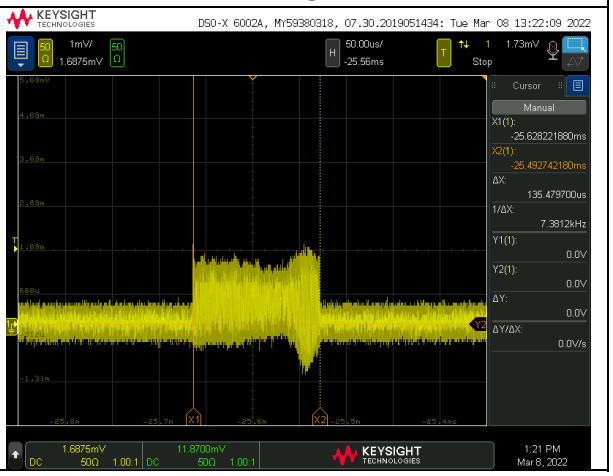
Duty

FCM 2 ch 1

Tx On + Tx Off

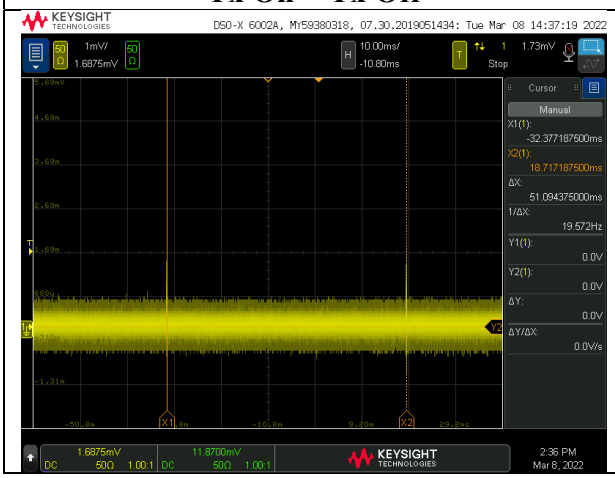


Tx On

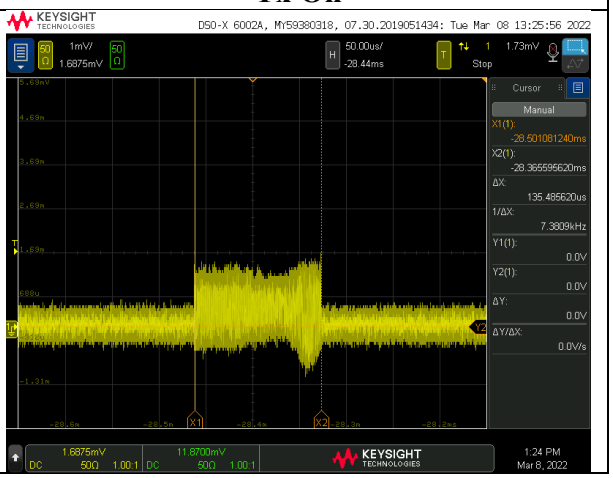


FCM 2 ch 2

Tx On + Tx Off



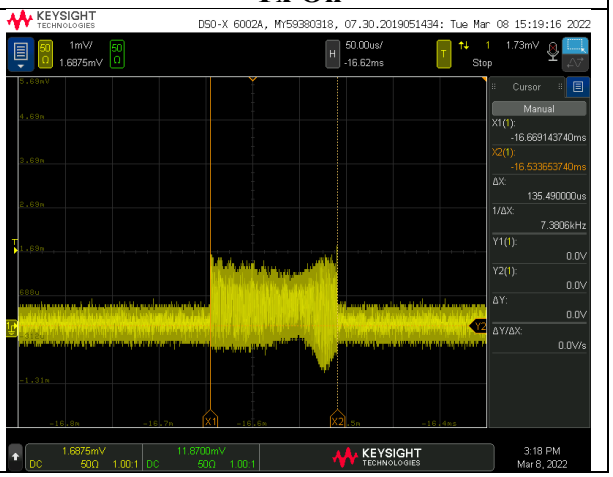
Tx On



FCM 2 ch 3

Tx On + Tx Off

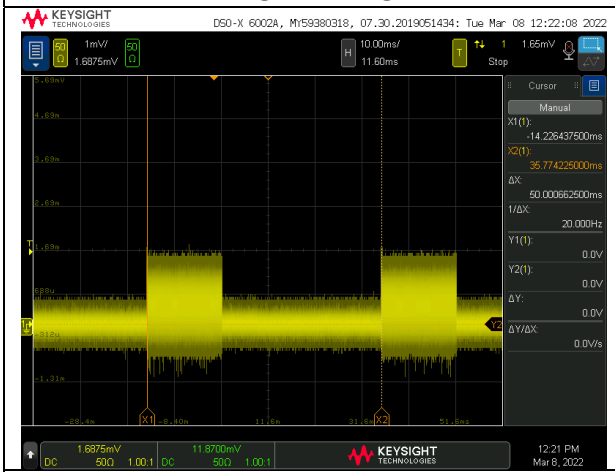
Tx On



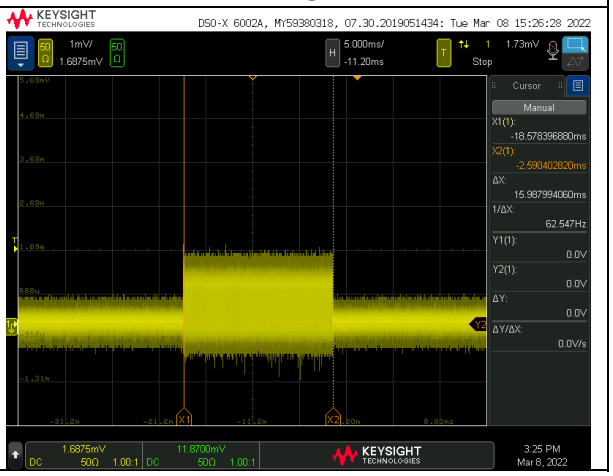
Duty

CW ch 1

Tx On + Tx Off

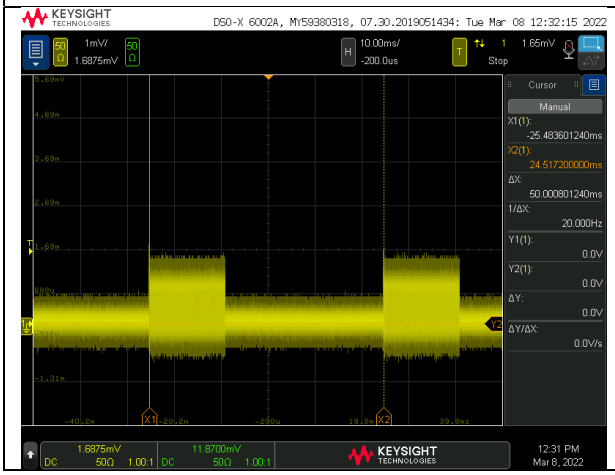


Tx On

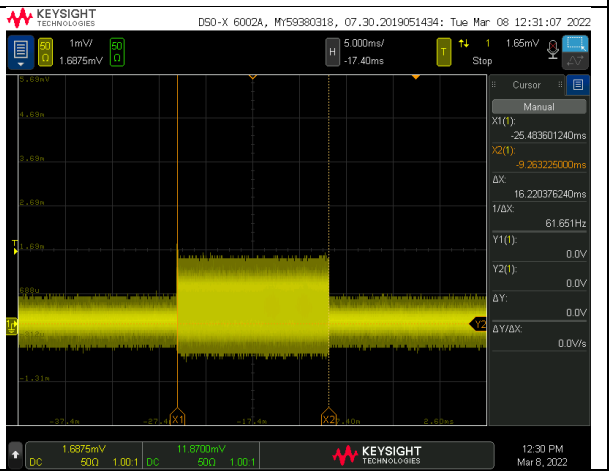


CW ch 2

Tx On + Tx Off

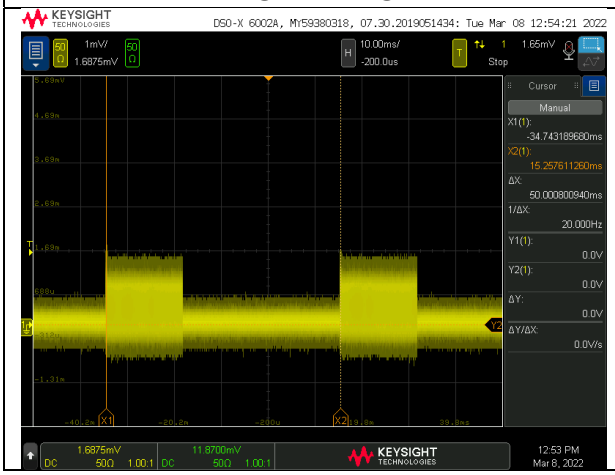


Tx On

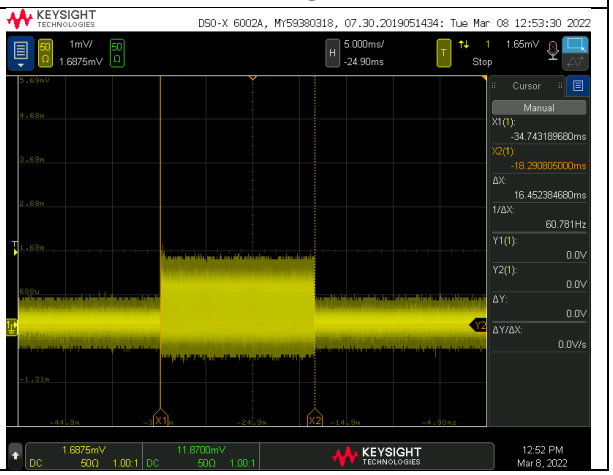


CW ch 3

Tx On + Tx Off



Tx On



Modulation characteristics

Test place	Ise EMC Lab.
Semi Anechoic Chamber	No. 2
Date	March 8, 2022
Temperature / Humidity	22 deg. C / 36 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode

[Duty Factor]

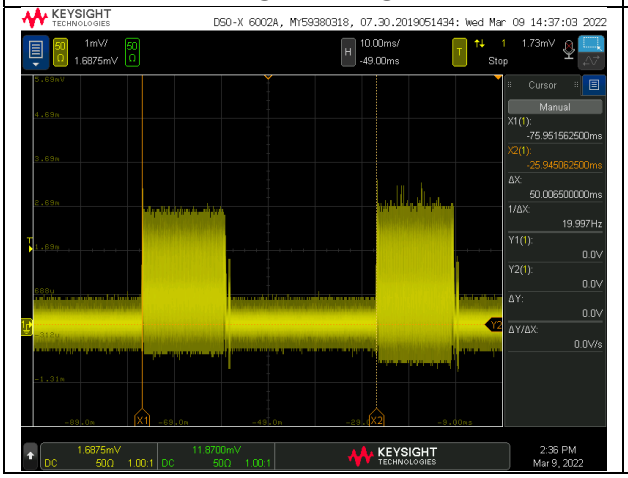
	Tx On time [ms]	Tx On + Tx Off time [ms]	Duty factor [dB]
Measured	18.89	50.00	-4.23
Declared *	18.60	50.00	-4.29

Duty factor = 10 * log (Tx On time / Tx On + Tx Off time)
* See the application document.

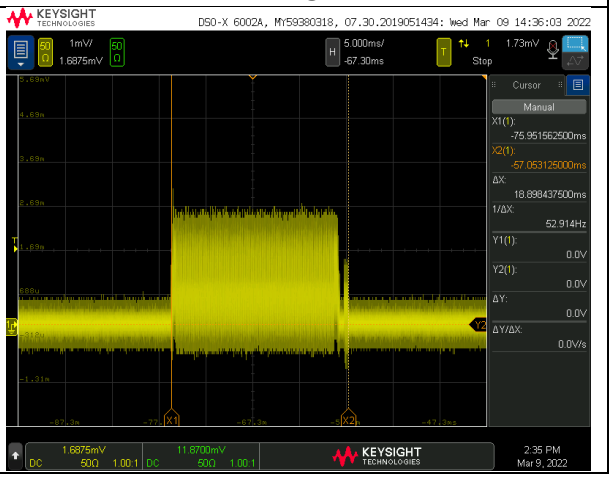
[Data]

(Reference) Normal operating mode

Tx On + Tx Off



Tx On



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

Field strength of spurious radiation
(Below 40 GHz)

Test place	Ise EMC Lab.	
Semi Anechoic Chamber	No. 4	No. 2
Date	March 6, 2022	March 11, 2022
Temperature / Humidity	21 deg. C / 33 % RH	22 deg. C / 36 % RH
Engineer	Shinya Watanabe (Below 1 GHz)	Yuichiro Yamazaki (Above 1 GHz)
Mode	Normal operating mode	

Polarity [Hori/Vert]	Frequency [MHz]	Reading (QP / PK) [dBuV]	Reading (AV) [dBuV]	Ant. Factor [dB/m]	Loss [dB]	Gain [dB]	Duty Factor [dB]	Result (QP / PK) [dBuV/m]	Result (AV) [dBuV/m]	Limit (QP / PK) [dBuV/m]	Limit (AV) [dBuV/m]	Margin (QP / PK) [dB]	Margin (AV) [dB]	Remark
Hori.	32.9	23.2	-	17.5	7.1	32.2	-	15.5	-	40.0	-	24.6	-	
Hori.	38.5	24.2	-	15.4	7.1	32.2	-	14.6	-	40.0	-	25.4	-	
Hori.	54.2	22.6	-	9.7	7.4	32.2	-	7.4	-	40.0	-	32.6	-	
Hori.	60.0	24.9	-	7.8	7.4	32.2	-	7.9	-	40.0	-	32.1	-	
Hori.	240.0	34.0	-	11.8	9.0	32.0	-	22.7	-	46.0	-	23.3	-	
Hori.	280.1	26.4	-	13.6	9.3	32.0	-	17.2	-	46.0	-	28.8	-	
Hori.	339.4	25.0	-	15.1	9.7	32.0	-	17.8	-	46.0	-	28.2	-	
Vert.	33.1	28.7	-	17.4	7.1	32.2	-	21.0	-	40.0	-	19.0	-	
Vert.	38.9	30.8	-	15.3	7.1	32.2	-	21.0	-	40.0	-	19.0	-	
Vert.	54.2	30.7	-	9.7	7.4	32.2	-	15.5	-	40.0	-	24.5	-	
Vert.	60.0	32.6	-	7.8	7.4	32.2	-	15.7	-	40.0	-	24.3	-	
Vert.	240.0	30.0	-	11.8	9.0	32.0	-	18.7	-	46.0	-	27.3	-	
Vert.	280.1	24.2	-	13.6	9.3	32.0	-	15.0	-	46.0	-	31.0	-	
Vert.	339.4	22.8	-	15.1	9.7	32.0	-	15.5	-	46.0	-	30.5	-	

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

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

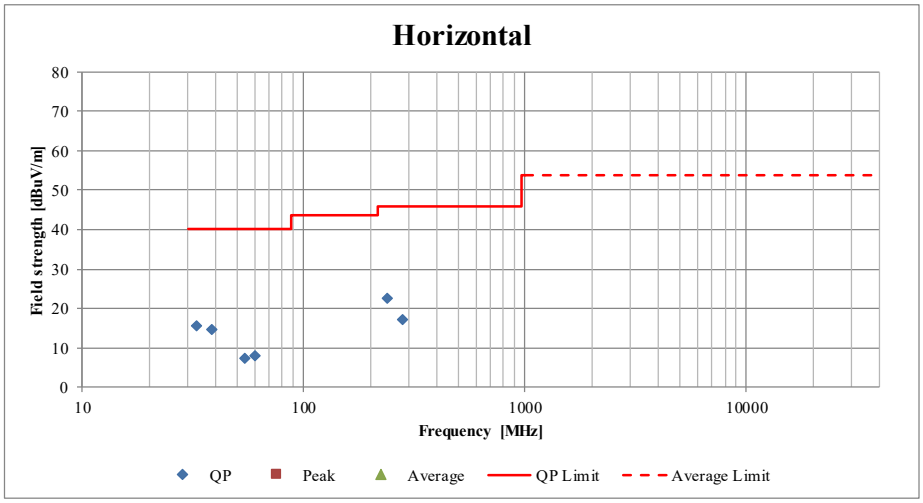
*Other frequency noises omitted in this report were not seen or had enough margin (more than 20 dB).

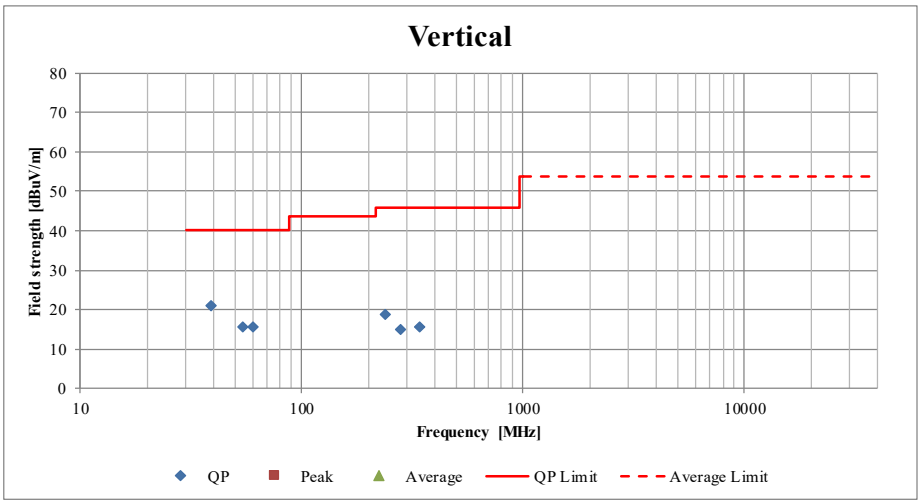
*QP detector was used up to 1GHz.

Distance factor: 1 GHz - 10 GHz 20log (3.67 m / 3.0 m) = 1.76 dB
10 GHz - 40 GHz 20log (1.0 m / 3.0 m) = -9.5 dB

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

Test place	Ise EMC Lab.	
Semi Anechoic Chamber	No. 4	No. 3
Date	March 6, 2022	March 11, 2022
Temperature / Humidity	21 deg. C / 33 % RH	22 deg. C / 36 % RH
Engineer	Shinya Watanabe (Below 1 GHz)	Yuichiro Yamazaki (Above 1 GHz)
Mode	Normal operating mode	





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

Field strength of spurious radiation
(Above 40 GHz)

Test place	Ise EMC Lab.
Semi Anechoic Chamber	No. 2
Date	March 9, 2022
Temperature / Humidity	22deg. C / 34 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode

Freq.	Reading	Rx Ant. gain	Filter loss	LNA gain	Mixer loss	IF cable loss	Meas. range *D*	FSL	EIRP		Power density at 3 m Result	Limit	Margin	Remarks
[GHz]	[dBm]	[dBi]	[dB]	[dB]	[dB]	[dB]	[m]	[dB]	[dBm]	[mW]	[pW/cm^2]	[pW/cm^2]	[dB]	
48.741	-58.28	22.18	0.00	32.50	0.00	8.94	1.0	66.20	-37.82	0.000165	0.15	600	36.14	NS
54.735	-69.00	23.27	0.22	26.73	0.00	0.00	1.0	67.21	-51.57	0.000007	0.01	600	49.89	NS
68.994	-64.06	24.34	0.44	21.79	0.00	0.00	1.0	69.22	-40.53	0.000089	0.08	600	38.85	NS
74.992	-61.45	24.50	2.23	20.78	0.00	0.00	1.0	69.94	-34.56	0.000350	0.31	600	32.87	NS
75.945	-82.20	23.04	0.00	0.00	-14.58	1.28	1.0	70.05	-48.49	0.000014	0.01	600	46.80	Average detected
82.596	-75.91	23.51	0.00	0.00	-12.27	2.68	1.0	70.78	-38.23	0.000150	0.13	600	36.54	NS
84.701	-55.81	23.66	0.52	31.74	0.00	0.00	0.5	64.98	-45.71	0.000027	0.02	600	44.03	NS
99.886	-49.01	24.50	0.28	33.28	0.00	0.00	0.5	66.41	-40.10	0.000098	0.09	600	38.41	NS
102.406	-47.16	24.55	0.32	32.11	0.00	0.00	0.5	66.63	-36.87	0.000206	0.18	600	35.18	NS
117.050	-87.17	22.54	0.00	18.20	55.50	0.00	0.01	33.81	-38.60	0.000138	0.12	600	36.92	NS
118.022	-87.24	22.57	0.00	18.73	57.77	0.00	0.01	33.88	-36.89	0.000205	0.18	600	35.20	NS
131.402	-87.83	22.99	0.00	20.02	53.92	0.00	0.01	34.81	-42.11	0.000062	0.05	600	40.42	NS
140.291	-89.23	23.19	0.00	18.70	55.90	0.00	0.01	35.38	-39.84	0.000104	0.09	600	38.16	NS
142.645	-90.28	23.23	0.00	19.24	55.84	0.00	0.01	35.53	-41.39	0.000073	0.06	600	39.70	NS
152.984	-90.77	23.35	0.00	18.13	57.82	0.00	0.01	36.13	-38.30	0.000148	0.13	600	36.61	NS
160.274	-91.68	23.40	0.00	16.37	60.13	0.00	0.01	36.54	-34.78	0.000332	0.29	600	33.10	NS
166.311	-92.82	23.41	0.00	13.97	61.83	0.00	0.01	36.86	-31.51	0.000706	0.62	600	29.83	NS
171.437	-86.84	22.43	0.00	0.00	59.24	0.00	0.01	37.12	-12.91	0.051190	45.26	600	11.22	NS
185.953	-88.61	22.76	0.00	0.00	58.00	0.00	0.01	37.83	-15.54	0.027931	24.70	600	13.86	NS
187.147	-87.90	22.78	0.00	0.00	55.91	0.00	0.01	37.89	-16.88	0.020514	18.14	600	15.20	NS
197.612	-89.23	22.98	0.00	0.00	56.96	0.00	0.01	38.36	-16.89	0.020446	18.08	600	15.21	NS
207.377	-89.72	23.13	0.00	0.00	57.76	0.00	0.01	38.78	-16.32	0.023351	20.65	1000	16.85	NS
208.045	-90.29	23.14	0.00	0.00	55.43	0.00	0.01	38.80	-19.20	0.012033	10.64	1000	19.73	NS
219.215	-91.20	23.26	0.00	0.00	55.46	0.00	0.01	39.26	-19.74	0.010620	9.39	1000	20.27	NS
224.431	-92.15	23.31	0.00	0.00	62.62	0.00	0.01	39.46	-13.37	0.045988	40.66	1000	13.91	NS

Calculation:

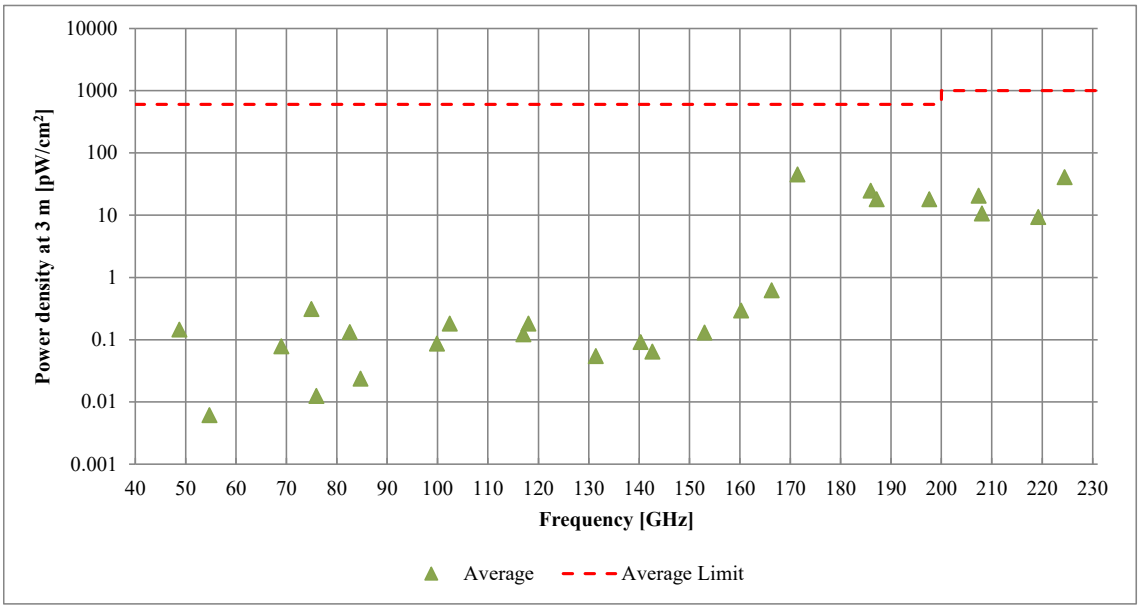
FSL (Free Space path Loss) = 10 * log $((4 * Pi * D / \lambda)^2)$
EIRP = Reading - Rx Ant. gain + Filter loss - LNA gain + Mixer loss + IF cable loss + FSL
Power density Result at 3 m = EIRP / $(4 * Pi * 300^2)$

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 converion loss is automatically corrected in the mixer, so the factor of data sheet were 0 dB.

NS: No signal detected.

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

Test place	Ise EMC Lab.
Semi Anechoic Chamber	No. 2
Date	March 9, 2022
Temperature / Humidity	22deg. C / 34 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode



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

Frequency Stability

Test place	Ise EMC Lab.	
Shielded Room	No. 6	No. 6
Date	March 14, 2022	March 15, 2022
Temperature / Humidity	25 deg. C / 31 % RH	23 deg. C / 29 % RH
Engineer	Yuichiro Yamazaki	Yuichiro Yamazaki
Mode	Tx	

FCM 1 Low

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
51.3	12.0	76.131	76.516	Customer requested temperature
50	12.0	76.131	76.516	
40	12.0	76.131	76.516	
30	12.0	76.131	76.516	
20	12.0	76.131	76.516	
20	10.2	76.132	76.516	85 % of the minimum operating voltage, DC 12 V * 0.85
20	13.8	76.132	76.516	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.132	76.517	
0	12.0	76.133	76.516	
-10	12.0	76.133	76.516	
-20	12.0	76.133	76.518	
-30	12.0	76.134	76.518	Customer requested temperature

FCM 1 Mid

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
51.3	12.0	76.331	76.717	Customer requested temperature
50	12.0	76.331	76.717	
40	12.0	76.331	76.717	
30	12.0	76.331	76.717	
20	12.0	76.331	76.717	
20	10.2	76.332	76.717	85 % of the minimum operating voltage, DC 12 V * 0.85
20	13.8	76.332	76.717	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.332	76.717	
0	12.0	76.332	76.717	
-10	12.0	76.333	76.717	
-20	12.0	76.334	76.718	
-30	12.0	76.334	76.718	Customer requested temperature

FCM 1 High

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
51.3	12.0	76.531	76.918	Customer requested temperature
50	12.0	76.531	76.918	
40	12.0	76.531	76.918	
30	12.0	76.531	76.918	
20	12.0	76.531	76.918	
20	10.2	76.531	76.918	85 % of the minimum operating voltage, DC 12 V * 0.85
20	13.8	76.532	76.918	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.532	76.918	
0	12.0	76.532	76.918	
-10	12.0	76.532	76.918	
-20	12.0	76.534	76.918	
-30	12.0	76.534	76.918	Customer requested temperature

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

Frequency Stability

Test place	Ise EMC Lab.	
Shielded Room	No. 6	No. 6
Date	March 14, 2022	March 15, 2022
Temperature / Humidity	25 deg. C / 31 % RH	23 deg. C / 29 % RH
Engineer	Yuichiro Yamazaki	Yuichiro Yamazaki
Mode	Tx	

FCM 2 ch 1

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
51.3	12.0	76.043	76.956	Customer requested temperature
50	12.0	76.043	76.956	
40	12.0	76.043	76.956	
30	12.0	76.043	76.956	
20	12.0	76.044	76.956	
20	10.2	76.044	76.956	85 % of the minimum operating voltage, DC 12 V * 0.85
20	13.8	76.044	76.956	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.045	76.958	
0	12.0	76.046	76.958	
-10	12.0	76.046	76.958	
-20	12.0	76.046	76.958	
-30	12.0	76.048	76.959	Customer requested temperature

FCM 2 ch 2

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
51.3	12.0	76.043	76.956	Customer requested temperature
50	12.0	76.043	76.956	
40	12.0	76.043	76.956	
30	12.0	76.043	76.956	
20	12.0	76.044	76.956	
20	10.2	76.044	76.956	85 % of the minimum operating voltage, DC 12 V * 0.85
20	13.8	76.044	76.958	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.045	76.958	
0	12.0	76.046	76.958	
-10	12.0	76.046	76.958	
-20	12.0	76.048	76.959	
-30	12.0	76.048	76.959	Customer requested temperature

FCM 2 ch 3

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
51.3	12.0	76.043	76.956	Customer requested temperature
50	12.0	76.043	76.956	
40	12.0	76.043	76.956	
30	12.0	76.043	76.956	
20	12.0	76.044	76.956	
20	10.2	76.044	76.956	85 % of the minimum operating voltage, DC 12 V * 0.85
20	13.8	76.044	76.956	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.045	76.958	
0	12.0	76.046	76.958	
-10	12.0	76.046	76.958	
-20	12.0	76.046	76.959	
-30	12.0	76.048	76.959	Customer requested temperature

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

Frequency Stability

Test place	Ise EMC Lab.	
Shielded Room	No. 6	No. 6
Date	March 14, 2022	March 15, 2022
Temperature / Humidity	25 deg. C / 31 % RH	23 deg. C / 29 % RH
Engineer	Yuichiro Yamazaki	Yuichiro Yamazaki
Mode	Tx	

CW ch 1

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
51.3	12.0	76.478	76.520	Customer requested temperature
50	12.0	76.478	76.521	
40	12.0	76.478	76.521	
30	12.0	76.478	76.518	
20	12.0	76.478	76.520	
20	10.2	76.479	76.520	85 % of the minimum operating voltage, DC 12 V * 0.85
20	13.8	76.479	76.520	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.479	76.523	
0	12.0	76.478	76.523	
-10	12.0	76.481	76.522	
-20	12.0	76.481	76.522	
-30	12.0	76.482	76.523	Customer requested temperature

CW ch 2

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
51.3	12.0	76.479	76.518	Customer requested temperature
50	12.0	76.480	76.518	
40	12.0	76.478	76.518	
30	12.0	76.480	76.520	
20	12.0	76.481	76.519	
20	10.2	76.481	76.520	85 % of the minimum operating voltage, DC 12 V * 0.85
20	13.8	76.481	76.520	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.482	76.517	
0	12.0	76.483	76.518	
-10	12.0	76.483	76.520	
-20	12.0	76.483	76.520	
-30	12.0	76.484	76.520	Customer requested temperature

CW ch 3

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
51.3	12.0	76.487	76.509	Customer requested temperature
50	12.0	76.486	76.509	
40	12.0	76.486	76.509	
30	12.0	76.487	76.511	
20	12.0	76.487	76.510	
20	10.2	76.487	76.512	85 % of the minimum operating voltage, DC 12 V * 0.85
20	13.8	76.487	76.512	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.488	76.512	
0	12.0	76.488	76.512	
-10	12.0	76.488	76.513	
-20	12.0	76.488	76.513	
-30	12.0	76.489	76.513	Customer requested temperature

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

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-41	192300	Thermo-Hygrometer	CUSTOM. Inc	CTH-201	0013	12/19/2021	12
RE	MMM-01	141542	Digital Tester	Fluke Corporation	FLUKE 26-3	78030611	08/10/2021	12
RE	COTS-MEMI-02	178648	EMI measurement program	TSJ (Techno Science Japan)	TEPTO-DV	-	-	-
RE	MAEC-02-SVSWR	142006	AC2_Semi Anechoic Chamber(SVSWR)	TDK	Semi Anechoic Chamber 3m	DA-06902	04/09/2021	24
RE	MSA-04	141885	Spectrum Analyzer	Keysight Technologies Inc	E4448A	US44300523	11/10/2021	12
RE	MMX-05	142050	Block Downconverter	Keysight Technologies Inc	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	MCC-67	141329	Microwave Cable 1G-40GHz	Suhner	SUCOFLEX102	28635/2	04/12/2021	12
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	MPA-23	142055	Power Amplifier	SAGE Millimeter, Inc.	SBP-5037532015-1515-N1	11599-01	03/05/2021	12
RE	MLF-01	201432	WR-15 Low Pass Filter	Oshima Prototype Engineering Co.	2020-0142-02	001	09/29/2021	12
RE	MMX-08	186077	Wave guide Harmonic Mixer	Keysight Technologies Inc	M1971W	MY56390146	05/18/2021	12
RE	MHF-29	154635	High Pass Filter 83 GHz - 110 GHz	Oshima Prototype Engineering Co.	A17-016	1	05/18/2021	12
RE	MPA-31	180607	Power Amplifier	SAGE Millimeter, Inc.	SBP-7531142515-1010-E1	17343-01	10/18/2021	12
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	MCC-135	142032	Microwave Cable	Huber+Suhner	SUCOFLEX102	37511/2	09/18/2021	12
RE	MDPLX-01	142026	Diplexer	OML INC.	DPL26	-	11/25/2021	12
RE	MMX-03	142049	Harmonic Mixer	OML INC.	M06HWD	D100709-1	11/17/2021	12
RE	MHA-26	142038	Horn Antenna	Custom Microwave Inc.	HO5R	-	09/30/2021	12
RE	MMX-04	142053	Harmonic Mixer	OML INC.	M04HWD	Y100709-1	12/07/2021	12
RE	MHA-06	141512	Horn Antenna 1-18GHz	Schwarzbeck Mess-Elektronik OHG	BBHA9120D	254	10/21/2021	12
RE	MCC-218	141394	Microwave Cable	Junkosha	MWX221	1607S141(1 m) / 1608S264(5 m)	09/30/2021	12
RE	MPA-10	141579	Pre Amplifier	Keysight Technologies Inc	8449B	3008A02142	02/22/2022	12
RE	MHA-04	141505	Horn Antenna 26.5-40GHz	EMCO	3160-10	1140	-	-
RE	MHA-16	141513	Horn Antenna 15-40GHz	Schwarzbeck Mess-Elektronik OHG	BBHA9170	BBHA9170306	06/07/2021	12
RE	MPM-22	168708	Power Meter	Boonton Electronics	RTP5006	10449	04/06/2021	12
RE	MCC-54	141325	Microwave Cable	Suhner	SUCOFLEX101	2873(1m) / 2876(5m)	03/02/2021	12
RE	MAEC-04	142011	AC4_Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 3m	DA-10005	05/25/2020	24
RE	MOS-15	141562	Thermo-Hygrometer	CUSTOM. Inc	CTH-201	0010	01/10/2022	12
RE	MBM-03	141342	Barometer	Sanoh Co., Ltd	SBR121	595	02/01/2021	36
RE	MMM-10	141545	DIGITAL HiTESTER	HIOKI E.E. CORPORATION	3805	51201148	01/16/2022	12
RE	MJM-29	142230	Measure	KOMELON	KMC-36	-	-	-
RE	MTR-10	141951	EMI Test Receiver	Rohde & Schwarz	ESR26	101408	03/09/2021	12
RE	MBA-05	141425	Biconical Antenna	Schwarzbeck Mess-Elektronik OHG	VHA9103+BBA9106	VHA 91031302	08/28/2021	12

Test equipment (2/2)

Test Item	Local ID	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Cal Int
RE	MLA-23	141267	Logperiodic Antenna (200-1000MHz)	Schwarzbeck Mess-Elektronik OHG	VUSLP9111B	9111B-192	08/28/2021	12
RE	MAT-34	141331	Attenuator(6dB)	TME	UFA-01	-	02/25/2022	12
RE	MPA-13	141582	Pre Amplifier	SONOMA INSTRUMENT	310	260834	02/25/2022	12
RE	MCC-50	141397	Coaxial Cable	UL Japan	-	-	11/03/2021	12
RE	MLPA-01	141254	Loop Antenna	Rohde & Schwarz	HFH2-Z2	100017	04/17/2021	12
RE	MCC-113	141217	Coaxial cable	Fujikura/Suhner/TSJ	5D-2W/SFM141/ 421-010/ sucoform141-PE/ RFM-E121(SW)	-/04178	06/02/2021	12
RE	MCC-225	166638	Coaxial cable	UL Japan, Inc.	MP4/6-5D-2W	MP4/6	12/22/2021	12
RE	MSA-10	141899	Spectrum Analyzer	Keysight Technologies Inc	E4448A	MY46180655	02/18/2022	12
RE	MOS-14	141561	Thermo-Hygrometer	CUSTOM. Inc	CTH-201	1401	01/10/2022	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	MDO-10	211944	Digital Storage Oscilloscope	Keysight Technologies Inc	DSOX6002A	MY59380318	2021/10/07	12
RE	MDT-05	142529	Detector	HEROTEK, INC.	DT1840P	484823	-	-
RE	MSA-19	182484	Signal Analyzer	Keysight Technologies Inc	N9030B	MY57143159	2021/06/18	12

***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