RADIO TEST REPORT

Test Report No. 15310343H-A-R1

Customer	**DENSO CORPORATION**
Description of EUT	**Millimeter Wave Radar Sensor**
Model Number of EUT	**DNMWR015**
FCC ID	**HYQDNMWR015**
Test Regulation	**FCC Part 95 Subpart M**
Test Result	**Complied**
Issue Date	**August 29, 2024**
Remarks	***For Permissive Change**

Representative test engineer	**Approved by**
Yuichiro Yamazaki Engineer	Ryota Yamanaka Engineer

CERTIFICATE 5107.02

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

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REVISION HISTORY

Original Test Report No.: 15310343H-A

This report is a revised version of 15310343H-A. 15310343H-A is replaced with this report.

Revision	Test Report No.	Date	Page Revised Contents
- (Original)	15310343H-A	July 24, 2024	-
1	15310343H-A-R1	August 29, 2024	Correction of erroneous description for title of table in Radiated Power data (page 17).
1	15310343H-A-R1	August 29, 2024	Correction of erroneous description for the Peak Power value in the Radiated Power data (page 17); from "-11.98" to "-11.93".
1	15310343H-A-R1	August 29, 2024	Change the Modulation characteristics data as follows (page 18); - Correction of the Calculating Formula - Correction of the Duty factor value - Addition of the note
1	15310343H-A-R1	August 29, 2024	Correction of the vertical axis value for [Plot data, Worst case] of Field strength of spurious radiation (Below 40 GHz) (page 19).

Reference: Abbreviations (Including words undescribed in this report)

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

CONTENTS PAGE

SECTION 1: Customer Information

Company Name	DENSO CORPORATION
Address	1-1, Showa-cho, Kariya-shi, Aichi-ken, 448-8661 Japan
Telephone Number	+81-566-56-0051
Contact Person	Yuko Suzuki

The information provided by the customer is as follows;
- Customer, Description of EUT, Model Number of EUT, FCC ID on the cover and other relevant pages
- Operating/Test Mode(s) (Mode(s)) on all the relevant pages
- SECTION 1: Customer Information
- SECTION 2: Equipment Under Test (EUT) other than the Receipt Date and Test Date
- SECTION 4: Operation of EUT during testing

SECTION 2: Equipment Under Test (EUT)

2.1 Identification of EUT

Description	Millimeter Wave Radar Sensor
Model Number	DNMWR015
Serial Number	Refer to SECTION 4.2
Condition	Production model
Modification	No Modification by the test lab
Receipt Date	June 13, 2024
Test Date	June 13 to 19, 2024

2.2 Product Description

General Specification

Rating	DC 12 V (Car battery), DC 9 V to 16 V (Operating range)
Operating temperature	-30 deg. C to +85 deg. C

Radio Specification

Equipment Type	Transceiver
Frequency of Operation	76.5 GHz
Bandwidth	500 MHz (Max.), 450 MHz (Typ.)
Type of Modulation	FM-CW
Antenna Gain	21.5 dBi
Steerable Antenna	Electronically (Receiving Part only)
Usage location	Forward-looking, vehicle-mounted

SECTION 3: Test specification, procedures & results

3.1 Test Specification

Test Specification	FCC Part 95 Subpart M The latest version on the first day of the testing period
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	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	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	No signal detected	Complied	Radiated
Frequency stability	**FCC:** ANSI C63.26-2015 5.6 Frequency stability testing	**FCC:** Section 95.3379 (b) Section 2.1055	See data.	Complied	Radiated

Note: UL Japan, Inc.'s EMI Work Procedures: Work Instructions-ULID-003591 and Work Instructions-ULID-003593.
* In case any questions arise about test procedure, ANSI C63.10-2013, ANSI C63.26-2015 and KDB653005 are also referred.

*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.

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

Measurement uncertainty is not taken into account when stating conformity with a specified requirement.
Note: When margins obtained from test results are less than the measurement uncertainty, the test results may exceed the limit.

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

Radiated emission

Measurement distance	Frequency range		Unit	Calculated Uncertainty (+/-)
3 m	9 kHz to 30 MHz		dB	3.3
10 m			dB	3.1
3 m	30 MHz to 200 MHz	Horizontal	dB	4.7
		Vertical	dB	4.7
	200 MHz to 1000 MHz	Horizontal	dB	4.8
		Vertical	dB	6.0
10 m	30 MHz to 200 MHz	Horizontal	dB	5.2
		Vertical	dB	5.1
	200 MHz to 1000 MHz	Horizontal	dB	5.2
		Vertical	dB	5.2
3 m	1 GHz to 6 GHz		dB	5.0
	6 GHz to 18 GHz		dB	5.2
1 m	10 GHz to 18 GHz		dB	5.3
	18 GHz to 26.5 GHz		dB	5.2
	26.5 GHz to 40 GHz		dB	4.7
0.5 m	26.5 GHz to 40 GHz		dB	4.8
>= 0.5 m	40 GHz to 50 GHz		dB	4.3
	50 GHz to 75 GHz		dB	5.9
	75 GHz to 110 GHz		dB	5.7
>= 3.8 cm	110 GHz to 170 GHz		dB	5.8*
>= 2.5 cm	170 GHz to 260 GHz		dB	5.2*

*under consideration about Uncertainty for testing at 1 cm distance.

Radiated emission (with Block downconverter)

Measurement distance	Frequency range	Uncertainty (+/-)
>= 0.5 m	75 GHz to 83 GHz	3.4 dB*

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

3.5 Test Location

UL Japan, Inc. Ise EMC Lab.
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 Japan
Telephone: +81-596-24-8999
A2LA Certificate Number: 5107.02 / FCC Test Firm Registration Number: 884919
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.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	-	-
Large Chamber	16.9 x 22.1 x 10.17	16.9 x 22.1	-	10 m
Small Chamber	5.3 x 6.69 x 3.59	5.3 x 6.69	-	-

3.6 Test data, Test instruments, and Test set up

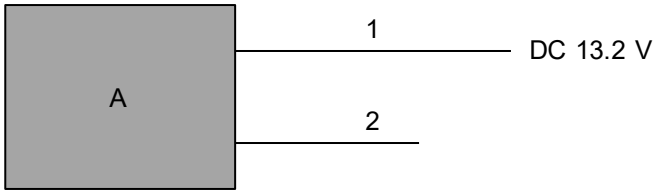
Refer to APPENDIX.

SECTION 4: Operation of EUT during testing

4.1 Operating Mode(s)

Mode	Test Item
Normal operating mode (Mode 2)	Occupied bandwidth, Radiated Power, Modulation characteristics, Field strength of spurious radiation, Frequency stability
*Power of the EUT was set by the software as follows; Power Setting: 30.5 dBm (Mode 2) Software: mwr_gen4_0061_p05 (Date: 2024.06.13, Storage location: EUT memory)	
*This setting of software is the worst case. Any conditions under the normal use do not exceed the condition of setting. In addition, end users cannot change the settings of the output power of the product.	

4.2 Configuration and peripherals



* Cabling and setup(s) were taken into consideration and test data was taken under worse case conditions.

Description of EUT

No.	Item	Model number	Serial number	Manufacturer	Remarks
A	Millimeter Wave Radar Sensor	DNMWR015	0140937768	DENSO CORPORATION	EUT

List of cables used

No.	Name	Length (m)	Shield		Remarks
			Cable	Connector	
1	DC Cable	4.1	Unshielded	Unshielded	-
2	Signal Cable	4.1	Unshielded	Unshielded	-

SECTION 5: Radiated Spurious Emission

Test Procedure

[For below 30 MHz]
The EUT was placed on a urethane platform of nominal size, 1.0 m by 1.5 m, raised 0.8 m above the conducting ground plane.
The Radiated Electric Field Strength has been measured in a Semi Anechoic Chamber with absorbent materials lined on a ground plane.
The loop antenna was fixed height at 1.0 m.
The EUT was rotated a full revolution in order to obtain the maximum value of the electric field intensity.
The measurements were performed for vertical polarization (antenna angle: 0 deg., 45 deg., 90 deg., 135 deg., and 180 deg.) and horizontal polarization.
*Refer to Figure 1 about Direction of the Loop Antenna.

[For above 30 MHz, up to 1 GHz]
The EUT was placed on a urethane platform of nominal size, 1.0 m by 1.5 m, raised 0.8 m above the conducting ground plane. The Radiated Electric Field Strength has been measured in a Semi Anechoic Chamber with a ground plane.
The height of the measuring antenna varied between 1 m and 4 m and EUT was rotated a full revolution in order to obtain the maximum value of the electric field strength.

[For above 1 GHz, up to 40 GHz]
The EUT was placed on a urethane platform of nominal size, 0.5 m by 0.5 m, raised 1.5 m above the conducting ground plane.
The Radiated Electric Field Strength has been measured in a Semi Anechoic Chamber with absorbent materials lined on a ground plane.
The height of the measuring antenna varied between 1 m and 4 m and EUT was rotated a full revolution in order to obtain the maximum value of the electric field strength.
Test antenna was aimed at the EUT for receiving the maximum signal and always kept within the illumination area of the 3 dB beamwidth of the antenna.

The measurements were performed for both vertical and horizontal antenna polarization with the Test Receiver, or the Spectrum Analyzer.
The measurements were made with the following detector function of the test receiver and the Spectrum analyzer.
The test was made with the detector (RBW/VBW) in the following table.

Test Antennas are used as below;

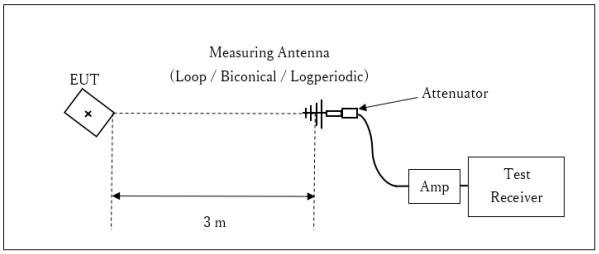
Frequency	Below 30 MHz	30 MHz to 200 MHz	200 MHz to 1 GHz	Above 1 GHz
Antenna Type	Loop	Biconical	Logperiodic	Horn

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

*1) A RMS average mode was applied according to KDB653005 4 (b) and 5.4 (f).

[Test setup]

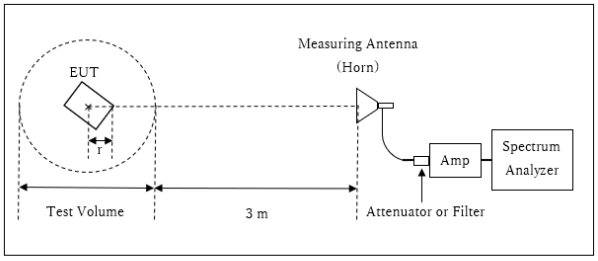
Below 1 GHz



× : Center of turn table

Test Distance: 3 m

1 GHz to 10 GHz



r : Radius of an outer periphery of EUT

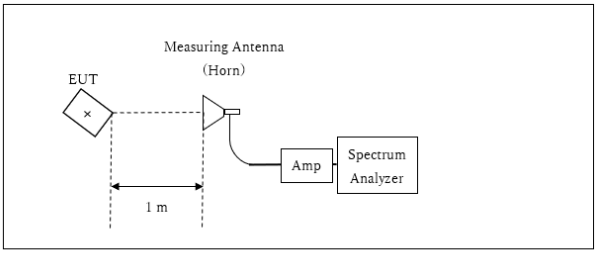
× : Center of turn table

Distance Factor: 20 x log (4.0 m*/3.0 m) = 2.5 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.

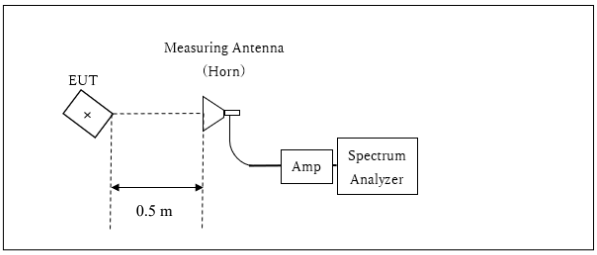
10 GHz to 26.5 GHz



× : 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 to 40 GHz

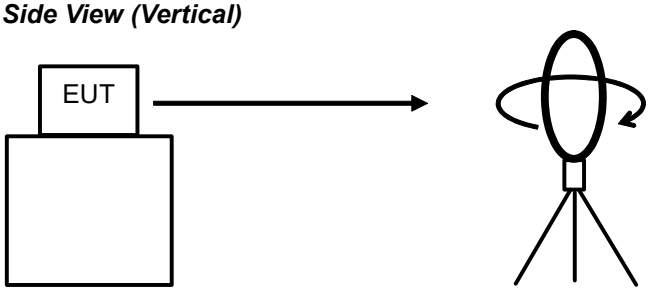


× : Center of turn table

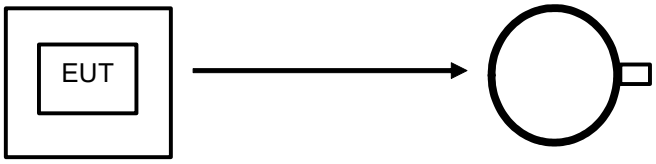
Distance Factor: 20 x log (0.5 m* / 3.0 m) = -15.6 dB
*Test Distance: 0.5 m

Figure 1: Direction of the Loop Antenna

Side View (Vertical)

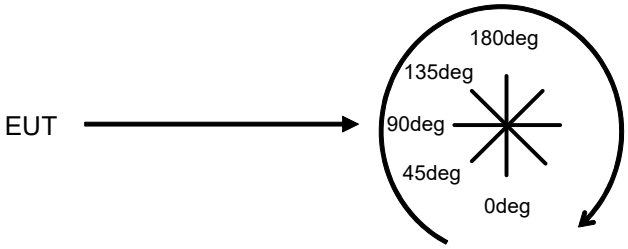


Top View (Horizontal)



Antenna was not rotated.

Top View (Vertical)



Front side: 0 deg.
Forward direction: clockwise

[Above 40 GHz (Expext for fundamental measurement)]

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

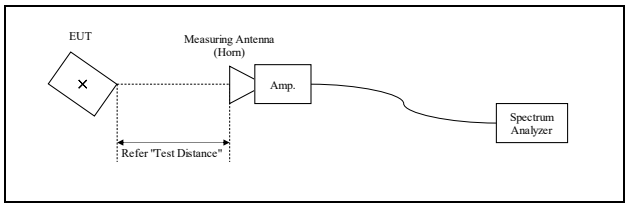
Set spectrum analyzer RBW, VBW, span, etc., to the proper values. Note these values. Enable two traces—one set to “clear write,” and the other set to “max hold.” Begin hand-held measurements with the test antenna (horn) at a distance of 1 m from the EUT in a horizontally polarized position. Slowly adjust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

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

The final test was performed with a 1 MHz RMS detctor at the following distances;

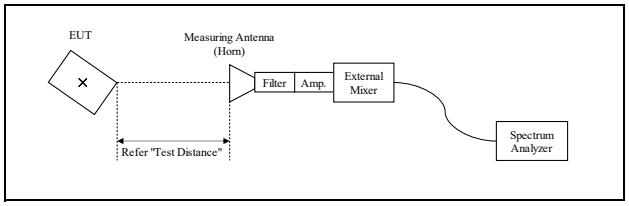
[Test setup]

40 GHz to 50 GHz



*Test Distance: 1.0 m

Above 50 GHz



*Test Distance:

50 GHz to 75 GHz	1.0 m
75 GHz to 76 GHz	1.0 m
81 GHz to 83 GHz	1.0 m
83 GHz to 110 GHz	0.5 m
110 GHz to 231 GHz	0.01 m

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

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

[About fundamental measurement]

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

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 Dimension			Far Field Boundary	Tested Distance
		EUT	Test Antenna	Maximum		
	Lambda			*D*	*r*	
[GHz]	[mm]	[m]	[m]	[m]	[m]	[m]
77	3.9	0.057000	0.025150	0.057000	1.668	1.8

The Radiated power test was performed with the EUT that was attached on the jig, since the antenna array was mounted on angularly-tilted.

The Peak Power results was applied to the desensitization correction factor by KDB653005 4 (c) and 5.4 (d).
The derivation of the FMCW Desensitization Factor is given in Keysight Application Note 5952 1039 Appendix B.

Desensitization factor was calculated from follow equation;

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

and
FMCW Desensitization factor = 20 Log (α)

Where
*F*s is FMCW Sweep Width or Chirp Width, is used the actual measurement value.
*T*s is FMCW Sweep Time, is referred to the values in the specifications.
B is -3dB Bandwidth of Gaussian RBW Filter, is used the actual measurement value.

F_s	T_s	*B*	*α*	FMCW Desensitization factor
[MHz]	[us]	[MHz]		[dB]
400.2154	412.0	1.0	0.959	-0.37

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

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

SECTION 6: Frequency Stability

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

The power supply was set to nominal operating voltage (110 %), and the spectrum mask was measured at 20 deg. C. After that, EUT power supply was varied between 85 % and 115 % of nominal voltage and the frequency excursion of the EUT emission mask was recorded.

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

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

Test data : APPENDIX
Test result : Pass

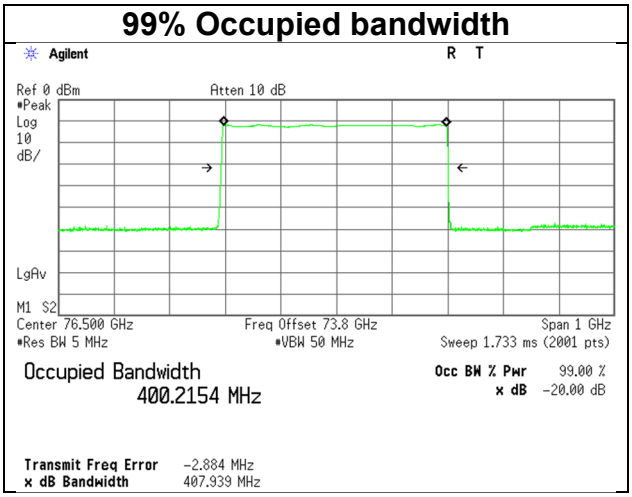
APPENDIX 1: Test data

Occupied bandwidth

Test place	Ise EMC Lab.
Semi Anechoic Chamber	No. 4
Date	June 13, 2024
Temperature / Humidity	21 deg. C / 45 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode (Mode 2)

99 % Occupied bandwidth [MHz]
400.2154

[Data]



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

Radiated Power

Test place	Ise EMC Lab.
Semi Anechoic Chamber	No. 4
Date	June 13, 2024
Temperature / Humidity	21 deg. C / 45 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode (Mode 2)

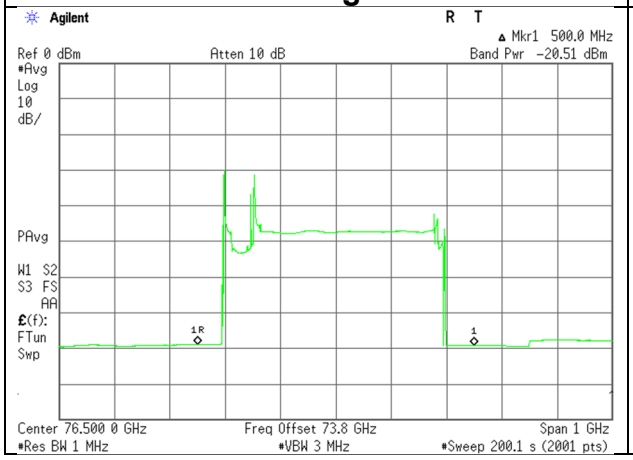
Power	Freq. [GHz]	Measured Power [dBm]	Rx Ant. Gain [dBi]	Down Converter Gain [dB]	IF Cable Loss [dB]	Tested Distance [m]	FSL [dB]	Duty Factor [dB]	FMCW desensitization Factor [dB]	EIRP [dBm]	EIRP [mW]	Limit [dBm]	Margin [dB]
Average	76.500	-20.51	23.06	15.06	1.70	1.8	75.22	7.94	-	26.23	419.76	50	23.77
Peak	76.362	-11.93	23.05	14.94	1.67	1.8	75.20	-	-0.37	27.32	539.51	55	27.68

Calculating formula:
FSL (Free Space path Loss) = 10 * log10((4 * Pi * Tested Distance / Lambda) ^2)
Average EIRP = Measured Power - Rx Ant. Gain - Down Converter Gain + IF Cable Loss + FSL + Duty Factor
Peak EIRP = Measured Power - Rx Ant. Gain - Down Converter Gain + IF Cable Loss + FSL - FMCW desensitization factor

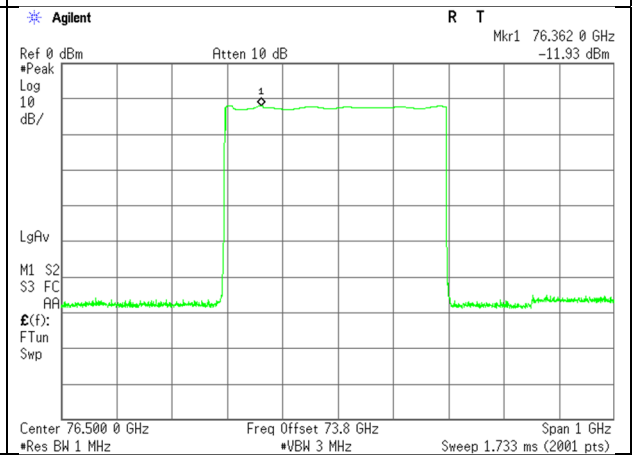
The test method referred to KDB653005 4 and 5.4.
The derivation of the Duty Factor is given in Duty data page.
The derivation of the FMCW Desensitization Factor is given in Keysight Application Note 5952 1039 Appendix B. (Refer Section 5)

[Data]

Average



Peak



Modulation characteristics

Test place	Ise EMC Lab.
Semi Anechoic Chamber	No. 4
Date	June 13, 2024
Temperature / Humidity	21 deg. C / 45 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode (Mode 2)

	Tx On 1 time [ms]	Tx On 2 time [ms]	Total Tx On time [ms]	Tx On + Tx Off time (1cycle) [ms]	Duty Factor [dB]
Measured	12.890	3.179	16.069	100.002	7.94
Declared *	13.360	3.700	17.060	100.000	7.68

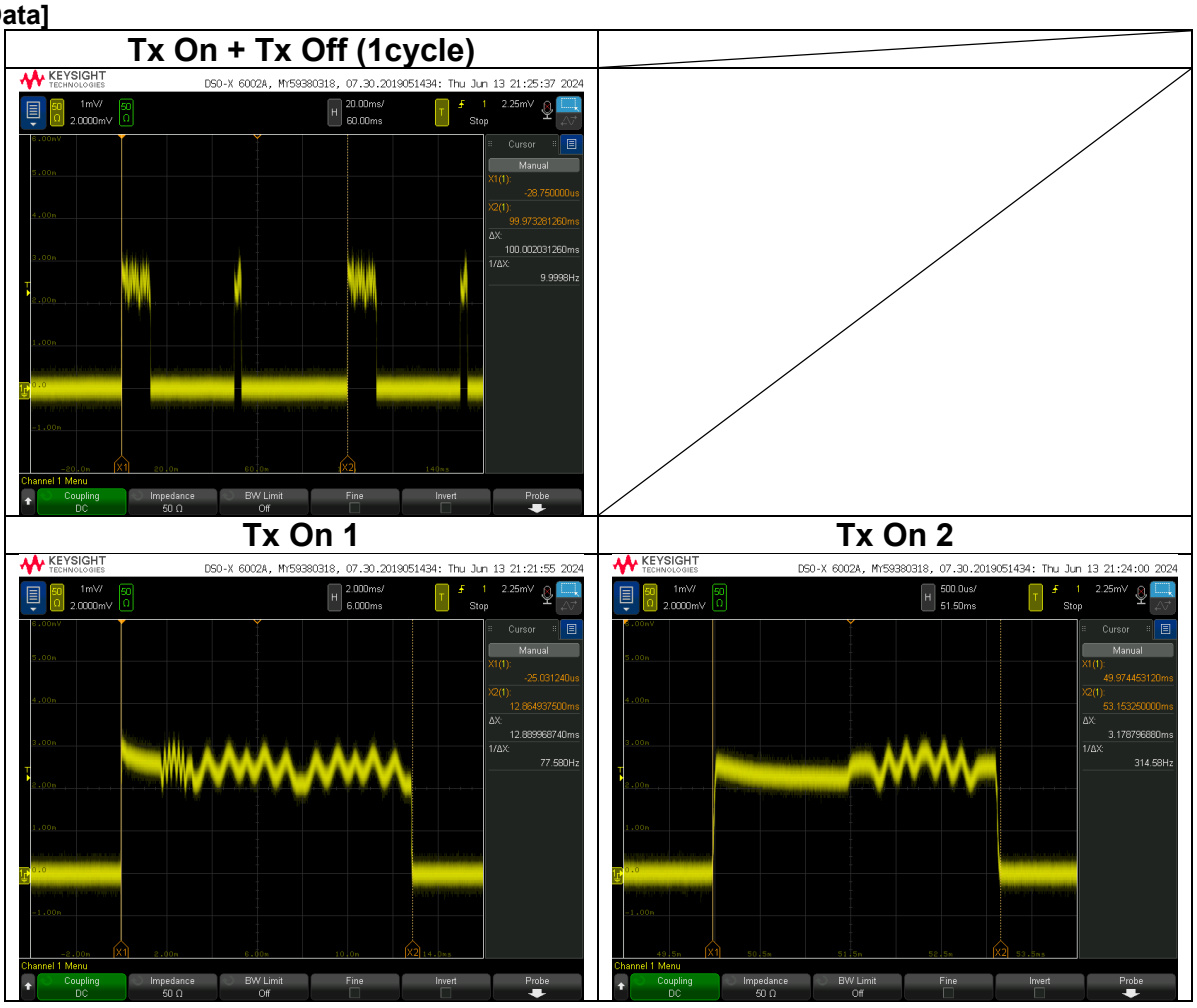
Calculating formula:

Total Tx On time =Tx On 1 time +Tx On 2 time
Duty = (Tx On time / Tx On + Tx Off time) * 100
Duty factor = 10 * log (Tx On + Tx Off time / Total Tx On time)

* See the application document.

[Data]

Tx On + Tx Off (1cycle)



Tx On 1

Tx On 2

Field strength of spurious radiation
(Below 40 GHz)

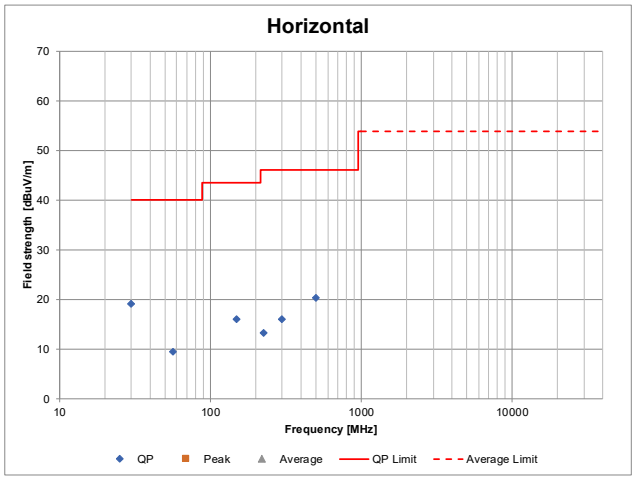
Test place	Ise EMC Lab.		
Semi Anechoic Chamber	No.4	No.4	No.2
Date	June 14, 2024	June 18, 2024	June 19, 2024
Temperature / Humidity	22 deg. C / 45 % RH	22 deg. C / 55 % RH	22 deg. C / 52 % RH
Engineer	Junki Nagatomi	Junki Nagatomi	Junki Nagatomi
	(26.5 GHz to 40 GHz)	(1 GHz to 26.5GHz)	(30 MHz to 1000 MHz)
			(Below 30 MHz)
Mode	Normal operating mode (Mode 2)		

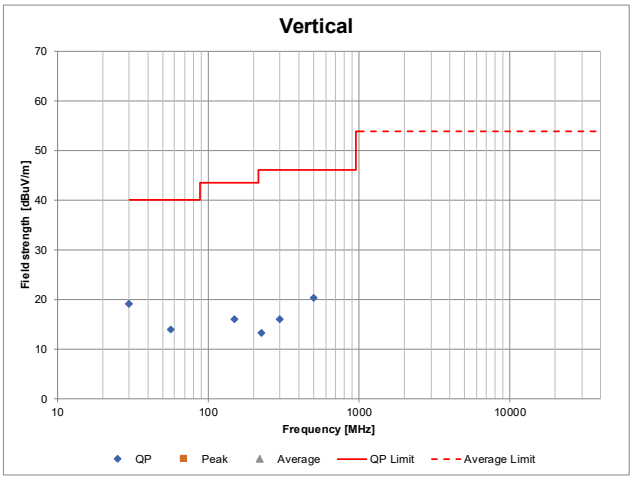
Polarity [Hori/Vert]	Frequency [MHz]	Reading (QP / PK) [dBuV]	Reading (AV) [dBuV]	Ant. Factor [dB/m]	Loss [dB]	Gain [dB]	Result (QP / PK) [dBuV/m]	Result (AV) [dBuV/m]	Limit (QP / PK) [dBuV/m]	Limit (AV) [dBuV/m]	Margin (QP / PK) [dB]	Margin (AV) [dB]	Remark
Hori.	30.0	22.4	-	18.7	6.6	28.6	19.1	-	40.0	-	20.9	-	Floor noise
Hori.	56.8	22.2	-	8.7	7.0	28.5	9.4	-	40.0	-	30.6	-	Floor noise
Hori.	150.0	21.6	-	15.0	7.8	28.2	16.1	-	43.5	-	27.4	-	Floor noise
Hori.	224.3	21.3	-	11.6	8.3	27.9	13.3	-	46.0	-	32.7	-	Floor noise
Hori.	299.7	21.2	-	13.8	8.7	27.7	15.9	-	46.0	-	30.1	-	Floor noise
Hori.	500.0	21.7	-	17.9	9.8	29.1	20.3	-	46.0	-	25.7	-	Floor noise
Vert.	30.0	22.4	-	18.7	6.6	28.6	19.1	-	40.0	-	20.9	-	Floor noise
Vert.	56.8	26.8	-	8.7	7.0	28.5	14.0	-	40.0	-	26.0	-	Floor noise
Vert.	150.0	21.6	-	15.0	7.8	28.2	16.1	-	43.5	-	27.4	-	Floor noise
Vert.	224.8	21.2	-	11.6	8.3	27.9	13.2	-	46.0	-	32.8	-	Floor noise
Vert.	300.0	21.2	-	13.8	8.7	27.7	15.9	-	46.0	-	30.1	-	Floor noise
Vert.	500.0	21.7	-	17.9	9.8	29.1	20.3	-	46.0	-	25.7	-	Floor noise

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).
*QP detector was used up to 1GHz.

[Plot data, Worst case]





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

Field strength of spurious radiation
(Above 40 GHz)

Test place	Ise EMC Lab.
Semi Anechoic Chamber	No. 4
Date	June 13, 2024
Temperature / Humidity	21 deg. C / 45 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode (Mode 2)

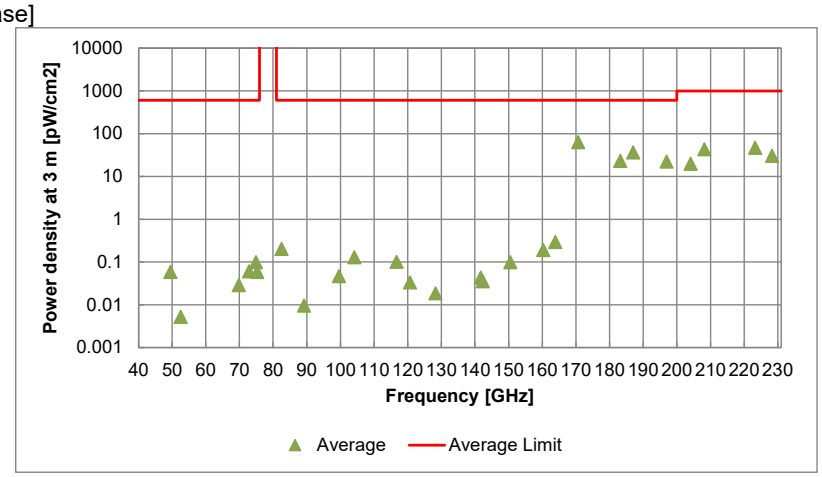
Frequency	Reading	Rx Ant. gain	Filter loss	LNA gain	Mixer conversion loss	IF Amp. gain	IF Cable loss	Meas. range *D*	FSL	EIRP		Power density at 3 m			Remarks
												Result	Limit	Margin	
[GHz]	[dBm]	[dBi]	[dB]	[dB]	[dB]	[dB]	[dB]	[m]	[dB]	[dBm]	[mW]	[pW/cm^2]	[pW/cm^2]	[dB]	
49.458	-62.92	22.39	0.00	31.61	0.00	0.00	8.81	1.0	66.33	-41.78	0.00007	0.06	600	40.10	NS
52.502	-69.64	23.08	0.31	26.72	0.00	0.00	0.00	1.0	66.85	-52.29	0.00001	0.01	600	50.60	NS
69.761	-69.45	24.29	0.53	20.97	0.00	0.00	0.00	1.0	69.31	-44.86	0.00003	0.03	600	43.18	NS
72.827	-66.43	24.42	0.86	21.35	0.00	0.00	0.00	1.0	69.69	-41.65	0.00007	0.06	600	39.97	NS
74.857	-65.62	24.50	1.79	21.11	0.00	0.00	0.00	1.0	69.93	-39.51	0.00011	0.10	600	37.83	NS
75.288	-74.85	22.96	0.00	0.00	-15.23	0.00	1.30	1.0	69.98	-41.76	0.00007	0.06	600	40.08	NS
82.477	-76.08	23.50	1.55	0.00	-12.24	0.00	3.10	1.0	70.77	-36.40	0.00023	0.20	600	34.71	NS
89.169	-57.90	23.87	0.52	33.78	0.00	0.00	0.00	0.5	65.43	-49.60	0.00001	0.01	600	47.92	NS
99.528	-51.40	24.45	0.41	33.71	0.00	0.00	0.00	0.5	66.38	-42.77	0.00005	0.05	600	41.09	NS
104.092	-50.21	24.66	0.37	30.62	0.00	0.00	0.00	0.5	66.77	-38.35	0.00015	0.13	600	36.67	NS
116.670	-87.46	22.52	0.00	17.49	54.31	0.00	0.00	0.01	33.78	-39.38	0.00012	0.10	600	37.70	NS
120.621	-86.84	22.66	0.00	19.01	50.21	0.00	0.00	0.01	34.07	-44.23	0.00004	0.03	600	42.54	NS
128.241	-88.28	22.90	0.00	20.52	50.31	0.00	0.00	0.01	34.60	-46.79	0.00002	0.02	600	45.10	NS
141.693	-89.71	23.22	0.00	18.77	53.15	0.00	0.00	0.01	35.47	-43.08	0.00005	0.04	600	41.40	NS
142.290	-90.63	23.23	0.00	18.73	53.10	0.00	0.00	0.01	35.51	-43.99	0.00004	0.04	600	42.30	NS
150.482	-90.98	23.33	0.00	17.94	56.76	0.00	0.00	0.01	35.99	-39.50	0.00011	0.10	600	37.81	NS
160.281	-92.07	23.40	0.00	16.31	58.59	0.00	0.00	0.01	36.54	-36.65	0.00022	0.19	600	34.96	NS
163.853	-93.06	23.40	0.00	15.00	59.94	0.00	0.00	0.01	36.73	-34.79	0.00033	0.29	600	33.11	NS
170.659	-87.09	22.41	0.00	0.00	60.95	0.00	0.00	0.01	37.08	-11.47	0.07134	63.08	600	9.78	NS
183.159	-88.62	22.70	0.00	0.00	57.82	0.00	0.00	0.01	37.70	-15.80	0.02629	23.24	600	14.12	NS
187.013	-87.83	22.78	0.00	0.00	58.90	0.00	0.00	0.01	37.88	-13.83	0.04139	36.60	600	12.15	NS
196.928	-90.28	22.97	0.00	0.00	58.93	0.00	0.00	0.01	38.33	-15.99	0.02516	22.25	600	14.31	NS
204.041	-89.61	23.08	0.00	0.00	57.59	0.00	0.00	0.01	38.64	-16.47	0.02256	19.95	1000	17.00	NS
208.139	-90.37	23.14	0.00	0.00	61.59	0.00	0.00	0.01	38.81	-13.11	0.04886	43.20	1000	13.64	NS
223.244	-91.74	23.30	0.00	0.00	62.86	0.00	0.00	0.01	39.42	-12.76	0.05292	46.79	1000	13.30	NS
228.263	-92.62	23.33	0.00	0.00	61.72	0.00	0.00	0.01	39.61	-14.62	0.03449	30.50	1000	15.16	NS

Calculation:
FSL (Free Space path Loss) = 10 * log ((4 * Pi * D / λ)^2)
EIRP = Reading - Rx Ant. gain + Filter loss - LNA gain + Mixer conversion 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 Mixer converion loss and IF Cable Loss are automatically corrected in the mixer, so the factor of data sheet were 0 dB.
The IF Cable loss is included in Mixer loss, so the factor of data sheet were 0 dB.
NS: No signal detected.

[Plot data, Worst case]



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

Frequency Stability

Test place	Ise EMC Lab.
Measurement Room	No. 6
Date	June 21, 2024
Temperature / Humidity	24 deg. C / 47 % RH
Engineer	Yuichiro Yamazaki
Mode	Normal operating mode (Mode 2)

Test Condition		Measured -20 dBc Frequency		Remarks
Temperature	Power Supply	Lower Result	Upper Result	
[deg. C]	[V]	[GHz]	[GHz]	
50	13.2	76.244	76.659	
40	13.2	76.256	76.668	
30	13.2	76.270	76.681	
20	13.2	76.297	76.706	
20	10.2	76.293	76.703	85 % of the rated voltage, DC 12 V * 0.85
20	13.8	76.297	76.707	115 % of the rated voltage, DC 12 V * 1.15
10	13.2	76.320	76.736	
0	13.2	76.316	76.726	
-10	13.2	76.309	76.717	
-20	13.2	76.300	76.710	

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

APPENDIX 2: Test instruments

Test equipment (1/2)

Test Item	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Cal Int
RE	141222	Coaxial Cable	Fujikura,HP, Mini-Circits,Fujikura	3D-2W (12m)/ 5D-2W (5m)/ 5D-2W (0.8m)/ 5D-2W (1m)	-	02/17/2024	12
RE	141265	Logperiodic Antenna (200-1000MHz)	Schwarzbeck Mess-Elektronik OHG	VUSLP9111B	9111B-190	07/11/2023	12
RE	141317	Coaxial Cable	UL Japan	-	-	09/12/2023	12
RE	141328	Microwave Cable 1G-40GHz	Suhner	SUCOFLEX102	28636/2	04/01/2024	12
RE	141427	Biconical Antenna	Schwarzbeck Mess-Elektronik OHG	VHA9103B+ BBA9106	08031	07/11/2023	12
RE	141429	Temperature and Humidity Chamber	Espec	PL-2KP	14015723	08/09/2023	12
RE	141504	Horn Antenna 26.5-40GHz	EMCO	3160-10	1150	09/21/2023	12
RE	141506	Horn Antenna 15-40GHz	Schwarzbeck Mess-Elektronik OHG	BBHA9170	BBHA9170307	08/09/2023	12
RE	141508	Horn Antenna 1-18GHz	Schwarzbeck Mess-Elektronik OHG	BBHA9120D	557	05/17/2024	12
RE	141542	Digital Tester	Fluke Corporation	FLUKE 26-3	78030611	08/01/2023	12
RE	141545	DIGITAL HiTESTER	HIOKI E.E. CORPORATION	3805	51201148	02/01/2024	12
RE	141558	Digital Tester (TRUE RMS MULTIMETER)	Fluke Corporation	115	17930030	05/17/2024	12
RE	141581	Microwave System Amplifier	Keysight Technologies Inc	83017A	00650	10/05/2023	12
RE	141583	Pre Amplifier	SONOMA INSTRUMENT	310	260833	04/04/2024	12
RE	141594	Pre Amplifier	Keysight Technologies Inc	8447D	2944A10150	02/17/2024	12
RE	141885	Spectrum Analyzer	Keysight Technologies Inc	E4448A	US44300523	11/29/2023	12
RE	141950	EMI Test Receiver	Rohde & Schwarz	ESU26	100412	11/20/2023	12
RE	142004	AC2_Semi Anechoic Chamber (NSA)	TDK	Semi Anechoic Chamber 3m	DA-06902	12/12/2023	24
RE	142011	AC4_Semi Anechoic Chamber (NSA)	TDK	Semi Anechoic Chamber 3m	DA-10005	12/13/2023	24
RE	142017	AC4_Semi Anechoic Chamber (SVSWR)	TDK	Semi Anechoic Chamber 3m	DA-10005	04/14/2023	24
RE	142026	Diplexer	OML INC.	DPL26	-	-	-
RE	142032	Microwave Cable	Huber+Suhner	SUCOFLEX102	37511/2	-	-
RE	142036	Horn Antenna	Custom Microwave Inc.	HO6R	-	09/05/2023	12
RE	142039	Horn Antenna	Custom Microwave Inc.	HO4R	-	09/05/2023	12
RE	142041	Horn Antenna	Oshima Prototype Engineering Co.	A16-187	1	09/05/2023	12
RE	142042	High Pass Filter 81-110GHz	AmTechs Corporation	HPF-10-778030	201	07/11/2023	12
RE	142049	Harmonic Mixer	OML INC.	M06HWD	D100709-1	12/04/2023	12
RE	142050	Block Downconverter	Keysight Technologies Inc	PS-X30-W10117A	13715	03/21/2024	12
RE	142053	Harmonic Mixer	OML INC.	M04HWD	Y100709-1	05/16/2024	12
RE	142055	Power Amplifier	SAGE Millimeter, Inc.	SBP-5037532015-1515-N1	11599-01	03/15/2024	12
RE	142152	Loop Antenna	Rohde & Schwarz	HFH2-Z2	836553/009	10/17/2023	12
RE	142225	Tape Measure	ASKUL	-	-	-	-
RE	142228	Measure, Tape, Steel	KOMELON	KMC-36	-	-	-
RE	142230	Measure, Tape, Steel	KOMELON	KMC-36	-	-	-
RE	142529	Detector	HEROTEK, INC.	DT1840P	484823	-	-
RE	151897	Microwave Cable	Huber+Suhner	SF101EA/11PC24/ 11PC24/2.5M	SN MY1726/ 1EA	04/14/2024	12
RE	154635	High Pass Filter 83 GHz - 110 GHz	Oshima Prototype Engineering Co.	A17-016	1	05/15/2024	12
RE	159919	Power Amplifier	SAGE Millimeter, Inc.	SBP-4035033018-2F2F-S1	12559-01	06/05/2024	12
RE	176027	D-Band Low Noise Amplifier	SAGE Millimeter, Inc.	SBL-1141741860-0606-EI	15235-01	07/11/2023	12
RE	178648	EMI measurement program	TSJ (Techno Science Japan)	TEPTO-DV	-	-	-

Test equipment (2/2)

Test Item	LIMS ID	Description	Manufacturer	Model	Serial	Last Calibration Date	Cal Int
RE	180544	Horn Antenna	SAGE Millimeter, Inc.	SAZ-2410-10-S1	17343-01	06/03/2024	12
RE	180607	Power Amplifier	SAGE Millimeter, Inc.	SBP-7531142515-1010-E1	17343-01	09/22/2023	12
RE	180634	Horn Antenna	SAGE Millimeter, Inc.	SAZ-2410-15-S1	17343-01	06/03/2024	12
RE	186076	Wave guide Harmonic Mixer	Keysight Technologies Inc	M1971V	MY56390208	09/22/2023	12
RE	186077	Wave guide Harmonic Mixer	Keysight Technologies Inc	M1971W	MY56390146	05/20/2024	12
RE	159670	Coaxial Cable	UL Japan	-	-	11/21/2023	12
RE	201432	WR-15 Low Pass Filter	Oshima Prototype Engineering Co.	2020-0142-02	001	09/13/2023	12
RE	211944	Digital Storage Oscilloscope	Keysight Technologies Inc	DSOX6002A	MY59380318	12/16/2023	12
RE	220646	Attenuator	Huber+Suhner	6806_N-50-1	-	03/12/2024	12
RE	234602	Microwave Cable	Huber+Suhner	SF126E/ 11PC35/11PC35/ 1000M,5000M	537063/126E / 537074/126E	03/08/2024	12
RE	237927	Broadband Amplifier	ERAVANT	SBB-0115033218-2F2F-E3	27554-01	07/10/2023	12
RE	244707	Thermo-Hygrometer	HIOKI E.E. CORPORATION	LR5001	231202102	01/25/2024	12
RE	244710	Thermo-Hygrometer	HIOKI E.E. CORPORATION	LR5001	231202104	01/25/2024	12
RE	244712	Thermo-Hygrometer	HIOKI E.E. CORPORATION	LR5001	231202106	01/25/2024	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