

TEST REPORT

Test Report Number: N2302R-0061

Applicant: OK Digital Co., Ltd.

Address of Applicant: Mega Bldg 1510, SKn Technopark, 124, Sagimakgol-ro, Jungwon-gu, Seongnam-si, Gyeonggi-do, Republic of Korea

Manufacturer OK Digital Co., Ltd.

Address of Manufacturer/Factory: Mega Bldg 1510, SKn Technopark, 124, Sagimakgol-ro, Jungwon-gu, Seongnam-si, Gyeonggi-do, Republic of Korea

Equipment Under Test (EUT)

Product Name: Digital Locker Lock

Model No.: LF23-HL

■ **FCC ID** : 2A9SA -LF23-HL

□ **IC**

Applicable standards: FCC CFR Title 47 Part 15 Subpart C (15.225)
ANSI C63.10-2013

Date of Test: November 4, 2022 to February 01, 2023

Date of report issued: February 02, 2023

Test Result: Compliance *

* In the configuration tested, the EUT complied with the standards specified above.

Prepared By:



Project Engineer

Date:

February 02, 2023

Check By:



Reviewer

Date:

February 02, 2023

Laboratory Manager

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REPORT REVISION HISTORY

Date	Revision	Page No
2023-02-02	Originally Issued	-

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1. General Information

1.1 General Description of EUT

Product Name:	Digital Locker Lock
Model No.:	LF23-HL
Variant Model No.:	N/A
Operation Frequency:	13.56 MHz
Channel numbers:	NFC: 1 Channel
Modulation technology:	NFC: ASK
Antenna Specification:	PCB Pattern Antenna
Power source	DC 4.5 V (AA type battery x3)

1.2 Channel list

Operation Frequency each of channel	
Channel	Frequency
1	13.560 MHz

1.3 Test condition

	Normal voltage
DC Power	4.50

1.4 Test Summary

Section in FCC Part 15 & 2	Parameter	Test results
15.225(a)	The field strength of fundamental	Pass
15.225(b)(c)	The field strength of spurious emission (In-band)	Pass
15.225(d) 15.209	The field strength of spurious emission (Out-band)	Pass
2.1049	20 dB bandwidth	Pass
15.225(e)	Frequency stability	Pass

1.5 Test Performed

RRA Designation No.: KR0157

KOLAS Accreditation No. : KT511

Laboratory	NTREE Co., Ltd.
1st laboratory Address	228-60, Saneop-ro 155beon-gil, Gwonseon-gu, Suwon-si, Gyeonggi-do, 16648, KOREA
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SITE MAP

1st laboratory



2nd laboratory



1.6 Test Instruments list

Item	Test Equipment	Manufacturer	Model No.	Serial No.	Cal. Date	Cal.Due date (mm-dd-yy)
1	Signal Analyzer	ROHDE & SCHWARZ	FSV40	100994	03-10-22	03-10-23
2	DC Power Supply	AGILENT	6632B	MY43004017	09-08-22	09-08-23
3	Signal Generator	ROHDE & SCHWARZ	SMB100A	177568	03-10-22	03-10-23
4	LOOP ANTENNA	Schwarzbeck	FMZB1519	1519-046	05-18-22	05-18-24
5	Tri-Log Antenna	Schwarzbeck	VULB 9168	9168-721	03-21-22	03-21-24
6	Tri-Log Antenna	Schwarzbeck	VULB 9168	9168-578	10-13-22	10-13-24
7	EMI Test Receiver	ROHDE & SCHWARZ	ESR7	101302	03-10-22	03-10-23
8	Amplifier	TESTEK	TK-PA01S	200103-L	11-02-22	11-02-23

1.7 Measurement uncertainty

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated in accordance with TR100028-1 [2] and shall correspond to an expansion factor (coverage factor) $k = 1.96$ or $k = 2$ (which provide confidence levels of respectively 95% and 95.5% in the case where the distributions characterizing the actual measurement uncertainties are normal.

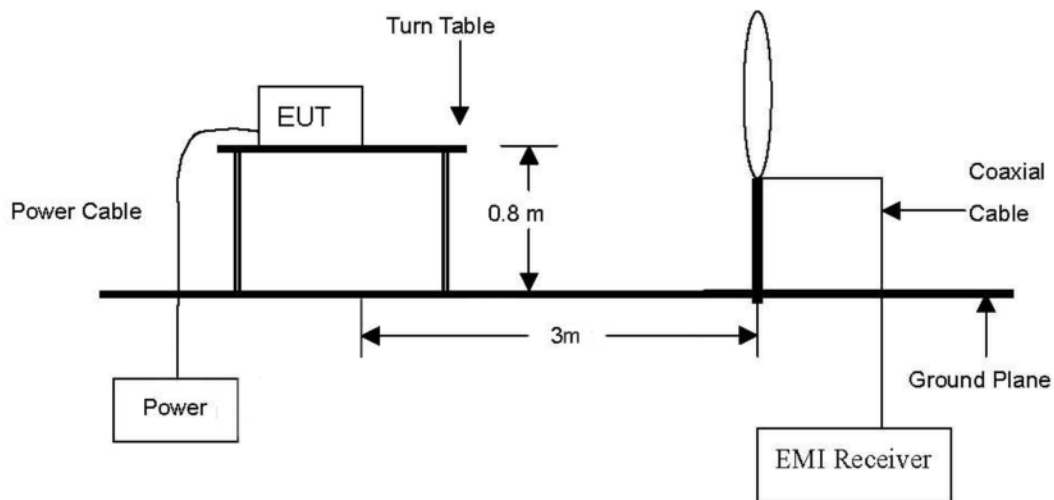
Parameter	Uncertainty
Transmitter output power (Conducted)	± 1.3 dB
Radiated spurious emission (Below 1 GHz)	± 4.8 dB
Radiated spurious emission (Above 1 GHz)	± 5.0 dB

2. Test Result

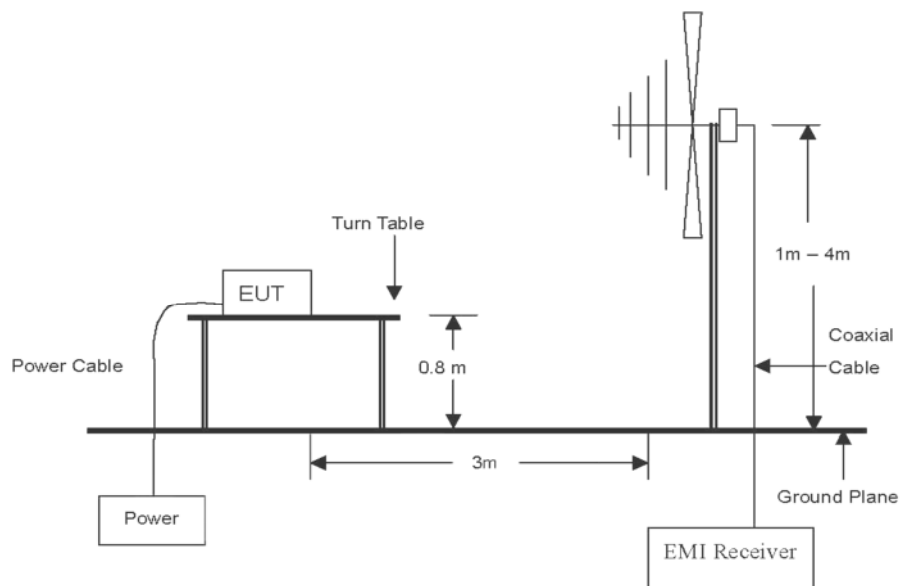
2.1 Spurious Emissions

Test setup

The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission from 30 MHz to 1 GHz emissions.



Test procedure

[9 kHz to 30 MHz]

The EUT was placed on the top of a rotating table 0.8 meter above the ground at a 3 meter anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. Then antenna is a loop antenna is fixed at one meter above the ground to determine the maximum value of the field strength. Both parallel and perpendicular of the antenna are set to make the measurement. For each suspected emission, the EUT was arranged to its worst case and then the table was turned from 0 degrees to 360 degrees to find the maximum reading. The test-receiver system was set to Quasi-peak function and specified bandwidth with maximum hold mode.

The spectrum analyzer is set to:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer 200 Hz for Quasi-peak detection (QP) at frequency below 9 kHz~ 150 kHz.
2. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer 9 kHz for Quasi-peak detection (QP) at frequency below 150 kHz~ 30 MHz.

[30 MHz to 1 GHz]

The height of the measuring antenna was varied between 1 to 4 m and the table was rotated a full revolution in order to obtain maximum values of the electric field intensity.

The measurement was made in both the vertical and horizontal polarization, and the maximum value is presented in the report.

The spectrum analyzer is set to:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Peak detection (PK) or Quasi-peak detection (QP) at frequency below 1 GHz.

Note.

According to exploratory test no any obvious emission were detected from 9 kHz to 30 MHz.

Although these test were performed other than open area test site, adequate comparison measurements were confirmed against 30 m open area test 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.

Limit

According to 15.209(a), for an intentional radiator devices, the general required of field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values :

Frequency (MHz)	Distance (Meters)	Radiated ($\mu V/m$)
0.009 ~ 0.490	300	$2400/F(\text{kHz})$
0.490 ~ 1.705	30	$24000/F(\text{kHz})$
1.705 ~ 30.0	30	30
30 ~ 88	3	100**
88 ~ 216	3	150**
216 ~ 960	3	200**
Above 960	3	500

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54 ~ 72 MHz, 76 ~ 88 MHz, 174 ~ 216 MHz or 470 ~ 806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

In the section 15.225:

- (a) The field strength of any emissions within the band 13.553 ~ 13.567 MHz shall not exceed 15,848 microvolts/meter (= 84 dB $\mu V/m$) at 30 meters.
- (b) Within the bands 13.410 ~ 13.553 MHz and 13.567 ~ 13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter (=50.5 dB $\mu V/m$) at 30 meters.
- (c) Within the bands 13.110 ~ 13.410 MHz and 13.710 ~ 14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter (=40.5 dB $\mu V/m$) at 30 meters.
- (d) The field strength of any emissions appearing outside of the 13.110 ~ 14.010 MHz band shall not exceed the general radiated emission limits in § 15.209.

Test results for fundamental

Operating frequency: 13.560 MHz

Distance of measurement: 3 meter

Test results for in-band (9 kHz to 30 MHz)

Radiated emissions		Ant.	Total factors		Total	Limit	
Frequency (MHz)	Reading (dBμV)	Pol.	Correction factor (dB/m)	Distance factor (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
13.204	3.28	G	19.60	40	-17.12	40.50	57.62
13.531	3.48	H	19.80	40	-16.72	50.50	67.22
13.561**	28.28	H	19.90	40	8.18	84.00	75.82
13.650	2.12	V	19.90	40	-17.98	50.50	68.48
13.896	2.02	V	20.10	40	-17.88	40.50	58.38

Note.

1. “ ** ” is fundamental.
2. All measurements were performed using a loop antenna. The antenna was positioned in three orthogonal positions (H : parallel, V : perpendicular, G : ground-parallel)
3. The EUT was positioned in three orthogonal planes to determine the orientation resulting in the worst case emissions.
4. Measurements were performed at 3m and the data was extrapolated to the specified measurement distance of 30m using the square of an inverse linear distance extrapolation factor (40 dB/decade) as specified in §15.31(f)(2). Extrapolation Factor = $20 \log_{10}(30/3)^2 = 40$ dB.
5. All measurements were recorded using a spectrum analyzer employing a peak detector.
6. Actual = Reading + Correction factors(Ant. factor + Cable loss) - Distance factor
7. Margin [dB] = Limit [dBμV/m] - Field Strength Level [dBμV/m]

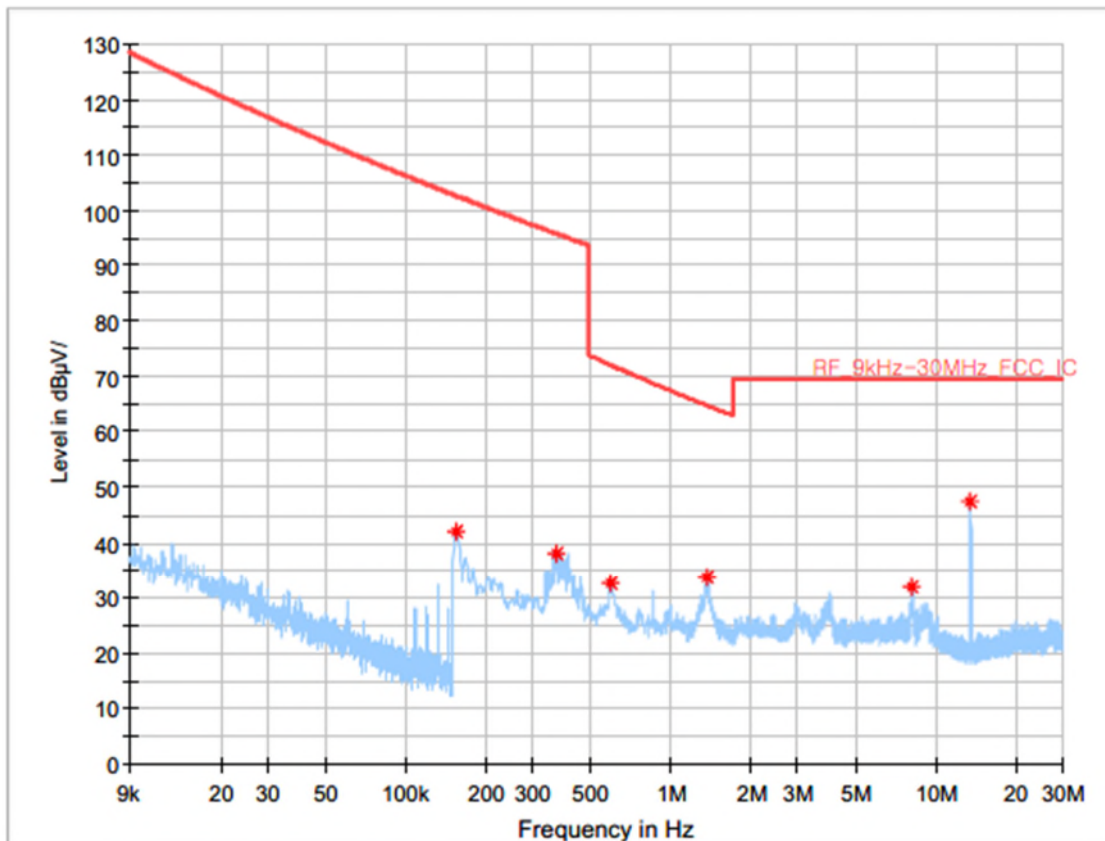
Test results (9 kHz to 30 MHz)

Parallel

Test Report

Common Information

Test Description: A2022-11527
 Operating Conditions: Temp. (20.6 ± 1.0) °C / Humi. (53.7 ± 1.0) % R.H.
 Operator Name: Joonyoung Jeon
 Antenna position: Parallel



Critical Freqs

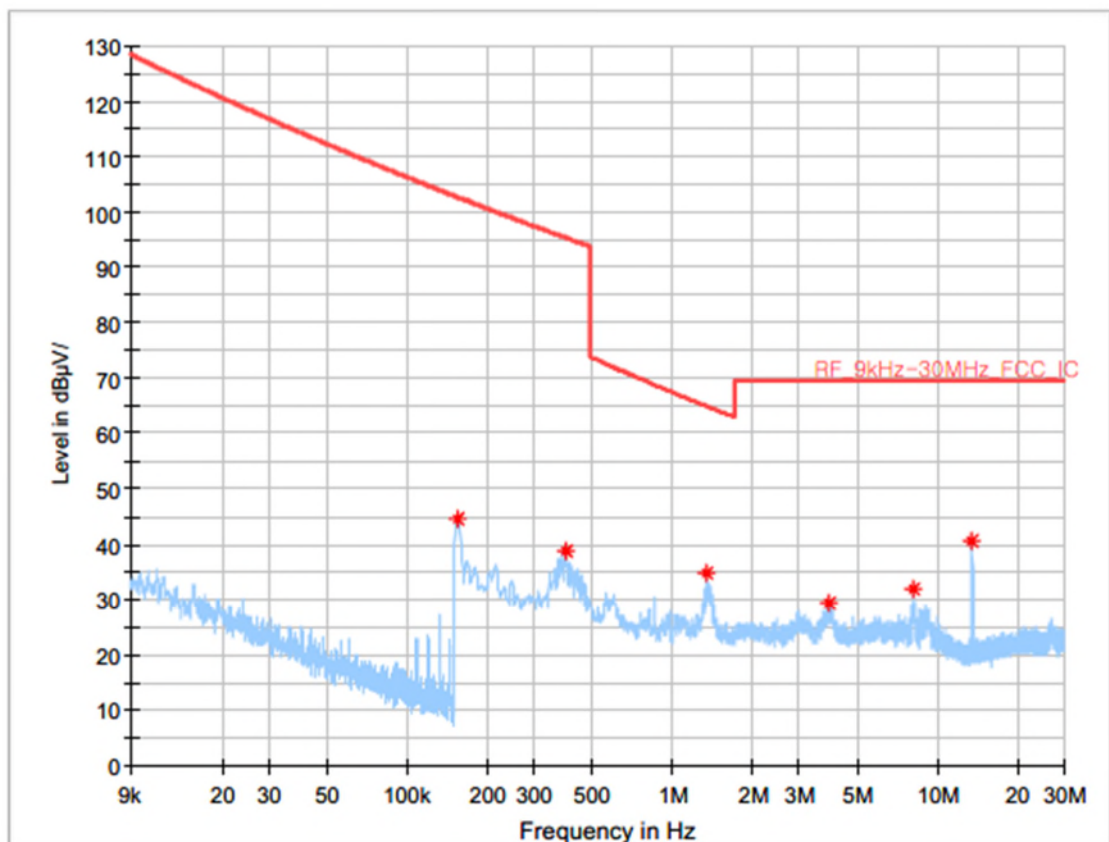
Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Azimuth (deg)	Corr. (dB)	Comment
0.155740	42.15	102.66	60.51	100.0	343.0	18.8	9:34:05 AM - 2/1/2023
0.372727	37.97	95.84	57.87	100.0	272.0	19.5	9:34:37 AM - 2/1/2023
0.587417	32.47	72.12	39.65	100.0	0.0	19.9	9:33:47 AM - 2/1/2023
1.374998	33.50	64.74	31.24	100.0	121.0	20.4	9:33:47 AM - 2/1/2023
8.157837	31.97	69.50	37.53	100.0	0.0	20.6	9:33:47 AM - 2/1/2023
13.560687	47.34	69.50	22.16	100.0	334.0	19.9	9:33:47 AM - 2/1/2023

Test results (9 kHz to 30 MHz)

Perpendicular

Common Information

Test Description: A2022-11527
Operating Conditions: Temp. (20.6 ± 1.0) °C / Humi. (53.7 ± 1.0) % R.H.
Operator Name: Joonyoung Jeon
Antenna position: Perpendicular



Critical Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Azimuth (deg)	Corr. (dB)	Comment
0.155740	44.43	102.66	58.23	100.0	0.0	18.8	10:22:54 AM - 2/1/2023
0.394540	38.86	95.41	56.55	100.0	185.0	19.5	10:22:56 AM - 2/1/2023
1.339408	34.73	64.96	30.23	100.0	149.0	20.4	10:22:59 AM - 2/1/2023
3.915692	29.42	69.50	40.08	100.0	36.0	21.1	10:23:21 AM - 2/1/2023
8.121098	31.71	69.50	37.79	100.0	0.0	20.7	10:23:05 AM - 2/1/2023
13.560687	40.69	69.50	28.81	100.0	84.0	19.9	10:21:29 AM - 2/1/2023

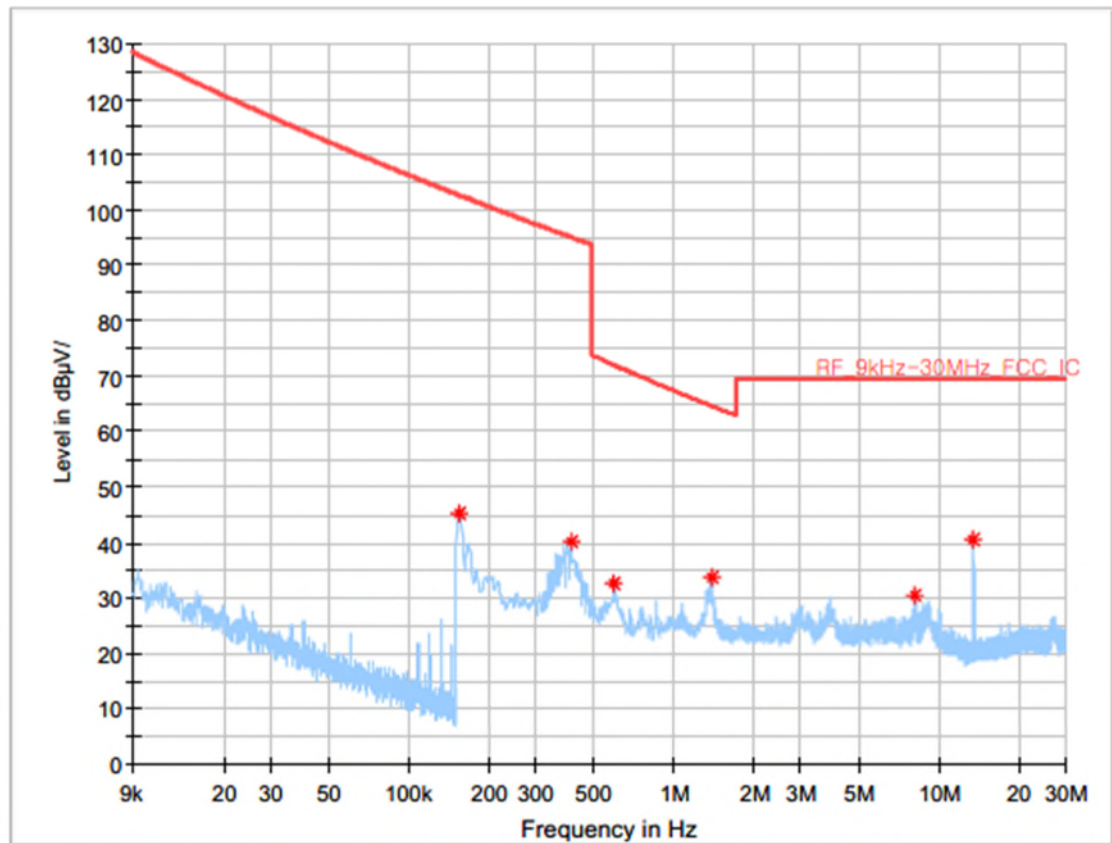
Test results (9 kHz to 30 MHz)

Ground-parallel

Test Report

Common Information

Test Description: A2022-11527
Operating Conditions: Temp. (20.6 ± 1.0) °C / Humi. (53.7 ± 1.0) % R.H.
Operator Name: Joonyoung Jeon
Antenna position: Ground-parallel



Critical Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Azimuth (deg)	Corr. (dB)	Comment
0.155740	45.14	102.66	57.52	100.0	158.0	18.8	10:33:07 AM - 2/1/2023
0.408317	40.24	95.16	54.91	100.0	46.0	19.6	10:33:10 AM - 2/1/2023
0.596602	32.74	71.98	39.24	100.0	122.0	20.0	10:33:53 AM - 2/1/2023
1.387627	33.58	64.67	31.09	100.0	46.0	20.4	10:33:14 AM - 2/1/2023
8.099285	30.56	69.50	38.94	100.0	0.0	20.7	10:33:22 AM - 2/1/2023
13.560687	40.39	69.50	29.11	100.0	340.0	19.9	10:32:39 AM - 2/1/2023

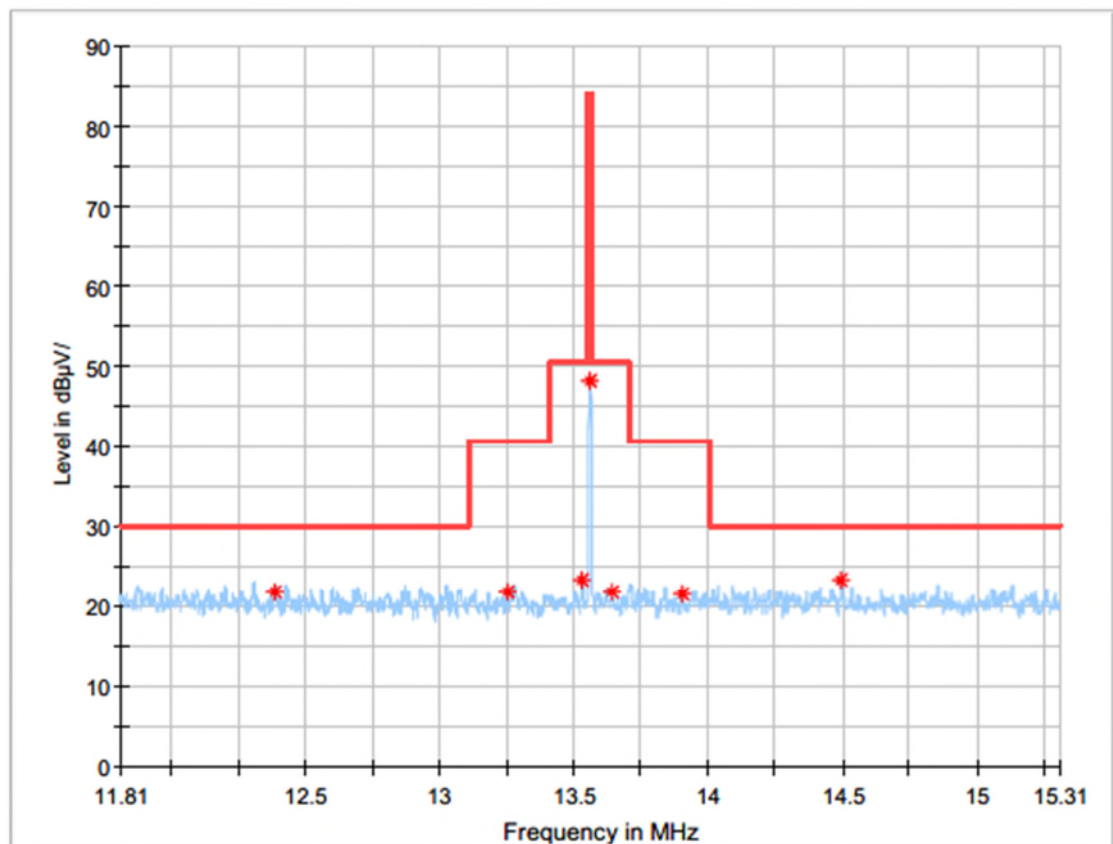
Test results (In band)

Parallel

Test Report

Common Information

Test Description: A2022-11527
 Operating Conditions: Temp. (20.6 ± 1.0) °C / Humi. (53.7 ± 1.0) % R.H.
 Operator Name: Joonyoung Jeon
 Antenna position: Parallel



Critical Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (deg)	Corr. (dB)	Comment
12.385056	21.92	30.00	8.08	197.0	19.8	9:53:00 AM - 2/1/2023
13.251854	21.90	40.50	18.60	142.0	19.6	9:53:11 AM - 2/1/2023
13.530837	23.28	50.50	27.22	259.0	19.8	9:53:24 AM - 2/1/2023
13.560687	48.18	84.00	35.82	0.0	19.9	9:48:40 AM - 2/1/2023
13.642200	21.79	50.50	28.71	78.0	19.9	9:53:30 AM - 2/1/2023
13.905110	21.58	40.50	18.92	347.0	20.1	9:53:15 AM - 2/1/2023
14.497517	23.27	30.00	6.73	0.0	20.4	9:53:04 AM - 2/1/2023

Test results (In band)

Perpendicular

Test Report

Common Information

Test Description:

A2022-11527

Operating Conditions:

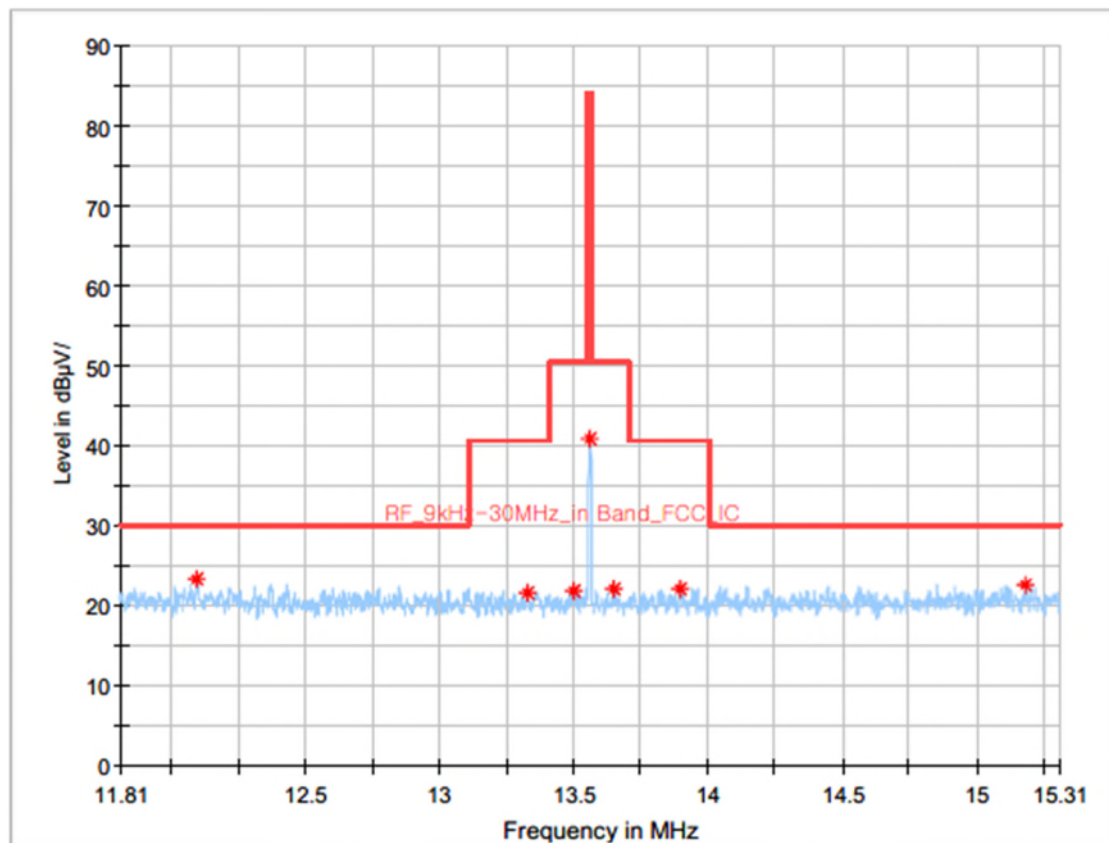
Temp. (20.6 ± 1.0) °C / Humi. (53.7 ± 1.0) % R.H.

Operator Name:

Joonyoung Jeon

Antenna position:

perpendicular



Critical Freqs

Frequency (MHz)	MaxPeak (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Azimuth (deg)	Corr. (dB)	Comment
12.094592	23.33	30.00	6.67	100.0	0.0	20.0	10:08:24 AM - 2/1/2023
13.327627	21.63	40.50	18.87	100.0	185.0	19.7	10:12:49 AM - 2/1/2023
13.500987	21.92	50.50	28.58	100.0	175.0	19.8	10:13:02 AM - 2/1/2023
13.560687	40.76	84.00	43.24	100.0	112.0	19.9	10:12:41 AM - 2/1/2023
13.650237	22.02	50.50	28.48	100.0	273.0	19.9	10:13:06 AM - 2/1/2023
13.895925	22.12	40.50	18.38	100.0	112.0	20.1	10:12:56 AM - 2/1/2023
15.185215	22.62	30.00	7.38	100.0	211.0	20.6	10:08:24 AM - 2/1/2023

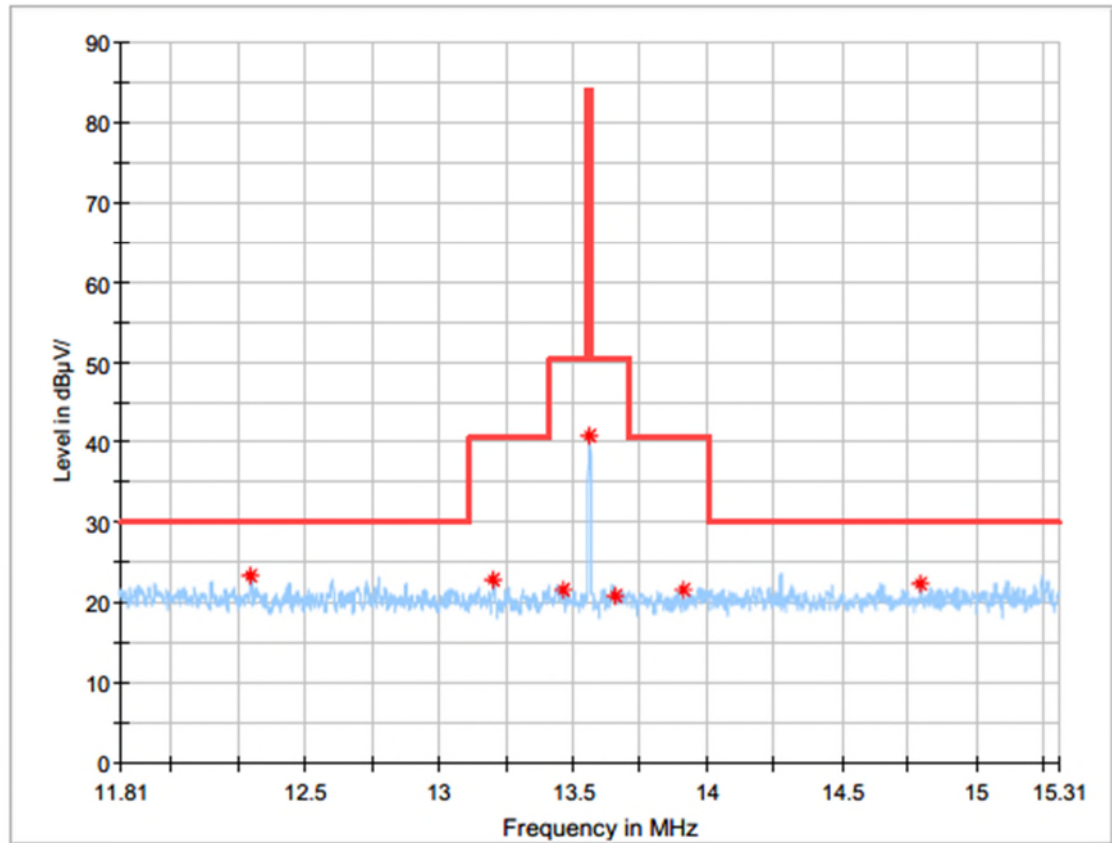
Test results (In band)

Ground-parallel

Test Report

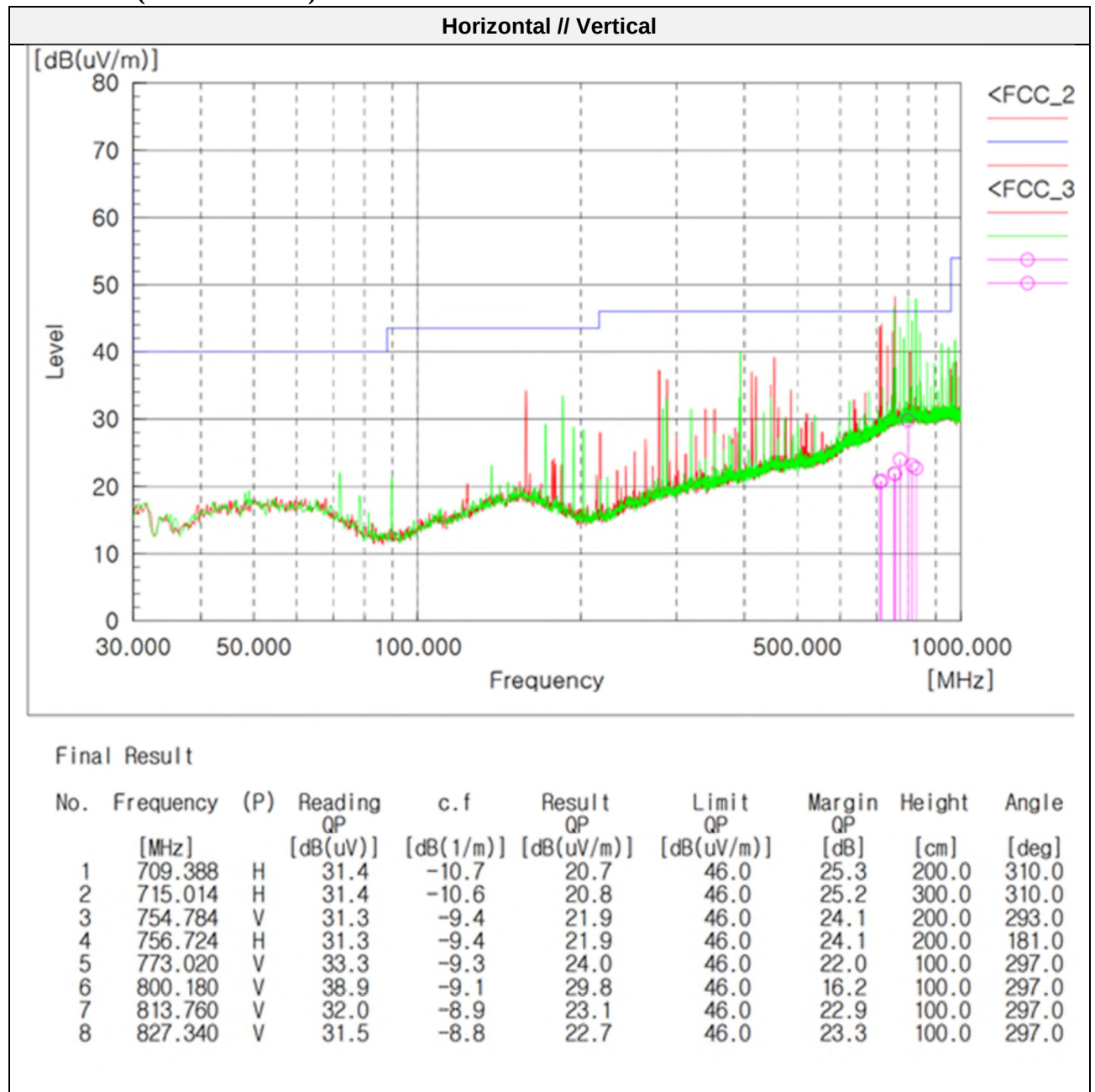
Common Information

Test Description: A2022-11527
Operating Conditions: Temp. (20.6 ± 1.0) °C / Humi. (53.7 ± 1.0) % R.H.
Operator Name: Joonyoung Jeon
Antenna position: Ground-parallel



Critical Freqs

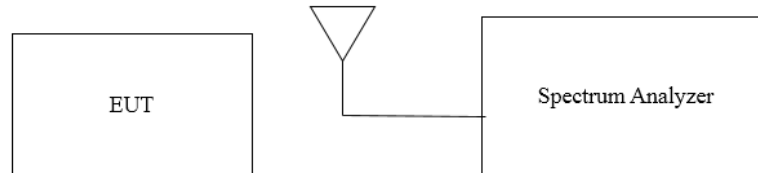
Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Azimuth (deg)	Corr. (dB)	Comment
12.298950	23.34	30.00	6.66	100.0	0.0	19.9	10:41:25 AM - 2/1/2023
13.203635	22.88	40.50	17.62	100.0	207.0	19.6	10:41:51 AM - 2/1/2023
13.460804	21.56	50.50	28.94	100.0	233.0	19.8	10:42:12 AM - 2/1/2023
13.560687	40.97	84.00	43.03	100.0	0.0	19.9	10:42:07 AM - 2/1/2023
13.659421	20.71	50.50	29.79	100.0	0.0	19.9	10:42:16 AM - 2/1/2023
13.910850	21.44	40.50	19.06	100.0	93.0	20.1	10:42:01 AM - 2/1/2023
14.797165	22.41	30.00	7.59	100.0	339.0	20.5	10:41:32 AM - 2/1/2023

Test results (Below 1 000 MHz)

Note.

1. All measurements were recorded using a spectrum analyzer employing a quasi-peak detector for emissions below 960 MHz.
2. Both Vertical and Horizontal polarities of the receive antenna were evaluated with the worst case emissions being reported. Below 30 MHz the loop antenna was positioned in 3 orthogonal planes (X front, Y side, Z top) to determine the orientation resulting in the worst case emissions.
3. The EUT was positioned in three orthogonal planes to determine the orientation resulting in the worst case emissions.
4. The spectrum is measured from 9 kHz to the 10th harmonic and the worst-case emissions are reported.
5. No spurious emissions levels were found to be greater than the level of the fundamental.

2.2 20 dB bandwidth

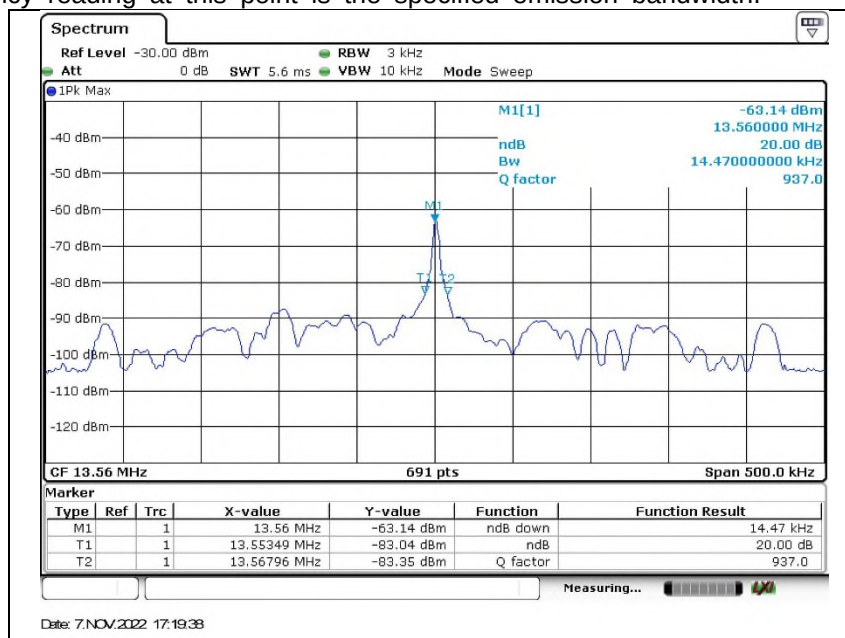
Test setup



Test procedure

ANSI C63.10-2013 – Section 6.9.2

1. Spectrum analyzer frequency is set to the nominal EUT channel center frequency.
2. RBW = 1~5% OBW
3. VBW $\geq 3 \times$ RBW
4. Reference level set to keep signal from exceeding maximum input mixer for linear operation.
5. Detector = Peak
6. Trace mode = Max hold
7. Sweep = Auto couple
8. The trace was allowed to stabilize
9. Using the marker-delta function, determine the “-20 dB down amplitude” using [(highest in band spectral density) – 20 dB]
10. Set a marker at the lowest frequency of the envelope of the spectral density, such that the marker is at or slightly below the “-20 dB down amplitude” determined in Step 9.
11. Reset Marker-delta function and move the marker to other side of the emission until the delta marker amplitude is the same level as reference amplitude. The marker delta frequency reading at this point is the specified emission bandwidth.



Note.

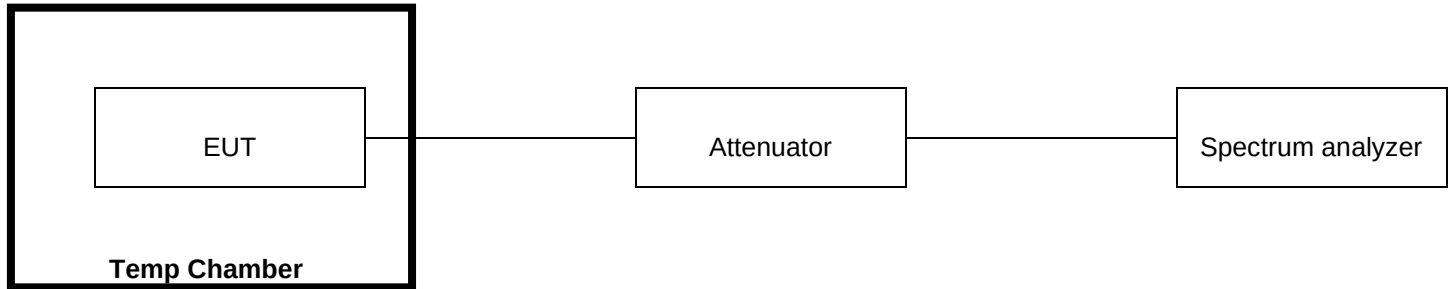
Because the measured signal is CW/CW-like, adjusting the RBW per C63.10 would not be practical since measured bandwidth will always follow the RBW and the result will be approximately twice the RBW.

2.3 Frequency stability

Test procedure

ANSI C63.10-2013, clause 6.8.1

Test setup



1. The EUT was placed inside the environmental test chamber and powered by nominal DC voltage.
2. Turn the EUT on and couple its output to a spectrum analyzer.
3. Turn the EUT off and set the chamber to the highest temperature specified.
4. Allow sufficient time (approximately 30 min) for the temperature of the chamber to stabilize, turn the EUT on and measure the operating frequency.
5. Repeat step 2 and 3 with the temperature chamber set to the lowest temperature.
6. The test chamber was allowed to stabilize at +20 degree C for a minimum of 30 minutes. The supply voltage was then adjusted on the EUT from 85% to 115% and the frequency recorded.
7. While maintaining a constant temperature inside the environmental chamber, turn the EUT on and record the operating frequency at startup, and at 2 minutes, 5 minutes, and 10 minutes after the EUT is energized. Four measurements in total are made.

Limit

According to §15.225 (e), the frequency tolerance of the carrier signal shall be maintained within $\pm 0.01\%$ of the operating frequency over a temperature variation of -20 degrees to +50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85 % to 115 % of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

Test results

Test voltage (%)	Test voltage (V)	Temperature (°C)	Maintaining time	Measure frequency (MHz)	Frequency deviation (Hz)	Deviation (%)
100 %	DC 4.5 V	-20	Startup	13.560 796	796	0.005 870
			2 minutes	13.560 796	796	0.005 870
			5 minutes	13.560 796	796	0.005 870
			10 minutes	13.560 796	796	0.005 870
100 %		-10	Startup	13.560 854	854	0.006 300
			2 minutes	13.560 854	854	0.006 300
			5 minutes	13.560 854	854	0.006 300
			10 minutes	13.560 854	854	0.006 300
100 %		0	Startup	13.560 883	883	0.006 512
			2 minutes	13.560 883	883	0.006 512
			5 minutes	13.560 883	883	0.006 512
			10 minutes	13.560 883	883	0.006 512
100 %		10	Startup	13.560 883	883	0.006 512
			2 minutes	13.560 883	883	0.006 512
			5 minutes	13.560 883	883	0.006 512
			10 minutes	13.560 883	883	0.006 512
100 %		20	Startup	13.560 883	883	0.006 512
			2 minutes	13.560 883	883	0.006 512
			5 minutes	13.560 883	883	0.006 512
			10 minutes	13.560 883	883	0.006 512
100 %		23	Startup	13.560 883	883	0.006 512
			2 minutes	13.560 883	883	0.006 512
			5 minutes	13.560 883	883	0.006 512
			10 minutes	13.560 883	883	0.006 512
100 %		30	Startup	13.560 839	839	0.006 187
			2 minutes	13.560 854	854	0.006 979
			5 minutes	13.560 854	854	0.006 979
			10 minutes	13.560 854	854	0.006 979
100 %		40	Startup	13.560 839	839	0.006 187
			2 minutes	13.560 839	839	0.006 187
			5 minutes	13.560 839	839	0.006 187
			10 minutes	13.560 839	839	0.006 187

100 %		50	Startup	13.560 593	593	0.004 373
			2 minutes	13.560 593	593	0.004 373
			5 minutes	13.560 579	579	0.004 270
			10 minutes	13.560 579	579	0.004 270
85 %	DC 3.825 V	23	Startup	13.560 883	883	0.006 512
			2 minutes	13.560 883	883	0.006 512
			5 minutes	13.560 883	883	0.006 512
			10 minutes	13.560 883	883	0.006 512
115 %	DC 5.175 V	23	Startup	13.560 883	883	0.006 512
			2 minutes	13.560 883	883	0.006 512
			5 minutes	13.560 883	883	0.006 512
			10 minutes	13.560 883	883	0.006 512

- End of Test Report -