

TEST REPORT

of

FCC Part 15 Subpart C §15.225

FCC ID: IYZHH8

Equipment Under Test : NFC Door Handle Sensor with touch sensors
Model Name : HH8
Variant Model Name(s) : -
Applicant : Marquardt GmbH
Manufacturer : Marquardt GmbH
Date of Receipt : 2024.10.28
Date of Test(s) : 2024.11.22 ~ 2024.11.28
Date of Issue : 2024.11.28

In the configuration tested, the EUT complied with the standards specified above. This test report does not assure KOLAS accreditation.

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- 2) The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received.
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Tested by:



Hahyun Sung

Technical
Manager:



Jinhyoung Cho

SGS Korea Co., Ltd. Gunpo Laboratory

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1. General Information

1.1. Testing Laboratory

SGS Korea Co., Ltd. (Gunpo Laboratory)

- 10-2, LS-ro 182beon-gil, Gunpo-si, Gyeonggi-do, Korea, 15807
- 4, LS-ro 182beon-gil, Gunpo-si, Gyeonggi-do, Korea, 15807
- Designation number: KR0150

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1.2. Details of Applicant

FCC Applicant : Marquardt GmbH

FCC Address : Schloss-Str. 16, Rietheim-Weilheim, Germany, 78604

Contact Person : Gerd Villing

Phone No. : 00497424991747

1.3. Details of manufacturer

Company : Same as applicant

Address : Same as applicant

1.4. Description of EUT

Kind of Product	NFC Door Handle Sensor with touch sensors
Model Name	HH8
Serial Number	9324000067274008
Power Supply	DC 12.0 V
Frequency Range	13.56 MHz (NFC)
Modulation Technique	ASK
Number of Channels	1 channel
Antenna Type	PCB loop antenna
H/W Version	H16
S/W Version	242171

1.5. Test Equipment List

Equipment	Manufacturer	Model	S/N	Cal. Date	Cal. Interval	Cal. Due
Signal Generator	R&S	SMBV100A	259067	Jun. 19, 2024	Annual	Jun. 19, 2025
DC Power Supply	R&S	HMP2020	102130	May 02, 2024	Annual	May 02, 2025
Temperature Chamber	ESPEC CORP.	PL-1J	15000793	Jun. 04, 2024	Annual	Jun. 04, 2025
Spectrum Analyzer	R&S	FSV30	103210	Mar. 27, 2024	Annual	Mar. 27, 2025
Amplifier	H.P.	8447F	2944A03909	Aug. 09, 2024	Annual	Aug. 09, 2025
Loop Antenna	Schwarzbeck Mess-Elektronik	FMZB 1519	1519-039	Aug. 21, 2023	Biennial	Aug. 21, 2025
Bilog Antenna	Schwarzbeck Mess-Elektronik	VULB 9163	9163-396	Apr. 02, 2024	Biennial	Apr. 02, 2026
EMI Test Receiver	R&S	ESU26	100109	Jan. 16, 2024	Annual	Jan. 16, 2025
Turn Table	Innco systems GmbH	DS 1200 S	N/A	N.C.R.	N/A	N.C.R.
Controller	Innco systems GmbH	CONTROLLER CO3000-4P	CO3000/963/3833 0516/L	N.C.R.	N/A	N.C.R.
Antenna Mast	Innco systems GmbH	MA4640-XP-ET	MA4640/536/3833 0516/L	N.C.R.	N/A	N.C.R.
Anechoic Chamber	SY Corporation	L × W × H (9.6 m × 6.4 m × 6.6 m)	N/A	N.C.R.	N/A	N.C.R.
Coaxial Cable	SENSORVIEW	NMST-13A26-NMST-5 m	TPC2402190004	Oct. 04, 2024	Semi-Annual	Apr. 04, 2025
Coaxial Cable	SENSORVIEW	NMST-13A26-NMST-10 m	TPC2402190001	Oct. 04, 2024	Semi-Annual	Apr. 04, 2025
Coaxial Cable	RADIALL	TESTPRO 3	182287	Oct. 11, 2024	Semi-Annual	Apr. 11, 2025

1.6. Summary of Test Results

The EUT has been tested according to the following specifications:

Applied standard : FCC Part15 subpart C		
Section in FCC	Test item(s)	Result
15.225(a)(b)(c)(d) 15.209	Radiated Emission, Spurious Emission and Field Strength of Fundamental	Pass
15.225(e)	Frequency Stability	Pass
15.215(c)	20 dB Bandwidth & 99 % Bandwidth	Pass
15.207	AC Power Line Conducted Emissions	N/A ¹⁾

Note;

1) The AC Power Line Conducted Emissions was not performed because the EUT use battery power for operation and which do not operate from the AC power lines.

1.7. Sample calculation

Where relevant, the following sample calculation is provided:

1.7.1. Radiation test

Field strength level (dB μ V/m) = Measured level (dB μ V) + Antenna factor (dB/m) + Cable loss (dB) - Amplifier gain(dB)

1.8. Information of software for test.

Using the software of Internal to testing of EUT.

1.9. Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

Parameter	Uncertainty	
20 dB Bandwidth	0.04 kHz	
Frequency Stability	0.11 kHz	
Radiated Emission, 9 kHz to 30 MHz	H	3.40 dB
	V	3.40 dB
Radiated Emission, below 1 GHz	H	4.60 dB
	V	5.00 dB

All measurement uncertainty values are shown with a coverage factor $k = 2$ to indicate a 95 % level of confidence.

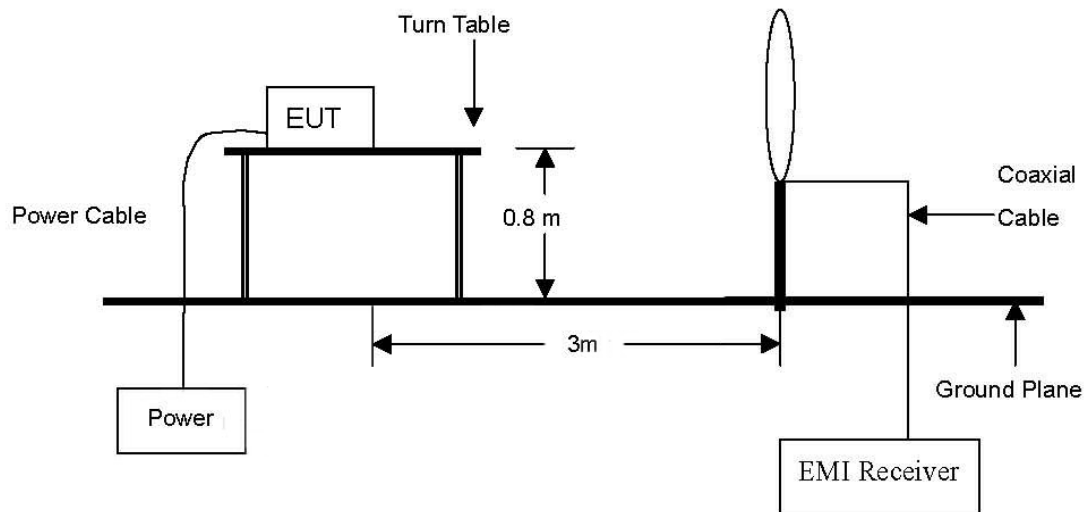
1.10. Test report revision

Revision	Report number	Date of Issue	Description
0	F690501-RF-RTL005596	2024.11.28	Initial

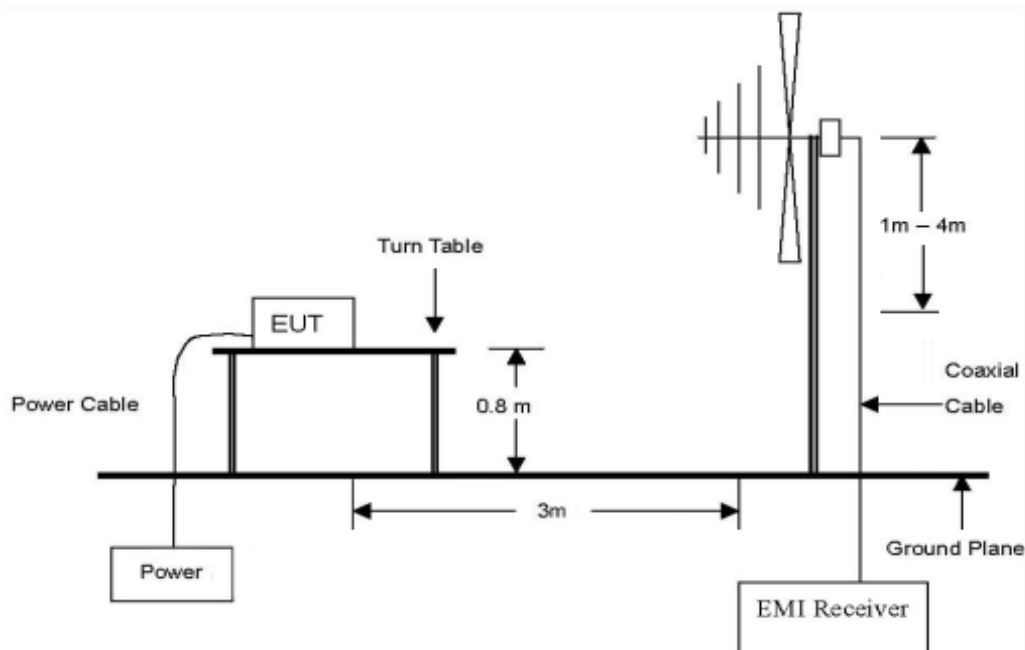
2. Radiated Emissions

2.1. 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 1 000 MHz Emissions.



2.2. Limit

According to §15.225,

- (a) The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15 848 microvolts/meter 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 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 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.

According to §15.209,

Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

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

** 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., §§15.231 and 15.241.

2.3. Test Procedures

Radiated emissions from the EUT were measured according to the dictates of ANSI C63.10-2013.

2.3.1. Test Procedures for emission below 30 MHz

1. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter anechoic chamber test site. The table was rotated 360 degrees to determine the position of the highest radiation.
2. 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.
3. 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.
4. The test-receiver system was set to Quasi peak Detect Function with Maximum Hold Mode.

2.3.2. Test Procedures for emission above 30 MHz

1. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter anechoic chamber test site. The table was rotated 360 degrees to determine the position of the highest radiation.
2. During performing radiated emission below 1 GHz, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower.
3. The antenna is a bi-log antenna and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
4. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the table was turned from 0 degrees to 360 degrees to find the maximum reading.
5. For measurements below 1 GHz resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.

Note;

The radiation test of the EUT was investigated in three orthogonal orientations X, Y, and Z, and the worst case data is reported.

2.4. Test Result

Ambient temperature : (23 ± 1) °C
 Relative humidity : 47 % R.H.

The following table shows the highest levels of radiated emissions.

- Fundamental within the band 13.553 MHz - 13.567 MHz

Radiated Emissions			Ant.	Correction Factors		Total		Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	Ant. Factor (dB/m)	Cable loss (dB)	Actual (dBμV/m) at 3 m	Actual (dBμV/m) at 30 m	Limit (dBμV/m) at 30 m	Margin (dB)
13.560	52.83	Peak	H	18.93	0.61	72.37	32.37	84.00	51.63

- Spurious emission within the bands 13.410 MHz - 13.553 MHz and 13.567 MHz - 13.710 MHz

Radiated Emissions			Ant.	Correction Factors		Total		Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	Ant. Factor (dB/m)	Cable loss (dB)	Actual (dBμV/m) at 3 m	Actual (dBμV/m) at 30 m	Limit (dBμV/m) at 30 m	Margin (dB)
13.553	47.48	Peak	H	18.93	0.61	67.02	27.02	50.47	23.45
13.567	47.54	Peak	H	18.93	0.61	67.08	27.08	50.47	23.39

- Spurious emission within the bands 13.110 MHz - 13.410 MHz and 13.710 MHz - 14.010 MHz

Radiated Emissions			Ant.	Correction Factors		Total		Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	Ant. Factor (dB/m)	Cable loss (dB)	Actual (dBμV/m) at 3 m	Actual (dBμV/m) at 30 m	Limit (dBμV/m) at 30 m	Margin (dB)
13.348	33.68	Peak	H	18.93	0.62	53.23	13.23	40.51	27.28
*13.410	28.51	Peak	H	18.93	0.62	48.06	8.06	29.54	21.48
13.764	27.01	Peak	H	18.92	0.60	46.53	6.53	40.51	33.98

- Spurious emission within the bands 9 MHz - 13.110 MHz

Radiated Emissions			Ant.	Correction Factors		Total		Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	Ant. Factor (dB/m)	Cable loss (dB)	Actual (dBμV/m) at 3 m	Actual (dBμV/m) at 30 or 300 m	Limit (dBμV/m) at 30 or 300 m	Margin (dB)
0.034	39.66	Peak	H	18.39	0.03	58.08	-21.92	36.97	58.89
1.064	30.95	Peak	H	18.41	0.76	50.12	-29.88	27.07	56.95
1.604	35.69	Peak	H	18.52	0.62	54.83	14.83	23.50	8.67
*12.290	31.07	Peak	H	18.95	0.63	50.65	10.65	29.54	18.89

- Spurious emission within the bands 14.010 MHz - 30 MHz

Radiated Emissions			Ant.	Correction Factors		Total		Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	Ant. Factor (dB/m)	Cable loss (dB)	Actual (dBμV/m) at 3 m	Actual (dBμV/m) at 30 m	Limit (dBμV/m) at 30 m	Margin (dB)
*16.421	10.82	Peak	H	19.07	0.62	30.51	-9.49	29.54	39.03
22.338	12.12	Peak	H	19.41	0.66	32.19	-7.81	29.54	37.35
*25.616	10.62	Peak	H	19.29	0.66	30.57	-9.43	29.54	38.97
Above 26.000	Not detected	-	-	-	-	-	-	-	-

Remark;

1. Fundamental limit ($\mu V/m$) = $20 \log(15\ 848) = 84.00\ dB\mu V/m$.
2. 30 m distance compensation = $40 \log(3/30) = -40\ dB\mu V/m$.
3. 300 m distance compensation = $40 \log(3/300) = -80\ dB\mu V/m$.
4. "*" means the restricted band.
5. If the spurious emissions are in the restricted band, the limit complied with §15.209.
6. All data were recorded using a spectrum analyzer employing a peak detector.
If PK results were meet Quasi-peak limit, Quasi-peak measurements were omitted.
7. Radiated spurious emission measurement as below 30 MHz.
(Actual (dBμA/m) at 3m = Reading (dBμV) + AF (dB/m) + CL (dB))

- Spurious emission above 30 MHz

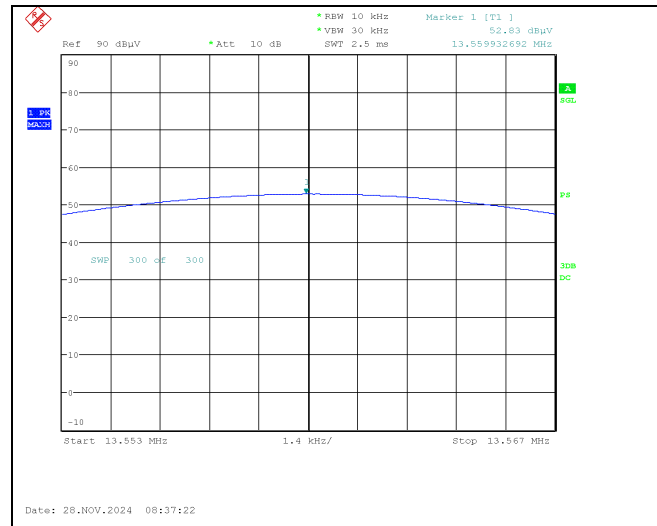
Radiated Emissions			Ant	Correction (dB/m)	Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.		Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
230.47	37.76	Quasi Peak	H	-7.71	30.05	46.00	15.95
910.57	28.20	Quasi Peak	H	4.40	32.60	46.00	13.40

Remark;

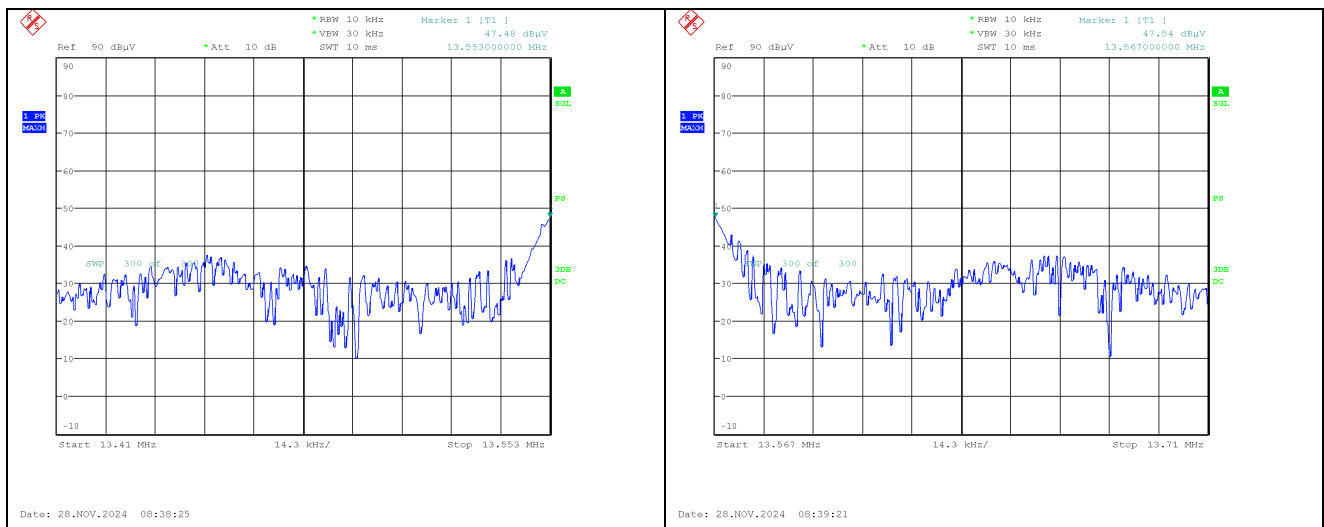
1. Radiated spurious emission measurement as below.
 (Actual (dBμA/m) = Reading (dBμV) + Correction)
 (Correction = Antenna Factor (dB/m) + AMP Factor (dB) + Cable Loss (dB))
2. According to §15.31(o), emission levels are not report much lower than the limits by over 20 dB.
3. Test from 30 MHz to 1 000 MHz was performed using the software of ELEKTRA(V5.02.1) from Rohde & Schwarz GmbH & Co. KG.

Test plots

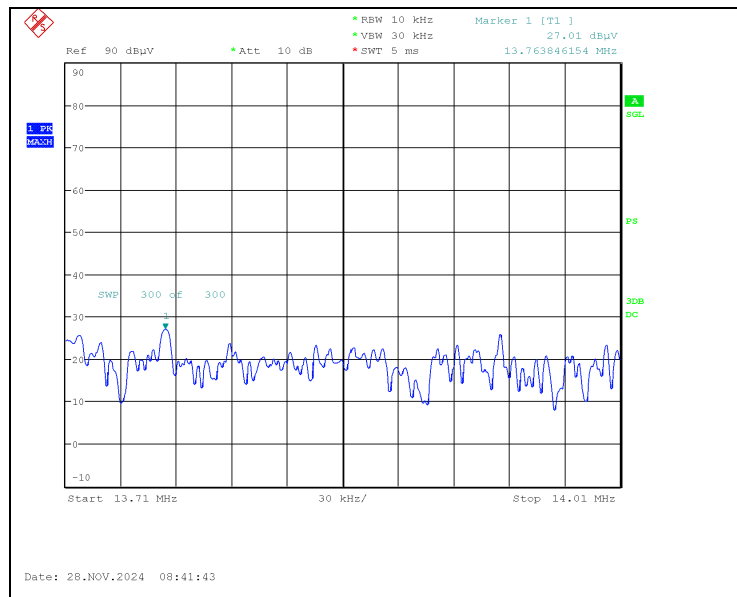
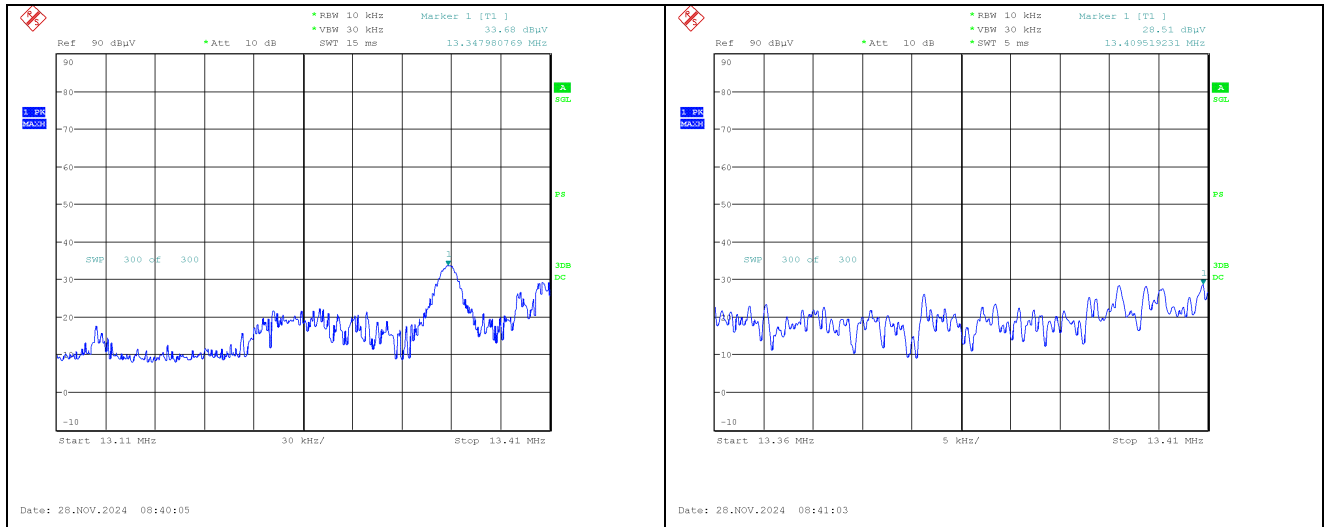
- Fundamental within the band 13.553 MHz - 13.567 MHz



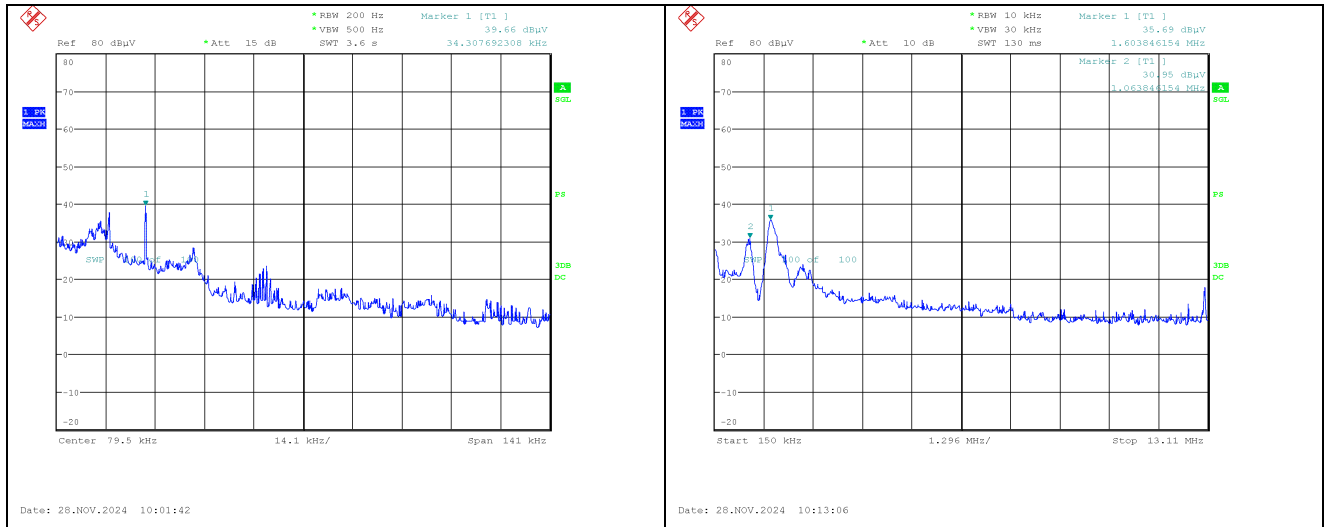
- Spurious emission within the bands 13.410 MHz - 13.553 MHz and 13.567 MHz - 13.710 MHz



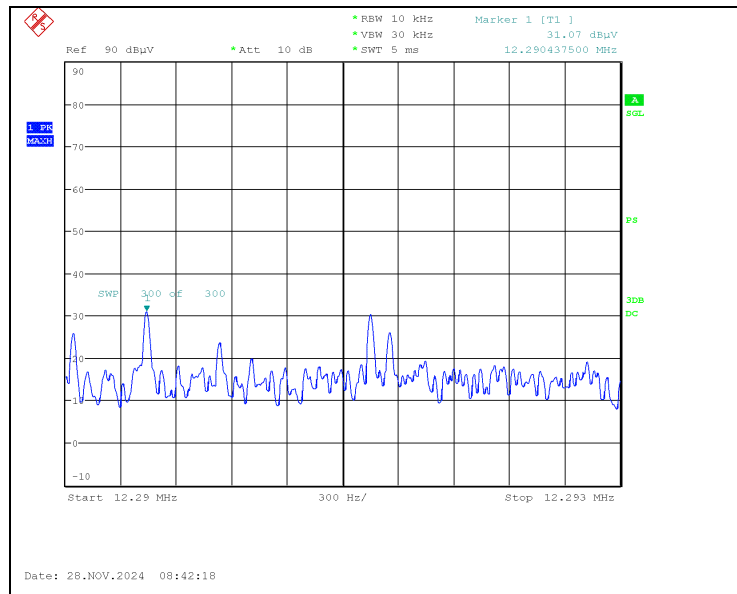
- Spurious emission within the bands 13.110 MHz - 13.410 MHz and 13.710 MHz - 14.010 MHz



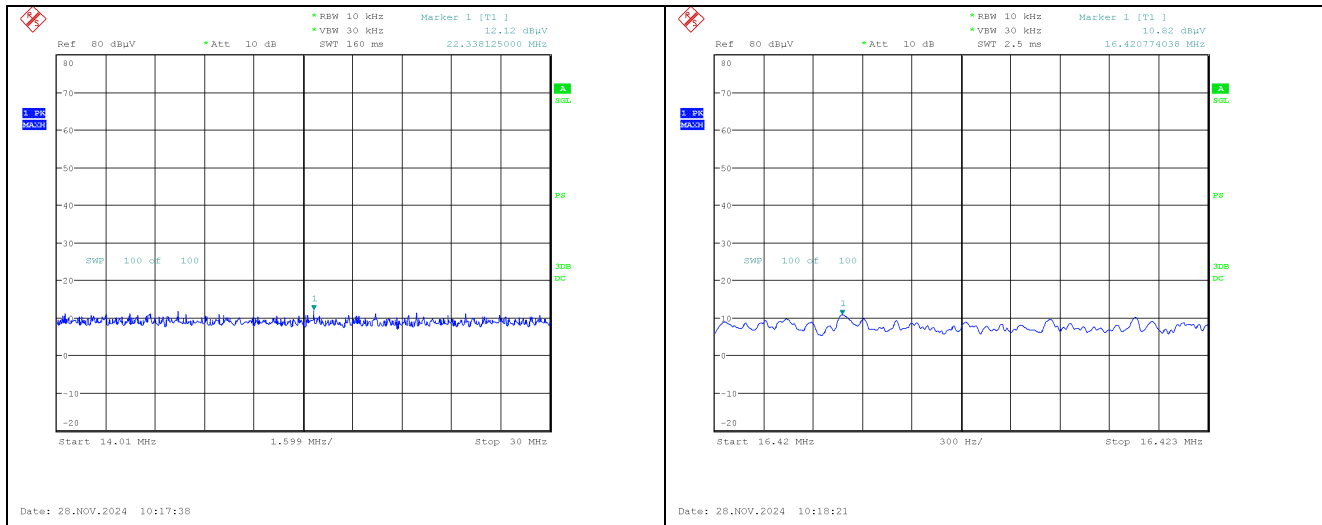
- Spurious emission within the bands 9 MHz – 13.110 MHz

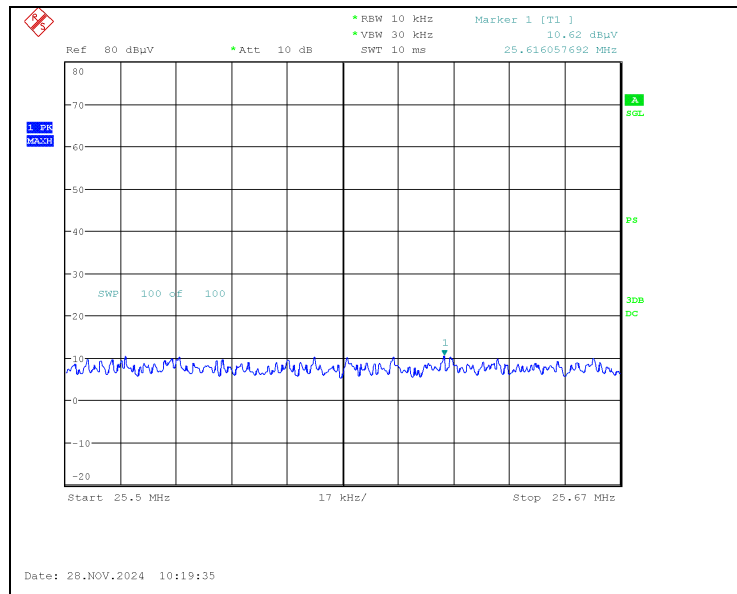


- Spurious emission within the bands 12.290 MHz – 12.293 MHz

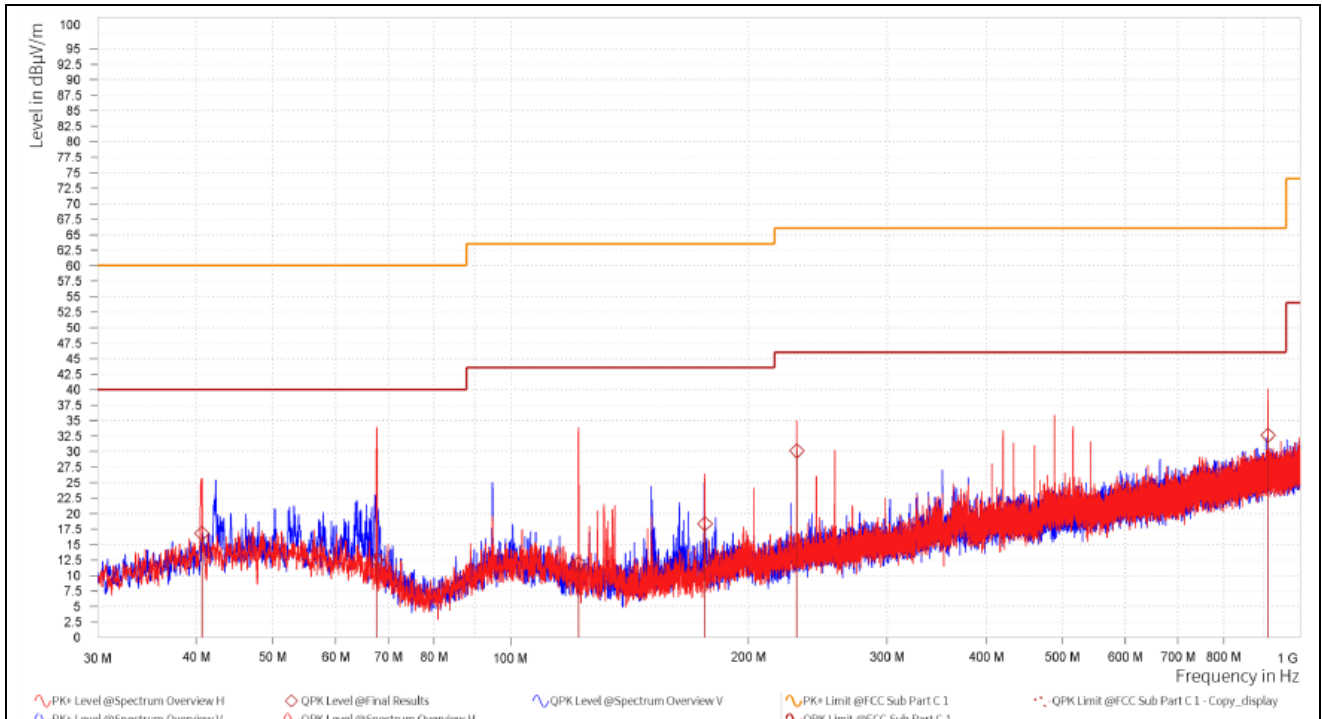


- Spurious emission within the bands 14.010 MHz – 30 MHz



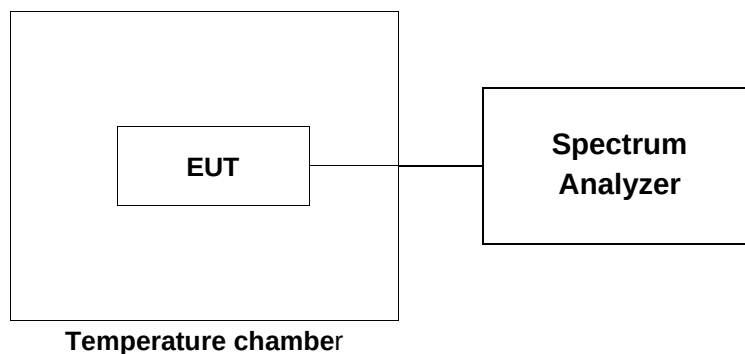


- Spurious emission above 30 MHz



3. Frequency Stability

3.1. Test Setup



3.2. Limit

According to §15.225(e), the frequency tolerance of the carrier signal shall be maintained within ± 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.

3.3. Test Procedures

1. Place the EUT on the table and set it in the transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
3. Set the environment into appropriate environment.
4. Set the spectrum analyzer as RBW = 100 Hz, VBW = 100 Hz, Span = 10 kHz, Sweep time = auto.
5. Mark the peak frequency and measure the frequency tolerance using frequency counter function.
6. Repeat until all the results are investigated.

3.4. Test Result

Ambient temperature : (23 ± 1) °C
 Relative humidity : 47 % R.H.

Operating Frequency : 13 560 000 Hz
 Deviation Limit : ± 0.01 % = ± 1 356 Hz

Startup

Temperature Variations

Power (V _{d.c})	Temperature (°C)	Frequency (Hz)	Freq. Dev. (Hz)	Deviation (%)
12	-20	13 560 135	135	0.000 996
	-10	13 560 092	92	0.000 678
	0	13 560 034	34	0.000 251
	+10	13 559 850	-150	-0.001 106
	+20	13 559 820	-180	-0.001 327
	+30	13 559 809	-191	-0.001 409
	+40	13 559 802	-198	-0.001 460
	+50	13 559 735	-265	-0.001 954

Voltage Variations

Power (V _{d.c})	Temperature (°C)	Frequency (Hz)	Freq. Dev. (Hz)	Deviation (%)
115 % (13.80)	+20	13 559 810	-190	-0.001 401
85 % (10.20)	+20	13 559 800	-200	-0.001 475

2 minutes

Temperature Variations

Power (V _{d.c})	Temperature (°C)	Frequency (Hz)	Freq. Dev. (Hz)	Deviation (%)
12	-20	13 560 156	156	0.001 150
	-10	13 560 080	80	0.000 590
	0	13 560 025	25	0.000 184
	+10	13 559 840	-160	-0.001 180
	+20	13 559 800	-200	-0.001 475
	+30	13 559 799	-201	-0.001 482
	+40	13 559 795	-205	-0.001 512
	+50	13 559 712	-288	-0.002 124

Voltage Variations

Power (V _{d.c})	Temperature (°C)	Frequency (Hz)	Freq. Dev. (Hz)	Deviation (%)
115 % (13.80)	+20	13 559 813	-187	-0.001 379
85 % (10.20)	+20	13 559 806	-194	-0.001 431

5 minutes

Temperature Variations

Power (V _{d.c})	Temperature (°C)	Frequency (Hz)	Freq. Dev. (Hz)	Deviation (%)
12	-20	13 560 189	189	0.001 394
	-10	13 560 095	95	0.000 701
	0	13 560 027	27	0.000 199
	10	13 559 840	-160	-0.001 180
	+20	13 559 790	-210	-0.001 549
	+30	13 559 785	-215	-0.001 586
	+40	13 559 776	-224	-0.001 652
	+50	13 559 685	-315	-0.002 323

Voltage Variations

Power (V _{d.c})	Temperature (°C)	Frequency (Hz)	Freq. Dev. (Hz)	Deviation (%)
115 % (13.80)	+20	13 559 822	-178	-0.001 313
85 % (10.20)	+20	13 559 821	-179	-0.001 320

10 minutes

Temperature Variations

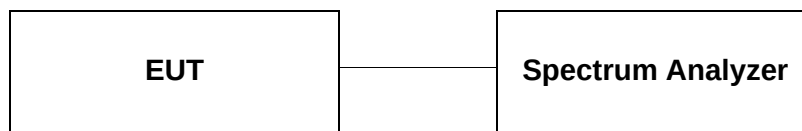
Power (V _{d.c})	Temperature (°C)	Frequency (Hz)	Freq. Dev. (Hz)	Deviation (%)
12	-20	13 560 205	205	0.001 512
	-10	13 560 094	94	0.000 693
	0	13 560 030	30	0.000 221
	10	13 559 830	-170	-0.001 254
	+20	13 559 770	-230	-0.001 696
	+30	13 559 753	-247	-0.001 822
	+40	13 559 740	-260	-0.001 917
	+50	13 559 712	-288	-0.002 124

Voltage Variations

Power (V _{d.c})	Temperature (°C)	Frequency (Hz)	Freq. Dev. (Hz)	Deviation (%)
115 % (13.80)	+20	13 559 799	-201	-0.001 482
85 % (10.20)	+20	13 559 801	-199	-0.001 468

4. 20 dB Bandwidth

4.1. Test Setup



4.2. Limit

None; for reporting purposes only.

4.3. Test Procedures

20 dB Bandwidth

1. Span = set to capture all products of the modulation process, including the emission skirts.
 RBW = 200 Hz, VBW = 200 Hz, Sweep = auto, Detector = peak, Trace = max hold.
2. The marker-to-peak function to set the mark to the peak of the emission. Use the marker-delta function to measure 20 dB down one side of the emission. Reset the function, and move the marker to the other side of the emission, until it is (as close as possible to) even with the reference marker level. The marker-delta reading at this point is 20 dB bandwidth of the emission.

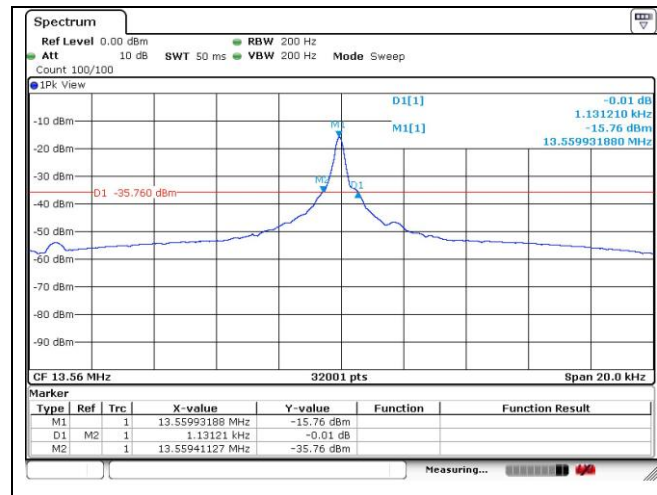
4.4. Test Result

Ambient temperature : (23 ± 1) °C
 Relative humidity : 47 % R.H.

Frequency (MHz)	20 dB Bandwidth (kHz)
13.56	1.131

-Test plot

20 dB Bandwidth



-End of the Test report-