TEST REPORT

Eurofins KCTL Co.,Ltd. 65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea TEL: 82-31-285-0894 FAX: 82-505-299-8311 www.kctl.co.kr	Report No.: KR22-SRF0200 Page (1) of (28)	eurofins | KCTL

1. Client

- Name : HYUNDAI M SYSTEMS Co.,Ltd.
- Address : #102-805, 88 Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, Korea
- Date of Receipt : 2022-09-21

2. Use of Report : Certification

3. Name of Product / Model : IP6K9K RADAR SENSOR / 22RA-22000

4. Manufacturer / Country of Origin : HYUNDAI M SYSTEMS Co.,Ltd. / Korea

5. FCC ID : 2ASWA-22RA-22000

6. IC : 25932-22RA22000

7. Date of Test : 2022-10-04 to 2022-10-18

8. Location of Test : ■ Permanent Testing Lab ☐ On Site Testing
(Address:65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea)

9. Test method used : FCC Part 2, FCC Part 95 Subpart M
RSS-251 Issue 2 July 2018, RSS-Gen Issue 5 April 2018

10. Test Result : Refer to the test result in the test report

Affirmation	Tested by Name : Euijung Kim (Signature)	Technical Manager Name : Heesu Ahn (Signature)

2022-11-22

Eurofins KCTL Co.,Ltd.

REPORT REVISION HISTORY

Date	Revision	Page No
2022-11-22	Originally issued	-

General remarks for test reports

Statement concerning the uncertainty of the measurement systems used for the tests

(may be required by the product standard or client)

☐ **Internal procedure used for type testing through which traceability of the measuring uncertainty has been established:**

Procedure number, issue date and title:

Calculations leading to the reported values are on file with the testing laboratory that conducted the testing.

☒ **Statement not required by the standard or client used for type testing**

CONTENTS

1. General information

Client	:	HYUNDAI M SYSTEMS Co.,Ltd.
Address	:	#102-805, 88 Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, Korea
Manufacturer	:	HYUNDAI M SYSTEMS Co.,Ltd.
Address	:	#102-805, 88 Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, Korea
Laboratory	:	Eurofins KCTL Co.,Ltd.
Address	:	65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea
Accreditations	:	FCC Site Designation No: KR0040, FCC Site Registration No: 687132 VCCI Registration No. : R-20080, G-20078, C-20059, T-20056 CAB Identifier: KR0040, ISED Number: 8035A KOLAS No.: KT231

2. Device information

Equipment under test	:	IP6K9K RADAR SENSOR
Model	:	22RA-22000
Modulation technique	:	FMCW
Frequency range	:	80 000 ㎒ ~ 81 000 ㎒
Power source	:	DC 24 Ⅴ
Antenna specification	:	Serial Feeding Antenna
Antenna gain	:	12.9 dBi
Software version	:	interface B'D : V1.0, Radar module : RM14_S4_HDMS_v1_9
Hardware version	:	interface B'D : V0.3, Radar module : V02
Operation temperature	:	-40 ℃ ~ 85 ℃

2.1. Frequency/channel operations

This device contains the following capabilities:
FMCW

Ch.	Frequency (㎓)
01	80 ~ 81

Table 2.1.1. FMCW

2.2. Far field distance

Far field distance(R_m)

Freq range [㎒]	Speed of light	Freq [㎒]	wavelength(λ) [m]	Largest Antenna Dimension [m]		Far Field Distance [m]	Measurement Distance [m]
				Measurement Antenna	EUT		
40000 - 60000	300	60000	0.0050	**0.0582**	0.0207	1.35	1.50
60000 - 90000	300	90000	0.0033	**0.0378**	0.0207	0.86	1.50
90000 - 140000	300	140000	0.0021	**0.0248**	0.0207	0.57	1.50
140000 - 220000	300	220000	0.0014	0.0158	**0.0207**	0.63	1.50
220000 - 243000	300	243000	0.0012	0.0105	**0.0207**	0.69	1.50
80000 - 81000	300	81000	0.0037	**0.0378**	0.0207	0.77	1.50

Note: EUT antenna dimension was provided by customer.

Note: Far-Field (Rayleigh) distance formula used is shown below (According to ANSI C63.26-2015 Section 4.4.3 Note f) $R_m = 2D^2 / \lambda$,where the Rm is the Rayleigh (far-field) distance, D is the largest dimension of the antenna aperture and λ is the free-space wavelength in meters at the frequency of measurement (calculated by speed of light divided by frequency).

Note: Measurements in report were made at distances greater than calculated far-field distances shown in table.

3. Summary of tests

FCC Part section(s)	IC Rule reference	Parameter	Test condition	Test results
2.1049	RSS-251(7), RSS-GEN(6.7)	Occupied Bandwidth	Radiated	Pass
95.3367(a)	RSS-251(8)	Maximum power(EIRP)		Pass
95.3367(b)	RSS-251(9)	Maximum peak power(EIRP)		Pass
2.1053 95.3379(a)	RSS-251(10) RSS-GEN(6.13)	Undesirable Emissions		Pass
2.1055 95.3379(b)	RSS-251(11) RSS-GEN(8.11)	Frequency Stability		Pass

Notes:

1. All modes of operation and data rates were investigated. The test results shown in the following sections represent the worst case emissions.
2. According to exploratory test no any obvious emission were detected from 9 ㎑ to 30 ㎒. Although these tests were performed other than open field site, adequate comparison measurements were confirmed against 30 m open field site. Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 414788.
3. The fundamental of the EUT was investigated in three orthogonal orientations X, Y and Z. It was determined that **X** orientation was worst-case orientation. Therefore, all final radiated testing was performed with the EUT in **X** orientation.
4. The test procedure(s) in this report were performed in accordance as following.
   - ANSI C63.10-2013
   - ANSI C63.26-2015
   - ANSI/TIA-603-E-2016
   - KDB 653005 D01v01r01

4. Measurement uncertainty

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013.

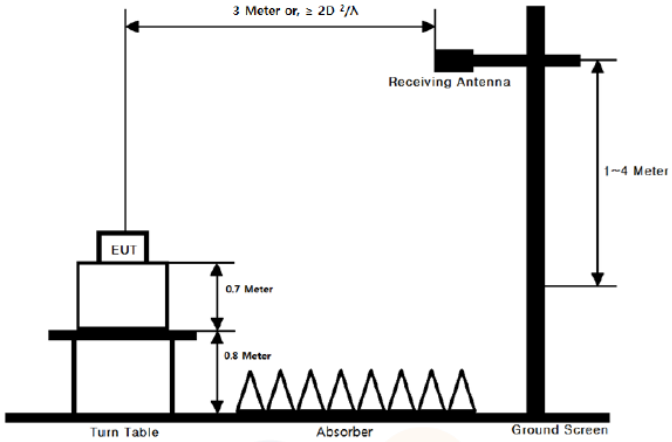
All measurement uncertainty values are shown with a coverage factor of k=2 to indicated a 95 % level of confidence. The measurement data shown herein meets of exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and thus, can be compared directly to specified limits to determine compliance.

Parameter	Expanded uncertainty (±)	
Radiated spurious emissions	9 ㎑ ~ 30 ㎒	2.3 ㏈
	30 ㎒ ~ 1 000 ㎒	2.2 ㏈
	1 000 ㎒ ~ 18 000 ㎒	5.6 ㏈
	Above 18 000 ㎓	5.7 ㏈

5. Test results
5.1. Occupied bandwidth

Test setup

Above 1 ㎓



These measurements were performed at 3 m test site. The equipment under test is placed on a non-conductive table 1.5-meters above a turntable which is flush with the ground plance and 3 meters from the receive antenna. For measurements above 1 GHz absorbers are placed on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections. For measurements below 1 ㎓, the absorbers are removed.

Limit

FCC

Within the designated 76 ~ 81 ㎓ frequency band

According to §2.1049, The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured.

IC

According to RSS-GEN(6.7), The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained.
The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

Test procedure

ANSI C63.26-2015 - Section 5.4.4

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power of a given emission.

Test settings

1. The signal analyzer's automatic bandwidth measurement capability was used to perform the 99 % occupied bandwidth and the 26 dB bandwidth. The bandwidth measurement was not influenced by any intermediate power nulls in the fundamental emission.
2. RBW = 1 ~ 5% of the expected OBW & VBW ≥ 3 X RBW
3. Detector = Peak
4. Trance mode = Max hold
5. Sweep = Auto couple
6. The trace was allowed to stabilize
7. If necessary, step 2 ~ 6 were repeated after changing the RBW such that it would be within 1 ~5 % of the 99 % occupied band width observed in step 6.

Note: The RBW and VBW were setting up to the limitations of the test equipment.

Test results

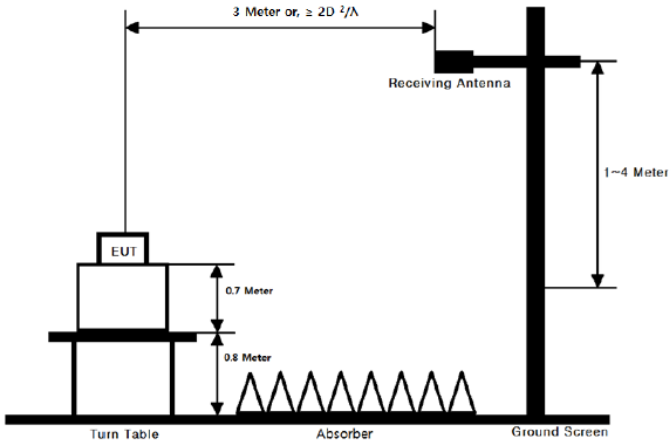
Test Condition	Frequency Range(㎒)	Occupied Bandwidth(㎒)
NTNV	80 500	939.74

Occupied Bandwidth

5.2. The Maximum Power(EIRP) & Maximum Peak Power(EIRP)

Test setup

Above 1 ㎓



These measurements were performed at 3 m test site. The equipment under test is placed on a non-conductive table 1.5-meters above a turntable which is flush with the ground plance and 3 meters from the receive antenna. For measurements above 1 ㎓ absorbers are placed on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections. For measurements below 1 ㎓, the absorbers are removed.

Limit

FCC

According to § 95.3367, The fundamental radiated emission limits within the 76-81 ㎓ band are expressed in terms of Equivalent Isotropically Radiated Power (EIRP) and are as follows:

(a) The maximum power(EIRP) within the 76-81 ㎓ band shall not exceed 50 ㏈m based on measurements employing a power averaging detector with a 1 ㎒ Resolution Bandwidth(RBW).

(b) The maximum peak power(EIRP) within the 76-81 ㎓ band shall not exceed 55 ㏈m based on measurements employing a peak detector with a 1 ㎒ RBW.

IC

According to RSS-251(8) Average equivalent isotropically radiated power (e.i.r.p.),
The radar device's total average e.i.r.p. shall not exceed 50 dBm over the occupied bandwidth.

According to RSS-251(9) Peak e.i.r.p. spectral density,
The radar device's peak e.i.r.p. spectral density shall not exceed 55 dBm/MHz.

Test procedure

ANSI C63.10-2013 - Section 9
ANSI C63.26-2015 - Section 5
KDB 653005 D01v01r01 – Section 4

Test setting

-Maximum power(EIRP) – Averaging detector

Note: The maximum power(averaging detector) measurements are performed using the “channel power” measurement capability and integrated over the 99 % OBW to obtain the result.

1. Measurement capability of instrument = channel power
2. Set RBW = 1 ㎒
3. Set VBW ≥ 3 X RBW
4. span to 2 x to 3 x the OBW
5. Channel bandwidth setting of instrument ≥ OBW
6. Detector = power averaging (rms)
7. Set number of points in sweep ≥ 2 x span / RBW
8. Sweep time = auto-couple
9. Trace = averaging

-Maximum peak power(EIRP) – Peak detector

1. Set RBW = 1 ㎒
2. Set VBW ≥ 3 X RBW
3. span to 2 x to 3 x the OBW
4. Detector = Peak
5. Set number of points in sweep ≥ 2 x span / RBW
6. Sweep time = auto-couple
7. Trace = max-hold

Note1.
Sample Calculation
E(㏈㎶/m)= Measured level(㏈㎶) +107 +AFCL(㏈/m)
Where, E=field strength / AFCL= Antenna Factor(㏈/m) + Cable Loss(㏈/m)
The mixer loss was applied to the measured level by SA correction factor.
EIRP(㏈m)= E(㏈㎶/m) +20log(D)-104.8;where, D is measurement distance(in the far field region) in m.

Note2.
P.C.F Calculation (P.C.F=Peak amplitude correction factor of the FMCW signal)

P.C.F = 20*log10(1/α)

- $\alpha = \frac{1}{\sqrt[4]{1+(\frac{2\ln(2)}{\pi})^2(\frac{F_S}{T_S B^2})^2}}$
- FS = Sweep Width of FMCW Signal Under Test = 825 ㎒
- TS = Sweep Time of FMCW Signal Under Test = 31 us
- B = 1 ㎒

(Sweep width and sweep time have been declared by the manufacturer.)

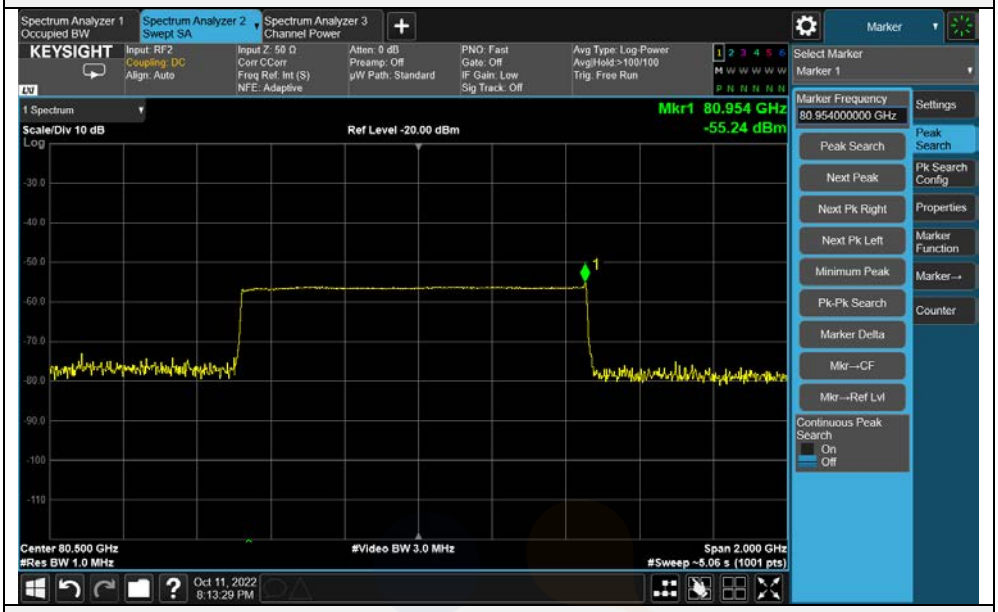
Test results

Measurement distance(D)	Frequency (㎓)	ANT Pol	EUT Position (Axis)	Detector Mode	Measured Level (㏈m)	AFCL (㏈/m)	P.C.F (㏈)	E (㏈㎶/m)	EIRP (㏈m)	Limit (㏈m)
1.5 m	80.95	V	X	Peak	-55.24	68.52	10.71	130.99	29.72	55.00
1.5 m	80.50	V	X	Average	-50.22	68.17	-	124.95	23.67	50.00

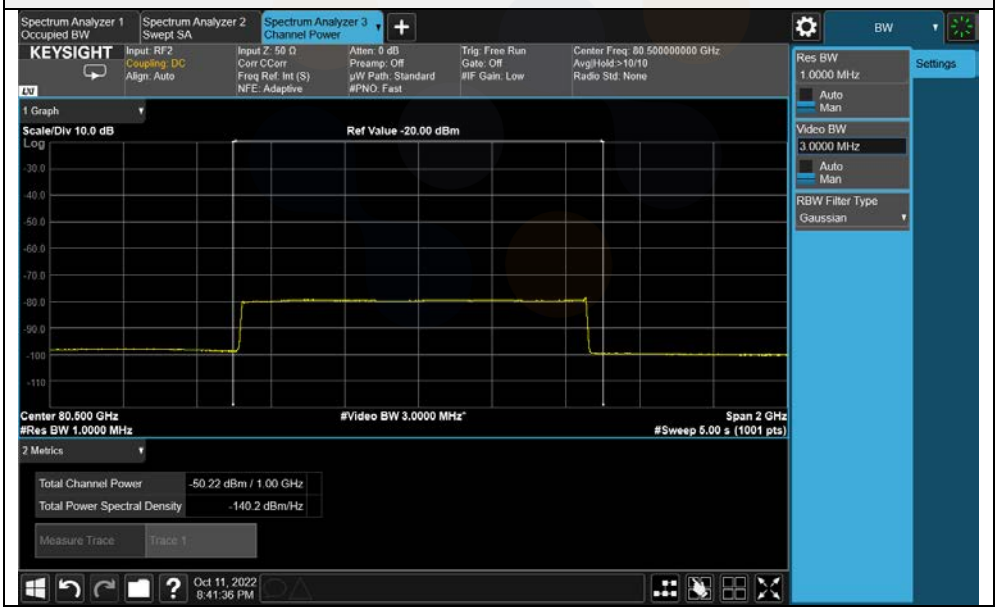
Note.
1. The EIRP was measured in each axis EUT positions and the worst case data was reported.

Test results

Maximum Peak power(EIRP)



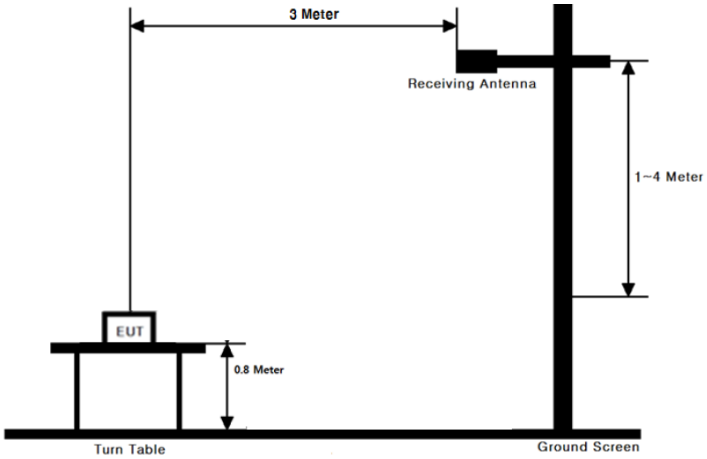
Average power(EIRP)



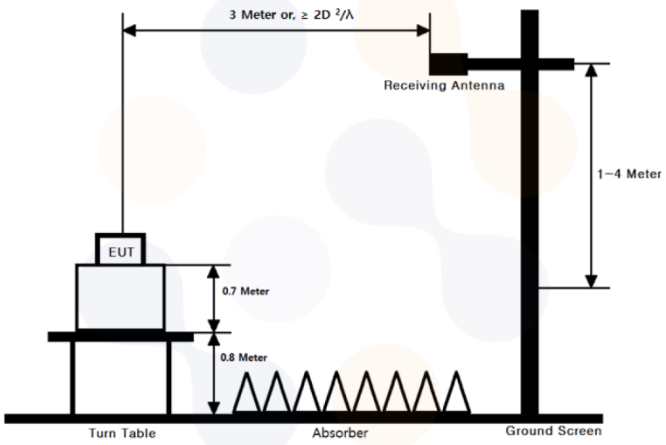
5.3. Undesirable emissions

Test setup

Below 1 ㎓



Above 1 ㎓



These measurements were performed at 3 test site. The equipment under test is placed on a non-conductive table 1.5-meters above a turntable which is flush with the ground plane and 3 meters(for below 1 ㎓: 0.8-m) from the receive antenna. For measurements above 1 ㎓ absorbers are placed on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections.
For measurements below 1 ㎓, the absorbers are removed.

Limit

FCC

(a) The power density of any emissions outside the 76-81 ㎓ band shall consist solely of spurious emissions and shall not exceed the following:

(1) Radiated emissions below 40 ㎓ shall not exceed the field strength as shown in the following emissions table.

Frequency (㎒)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(㎑)	300
0.490-1.705	24000/F(㎑)	30
1.705-30.0	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

(i) In the emissions table in paragraph (a)(1) of this section, the tighter limit applies at the band edges.

(ii) The limits in the table in paragraph (a)(1) of this section are based on the frequency of the unwanted emissions and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

(iii) The emissions limits shown in the table in paragraph (a)(1) of this section are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9.0-90.0 ㎑, 110.0-490.0 ㎑, and above 1000 ㎒. Radiated emissions limits in these three bands are based on measurements employing an average detector with a 1 ㎒ RBW.

(2) The power density of radiated emissions outside the 76-81 ㎓ band above 40.0 ㎓ shall not exceed the following, based on measurements employing an average detector with a 1 ㎒ RBW:

(i) For radiated emissions outside the 76-81 ㎓ band between 40 ㎓ and 200 ㎓ from field disturbance sensors and radar systems operating in the 76-81 ㎓ band: 600 pW/cm^2 at a distance of 3 meters from the exterior surface of the radiating structure.

(ii) For radiated emissions above 200 ㎓ from field disturbance sensors and radar systems operating in the 76-81 ㎓ band: 1000 pW/cm^2 at a distance of 3 meters from the exterior surface of the radiating structure.

(3) For field disturbance sensors and radar systems operating in the 76-81 ㎓ band, the spectrum shall be investigated up to 231.0 ㎓.

According to section 15.205(a) and (b), only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.009 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
0.495 - 0.505	16.694 75 - 16.695 25	608 - 614	5.35 - 5.46
2.173 5 - 2.190 5	16.804 25 - 16.804 75	960 – 1 240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1 300 – 1 427	8.025 - 8.5
4.177 25 - 4.177 75	37.5 - 38.25	1 435 – 1 626.5	9.0 - 9.2
4.207 25 - 4.207 75	73 - 74.6	1 645.5 – 1 646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1 660 – 1 710	10.6 - 12.7
6.267 75 - 6.268 25	108 - 121.94	1 718.8 – 1 722.2	13.25 - 13.4
6.311 75 - 6.312 25	123 - 138	2 200 – 2 300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2 310 – 2 390	15.35 - 16.2
8.362 - 8.366	156.524 75 - 156.525	2 483.5 – 2 500	17.7 - 21.4
8.376 25 - 8.386 75	25	2 690 – 2 900	22.01 - 23.12
8.414 25 - 8.414 75	156.7 - 156.9	3 260 – 3 267	23.6 - 24.0
12.29 - 12.293	162.012 5 - 167.17	3 332 – 3 339	31.2 - 31.8
12.519 75 - 12.520 25	167.72 - 173.2	3 345.8 – 3 358	36.43 - 36.5
12.576 75 - 12.577 25	240 - 285	3 600 – 4 400	Above 38.6
13.36 - 13.41	322 - 335.4		

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in section 15.209. At frequencies equal to or less than 1 000 MHz, compliance with the limits in section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1 000 MHz, compliance with the emission limits in section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in section 15.35 apply to these measurements.

IC

According to RSS-251(10.2), The radar device's unwanted emissions outside the 76-81 GHz frequency band shall comply with the limits in table 1, below.

Table 1: Unwanted emissions limits outside the 76-81 GHz frequency band

Emission frequency range	Limit	Applicable detector
Below 40 GHz	RSS-Gen general field strength limits for licence-exempt radio apparatus	RSS-Gen requirements
40-162 GHz*	-30 dBm/MHz (e.i.r.p.)	RMS detector
Note: * For radar devices that operate solely in the 76-77 GHz band (i.e. the occupied bandwidth is entirely contained in the 76-77 GHz band), an unwanted emissions limit of 0 dBm/MHz shall apply for the unwanted emission that fall in the 73.5-76 GHz band. Outside of the 73.5-76 GHz band, the unwanted emission limits prescribed in table 1 shall apply.		

According to RSS-Gen(8.9), Except where otherwise indicated in the applicable RSS, radiated emissions shall comply with the field strength limits shown in table 5 and table 6. Additionally, the level of any transmitter unwanted emission shall not exceed the level of the transmitter's fundamental emission.

Table 5- General field strength limits at frequencies above 30 ㎒

Frequency(㎒)	Field strength (μV/m at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

Table 6- General field strength limits at frequencies below 30 ㎒

Frequency	Magnetic field strength (H-Field) (㎂ A/m)	Measurement distance(m)
9 – 490 ㎑ 1)	6.37/F (F in ㎑)	300
490 – 1705 ㎑	63.7/F (F in ㎑)	30
1.705 - 30 ㎒	0.08	30

Note 1: The emission limits for the ranges 9-90 ㎑ and 110-490 ㎑ are based on measurements employing a linear average detector.

According to RSS-Gen(8.10), Restricted frequency bands, identified in table 7, are designated primarily for safety-of-life services (distress calling and certain aeronautical activities), certain satellite downlinks, radio astronomy and some government uses. Except where otherwise indicated, the following conditions related to the restricted frequency bands apply:

(a) The transmit frequency, including fundamental components of modulation, of licence-exempt radio apparatus shall not fall within the restricted frequency bands listed in table 7 except for apparatus compliant with RSS-287, Emergency Position Indicating Radio Beacons (EPIRB), Emergency Locator Transmitters (ELT), Personal Locator Beacons (PLB), and Maritime Survivor Locator Devices (MSLD).
(b) Unwanted emissions that fall into restricted frequency bands listed in table 7 shall comply with the limits specified in table 5 and table 6.
(c) Unwanted emissions that do not fall within the restricted frequency bands listed in table 7 shall comply either with the limits specified in the applicable RSS or with those specified in table 5 and table 6.

Table 7- Restricted frequency bands*

MHz	MHz	GHz
0.090 - 0.110	149.9 - 150.05	9.0 - 9.2
0.495 - 0.505	156.52475 - 156.52525	9.3 - 9.5
2.1735 - 2.1905	156.7 - 156.9	10.6 - 12.7
3.020 - 3.026	162.0125 - 167.17	13.25 - 13.4
4.125 - 4.128	167.72 - 173.2	14.47 - 14.5
4.17725 - 4.17775	240 - 285	15.35 - 16.2
4.20725 - 4.20775	322 - 335.4	17.7 - 21.4
5.677 - 5.683	399.9 - 410	22.01 - 23.12
6.215 - 6.218	608 - 614	23.6 - 24.0
6.26775 - 6.26825	960 - 1427	31.2 - 31.8
6.31175 - 6.31225	1435 - 1626.5	36.43 - 36.5
8.291 - 8.294	1645.5 - 1646.5	Above 38.6
8.362 - 8.366	1660 - 1710	
8.37625 - 8.38675	1718.8 - 1722.2	
8.41425 - 8.41475	2200 - 2300	
12.29 - 12.293	2310 - 2390	
12.51975 - 12.52025	2483.5 - 2500	
12.57675 - 12.57725	2655 - 2900	
13.36 - 13.41	3260 - 3267	
16.42 - 16.423	3332 - 3339	
16.69475 - 16.69525	3345.8 - 3358	
16.80425 - 16.80475	3500 - 4400	
25.5 - 25.67	4500 - 5150	
37.5 - 38.25	5350 - 5460	
73 - 74.6	7250 - 7750	
74.8 - 75.2	8025 - 8500	
108 - 138	--	

* Certain frequency bands listed in table 7 and in bands above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.

Test procedure

ANSI C63.26-2015 - Section 5.5

Test settings

Below 1 ㎓

RBW = 100 or 120 ㎑, VBW = 3 x RBW, Detector= Peak or Quasi Peak

1 ~ 40 ㎓

Peak Measurement
RBW: 1 ㎒, VBW= 3 ㎒, Detector = Peak, Sweep time = Auto,
Trace mode = Max Hold until the trace stabilizes

Average Measurement
RBW: 1 ㎒, VBW= 3 ㎒, Detector = RMS, Sweep time = Auto,
Trace mode = Averaging or Max Hold

Above 40 ㎓

Average Measurement
RBW: 1 ㎒, VBW= 3 ㎒, Detector = RMS, Sweep time = Auto,
Trace mode = Averaging or Max Hold

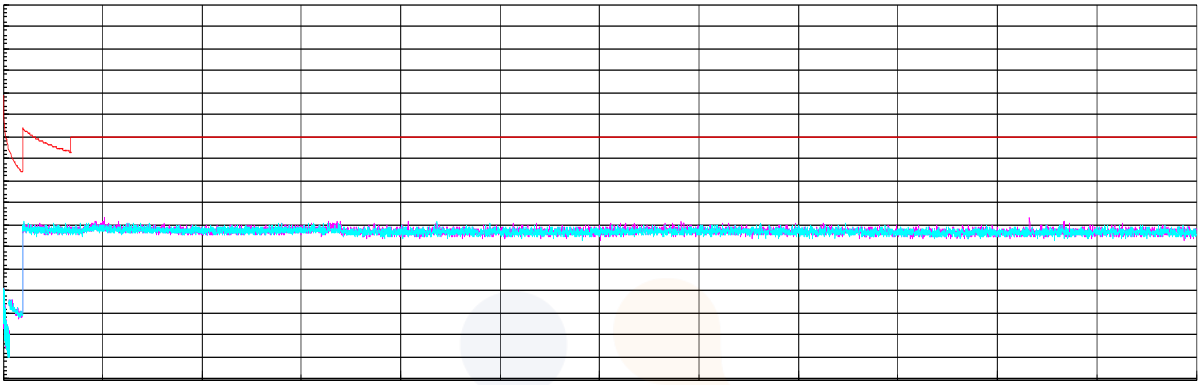
The limits in CFR 47, part 15, Subpart C, paragraph 15.209 (a), are identical to those in RSS-GEN Section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impendance of 377Ω. For example, the measurement frequency X ㎑ resulted in a level of Y ㏈㎶/m, which is equivalent to Y - 51.5 = Z ㏈㎶/m, which has the same margin, W ㏈, to the corresponding RSS-GEN Table 6 limit as it has to be 15.209 (a) limit.

Test results

Frequency Range: 9 ㎑ ~ 30 ㎒

Frequency (㎒)	ANT Pol	EUT Position (Axis)	Detector Mode	Measured Level (dB㎶)	T.F (dB/m)	Distance Factor (dB)	Result (dB(㎶/m))	Limit (dB(㎶/m))	Margin (dB)
No spurious emissions were detected within 20 dB of the limit.									

Horizontal/Vertical

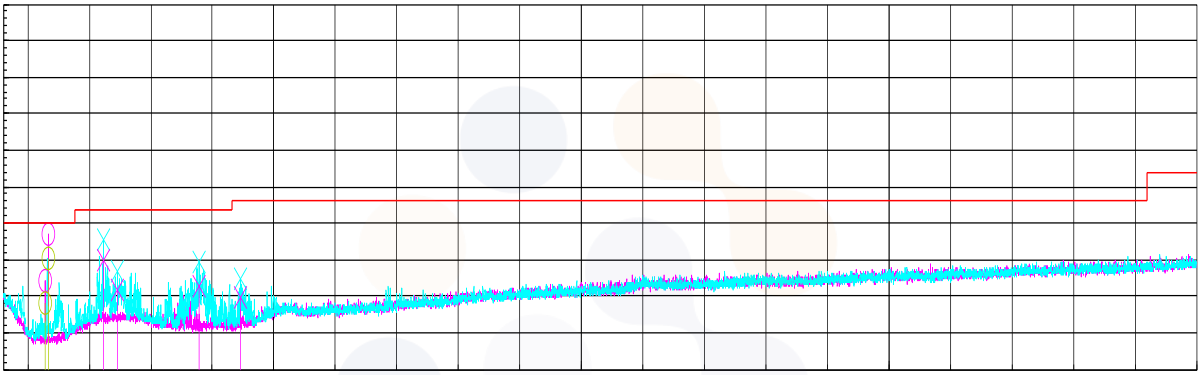


Note.
1. No other spurious and harmonic emissions were found above listed frequencies.
2. Information of Distance Factor
For finding emissions, the test distance might be reduced. In this case, the distance factor is applied to the result.
-Calculation of distance factor = 20 log(applied distance / required distance)
When distance factor is “N/A”, the distance is 3 m and distance factor is not applied.
3. Sample Calculation.
Margin=Limit - Result / Result = Measured Level + T.F + Distance factor / T.F = AF + CL - AG
Where, T.F= Total Factor, AF= Antenna Factor, CL= Cable Loss, AG= Amplifier Gain

Frequency Range: 30 ㎒ ~ 1 ㎓

Frequency (㎒)	ANT Pol	EUT Position (Axis)	Detector Mode	Measured Level (dB㎶)	T.F (dB/m)	Distance Factor (dB)	Result (dB(㎶/m))	Limit (dB(㎶/m))	Margin (dB)
63.95	H	X	QP	35.10	12.11	-28.94	18.27	40.00	21.73
66.86	H	X	QP	47.20	12.19	-28.76	30.63	40.00	9.37
*111.48	V	X	QP	39.60	17.76	-27.76	29.60	43.50	13.90
122.51	V	X	QP	31.50	17.90	-27.57	21.83	43.50	21.67
189.08	V	X	QP	34.20	14.90	-26.38	22.72	43.50	20.78
223.27	V	X	QP	30.20	15.36	-26.00	19.56	46.00	26.44

Horizontal/Vertical

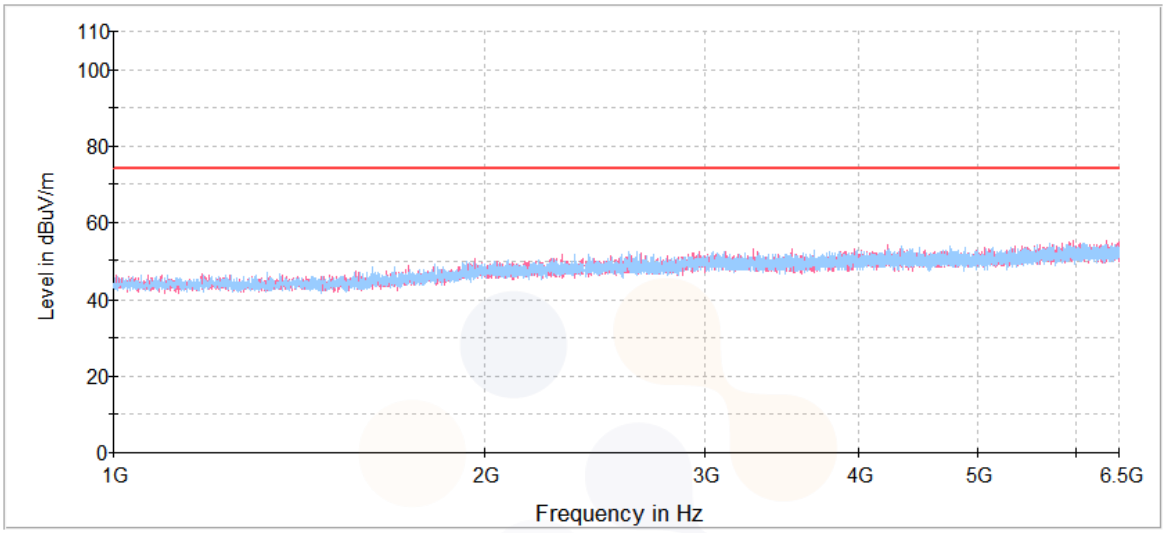


Note.
1. No other spurious and harmonic emissions were found above listed frequencies.
2. Information of Distance Factor
For finding emissions, the test distance might be reduced. In this case, the distance factor is applied to the result.
-Calculation of distance factor = 20 log(applied distance / required distance)
When distance factor is “N/A”, the distance is 3 m and distance factor is not applied.
3. Sample Calculation.
Margin=Limit - Result / Result = Measured Level + T.F + Distance factor / T.F = AF + CL - AG
Where, T.F= Total Factor, AF= Antenna Factor, CL= Cable Loss, AG= Amplifier Gain

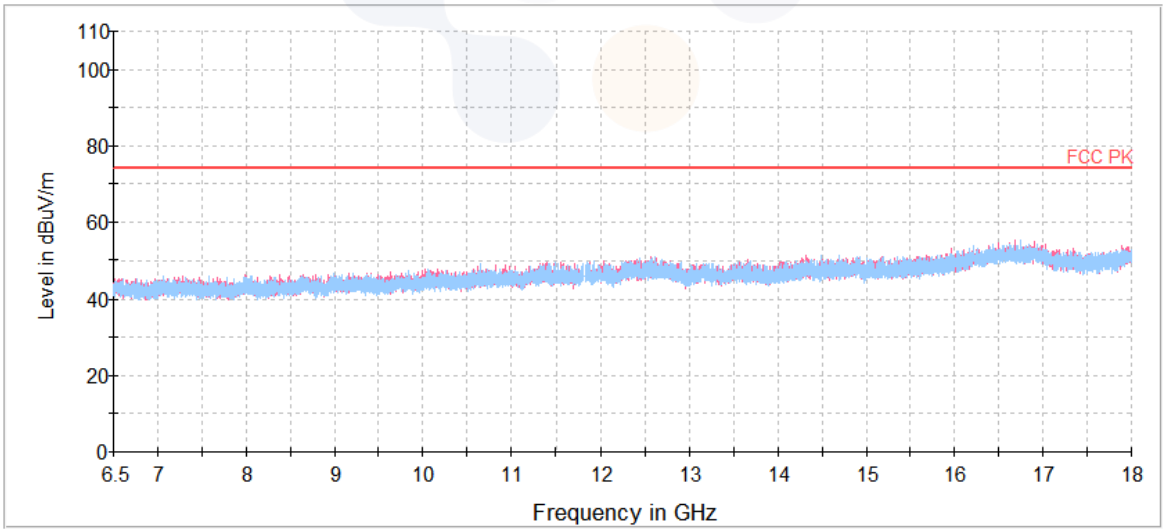
Frequency Range: 1 ㎓ ~ 40 ㎓

Frequency (㎒)	ANT Pol	EUT Position (Axis)	Detector Mode	Measured Level (dB(㎶))	T.F (dB/m)	Distance Factor (dB)	Result (dB(㎶/m))	Limit (dB(㎶/m))	Margin (dB)
No spurious emissions were detected.									

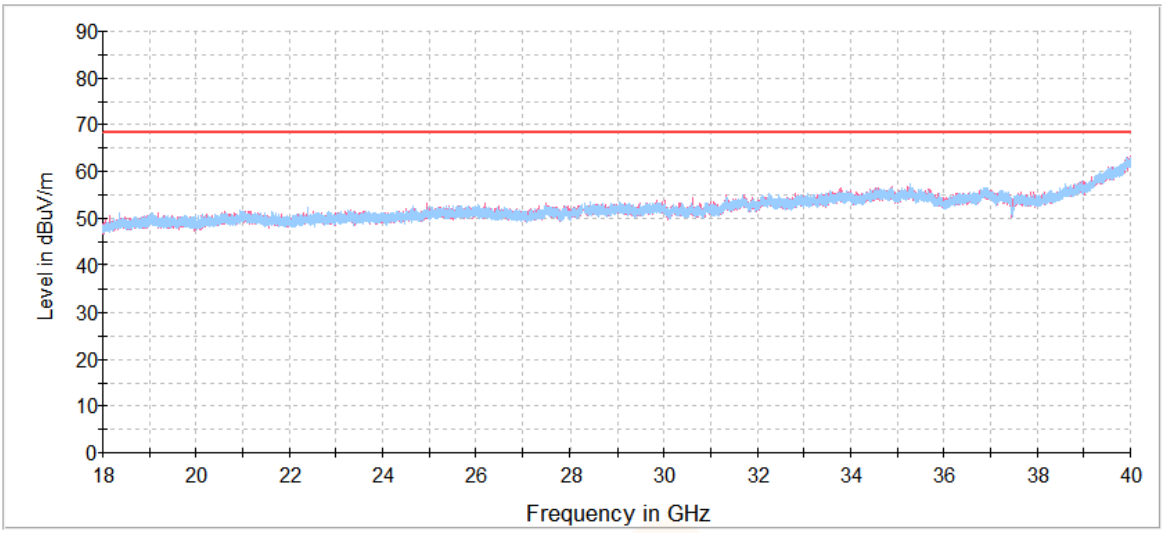
Horizontal/Vertical_1~6.5 ㎓



Horizontal/Vertical_1.6 ~ 18 ㎓



Horizontal/Vertical_18~40 ㎓



Note.
1. No other spurious and harmonic emissions were found above listed frequencies.
2. Information of Distance Factor
For finding emissions, the test distance might be reduced. In this case, the distance factor is applied to the result.
-Calculation of distance factor = 20 log(applied distance / required distance)
When distance factor is “N/A”, the distance is 3 m and distance factor is not applied.
3. Sample Calculation.
Margin=Limit - Result / Result = Measured Level + T.F + Distance factor / T.F = AF + CL - AG
Where, T.F= Total Factor, AF= Antenna Facotr, CL= Cable Loss, AG= Amplifier Gain
4. *Noise floor.

Frequency Range: 40 ㎓ ~ 90 ㎓

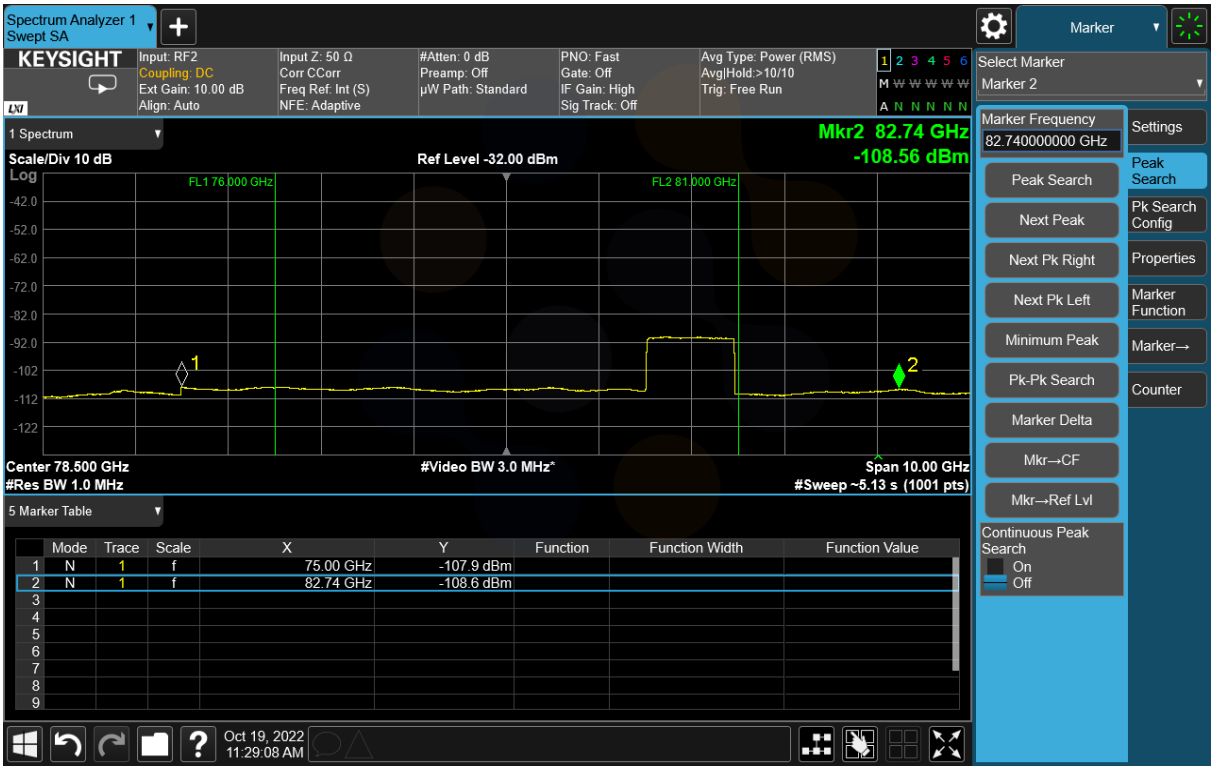
- FCC

Frequency (㎓)	ANT Pol	EUT Position (Axis)	Measured Level (dBm)	AFCL (dB/m)	E (dB(㎶/m))	EIRP (dBm)	Power density (pW/cm²)	Limit (pW/cm²)
75.00	V	X	-107.90	66.25	65.35	-35.83	0.92	600.00
82.74	V	X	-108.60	68.56	66.96	-34.22	1.34	600.00

- IC

Frequency (㎓)	ANT Pol	EUT Position (Axis)	Measured Level (dBm)	AFCL (dB/m)	E (dB(㎶/m))	EIRP (dBm)	Limit (dBm)	Margin (dB)
75.00	V	X	-107.90	66.25	65.35	-35.83	-30.00	5.83
82.74	V	X	-108.60	68.56	66.96	-34.22	-30.00	4.22

Horizontal/Vertical for Worst Data



Note.

1. The radiated emissions were investigated up to 250 ㎓. And no other spurious and harmonic emissions were found above listed frequencies.
2. Sample Calculation.

E(dB㎶/m) = Measured level (dB㎶) + 107 +AFCL(dB/m)

The mixer loss was applied to the measured level by SA correction factor.

Where, E=field strength / AFCL = Antenna Factor(dB/m) + Cable Loss(dB/m)

EIRP(dBm) = E(dB㎶/m) + 20log(D) - 104.8; where, D is measurement distance(in the far field region) in m.

$PD = EIRP_{Linear}/4\pi d^2$

Where, PD = the power density at the distance specified by the limit, in W/m^2

$EIRP_{Linear}$=EIRP, in watts

D= is the distance at which the power density limit is specified, in m

3.*Noise floor

4. Band edge test results.

Frequency Range: 90 ㎓ ~ 250 ㎓

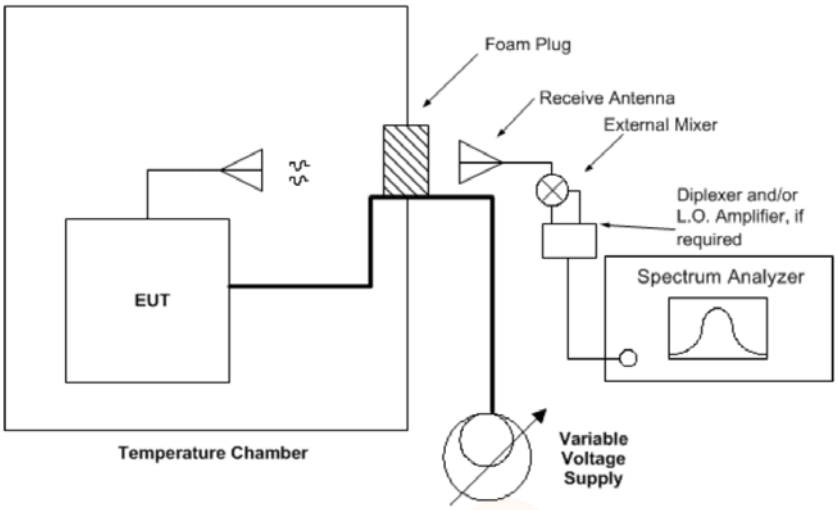
Frequency (㎒)	ANT Pol	EUT Position (Axis)	Measured Level (dBm)	AFCL (dB/m)	E (dB(㎶/m))	EIRP (dBm)	Power density (pW/cm²)	Limit (pW/cm²)
No spurious emissions were detected.								

Note.

1. Measuring frequencies from 1 ㎓ to the 10th harmonic of highest fundamental frequency.
2. Measurements above show only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 ㏈ from the applicable limit) and considered that's already beyond the background noise floor.
3. Radiated emissions measured in frequency above 1000 ㎒ were made with an instrument using Peak detector mode and average detector mode of the emission shown
in Actual FS column.
4. Total = Reading Value + Antenna Factor + Cable Loss - Amplifier Gain + Distance Factor

5.4. Frequency stability

Test setup



Limit

FCC

According to § 95.3379(b), Fundamental emissions must be contained within the frequency bands specified in Part 95(M) during all conditions of operation. Equipment is presumed to operate over the temperature range -20 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

IC

According to RSS 251(11.2), The radar device's occupied bandwidth (i.e. 99% emission bandwidth) shall be maintained within the 76-81 GHz frequency band while subjected to all conditions of operation specified in RSS-Gen.

RSS GSN(8.11), If the frequency stability of the licence-exempt radio apparatus is not specified in the applicable RSS, the fundamental emissions of the radio apparatus should be kept within at least the central 80% of its permitted operating frequency band in order to minimize the possibility of out-of-band operation.In addition, its occupied bandwidth shall be entirely outside the restricted bands and the prohibited TV bands of 54-72 MHz, 76-88 MHz, 174-216 MHz, and 470-602 MHz, unless otherwise indicated.

Test procedure

ANSI C63.26-2015 – Section 5.6

The frequency stability of the transmitter is measured by:

1. At 10 ℃ intervals of temperatures between -30℃ and +50℃ at the manufacturer's rated supply voltage, and
2. At +20℃ temperature and ±15% supply voltage variations. If a product is specified to operate over a range of input voltage then the -15% variation is applied to the lowermost voltage and the +15% is applied to the uppermost voltage.

Time period and procedure:

1. The carrier frequency of the transmitter is measured at room temperature.
   (20 ℃ to provide a reference)
2. The equipment is turned on in a “standby” condition for one minute before applying power to the transmitter. Measurement of the carrier frequency of the transmitter is made within one minute after applying power to the transmitter.
3. Frequency measurements are made at 10℃ internals ranging from -30℃ to +50℃.
   A period of at least one half-hour is provided to allow stabilization of the equipment at each temperature level.

Test results

Voltage	Voltage	TEMP	Measure Frequency(F_L)	Measure Frequency(F_H)
[%]	[V]	[℃]	[㎒]	[㎒]
100	24.00	20(Ref.)	80 019.14	80 958.92
		-40	80 017.11	80 958.85
		-30	80 014.30	80 959.73
		-20	80 016.13	80 958.80
		-10	80 016.92	80 958.15
		0	80 017.47	80 958.10
		10	80 017.36	80 957.46
		20	80 018.09	80 957.74
		30	80 019.05	80 957.76
		40	80 019.32	80 957.63
		50	80 019.90	80 957.88
		60	80 017.58	80 959.47
		70	80 015.12	80 960.44
		80	80 020.91	80 960.22
		85	80 019.83	80 960.75
115	27.60	20(Ref.)	80 018.11	80 958.87
85	20.40*	20(Ref.)	80 019.51	80 958.17

Note: Fundamental emissions were contained within the frequency bands.
Note:*-15%variation was applied to the lowermost voltage.

6. Measurement equipment

Equipment Name	Manufacturer	Model No.	Serial No.	Next Cal. Date
UXA Signal Analyzer	KEYSIGHT	N9041B	MY60100003	23.02.09
Temp & Humid Chamber	Myeongseong R&P	CTHC-50P-DT	20150824-1	22.12.21
DC Power Supply	AGILENT	E3632A	MY40027567	23.05.02
Millimeter Wave Source Module	OML, Inc.	S19MS-A	190725-1	23.10.26
Millimeter Wave Source Module	OML, Inc.	S12MS-A	190621-1	23.10.26
Millimeter Wave Source Module	OML, Inc.	S08MS-A	190621-1	23.10.25
Millimeter Wave Source Module	OML, Inc.	S05MS-A	190621-1	23.10.25
Millimeter Wave Source Module	OML, Inc.	S03MS-A	190621-1	23.10.25
Harmonic Mixer	OML, Inc.	M19HWD	190621-1	23.10.26
Harmonic Mixer	OML, Inc.	M12HWD	190621-1	23.10.26
Harmonic Mixer	OML, Inc.	M08HWD	190621-1	23.10.27
Harmonic Mixer	OML, Inc.	M05HWD	190621-1	23.10.26
Harmonic Mixer	OML, Inc.	M03HWD	190621-1	23.10.26
Horn Antenna	OML, Inc.	M19RH	190621-1	23.10.28
Horn Antenna	OML, Inc.	M12RH	190621-1	23.10.28
Horn Antenna	OML, Inc.	M08RH	190621-1	23.10.28
Horn Antenna	OML, Inc.	M05RH	190621-1	23.10.27
Horn Antenna	OML, Inc.	M03RH	190621-1	23.10.27
Horn Antenna	OML, Inc.	M19RH	190621-2	23.10.28
Horn Antenna	OML, Inc.	M12RH	190621-2	23.10.28
Horn Antenna	OML, Inc.	M08RH	190621-2	23.10.28
Horn Antenna	OML, Inc.	M05RH	190621-2	23.10.27
Horn Antenna	OML, Inc.	M03RH	190621-2	23.10.27
Spectrum Analyzer	R&S	FSV40	100989	23.10.14
Horn antenna	ETS.lindgren	3117	155787	23.09.29
Horn antenna	ETS.lindgren	3116	86635	23.05.04
Attenuator	API Inmet	40AH2W-10	12	23.05.03
AMPLIFIER	B&Z Technologies	BZRT-00504000-481055-382525	26299-27735	23.09.19
AMPLIFIER	B&Z Technologies	BZR-0050400-551028-252525	27736	23.09.19

Antenna Mast	Innco Systems	MA4640-XP-ET	-	-
Turn Table	Innco Systems	CO3000	1175/45850319/P	-
Vector Signal Generator	R&S	SMBV100A	257566	23.07.04
Signal Generator	R&S	SMB100A	176206	23.01.19
mmWave Single-Axis measuring jig	C&K Technologies, Inc.	-	-	-
EMI TEST RECEIVER	R&S	ESCI7	100732	23.03.04
Bilog Antenna	TESEQ	CBL 6112D	62438	24.08.24
ATTENUATOR	KEYSIGHT	8491B-6dB	MY39271082	24.08.24
EMI TEST RECEIVER	R&S	ESCI7	100732	23.03.04
Loop Antenna	R&S	HFH2-Z2	100355	24.08.10
AMPLIFIER	SONOMA	315	300314	23.01.19
ISOLATION TRANSFORMER	ONETECH CO., LTD	OT-IT500VA	OTR1-16026	23.03.28
Antenna Mast	Innco Systems	MA4000-EP	303	-
Turn Table	DT2000	Innco Systems	79	-

End of test report