RADIO TEST REPORT

Test Report No. : 13785588H-A-R1

Applicant	:	**DENSO CORPORATION**
Type of Equipment	:	**Millimeter Wave Radar Sensor**
Model No.	:	**DNMWR010**
Test regulation	:	**FCC Part 95 Subpart M: 2017** ***for Permissive change**
FCC ID	:	**HYQDNMWR010**
Test Result	:	**Complied (Refer to SECTION 3)**

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2. The results in this report apply only to the sample tested.
3. This sample tested is in compliance with the limits of the above regulation.
4. The test results in this test report are traceable to the national or international standards.
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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, Inc has been accredited.
9. The information provided from the customer for this report is identified in Section 1.
10 This report is a revised version of 13785588H-A. 13785588H-A is replaced with this report.

Date of test: May 31 to June 3, 2021

Representative test engineer:
Yuichiro Yamazaki
Engineer

Approved by:
Tsubasa Takayama
Leader

CERTIFICATE 5107.02

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

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REVISION HISTORY

Original Test Report No.: 13785588H-A

Revision	Test report No.	Date	Page revised	Contents
- (Original)	13785588H-A	June 28, 2021	-	-
1	13785588H-A-R1	August 3, 2021	P.15	Correction of EUT antenna dimension; From 0.018500 m to 0.013695 m
1	13785588H-A-R1	August 3, 2021	P.18, 19	Deletion of "(Reference data)" from Radiated Power

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 Bandwidth
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 Bandwidth
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

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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	:	DNMWR010
Serial Number	:	Refer to Clause 4.2
Rating	:	DC 12 V (Car battery), DC 8 V to 16 V(Operating range)
Receipt Date	:	May 27, 2021
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: DNMWR010 (referred to as the EUT in this report) is the 76 GHz - 77 GHz vehicle-mounted field disturbance sensor that is a millimeter wave frequency modulated (FM-CW and FCM) radar operating at 76.5 GHz.
- FM-CW: Frequency Modulated Continuous Wave
- FCM: Fast Chirp Modulation

General Specification

Clock frequency(ies) in the system	:	40 MHz

Radio Specification

Radio Type	:	Transceiver
Frequency of Operation	:	76.5 GHz
Modulation	:	Frequency modulation (FM-CW, FCM)
Antenna Type	:	Microstrip array antenna
Antenna Connector	:	None (Internal Antenna)
Antenna Gain	:	Tx_N (FM-CW): 16.2 dBi Tx_W (FCM): 13.8 dBi
Steerable Antenna	:	Electronically (Receiving Part only)
Usage location	:	Vehicle-mounted

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	20.8 dB 34314.880 MHz Vertical, AV	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

UL Japan, Inc. Ise EMC Lab.
*A2LA Certificate Number: 5107.02 / FCC Test Firm Registration Number: 199967
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

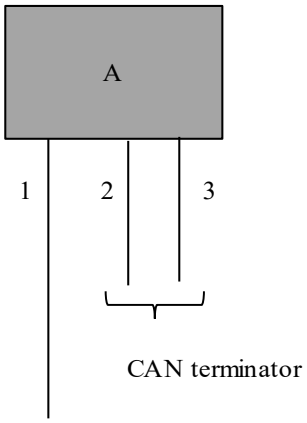
Refer to APPENDIX.

SECTION 4: Operation of EUT during testing

4.1 Operating Mode(s)

Mode	Test Item
Transmitting mode (Tx) - FCM - FM-CW	Occupied bandwidth Radiated Power Duty
Transmitting mode (Tx) - Normal operating mode	Occupied bandwidth Modulation characteristics Field strength of spurious radiation Frequency stability
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. *Power of the EUT was set by the software as follows; - Power settings: Same as production model - Software: mwr_gen5_0060_ p01 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



DC 12 V

* 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	DNMWR010	804100065001	DENSO CORPORATION	EUT

List of cables used

No.	Name	Length (m)	Shield		Remark
			Cable	Connector	
1	DC Cable	1.9	Unshielded	Unshielded	-
2	CAN 1 Cable	1.9	Unshielded	Unshielded	-
3	CAN 2 Cable	1.9	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 0.5 m, raised 1.5 m above the conducting ground plane.
The Radiated Electric Field Strength has been measured in a Semi Anechoic Chamber with absorbent materials lined on a ground plane.

The height of the measuring antenna varied between 1 m and 4 m (frequency range 9 kHz - 30 MHz: loop antenna was fixed height at 1.0 m) and EUT was rotated a full revolution in order to obtain the maximum value of the electric field strength.
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;

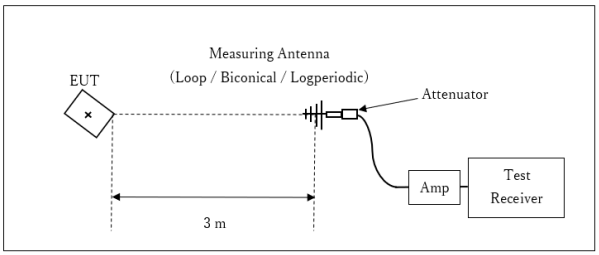
Frequency	Below 30 MHz	30 MHz to 200 MHz	200 MHz to 1 GHz	Above 1 GHz
Antenna Type	Loop	Biconical	Logperiodic	Horn

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 sweep time / number-of-bins not exceeding one millisecond)

[Test setup]

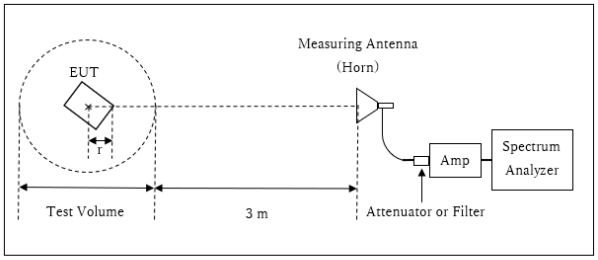
Below 1 GHz



× : Center of turn table

Test Distance: 3 m

1 GHz - 10 GHz



r : Radius of an outer periphery of EUT

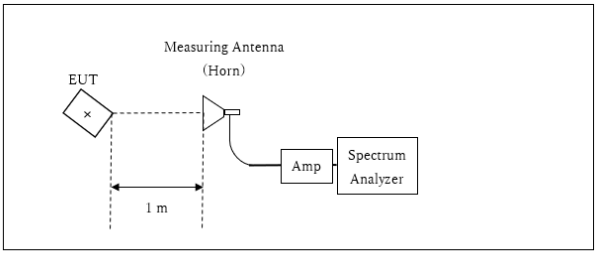
× : Center of turn table

Distance Factor: 20 x log (4.0 m*/3.0 m) = 2.50 dB
* Test Distance: (3 + Test Volume /2) - r = 4.0 m

Test Volume: 2 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 - 40 GHz

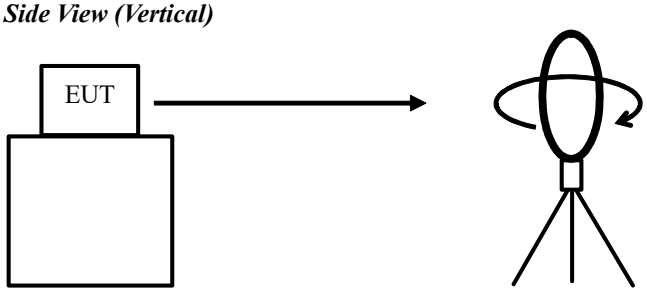


× : Center of turn table

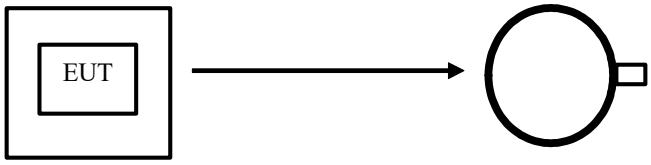
Distance Factor: 20 x log (1.0 m* / 3.0 m) = -9.54 dB
*Test Distance: 1 m

Figure 1: Direction of the Loop Antenna

Side View (Vertical)

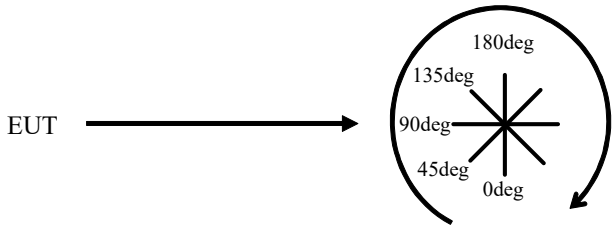


Top View (Horizontal)



Antenna was not rotated.

Top View (Vertical)



Front side: 0 deg.
Forward direction: clockwise

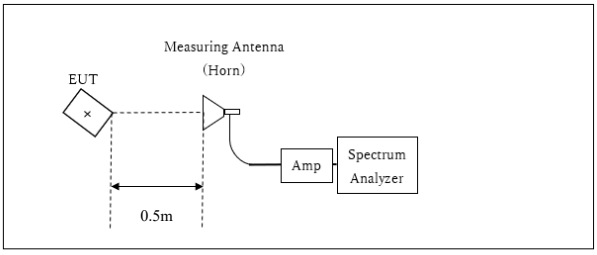
[Above 40 GHz]
The test was performed based on "Procedures for testing millimeter-wave systems" of ANSI C63.10-2013. The EUT was placed on a urethane platform, raised 1.5 m above the conducting ground plane. The measurements were performed on handheld method.

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

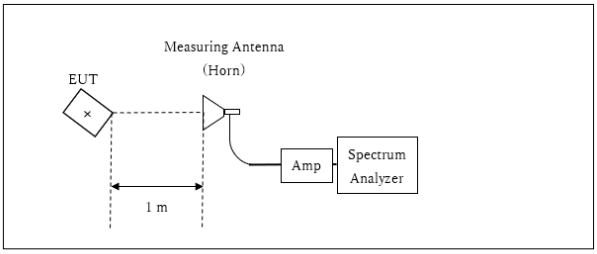
[Test setup]
40 GHz - 50 GHz, 81 GHz - 110 GHz



× : Center of turn table

*Test Distance: 0.5 m

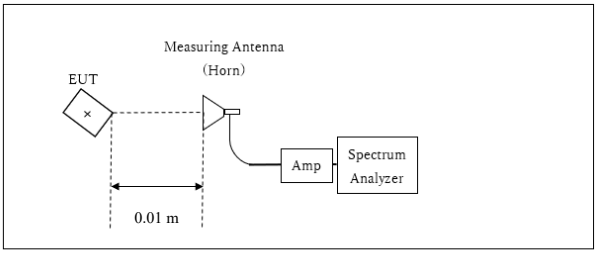
50 GHz - 76 GHz



× : Center of turn table

*Test Distance: 1.0 m

110 GHz – 231 GHz



× : Center of turn table

*Test Distance: 0.01 m

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

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

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

where

r is the distance from the radiating element of the EUT to the edge of the far field, in m
D is the largest dimension of both the radiating element and the test antenna (horn), in m
(The antenna aperture size of test antenna was used for this 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

- For the carrier measurement, the measuring antenna was angularly-tilted, since the EUT has angularly-tilted linear polarized antenna.

- The noise levels were confirmed at each position of X and Y axes of EUT to see the position of maximum noise, and the test was made at the position that has the maximum noise.

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

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 Ts refer to Theory of Operation-Specification.

Mode	F_s	T_s	B	α	FMCW Desensitization factor
	[MHz]	[usec]	[MHz]		[dB]
FCM	369.4549	33.6	1.0	0.449	-6.95
FM-CW	303.9847	2054.0	1.0	0.999	-0.01

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 80 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

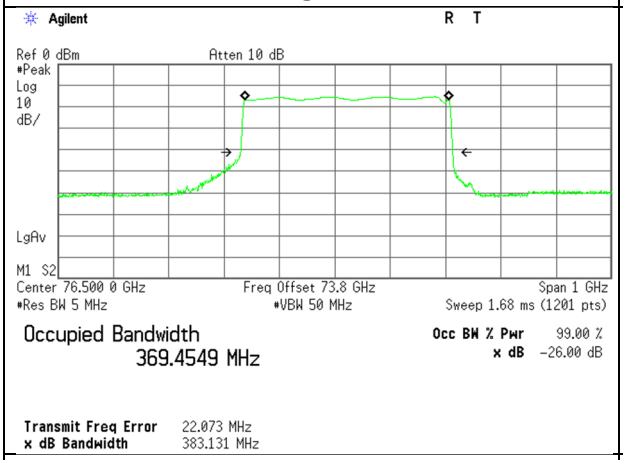
APPENDIX 1: Test data

Occupied bandwidth

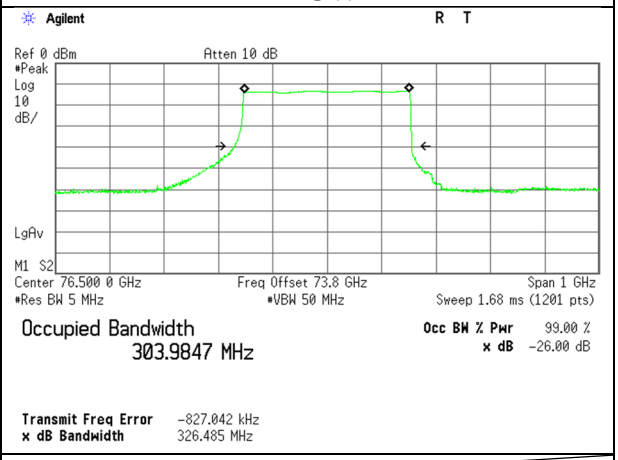
Report No.	13785588H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.4
Date	May 31, 2021
Temperature / Humidity	21 deg. C / 45 % RH
Engineer	Yuichiro Yamazaki
Mode	Tx

Mode	Frequency [GHz]	99 % Occupied bandwidth [MHz]
FCM	76.5	369.4549
FMCW	76.5	303.9847
Normal	76.5	369.5071

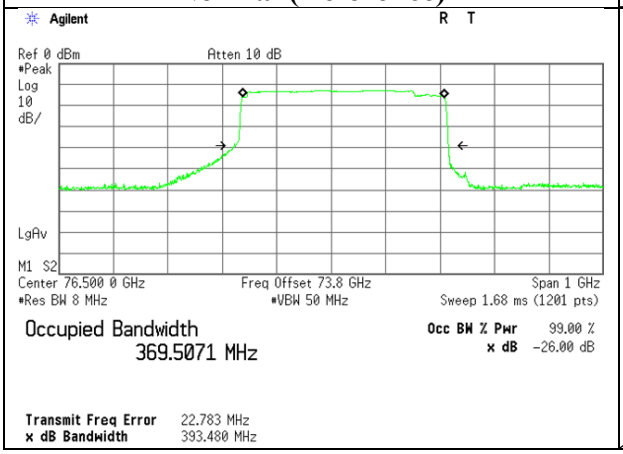
FCM



FMCW



Normal (Reference)



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

Radiated Power

Report No.	13785588H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.4
Date	May 31, 2021
Temperature / Humidity	21 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]
FCM	Average	76.5	-24.79	1.5	23.06	14.73	1.44	73.64	12.50	17.77
	Peak	76.5	-17.10	1.5	23.06	14.73	1.44	73.64	20.19	104.40
FM-CW	Average	76.5	-20.75	1.5	23.06	14.73	1.44	73.64	16.54	45.05
	Peak	76.5	-13.62	1.5	23.06	14.73	1.44	73.64	23.67	232.64

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

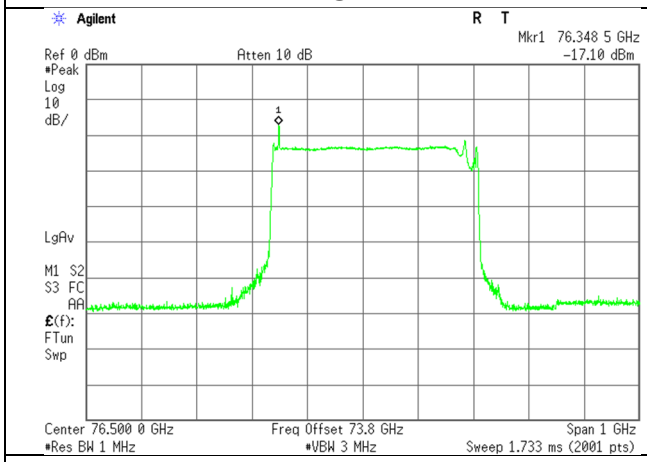
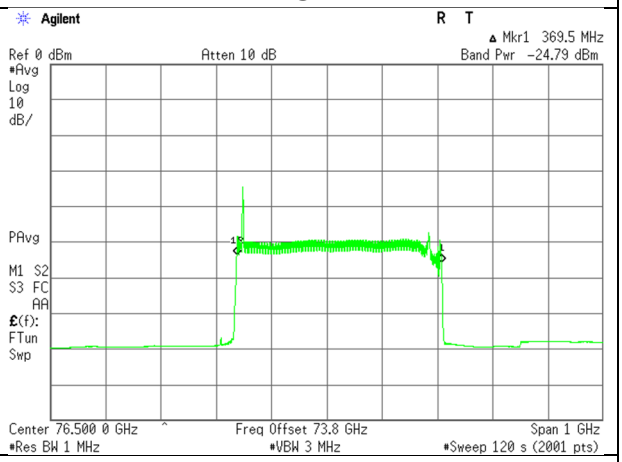
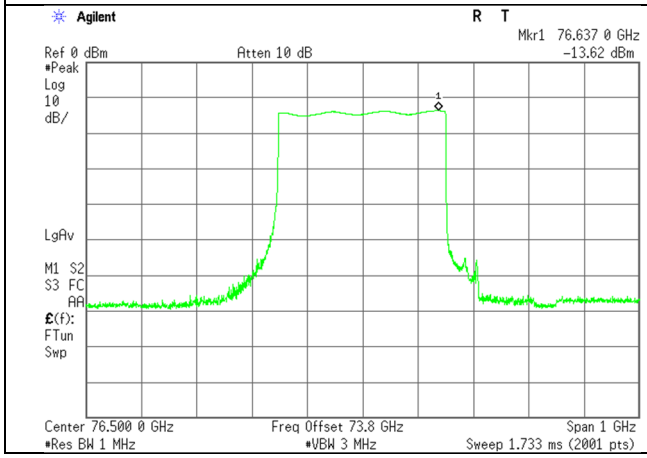
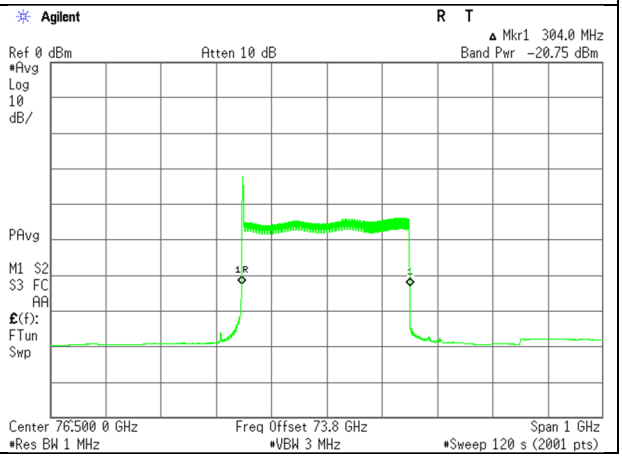
Mode	Power	EIRP Spectrum Analyzer [dBm]	Duty Factor [dB]	desensitization Factor [dB]	Result [mW]	Result [dBm]	Limit [dBm]	Margin [dB]
FCM	Average	12.50	8.95	-	139.53	21.45	50	28.55
	Peak	20.19	-	6.95	517.18	27.14	55	27.86
FM-CW	Average	16.54	7.38	-	246.42	23.92	50	26.08
	Peak	23.67	-	0.01	233.13	23.68	55	31.32

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

Peak	Average
FCM	FCM
	
FMCW	FMCW
	

Duty

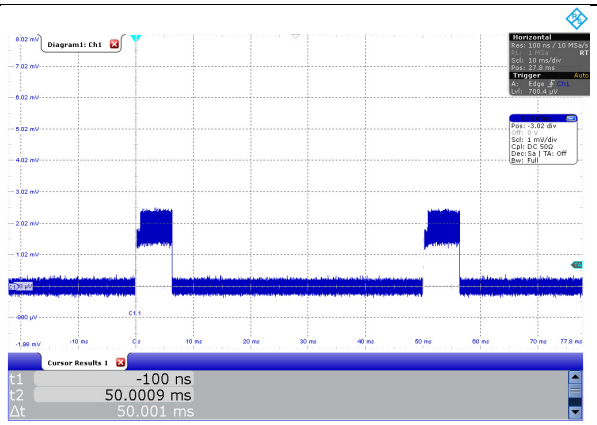
Report No.	13785588H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.4
Date	May 31, 2021
Temperature / Humidity	21 deg. C / 45 % RH
Engineer	Yuichiro Yamazaki
Mode	Tx

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

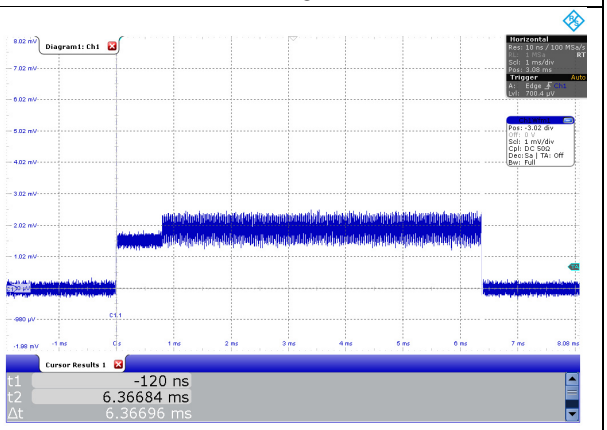
Calculation: Duty Factor = 10 * log(Tx on time / Tx on + Tx off time)

FCM

Tx on + Tx off

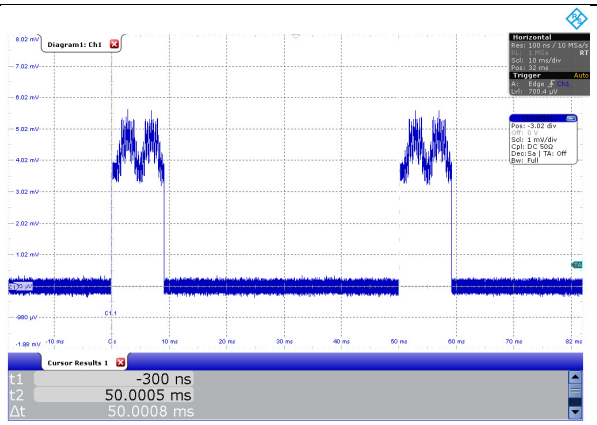


Tx on

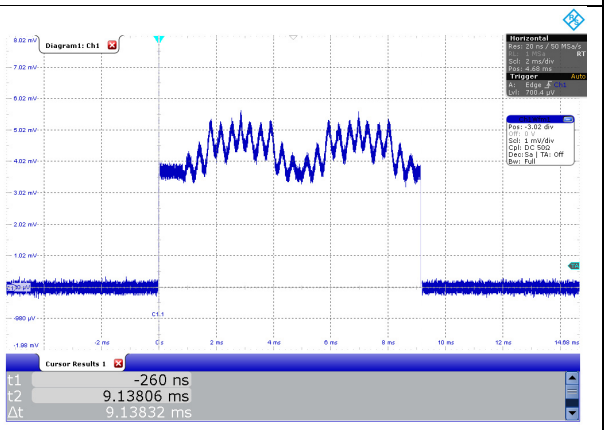


FMCW

Tx on + Tx off



Tx on



Modulation characteristics

Report No.	13785588H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No.4
Date	May 31, 2021
Temperature / Humidity	21 deg. C / 45 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode

[Duty Factor]

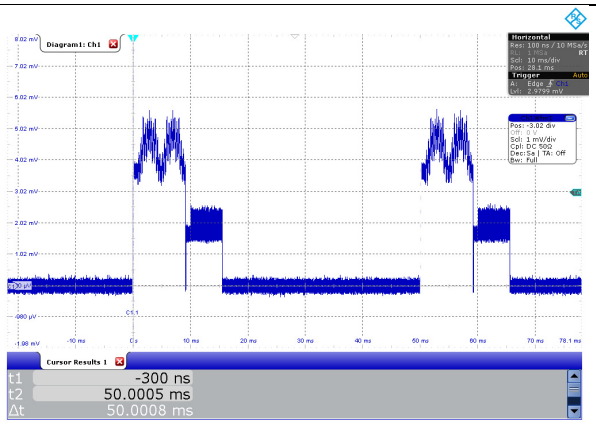
	Tx On time [ms]	Tx On + Off time [ms]	Duty factor [dB]
Measured	18.59	50.00	-4.30
Declared *	15.58	50.00	-5.06

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

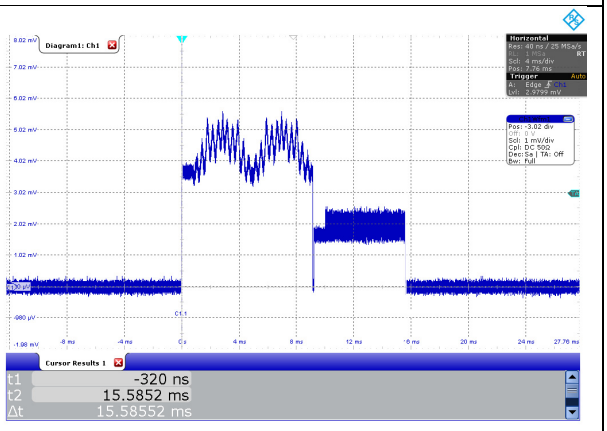
[Data]

(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)

Report No.	13785588H	
Test place	Ise EMC Lab.	
Semi Anechoic Chamber	No.4	No.4
Date	May 31, 2021	June 1, 2021
Temperature / Humidity	22 deg. C / 44 % RH	21 deg. C / 46 % RH
Engineer	Yuichiro Yamazaki	Yuichiro Yamazaki
	(Below 30 MHz)	(30 MHz - 1000 MHz)
	(1 GHz - 26.5 GHz)	(26.5 GHz - 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.	34.066	QP	22.0	16.9	7.2	32.0	-	14.1	40.0	25.9	
Hori.	55.118	QP	22.4	9.2	7.5	32.0	-	7.1	40.0	32.9	
Hori.	67.132	QP	22.2	6.5	7.6	32.0	-	4.3	40.0	35.7	
Hori.	99.762	QP	22.8	10.1	8.0	32.0	-	8.8	43.5	34.7	
Hori.	115.021	QP	22.1	12.2	8.1	32.0	-	10.4	43.5	33.1	
Hori.	135.143	QP	22.2	14.0	8.3	32.0	-	12.6	43.5	31.0	
Hori.	34314.880	AV	60.3	43.5	4.0	76.1	-	31.7	53.9	22.2	RMS Average
Vert.	41.431	QP	28.7	14.2	7.3	32.0	-	18.2	40.0	21.8	
Vert.	55.058	QP	32.7	9.3	7.5	32.0	-	17.4	40.0	22.6	
Vert.	67.764	QP	33.8	6.4	7.6	32.0	-	15.8	40.0	24.2	
Vert.	96.937	QP	32.7	9.6	7.9	32.0	-	18.3	43.5	25.3	
Vert.	99.761	QP	34.3	10.1	8.0	32.0	-	20.3	43.5	23.2	
Vert.	114.818	QP	30.1	12.2	8.1	32.0	-	18.4	43.5	25.1	
Vert.	34314.880	AV	61.6	43.5	4.0	76.1	-	33.1	53.9	20.8	RMS Average

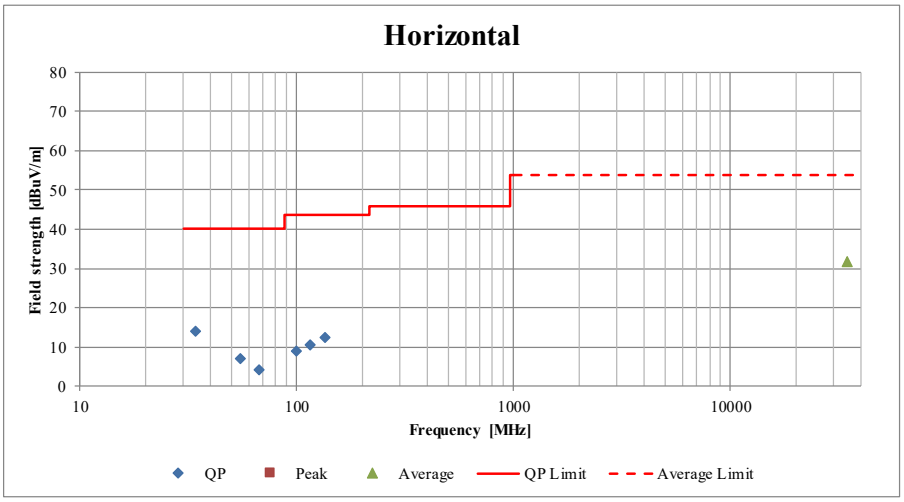
Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter+Distance factor(above 1 GHz)) - Gain(Amplifier)

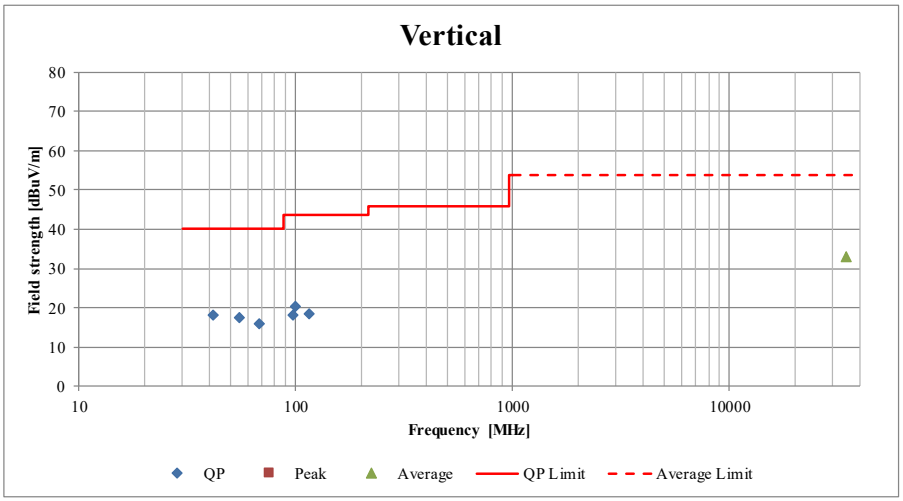
*Other frequency noises omitted in this report were not seen or had enough margin (more than 20 dB).

Distance factor: 1 GHz - 10 GHz 20log (4.0 m / 3.0 m) = 2.50 dB
10 GHz - 40.0 GHz 20log (1.0 m / 3.0 m) = -9.54 dB

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

Report No.	13785588H	
Test place	Ise EMC Lab.	
Semi Anechoic Chamber	No.4	No.4
Date	May 31, 2021	June 1, 2021
Temperature / Humidity	22 deg. C / 44 % RH	21 deg. C / 46 % RH
Engineer	Yuichiro Yamazaki	Yuichiro Yamazaki
	(Below 30 MHz)	(30 MHz - 1000 MHz)
	(1 GHz - 26.5 GHz)	(26.5 GHz - 40 GHz)
Mode	Normal operating mode	





Field strength of spurious radiation
(above 40 GHz)

Report No.	13785588H
Test place	Ise EMC Lab.
Semi Anechoic Chamber	No. 4
Date	May 31, 2021
Temperature / Humidity	22 deg. C / 44 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode

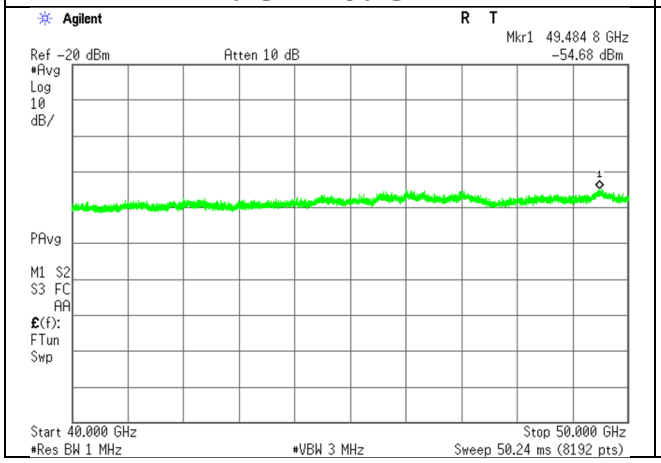
Freq. [GHz]	Reading [dBm]	Rx ant. gain [dBi]	Filter loss [dB]	LNA gain [dB]	Mixer loss [dB]	IF amp. gain [dB]	IF cable loss [dB]	Meas. range *D* [m]	FSL [dB]	EIRP [dBm]	EIRP [mW]	Power density at 3 m Result [pW/cm^2]	Power density at 3 m Limit [pW/cm^2]	Power density at 3 m Margin [dB]	Remarks
49.485	-54.68	22.40	0.00	31.76	0.00	0.00	9.01	0.5	60.31	-39.52	0.000112	0.10	600	37.84	No signal detected.
74.545	-63.51	24.49	1.15	20.48	0.00	0.00	0.00	1.0	69.89	-37.44	0.000180	0.16	600	35.76	No signal detected.
75.067	-67.69	22.96	0.00	0.00	-15.25	0.00	0.99	1.0	69.95	-34.96	0.000319	0.28	600	33.28	No signal detected.
82.348	-71.83	23.50	0.20	0.00	-12.12	0.00	2.65	0.5	64.73	-39.86	0.000103	0.09	600	38.18	No signal detected.
87.567	-50.40	23.84	0.74	31.65	0.00	0.00	0.00	0.5	65.27	-39.89	0.000103	0.09	600	38.20	No signal detected.
102.252	-46.67	24.53	0.37	31.82	0.00	0.00	0.00	0.5	66.61	-36.03	0.000249	0.22	600	34.35	No signal detected.
123.976	-90.16	22.77	0.00	19.64	51.96	0.00	0.00	0.01	34.31	-46.30	0.000023	0.02	600	44.62	No signal detected.
131.998	-90.96	23.00	0.00	19.42	53.01	0.00	0.00	0.01	34.85	-45.51	0.000028	0.02	600	43.83	No signal detected.
152.264	-88.58	23.35	0.00	17.78	56.69	0.00	0.00	0.01	36.09	-36.93	0.000203	0.18	600	35.24	No signal detected.
155.088	-92.02	23.37	0.00	17.73	57.25	0.00	0.00	0.01	36.25	-39.61	0.000109	0.10	600	37.93	No signal detected.
170.772	-90.89	22.41	0.00	0.00	60.20	0.00	0.00	0.01	37.09	-16.01	0.025050	22.15	600	14.33	No signal detected.
192.124	-90.89	22.88	0.00	0.00	57.30	0.00	0.00	0.01	38.11	-18.35	0.014616	12.92	600	16.67	No signal detected.
210.824	-91.75	23.17	0.00	0.00	57.59	0.00	0.00	0.01	38.92	-18.41	0.014422	12.75	1000	18.94	No signal detected.
228.800	-88.08	23.34	0.00	0.00	62.39	0.00	0.00	0.01	39.63	-9.40	0.114866	101.56	1000	9.93	No signal detected.

Calculation:

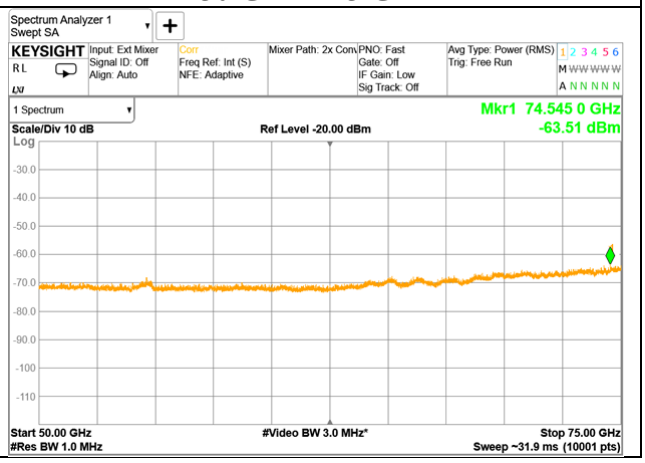
FSL (Free Space path Loss) = 10 * log ((4 * Pi * D / λ) ^{2})
EIRP = Reading - Rx ant. gain + Filter loss - LNA gain + Mixer loss - IF amp. gain + IF cable loss + FSL
Power density Result at 3 m = EIRP / (4 * Pi * 300 ^{2})

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.
The conversion loss is autmatically corrected inte mixer, so the factor of data sheet were set to o dB.

40 GHz - 50 GHz



50 GHz - 75 GHz



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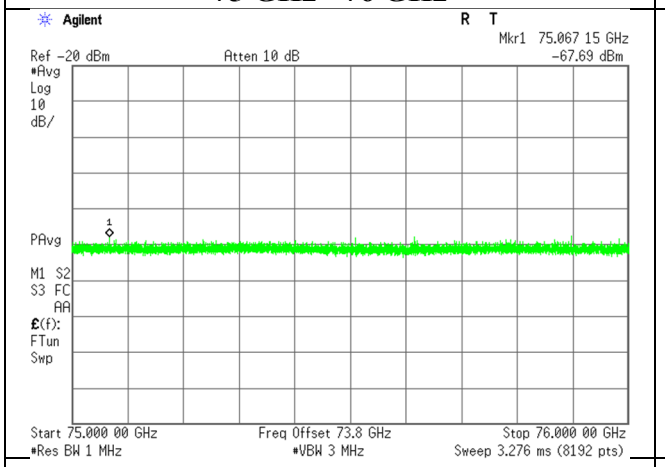
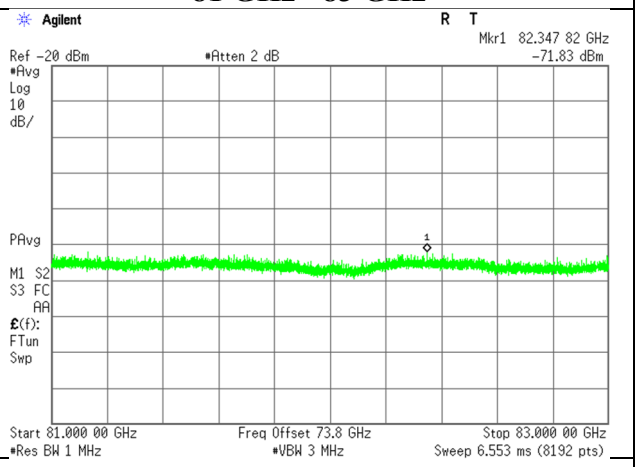
Field strength of spurious radiation
(above 40 GHz)

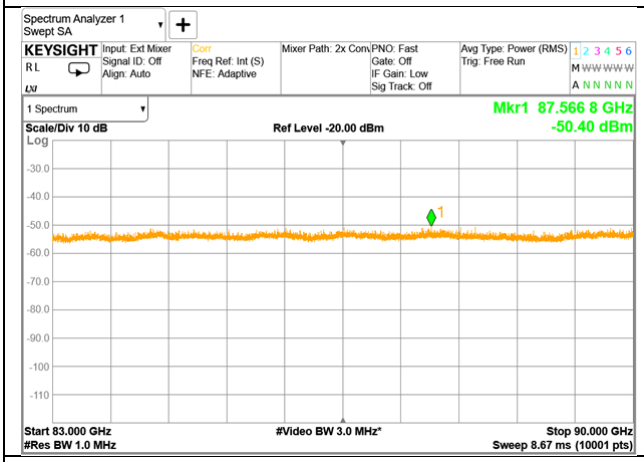
75 GHz - 76 GHz



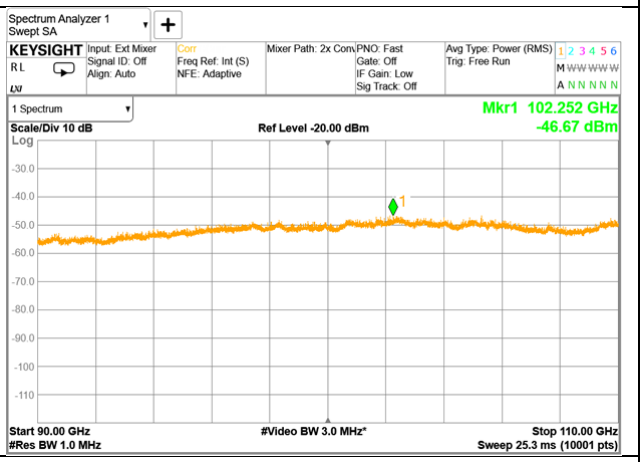
81 GHz - 83 GHz



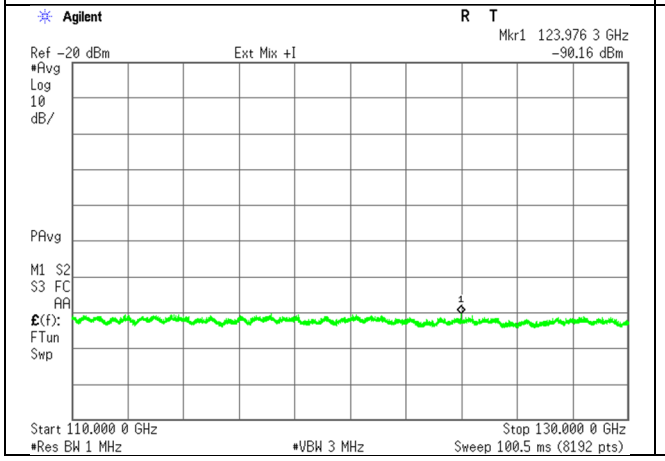
83 GHz - 90 GHz



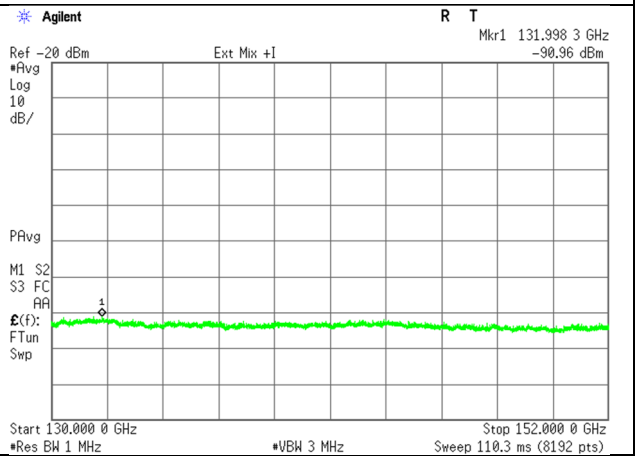
90 GHz - 110 GHz



110 GHz - 130 GHz



130 GHz - 152 GHz



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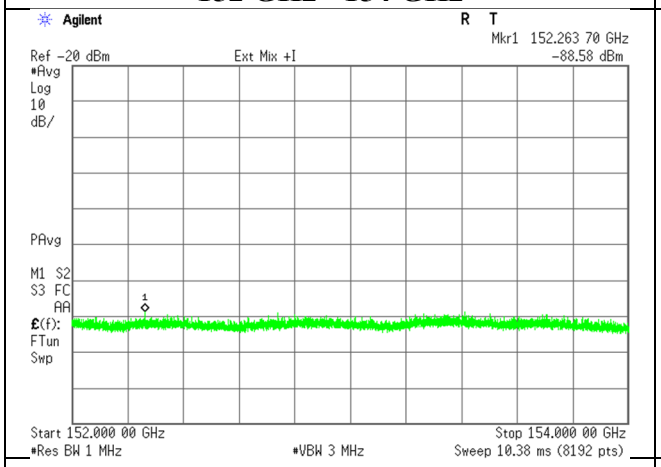
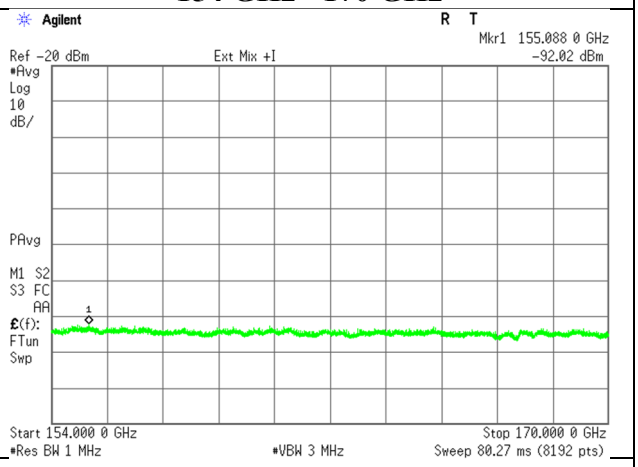
Field strength of spurious radiation
(above 40 GHz)

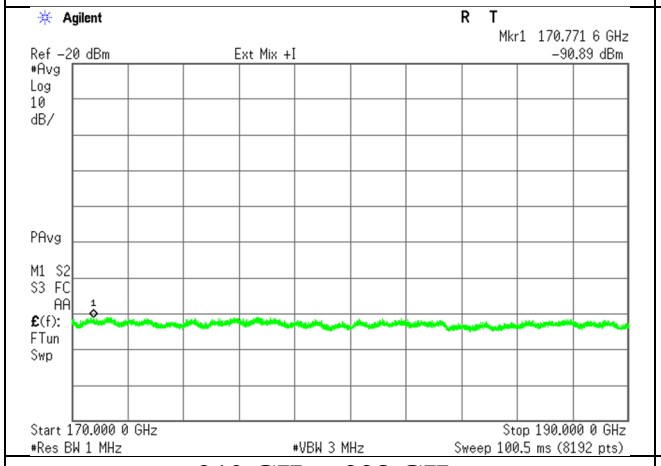
152 GHz - 154 GHz



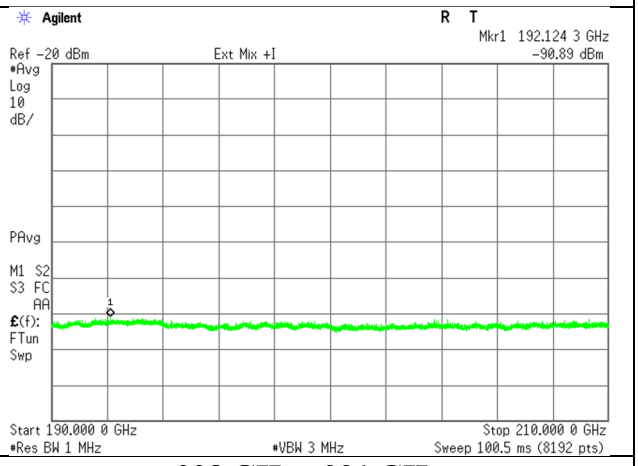
154 GHz - 170 GHz



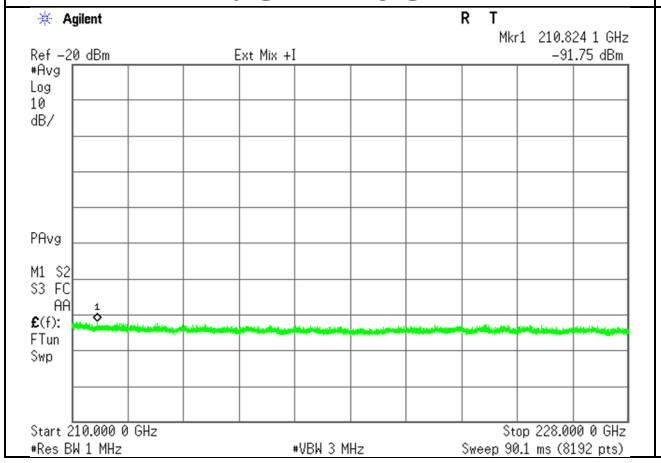
170 GHz - 190 GHz



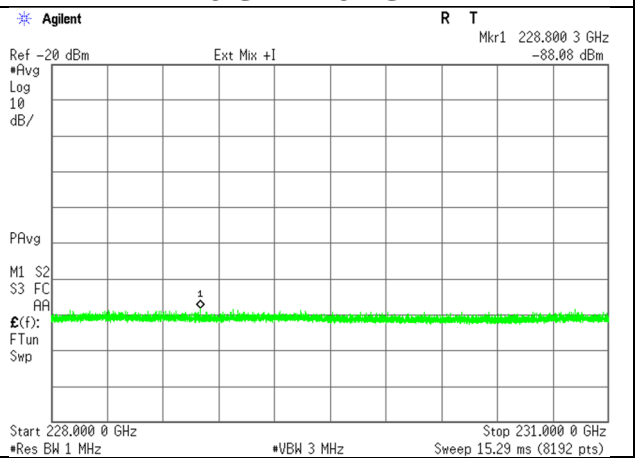
190 GHz - 210 GHz



210 GHz - 228 GHz



228 GHz - 231 GHz



Frequency Stability

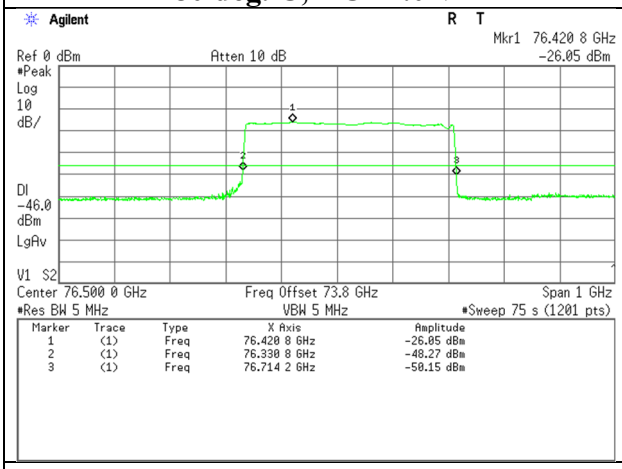
Report No.	13785588H
Test place	Ise EMC Lab. No.6 Measurement Room
Date	June 3, 2021
Temperature / Humidity	22 deg. C / 47 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature [deg. C]	Power Supply [V]	Lower Result [GHz]	Upper Result [GHz]	
80	12.0	76.331	76.714	Customer requested temperature
70	12.0	76.332	76.714	Customer requested temperature
60	12.0	76.331	76.714	Customer requested temperature
50	12.0	76.331	76.714	
40	12.0	76.333	76.713	
30	12.0	76.333	76.714	
20	12.0	76.333	76.713	
20	10.2	76.333	76.713	85 % of the minimum operating voltage, DC 12V * 0.85
20	13.8	76.333	76.713	115 % of the maximum operating voltage, DC 12 V * 1.15
10	12.0	76.333	76.714	
0	12.0	76.334	76.715	
-10	12.0	76.334	76.715	
-20	12.0	76.334	76.715	
-30	12.0	76.334	76.716	Customer requested temperature

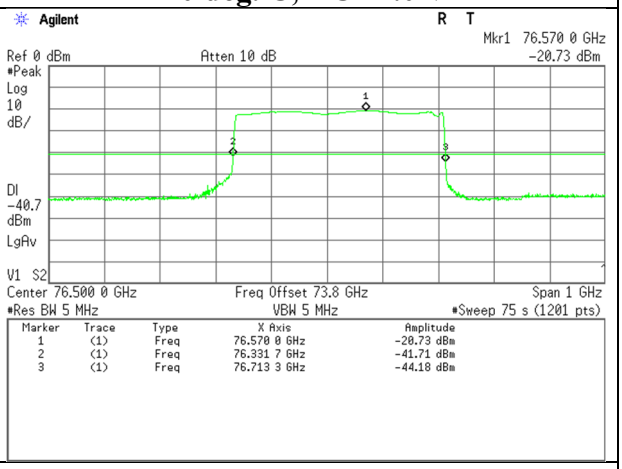
Fundamental emissions were contained within the frequency band 76 GHz to 77 GHz during all conditions of operation.

Frequency Stability

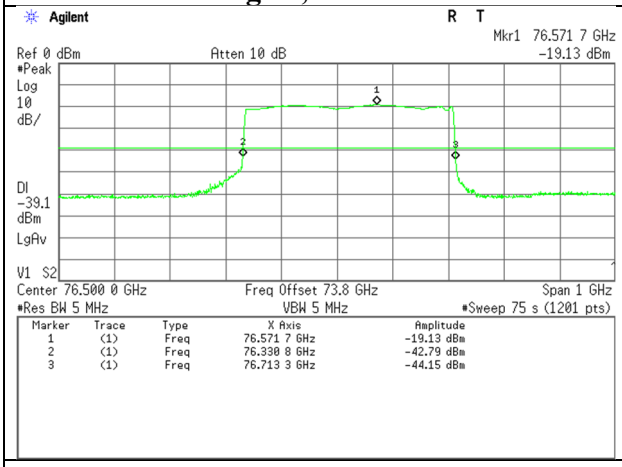
80 deg. C, DC 12.0 V



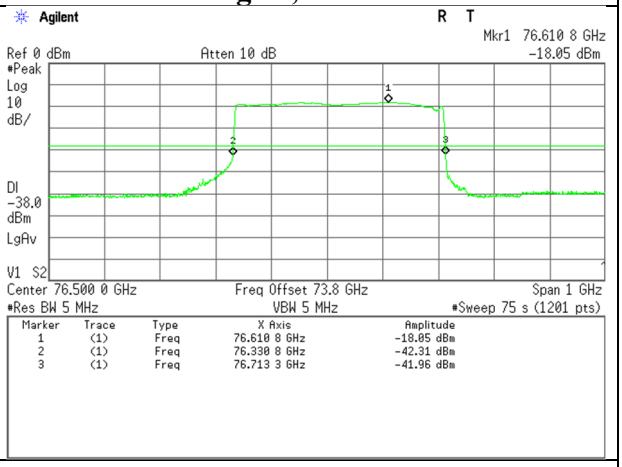
70 deg. C, DC 12.0 V



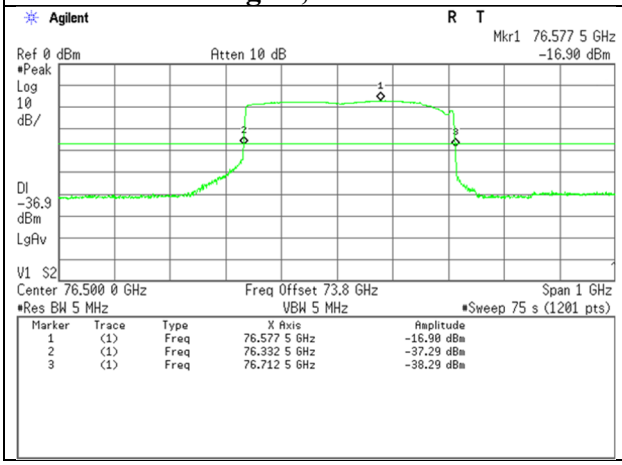
60 deg. C, DC 12.0 V



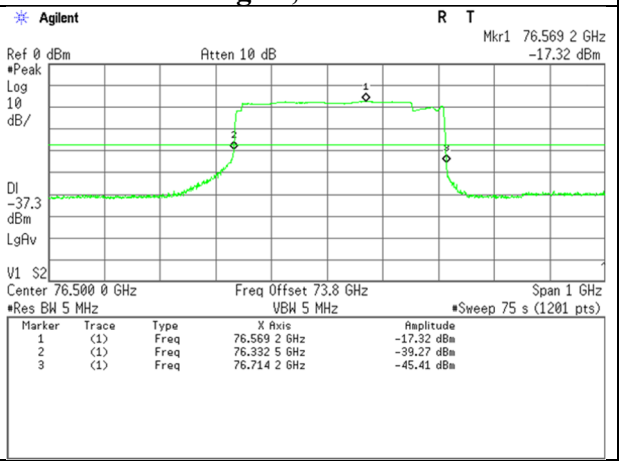
50 deg. C, DC 12.0 V



40 deg. C, DC 12.0 V

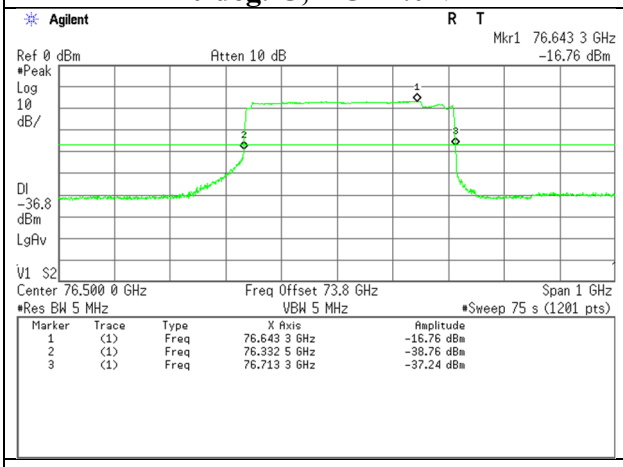


30 deg. C, DC 12.0 V

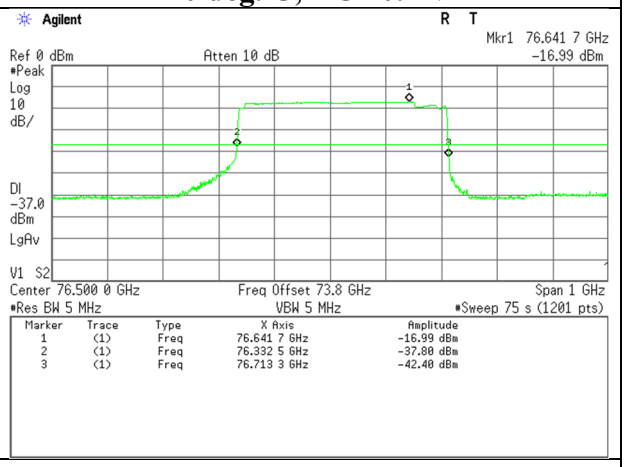


Frequency Stability

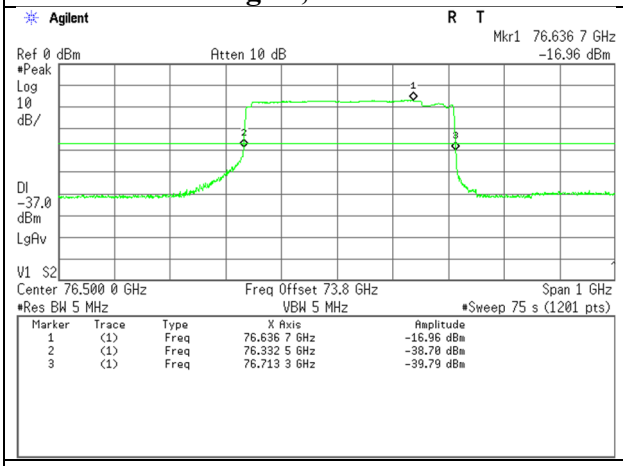
20 deg. C, DC 12.0 V



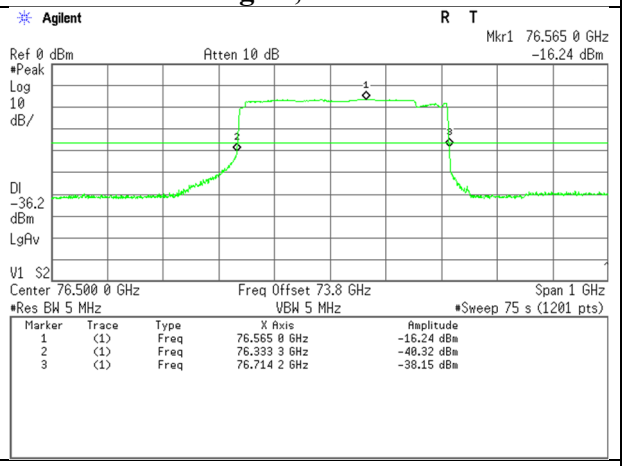
20 deg. C, DC 10.2 V



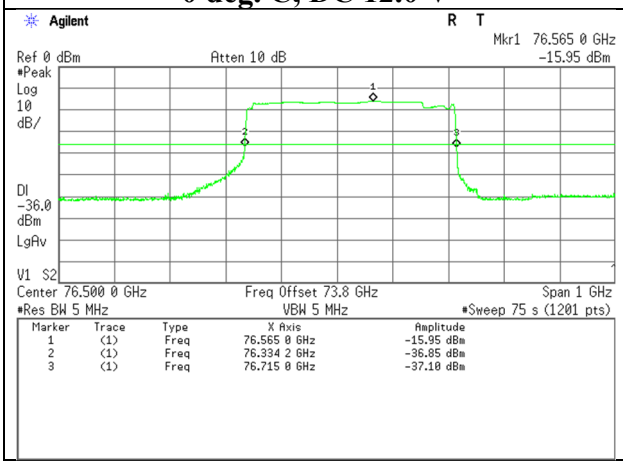
20 deg. C, DC 13.8 V



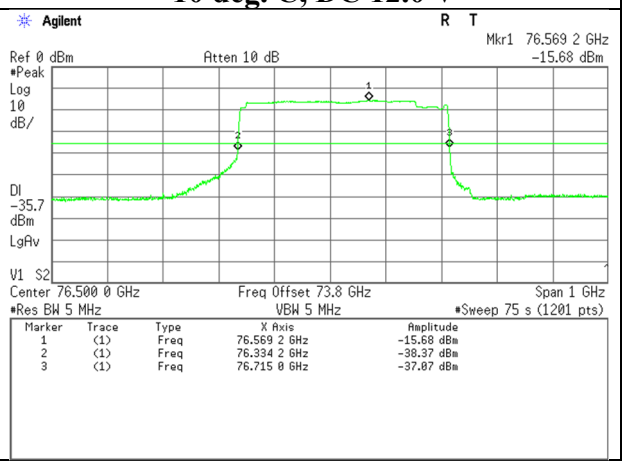
10 deg. C, DC 12.0 V



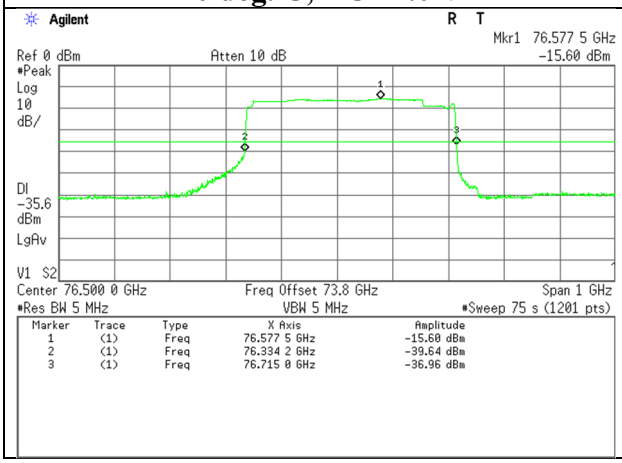
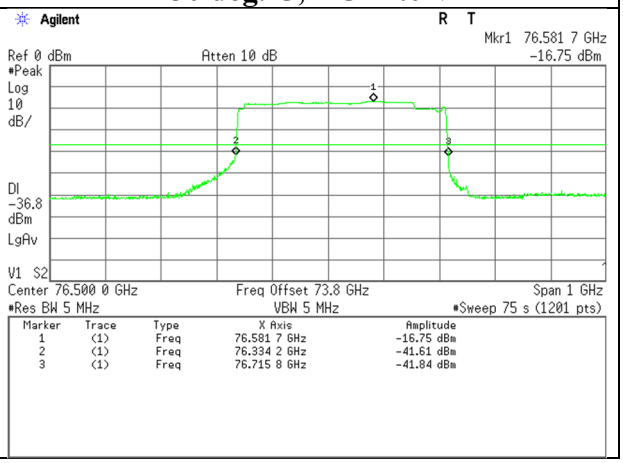
0 deg. C, DC 12.0 V



-10 deg. C, DC 12.0 V



Frequency Stability

-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	MOS-15	141562	Thermo-Hygrometer	CUSTOM. Inc	CTH-201	0010	01/15/2021	12
RE	MMM-10	141545	DIGITAL HiTESTER	HIOKI E.E. CORPORATION	3805	51201148	01/07/2021	12
RE	MJM-29	142230	Measure	KOMELON	KMC-36	-	-	-
RE	COTS-MEMI-02	178648	EMI measurement program	TSJ (Techno Science Japan)	TEPTO-DV	-	-	-
RE	MAEC-04-SVSWR	142017	AC4_Semi Anechoic Chamber(SVSWR)	TDK	Semi Anechoic Chamber 3m	DA-10005	04/12/2021	24
RE	MSA-03	141884	Spectrum Analyzer	Keysight Technologies Inc	E4448A	MY44020357	03/10/2021	12
RE	MMX-05	142050	Block Downconverter	EMC Instruments Corporation	PS-X30-W10117A	13715	03/02/2021	12
RE	MHA-35	180544	Horn Antenna	SAGE Millimeter, Inc.	SAZ-2410-10-S1	17343-01	06/24/2020	12
RE	MCC-67	141329	Microwave Cable 1G-40GHz	Suhner	SUCOFLEX102	28635/2	04/12/2021	12
RE	OSC-01	141962	Digital Oscilloscope	Rohde & Schwarz	RTO1004	200355	08/18/2020	12
RE	MDT-05	142529	Detector	HEROTEK, INC.	DT1840P	484823	-	-
RE	MHF-30	183867	WR-10 HighPass Filter	Oshima Prototype Engineering Co.	A19-206	001	03/05/2021	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	06/02/2021	12
RE	MCC-220	151897	Microwave Cable	Huber+Suhner	SF101EA/11PC24/11PC24/2.5M	SN MY1726/1EA	04/12/2021	12
RE	MDPLX-01	142026	Diplexer	OML INC.	DPL26	-	11/10/2020	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	03/05/2021	12
RE	MMX-03	142049	Harmonic Mixer	OML INC.	M06HWD	D100709-1	11/09/2020	12
RE	MCC-135	142032	Microwave Cable	Huber+Suhner	SUCOFLEX102	37511/2	09/16/2020	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	MSA-19	182484	Signal Analyzer	Keysight Technologies Inc	N9030B	MY57143159	06/24/2020	12
RE	MHA-33	180634	Horn Antenna	SAGE Millimeter, Inc.	SAZ-2410-15-S1	17343-01	06/24/2020	12
RE	MLF-01	201432	WR-15 Low Pass Filter	Oshima Prototype Engineering Co.	2020-0142-02	001	09/23/2020	12
RE	MPA-23	142055	Power Amplifier	SAGE Millimeter, Inc.	SBP-5037532015-1515-N1	11599-01	03/05/2021	12
RE	MMX-07	186076	Wave guide Harmonic Mixer	Keysight Technologies Inc	M1971V	MY56390208	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	10/26/2020	12
RE	MMX-08	186077	Wave guide Harmonic Mixer	Keysight Technologies Inc	M1971W	MY56390146	05/18/2021	12
RE	MHA-17	141506	Horn Antenna 15-40GHz	Schwarzbeck Mess-Elektronik OHG	BBHA9170	BBHA9170307	07/16/2020	12
RE	MCC-246	199563	Microwave Cable	Huber+Suhner	SF126E/11PC35/11PC35/1000M,5000M	537061/126E / 537072/126E	06/11/2020	12
RE	MPA-12	141581	MicroWave System Amplifier	Keysight Technologies Inc	83017A	00650	10/19/2020	12
RE	MHA-21	141508	Horn Antenna 1-18GHz	Schwarzbeck Mess-Elektronik OHG	BBHA9120D	557	05/10/2021	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 Inc.	-	-	11/17/2020	12

Test equipment (2/2)

Test Item	Local ID	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Cal Int
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	MAT-34	141331	Attenuator(6dB)	TME	UFA-01	-	02/02/2021	12
RE	MPA-14	141583	Pre Amplifier	SONOMA INSTRUMENT	310	260833	02/18/2021	12
RE	MTR-03	141942	Test Receiver	Rohde & Schwarz	ESCI	100300	08/18/2020	12
RE	MHA-29	141517	Horn Antenna 26.5-40GHz	ETS-Lindgren	3160-10	152399	08/03/2020	12
RE	MPA-22	141588	Pre Amplifier	MITEQ, Inc	AMF-6F-2600400-33-8P / AMF-4F-2600400-33-8P	1871355 / 1871328	09/07/2020	12
RE	MCC-224	160324	Coaxial Cable	Huber+Suhner	SUCOFLEX 102A	MY009/2A	11/17/2020	12
RE	MPA-03	141577	Microwave System Power Amplifier	Keysight Technologies Inc	83050A	MY39500610	10/19/2020	12
RE	MHA-04	141505	Horn Antenna 26.5-40GHz	EMCO	3160-10	1140	08/03/2020	12
RE	MAEC-04	142011	AC4_Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 3m	DA-10005	05/25/2020	24
RE	MBA-05	141425	Biconical Antenna	Schwarzbeck Mess-Elektronik OHG	VHA9103+BBA9106	VHA 91031302	08/31/2020	12
RE	MCC-50	141397	Coaxial Cable	UL Japan	-	-	11/06/2020	12
RE	MLA-23	141267	Logperiodic Antenna(200-1000MHz)	Schwarzbeck Mess-Elektronik OHG	VUSLP9111B	9111B-192	09/02/2020	12
RE	MCH-04	141429	Temperature and Humidity Chamber	Espec	PL-2KP	14015723	08/24/2020	12
RE	MOS-14	141561	Thermo-Hygrometer	CUSTOM. Inc	CTH-201	1401	01/15/2021	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 test