Certificate # 3939.01

RADIO TEST REPORT

(FCC Part 15 Subpart C)

Applicant:	Marquardt GmbH
Address:	Schloss-str.16,78604 Rietheim-Weilheim,Germany

Manufacturer:	Marquardt GmbH
Address:	Schloss-str.16,78604 Rietheim-Weilheim,Germany
Product:	Lotus NFC Reader
Brand Name:	Marquardt
Model Name:	GR1
FCC ID:	IYZGR1
Date of tests:	Jun. 29, 2023 ~ Jul. 10, 2023

The tests have been carried out according to the requirements of the following standard:

☒ **Part 15 Subpart C §15. 225**

☒ **RSS-Gen Issue 5, Amendment 2 (February 2021)**

☒ **ANSI C63.10-2013**

CONCLUSION: The submitted sample was found to COMPLY with the test requirement

Prepared by Simon Wang Engineer / Mobile Department	Approved by Luke Lu Manager / Mobile Department
Simon Wang Date: Jul. 10, 2023	Luke Lu Date: Jul. 10, 2023

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REPORT REVISE RECORD

ISSUE NO.	REASON FOR CHANGE	DATE ISSUED
W7L-230608W0036RF01	Original release	Jul. 10, 2023

SUMMARY OF TEST RESULT

FCC Rule	IC Rule	Description	Limit	Result	Remark
-	RSS-Gen 6.7	99% Bandwidth	-	Pass	-
15.225(a)(b)(c)	RSS-210 Annex B.6	Field Strength of Fundamental Emissions	15.225(a)(b)(c) RSS-210 Annex B.6	Pass	-
15.215	-	20dB Spectrum Bandwidth	15.215	Pass	-
15.225(d) 15.209	RSS-210 Annex B.6	Radiated Emission	15.225(d) & 15.209 RSS-210 Annex B.6	Pass	See note 1
15.207	RSS-GEN 8.8	AC Conducted Emission	15.207(a)	Note	See note 1
15.225(e)	Annex B.6	Frequency Stability	< ±100 ppm	Pass	-
15.203	RSS-Gen 6.8	Antenna Requirement	N/A	Pass	-

1 GENERAL DESCRIPTION

1.1 GENERAL DESCRIPTION OF EUT

Items	Description
Tx/Rx Frequency Range	13.553MHz ~ 13.567MHz
Channel Number	1
20dBW	2.731 kHz
99%OBW	2.402 kHz
Antenna Type	PCB Antenna
Type of Modulation	ASK

Remark: The above EUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

1.2 MODIFICATION OF EUT

No modifications are made to the EUT during all test items.

1.3 APPLICABLE STANDARDS

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

- FCC Part 15 Subpart C §15.225
- ANSI C63.10-2013
- RSS-210 Issue 10
- RSS-Gen Issue 5

2 TEST CONFIGURATION OF EQUIPMENT UNDER TEST

2.1 DESCRIPTIONS OF TEST MODE

Investigation has been done on all the possible configurations for searching the worst cases. The following table is a list of the test modes shown in this test report.

Test Items	
AC Power Line Conducted Emissions	Field Strength of Fundamental Emissions
20dB Spectrum Bandwidth	Frequency Stability
Radiated Emissions 9kHz~30MHz	Radiated Emissions 30MHz~1GHz

Note:

1. The EUT was programmed to be in continuously transmitting mode.
2. The ancillary equipment, NFC card, is used to make the EUT (NFC) continuously transmit at 13.56MHz and is placed around 3 cm gap to the EUT.
3. Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, work in modes and data rates. Selected for the final test as listed below.

Frequency	Work in Modes	Type	Data Rate (Kbps)
13.56 MHz	☐ Card Emulation ☑ Reader/Writer ☐ Peer-to-Peer	☐ A ☐ B ☑ F ☐ V	☐ 106 ☑ 212 ☐ 424 ☐ 848

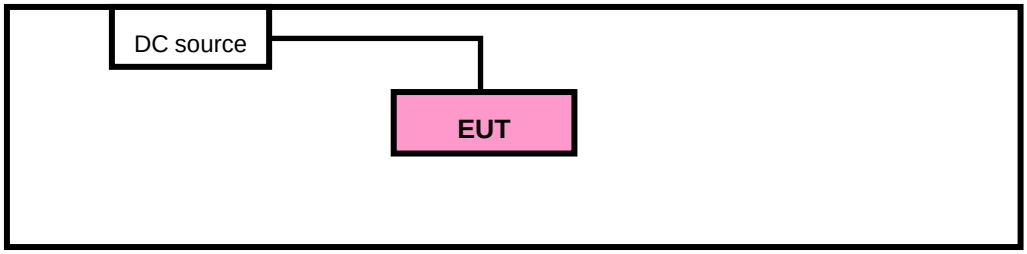
Remark:

The mark"☑" means is chosen for testing;

The mark"☐" means is not chosen for testing.

2.2 TEST CONFIGURATIONS

< For Fundamental Emissions and Mask and Radiated Emissions Measurement >



*Test Table

* Kept in a remote area

2.3 SUPPORT EQUIPMENT

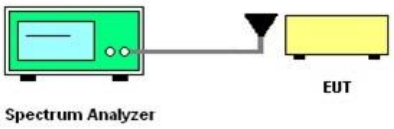
NO.	PRODUCT	BRAND	MODEL NO.	SERIAL NO.	FCC ID
1	N/A	N/A	N/A	N/A	N/A

2.4 TEST SETUP

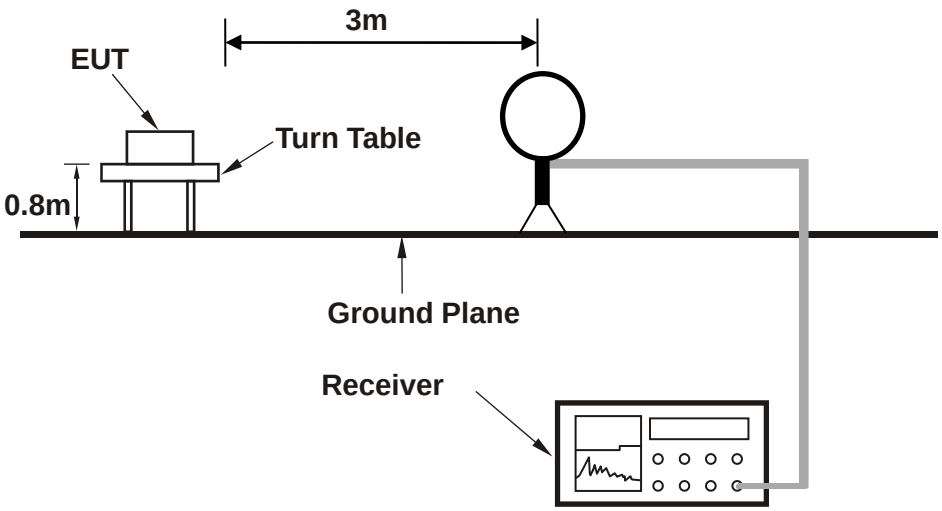
The EUT is continuously communicating during the tests.

EUT was set in the Hidden menu mode to enable NFC communications.

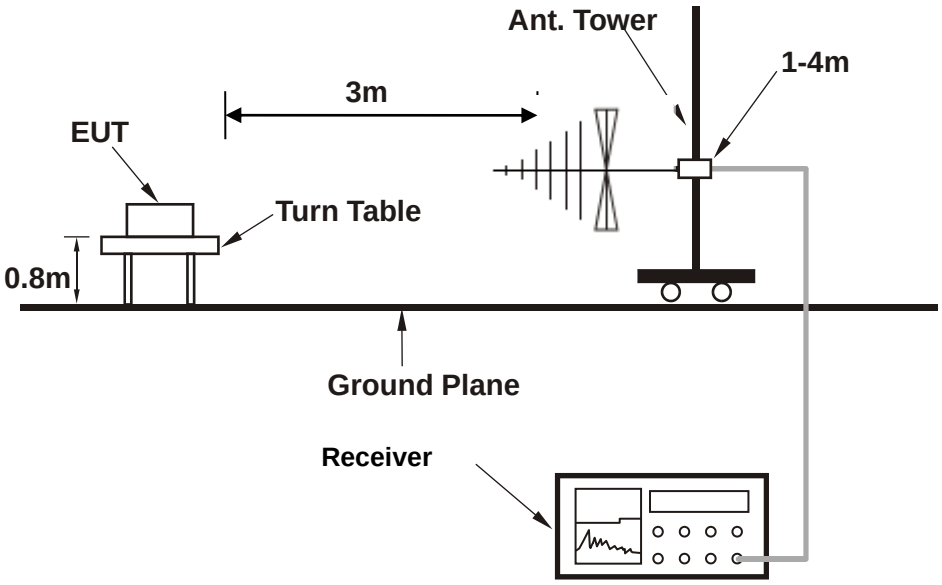
Setup diagram for Conducted Test



Setup diagram for Radiation(9KHz~30MHz) Test



Setup diagram for Radiation(Below 1G) Test



2.5 MEASUREMENT RESULTS EXPLANATION EXAMPLE

For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

Example:

The spectrum analyzer offset is derived from RF cable loss and attenuator factor.

Offset = RF cable loss + attenuator factor.

Following shows an offset computation example with cable loss 5 dB and 10dB attenuator.

Offset(dB) = RF cable loss(dB) + attenuator factor(dB).

= 5 + 10 = 15 (dB)

3 TEST RESULT

3.1 20DB AND 99% BANDWIDTH MEASUREMENT

3.1.1 LIMIT OF 20DB AND 99% BANDWIDTH

Intentional radiators must be designed to ensure that the 20dB and 99% emission bandwidth in the specific band 13.553~13.567MHz.

3.1.2 TEST PROCEDURES

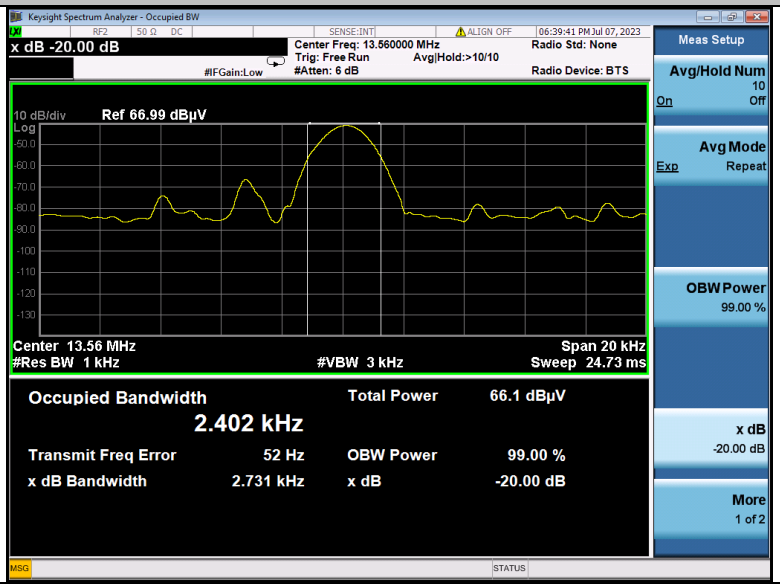
1. The spectrum analyzer connected via a receive antenna placed near the EUT in peak Max hold mode.
2. The resolution bandwidth of 1 kHz and the video bandwidth of 3 kHz were used. (Since the signal being measured is CW or CW-like, it is impractical to adjust RBW according to C63.10 because the bandwidth measured will always follow RBW and the result will be approximately twice as large as RBW.)
3. Measured the spectrum width with power higher than 20dB below carrier.
4. Measured the 99% OBW.

3.1.3 TEST RESULT OF 20DB AND 99% BANDWIDTH

Test Mode :	NFC	**Temperature :**	23℃
Test Engineer :	Jace hu	**Relative Humidity :**	50%

Mode	**Frequency**	**20dB Bandwidth [kHz]**	**99% OBW[kHz]**	**Verdict**
NFC Type F_212 Kbps	13.56MHz	2.731	2.402	PASS

20dB Bandwidth & 99% Bandwidth Plot

Graphs			
NFC Type F_212 Kbps			

3.2 FREQUENCY STABILITY MEASUREMENT

3.2.1 LIMIT OF FREQUENCY STABILITY

The frequency tolerance of the carrier signal shall be maintained within +/- 0.01% (100ppm) 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.

3.2.2 TEST PROCEDURES

1. The spectrum analyzer connected via a receive antenna placed near the EUT.
2. EUT have transmitted signal and fixed channelize.
3. Set the spectrum analyzer span to view the entire emissions bandwidth.
4. Set RBW = 1 kHz, VBW = 3 kHz with peak detector and maxhold settings.
5. The fc is declaring of channel frequency. Then the frequency error formula is (fc-f)/fc × 10^6 ppm and the limit is less than ±100ppm.
6. Extreme temperature rule is -20°C~50°C.

3.2.3 TEST RESULT OF FREQUENCY STABILITY

The NFC Type F_212 Kbps is the worst case, Only report worst mode data

NFC Type F_212 Kbps

Voltage (Vdc)	Temperature (℃)	Measurement Frequency (MHz)	Frequency Tolerance(ppm)	Limit(ppm)	Result
10.2	20	13.55999	-0.74	±100	Pass
13.8		13.56028	20.65		Pass
12	-20	13.56014	10.32		Pass
	-10	13.56031	22.86		Pass
	0	13.55976	-17.70		Pass
	10	13.55982	-13.27		Pass
	20	13.56001	0.74		Pass
	30	13.5599	-7.37		Pass
	40	13.55978	-16.22		Pass
	50	13.5601	7.37		Pass

3.3 FIELD STRENGTH OF FUNDAMENTAL EMISSIONS AND MASK MEASUREMENT

3.3.1 LIMIT OF FIELD STRENGTH OF FUNDAMENTAL EMISSIONS AND MASK

Rules and specifications	FCC CFR 47 Part 15 section 15.225 IC RSS-210 B.6			
Description	Compliance with the spectrum mask is tested with RBW set to 9kHz.			
Freq. of Emission (MHz)	Field Strength (μV/m) at 30m	Field Strength (dBμV/m) at 30m	Field Strength (dBμV/m) at 10m	Field Strength (dBμV/m) at 3m
1.705~13.110	30	29.5	48.58	69.5
13.110~13.410	106	40.5	59.58	80.5
13.410~13.553	334	50.5	69.58	90.5
13.553~13.567	15848	84.0	103.08	124.0
13.567~13.710	334	50.5	69.58	90.5
13.710~14.010	106	40.5	59.58	80.5
14.010~30.000	30	29.5	48.58	69.5

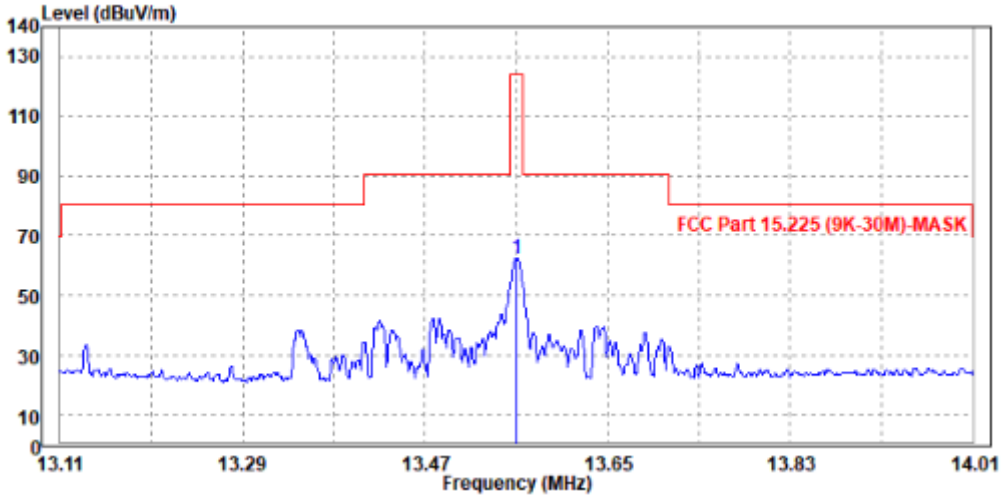
3.3.2 TEST PROCEDURES

1. Configure the EUT according to ANSI C63.10. The EUT was placed on the top of the turntable 0.8 meter above ground. The phase center of the loop receiving antenna mounted antenna tower was placed 3 meters far away from the turntable.
2. Power on the EUT and all the supporting units. The turntable was rotated by 360 degrees to determine the position of the highest radiation.
3. The height of the receiving antenna was fixed at one meter above ground to find the maximum emissions field strength.
4. For Fundamental emissions, use the receiver to measure QP reading.
5. When the radiated emissions limits are expressed in terms of the average value of the emissions, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value.
6. Compliance with the spectrum mask is tested with RBW set to 9kHz.

   Note: Emission level (dBμV/m) = 20 log Emission level (μV/m).

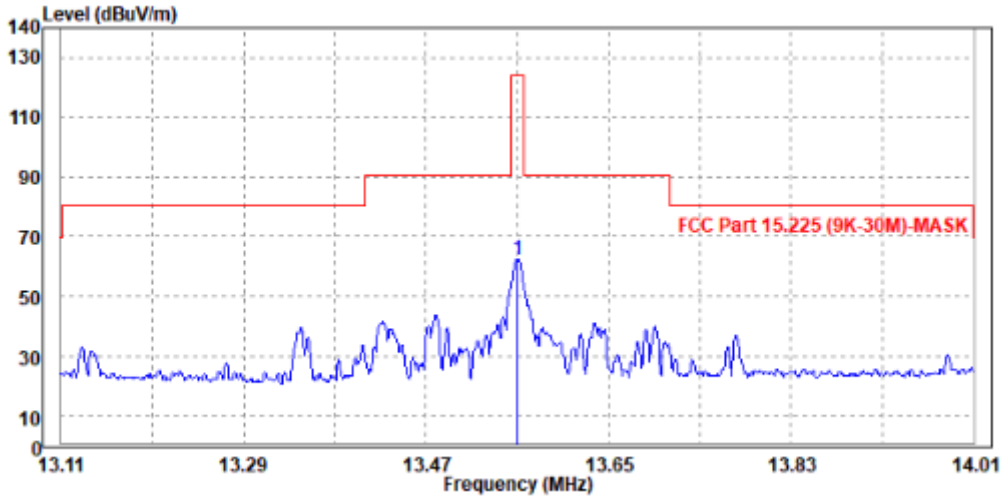
3.3.3 TEST RESULTS OF FIELD STRENGTH OF FUNDAMENTAL EMISSIONS AND MASK (1.705 MHZ ~ 30 MHZ)

Test Mode :	NFC (13.56 MHz)	Temperature :	23℃
Test Engineer :	Jace hu	Relative Humidity :	50%
Frequency Range	13.11MHz~14.01MHz	Polarization :	Horizontal



	Freq	Level	Read Level	Limit Line	Over Limit	Factor	Remark	Pol/Phase
	MHz	dBuV/m	dBuV	dBuV/m	dB	dB/m		
1 PP	13.560	62.34	79.33	124.00	-61.66	-16.99	Peak	Horizontal

Test Mode :	NFC (13.56 MHz)	Temperature :	23℃
Test Engineer :	Jace hu	Relative Humidity :	50%
Frequency Range	13.11MHz~14.01MHz	Polarization :	Vertical



	Freq	Level	Read Level	Limit Line	Over Limit	Factor	Remark	Pol/Phase
	MHz	dBuV/m	dBuV	dBuV/m	dB	dB/m		
1 PP	13.560	62.50	79.49	124.00	-61.50	-16.99	Peak	Vertical

3.4 RADIATED EMISSIONS MEASUREMENT

3.4.1 LIMIT

The field strength of any emissions which appear outside of 13.110 ~14.010MHz band shall not exceed the general radiated emissions limits.

Frequencies (MHz)	Field Strength (μV/m)	Measurement Distance (meters)
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

3.4.2 MEASURING INSTRUMENT SETTING

The following table is the setting of receiver.

Receiver Parameter	Setting
Attenuation	Auto
Frequency Range: 9kHz~150kHz	RBW 200Hz for QP
Frequency Range: 150kHz~30MHz	RBW 9kHz for QP
Frequency Range: 30MHz~1000MHz	RBW 120kHz for Peak

Note: The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz. Radiated emission limits in these two bands are based on measurements employing an average detector.

3.4.3 TEST PROCEDURES

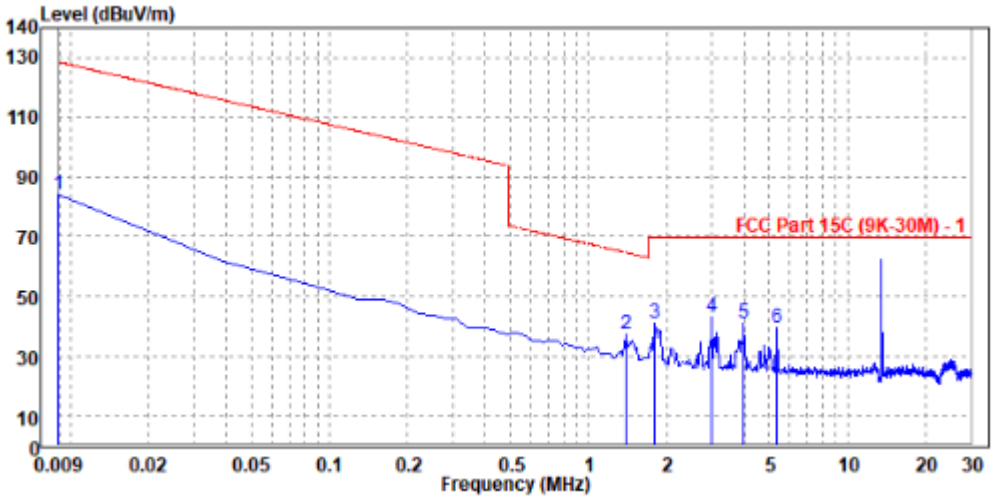
1. Configure the EUT according to ANSI C63.10. The EUT was placed on the top of the turntable 0.8 meter above ground. The phase center of the receiving antenna mounted on the top of a height-variable antenna tower was placed 3 meters far away from the turntable.
2. Power on the EUT and all the supporting units. The turntable was rotated by 360 degrees to determine the position of the highest radiation.
3. The height of the broadband receiving antenna was varied between one meter and four meters above ground to find the maximum emissions field strength of both horizontal and vertical polarization.
4. For each suspected emissions, the antenna tower was scan (from 1 M to 4 M) and then the

turntable was rotated (from 0 degree to 360 degrees) to find the maximum reading.

5. Set the test-receiver system to Peak or CISPR quasi-peak Detect Function with specified bandwidth under Maximum Hold Mode.
6. When the radiated emissions limits are expressed in terms of the average value of the emissions, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value.
7. In case the emission is lower than 30MHz, loop antenna has to be used for measurement and the recorded data should be QP measured by receiver.

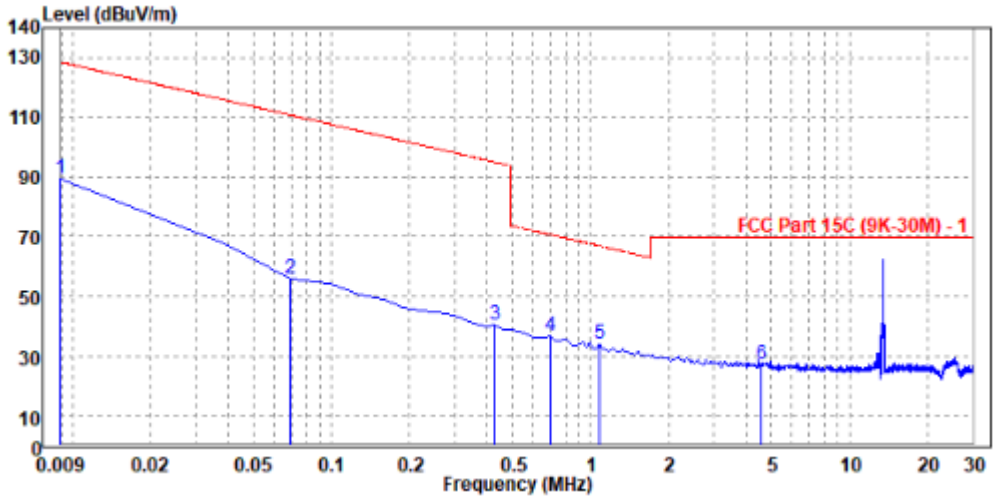
3.4.4 TEST RESULTS OF RADIATED EMISSIONS (9 KHZ ~ 30 MHZ)

Test Mode :	NFC (13.56 MHz)	Temperature :	23℃
Test Engineer :	Jace hu	Relative Humidity :	50%
Frequency Range	9 KHz ~ 30 MHz	Polarization :	Horizontal



		Freq	Level	Read Level	Limit Line	Over Limit	Factor	Remark	Pol/Phase
		MHz	dBuV/m	dBuV	dBuV/m	dB	dB/m		
1		0.009	84.21	101.00	128.52	-44.31	-16.79	Peak	Horizontal
2		1.389	37.37	53.78	64.75	-27.38	-16.41	Peak	Horizontal
3		1.808	40.96	57.46	69.54	-28.58	-16.50	Peak	Horizontal
4	PP	3.008	43.17	59.82	69.54	-26.37	-16.65	Peak	Horizontal
5		3.968	41.01	57.74	69.54	-28.53	-16.73	Peak	Horizontal
6		5.347	39.59	56.35	69.54	-29.95	-16.76	Peak	Horizontal

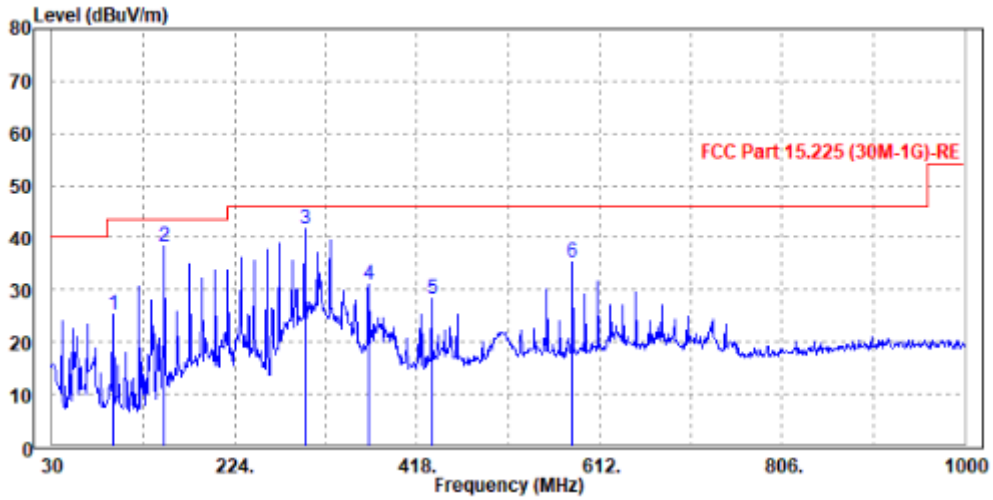
Test Mode :	NFC (13.56 MHz)	Temperature :	23℃
Test Engineer :	Jace hu	Relative Humidity :	50%
Frequency Range	9 KHz ~ 30 MHz	Polarization :	Vertical



	Freq	Level	Read Level	Limit Line	Over Limit	Factor	Remark	Pol/Phase
	MHz	dBuV/m	dBuV	dBuV/m	dB	dB/m		
1	0.009	89.24	106.03	128.52	-39.28	-16.79	Peak	Vertical
2	0.069	55.87	72.45	110.83	-54.96	-16.58	Peak	Vertical
3	0.429	40.55	57.07	94.96	-54.41	-16.52	Peak	Vertical
4	0.699	36.99	53.45	70.72	-33.73	-16.46	Peak	Vertical
5 PP	1.089	33.82	50.16	66.87	-33.05	-16.34	Peak	Vertical
6	4.568	27.13	43.88	69.54	-42.41	-16.75	Peak	Vertical

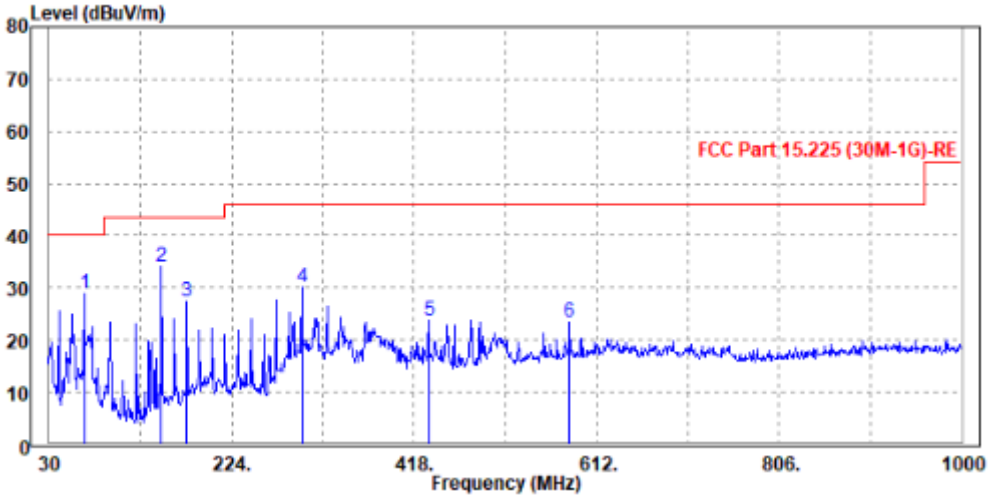
3.4.5 TEST RESULT OF RADIATED SPURIOUS EMISSION (30MHZ ~ 1GHZ)

Test Mode :	NFC (13.56MHz)	Temperature :	23℃
Test Engineer :	Jace hu	Relative Humidity :	50%
Frequency Range	30MHz~1GHz	Polarization :	Horizontal



		Freq	Level	Read Level	Limit Line	Over Limit	Factor	Remark	Pol/Phase
		MHz	dBuV/m	dBuV	dBuV/m	dB	dB/m		
1		94.990	25.20	51.86	43.50	-18.30	-26.66	Peak	Horizontal
2		149.310	38.33	64.57	43.50	-5.17	-26.24	Peak	Horizontal
3	PP	298.690	41.75	63.11	46.00	-4.25	-21.36	Peak	Horizontal
4		366.590	30.97	50.86	46.00	-15.03	-19.89	Peak	Horizontal
5		433.520	28.26	46.79	46.00	-17.74	-18.53	Peak	Horizontal
6		582.900	35.42	51.46	46.00	-10.58	-16.04	Peak	Horizontal

Test Mode :	NFC (13.56MHz)	Temperature :	23℃
Test Engineer :	Jace hu	Relative Humidity :	50%
Frequency Range	30MHz~1GHz	Polarization :	Vertical



	Freq	Level	Read Level	Limit Line	Over Limit	Factor	Remark	Pol/Phase
	MHz	dBuV/m	dBuV	dBuV/m	dB	dB/m		
1	67.830	28.90	57.19	40.00	-11.10	-28.29	Peak	Vertical
2 PP	149.310	34.09	59.60	43.50	-9.41	-25.51	Peak	Vertical
3	176.470	27.24	51.81	43.50	-16.26	-24.57	Peak	Vertical
4	298.690	30.15	51.54	46.00	-15.85	-21.39	Peak	Vertical
5	433.520	23.77	42.40	46.00	-22.23	-18.63	Peak	Vertical
6	582.900	23.32	39.53	46.00	-22.68	-16.21	Peak	Vertical

3.5 ANTENNA REQUIREMENTS

3.5.1 STANDARD APPLICABLE

Except for special regulations, the Low-power Radio-frequency Devices must not be equipped with any jacket for installing an antenna with extension cable. An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited.

3.5.2 ANTENNA CONNECTED CONSTRUCTION

An PCB Antenna design is used.

3.5.3 ANTENNA GAIN

The antenna peak gain of EUT is less than 6 dBi.

4 LIST OF MEASURING EQUIPMENT

Equipment	Manufacturer	Model No.	Serial No.	Last Cal.	Next Cal.
3m Semi-anechoic Chamber	ETS-LINDGREN	9m*6m*6m	Euroshieldpn-CT0001143-1216	May. 18,23	May. 17,26
Bilog Antenna	ETS-LINDGREN	3143B	00161965	Feb. 18,23	Feb. 17,24
MXE EMI Receiver	KEYSIGHT	N9038A-544	MY54450026	Mar. 28,23	Mar. 27,24
Signal Pre-Amplifier	EMSI	EMC 9135	980249	May. 06,23	May. 05,24
E3 Test Software	E3	V 9.160323	N/A	N/A	N/A
Loop Antenna	Schwarzbeck	FMZB 1519B	00173	Sep.03,22	Sep.02,23

NOTE: 1. The calibration interval of the above test instruments is 12 months or 36 months and the calibrations are traceable to CEPREI/CHINA, GRGT/CHINA and NIM/CHINA.

2. The test was performed in 3m Chamber.

3. The FCC Site Registration No. is 525120; The Designation No. is CN1171.

5 UNCERTAINTY OF EVALUATION

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

MEASUREMENT	UNCERTAINTY
AC Power Conducted emissions	±2.70dB
Radiated emissions (9KHz~30MHz)	±2.68dB
Radiated emissions (30MHz~1GHz)	±4.98dB
Occupied Channel Bandwidth	±43.58KHz
Frequency Stability	±76.97Hz

This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

----------End of the report----------