RADIO TEST REPORT

Test Report No. : 13652400H-A-R2

Applicant	:	**DENSO CORPORATION**
Type of Equipment	:	**Millimeter Wave Radar Sensor**
Model No.	:	**DNMWR009**
Test regulation	:	**FCC Part 95 Subpart M: 2017** ***for Permissive change**
FCC ID	:	**HYQDNMWR009**
Test Result	:	**Complied (Refer to SECTION 3.2)**

1. This test report shall not be reproduced in full or partial, without the written approval of UL Japan, Inc.
2. The results in this report apply only to the sample tested.
3. This sample tested is in compliance with the limits of the above regulation.
4. The test results in this test report are traceable to the national or international standards.
5. This test report must not be used by the customer to claim product certification, approval, or endorsement by the A2LA accreditation body.
6. This test report covers Radio technical requirements. It does not cover administrative issues such as Manual or non-Radio test related Requirements. (if applicable)
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 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 13652400H-A-R1. 13652400H-A-R1 is replaced with this report.

Date of test: January 5 to 14, 2021

Representative test engineer:
Yuichiro Yamazaki
Engineer
Consumer Technology Division

Approved by:
Tsubasa Takayama
Leader
Consumer Technology Division

CERTIFICATE 5107.02

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

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REVISION HISTORY

Original Test Report No.: 13652400H-A

Revision	Test report No.	Date	Page revised	Contents
- (Original)	13652400H-A	February 10, 2021	-	-
1	13652400H-A-R1	April 23, 2021	P.10	Correction of Configuration and peripherals of Clause 4.2
1	13652400H-A-R1	April 23, 2021	P.12	Correction of Distance Factor, Test distance and Test Volume: Test setup 1 GHz -10 GHz; From; * Test Distance: (3 + Test Volume /2) – r = 4.0 m Test Volume: 2 m to; * Test Distance: (3 + Test Volume /2) – r = 3.75 m Test Volume: 1.5 m
1	13652400H-A-R1	April 23, 2021	P.16	Correction of temperature range for measurement method
1	13652400H-A-R1	April 23, 2021	P.26, 29	Addition of “Customer requested temperature” in Remarks of -30 deg.C.
2	13652400H-A-R2	April 26, 2021	P.12	Correction of Distance Factor: Test setup 1 GHz -10 GHz; From; Distance Factor: 20 x log (3.75 m*/3.0 m) = 1.90 dB to; Distance Factor: 20 x log (3.75 m*/3.0 m) = 1.9 dB
2	13652400H-A-R2	April 26, 2021	P.16	Correction of the description in Section 6. From; Both lower and upper frequencies of the 99% OBW were recorded. To; Both lower and upper frequencies of the -20dB Bandwidth were recorded.

Reference: Abbreviations (Including words undescribed in this report)

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

CONTENTS **PAGE**

SECTION 1: Customer information

Company Name	:	DENSO CORPORATION
Address	:	1-1, Showa-cho, Kariya-shi, Aichi-ken, 448-8661 Japan
Telephone Number	:	+81-78-682-2674
Facsimile Number	:	+81-78-682-2046
Contact Person	:	Shozo Taniguchi

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 Sensor
Model Number	:	DNMWR009
Serial Number	:	Refer to Clause 4.2
Rating	:	DC 12 V (Car battery), DC 8 V to 16 V (Operating range)
Receipt Date	:	December 25, 2020
Country of Mass-production	:	Japan
Condition	:	Production prototype (Not for Sale: This sample is equivalent to mass-produced items.)
Modification	:	No Modification by the test lab

2.2 Product Description

Model: DNMWR009 (referred to as the EUT in this report) is the 76.0 GHz - 77.0 GHz vehicle-mounted field disturbance sensor that is a millimeter wave fast chirp modulation (FM-CW and FCM) radar operating at 76.0 GHz - 77.0 GHz (Nominal: 76.5 GHz).

FM-CW: Frequency Modulated Continuous Wave
FCM: Fast Chirp Modulation

Radio Specification

Radio Type	:	Transceiver
Frequency of Operation	:	76.5 GHz
Modulation	:	QXN (FCM, FM-CW)
Antenna Type	:	Microstrip array antenna
Antenna Connector	:	None (Internal Antenna)
Antenna Gain	:	Tx_N: 16.2 dBi (Typ) Tx_W: 13.8 dBi (Typ)
Scanning Antenna (transmit)	:	Fixed beam
Usage location	:	Vehicle-mounted
Clock Frequency (maximum)	:	40 MHz (Crystal)
Radome loss	:	0.5 dB (Typ)

SECTION 3: Test specification, procedures & results

3.1 Test Specification

Test Specification : FCC Part 95 Subpart M
FCC Part 95 final revised on September 20, 2017

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 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	11.64 dB 228.284 GHz	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.

3.4 Uncertainty

EMI

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

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

Ise EMC Lab.

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.

3.5 Test Location

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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
* A2LA Certificate Number: 5107.02 / FCC Test Firm Registration Number: 199967
ISED Lab Company Number: 2973C / CAB identifier: JP0002

Test site	Width x Depth x Height (m)	Size of reference ground plane (m) / horizontal conducting plane	Other rooms	Maximum measurement distance
No.1 semi-anechoic chamber	19.2 x 11.2 x 7.7	7.0 x 6.0	No.1 Power source room	10 m
No.2 semi-anechoic chamber	7.5 x 5.8 x 5.2	4.0 x 4.0	-	3 m
No.3 semi-anechoic chamber	12.0 x 8.5 x 5.9	6.8 x 5.75	No.3 Preparation room	3 m
No.3 shielded room	4.0 x 6.0 x 2.7	N/A	-	-
No.4 semi-anechoic chamber	12.0 x 8.5 x 5.9	6.8 x 5.75	No.4 Preparation room	3 m
No.4 shielded room	4.0 x 6.0 x 2.7	N/A	-	-
No.5 semi-anechoic chamber	6.0 x 6.0 x 3.9	6.0 x 6.0	-	-
No.5 measurement room	6.4 x 6.4 x 3.0	6.4 x 6.4	-	-
No.6 shielded room	4.0 x 4.5 x 2.7	4.0 x 4.5	-	-
No.6 measurement room	4.75 x 5.4 x 3.0	4.75 x 4.15	-	-
No.7 shielded room	4.7 x 7.5 x 2.7	4.7 x 7.5	-	-
No.8 measurement room	3.1 x 5.0 x 2.7	3.1 x 5.0	-	-
No.9 measurement room	8.8 x 4.6 x 2.8	2.4 x 2.4	-	-
No.11 measurement room	6.2 x 4.7 x 3.0	4.8 x 4.6	-	-

* Size of vertical conducting plane (for Conducted Emission test) : 2.0 m 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

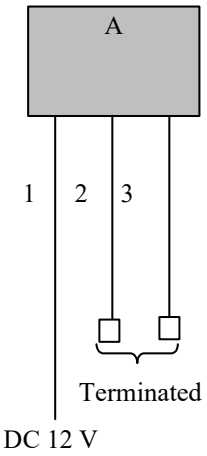
Refer to APPENDIX.

SECTION 4: Operation of EUT during testing

4.1 Operating Mode(s)

Mode	Test Item
Transmitting mode (Tx) - FM-CW - FCM	Occupied bandwidth Radiated Power Duty Frequency stability
Normal operating mode	Modulation characteristics Field strength of spurious radiation
In actual operation, there are FM-CW and FCM modulation parts in one transmission burst. First, the EUT transmits FM-CW modulation. After that, FCM transmission starts immediately. These two modulations do not transmit at the same time. These modulations have individual transmit antennas. (Switching antenna Tx_N: FM-CW and Tx_W: FCM alternately.) The test modes (FM-CW only, FCM only) were used for the purpose of power measurement. EUT has the power settings by the software as follows; Power settings: Same as production model Software: mwr_gen5_0057_ p04.s 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 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 Sensor	DNMWR009	801601793959	DENSO CORPORATION	EUT

List of cables used

No.	Name	Length (m)	Shield		Remark
			Cable	Connector	
1	DC Cable	9.0	Unshielded	Unshielded	-
2	CAN Cable	1.2	Unshielded	Unshielded	-
3	CAN Cable	1.2	Unshielded	Unshielded	-

SECTION 5: Radiated Spurious Emission

Test Procedure

[For below 30 MHz]
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]
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]
EUT was placed on a urethane platform of nominal size, 0.5 m by 1.0 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.
Test antenna was aimed at the EUT for receiving the maximum signal and always kept within the illumination area of the 3 dB beamwidth of the antenna.
The measurements were performed for both vertical and horizontal antenna polarization with the Test Receiver, or the Spectrum Analyzer.
The measurements were made with the following detector function of the test receiver and the Spectrum analyzer (in linear voltage average mode).
The test was made with the detector (RBW/VBW) in the following table.
When using Spectrum analyzer, the test was made with adjusting span to zero by using peak hold.

Test Antennas are used as below;

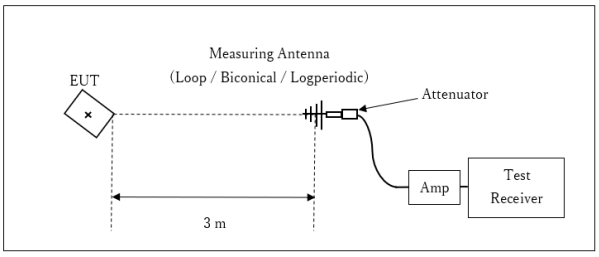
Frequency	Below 30 MHz	30 MHz to 200 MHz	200 MHz to 1 GHz	Above 1 GHz
Antenna Type	Loop	Biconical	Logperiodic	Horn

Frequency	9 kHz 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) An RMS average mode was used: 1 ms or less averaging time (integration time period for each spectrum analyzer bin; spectrum analyzer sweeptime / number-of-bins not exceeding one millisecond)

[Test setup]

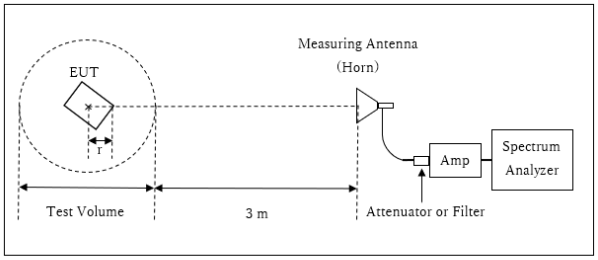
Below 1 GHz



× : Center of turn table

Test Distance: 3 m

1 GHz - 10 GHz



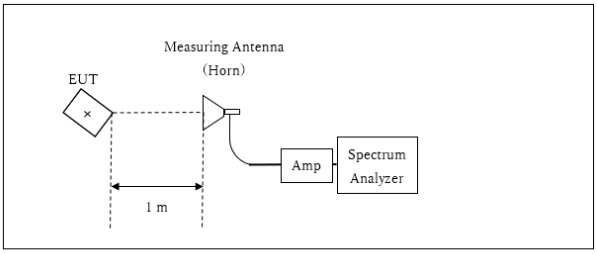
r : Radius of an outer periphery of EUT
× : Center of turn table

Distance Factor: 20 x log (3.75 m*/3.0 m) = 1.9 dB
* Test Distance: (3 + Test Volume /2) - r = 3.75 m

Test Volume: 1.5 m
(Test Volume has been calibrated based on CISPR 16-1-4.)
r = 0.0 m

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

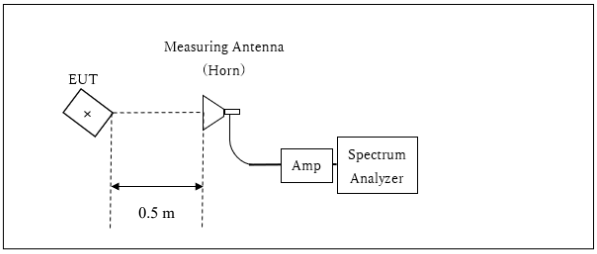
10 GHz - 26.5 GHz



× : Center of turn table

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

26.5 GHz - 40 GHz

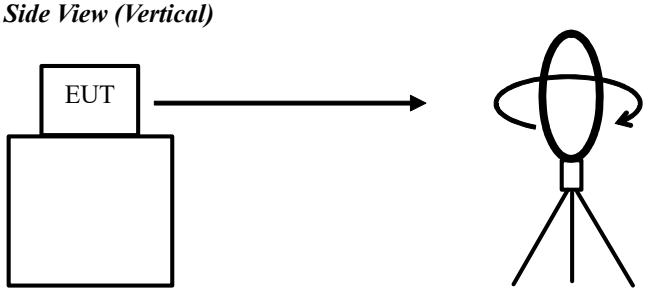


× : Center of turn table

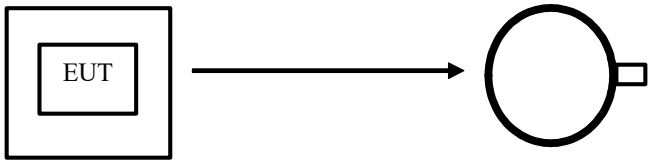
Distance Factor: 20 x log (0.5 m* / 3.0 m) = -15.6 dB
*Test Distance: 0.5 m

Figure 1: Direction of the Loop Antenna

Side View (Vertical)

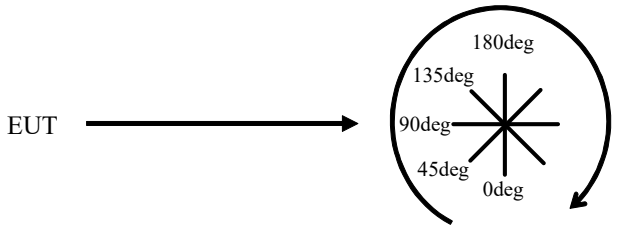


Top View (Horizontal)



Antenna was not rotated.

Top View (Vertical)



Front side: 0 deg.
Forward direction: clockwise

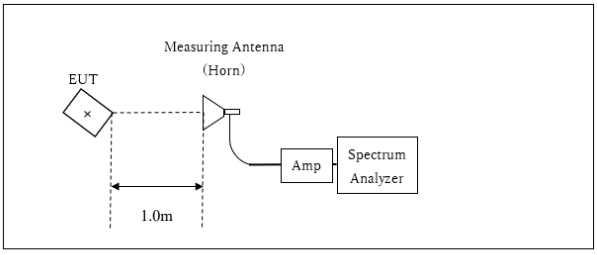
[Above 40 GHz]
The test was performed based on "Procedures for testing millimeter-wave systems" of ANSI C63.10-2013. The EUT was placed on a urethane platform, raised 1.5 m above the conducting ground plane. The measurements were performed on handheld method.

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, 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 76 GHz	81 GHz to 83 GHz	83 GHz to 110 GHz	110 GHz to 170 GHz	170 GHz to 231 GHz
Final measurement distance with 1 MHz Peak detector	1.0 m	1.0 m	0.5 m	1.0 m	0.01 m	0.01 m

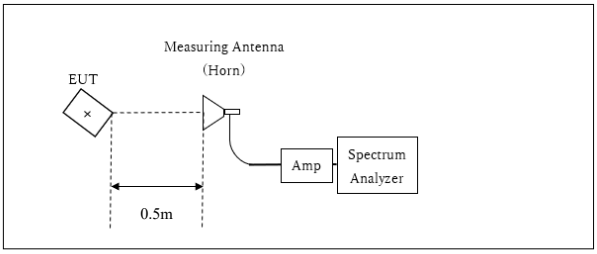
[Test setup]
40 GHz - 76 GHz, 83 GHz - 110 GHz



*Test Distance: 1.0 m

× : Center of turn table

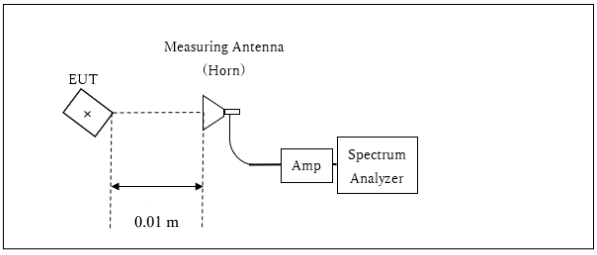
81 GHz - 83 GHz



*Test Distance: 0.5 m

× : Center of turn table

110 GHz - 231 GHz



*Test Distance: 0.01 m

× : Center of turn table

[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
		EUT	Test Antenna	Maximum	Boundary
	Lambda			*D*	*r*
[GHz]	[mm]	[m]	[m]	[m]	[m]
77.0	3.9	0.013695	0.025150	0.025150	0.325

- 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
Fs = FMCW Sweep Width or Chirp Width
Ts = FMCW Sweep Time
B = -3dB bandwidth of Gaussian RBW Filter

For the values of Fs, Ts and B, refer to Theory of Operation-Specification.

Measurement range : 9 kHz - 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 60 deg. C, and the frequency excursion of the EUT emission mask was recorded. Measurements were repeated at each 10 deg. C decrement down to -30 deg. C.

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

Test data : APPENDIX
Test result : Pass

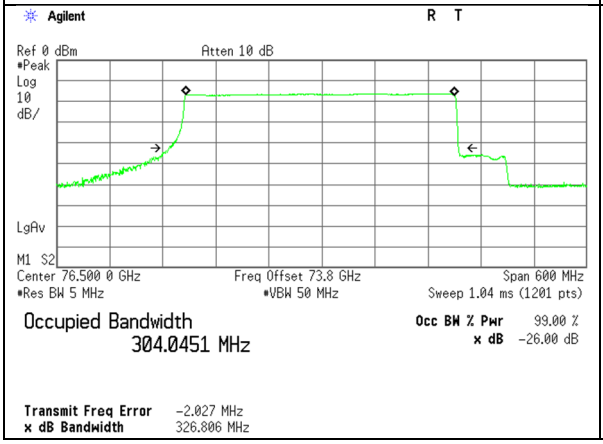
APPENDIX 1: Test data

Occupied bandwidth

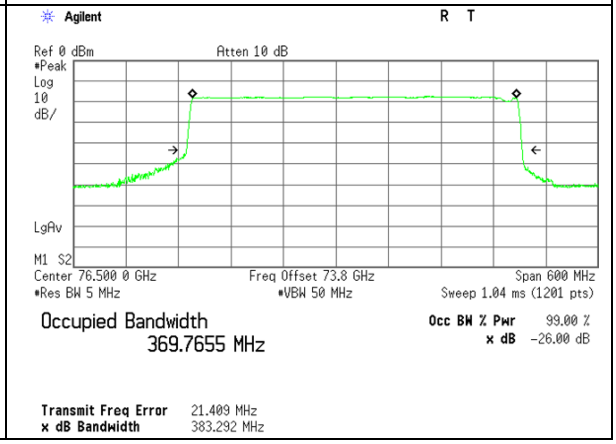
Report No.	13652400H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.2
Date	January 5, 2021
Temperature / Humidity	23 deg. C / 45 % RH
Engineer	Yuichiro Yamazaki
Mode	Tx

Mode	Frequency [GHz]	99 % Occupied bandwidth [MHz]
FM-CW	76.5	304.0451
FCM	76.5	369.7655

FM-CW



FCM



Radiated Power

Report No.	13652400H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.2
Date	January 5, 2021
Temperature / Humidity	23 deg. C / 45 % RH
Engineer	Yuichiro Yamazaki
Mode	Tx

Measured data in Test modes

Mode	Power	Freq. [GHz]	Measured Power [dBm]	Tested Distance [m]	Rx Antenna Gain [dBi]	Down Converter Gain [dB]	IF Cable Loss [dB]	FSL [dB]	EIRP [dBm]	EIRP [mW]
FM-CW	Average	76.5	-23.79	2.0	23.06	14.76	1.41	76.14	15.94	39.22
	Peak	76.5	-16.31	2.0	23.06	14.76	1.41	76.14	23.42	219.56
FCM	Average	76.5	-28.03	2.0	23.06	14.76	1.41	76.14	11.70	14.78
	Peak	76.5	-20.66	2.0	23.06	14.76	1.41	76.14	19.07	80.64

Calculating formula:

FSL (Free Space path Loss) = 10 * log10((4 * Pi * Tested Distance / Lambda) ^2)

EIRP = Measured Power - Rx Antenna Gain - Down Converter Gain + IF Cable Loss + FSL

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

Final result in Test modes

Mode	Power	EIRP Spectrum Analyzer [dBm]	Duty Factor [dB]	desensitization Factor [dB]	Result [mW]	Result [dBm]	Limit [dBm]	Margin [dB]
FM-CW	Average	15.94	7.38	-	214.57	23.32	50	26.68
	Peak	23.42	-	0.01	220.06	23.43	55	31.57
FCM	Average	11.70	8.95	-	116.03	20.65	50	29.35
	Peak	19.07	-	6.90	395.31	25.97	55	29.03

Calculating formula:

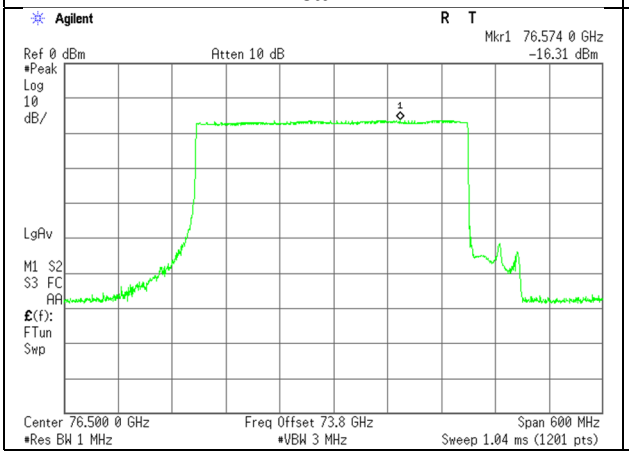
EIRP Result (Average) = EIRP(Spectrum Analyzer) + Duty Factor

For the peak power result, it is a maximum power.
The test method referred to KDB653005.
The derivation of the FMCW Desensitization Factor is given in Keysight Application Note 5952 1039 Appendix B.

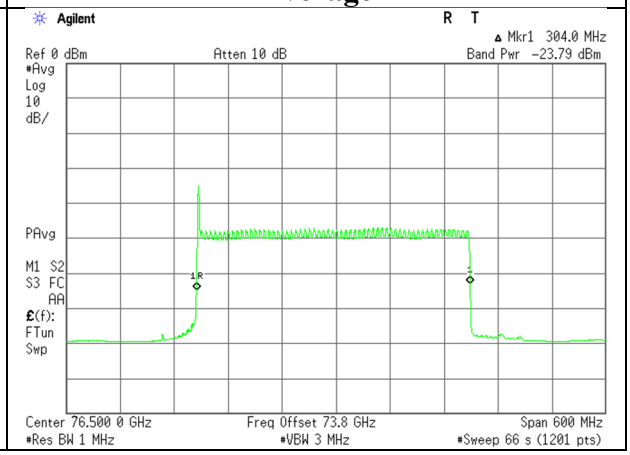
Radiated Power

FM-CW

Peak

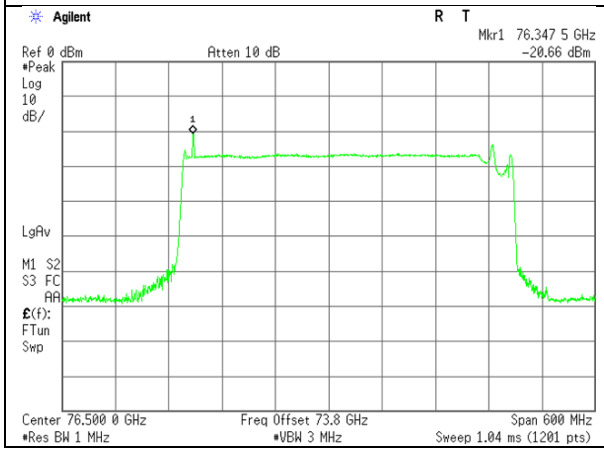


Average

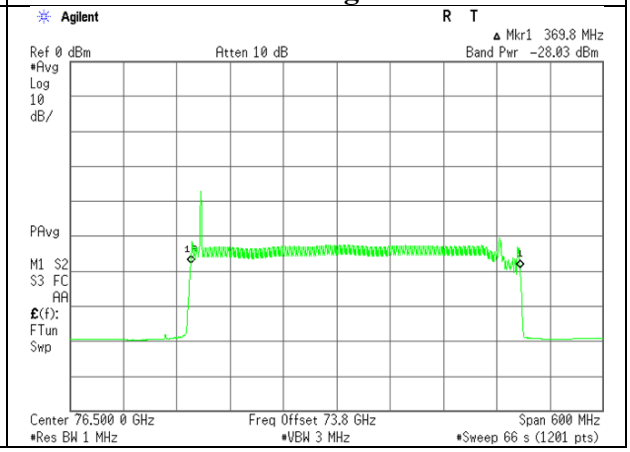


FCM

Peak



Average



Duty

Report No.	13652400H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.2
Date	January 6, 2021
Temperature / Humidity	21 deg. C / 36 % RH
Engineer	Yuichiro Yamazaki
Mode	Tx

[Duty Factor]

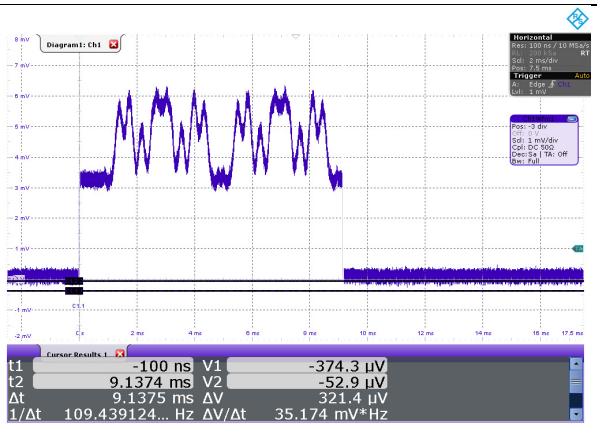
Mode	Tx on time [ms]	Tx on + Tx off time [ms]	Duty Factor [dB]
FM-CW	9.14	50.00	-7.38
FCM	6.37	50.00	-8.95

Calculation: Duty Factor = 10 * log(Tx on time / Tx on + Tx off time)

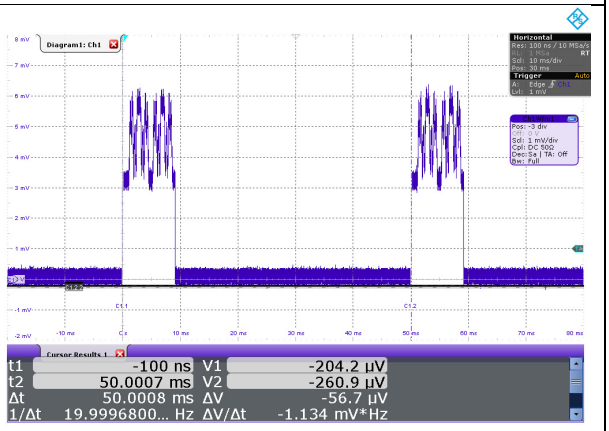
[Data]

FMCW

Tx on

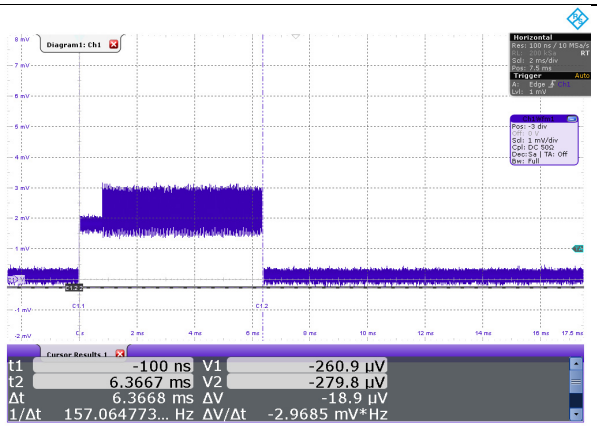


Tx on + Tx off

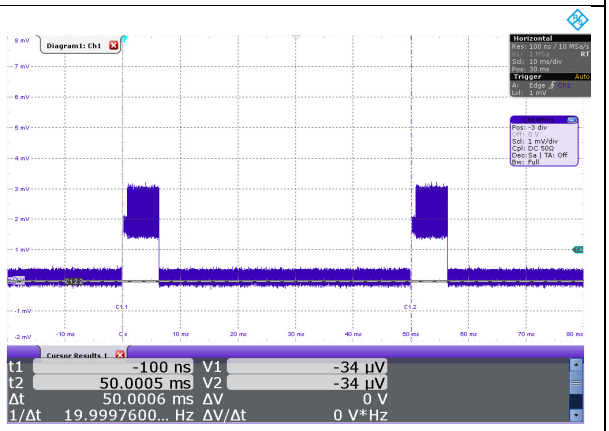


FCM

Tx on



Tx on + Tx off



Duty

Report No.	13652400H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.2
Date	January 6, 2021
Temperature / Humidity	21 deg. C / 36 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode

[Duty Factor]

	Tx On time [ms]	Tx On + Off time [ms]	Duty factor [dB]
Measured	15.58	50.00	-5.06
Declared *	15.00	50.00	-5.23

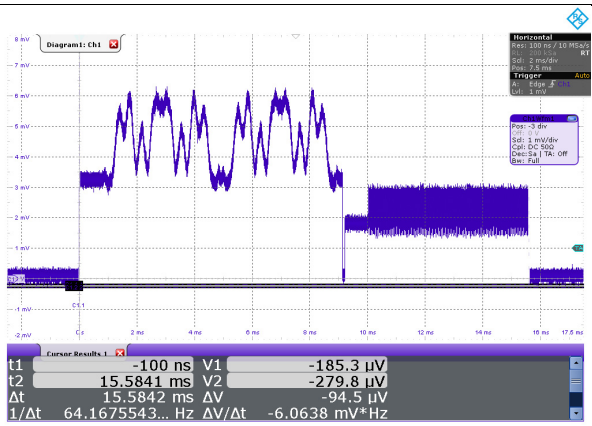
Duty factor = 10 * log (Tx On time / Tx On + Off time)

* See the application document.

[Data]

(Reference) Normal operating mode

Tx on



Tx on + Tx off

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

Field strength of spurious radiation
(below 40 GHz)

Report No.	13652400H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.2
Date	January 6, 2021
Temperature / Humidity	21 deg. C / 36 % RH
Engineer	Yuichiro Yamazaki
	9 kHz - 40 GHz
Mode	Normal operating mode

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Duty Factor [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori.	31.386	QP	22.1	18.0	6.8	28.6	-	18.2	40.0	21.8	
Hori.	34.781	QP	21.0	16.8	6.8	28.6	-	16.0	40.0	24.1	
Hori.	48.915	QP	21.4	11.6	7.0	28.6	-	11.3	40.0	28.7	
Hori.	126.873	QP	21.7	13.3	7.7	28.4	-	14.2	43.5	29.3	
Hori.	318.663	QP	21.5	14.1	9.0	27.9	-	16.7	46.0	29.3	
Hori.	619.306	QP	22.8	19.5	10.3	29.4	-	23.2	46.0	22.9	
Vert.	31.386	QP	22.6	18.0	6.8	28.6	-	18.7	40.0	21.3	
Vert.	34.781	QP	22.2	16.8	6.8	28.6	-	17.2	40.0	22.9	
Vert.	48.936	QP	36.9	11.6	7.0	28.6	-	26.8	40.0	13.2	
Vert.	126.873	QP	22.5	13.3	7.7	28.4	-	15.0	43.5	28.5	
Vert.	318.663	QP	21.7	14.1	9.0	27.9	-	16.9	46.0	29.1	
Vert.	619.306	QP	22.6	19.5	10.3	29.4	-	23.0	46.0	23.1	

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

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

Distance factor: 1 GHz - 10 GHz 20log (3.75 m / 3.0 m) = 1.9 dB
10 GHz - 26.5 GHz 20log (1.0 m / 3.0 m) = -9.5 dB
26.5 GHz - 40 GHz 20log (0.5 m / 3.0 m) = -15.6 dB

Field strength of spurious radiation
(above 40 GHz)

Report No.	13652400H	
Test place	Ise EMC Lab.	
Semi Anechoic Chamber	No.2	No.2
Date	January 6, 2021	January 7, 2021
Temperature / Humidity	21 deg. C /36 % RH	22 deg. C /34 % RH
Engineer	Yuichiro Yamazaki	Yuichiro Yamazaki
	75 GHz - 76 GHz	40 GHz - 75 GHz
	81 GHz - 83 GHz	83 GHz - 231 GHz
Mode	Normal operating mode	

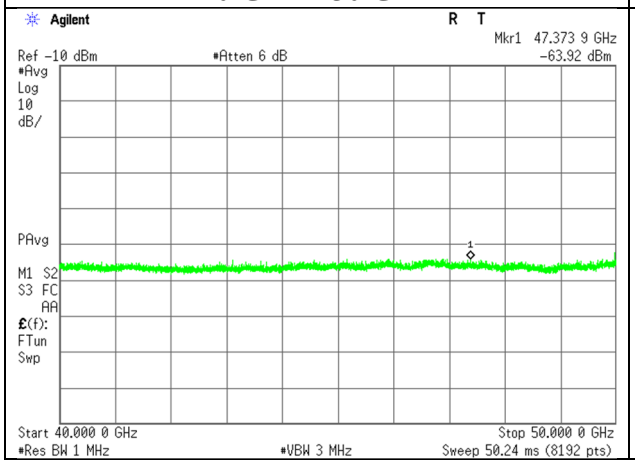
Freq.	Reading	Rx ant. gain	Filter loss	LNA gain	Mixer loss	IF amp. gain	IF cable loss	Meas. range *D*	FSL	EIRP		Power density at 3 m			Remarks
												Result	Limit	Margin	
[GHz]	[dBm]	[dBi]	[dB]	[dB]	[dB]	[dB]	[dB]	[m]	[dB]	[dBm]	[mW]	[pW/cm^2]	[pW/cm^2]	[dB]	
47.374	-63.92	22.15	0.00	32.98	0.00	0.00	8.74	1.0	65.95	-44.36	0.000037	0.03	600	42.67	
51.294	-76.94	22.89	0.00	26.40	46.73	31.77	0.12	1.0	66.64	-44.51	0.000035	0.03	600	42.83	
75.285	-70.02	22.96	0.00	0.00	-15.06	0.00	1.26	1.0	69.98	-36.81	0.000209	0.18	600	35.12	
81.483	-71.22	23.44	0.00	0.00	-12.45	0.00	2.55	0.5	64.64	-39.92	0.000102	0.09	600	38.23	
83.579	-55.42	23.55	2.50	32.55	0.00	0.00	0.00	1.0	70.88	-38.14	0.000154	0.14	600	36.45	
90.004	-61.48	23.89	0.77	33.48	0.00	0.00	0.00	1.0	71.53	-46.55	0.000022	0.02	600	44.87	
117.027	-91.13	22.54	0.00	18.79	58.99	0.00	0.00	0.01	33.81	-39.66	0.000108	0.10	600	37.98	
131.322	-92.62	22.98	0.00	20.00	53.36	0.00	0.00	0.01	34.81	-47.43	0.000018	0.02	600	45.75	
152.525	-87.49	23.35	0.00	17.83	56.98	0.00	0.00	0.01	36.11	-35.58	0.000277	0.24	600	33.90	
156.582	-92.95	23.38	0.00	17.75	58.46	0.00	0.00	0.01	36.34	-39.29	0.000118	0.10	600	37.60	
171.236	-91.38	22.42	0.00	0.00	59.67	0.00	0.00	0.01	37.11	-17.02	0.019864	17.6	600	15.34	
192.959	-92.30	22.90	0.00	0.00	57.65	0.00	0.00	0.01	38.15	-19.40	0.011492	10.2	600	17.71	
210.949	-93.17	23.17	0.00	0.00	57.58	0.00	0.00	0.01	38.93	-19.83	0.010395	9.2	1000	20.37	
228.284	-89.17	23.33	0.00	0.00	61.78	0.00	0.00	0.01	39.61	-11.10	0.077540	68.6	1000	11.64	

Calculation:

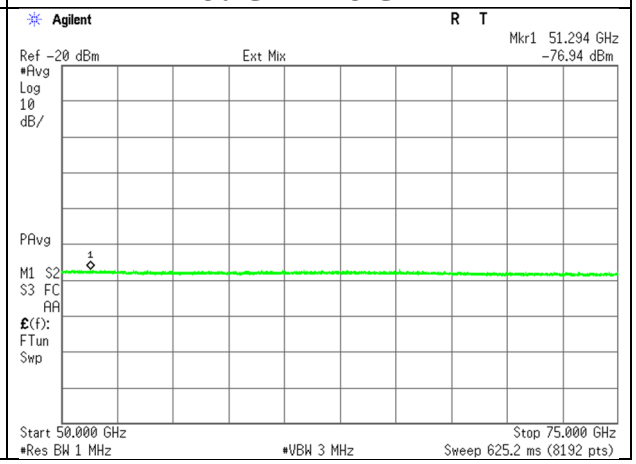
FSL (Free Space path Loss) = 10 * log (($4 * Pi * D / \lambda$) ^{2})
EIRP = Reading - Rx ant. gain + Filter loss - LNA gain + Mixer loss - IF amp. gain + IF cable loss + FSL
Power density Result at 3 m = EIRP / (4 * Pi * 300 ^{2})

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.

40 GHz - 50 GHz

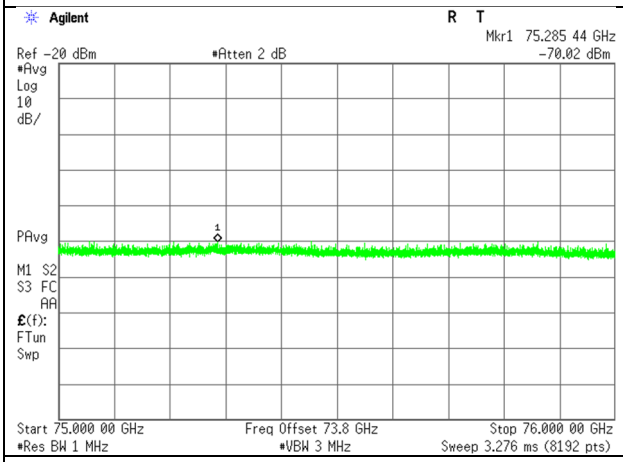


50 GHz - 75 GHz

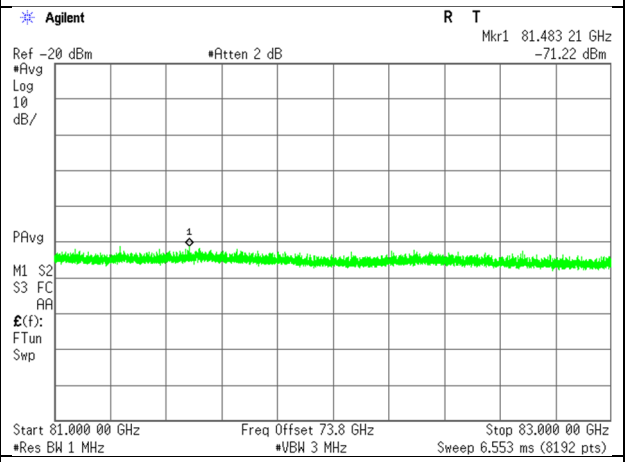


Field strength of spurious radiation
(above 40 GHz)

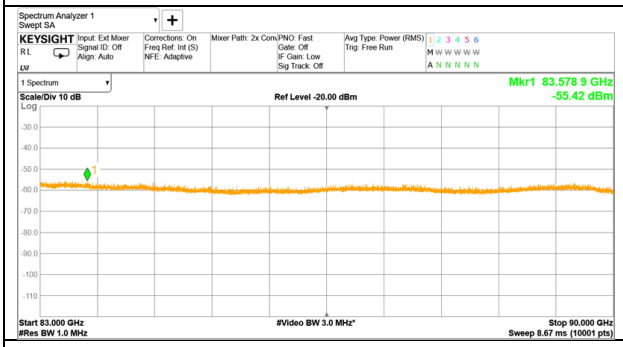
75 GHz - 76 GHz



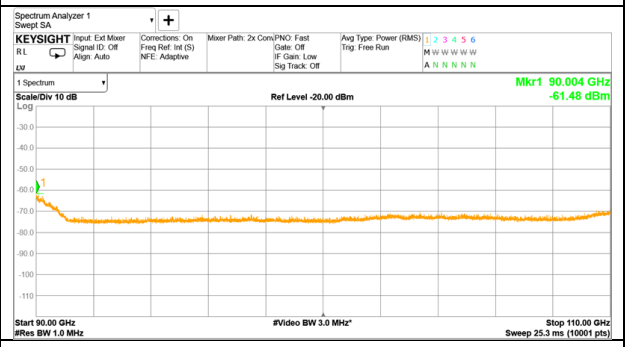
81 GHz - 83 GHz



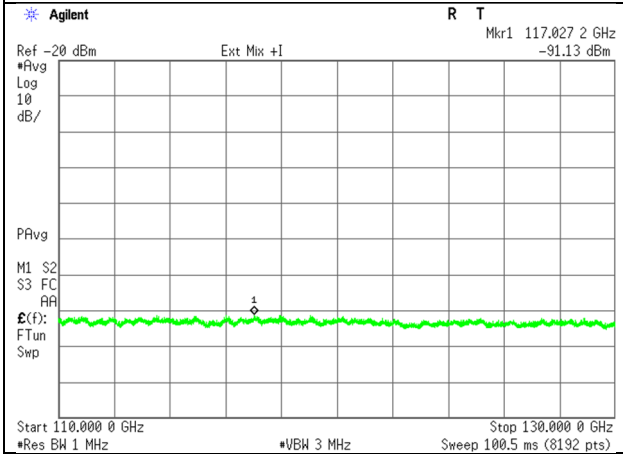
83 GHz - 90 GHz



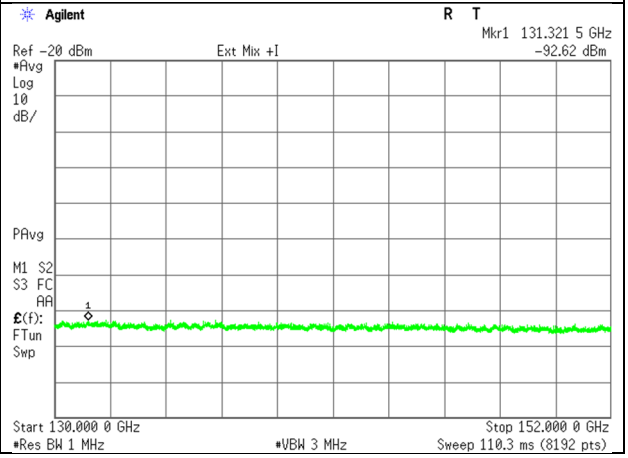
90 GHz - 110 GHz



110 GHz - 130 GHz

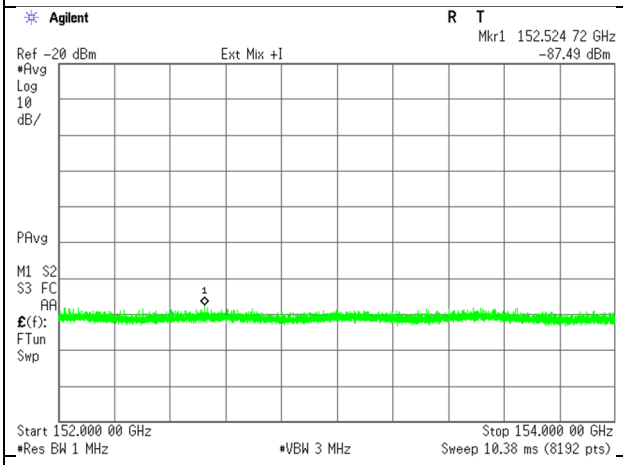


130 GHz - 152 GHz

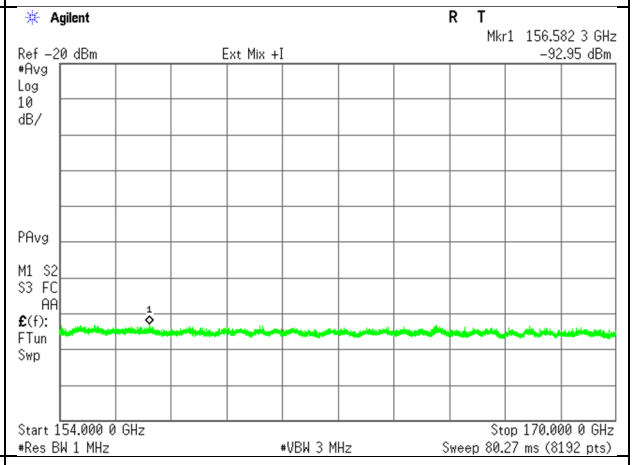


Field strength of spurious radiation
(above 40 GHz)

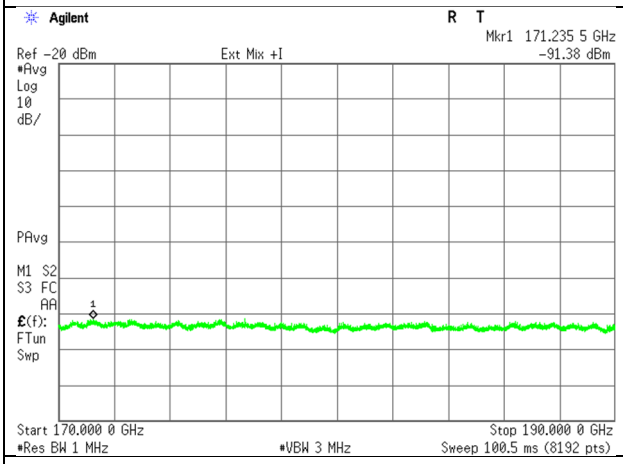
152 GHz - 154 GHz



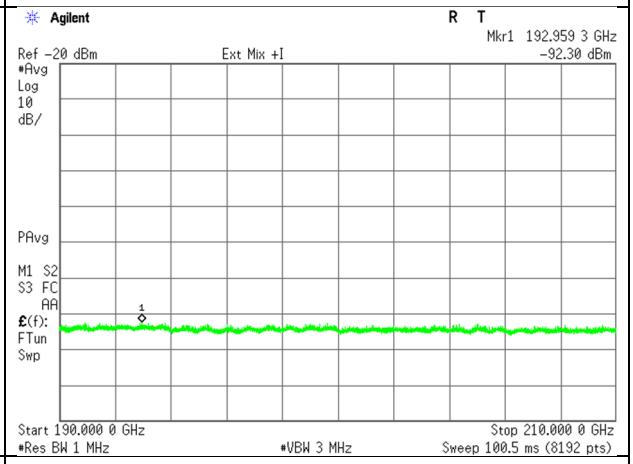
154 GHz - 170 GHz



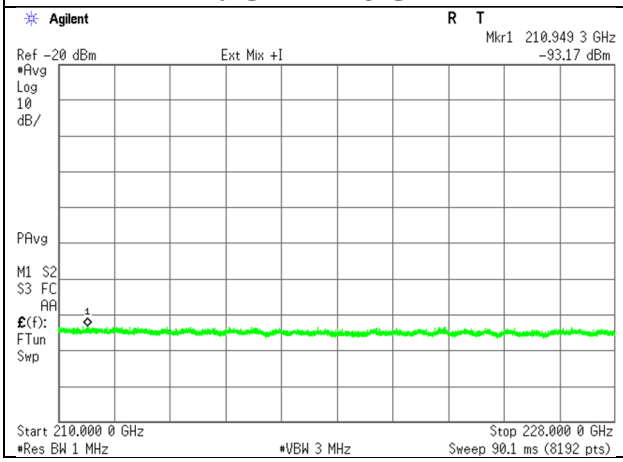
170 GHz - 190 GHz



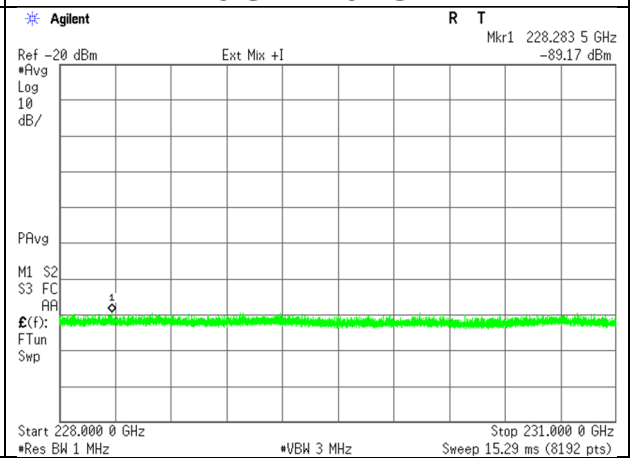
190 GHz - 210 GHz



210 GHz - 228 GHz



228 GHz - 231 GHz



Frequency Stability

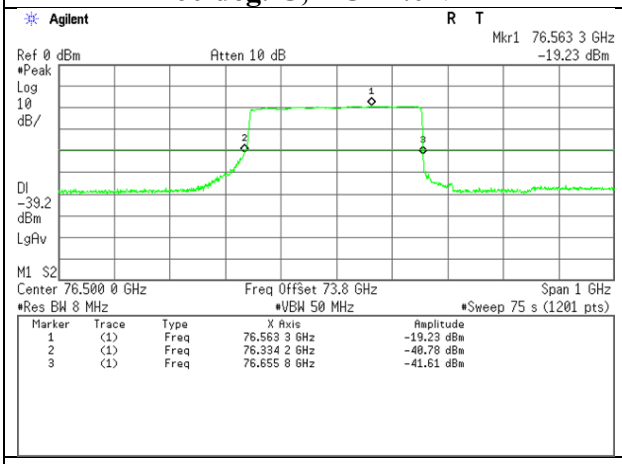
Report No.	13652400H
Test place	Ise EMC Lab. No.6 Measurement Room
Date	January 14, 2021
Temperature / Humidity	23 deg. C / 41 % RH
Engineer	Yuichiro Yamazaki
Mode	Tx FM-CW

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
60	12.0	76.334	76.656	Customer requested temperature
50	12.0	76.334	76.657	
40	12.0	76.338	76.657	
30	12.0	76.336	76.658	
20	12.0	76.332	76.657	
20	10.2	76.332	76.657	85 % of the minimum operating voltage, DC 12V * 0.85
20	13.8	76.331	76.657	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.339	76.658	
0	12.0	76.338	76.658	
-10	12.0	76.339	76.659	
-20	12.0	76.338	76.659	
-30	12.0	76.340	76.659	Customer requested temperature

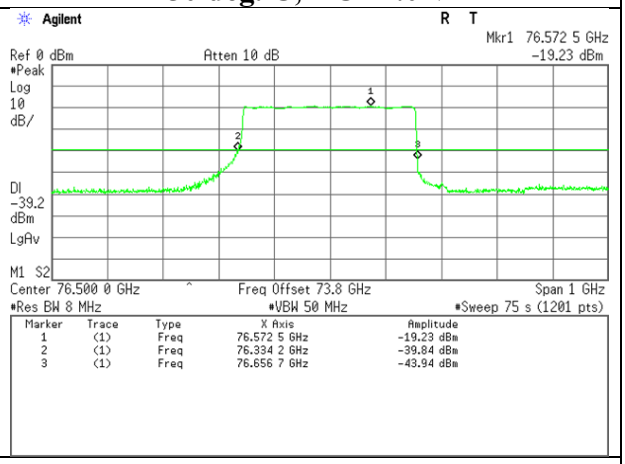
Fundamental emissions were contained within the frequency band 76 GHz to 77 GHz during all conditions of operation.

Frequency Stability

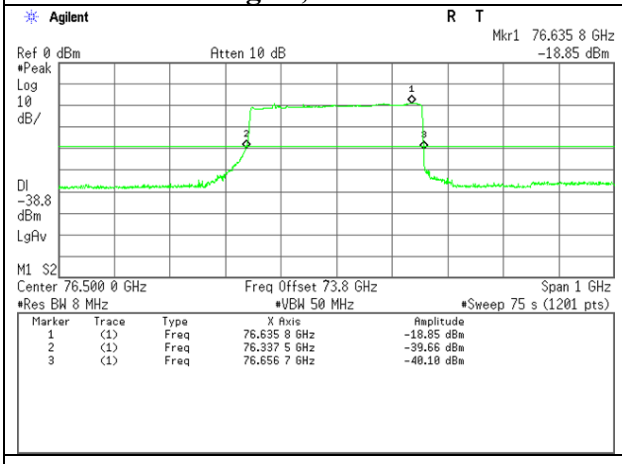
60 deg. C, DC 12.0 V



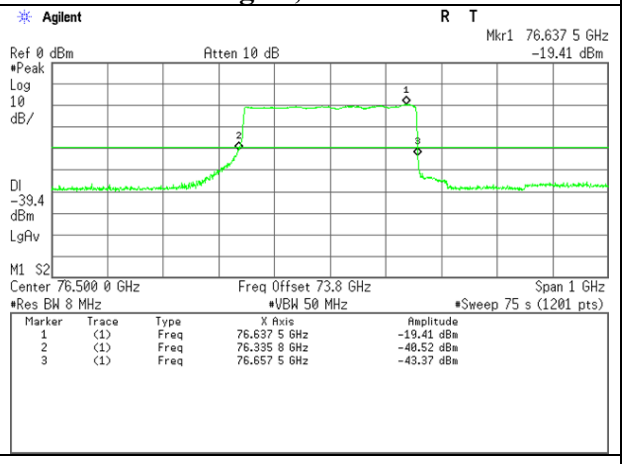
50 deg. C, DC 12.0 V



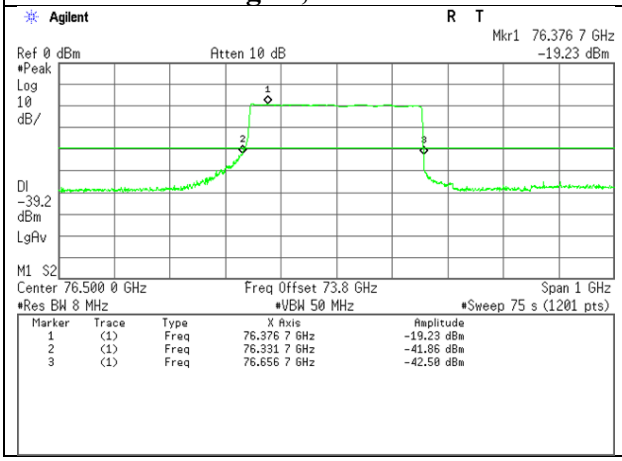
40 deg. C, DC 12.0 V



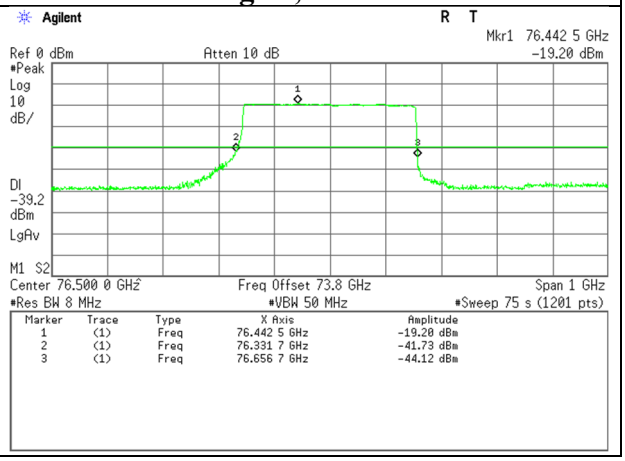
30 deg. C, DC 12.0 V



20 deg. C, DC 12.0 V

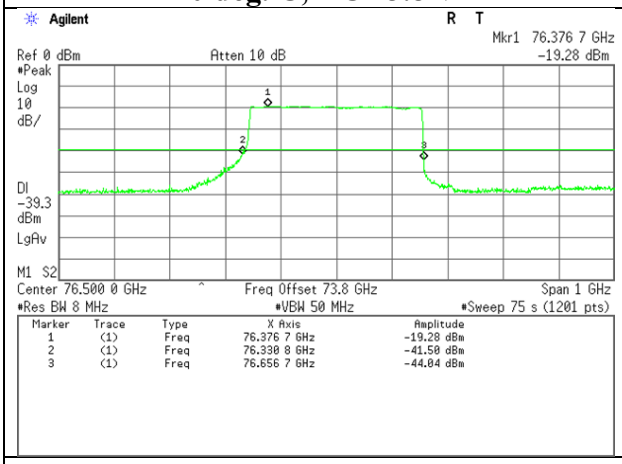


20 deg. C, DC 10.2 V

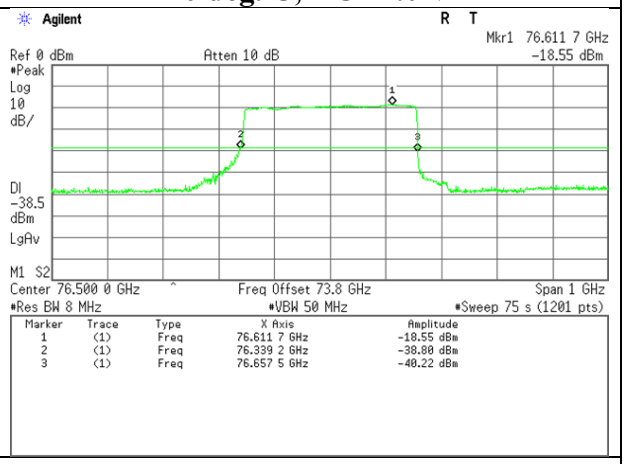


Frequency Stability

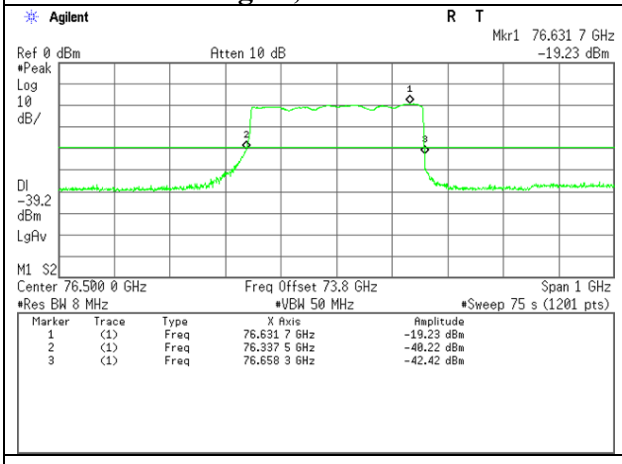
20 deg. C, DC 13.8 V



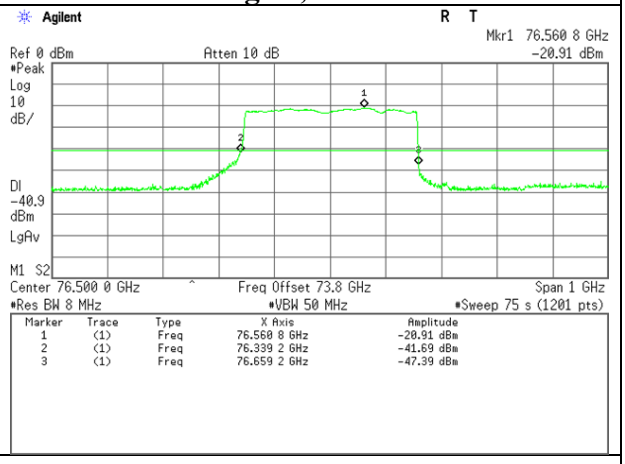
10 deg. C, DC 12.0 V



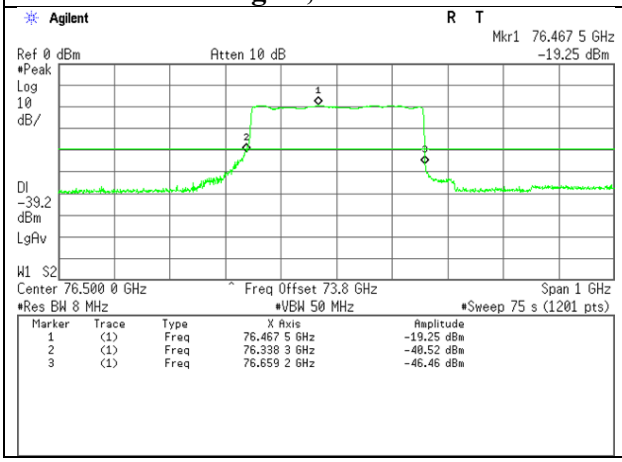
0 deg. C, DC 12.0 V



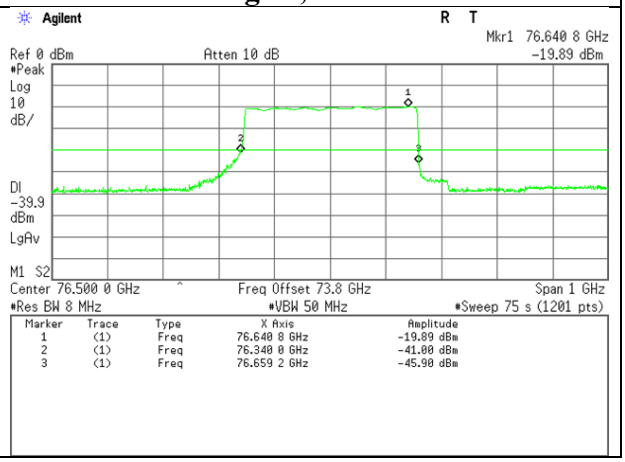
-10 deg. C, DC 12.0 V



-20 deg. C, DC 12.0 V



-30 deg. C, DC 12.0 V



Frequency Stability

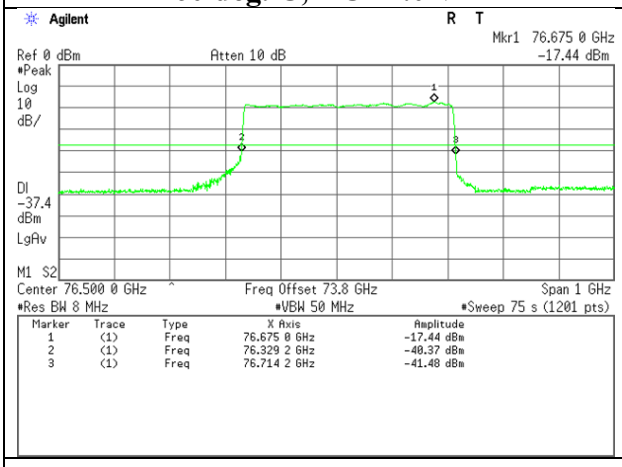
Report No.	13652400H
Test place	Ise EMC Lab. No.6 Measurement Room
Date	January 14, 2021
Temperature / Humidity	23 deg. C / 41 % RH
Engineer	Yuichiro Yamazaki
Mode	Tx FCM

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
60	12.0	76.329	76.714	Customer requested temperature
50	12.0	76.330	76.715	
40	12.0	76.330	76.715	
30	12.0	76.331	76.715	
20	12.0	76.329	76.715	
20	10.2	76.330	76.715	85 % of the minimum operating voltage, DC 12V * 0.85
20	13.8	76.330	76.715	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.338	76.658	
0	12.0	76.337	76.658	
-10	12.0	76.332	76.717	
-20	12.0	76.333	76.718	
-30	12.0	76.333	76.717	Customer requested temperature

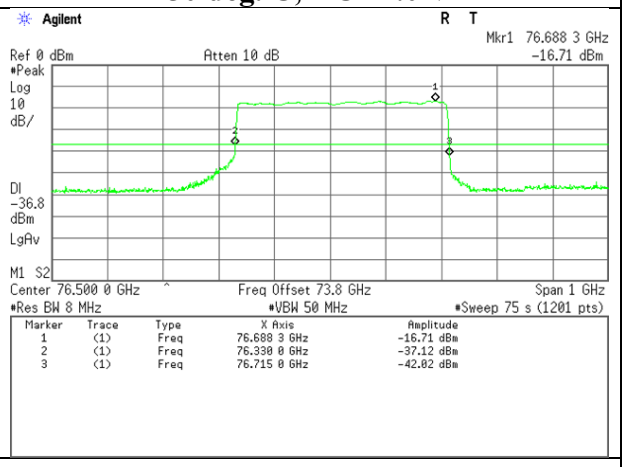
Fundamental emissions were contained within the frequency band 76 GHz to 77 GHz during all conditions of operation.

Frequency Stability

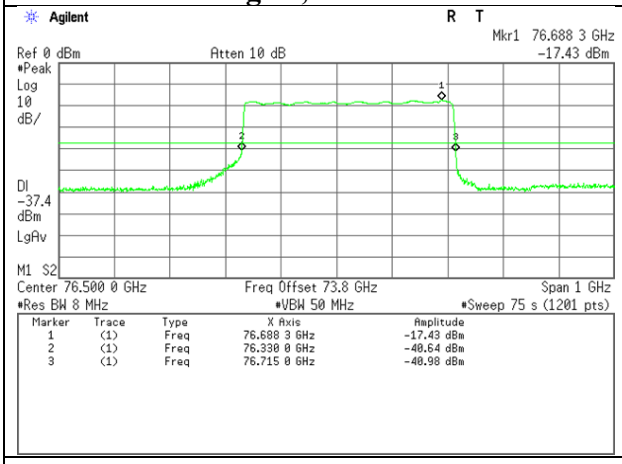
60 deg. C, DC 12.0 V



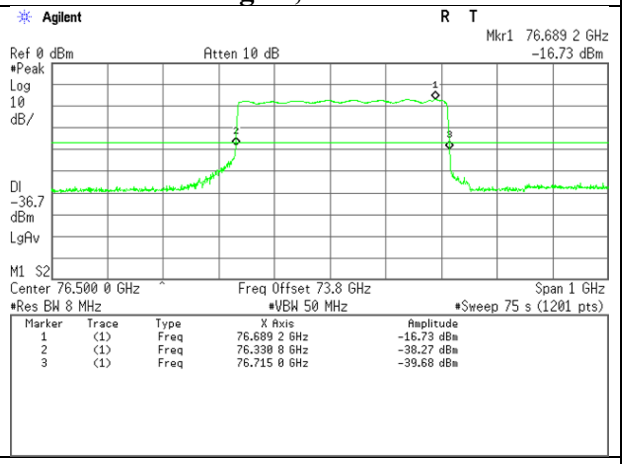
50 deg. C, DC 12.0 V



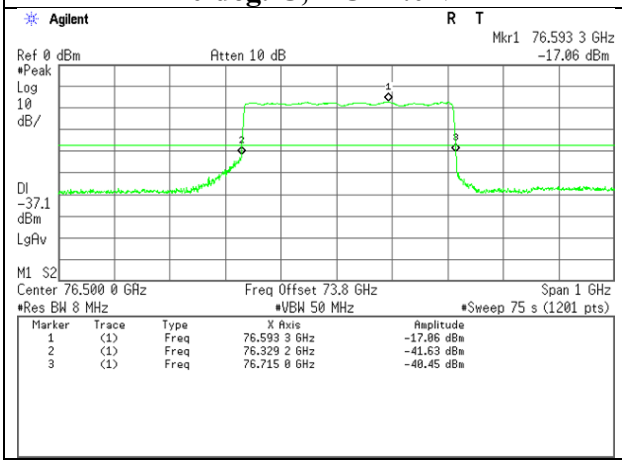
40 deg. C, DC 12.0 V



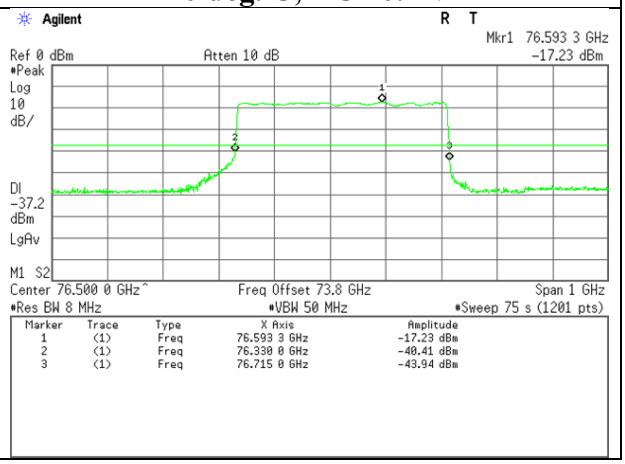
30 deg. C, DC 12.0 V



20 deg. C, DC 12.0 V

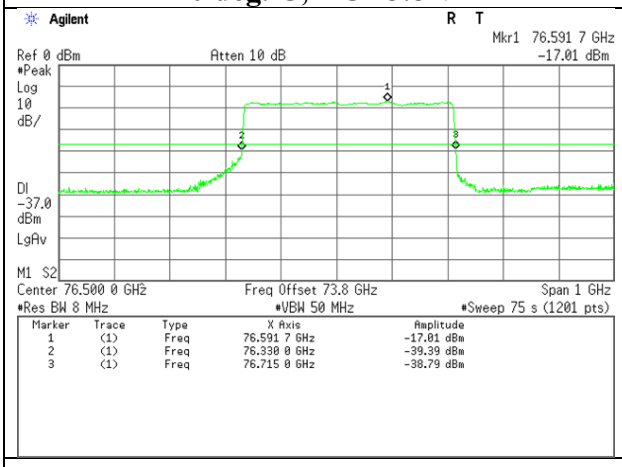


20 deg. C, DC 10.2 V

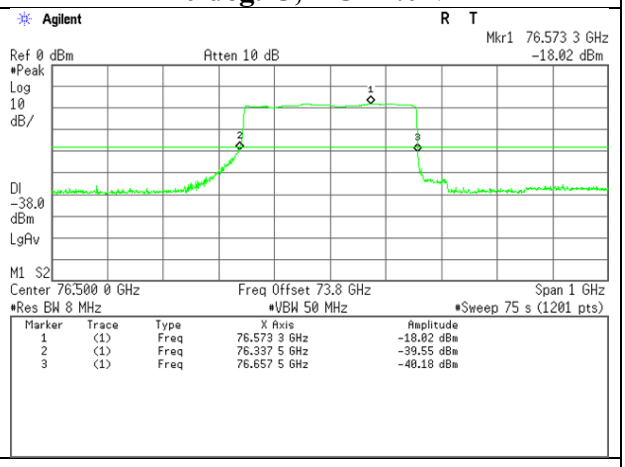


Frequency Stability

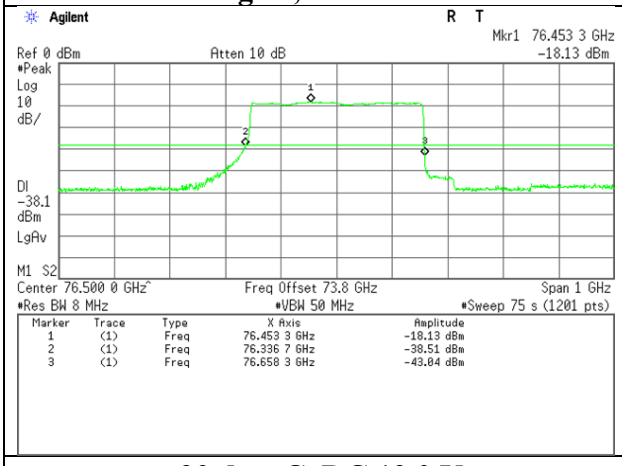
20 deg. C, DC 13.8 V



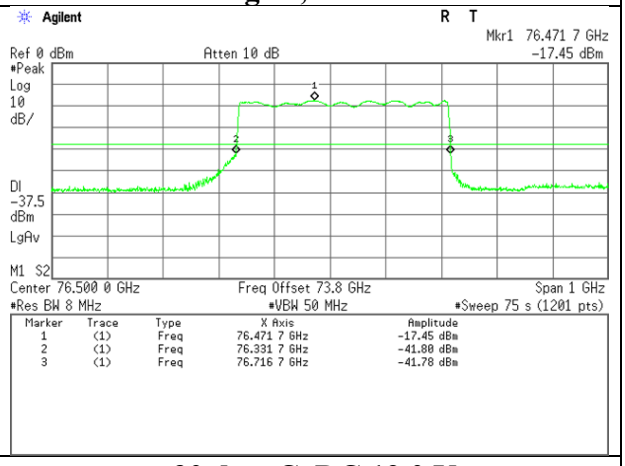
10 deg. C, DC 12.0 V



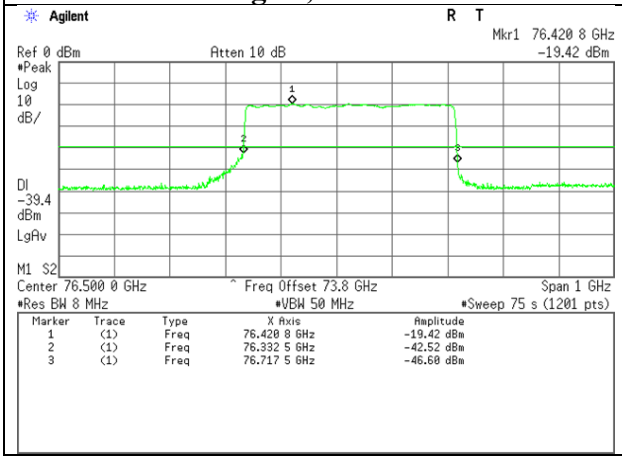
0 deg. C, DC 12.0 V



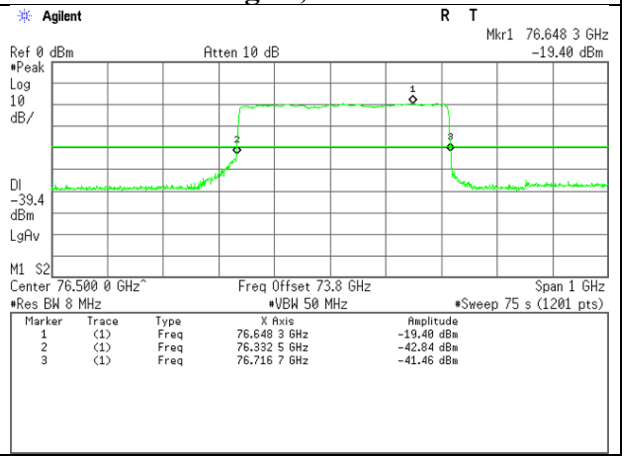
-10 deg. C, DC 12.0 V



-20 deg. C, DC 12.0 V



-30 deg. C, DC 12.0 V



APPENDIX 2: Test instruments

Test equipment (1/2)

Test Item	Local ID	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Cal Int
RE	MAEC-02	142004	AC2_Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 3m	DA-06902	05/26/2020	24
RE	MOS-41	192300	Thermo-Hygrometer	CUSTOM. Inc	CTH-201	0013	12/06/2020	12
RE	MMM-01	141542	Digital Tester	Fluke Corporation	FLUKE 26-3	78030611	08/18/2020	12
RE	MJM-27	142228	Measure	KOMELON	KMC-36	-	-	-
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	04/01/2019	24
RE	MAT-07	141203	Attenuator(6dB)	Weinschel Corp	2	BK7970	11/13/2020	12
RE	MBA-08	141427	Biconical Antenna	Schwarzbeck Mess - Elektronik	VHA9103B+BBA9106	8031	07/29/2020	12
RE	MCC-12	141317	Coaxial Cable	UL Japan Inc.	-	-	09/25/2020	12
RE	MLA-21	141265	Logperiodic Antenna(200-1000MHz)	Schwarzbeck Mess - Elektronik	VUSLP9111B	9111B-190	07/29/2020	12
RE	MPA-24	141594	Pre Amplifier	Keysight Technologies Inc	8447D	2944A10150	02/10/2020	12
RE	MTR-08	141949	Test Receiver	Rohde & Schwarz	ESCI	100767	08/18/2020	12
RE	MHA-06	141512	Horn Antenna 1-18GHz	Schwarzbeck Mess - Elektronik	BBHA9120D	254	09/14/2020	12
RE	MCC-216	141392	Microwave Cable	Junkosha	MWX221	1604S253(1 m) / 537073/126E(5 m)	02/18/2020	12
RE	MPA-10	141579	Pre Amplifier	Keysight Technologies Inc	8449B	3008A02142	01/12/2021	12
RE	MHA-16	141513	Horn Antenna 15-40GHz	Schwarzbeck Mess - Elektronik	BBHA9170	BBHA9170306	05/21/2020	12
RE	MHA-29	141517	Horn Antenna 26.5-40GHz	ETS LINDGREN	3160-10	152399	08/03/2020	12
RE	MCC-224	160324	Coaxial Cable	Huber+Suhner	SUCOFLEX 102A	MY009/2A	11/17/2020	12
RE	MSA-10	141899	Spectrum Analyzer	Keysight Technologies Inc	E4448A	MY46180655	08/04/2020	12
RE	MCC-13	141222	Coaxial Cable	Fujikura,HP,Mini-Circits,Fujikura	3D-2W(12m)/ 5D-2W(5m)/ 5D-2W(0.8m)/ 5D-2W(1m)	-	02/25/2020	12
RE	MLPA-02	142152	Loop Antenna	Rohde & Schwarz	HFH2-Z2	836553/009	12/04/2020	12
RE	MCC-219	159670	Coaxial Cable	UL Japan	-	-	11/17/2020	12
RE	MHA-35	180544	Horn Antenna	SAGE Millimeter, Inc.	SAZ-2410-10-S1	17343-01	06/24/2020	12
RE	MMX-05	142050	Block Downconverter	EMC Instruments Corporation	PS-X30-W10117A	13715	02/19/2020	12
RE	MCC-220	151897	Microwave Cable	Huber+Suhner	SF101EA/11PC24/11PC24/2.5M	SN MY1726/1EA	04/13/2020	12
RE	MHA-31	142041	Horn Antenna	Oshima Prototype Engineering Co.	A16-187	1	09/24/2020	12
RE	MPA-25	159919	Power Amplifier	SAGE Millimeter, Inc.	SBP-4035033018-2F2F-S1	12559-01	06/30/2020	12
RE	MHA-33	180634	Horn Antenna	SAGE Millimeter, Inc.	SAZ-2410-15-S1	17343-01	06/24/2020	12
RE	MPA-23	142055	Power Amplifier	SAGE Millimeter, Inc.	SBP-5037532015-1515-N1	11599-01	12/11/2020	12
RE	MMX-01	142047	Preselected Millimeter Mixer	Keysight Technologies Inc	11974V-E01	3001A00412	05/25/2020	12
RE	MPA-14	141583	Pre Amplifier	SONOMA INSTRUMENT	310	260833	02/18/2020	12
RE	MCC-177	141226	Microwave Cable	Junkosha	MMX221-00500DMSDMS	1502S304	03/18/2020	12
RE	MCC-66	141328	Microwave Cable 1G-40GHz	Suhner	SUCOFLEX102	28636/2	04/02/2020	12
RE	MHF-29	154635	High Pass Filter 83 GHz - 110 GHz	Oshima Prototype Engineering Co.	A17-016	1	05/26/2020	12

Test equipment (2/2)

Test Item	Local ID	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Cal Int
RE	MMX-08	186077	Wave guide Harmonic Mixer	Keysight Technologies Inc	M1971W	MY56390146	05/25/2020	12
RE	MPA-31	180607	Power Amplifier	SAGE Millimeter, Inc.	SBP-7531142515-1010-E1	17343-01	10/26/2020	12
RE	MHA-24	142036	Horn Antenna	Custom Microwave Inc.	HO6R	-	09/24/2020	12
RE	MPA-29	176027	D-Band Low Noise Amplifier	SAGE Millimeter, Inc.	SBL-1141741860-0606-EI	15235-01	12/07/2020	12
RE	MMX-03	142049	Harmonic Mixer	OML INC.	M06HWD	D100709-1	11/09/2020	12
RE	MHA-27	142039	Horn Antenna	Custom Microwave Inc.	HO4R	-	09/24/2020	12
RE	MMX-04	142053	Harmonic Mixer	OML INC.	M04HWD	Y100709-1	12/02/2020	12
RE	MDPLX-01	142026	Diplexer	OML INC.	DPL26	-	11/10/2020	12
RE	MOS-14	141561	Thermo-Hygrometer	CUSTOM. Inc	CTH-201	1401	01/15/2021	12
RE	MMM-12	141547	DIGITAL HiTESTER	HIOKI E.E. CORPORATION	3805	60500120	02/03/2020	12
RE	MJM-24	142225	Measure	ASKUL	-	-	-	-
RE	MCH-04	141429	Temperature and Humidity Chamber	Espec	PL-2KP	14015723	08/24/2020	12
RE	OSC-01	141962	Digital Oscilloscope	Rohde & Schwarz	RTO1004	200355	08/18/2020	12
RE	MDT-05	142529	Detector	HEROTEK, INC.	DT1840P	484823	-	-

***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 test